

Volume 1
DISCRETE PRODUCTS
Series A

Semiconductor Data Library

Data Sheets For:
• EIA Registered Type Numbers
to
1N5000 and 2N5000

THE SEMICONDUCTOR DATA LIBRARY

SERIES A
VOLUME I

prepared by
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Series A
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VOLUME I

This volume contains complete data sheets for Motorola-manufactured devices with EIA registered type numbers up to 1N4999 and 2N4999. Data sheets are in numerical sequence according to device type number except for those data sheets that cover several devices with different type numbers. The numerical index in front of the book permits the user to quickly locate the page number of the data sheet for any device characterized in the book.

Econocap, Epibase, Epicap, Glassivated, Isothermal, *k-Pak, McMOS, Meg-A-Life II, MDTL, MECL, MECL 10,000, MHTL, Micro-T, MIDA, MRTL, mW MRTL, MTTL, Multi-Cell II, RamRod, Surmetic, Surmetic 20, Surmetic 30, Surmetic 40, Thermopad, Thermowatt, Unibase, Unibloc and Uniwatt are trademarks of Motorola Inc.

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2N4237	2-757	2N4858,A	2-842
2N4238	2-757	2N4859,A	2-844
2N4239	2-757	2N4860,A	↓
2N4240	2-537	2N4861,A	2-842
2N4260	2-761	2N4870	2-844
2N4261	2-761	2N4871	2-844
2N4264	2-765	2N4877	2-848
2N4265	2-765	2N4890S	2-850
2N4276	2-770	2N4898	2-852
2N4277	↓	2N4899	2-852
2N4278	↓	2N4900	2-852
2N4279	↓	2N4901	2-856
2N4280	↓	2N4902	2-856
2N4281	↓	2N4903	2-856
2N4282	↓	2N4904	2-860
2N4283	2-770	2N4905	2-860
2N4342	2-774	2N4906	2-860
2N4351	2-776	2N4910	2-864
2N4352	2-780	2N4911	2-864
2N4360	2-784	2N4912	2-864
2N4361	2-786	2N4913	2-868
2N4362	↓	2N4914	2-868
2N4363	↓	2N4915	2-868
2N4364	↓	2N4918	2-872
2N4365	↓	2N4919	2-872
2N4366	↓	2N4920	2-872
2N4367	↓	2N4921	2-876
2N4368	↓	2N4922	2-876
2N4371	↓	2N4923	2-876
2N4372	↓	2N4924S	2-880
2N4373	↓	2N4925	2-880
2N4374	↓	2N4926	2-882
2N4375	↓	2N4927	2-882
2N4376	↓	2N4928S	2-884
2N4377	↓	2N4929S	↓
2N4378	2-786	2N4930S,JAN,JT X	2-884
2N4391	2-790	2N4931S,JAN,JT X	2-886
2N4392	2-790	2N4937	↓
2N4392	2-790	2N4938	2-886
2N4398	2-792	2N4939	↓
2N4399	2-792	2N4940	2-886
2N4400	2-797	2N4941	2-888
2N4401	2-797	2N4942	2-888
2N4402	2-802	2N4948	2-888
2N4403	2-802	2N4949	↓
2N4404	2-807	2N4957	2-890
2N4405	2-807	2N4958	2-890
2N4406	2-813	2N4959	2-890
2N4407	2-813	2N4993	2-899
2N4409	2-817		
2N4410	2-817		
2N4416	2-819		
2N4427	2-826		

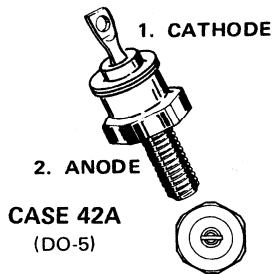
1N... JEDEC REGISTERED DEVICE SPECIFICATIONS

1N248B, C thru 1N250B, C

1N1191 thru 1N1198

1N1195A thru 1N1198A

1N3213, 1N3214



Medium current silicon rectifiers. Type numbers shown have cathode connected to case, but reverse-polarity units can be obtained by adding suffix "R" to standard type number, e.g. 1N248BR.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Repetitive Reverse Voltage and DC Blocking Voltage 1N248B, 1N1191 1N248C 1N249B, 1N1192 1N249C 1N1193 1N250B, 1N1194 1N250C 1N1195, 1N1195A 1N1196, 1N1196A 1N1197, 1N1197A, 1N3213 1N1198, 1N1198A, 1N3214	V_{RRM} V_R	— 50 55 100 110 150 200 220 300 400 500 600	Volts
RMS Reverse Voltage 1N248B, 1N1191 1N248C 1N249B, 1N1192 1N249C 1N1193 1N250B, 1N1194 1N250C 1N1195, 1N1195A 1N1196, 1N1196A 1N1197, 1N1197A, 1N3213 1N1198, 1N1198A, 1N3214	$V_{R(RMS)}$	35 38.5 70 77 105 140 154 210 280 350 420	Volts
Average 1/2-Wave Rectified Forward Current (Resistive Load, 60 Hz, $T_C = 150^\circ\text{C}$)	I_O	20	Amp
Peak Repetitive Forward Current ($T_C = 150^\circ\text{C}$)	I_{FRM}	90	Amp
Peak Surge Current ($T_C = 150^\circ\text{C}$, superimposed on Rated Current at Rated Voltage, 1/2-Cycle, 1/120 sec)	I_{FSM}	350	Amp

THERMAL CHARACTERISTICS

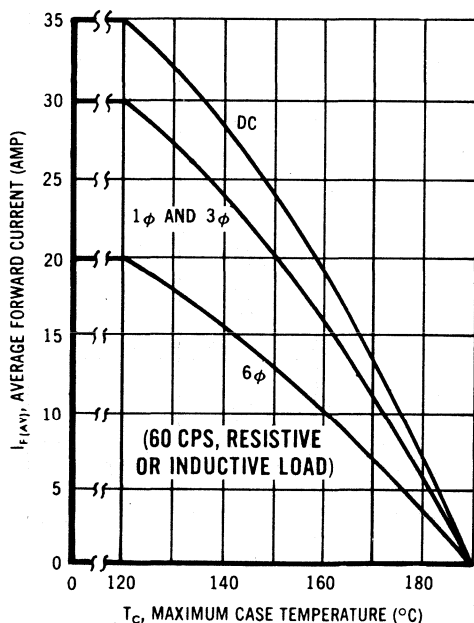
Maximum Operating and Storage Temperature: -65 to $+190^{\circ}\text{C}$

Maximum Thermal Impedance, Junction to Case: $\theta_{JC} = 1.50^{\circ}\text{C/W DC}$

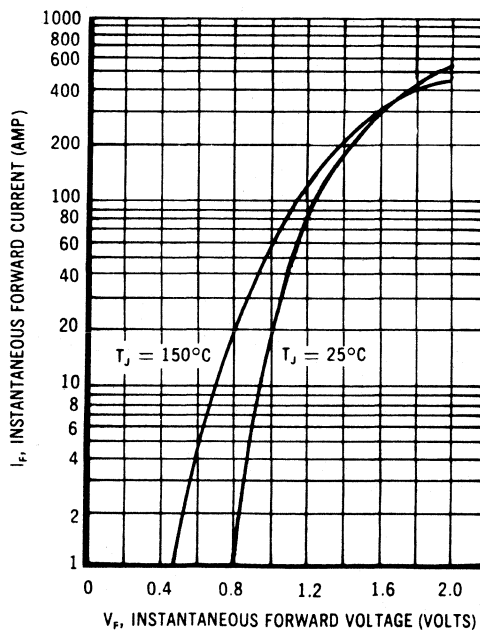
ELECTRICAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (I_O (max), rated V_F , 60 cps, $T_C = 150^{\circ}\text{C}$)	$V_{F(AV)}$	0.6	Volts
Instantaneous Forward Voltage Drop ($I_F = 100$ Amps, $T_J = 25^{\circ}\text{C}$)	v_F	1.5	Volts
Full Cycle Average Reverse Current (I_O (max), rated V_R , 60 cps, $T_C = 150^{\circ}\text{C}$) 1N248B thru 1N250B, 1N1191 thru 1N1198 1N248C 1N249C 1N250C 1N1195A 1N1196A 1N1197A 1N1198A 1N3213 and 1N3214	$I_{R(AV)}$	5.0 3.8 3.6 3.4 3.2 2.5 2.2 1.5 10.0	mA
DC Reverse Current (Rated V_R , $T_C = 25^{\circ}\text{C}$)	I_R	1.0	mA

**MAXIMUM AVERAGE FORWARD CURRENT RATING
versus MAXIMUM CASE TEMPERATURE**



TYPICAL FORWARD CHARACTERISTICS



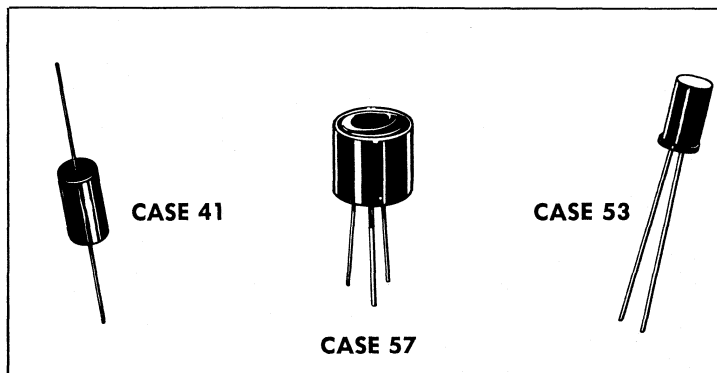
1N429

1N1530 series

1N1735 series

1N4057 series

Temperature compensated zener reference diodes designed for reference sources utilizing an oxide-passivated junction for long-term voltage stability, high uniformity and reliable operation.



MAXIMUM RATINGS ($T_A = 25^{\circ}\text{C}$ unless otherwise noted)

Rating	Symbol	Value	Unit
Operating Junction Temperature Range	T_J	-55 to +175	$^{\circ}\text{C}$
Storage Temperature Range	T_{stg}	-65 to +175	$^{\circ}\text{C}$
Power Dissipation*	P_D	See Tables 1 & 2*	W

*The devices are designed for operation at the specified I_{ZT} . Operation above or below this current is not recommended, since the temperature coefficient is no longer valid. See Note 2 and Figure 4.

MECHANICAL CHARACTERISTICS

Case:	Discrete glass package devices encapsulated in a transfer molded plastic package
Polarity:	Indicated by diode symbol except 1N429, 1N1530, 1N1530A where cathode indicated by polarity dot of contrasting color
Weight:	Varies according to device 0.5 grams (min) 12 grams (max)
Finish:	All external surfaces corrosion resistant and leads readily solderable.

TABLE 1 – ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

TYPE	CASE	Zener Voltage $\pm 5\%$ VZ @ IZT Volts mA		ZZT Ohms (Note 3)	Temperature Coefficient %/°C (Note 2)	$\Delta V_Z @ I_{ZT}$ (+25 to +100°C) Volts (Note 2)	ΔV_Z (-55 to +25°C) Volts (Note 2)	P _D * $T_A = 25^\circ\text{C}$ W
1N4057	41-8	12.4	10	25	0.005	0.047	0.050	1.5
1N4057A		12.4		25	0.002	0.019	0.020	
1N4058		14.6		30	0.005	0.055	0.058	
1N4058A		14.6			0.002	0.022	0.023	
1N4059		16.8		↓	0.005	0.063	0.067	
1N4059A		16.8			0.002	0.025	0.027	
1N4060		18.5			0.005	0.069	0.074	
1N4060A		18.5			0.002	0.028	0.030	
1N4061		21			0.005	0.079	0.084	
1N4061A		21	↓	35	0.002	0.032	0.034	
1N4062		23		40	0.005	0.086	0.092	
1N4062A		23		40	0.002	0.035	0.037	
1N4063		27		45	0.005	0.101	0.108	
1N4063A		27		45	0.002	0.041	0.043	
1N4064		30	↓	50	0.005	0.113	0.120	
1N4064A		30		50	0.002	0.045	0.048	
1N4065		33		55	0.005	0.124	0.132	
1N4065A		33		55	0.002	0.050	0.053	
1N4066		37		80	0.005	0.139	0.148	
1N4066A	↓	37	↓	80	0.002	0.056	0.059	↓
1N4067		43		90	0.005	0.161	0.172	
1N4067A		43		90	0.002	0.065	0.069	
1N4068		47		100	0.005	0.176	0.188	
1N4068A		47		100	0.002	0.071	0.075	
1N4069	41-9	51	↓	110	0.005	0.191	0.204	2.0
1N4069A		51		110	0.002	0.077	0.082	
1N4070		56		120	0.005	0.210	0.224	
1N4070A		56		120	0.002	0.084	0.090	
1N4071		62		135	0.005	0.232	0.248	
1N4071A		62	↓	135	0.002	0.093	0.099	
1N4072		68		230	0.005	0.255	0.272	
1N4072A		68		230	0.002	0.102	0.109	
1N4073		75		250	0.005	0.281	0.300	
1N4073A		75		250	0.002	0.113	0.120	
1N4074		82	↓	270	0.005	0.307	0.328	
1N4074A		82		270	0.002	0.123	0.131	
1N4075		87		290	0.005	0.326	0.348	
1N4075A		87		290	0.002	0.131	0.139	
1N4076		91		310	0.005	0.341	0.364	
1N4076A	↓	91	↓	310	0.002	0.137	0.146	↓
1N4077		100		340	0.005	0.375	0.400	
1N4077A		100		340	0.002	0.150	0.160	
1N4078		105		700	0.005	0.394	0.420	
1N4078A		105		700	0.002	0.158	0.168	
1N4079	↓	110	↓	740	0.005	0.413	0.440	↓
1N4079A		110		740	0.002	0.165	0.176	
1N4080		120		800	0.005	0.450	0.480	
1N4080A		120		800	0.002	0.180	0.192	
1N4081		130		840	0.005	0.488	0.520	
1N4081A	41-10	130	↓	840	0.002	0.195	0.208	↓
1N4082		140		960	0.005	0.525	0.560	
1N4082A		140		960	0.002	0.210	0.224	
1N4083		150		1020	0.005	0.563	0.600	
1N4083A		150		1020	0.002	0.225	0.240	
1N4084	↓	175	↓	1150	0.005	0.656	0.700	↓
1N4084A		175		1150	0.002	0.263	0.280	
1N4085		200		1350	0.005	0.750	0.800	
1N4085A		200		1350	0.002	0.300	0.320	

*Derate linearly from 25°C to 175°C .

TABLE 2 – ELECTRICAL CHARACTERISTICS ($I_{ZT} = 7.5 \text{ mA}$, $T_A = 25^\circ\text{C}$ unless otherwise noted)

Type Number	Zener Voltage $V_Z \pm 5\%$ (Volts)	Max Voltage Change @ -55, +25, +100°C ΔV_Z (Volts) (Note 2)	Max Dynamic Impedance (Note 3) Z_{ZT} (Ohms)	Temperature Coefficient (Note 2) (%/°C)	Power* Dissipation P_D (mW)	Case Number	Figure Number
1N429 ①	6.2	0.050	20	0.01	200	53	1
1N1735	6.2	0.050	20	0.01	200	41-6	2
1N1530** 1N1530A** ②	8.4	0.014 0.007	15	0.002 0.001	250	57	3
1N1736 1N1736A	12.4	0.100 0.050	40	0.01 0.005	400	41-3	2
1N1737 1N1737A	18.6	0.150 0.075	60	0.01 0.005	600	41-5	2
1N1738 1N1738A	24.8	0.200 0.100	80	0.01 0.005	800	41-5	2
1N1739 1N1739A	31.0	0.250 0.125	100	0.01 0.005	1000	41-4	2
1N1740 1N1740A	37.2	0.300 0.150	120	0.01 0.005	1200	41-4	2
1N1741 1N1741A	43.4	0.350 0.175	140	0.01 0.005	1400	41-4	2
1N1742 ③ 1N1742A	49.6	0.400 0.200	180	0.01 0.005	1600	41-4	2

*Derate linearly from 25°C to 175°C ** $I_{ZT} = 10 \text{ mA}$

① Available to MIL-S-19500/299 Specifications.

② Available to MIL-S-19500/320 Specifications.

③ Available to MIL-S-19500/298 Specifications.

TEMPERATURE-COMPENSATED REFERENCE DIODES

Temperature compensated reference diodes are made possible by taking advantage of the differing thermal characteristics of forward and reverse biased silicon PN junctions. A forward biased junction has a negative temperature coefficient of approximately 2.0 millivolts/°C. Reverse biased junctions above 5.0 volts have a positive temperature coefficient and therefore it is possible by judicious selection of combinations of forward and reverse biased junctions to obtain a device which shows a very low temperature coefficient due to cancellation. Because of the differing impedance versus temperature characteristics of the junctions involved, optimum temperature stability is obtained by operating in the zener current range at which the temperature coefficient is a minimum (Figure 4)

Further information, including a method of effective impedance cancellation in a bridge circuit for ultra-stable reference supplies, is contained in the Zener Diode Handbook. The handbook, containing valuable theory, design, and application information, is available from your distributor.

NOTE 1 — Voltage-Current Characteristics

Figure 4 shows the voltage-current characteristics of a typical temperature compensated unit at three different temperatures. The exploded view illustrates the cross-over area (optimum temperature stability point), the non-linearity of the temperature-voltage relationship, and the maximum voltage variation (ΔV_Z) for the three temperatures shown.

Because of device impedance, the reference voltage will vary with

changes in zener current. These variations can be minimized by driving the device from a constant current source.

NOTE 2 — Voltage Variation (ΔV_Z) and Temperature Coefficient

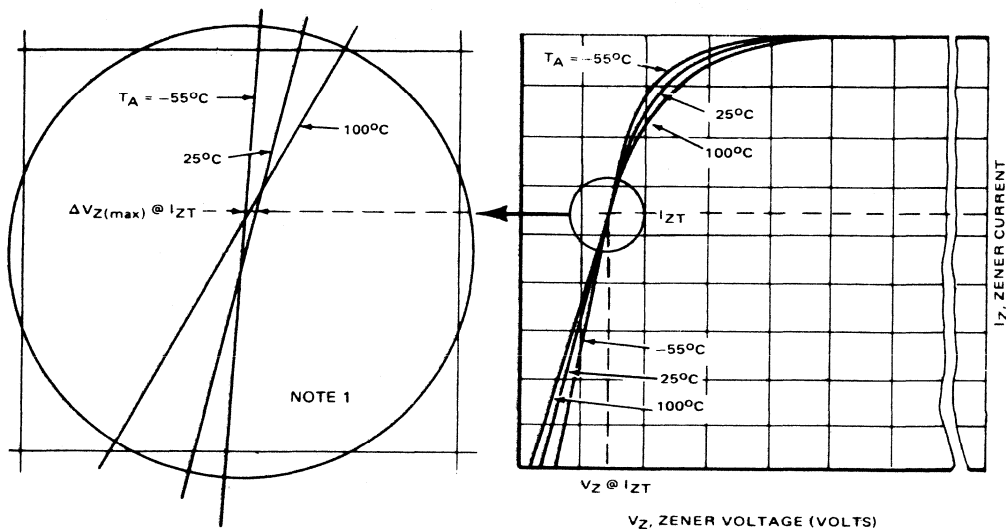
All reference diodes are characterized by the "box" method. This method provides for a guaranteed maximum voltage variation (ΔV_Z in mV) over a specified temperature range at the specified I_{ZT} verified by tests at several points within the range. (Maximum voltage variations over the specified temperature ranges are given in Tables 1 and 2.) The design engineer now has a number (without any calculations) telling him the stability of the voltage over the temperature range of interest thus giving him the maximum flexibility as well as economy in selecting the temperature stability required. The referenced military specifications use this approach to characterize these devices.

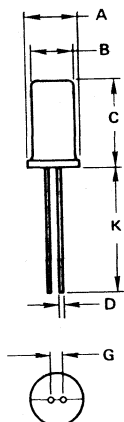
Since reference diodes have a non-linear voltage-temperature relationship (illustrated in exploded view, Figure 4) the temperature coefficients in %/°C are tabulated primarily for reference purposes and are guaranteed only at the end points of the temperature range.

NOTE 3 — Zener Impedance Derivation

The dynamic zener impedance, Z_{ZT} , is derived from the 60 Hz ac voltage which results when an ac current with an rms value equal to 10% of the dc zener current, I_{ZT} , is superimposed on I_{ZT} . A cathode-ray tube curve trace test on a sample basis is used to ensure that each zener characteristic has a sharp and stable knee region.

FIGURE 4 — TYPICAL OPERATING CHARACTERISTICS



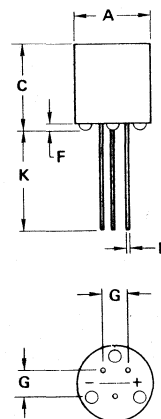


DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.33	5.84	0.210	0.230
B	4.57	5.08	0.180	0.200
C	8.89	9.40	0.350	0.370
D	0.48	0.56	0.019	0.022
G	1.14	1.40	0.045	0.055
K	26.97	—	1.062	—

NOTE:

1. POLARITY INDICATED BY CATHODE DOT ON BODY ADJACENT TO CATHODE LEAD.

CASE 53



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	—	14.22	—	0.560
C	—	16.26	—	0.640
D	0.74	0.89	0.029	0.035
F	—	1.02	—	0.040
G	5.08 BSC		0.200 BSC	
K	19.05	—	0.750	—

CASE 57

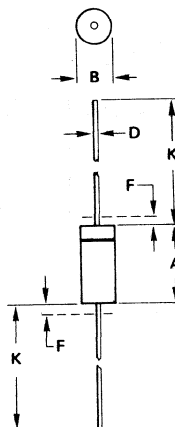
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	—	25.40	—	1.000
B	—	12.70	—	0.500
D	0.76	0.86	0.030	0.034
F	—	1.27	—	0.050
K	31.75	—	1.250	—

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	—	26.16	—	1.030
B	—	9.60	—	0.378
D	0.76	0.86	0.030	0.034
F	—	1.27	—	0.050
K	31.75	—	1.250	—

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	—	30.99	—	1.220
B	—	16.28	—	0.641
D	0.76	0.86	0.030	0.034
F	—	1.27	—	0.050
K	44.45	—	1.750	—

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	—	16.64	—	0.655
B	—	16.28	—	0.641
D	0.76	0.86	0.030	0.034
F	—	1.27	—	0.050
K	31.75	—	1.250	—

CASE 41



NOTE:

1. LEAD FINISH & DIA UNCONTROLLED IN AREA "F".

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	—	13.21	—	0.520
B	—	6.98	—	0.275
D	0.46	0.56	0.018	0.022
F	—	1.27	—	0.050
K	31.75	—	1.250	—

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	—	13.21	—	0.520
B	6.10	6.60	0.240	0.260
D	0.71	0.81	0.028	0.032
F	—	1.27	—	0.050
K	25.40	—	1.000	—

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	—	19.81	—	0.780
B	6.10	6.60	0.240	0.260
D	0.58	0.81	0.023	0.032
F	—	1.27	—	0.050
K	25.40	—	1.000	—

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	—	29.34	—	1.155
B	7.70	8.20	0.303	0.323
D	0.71	0.81	0.028	0.032
F	—	1.27	—	0.050
K	25.40	—	1.000	—

1N702 thru 1N745 (ZENER DIODES)



CASE 51
(DO-7)



Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N5221 series.

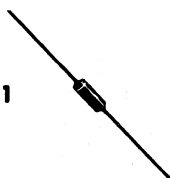
1/4 watt, 2-200 volts

Polarity Indicated by Cathode Band

1N746 thru 1N759 1N746A thru 1N759A (ZENER DIODES) 1N4370 thru 1N4372 1N4370A thru 1N4372A



CASE 51



Hermetically sealed, all-glass case with all external surfaces corrosion resistant.

Polarity Indicated by Cathode Band

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to $+175^{\circ}\text{C}$

D C Power Dissipation: 400 Milliwatts at 50°C Ambient (Derate $3.2 \text{ mW}/^{\circ}\text{C}$ Above 50°C Ambient)

TOLERANCE DESIGNATIONS

The type numbers shown have tolerance designations as follows:

1N4370 series: $\pm 10\%$, suffix A for $\pm 5\%$ units.

1N746 series: $\pm 10\%$, suffix A for $\pm 5\%$ units.

ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}\text{C}$ unless otherwise noted)

TYPE NUMBER	NOMINAL ZENER VOLTAGE $V_Z @ I_{ZT}$ VOLTS	TEST CURRENT I_{ZT} mA	MAXIMUM ZENER IMPEDANCE $Z_{ZT} @ I_{ZT}$ Ohms	MAXIMUM DC ZENER CURRENT I_{ZM} mA	MAXIMUM REVERSE LEAKAGE CURRENT	
					$T_A = 25^{\circ}\text{C}$ $I_R @ V_R = 1 \text{ V}$ μA	$T_A = 150^{\circ}\text{C}$ $I_R @ V_R = 1 \text{ V}$ μA
1N4370	2.4	20	30	150	100	200
1N4371	2.7	20	30	135	75	150
1N4372	3.0	20	29	120	50	100
1N746	3.3	20	28	110	10	30
1N747	3.6	20	24	100	10	30
1N748	3.9	20	23	95	10	30
1N749	4.3	20	22	85	2	30
1N750	4.7	20	19	75	2	30
1N751	5.1	20	17	70	1	20
1N752	5.6	20	11	65	1	20
1N753	6.2	20	7	60	0.1	20
1N754	6.8	20	5	55	0.1	20
1N755	7.5	20	6	50	0.1	20
1N756	8.2	20	8	45	0.1	20
1N757	9.1	20	10	40	0.1	20
1N758	10.0	20	17	35	0.1	20
1N759	12.0	20	30	30	0.1	20

POLARITY: Cathode End, Indicated by Color Band, Will Be Positive When Operate Operated In The Zener Region.

1N746 thru 1N759 (continued)

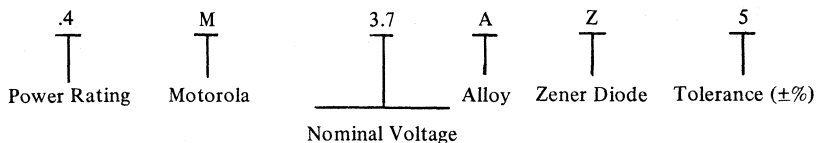
SPECIAL SELECTIONS AVAILABLE INCLUDE: (See Selector Guide for details)

- 1 - Nominal zero voltages between those shown.

To designate units with zener voltages other than those listed, the Motorola type number should be modified as shown below. Unless otherwise specified, the electrical characteristics other than the nominal

voltage (V_z) and test voltage for leakage current will conform to the characteristics of the next higher voltage type shown in the table.

EXAMPLE: 1N746 series, 1N4370 series



1N761 thru 1N769 Recommended for applications requiring an exact replacement only. For new designs see 1N5221 series.

.4M.64FR10/1N816

.4M1.36FR5

.4M1.36FR2

.4M2.04FR5

.4M2.04FR2

MZ2360

MZ2361

MZ2362



**CONSTANT-VOLTAGE REFERENCE DIODES FOR
LOW-VOLTAGE APPLICATIONS**

... high-conductance silicon diodes designed as a stable forward reference source for biasing transistor amplifiers and similar applications.

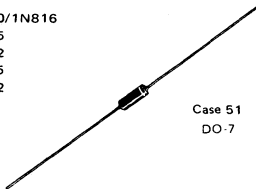
- Guaranteed Forward Voltage Range
- Choice of Package
- Temperature Effects Provided

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Power Dissipation @ $T_L = 30^\circ\text{C} \pm 3^\circ\text{C}$, Lead Length = 3/8"	P_D	400	mW
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	$^\circ\text{C}$

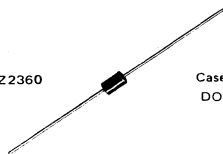
**FORWARD REFERENCE
DIODES
— STABISTORS —**

.4M.64FR10/1N816
.4M1.36FR5
.4M1.36FR2
.4M2.04FR5
.4M2.04FR2
MZ2361
MZ2362



Case 51
DO-7

MZ2360



Case 59
DO-41

MECHANICAL CHARACTERISTICS

Case: Choice of package, either Glass or Surmetic

Dimensions: See outline drawings

Finish: All external surfaces are corrosion resistant and leads are readily solderable and weldable

Polarity: Cathode indicated by polarity band. Cathode negative for forward reference application.

Weight: 0.2 Gram (approximate)

Mounting Positions: Any

**.4M.64FR10/1N816, .4M1.36FR5, .4M1.36FR2, .4M2.04FR5,
.4M2.04FR2, MZ2360, MZ2361, MZ2362 (continued)**

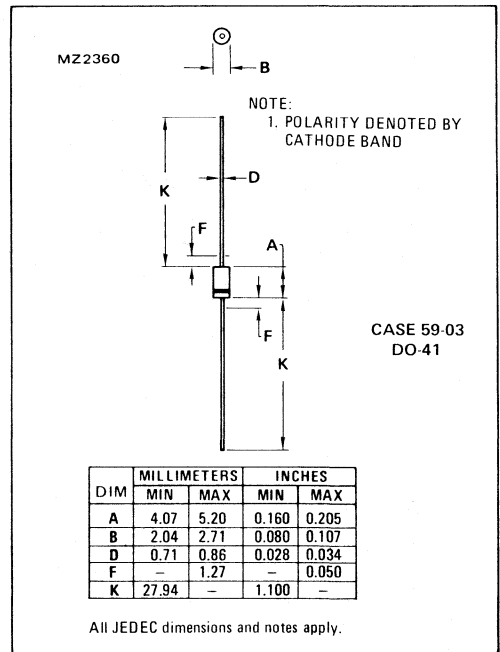
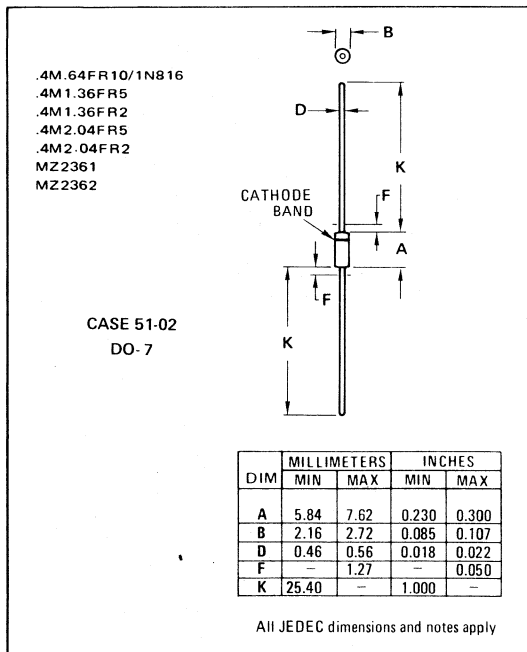
ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Type Number	Forward Reference Voltage (1)		Reverse Leakage Current (Max)		Package	Case
	V_F Volts Min/Max	I_F mA	I_R μA	V_R Volts		
.4M.64FR10/ 1N816* (2)	0.58/0.70	1.0	0.1	4.0	Glass	51
.4M1.36FR5	1.29/1.43	10	0.1	4.0	Glass	51
.4M1.36FR2	1.33/1.39	10	0.1	4.0	Glass	51
.4M2.04FR5	1.94/2.14	10	0.1	4.0	Glass	51
.4M2.04FR2	2.00/2.08	10	0.1	4.0	Glass	51
MZ2360	0.63/0.71	10	10	5.0	Surmetic	59
MZ2361	1.24/1.38	10	10	5.0	Surmetic	51
MZ2362	1.90/2.10	10	10	5.0	Glass	51

*Indicates JEDEC Registered Data for 1N816

(1) Motorola guarantees the forward reference voltage when measured at 90 seconds while maintaining the lead temperature (T_L) at $30^\circ\text{C} \pm 1^\circ\text{C}$, 3/8" from the diode body.

(2) Minimum Saturation Voltage for 1N816 = 40 V @ 100 μA .



.4M.64FR10/1N816, .4M1.36FR5, .4M1.36FR2, .4M2.04FR5,
.4M2.04FR2, MZ2360, MZ2361, MZ2362 (continued)

TYPICAL FORWARD VOLTAGE CHARACTERISTICS

FIGURE 1 — .4M.64FR10/1N816

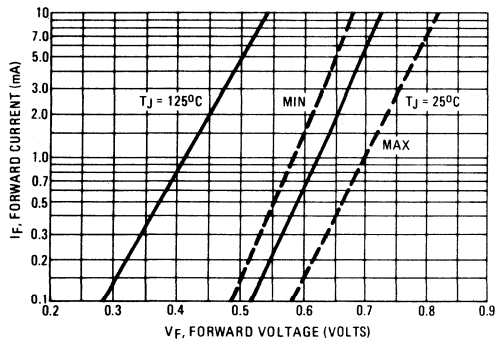


FIGURE 2 — .4M1.36FR5

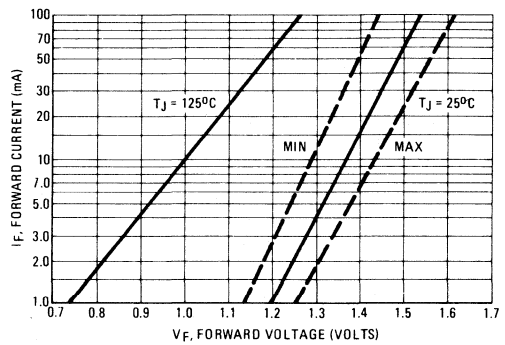


FIGURE 3 — .4M2.04FR5

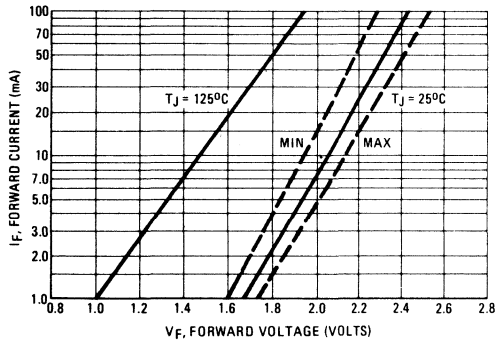


FIGURE 4 — MZ2360

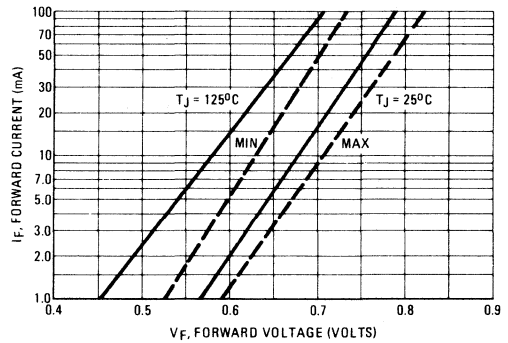


FIGURE 5 — MZ2361

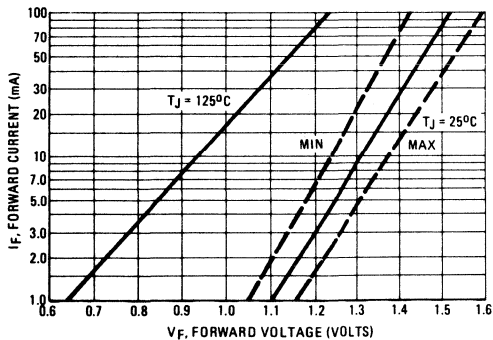
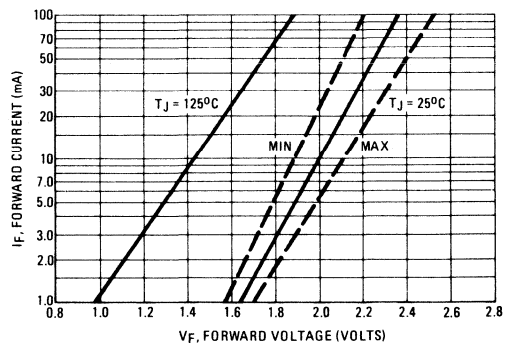


FIGURE 6 — MZ2362



TYPICAL TEMPERATURE COEFFICIENT

FIGURE 7 — .4M.64FR10/1N816

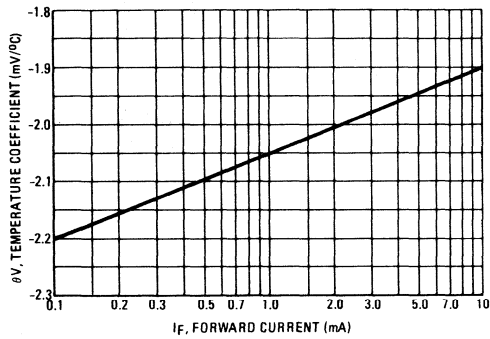


FIGURE 8 — MZ2360

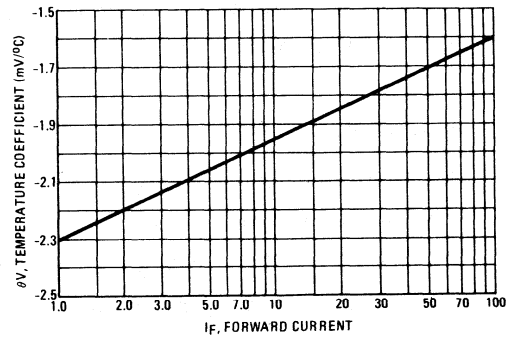


FIGURE 9 — .4M1.36FR5/MZ2361

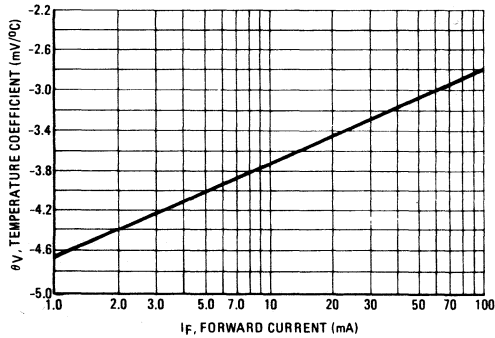
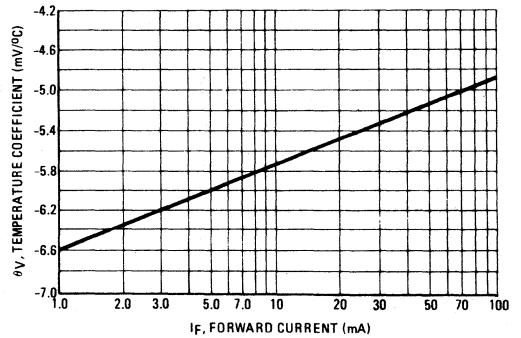
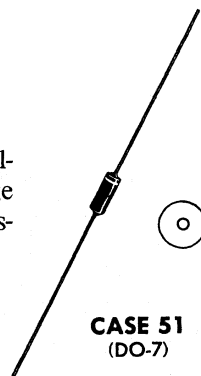


FIGURE 10 — .4M2.04FR5/MZ2362



1N821, A, 1N823, A (SILICON) **1N825, A, 1N827, A** **1N829, A**

Temperature-compensated zener reference diodes utilizing an oxide-passivated junction for long-term voltage stability. RamRod construction provides a rugged, glass-enclosed, hermetically sealed structure.



MAXIMUM RATINGS

Junction Temperature: -55 to +175°C
 Storage Temperature: -65 to +175°C
 DC Power Dissipation: 400 mW @ $T_A = 50^\circ\text{C}$

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, all-glass
DIMENSIONS: See outline drawing.
FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.
POLARITY: Cathode indicated by polarity band.
WEIGHT: 0.2 Gram (approx)
MOUNTING POSITION: Any

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

JEDEC Type No. (Note 1)	Maximum Voltage Change ΔV_Z (Volts) (Note 2)	Ambient Test Temperature $^\circ\text{C}$ $\pm 1^\circ\text{C}$	Temperature Coefficient $\frac{V_Z}{^\circ\text{C}}$ (Note 2)	Maximum Dynamic Impedance Z_{ZT} Ohms (Note 3)
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$$V_Z = 6.2 \text{ V} \pm 5.0\% * @ I_{ZT} = 7.5 \text{ mA}$$

1N821	0.096	-55, 0, +25, +75, +100	0.01	15 ↓ 10 ↓
1N823	0.048		0.005	
1N825	0.019		0.002	
1N827	0.009		0.001	
1N829	0.005		0.0005	
1N821A	0.096		0.01	
1N823A	0.048		0.005	
1N825A	0.019		0.002	
1N827A	0.009		0.001	
1N829A	0.005		0.0005	

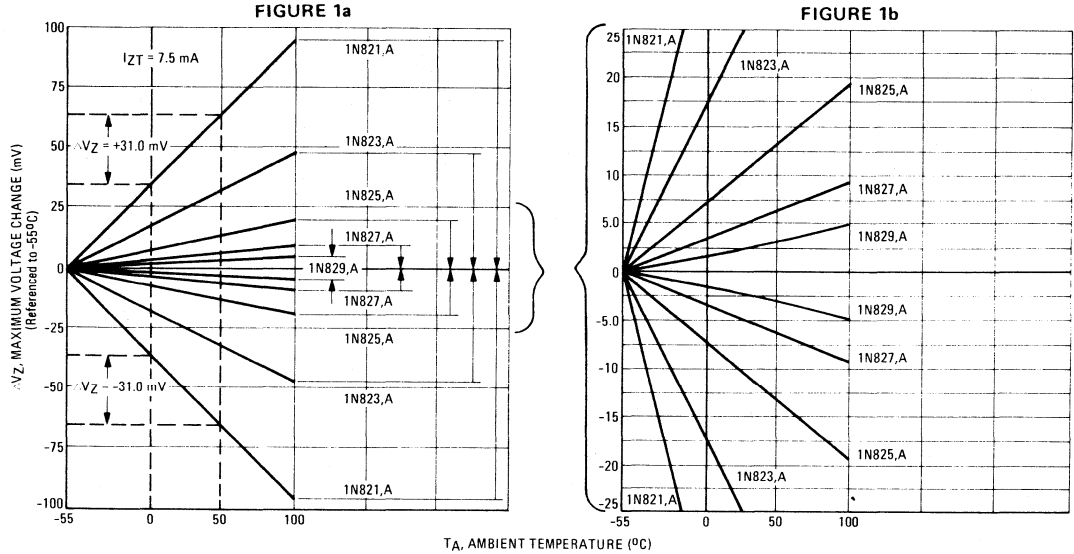
*Tighter-tolerance units available on special request.

CAPACITANCE (C) = 30 to 400 pF @ 90% of V_Z
 FORWARD BREAKDOWN VOLTAGE (V_F) = 15 to 400 V

MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE

(with $I_{ZT} = 7.5 \text{ mA} \pm 0.01 \text{ mA}$) (See Note 4)

1N821 thru 1N829



ZENER CURRENT versus MAXIMUM VOLTAGE CHANGE

(At Specified Temperatures)

(See Note 5)

MORE THAN 95% OF THE UNITS ARE IN THE RANGES INDICATED BY THE CURVES.

FIGURE 2 – 1N821 SERIES

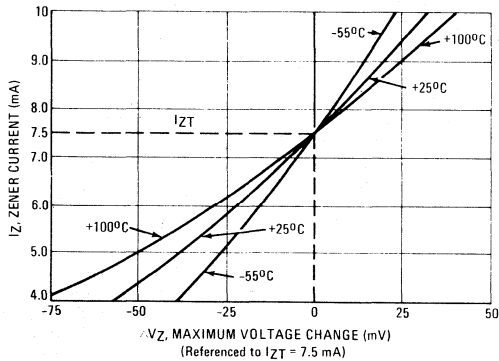
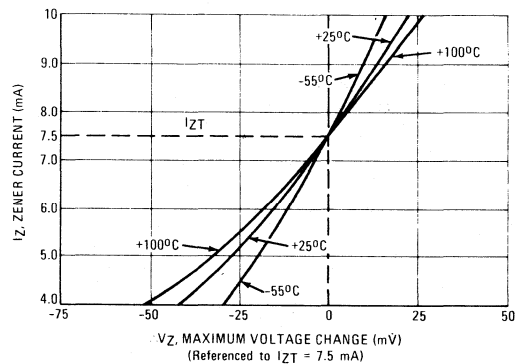


FIGURE 3 – 1N821A SERIES



MAXIMUM ZENER IMPEDANCE versus ZENER CURRENT

(See Note 3)

MORE THAN 95% OF THE UNITS ARE IN THE RANGES INDICATED BY THE CURVES.

FIGURE 4 – 1N821 SERIES

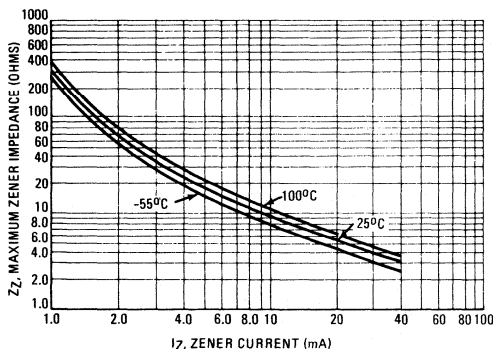


FIGURE 5 – 1N821A SERIES

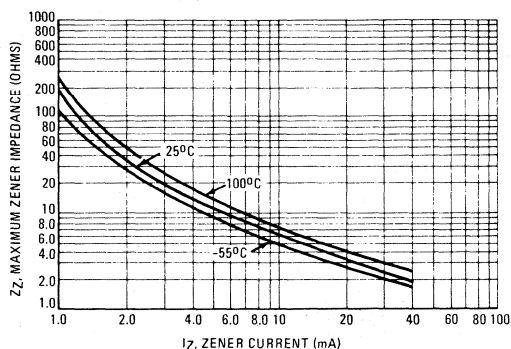
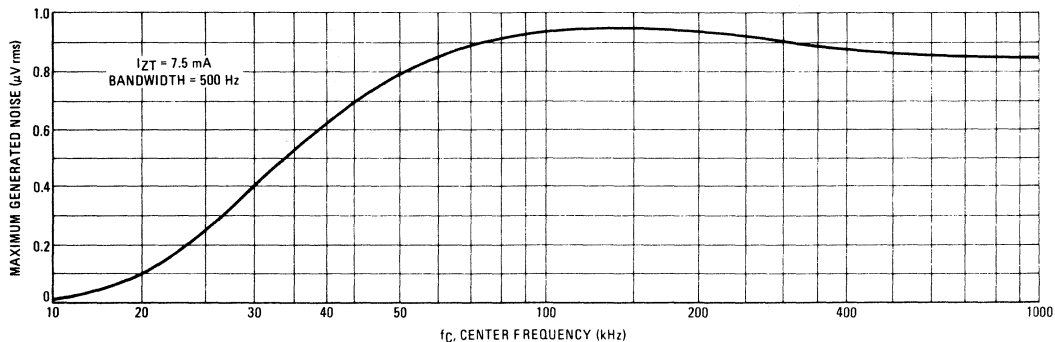


FIGURE 6 – DISTRIBUTION OF MAXIMUM GENERATED NOISE



NOTE 1:

Types 1N821, 1N823, 1N825, 1N827, and 1N829 are available to MIL-S-19500/159.

NOTE 2:

Voltage Variation (ΔV_Z) and Temperature Coefficient.

All reference diodes are characterized by the "box method". This guarantees a maximum voltage variation (ΔV_Z) over the specified temperature range, at the specified test current (I_{ZT}), verified by tests at indicated temperature points within the range. V_Z is measured and recorded at each temperature specified. The ΔV_Z between the highest and lowest values must not exceed the maximum ΔV_Z given. This method of indicating voltage stability is now used for JEDEC registration as well as for military qualification. The former method of indicating voltage stability — by means of temperature coefficient — accurately reflects the voltage deviation at the temperature extremes, but is not necessarily accurate within the temperature range because reference diodes have a nonlinear temperature relationship. The temperature coefficient, therefore, is given only as a reference.

NOTE 3:

The dynamic zener impedance, Z_{ZT} , is derived from the 60-Hz ac voltage drop which results when an ac current with an rms value

equal to 10% of the dc zener current, I_{ZT} , is superimposed on I_{ZT} . Curves showing the variation of zener impedance with zener current for each series are given in Figures 4 and 5. A cathode-ray tube curve-trace test on a sample basis is used to ensure that each zener characteristic has a sharp and stable knee region.

NOTE 4:

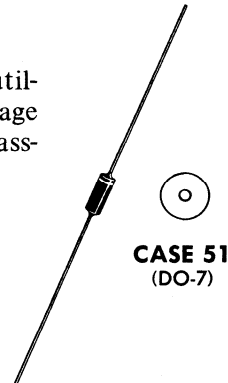
These graphs can be used to determine the maximum voltage change of any device in the series over any specific temperature range. For example, a temperature change from 0 to +50°C will cause a voltage change no greater than +31 mV or -31 mV for 1N821 or 1N821A, as illustrated by the dashed lines in Figure 1. The boundaries given are maximum values. For greater resolution, an expanded view of the shaded area in Figure 1a is shown in Figure 1b.

NOTE 5:

The maximum voltage change, ΔV_Z , Figures 2 and 3 is due entirely to the impedance of the device. If both temperature and I_{ZT} are varied, then the total voltage change may be obtained by graphically adding ΔV_Z in Figure 2 or 3 to the ΔV_Z in Figure 1 for the device under consideration. If the device is to be operated at some stable current other than the specified test current, a new set of characteristics may be plotted by superimposing the data in Figure 2 or 3 on Figure 1. For a more detailed explanation see AN-437 (Application Note).

1N935, A, B (SILICON) thru 1N939, A, B

Temperature-compensated zener reference diodes utilizing an oxide-passivated junction for long-term voltage stability. RamRod construction provides a rugged, glass-enclosed, hermetically sealed structure.



MAXIMUM RATINGS

Junction Temperature: -55 to +175°C

Storage Temperature: -65 to +175°C

DC Power Dissipation: 500 mW @ $T_A = 25^\circ\text{C}$

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, all-glass

DIMENSIONS: See outline drawing.

FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

POLARITY: Cathode indicated by polarity band.

WEIGHT: 0.2 Gram (approx)

MOUNTING POSITION: Any

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

JEDEC Type No. (Note 1)	Maximum Voltage Change ΔV_Z (Volts) (Note 2)	Ambient Test Temperature $^\circ\text{C}$ $\pm 1^\circ\text{C}$	Temperature Coefficient $\frac{\%}{^\circ\text{C}}$ (Note 2)	Maximum Dynamic Impedance Z_{ZT} (Ohms) (Note 3)
$V_Z = 9.0 \text{ V} \pm 5.0\% * @ I_{ZT} = 7.5 \text{ mA}$				
1N935	0.067	0, +25, +75	0.01	20
1N936	0.033		0.005	
1N937	0.013		0.002	
1N938	0.006		0.001	
1N939	0.003		0.0005	
1N935A	0.139	-55, 0, +25, +75, +100	0.01	20
1N936A	0.069		0.005	
1N937A	0.027		0.002	
1N938A	0.013		0.001	
1N939A	0.007		0.0005	
1N935B	0.184	-55, 0, +25, +75, +100, +150	0.01	20
1N936B	0.092		0.005	
1N937B	0.037		0.002	
1N938B	0.018		0.001	
1N939B	0.009		0.0005	

*Tighter-tolerance units available on special request.

CAPACITANCE (C) = 20 to 180 pF @ 90% of V_Z

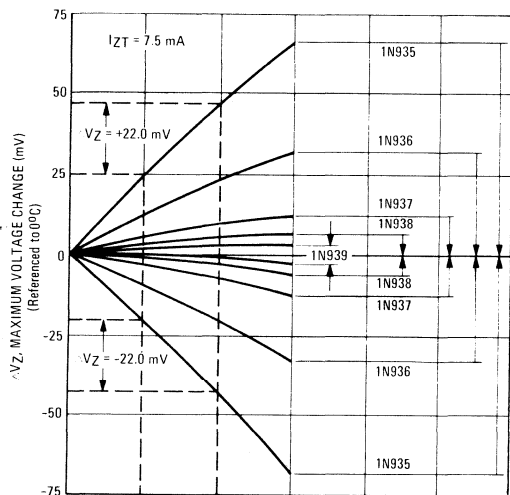
FORWARD BREAKDOWN VOLTAGE (V_F) = 100 to 800 V

MAXIMUM VOLTAGE CHANGE versus TEMPERATURE

(with $I_{ZT} = 7.5 \text{ mA} \pm 0.01 \text{ mA}$) (See Note 4)

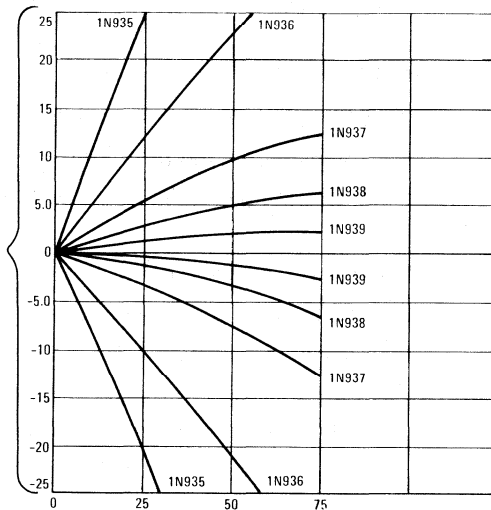
1N935 thru 1N939

FIGURE 1a



T_A , AMBIENT TEMPERATURE ($^{\circ}\text{C}$)

FIGURE 1b

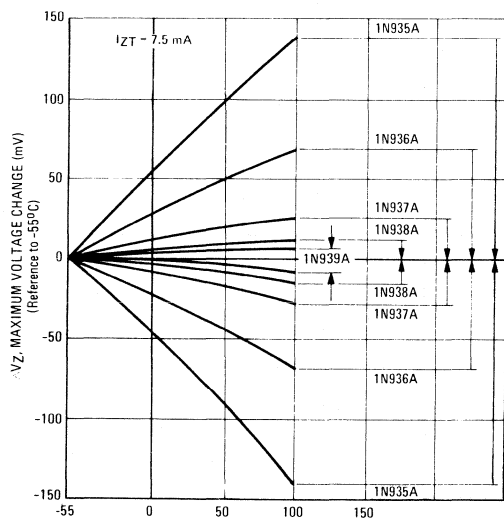


MAXIMUM VOLTAGE CHANGE versus TEMPERATURE

(with $I_{ZT} = 7.5 \text{ mA} \pm 0.01 \text{ mA}$) (See Note 4)

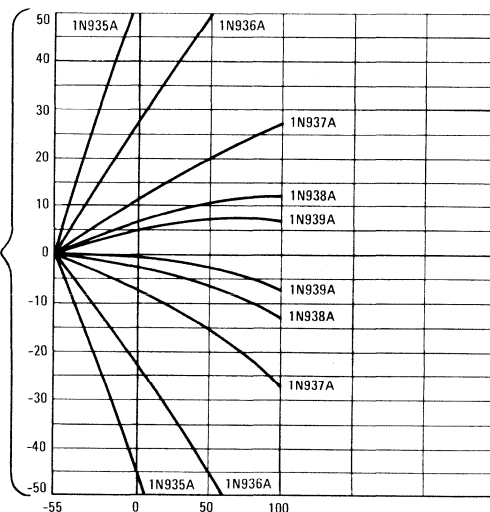
1N935A thru 1N939A

FIGURE 2a



T_A , AMBIENT TEMPERATURE ($^{\circ}\text{C}$)

FIGURE 2b

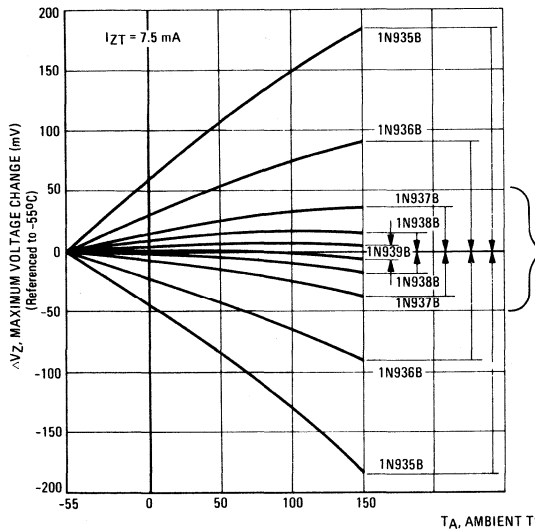


1N935, A, B thru 1N939, A, B (continued)

MAXIMUM VOLTAGE CHANGE versus TEMPERATURE

(with $I_{ZT} = 7.5 \text{ mA} \pm 0.01 \text{ mA}$) (See Note 4)

FIGURE 3a



1N935B thru 1N939B

FIGURE 3b

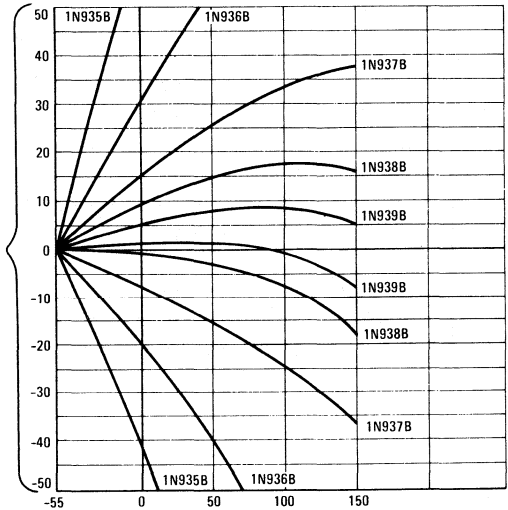


FIGURE 4 – ZENER CURRENT versus MAXIMUM VOLTAGE CHANGE (at specified temperatures)

(See Note 5)

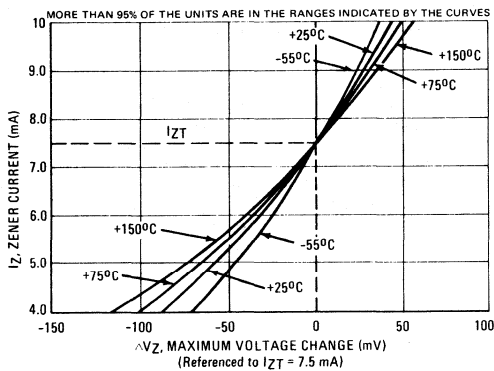


FIGURE 5 – MAXIMUM ZENER IMPEDANCE versus ZENER CURRENT

(See Note 3)

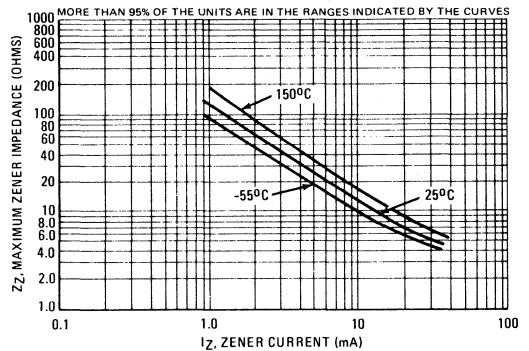
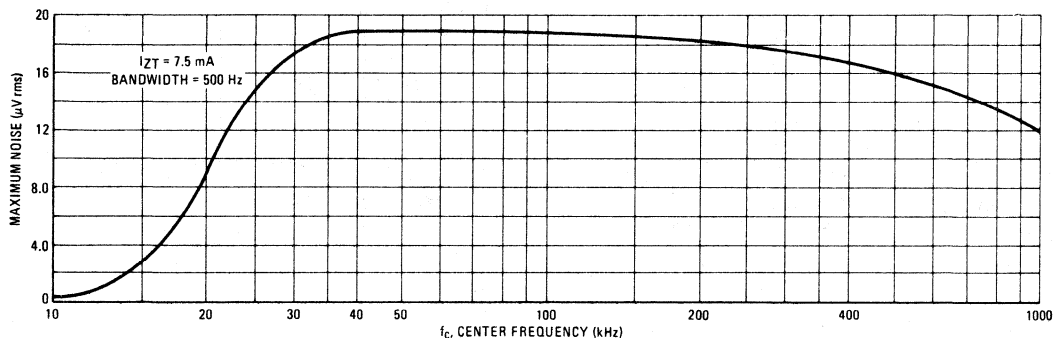


FIGURE 6 – DISTRIBUTION OF MAXIMUM GENERATED NOISE



NOTE 1:

Types 1N935B, 1N937B, and 1N939B are available to MIL-S-19500/156.

NOTE 2:

Voltage Variation (ΔV_Z) and Temperature Coefficient.

All reference diodes are characterized by the "box method". This guarantees a maximum voltage variation (ΔV_Z) over the specified temperature range, at the specified test current (I_{ZT}), verified by tests at indicated temperature points within the range. This method of indicating voltage stability is now used for JEDEC registration as well as for military qualification. The former method of indicating voltage stability — by means of temperature coefficient — accurately reflects the voltage deviation at the temperature extremes, but is not necessarily accurate within the temperature range because reference diodes have a nonlinear temperature relationship. The temperature coefficient, therefore, is given only as a reference.

NOTE 3:

Zener Impedance Derivation

The dynamic zener impedance, Z_{ZT} , is derived from the 60-Hz ac voltage drop which results when an ac current with an rms value equal to 10% of the dc zener current, I_{ZT} , is superimposed on I_{ZT} .

Curves showing the variation of zener impedance with zener current for each series are given in Figure 5. A cathode-ray tube curve-trace test on a sample basis is used to ensure that each zener characteristic has a sharp and stable knee region.

NOTE 4:

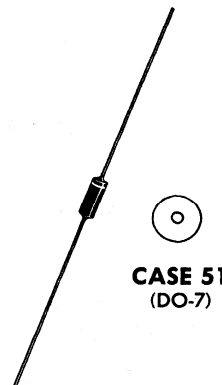
These graphs can be used to determine the maximum voltage change of any device in the series over any specific temperature range. For example, a temperature change from $+25$ to $+50^\circ\text{C}$ will cause a voltage change no greater than $+22 \text{ mV}$ or -22 mV for 1N935, as illustrated by the dashed lines in Figure 1. The boundaries given are maximum values. For greater resolution, expanded views of the shaded areas in Figures 1a, 2a, and 3a are shown in Figures 1b, 2b, and 3b respectively.

NOTE 5:

The maximum voltage change, ΔV_Z , in Figure 4 is due entirely to the impedance of the device. If both temperature and I_{ZT} are varied, then the total voltage change may be obtained by adding ΔV_Z in Figure 4 to the ΔV_Z in Figure 1, 2, or 3 for the device under consideration. If the device is to be operated at some stable current other than the specified test current, a new set of characteristics may be plotted by superimposing the data in Figure 4 on Figure 1, 2, or 3.

1N941, A, B (SILICON) thru 1N945, A, B

Temperature-compensated zener reference diodes utilizing an oxide-passivated junction for long-term voltage stability. RamRod construction provides a rugged, glass-enclosed, hermetically sealed structure.



MAXIMUM RATINGS

Junction Temperature: -55 to +175°C

Storage Temperature: -65 to +175°C

DC Power Dissipation: 500 mW @ $T_A = 25^\circ\text{C}$

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, all-glass

DIMENSIONS: See outline drawing.

FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

POLARITY: Cathode indicated by polarity band.

WEIGHT: 0.2 Gram (approx)

MOUNTING POSITION: Any

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

JEDEC Type No. (Note 1)	Maximum Voltage Change ΔV_Z (Volts) (Note 2)	Ambient Test Temperature $^\circ\text{C}$ $\pm 1^\circ\text{C}$	Temperature Coefficient $\%/^\circ\text{C}$ (Note 2)	Maximum Impedance Z_{ZT} (Ohms) (Note 3)
$V_Z = 11.7 \text{ V} \pm 5.0\% * @ I_{ZT} = 7.5 \text{ mA}$				
1N941	0.088	0, +25, +75	0.01	30
1N942	0.044		0.005	
1N943	0.018		0.002	
1N944	0.009		0.001	
1N945	0.004		0.0005	
1N941A	0.181	-55, 0, +25, +75, +100	0.01	30
1N942A	0.090		0.005	
1N943A	0.036		0.002	
1N944A	0.018		0.001	
1N945A	0.009		0.0005	
1N941B	0.239	-55, 0, +25, +75, +100, +150	0.01	30
1N942B	0.120		0.005	
1N943B	0.047		0.002	
1N944B	0.024		0.001	
1N945B	0.012		0.0005	

*Tighter-tolerance units available on special request.

CAPACITANCE (C) = 14 to 35 pF @ 90% of V_Z

FORWARD BREAKDOWN VOLTAGE (V_F) = 150 to 1200 V

1N941, A, B thru 1N945, A, B (continued)

MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE

(With $I_{ZT} = 7.5 \text{ mA} \pm 0.01 \text{ mA}$) (See Note 4)

1N941 thru 1N945

FIGURE 1a

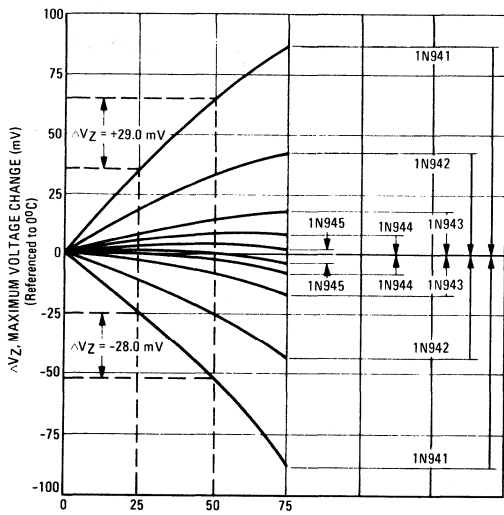
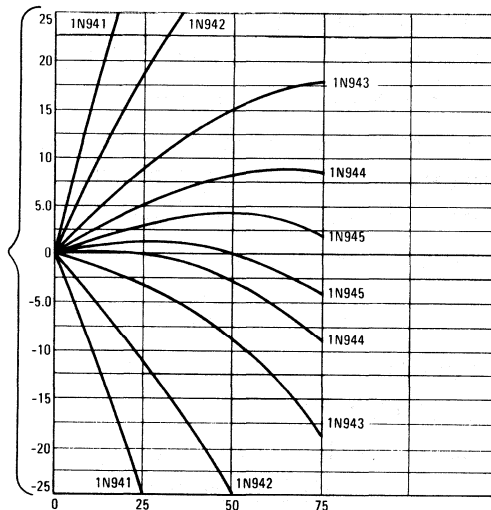


FIGURE 1b



T_A , AMBIENT TEMPERATURE ($^{\circ}\text{C}$)

MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE

(With $I_{ZT} = 7.5 \text{ mA} \pm 0.01 \text{ mA}$) (See Note 4)

1N941A thru 1N945A

FIGURE 2a

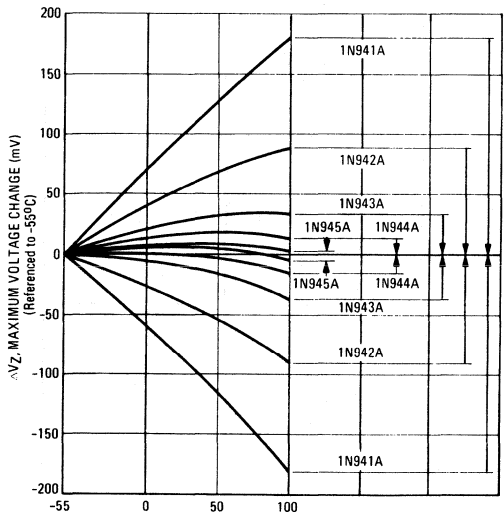
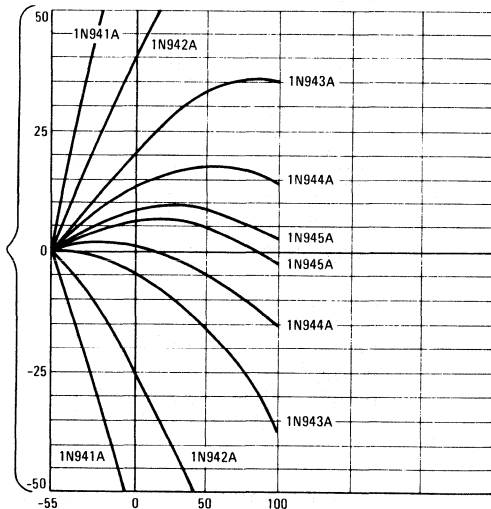


FIGURE 2b



T_A , AMBIENT TEMPERATURE ($^{\circ}\text{C}$)

MAXIMUM VOLTAGE CHANGE versus TEMPERATURE

(with $I_{ZT} = 7.5 \text{ mA} \pm 0.01 \text{ mA}$) (See Note 4)

1N941B thru 1N945B

FIGURE 3a

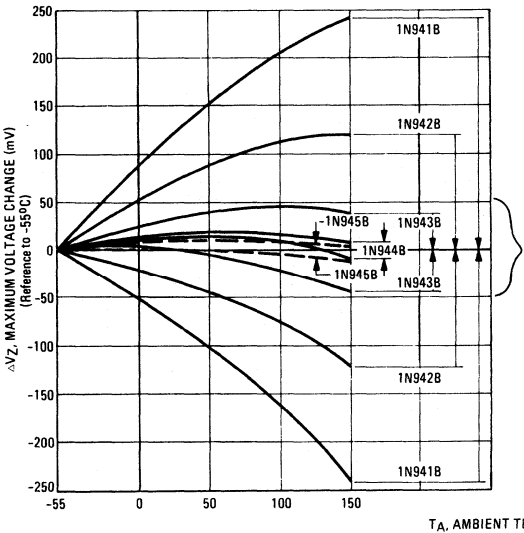


FIGURE 3b

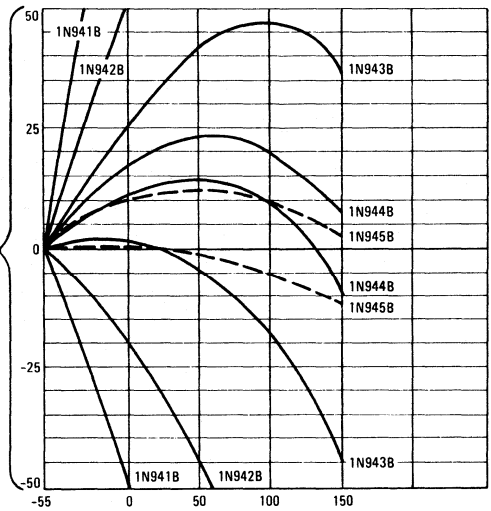


FIGURE 4 – ZENER CURRENT versus MAXIMUM VOLTAGE CHANGE (At specified temperatures)

(See Note 5)

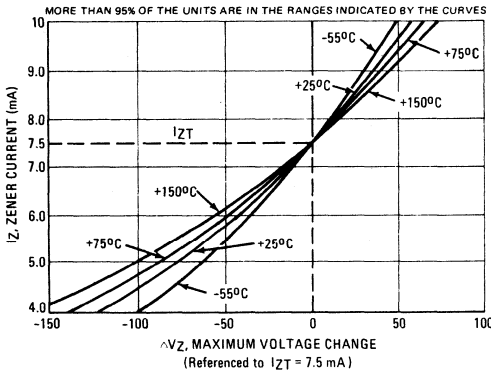


FIGURE 5 – MAXIMUM ZENER IMPEDANCE versus ZENER CURRENT

(See Note 3)

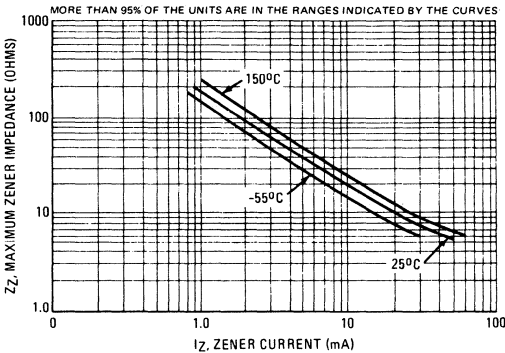
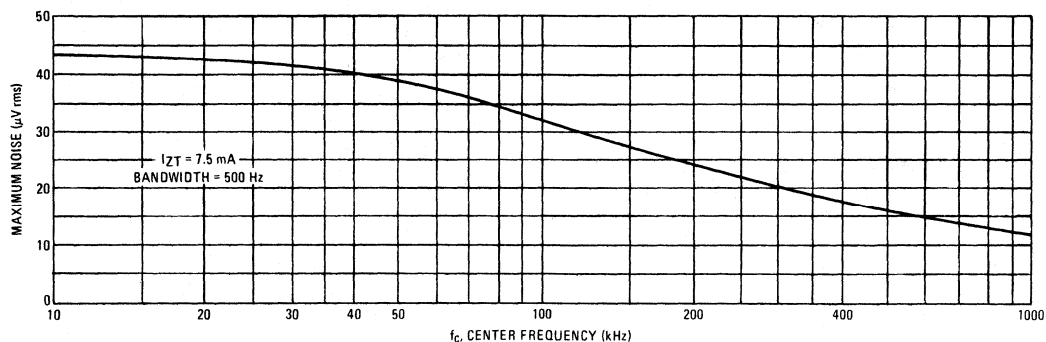


FIGURE 6 – DISTRIBUTION OF MAXIMUM GENERATED NOISE



NOTE 1:

Types 1N941B, 1N943B, and 1N944B are available to MIL-S-19500/157.

NOTE 2:

Voltage Variation (ΔV_Z) and Temperature Coefficient.

All reference diodes are characterized by the "box method". This guarantees a maximum voltage variation (ΔV_Z) over the specified temperature range, at the specified test current (I_{ZT}), verified by tests at indicated temperature points within the range. This method of indicating voltage stability is now used for JEDEC registration as well as for military qualification. The former method of indicating voltage stability — by means of temperature coefficient — accurately reflects the voltage deviation at the temperature extremes, but is not necessarily accurate within the temperature range because reference diodes have a nonlinear temperature relationship. The temperature coefficient, therefore, is given only as a reference.

NOTE 3:

Zener Impedance Derivation

The dynamic zener impedance, Z_{ZT} , is derived from the 60-Hz ac voltage drop which results when an ac current with an rms value equal to 10% of the dc zener current, I_{ZT} , is superimposed on I_{ZT} .

Curves showing the variation of zener impedance with zener current for each series are given in Figure 5. A cathode-ray tube curve-trace test on a sample basis is used to ensure that each zener characteristic has a sharp and stable knee region.

NOTE 4:

These graphs can be used to determine the maximum voltage change of any device in the series over any specific temperature range. For example, a temperature change from +25 to +50°C will cause a voltage change no greater than +29 mV or -28 mV for 1N941, as illustrated by the dashed lines in Figure 1. The boundaries given are maximum values. For greater resolution, expanded views of the shaded areas in Figures 1a, 2a, and 3a are shown in Figures 1b, 2b, and 3b respectively.

NOTE 5:

The maximum voltage change, ΔV_Z , in Figure 4 is due entirely to the impedance of the device. If both temperature and I_{ZT} are varied, then the total voltage change may be obtained by adding ΔV_Z in Figure 4 to the ΔV_Z in Figure 1, 2, or 3 for the device under consideration. If the device is to be operated at some stable current other than the specified test current, a new set of characteristics may be plotted by superimposing the data in Figure 4 on Figure 1, 2, or 3.

CASE 51
(DO-7)


Hermetically sealed, all-glass case with all external surfaces corrosion resistant. Cathode end, indicated by color band, will be positive with respect to anode end when operated in the zener region.

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to +175°C

D C Power Dissipation: 400 Milliwatts at 50°C Ambient (Derate 3.2 mW/°C Above 50°C Ambient)

TOLERANCE DESIGNATIONS

With no suffix, tolerance is ±20%, for ±10% units, add suffix A, for ±5% units, add suffix B.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Motorola Guarantees the Zener Voltage at 90 Seconds with Lead Temperature of 30°C ± 1°C, 3/8" from Unit Body.

TYPE NUMBER	NOMINAL ZENER VOLTAGE V _Z VOLTS	TEST CURRENT I _{ZT} mA	MAXIMUM ZENER IMPEDANCE			MAXIMUM DC ZENER CURRENT I _{ZM} mA	REVERSE LEAKAGE CURRENT		
			Z ₁₇ @ I _{ZT} Ohms	Z _{ZK} @ I _{ZK} Ohms	I _{ZK} mA		I _R MAXIMUM (μA)	TEST VOLTAGE V _{R1}	V _{ZK} * V _{R2}
1N957	6.8	18.5	4.5	700	1.0	47	150	5.2	4.9
1N958	7.5	16.5	5.5	700	0.5	42	75	5.7	5.4
1N959	8.2	15	6.5	700	0.5	38	50	6.2	5.9
1N960	9.1	14	7.5	700	0.5	35	25	6.9	6.6
1N961	10	12.5	8.5	700	0.25	32	10	7.6	7.2
1N962	11	11.5	9.5	700	0.25	28	5	8.4	8.0
1N963	12	10.5	11.5	700	0.25	26	5	9.1	8.6
1N964	13	9.5	13	700	0.25	24	5	9.9	9.4
1N965	15	8.5	16	700	0.25	21	5	11.4	10.8
1N966	16	7.8	17	700	0.25	19	5	12.2	11.5
1N967	18	7.0	21	750	0.25	17	5	13.7	13.0
1N968	20	6.2	25	750	0.25	15	5	15.2	14.4
1N969	22	5.6	29	750	0.25	14	5	16.7	15.8
1N970	24	5.2	33	750	0.25	13	5	18.2	17.3
1N971	27	4.6	41	750	0.25	11	5	20.6	19.4
1N972	30	4.2	49	1000	0.25	10	5	22.8	21.6
1N973	33	3.8	58	1000	0.25	9.2	5	25.1	23.8
1N974	36	3.4	70	1000	0.25	8.5	5	27.4	25.9
1N975	39	3.2	80	1000	0.25	7.8	5	29.7	28.1
1N976	43	3.0	93	1500	0.25	7.0	5	32.7	31.0
1N977	47	2.7	105	1500	0.25	6.4	5	35.8	33.8
1N978	51	2.5	125	1500	0.25	5.9	5	38.8	36.7
1N979	56	2.2	150	2000	0.25	5.4	5	42.6	40.3
1N980	62	2.0	185	2000	0.25	4.9	5	47.1	44.6
1N981	68	1.8	230	2000	0.25	4.5	5	51.7	49.0
1N982	75	1.7	270	2000	0.25	4.0	5	56.0	54.0
1N983	82	1.5	330	3000	0.25	3.7	5	62.2	59.0
1N984	91	1.4	400	3000	0.25	3.3	5	69.2	65.5
1N985	100	1.3	500	3000	0.25	3.0	5	76.0	72.0
1N986	110	1.1	750	4000	0.25	2.7	5	83.6	79.2
1N987	120	1.0	900	4500	0.25	2.5	5	91.2	86.4
1N988	130	0.95	1100	5000	0.25	2.3	5	98.8	93.6
1N989	150	0.85	1500	6000	0.25	2.0	5	114.0	108.0
1N990	160	0.80	1700	6500	0.25	1.9	5	121.6	115.2
1N991	180	0.68	2200	7100	0.25	1.7	5	136.8	129.6
1N992	200	0.65	2500	8000	0.25	1.5	5	152.0	144.0

SPECIAL SELECTIONS AVAILABLE INCLUDE: (See Selector Guide for details)

- 1 — Nominal zener voltages between those shown.
- 2 — Matched sets: (Standard Tolerances are $\pm 5.0\%$, $\pm 3.0\%$, $\pm 2.0\%$, $\pm 1.0\%$) depending on voltage per device.
 - a. Two or more units for series connection with specified tolerance on total voltage. Series matched sets make possible higher zener voltages and provide lower temperature coefficients, lower dynamic impedance and greater power handling ability.
 - b. Two or more units matched to one another with any specified tolerance.
- 3 — Tight voltage tolerances: 1.0%, 2.0%, 3.0%.

* V_{R1} — Test Voltage for 5% Tolerance Device

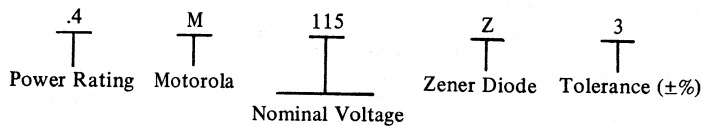
V_{R2} — Test Voltage for 10% Tolerance Device

No Leakage Specified as 20% Tolerance Device

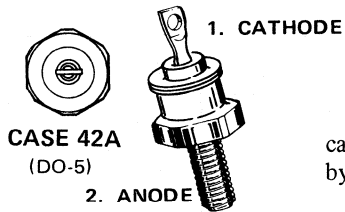
To designate units with zener voltages other than those listed, the Motorola type number should be modified as shown below. Unless otherwise specified, the electrical characteristics other than the nominal

voltage (V_Z) and test voltage for leakage current will conform to the characteristics of the next higher voltage type shown in the table.

EXAMPLE: 1N957 series



1N1183 thru 1N1190 (SILICON)



Medium current silicon rectifiers. Type numbers shown have cathode connected to case, but reverse-polarity units can be obtained by adding suffix "R" to standard type number, e.g. 1N1183R.

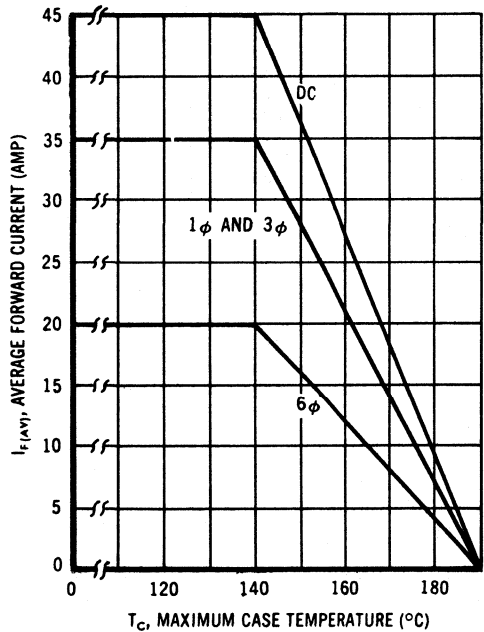
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Repetitive Reverse Voltage and DC Blocking Voltage 1N1183 1N1184 1N1185 1N1186 1N1187 1N1188 1N1189 1N1190	V_{RRM} V_R	50 100 150 200 300 400 500 600	Volts
RMS Reverse Voltage 1N1183 1N1184 1N1185 1N1186 1N1187 1N1188 1N1189 1N1190	$V_{R(RMS)}$	35 70 105 140 210 280 350 420	Volts
Average 1/2-Wave Rectified Forward Current (Resistive Load, 60 Hz, $T_C = 140^\circ\text{C}$)	I_O	35	Amp
Peak Repetitive Forward Current ($T_C = 140^\circ\text{C}$)	I_{FRM}	150	Amp
Peak Surge Current ($T_C = 140^\circ\text{C}$, superimposed on Rated Current at Rated Voltage)	I_{FSM}	400	Amp
Operating and Storage Temperature	T_J, T_{stg}	-65 to +190	$^\circ\text{C}$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.0	$^\circ\text{C/W}$

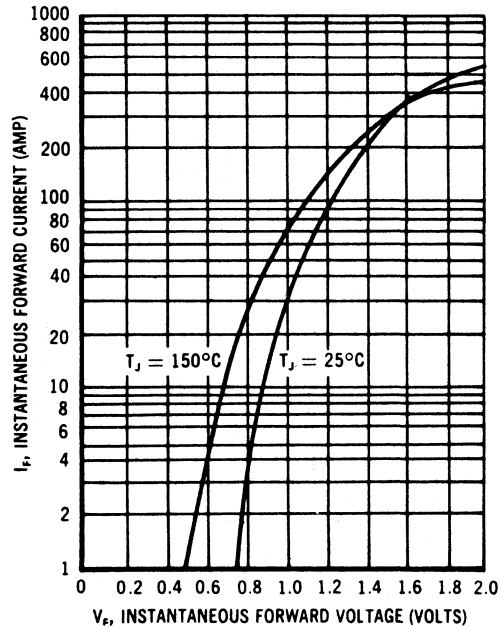
ELECTRICAL CHARACTERISTICS

Characteristics	Symbol	Value	Unit
Max Full Cycle Average Forward Voltage Drop (I_O (max), rated V_r , 60 Hz, $T_C = 140^\circ\text{C}$)	$V_{F(AV)}$	0.6	Volts
Max Instantaneous Forward Voltage Drop ($I_F = 100$ Amps, $T_J = 25^\circ\text{C}$)	v_F	1.3	Volts
Max Full Cycle Average Reverse Current (I_O (max), rated V_r , 60 Hz, $T_C = 140^\circ\text{C}$)	$I_{R(AV)}$	10.0	mA
Max DC Reverse Current (Rated V_R , $T_C = 25^\circ$)	I_R	1.0	mA

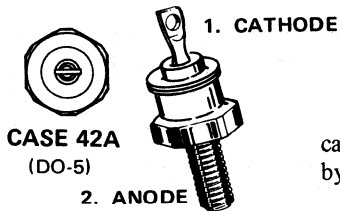
MAXIMUM AVERAGE FORWARD CURRENT RATING
versus MAXIMUM CASE TEMPERATURE
(60 CPS, RESISTIVE OR INDUCTIVE LOAD)



TYPICAL FORWARD CHARACTERISTICS



1N1183A thru 1N1189A (SILICON)



Medium current silicon rectifiers. Type numbers shown have cathode connected to case, but reverse-polarity units can be obtained by adding suffix "R" to standard type number, e.g. 1N1183RA.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Repetitive Reverse Voltage and DC Blocking Voltage 1N1183A 1N1184A 1N1185A 1N1186A 1N1187A 1N1188A 1N1189A	V_{RRM} V_R	50 100 150 200 300 400 500	Volts
RMS Reverse Voltage 1N1183A 1N1184A 1N1185A 1N1186A 1N1187A 1N1188A 1N1189A	$V_{R(RMS)}$	35 70 105 140 210 280 350	Volts
Average 1/2-Wave Rectified Forward Current (Resistive Load, 60 Hz, $T_C = 150^\circ\text{C}$)	I_O	40	Amp
Peak Surge Current ($T_C = 150^\circ\text{C}$, superimposed on Rated Current at Rated Voltage)	I_{FSM}	800	Amp
Operating and Storage Temperature	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.0	$^\circ\text{C/W}$

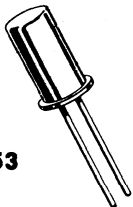
ELECTRICAL CHARACTERISTICS

Characteristics	Symbol	Value	Unit
Max Instantaneous Forward Voltage ($I_{O(max)}$, rated V_R , 60 Hz, $T_C = 150^\circ\text{C}$)	v_{pk}	1.3	Volts
Max Instantaneous Forward Voltage Drop ($I_F = 100$ Amps, $T_C = 25^\circ\text{C}$)	v_F	1.1	Volts
Max Full Cycle Average Reverse Current ($I_{O(max)}$, rated V_R , 60 Hz, $T_C = 150^\circ\text{C}$)	$I_{R(AV)}$	2.5	mA
Max DC Reverse Current (Rated V_R , $T_C = 150^\circ\text{C}$)	I_R	5.0	mA

1N1191 thru 1N1198
1N1195A thru 1N1198A

For Specifications, See 1N248B Data.

1N1313 thru 1N1327



CASE 53



Very low power zener diodes with standard $\pm 10\%$ tolerances. Available with $\pm 5.0\%$ tolerance by adding suffix "A" to type number.

Standard cathode-to-case polarity.

For new designs and for industry preferred replacement devices, see 1N5837A series.

MAXIMUM RATINGS

Junction and Storage Temperature Range: -65 to $+175^{\circ}\text{C}$ (Derate $1\text{ mW}/^{\circ}\text{C}$ above 25°C).

ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}\text{C}$ unless otherwise noted)

Type	Nominal Voltage $V_Z @ I_{ZT} = 200\text{ }\mu\text{A}$ volts	Max Reverse Current		Test Voltage V_R volts
		$T_A = 25^{\circ}\text{C}$ $I_R @ V_R$ μA	$T_A = 100^{\circ}\text{C}$ $I_A @ V_R$ μA	
1N1313	8.75	0.5	5	6.8
1N1314	10.50	0.5	5	8.2
1N1315	12.75	0.5	5	10
1N1316	15.75	0.5	5	12
1N1317	19.00	0.5	5	15

Type	Nominal Voltage $V_Z @ I_{ZT} = 200\text{ }\mu\text{A}$ volts	Max Reverse Current		Test Voltage V_R volts
		$T_A = 25^{\circ}\text{C}$ $I_R @ V_R$ μA	$T_A = 100^{\circ}\text{C}$ $I_A @ V_R$ μA	
1N1318	23.50	0.1	10	18
1N1319	28.50	0.1	10	22
1N1320	34.50	0.1	10	27
1N1321	41.00	0.1	10	33
1N1322	48.50	0.1	10	39

Type	Nominal Voltage $V_Z @ I_{ZT} = 200\text{ }\mu\text{A}$ volts	Max Reverse Current		Test Voltage V_R volts
		$T_A = 25^{\circ}\text{C}$ $I_R @ V_R$ μA	$T_A = 100^{\circ}\text{C}$ $I_A @ V_R$ μA	
1N1323	58.00	0.1	10	47
1N1324	71.00	1.0	50	56
1N1325	87.50	1.0	50	68
1N1326	105.0	1.0	50	82
1N1327	127.5	1.0	50	100

1N1351 thru 1N1375



CASE 56
(DO-4)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N2970 series.

1N1507 thru 1N1517



CASE 52
(DO-13)



Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1.0-watt, 1N4728 series.

1N1518 thru 1N1528



CASE 52
(DO-13)



Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N4728 series.

1N1530, A

For Specifications, See 1N429 Data.

1N1588 thru 1N1598



CASE 56
(DO-4)



Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N3993 series.

1N1599 thru 1N1609



CASE 56
(DO-4)



Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N3993 series.

1N1735 thru 1N1742 (REFERENCE DIODES)

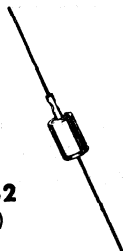
1N1736A thru 1N1742A

For Specifications, See 1N429 Data.

1N1765 thru 1N1802 (ZENER DIODES)

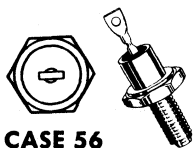


CASE 52
(DO-13)



Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N4728 series.

1N1803 thru 1N1836 (ZENER DIODES)



CASE 56
(DO-4)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N3993 series, and 1N2970 series.

1N1816 thru 1N1836 are available as clipper devices. To order, add suffix "C" for $\pm 10\%$, suffix "CA" for $\pm 5\%$.

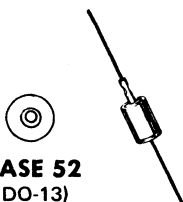
1N2008 thru 1N2012 (ZENER DIODES)



CASE 56
(DO-4)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N2970 series.

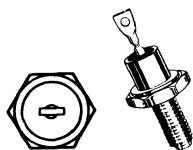
1N2032 thru 1N2040 (ZENER DIODES)



CASE 52
(DO-13)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N4728 series.

1N2041 thru 1N2049 (ZENER DIODES)



CASE 56
(DO-4)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N3993 series.

1N2163 thru 1N2171 (SILICON)

1N2163A thru 1N2171A

1N3580, A, B thru 1N3583, A, B

TEMPERATURE-COMPENSATED ZENER REFERENCE DIODES

Highly reliable reference sources utilizing an oxide-passivated junction for long-term voltage stability. Construction consists of welded hermetically sealed metal and glass case.

- Low Dynamic Impedance
- Choice of Three Temperature Ranges
- "Box Method" Specifications Guarantee Maximum Voltage Deviation.

Temperature compensated reference diodes are made by taking advantage of the differing thermal characteristics of forward and reverse biased silicon PN junctions. A forward biased junction has a negative temperature coefficient of approximately 2.0 millivolts/°C. Reverse biased junctions above 5.0 volts have a positive temperature coefficient and therefore it is possible by judicious selection of combinations of forward and reverse biased junctions to obtain a device that shows a very low temperature coefficient due to cancellation. Because of the differing impedance versus temperature characteristics of the junctions involved, optimum temperature stability is obtained by operating in the zener current range at which the temperature coefficient is a minimum.

MAXIMUM RATINGS

Junction Temperature: -55 to +200°C
Storage Temperature: -65 to +200°C
DC Power Dissipation: 750 mW @ $T_A = 25^\circ\text{C}$

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, welded metal glass

DIMENSIONS: See outline drawing.

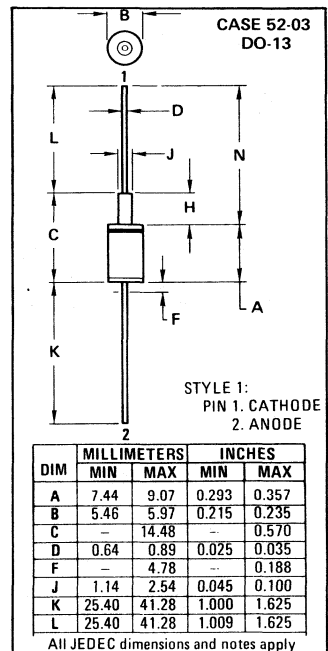
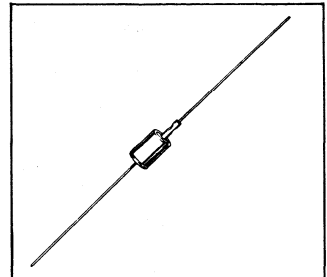
FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

POLARITY: Cathode to case

WEIGHT: 1.5 Grams (approx)

MOUNTING POSITION: Any

TEMPERATURE-COMPENSATED SILICON ZENER REFERENCE DIODES



1N2163 thru 1N2171, 1N2163A thru 1N2171A, 1N3580, A, B thru 1N3583, A, B (continued)

ELECTRICAL CHARACTERISTICS

$V_Z = 9.4 \text{ Volts} \pm 0.4 \text{ V} (\pm 0.2 \text{ V Suffix "A"}) @ (I_{ZT} = 10 \text{ mA})$				
Type Number	Max Voltage Change (Note 1) ΔV_Z (Volts)	Test Temperatures	Temperature Coefficient (Note 1) %/°C	Max Dynamic Impedance (Note 2) Z_{ZT} (Ohms)
		°C		
1N2163,A	0.033	0, +25, +70	0.005	15
1N2164,A	0.086	-55, 0, +25, +75, +125	0.005	
1N2165,A	0.115	-55, 0, +25, +75, +125, +185	0.005	
1N2166,A	0.007	0, +25, +70	0.001	15
1N2167,A	0.017	-55, 0, +25, +75, +125	0.001	
1N2168,A	0.023	-55, 0, +25, +75, +125, +185	0.001	
1N2169,A	0.004	0, +25, +70	0.0005	15
1N2170,A	0.009	-55, 0, +25, +75, +125	0.0005	
1N2171,A	0.012	-55, 0, +25, +75, +125, +185	0.0005	

NOTE 1:

Voltage Variation (ΔV_Z) and Temperature Coefficient.

All reference diodes are characterized by the "box method". This guarantees a maximum voltage variation (ΔV_Z) over the specified temperature range, at the specified test current (I_{ZT}), verified by tests at indicated temperature points within the range. V_Z is measured and recorded at each temperature specified. The ΔV_Z between the highest and lowest values must not exceed the maximum ΔV_Z given.

This method of indicating voltage stability is now used for JEDEC registration as well as for military qualification. The former method of indicating voltage stability — by means of temperature coefficient — accurately reflects the voltage deviation at the temperature extremes, but is not necessarily accurate within the temperature range because reference diodes have a nonlinear temperature relationship. The temperature coefficient, therefore, is given only as a reference.

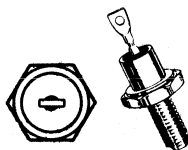
ELECTRICAL CHARACTERISTICS

$V_Z = 11.7 \text{ Volts} \pm 5.0\% (I_{ZT} = 7.5 \text{ mA})$				
Type Number	Max Voltage Change (Note 1) ΔV_Z (Volts)	Test Temperatures	Temperature Coefficient (Note 1) %/°C	Max Dynamic Impedance (Note 2) Z_{ZT} (Ohms)
		°C		
1N3580	0.088	0, +25, +75	0.01	25
1N3581	0.044		0.005	
1N3582	0.018		0.002	
1N3583	0.009		0.001	
1N3580A	0.181	-55, 0, +25, +75, +100	0.01	25
1N3581A	0.090		0.005	
1N3582A	0.036		0.002	
1N3583A	0.018		0.001	
1N3580B	0.239	-55, 0, +25, +75, +100, +150	0.01	25
1N3581B	0.120		0.005	
1N3582B	0.048		0.002	
1N3583B	0.024		0.001	

NOTE 2:

The dynamic zener impedance, Z_{ZT} , is derived from the 60-Hz ac voltage drop which results when an ac current with an rms value equal to 10% of the dc zener current, I_{ZT} , is superimposed on I_{ZT} . A cathode-ray tube curve-trace test on a sample basis is used to ensure that the zener has a sharp and stable knee region.

1N2498 thru 1N2500



CASE 56
(DO-4)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N2970 series.

1N2609 thru 1N2617

Obsolete, discontinued types, replace with devices from the 1N4001 series.

1N2620, A, B (SILICON)

thru

1N2624, A, B

Temperature-compensated zener reference diodes utilizing an oxide-passivated junction for long-term voltage stability. Construction consists of welded hermetically sealed metal and glass case.



CASE 52
(DO-13)



MAXIMUM RATINGS

Junction Temperature: -55 to $+175^{\circ}\text{C}$

Storage Temperature: -65 to $+175^{\circ}\text{C}$

DC Power Dissipation: 750 mW @ $T_A = 25^{\circ}\text{C}$

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, welded metal and glass

DIMENSIONS: See outline drawing.

FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

POLARITY: Cathode to case

WEIGHT: 1.5 Grams (approx)

MOUNTING POSITION: Any

ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}\text{C}$ unless otherwise noted)

JEDEC Type No.	Maximum Voltage Change ΔV_Z (Volts) (Note 1)	Ambient Test Temperature $^{\circ}\text{C}$ $\pm 1^{\circ}\text{C}$	Temperature Coefficient $\frac{\%}{^{\circ}\text{C}}$ (Note 1)	Maximum Dynamic Impedance Z_{ZT} (Ohms) (Note 2)
$V_Z = 9.3\text{ V} \pm 5.0\% * @ I_{ZT} = 10\text{ mA}$				
1N2620	0.070	0, +25, +75	0.01	15
1N2621	0.035		0.005	
1N2622	0.014		0.002	
1N2623	0.007		0.001	
1N2624	0.003		0.0005	
1N2620A	0.144	-55, 0, +25, +75, +100	0.01	15
1N2621A	0.072		0.005	
1N2622A	0.029		0.002	
1N2623A	0.014		0.001	
1N2624A	0.007		0.0005	
1N2620B	0.191	-55, 0, +25, +75, +100, +150	0.01	15
1N2621B	0.095		0.005	
1N2622B	0.038		0.002	
1N2623B	0.019		0.001	
1N2624B	0.010		0.0005	

*Tighter-tolerance units available on special request.

CAPACITANCE (C) = 75 to 200 pF @ 90% of V_Z

FORWARD BREAKDOWN VOLTAGE (V_F) = 100 to 800 V

1N2620, A, B thru 1N2624, A, B (continued)

MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE

(With $I_{ZT} = 10 \text{ mA} \pm 0.01 \text{ mA}$) (See Note 3)

1N2620 thru 1N2624

FIGURE 1a

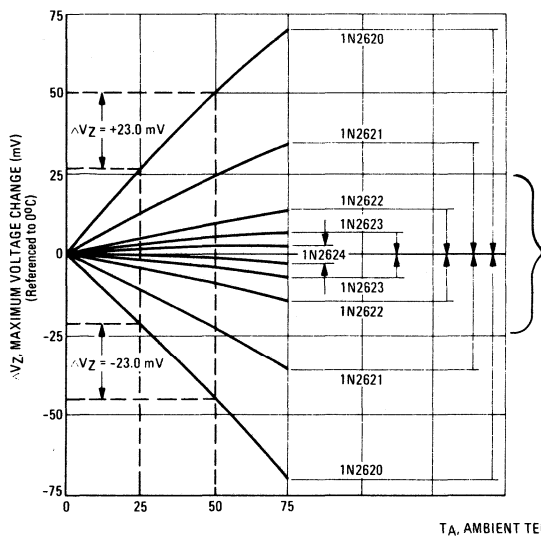
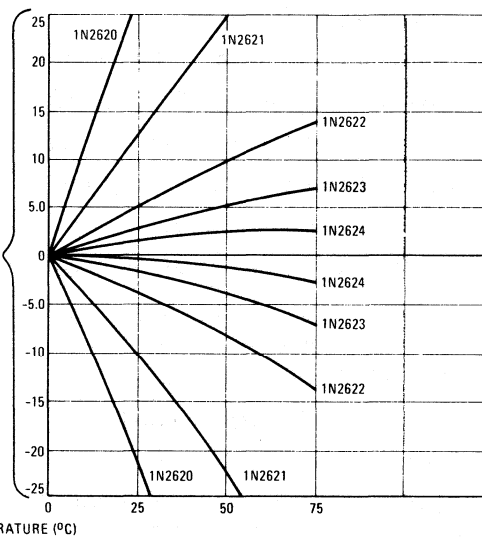


FIGURE 1b



MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE

(With $I_{ZT} = 10 \text{ mA} \pm 0.01 \text{ mA}$) (See Note 3)

1N2620A thru 1N2624A

FIGURE 2a

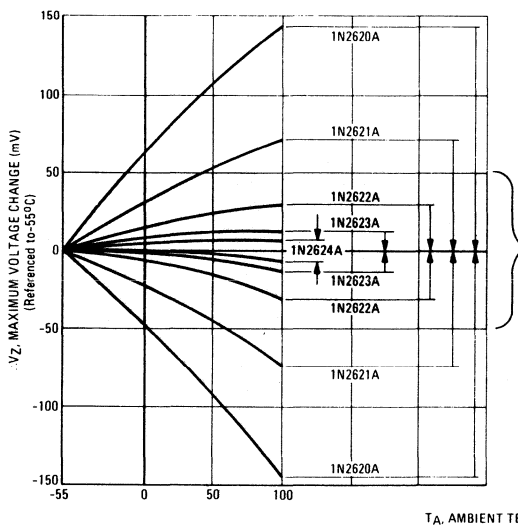
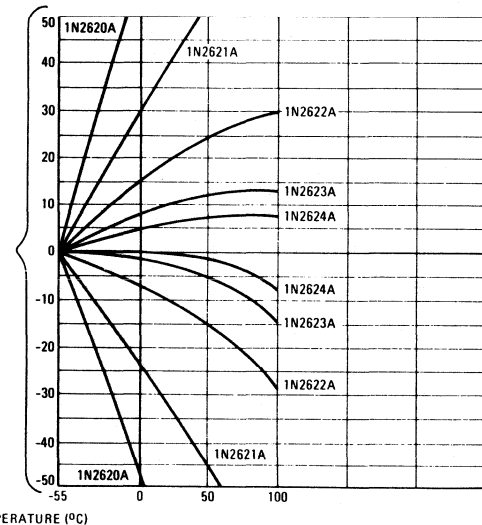


FIGURE 2b



1N2620, A, B thru 1N2624, A, B (continued)

MAXIMUM VOLTAGE CHANGE versus TEMPERATURE

(with $I_{ZT} = 10 \text{ mA} \pm 0.01 \text{ mA}$) (See Note 4)

1N2620B thru 1N2624B

FIGURE 3a

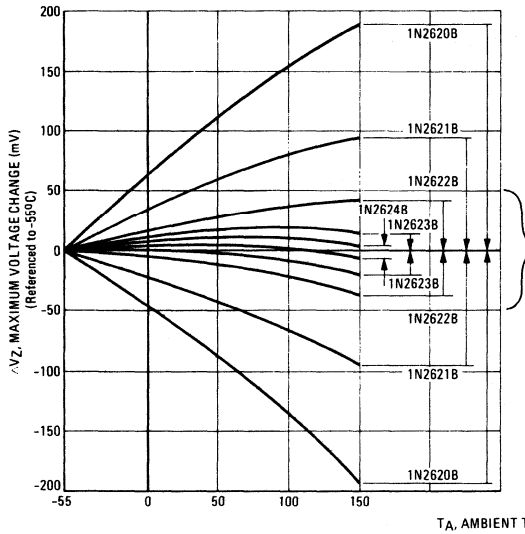


FIGURE 3b

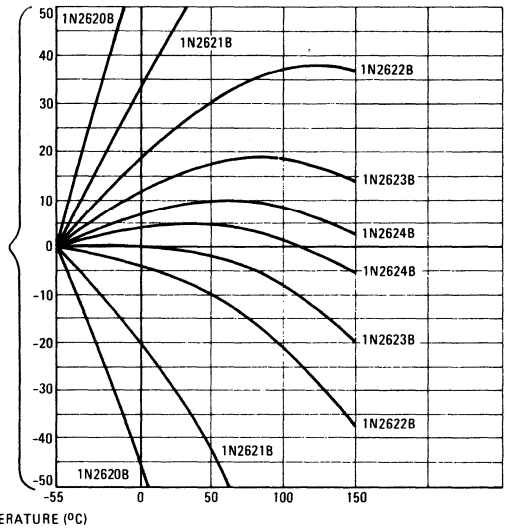


FIGURE 4 – ZENER CURRENT versus MAXIMUM VOLTAGE CHANGE (at specified temperatures) (See Note 4)

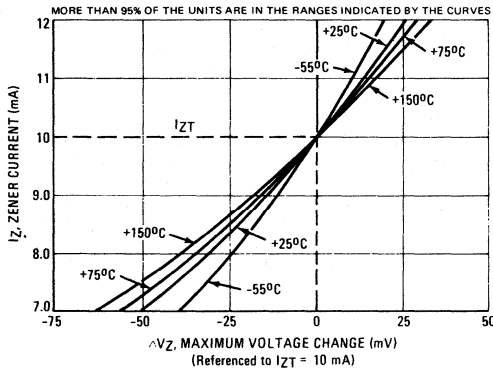


FIGURE 5 – MAXIMUM ZENER IMPEDANCE versus ZENER CURRENT (See Note 2)

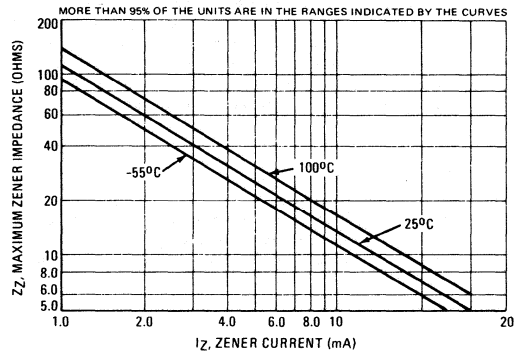
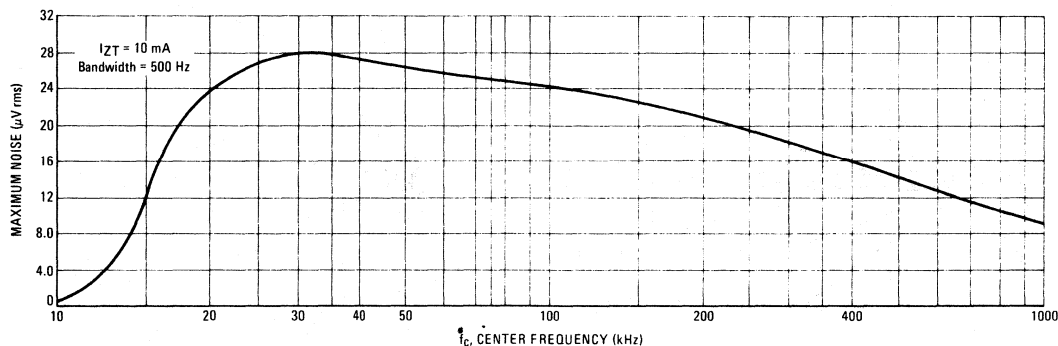


FIGURE 6 – DISTRIBUTION OF MAXIMUM GENERATED NOISE



NOTE 1:

Voltage Variation (ΔV_Z) and Temperature Coefficient.

All reference diodes are characterized by the "box method". This guarantees a maximum voltage variation (ΔV_Z) over the specified temperature range, at the specified test current (I_{ZT}), verified by tests at indicated temperature points within the range. This method of indicating voltage stability is now used for JEDEC registration as well as for military qualification. The former method of indicating voltage stability — by means of temperature coefficient — accurately reflects the voltage deviation at the temperature extremes, but is not necessarily accurate within the temperature range because reference diodes have a nonlinear temperature relationship. The temperature coefficient, therefore, is given only as a reference.

NOTE 2:

Zener Impedance Derivation

The dynamic zener impedance, Z_{ZT} , is derived from the 60-Hz ac voltage drop which results when an ac current with an rms value equal to 10% of the dc zener current, I_{ZT} , is superimposed on I_{ZT} . Curves showing the variation of zener impedance with zener current

for each series are given in Figure 5. A cathode-ray tube curve-trace test on a sample basis is used to ensure that each zener characteristic has a sharp and stable knee region.

NOTE 3:

These graphs can be used to determine the maximum voltage change of any device in the series over any specific temperature range. For example, a temperature change from $+25$ to $+50^\circ\text{C}$ will cause a voltage change no greater than $+23 \text{ mV}$ or -23 mV for 1N2620, as illustrated by the dashed lines in Figure 1. The boundaries given are maximum values. For greater resolution, expanded views of the shaded areas in Figures 1a, 2a, and 3a are shown in Figures 1b, 2b, and 3b respectively.

NOTE 4:

The maximum voltage change, ΔV_Z , in Figure 4 is due entirely to the impedance of the device. If both temperature and I_{ZT} are varied, then the total voltage change may be obtained by adding ΔV_Z in Figure 4 to the ΔV_Z in Figure 1, 2, or 3 for the device under consideration. If the device is to be operated at some stable current other than the specified test current, a new set of characteristics may be plotted by superimposing the data in Figure 4 on Figure 1, 2, or 3.

1N2804 thru 1N2846 (ZENER DIODES)

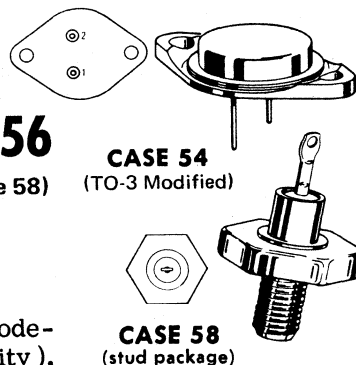
6.8V thru 200V (Case 54)

1N4557 thru 1N4564 1N4549 thru 1N4556

3.9V thru 7.5V (Case 54) 3.9V thru 7.5V (Case 58)

1N3305 thru 1N3350

6.8V thru 200V (Case 58)



CASE 54
(TO-3 Modified)

CASE 58
(stud package)

Units are available with anode-to-case and cathode-to-case connections (standard and reverse polarity). For reverse polarity, add suffix "R" to type number.

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to $+175^{\circ}\text{C}$.

D C Power Dissipation: 50 Watts. (Derate 0.5 W/ $^{\circ}\text{C}$ above 75°C).

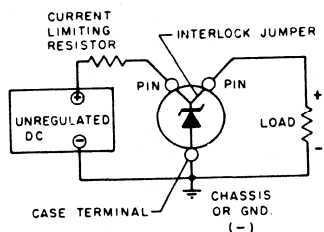
TOLERANCE DESIGNATION

The type numbers shown have a standard tolerance of $\pm 20\%$ on the nominal zener voltage. Add suffix "A" for $\pm 10\%$ units or "B" for $\pm 5\%$ units. (2% and 1% tolerance also available).

CASE 54 APPLICATIONS INFORMATION

If these units are used with a socket, the unregulated line should be connected to one pin through a suitable current limiting resistor and the load should be connected to the other pin. The load will now be disconnected from the line if the unit is removed from the socket.

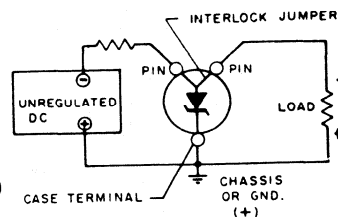
Typical circuit connections for anode-to-case and cathode-to-case polarities (standard and reverse polarities, respectively) are shown below



CIRCUIT CONNECTIONS

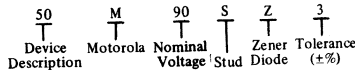
STANDARD POLARITY
(ANODE TO CASE)

REVERSE POLARITY
(CATHODE TO CASE)
(RED DOT ON CASE AND
"R" SUFFIX ON TYPE NO.)



(A) NOMINAL ZENER VOLTAGES BETWEEN THE VOLTAGES SHOWN AND TIGHTER VOLTAGE TOLERANCES:

To designate units with zener voltages other than those assigned JEDEC numbers and/or tight voltage tolerances ($\pm 3\%$, $\pm 2\%$, $\pm 1\%$), the Motorola type number should be used.

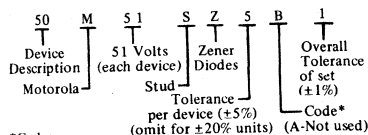


Example: 50M90ZS3

(B) MATCHED SETS: (Standard Tolerances are $\pm 5.0\%$ $\pm 2.0\%$, $\pm 1.0\%$).

Zener diodes can be obtained in sets consisting of two or more matched devices. The method for specifying such matched sets is similar to the one described in (A) for specifying units with a special voltage and/or tolerance except that two extra suffixes are added to the code number described.

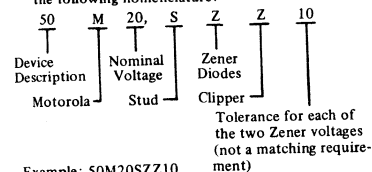
These units are marked with code letters to identify the matched sets and, in addition, each unit in a set is marked with the same serial number which is different for each set being ordered.



*Code:
B = Two devices in series
C = Three devices in series
D = Four devices in series
Example: 50M51SZ5B1

(C) ZENER CLIPPERS: (Standard Tolerance $\pm 10\%$ and $\pm 5\%$).

Special clipper diodes with opposing Zener junctions built into the device are available by using the following nomenclature:



Example: 50M20SZZ10

1N2804 thru 1N2846 (continued)

ELECTRICAL CHARACTERISTICS

($T_C = 30^\circ\text{C}$ unless otherwise specified) $V_F = 1.5\text{ V max @ } 10\text{ A}$ on all types.

50 Watt CASE 54	50 Watt CASE 58	Nominal Zener Voltage @ I_{ZT} (V_Z) Volts	Test Current (I_{ZT}) mA	Max Zener Impedance		Max DC Zener Current 75°C Case Temp (I_{ZM}) mA	REVERSE * LEAKAGE CURRENT			Typical Zener Voltage Temp. Coeff. %/°C
				$Z_{ZT} @ I_{ZT}$ ohms	$Z_{ZK} @ I_{ZK} = 5\text{mA}$ ohms		$I_R \text{ MAX}$ (μA)	V_{R1}	V_{R2}	
1N4557	1N4549	3.9	3200	0.16	400	11900	150	0.5	0.5	-.025
1N4558	1N4550	4.3	2900	0.16	500	10650	150	0.5	0.5	-.025
1N4559	1N4551	4.7	2650	0.12	600	9700	100	1.0	1.0	.010
1N4560	1N4552	5.1	2450	0.12	650	8900	20	1.0	1.0	.015
1N4561	1N4553	5.6	2250	0.12	900	8100	20	1.0	1.0	.030
1N4562	1N4554	6.2	2000	0.14	1000	7300	20	2.0	2.0	.040
1N2804	1N3305	6.8	1850	0.2	70	6600	150	4.5	4.3	.040
1N4563	1N4555	6.8	1850	0.16	200	6650	10	2.0	2.0	.045
1N2805	1N3306	7.5	1700	0.3	70	5900	75	5.0	4.7	.045
1N4564	1N4556	7.5	1650	0.24	100	6050	10	3.0	3.0	.053
1N2806	1N3307	8.2	1500	0.4	70	5200	50	5.4	5.2	.048
1N2807	1N3308	9.1	1370	0.5	70	4800	25	6.1	5.7	.051
1N2808	1N3309	10	1200	0.6	80	4300	10	6.7	6.3	.055
1N2809	1N3310	11	1100	0.8	80	3900	5	8.4	8.0	.060
1N2810	1N3311	12	1000	1.0	80	3600	5	9.1	8.6	.065
1N2811	1N3312	13	960	1.1	80	3300	5	9.9	9.4	.065
1N2812	1N3313	14	890	1.2	80	3000	5	10.6	10.1	.070
1N2813	1N3314	15	830	1.4	80	2800	5	11.4	10.8	.070
1N2814	1N3315	16	780	1.6	80	2650	5	12.2	11.5	.070
1N2815	1N3316	17	740	1.8	80	2500	5	13.0	12.2	.075
1N2816	1N3317	18	700	2.0	80	2300	5	13.7	13.0	.075
1N2817	1N3318	19	660	2.2	80	2200	5	14.4	13.7	.075
1N2818	1N3319	20	630	2.4	80	2100	5	15.2	14.4	.075
1N2819	1N3320	22	570	2.5	80	1900	5	16.7	15.8	.080
1N2820	1N3321	24	520	2.6	80	1750	5	18.2	17.3	.080
1N2821	1N3322	25	500	2.7	90	1550	5	19.0	18.0	.080
1N2822	1N3323	27	460	2.8	90	1500	5	20.6	19.4	.085
1N2823	1N3324	30	420	3.0	90	1400	5	22.8	21.6	.085
1N2824	1N3325	33	380	3.2	90	1300	5	25.1	23.8	.085
1N2825	1N3326	36	350	3.5	90	1150	5	27.4	25.9	.085
1N2826	1N3327	39	320	4.0	90	1050	5	29.7	28.1	.090
1N2827	1N3328	43	290	4.5	90	975	5	32.7	31.0	.090
1N2828	1N3329	45	280	4.5	100	930	5	34.2	32.4	.090
1N2829	1N3330	47	270	5.0	100	880	5	35.8	33.8	.090
1N2830	1N3331	50	250	5.0	100	830	5	38.0	36.0	.090
1N2831	1N3332	51	245	5.2	100	810	5	38.8	36.7	.090
-	1N3333	52	240	5.5	100	790	5	39.5	37.4	.090
1N2832	1N3334	56	220	6	110	740	5	42.6	40.3	.090
1N2833	1N3335	62	200	7	120	660	5	47.1	44.6	.090
1N2834	1N3336	68	180	8	140	600	5	51.7	49.0	.090
1N2835	1N3337	75	170	9	150	540	5	56.0	54.0	.090
1N2836	1N3338	82	150	11	160	490	5	62.2	59.0	.090
1N2837	1N3339	91	140	15	180	420	5	69.2	65.5	.090
1N2838	1N3340	100	120	20	200	400	5	76.0	72.0	.090
1N2839	1N3341	105	120	25	210	380	5	79.8	75.6	.095
1N2840	1N3342	110	110	30	220	365	5	83.6	79.2	.095
1N2841	1N3343	120	100	40	240	335	5	91.2	86.4	.095
1N2842	1N3344	130	95	50	275	310	5	98.8	93.6	.095
-	1N3345	140	90	60	325	290	5	106.4	100.8	.095
1N2843	1N3346	150	85	75	400	270	5	114.0	108.0	.095
1N2844	1N3347	160	80	80	450	250	5	121.6	115.2	.095
-	1N3348	175	70	85	500	230	5	133.0	126.0	.095
1N2845	1N3349	180	68	90	525	220	5	136.8	129.6	.095
1N2846	1N3350	200	65	100	600	200	5	152.0	144.0	.100

SPECIAL SELECTIONS AVAILABLE INCLUDE: (See Selector Guide for details)

* V_{R1} - Test Voltage for 5% Tolerance Device

V_{R2} - Test Voltage for 10% Tolerance Device

No Leakage Specified as 20% Tolerance Device

FIGURE 1 — TEMPERATURE CHARACTERISTICS

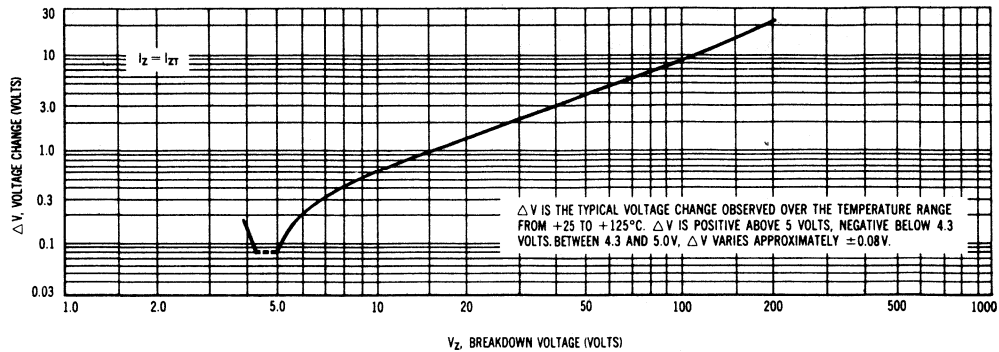


FIGURE 2 —
POWER-TEMPERATURE DERATING CURVE

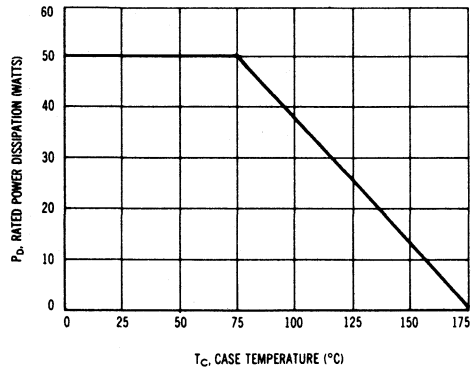


FIGURE 3 — LEAKAGE CURRENT

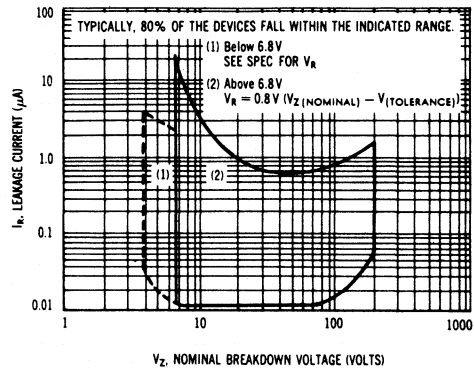
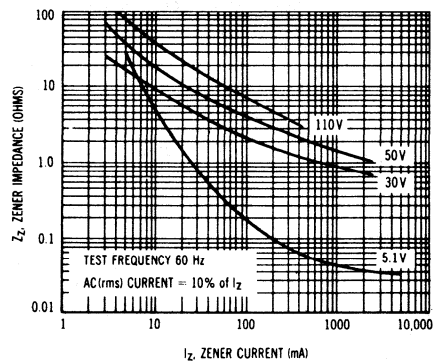
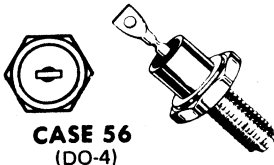


FIGURE 4 — ZENER IMPEDANCE
versus ZENER CURRENT



1N2970 thru 1N3015 (ZENER DIODES)



Diffused-junction zener diodes for both military and high-reliability industrial applications. Available with anode-to-case and cathode-to-case connections (standard and reverse polarity), i. e., 1N2970 and 1N2970R. Supplied with mounting hardware.

The type numbers shown have a standard tolerance of $\pm 20\%$ on the nominal zener voltage. Add suffix "A" for $\pm 10\%$ units or "B" for $\pm 5\%$ units. (2% and 1% tolerance also available.)

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to $+175^{\circ}\text{C}$.

D C Power Dissipation: 10 Watts. (Derate 83.3 mW/ $^{\circ}\text{C}$ above 55°C).

ELECTRICAL CHARACTERISTICS

($T_C = 25^{\circ}\text{C}$ unless otherwise noted)

$V_F = 1.5 \text{ V max @ } I_F = 2 \text{ amp on all types.}$

Type No.	Nominal Zener Voltage $V_Z @ I_{ZT}$ Volts	Test Current I_{ZT} mA	Max Zener Impedance			Max DC Zener Current I_{ZM} mA	Max. Reverse Current *		
			$Z_{ZT} @ I_{ZT}$ Ohms	$Z_{ZK} @ I_{ZK}$ Ohms	I_{ZK} mA		$I_R \text{ Max}$ (μA)	V_{R1}	V_{R2}
1N2970	6.8	370	1.2	500	1.0	1,320	150	5.2	4.9
1N2971	7.5	335	1.3	250	1.0	1,180	75	5.7	5.4
1N2972	8.2	305	1.5	250	1.0	1,040	50	6.2	5.9
1N2973	9.1	275	2.0	250	1.0	960	25	6.9	6.6
1N2974	10	250	3	250	1.0	860	10	7.6	7.2
1N2975	11	230	3	250	1.0	780	5	8.4	8.0
1N2976	12	210	3	250	1.0	720	5	9.1	8.6
1N2977	13	190	3	250	1.0	660	5	9.9	9.4
1N2978	14	180	3	250	1.0	600	5	10.6	10.1
1N2979	15	170	3	250	1.0	560	5	11.4	10.8
1N2980	16	155	4	250	1.0	530	5	12.2	11.5
1N2982	18	140	4	250	1.0	460	5	13.7	13.0
1N2983	19	130	4	250	1.0	440	5	14.4	13.7
1N2984	20	125	4	250	1.0	420	5	15.2	14.4
1N2985	22	115	5	250	1.0	380	5	16.7	15.8
1N2986	24	105	5	250	1.0	350	5	18.2	17.3
1N2988	27	95	7	250	1.0	300	5	20.6	19.4
1N2989	30	85	8	300	1.0	280	5	22.8	21.6
1N2990	33	75	9	300	1.0	260	5	25.1	23.8
1N2991	36	70	10	300	1.0	230	5	27.4	25.9

* V_{R1} — Test Voltage for 5% Tolerance Device. V_{R2} — Test Voltage for 10% Tolerance Device. No Leakage Specified as 20% Tolerance Device.

(A) NOMINAL ZENER VOLTAGES BETWEEN THE VOLTAGES SHOWN AND TIGHTER VOLTAGE TOLERANCES:

To designate units with zener voltages other than those assigned JEDEC numbers and/or tight voltage tolerances ($\pm 3\%$, $\pm 2\%$, $\pm 1\%$), the Motorola type number should be used.

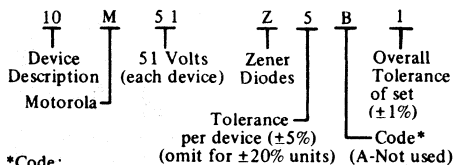


Example: 10M90Z3

(B) MATCHED SETS: (Standard Tolerances are $\pm 5.0\%$, $\pm 2.0\%$, $\pm 1.0\%$).

Zener diodes can be obtained in sets consisting of two or more matched devices. The method for specifying such matched sets is similar to the one described in (A) for specifying units with a special voltage and/or tolerance except that two extra suffixes are added to the code number described.

These units are marked with code letters to identify the matched sets and, in addition, each unit in a set is marked with the same serial number, which is different for each set being ordered.



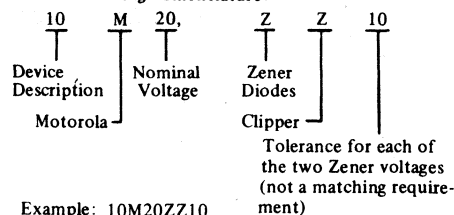
*Code:

- B — Two devices in series
- C — Three devices in series
- D — Four devices in series

Example: 10M51Z5B1

(C) ZENER CLIPPERS: (Standard Tolerance $\pm 10\%$ and $\pm 5\%$).

Special clipper diodes with opposing Zener junctions built into the device are available by using the following nomenclature:



Example: 10M20ZZ10

1N2970 thru 1N3015 (continued)

ELECTRICAL CHARACTERISTICS

($T_C = 25^\circ\text{C}$ unless otherwise noted)

$V_F = 1.5 \text{ V max @ } I_F = 2 \text{ amp on all types.}$

Type No.	Nominal Zener Voltage $V_Z @ I_{ZT}$ Volts	Test Current I_{ZT} mA	Max Zener Impedance			Max DC Zener Current I_{ZM} mA	Max. Reverse Current *		
			$Z_{ZT} @ I_{ZT}$ Ohms	$Z_{ZK} @ I_{ZK}$ Ohms	I_{ZK} mA		$I_R \text{ Max}$ (μA)	V_{R1}	V_{R2}
1N2992	39	65	11	300	1.0	210	5	29.7	28.1
1N2993	43	60	12	400	1.0	195	5	32.7	31.0
1N2995	47	55	14	400	1.0	175	5	35.8	33.8
1N2996	50	50	15	500	1.0	165	5	38.0	36.0
1N2997	51	50	15	500	1.0	163	5	38.8	36.7
1N2998	52	50	15	500	1.0	160	5	39.5	37.4
1N2999	56	45	16	500	1.0	150	5	42.6	40.3
1N3000	62	40	17	600	1.0	130	5	47.1	44.6
1N3001	68	37	18	600	1.0	120	5	51.7	49.0
1N3002	75	33	22	600	1.0	110	5	56.0	54.0
1N3003	82	30	25	700	1.0	100	5	62.2	59.0
1N3004	91	28	35	800	1.0	85	5	69.2	65.5
1N3005	100	25	40	900	1.0	80	5	76.0	72.0
1N3006	105	25	45	1,000	1.0	75	5	79.8	75.6
1N3007	110	23	55	1,100	1.0	72	5	83.6	79.2
1N3008	120	20	75	1,200	1.0	67	5	91.2	86.4
1N3009	130	19	100	1,300	1.0	62	5	98.8	93.6
1N3010	140	18	125	1,400	1.0	58	5	106.4	100.8
1N3011	150	17	175	1,500	1.0	54	5	114.0	108.0
1N3012	160	16	200	1,600	1.0	50	5	121.6	115.2
1N3014	180	14	260	1,850	1.0	45	5	136.8	129.6
1N3015	200	12	300	2,000	1.0	40	5	152.0	144.0

SPECIAL SELECTIONS AVAILABLE INCLUDE: (See Selector Guide for details)

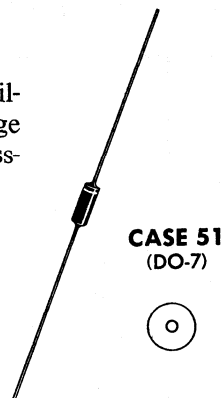
* V_{R1} — Test Voltage for 5% Tolerance Device. V_{R2} — Test Voltage for 10% Tolerance Device. No Leakage Specified as 20% Tolerance Device.

1N3016 thru 1N3051

For Specifications, See 1N3821 Data.

1N3154, A (SILICON) thru 1N3157, A

Temperature-compensated zener reference diodes utilizing an oxide-passivated junction for long-term voltage stability. RamRod construction provides a rugged, glass-enclosed, hermetically sealed structure.



MAXIMUM RATINGS

Junction Temperature: -55 to +175°C

Storage Temperature: -65 to +175°C

DC Power Dissipation: 500 mW @ $T_A = 25^\circ\text{C}$

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, all-glass

DIMENSIONS: See outline drawing.

FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

POLARITY: Cathode indicated by polarity band.

WEIGHT: 0.2 Gram (approx)

MOUNTING POSITION: Any

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

JEDEC Type No. (Note 1)	Maximum Voltage Change ΔV_Z (Volts) (Note 2)	Ambient Test Temperature $^\circ\text{C}$ $\pm 1^\circ\text{C}$	Temperature Coefficient $\frac{1}{V_Z} \frac{dV_Z}{dT}$ $^\circ\text{C}^{-1}$ (Note 2)	Maximum Dynamic Impedance Z_{ZT} (Ohms) (Note 3)
$V_Z = 8.4 \text{ V} \pm 5.0\% * @ I_{ZT} = 10 \text{ mA}$				
1N3154	0.130	-55, 0, +25, +75, +100	0.01	15
1N3155	0.065		0.005	
1N3156	0.026		0.002	
1N3157	0.013		0.001	
1N3154A	0.172	-55, 0, +25, +75, +100, +150	0.01	15
1N3155A	0.086		0.005	
1N3156A	0.034		0.002	
1N3157A	0.017		0.001	

*Tighter-tolerance units available on special request.

CAPACITANCE (C) = 20 to 180 pF @ 90% of V_Z

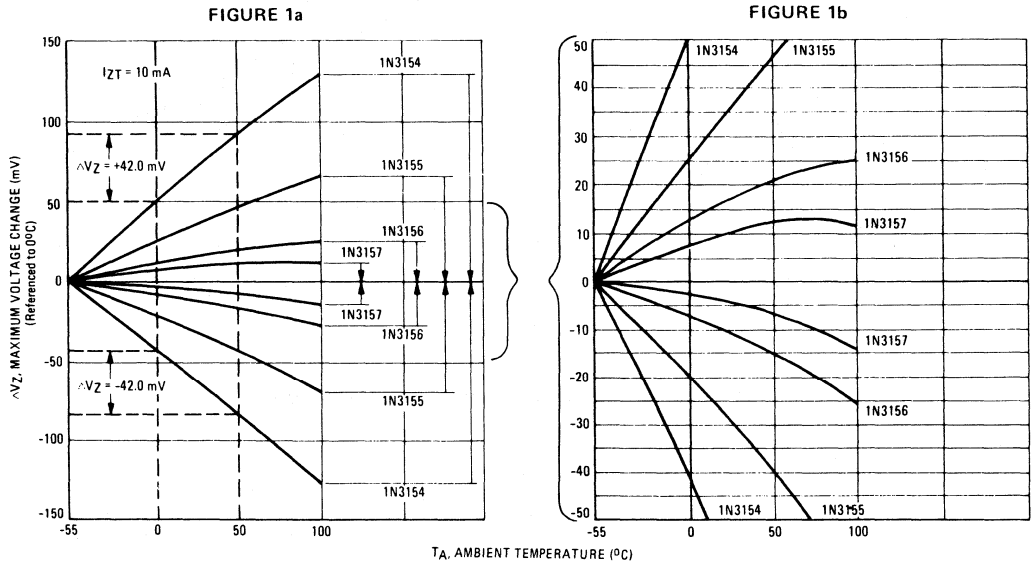
FORWARD BREAKDOWN VOLTAGE (V_F) = 100 to 800 V

1N3154, A thru 1N3157, A (continued)

MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE

(with $I_{ZT} = 10 \text{ mA} \pm 0.01 \text{ mA}$) (See Note 4)

1N3154 thru 1N3157



MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE

(with $I_{ZT} = 10 \text{ mA} \pm 0.01 \text{ mA}$) (See Note 4)

1N3154A thru 1N3157A

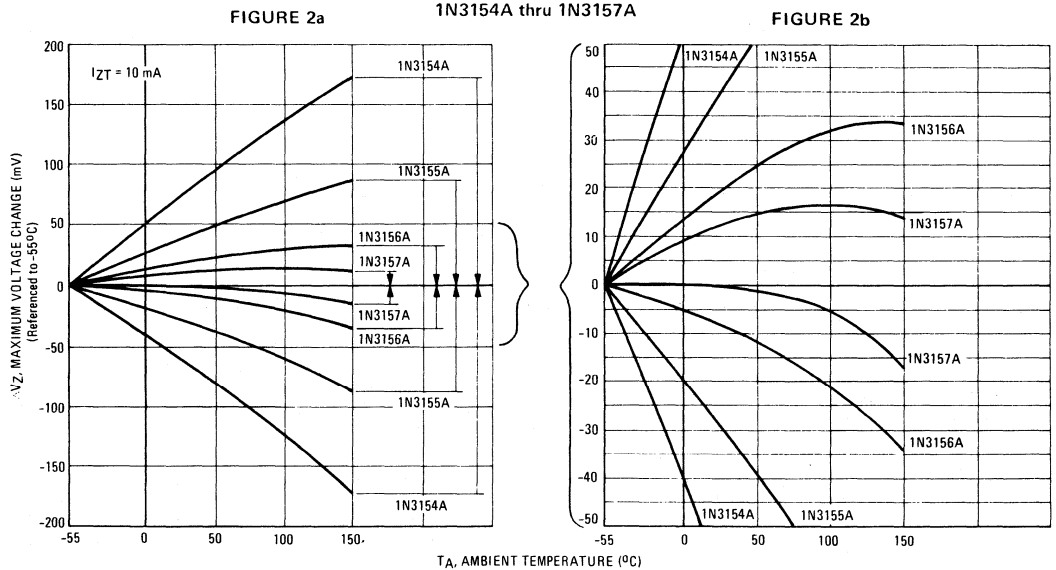


FIGURE 3 – ZENER CURRENT versus MAXIMUM VOLTAGE CHANGE (at specified temperatures)
(See Note 5)

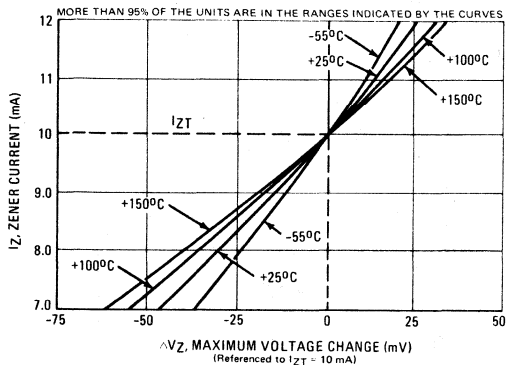


FIGURE 4 – MAXIMUM ZENER IMPEDANCE versus ZENER CURRENT
(See Note 3)

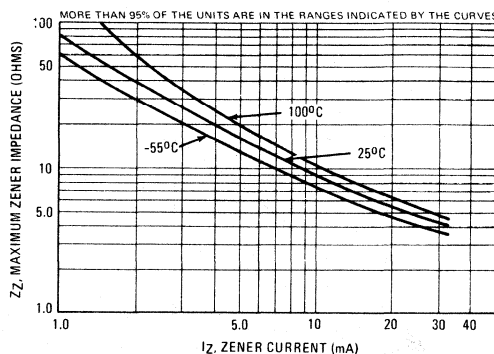
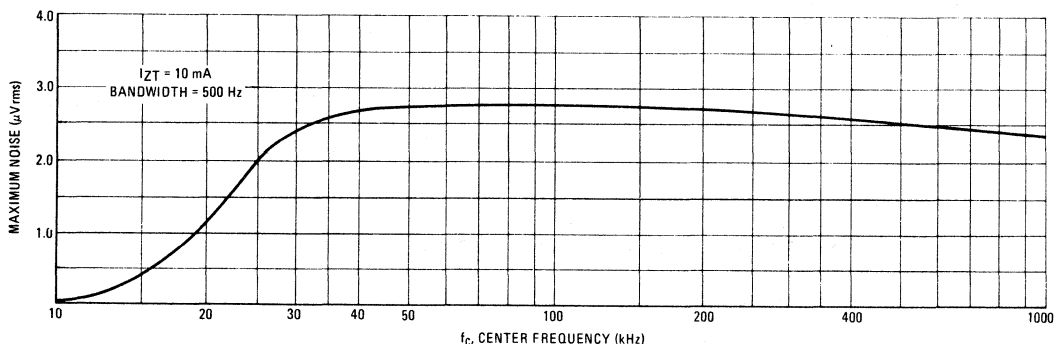


FIGURE 5 – DISTRIBUTION OF MAXIMUM GENERATED NOISE



NOTE 1:

Types 1N3154 thru 1N3157 are available to MIL-S-19500/158

NOTE 2:

Voltage Variation (ΔV_Z) and Temperature Coefficient.

All reference diodes are characterized by the "box method". This guarantees a maximum voltage variation (ΔV_Z) over the specified temperature range, at the specified test current (I_{ZT}), verified by tests at indicated temperature points within the range. This method of indicating voltage stability is now used for JEDEC registration as well as for military qualification. The former method of indicating voltage stability — by means of temperature coefficient — accurately reflects the voltage deviation at the temperature extremes, but is not necessarily accurate within the temperature range because reference diodes have a nonlinear temperature relationship. The temperature coefficient, therefore, is given only as a reference.

NOTE 3:

Zener Impedance Derivation

The dynamic zener impedance, Z_{ZT} , is derived from the 60-Hz ac voltage drop which results when an ac current with an rms value equal to 10% of the dc zener current, I_{ZT} , is superimposed on I_{ZT} .

Curves showing the variation of zener impedance with zener current for each series are given in Figure 4. A cathode-ray tube curve-trace test on a sample basis is used to ensure that each zener characteristic has a sharp and stable knee region.

NOTE 4:

These graphs can be used to determine the maximum voltage change of any device in the series over any specific temperature range. For example, a temperature change from 0 to +50°C will cause a voltage change no greater than +42 mV or -42 mV for 1N3154, as illustrated by the dashed lines in Figure 1. The boundaries given are maximum values. For greater resolution, expanded views of the shaded areas in Figures 1a and 2a are shown in Figures 1b and 2b respectively.

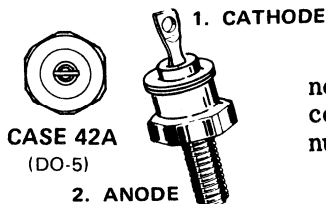
NOTE 5:

The maximum voltage change, ΔV_Z , in Figure 3 is due entirely to the impedance of the device. If both temperature and I_{ZT} are varied, then the total voltage change may be obtained by adding ΔV_Z in Figure 3 to the ΔV_Z in Figure 1 or 2 for the device under consideration. If the device is to be operated at some stable current other than the specified test current, a new set of characteristics may be plotted by superimposing the data in Figure 3 on Figure 1 or 2.

1N3189 thru 1N3191

Obsolete, discontinued types, replace with devices from the 1N4001 series.

1N3208 thru 1N3212 (SILICON)



Medium-current silicon rectifiers. Cathode connected to case, but reverse polarity (anode-to-case connection) also available by adding suffix "R" to type number, e.g. 1N3208R.

MAXIMUM RATINGS

Rating	Symbol	1N3208 1N3208R	1N3209 1N3209R	1N3210 1N3210R	1N3211 1N3211R	1N3212 1N3212R	Unit
D C Blocking Voltage	V_R	50	100	200	300	400	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	210	280	Volts
Average Half-Wave Rectified Forward Current With Resistive Load	I_O^*	15	15	15	15	15	Amp
Peak One Cycle Surge Current (60 cps & 25°C Case Temp)	I_{FSM}	250	250	250	250	250	Amp
Operating Junction Temperature	T_J	-65 to + 175					°C
Storage Temperature	T_{stg}	-65 to + 175					°C

* $T_C = 150^\circ\text{C}$

ELECTRICAL CHARACTERISTICS (All Types) at 25°C Case Temp.

Characteristic	Symbol	Value	Unit
Maximum Forward Voltage at 40 Amp D-C Forward Current	V_F	1.5	Volts
Maximum Reverse Current at Rated D-C Reverse Voltage	I_R	1.0	mAdc
Typical Thermal Resistance, Junction To Case	$R_{\theta JC}$	1.7	C/W

1N3213, 1N3214

For Specifications, See 1N248B Data.

1N3305 thru 1N3350

For Specifications, see 1N2804 Data.

1N3491 thru 1N3495 (SILICON)

MR327, MR328, MR330, MR331

CASE 43
(DO-21)



Medium-current silicon rectifiers – compact, highly efficient silicon rectifiers for medium-current applications.

MAXIMUM RATINGS

Rating	Symbol	1N3491	1N3492	1N3493	1N3494	1N3495	MR327	MR328	MR330	MR331	Unit
Peak Repetitive Reverse Voltage	V_{RRM}										
Working Peak Reverse Voltage	V_{RWM}	50	100	200	300	400	500	600	800	1000	Volts
DC Blocking Voltage	V_R										
Non-Repetitive Peak Reverse Voltage (halfwave, single phase, 60 cycle peak)	V_{RSM}	100	200	300	400	500	600	720	1000	1200	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	210	280	350	420	560	700	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, see Figure 3) $T_C = 130^\circ\text{C}$	I_O	25									Amp
Non-Repetitive Peak Surge Current (surge applied at rated load conditions, see Figure 5)	I_{FSM}	300 (for 1/2 cycle)									Amp
I^2t Rating (non-repetitive, for t greater than 1 ms and less than 8.3 ms)	I^2t	375									$A_{(rms)}^2 \text{ sec}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175									$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.2	$^\circ\text{C/Watt}$

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed construction.

FINISH: All external surfaces corrosion-resistant and the terminal lead is readily solderable.

POLARITY: CATHODE TO CASE (reverse polarity units are available upon request and are designated by an "R" suffix i.e. MR327R or 1N3491R).

MOUNTING POSITIONS: Any.

ELECTRICAL CHARACTERISTICS

Characteristic and Conditions	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (rated I_O and V_F , single phase, 60 Hz, $T_C = 150^\circ\text{C}$)	$V_{F(AV)}$	0.6	Volts
Instantaneous Forward Voltage Drop ($i_F = 100$ Amps, $T_J = 25^\circ\text{C}$)	v_F	1.5	Volts
Full Cycle Average Reverse Current (rated I_O and V_R , single phase, 60 Hz, $T_C = 150^\circ\text{C}$) 1N3491 1N3492 1N3493 1N3494 1N3495 MR327 MR328 MR330 MR331	$I_{R(AV)}$	10 10 8.0 6.0 4.0 3.0 2.5 2.0 1.5	mA
DC Reverse Current (Rated V_R , $T_C = 25^\circ\text{C}$)	I_R	1.0	mA

FIGURE 1 — MAXIMUM FORWARD VOLTAGE DROP

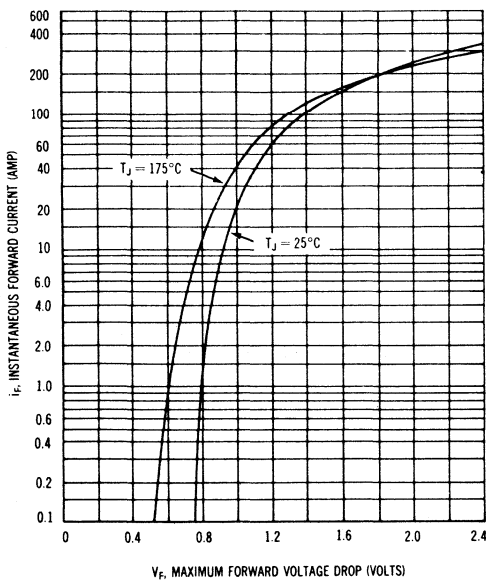


FIGURE 2 — MAXIMUM FORWARD POWER DISSIPATION

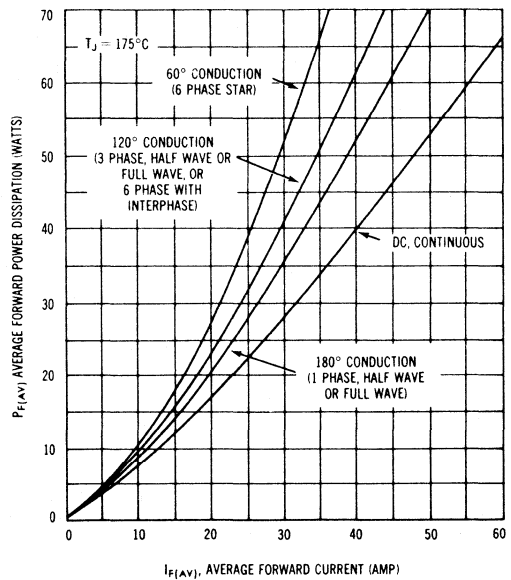


FIGURE 3 — MAXIMUM CURRENT RATINGS

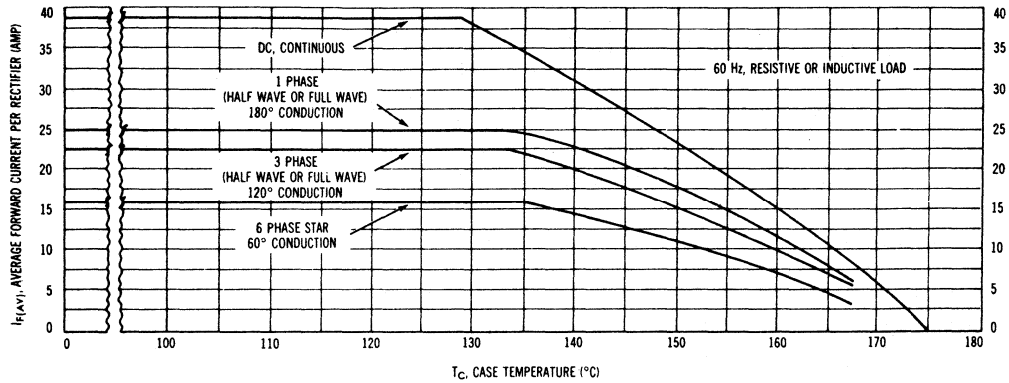


FIGURE 4 — MAXIMUM EFFECTIVE TRANSIENT THERMAL IMPEDANCE

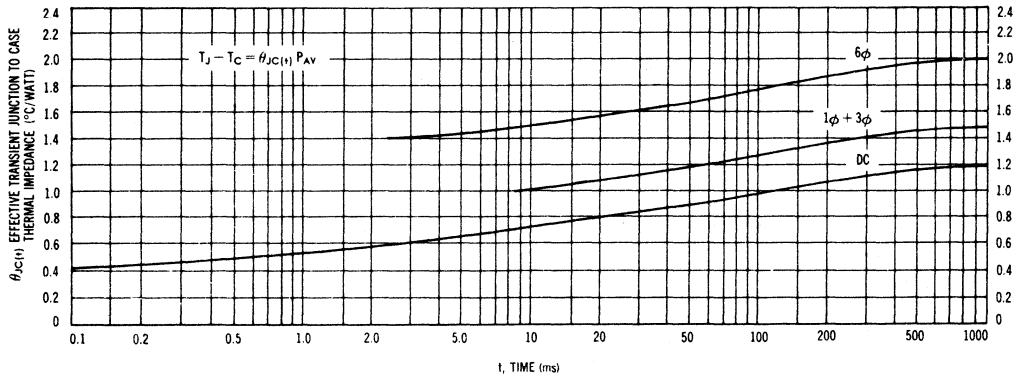
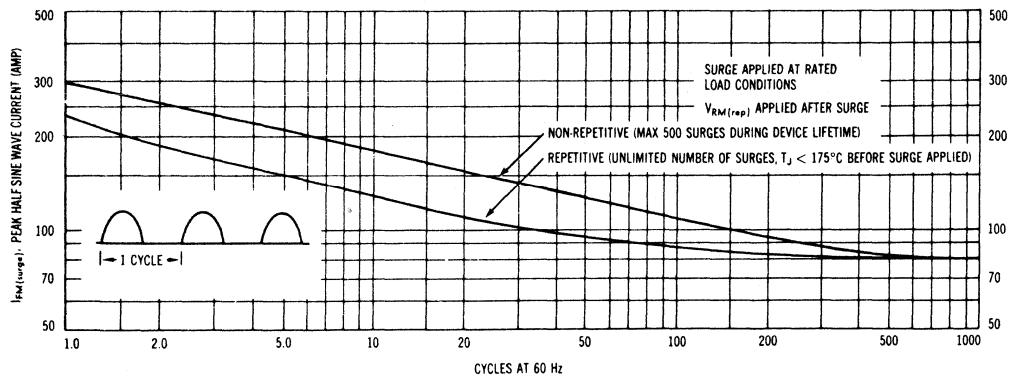


FIGURE 5 — MAXIMUM ALLOWABLE SURGE CURRENT



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 6 — RECTIFICATION EFFICIENCY

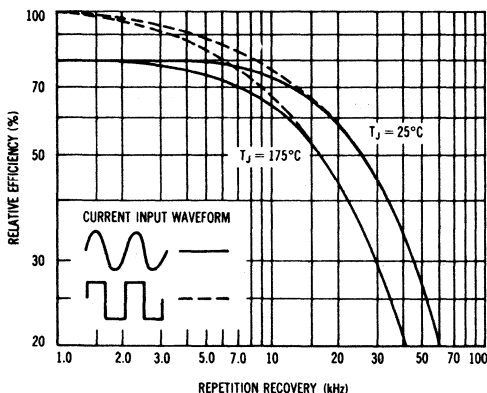


FIGURE 7 — REVERSE RECOVERY TIME

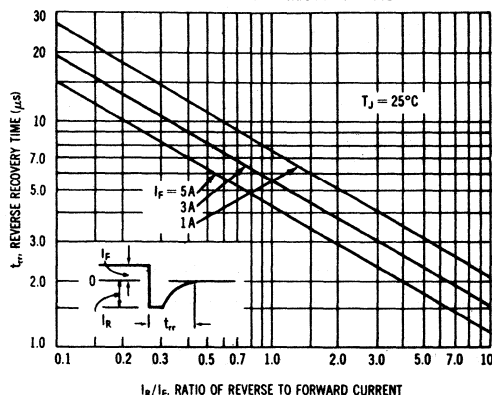


FIGURE 8 — JUNCTION CAPACITANCE

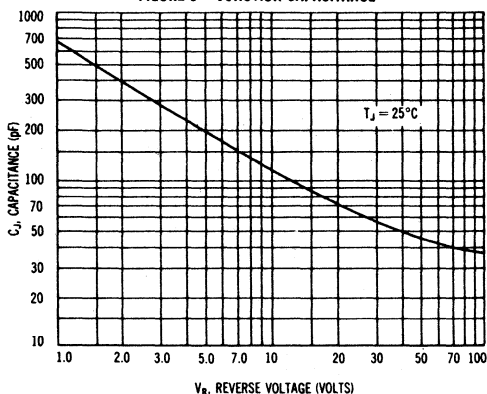
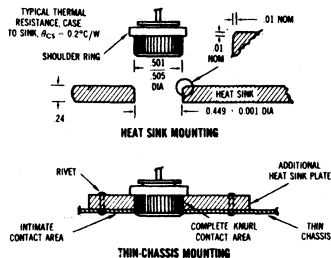
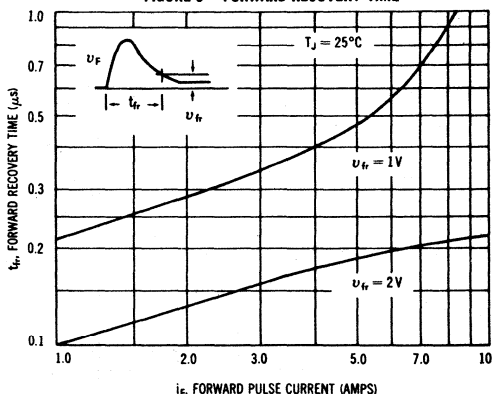


FIGURE 9 — FORWARD RECOVERY TIME



MOUNTING PROCEDURES

MR327-MR331 and 1N3491-1N3495 rectifiers are designed to be press-fitted in a heat sink in order to attain full device ratings. Recommended procedures for this type of mounting are as follows:

1. Drill a hole in the heat sink $0.499 \pm .001$ inch in diameter.
2. Break the hole edge as shown to prevent shearing off the knurled edge of the rectifier when it is pressed into the hole.
3. The depth and width of the break should be 0.010 inch maximum to retain maximum heat sink surface contact.
4. To prevent damage to the rectifier during press-in, the pressing force should be applied only on the shoulder ring of the rectifier case as shown in the figure.
5. The pressing force should be applied evenly about the shoulder ring to avoid tilting or canting of the rectifier case in the hole during the press-in operation. Also, the use of a light industrial lubricant will be of considerable aid.

1N3580, A, B thru 1N3583, A, B

For Specifications, See 1N2163 Data.

1N3649, 1N3650

Obsolete, discontinued types, replace with devices from the MR1120 series.

1N3659 thru 1N3663 (SILICON)

CASE 43
(DO-21)



Low-cost silicon rectifiers in hermetically sealed, press-fit case, designed for operation under severe environmental conditions. Cathode connected to case, but available with reverse polarity by adding suffix "R" to type number.

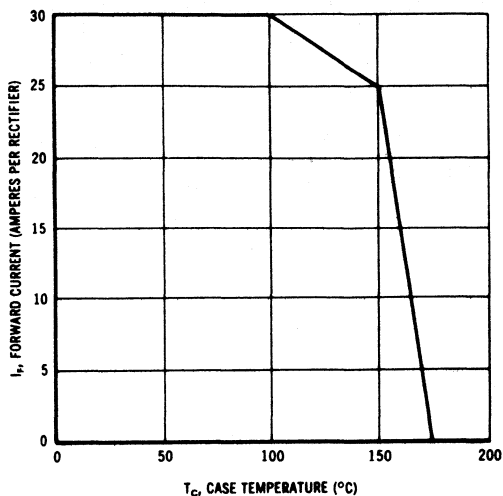
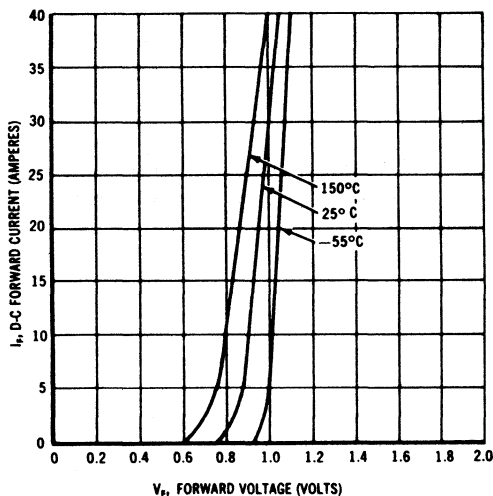
MAXIMUM RATINGS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Rating	Symbol	1N3659 1N3659R	1N3660 1N3660R	1N3661 1N3661R	1N3662 1N3662R	1N3663 1N3663R	Units
Peak Repetitive Reverse Voltage DC Blocking Voltage	V_{RRM} V_R	50	100	200	300	400	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	210	280	Volts
Average Half-Wave Rectified Forward Current with Resistive Load @ 100°C case @ 150°C case	I_O	30 25					Amp Amp
Peak One Cycle Surge Current (150°C case temp, 60 Hz)	I_{FSM}	400					Amp
Operating Junction Temperature	T_J	-65 to +175					°C
Storage Temperature	T_{stg}	-65 to +200					°C

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	1N3659 1N3659R	1N3660 1N3660R	1N3661 1N3661R	1N3662 1N3662R	1N3663 1N3663R	Unit
Maximum Forward Voltage at 25 Amp DC Forward Current	V_F	1.2	1.2	1.2	1.2	1.2	Volts
Maximum Full Cycle Average Forward Voltage Drop @ Rated PIV and Current	$V_{F(AV)}$	0.7	0.7	0.7	0.7	0.7	Volts
Maximum Full Cycle Average Reverse Current @ Rated PIV and Current (as half-wave rectifier, resistive load, 150°C)	$I_{R(AV)}$	5.0	4.5	4.0	3.5	3.0	mA
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.0					°C/W

1N3659 thru 1N3663 (continued)

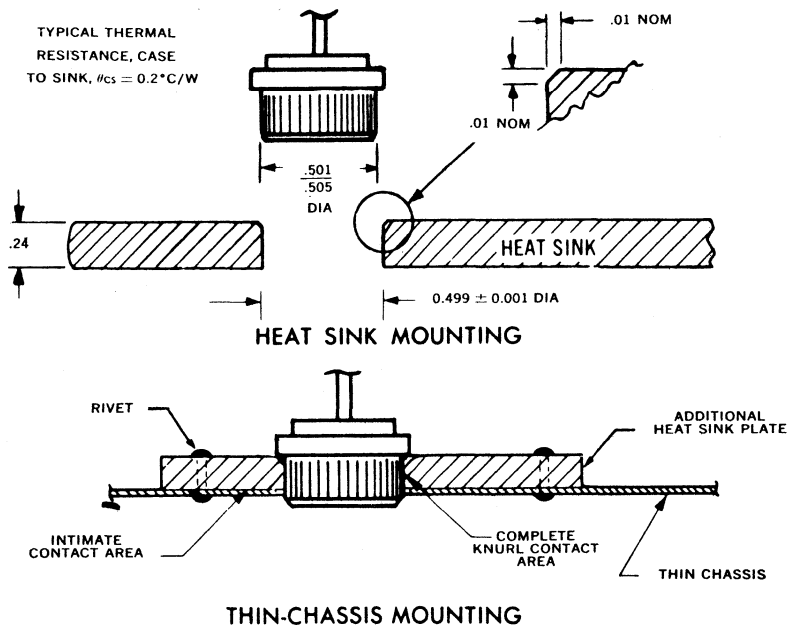


1N3659-1N3663 rectifiers are designed for press-fitted mounting in a heat sink. Recommended procedures for this type of mounting are as follows:

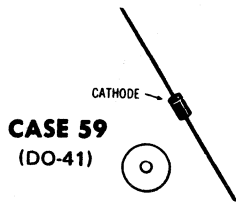
1. Drill a hole in the heat sink $0.499 \pm .001$ inch in diameter.
2. Break the hole edge as shown to prevent shearing off the knurled edge of the rectifier when it is pressed into the hole.
3. The depth of the break should be 0.010 inch maximum to retain maximum heat sink surface contact with the knurled rectifier surface.
4. Width of the break should be 0.010 inch as shown.

These procedures will allow proper entry of the rectifier knurled surface, provide good rectifier-heat sink surface contact, and assure reliable rectifier operation. If the break is made too deep, thereby reducing contact area for heat transfer, reliability of operation will be impaired.

These devices can be mounted in a thin chassis by inserting the rectifier through an additional heat sink plate which is mounted in intimate contact with the upper side of the chassis. This provides additional contact area for the rectifier knurled edge, as well as additional heat sink capacity.



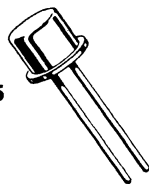
1N3675 thru 1N3703 (SILICON)



Recommended for applications requiring an exact replacement only.
For new designs and industry preferred replacement devices, see
1N4728 series.

1N3785 thru 1N3820

CASE 55



Low silhouette single-ended package for printed circuit or socket mounting. Cathode connected to case.

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to $+175^{\circ}\text{C}$.

D C Power Dissipation: 1.5 Watts at 25°C Ambient. (Derate 10 mW/ $^{\circ}\text{C}$).

The type numbers shown have a standard tolerance of $\pm 20\%$ on the zener voltage. Standard tolerances of $\pm 10\%$ and $\pm 5\%$ on individual units are also available and are indicated by suffixing "A" for $\pm 10\%$ and "B" for $\pm 5\%$ units to the standard type number.

ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}\text{C}$ unless otherwise noted)

$V_F = 1.5 \text{ V max @ } 300 \text{ mA}$

Type No.	Nominal Zener Voltage @ I_{ZT} (V_Z) Volts	Test Current (I_{ZT}) mA	Max Zener Impedance			Max DC Zener Current (I_{ZM}) mA	Reverse Leakage Current*			Typical Zener Voltage Temp. Coeff. %/°C
			$Z_{KT} @ I_{ZT}$ ohms	$Z_{ZK} @ I_{ZK}$ ohms	I_{ZK} mA		I_R Max (μA)	V_{R1}	V_{R2}	
1N3785	6.8	55	2.7	700	1.0	195	150	5.2	4.9	.040
1N3786	7.5	50	3.0	700	0.5	175	75	5.7	5.4	.045
1N3787	8.2	46	3.5	700	0.5	155	50	6.2	5.9	.048
1N3788	9.1	41	4.0	700	0.5	140	25	6.9	6.6	.051
1N3789	10	37	5	700	0.25	125	10	7.6	7.2	.055
1N3790	11	34	6	700	0.25	115	5	8.4	8.0	.060
1N3791	12	31	7	700	0.25	105	5	9.1	8.6	.065
1N3792	13	29	8	700	0.25	98	5	9.9	9.4	.065
1N3793	15	25	10	700	0.25	85	5	11.4	10.8	.070
1N3794	16	23	11	700	0.25	80	5	12.2	11.5	.070
1N3795	18	21	13	750	0.25	70	5	13.7	13.0	.075
1N3796	20	19	15	750	0.25	62	5	15.2	14.4	.075
1N3797	22	17	16	750	0.25	56	5	16.7	15.8	.080
1N3798	24	16	17	750	0.25	51	5	18.2	17.3	.080
1N3799	27	14	20	750	0.25	46	5	20.6	19.4	.085
1N3800	30	12	25	1,000	0.25	41	5	22.8	21.6	.085
1N3801	33	11	30	1,000	0.25	38	5	25.1	23.8	.085
1N3802	36	10	35	1,000	0.25	35	5	27.4	25.9	.085
1N3803	39	10	40	1,000	0.25	31	5	29.7	28.1	.090
1N3804	43	9.0	45	1,500	0.25	28	5	32.7	31.0	.090
1N3805	47	8.0	55	1,500	0.25	26	5	35.8	33.8	.090
1N3806	51	7.4	65	2,000	0.25	24	5	38.8	36.6	.090
1N3807	56	6.7	75	2,000	0.25	22	5	42.6	40.3	.090
1N3808	62	6.0	85	2,000	0.25	20	5	47.1	44.6	.090
1N3809	68	5.5	95	2,000	0.25	18	5	51.7	49.0	.090
1N3810	75	5.0	110	2,000	0.25	16	5	56.0	54.0	.090
1N3811	82	4.5	130	3,000	0.25	14	5	62.0	59.0	.090
1N3812	91	4.1	150	3,000	0.25	13	5	69.2	65.5	.090
1N3813	100	3.7	200	3,000	0.25	12.0	5	76.0	72.0	.090
1N3814	110	3.4	300	4,000	0.25	11.0	5	83.6	79.2	.095
1N3815	120	3.1	350	4,500	0.25	10.5	5	91.2	86.4	.095
1N3816	130	2.9	400	5,000	0.25	9.0	5	98.8	93.6	.095
1N3817	150	2.5	700	6,000	0.25	8.0	5	114.0	108.0	.095
1N3818	160	2.3	750	6,500	0.25	8.0	5	121.8	115.0	.095
1N3819	180	2.1	800	7,000	0.25	7.0	5	137.0	130.0	.095
1N3820	200	1.9	1,000	8,000	0.25	6.0	5	152.0	144.0	.100

SPECIAL SELECTIONS AVAILABLE INCLUDE: (See Selector Guide for details)

1 — Nominal zener voltages between those shown.

2 — Matched sets: (Standard Tolerances are $\pm 5.0\%$, $\pm 3.0\%$, $\pm 2.0\%$, $\pm 1.0\%$) depending on voltage per device.

a. Two or more units for series connection with specified tolerance on total voltage. Series matched sets make possible higher zener voltages and provide lower temperature coefficients, lower dynamic impedance and greater power handling ability.

b. Two or more units matched to one another with any specified tolerance.

3 — Tight voltage tolerances: 1.0%, 2.0%, 3.0%.

* V_{R1} — Test Voltage for 5% Tolerance Device. V_{R2} — Test Voltage for 10% Tolerance Device. No Leakage Specified as 20% Tolerance Device.

1N3821 thru 1N3830 (SILICON)

SERIES

(1M3.3AZ10 thru 1M7.5AZ10)

1N3016 thru 1N3051

SERIES

(1M6.8Z thru 1M200Z)

Designers Data Sheet

1.0 WATT METAL SILICON ZENER DIODES

... a complete series of 1.0 Watt Zener Diodes with limits and operating characteristics that reflect the superior capabilities of silicon-oxide-passivated junctions. All this in an axial-lead, metal package offering protection in all common environmental conditions.

- To 100 Watts Surge Rating @ 10 ms
- Maximum Limits Guaranteed on Five Electrical Parameters
- Power Capability to MIL-S-19500 Specifications

Designer's Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C (See Figure 1)	P_D	1.0 6.67	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	$^\circ\text{C}$
Lead Temperature 230°C at a distance not less than 1/16" from the case for 10 seconds.			

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed metal and glass.

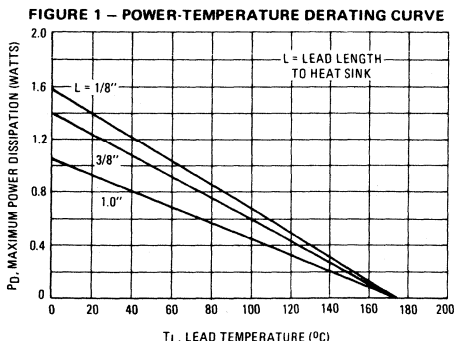
DIMENSIONS: See outline drawing.

FINISH: All external surfaces are corrosion-resistant and leads are readily solderable and weldable.

POLARITY: Cathode connected to the case. When operated in zener mode, cathode will be positive with respect to anode.

WEIGHT: 1.4 Grams (approx)

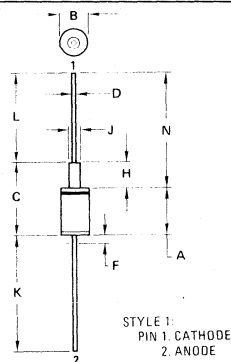
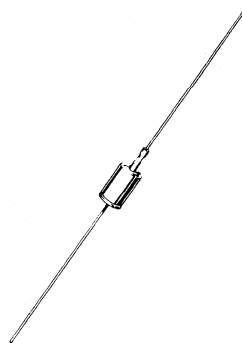
MOUNTING POSITION: Any



*Indicates JEDEC Registered Data.

1.0 WATT ZENER REGULATOR DIODES

3.3–200 VOLTS



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	7.44	9.07	0.293	0.357
B	5.46	5.97	0.215	0.235
C	14.48			0.570
D	0.64	0.89	0.025	0.035
E	4.78			0.188
F	1.14	2.54	0.045	0.100
G	25.40	41.28	1.000	1.625
H	25.40	41.28	1.000	1.625

All JEDEC dimensions and notes apply

CASE 52-03
DO-13

1N3821 thru 1N3830, 1N3016 thru 1N3051 (continued)

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

$V_F = 1.5\text{ V max}$ @ $I_F = 200\text{ mA}$ for all types

JEDEC Type No. (Flangless) (Note 1 & 2)	*Nominal Zener Voltage V_Z @ I_Z Volts (Note 3)	*Test Current I_Z mA	*Max Zener Impedance (Note 4)			Max Reverse Current (Note 5)			*Max DC Zener Current I_{ZM} mA (Note 6)
			Z_{ZT} @ I_Z Ohms	Z_{ZK} @ I_{ZK} Ohms	I_{ZK} mA	I_R Max (μA)	V_{R1} 5%	V_{R2} 10%	
1N3821	3.3	76	10	400	1.0	*100	*1.0	1.0	276
1N3822	3.6	69	10	400	1.0	*100	*1.0	1.0	252
1N3823	3.9	64	9.0	400	1.0	*50	*1.0	1.0	238
1N3824	4.3	58	9.0	400	1.0	*10	*1.0	1.0	213
1N3825	4.7	53	8.0	500	1.0	*10	*1.0	1.0	194
1N3826	5.1	49	7.0	550	1.0	*10	*1.0	1.0	178
1N3827	5.6	45	5.0	600	1.0	*10	*2.0	2.0	162
1N3828	6.2	41	2.0	700	1.0	*10	*3.0	3.0	146
1N3829	6.8	37	1.5	500	1.0	*10	*3.0	3.0	133
1N3830	7.5	34	1.5	250	1.0	*10	*3.0	3.0	121
1N3016	6.8	37	3.5	700	1.0	10	5.2	4.9	140
1N3017	7.5	34	4.0	700	0.5	10	5.7	5.4	125
1N3018	8.2	31	4.5	700	0.5	10	6.2	5.9	115
1N3019	9.1	28	5.0	700	0.5	7.5	6.9	6.6	105
1N3020	10	25	7.0	700	0.25	5.0	7.6	7.2	95
1N3021	11	23	8.0	700	0.25	5.0	8.4	8.0	85
1N3022	12	21	9.0	700	0.25	2.0	9.1	8.6	80
1N3023	13	19	10	700	0.25	1.0	9.9	9.4	74
1N3024	15	17	14	700	0.25	1.0	11.4	10.8	63
1N3025	16	15.5	16	700	0.25	1.0	12.2	11.5	60
1N3026	18	14	20	750	0.25	0.5	13.7	13.0	52
1N3027	20	12.5	22	750	0.25	0.5	15.2	14.4	47
1N3028	22	11.5	23	750	0.25	0.5	16.7	15.8	43
1N3029	24	10.5	25	750	0.25	0.5	18.2	17.3	40
1N3030	27	9.5	35	750	0.25	0.5	20.6	19.4	34
1N3031	30	8.5	40	1000	0.25	0.5	22.8	21.6	31
1N3032	33	7.5	45	1000	0.25	0.5	25.1	23.8	28
1N3033	36	7.0	50	1000	0.25	0.5	27.4	25.9	26
1N3034	39	6.5	60	1000	0.25	0.5	29.7	28.1	23
1N3035	43	6.0	70	1500	0.25	0.5	32.7	31.0	21
1N3036	47	5.5	80	1500	0.25	0.5	35.8	33.8	19
1N3037	51	5.0	95	1500	0.25	0.5	38.8	36.7	18
1N3038	56	4.5	110	2000	0.25	0.5	42.6	40.3	17
1N3039	62	4.0	125	2000	0.25	0.5	47.1	44.6	15
1N3040	68	3.7	150	2000	0.25	0.5	51.7	49.0	14
1N3041	75	3.3	175	2000	0.25	0.5	56.0	54.0	12
1N3042	82	3.0	200	3000	0.25	0.5	62.2	59.0	11
1N3043	91	2.8	250	3000	0.25	0.5	69.2	65.5	10
1N3044	100	2.5	350	3000	0.25	0.5	76.0	72.0	9.0
1N3045	110	2.3	450	4000	0.25	0.5	83.6	79.2	8.3
1N3046	120	2.0	550	4500	0.25	0.5	91.2	86.4	8.0
1N3047	130	1.9	700	5000	0.25	0.5	98.8	93.6	6.9
1N3048	150	1.7	1000	6000	0.25	0.5	114.0	108.0	5.7
1N3049	160	1.6	1100	6500	0.25	0.5	121.6	115.2	5.4
1N3050	180	1.4	1200	7000	0.25	0.5	136.8	129.6	4.9
1N3051	200	1.2	1500	8000	0.25	0.5	152.0	144.0	4.6

* JEDEC Registered Data on 1N3821 thru 1N3830 and 1N3016 thru 1N3051

NOTE 1 — TOLERANCE AND TYPE NUMBER DESIGNATION

1N3821 thru 1N3830 — The JEDEC type numbers shown have a standard tolerance for the nominal zener voltage of $\pm 10\%$. A standard tolerance of $\pm 5\%$ for individual units is also available and is indicated by adding suffix "A" to the standard type number.

1N3016 thru 1N3051 — The JEDEC type numbers shown have a standard tolerance of $\pm 20\%$ for the nominal zener voltage. Suffix "A" for $\pm 10\%$ units or "B" for $\pm 5\%$ units.

NOTE 2 — SPECIALS AVAILABLE INCLUDE:

(A) NOMINAL ZENER VOLTAGES BETWEEN THE VOLTAGES SHOWN AND TIGHTER VOLTAGE TOLERANCES: To designate units with zener voltages other than those assigned JEDEC numbers and/or tight voltage tolerances ($\pm 3\%$, $\pm 2\%$, $\pm 1\%$), the Motorola type number should be used.

Device Description — 1 — M — 5.1 — A — Z — 3 —
Motorola Nominal Voltage 1N3821 thru 1N3830 only Zener Diode Tolerance ($\pm\%$)

EXAMPLE 1M5.1AZ3

(B) MATCHED SETS: (Standard Tolerances are $\pm 5.0\%$, $\pm 2.0\%$, $\pm 1.0\%$).

Zener diodes are available in sets consisting of two or more matched devices. The method for specifying matched sets is similar to the one described in (A) except that two additional suffixes are added to the code number described.

These devices are marked with code letters to identify the matched sets and, in addition, each unit in a set is marked with the same serial number, which is different for each set ordered.

1 — Device Description
M — Motorola
5 — 51 Volts (each device)
1 — 1N3821 thru 1N3830 only
A — Tolerance per device $\pm 5\%$ (omit for $\pm 20\%$ units)
5 — B — Overall Tolerance of set ($\pm 1\%$)
1 — Code
A — Not used
B — Two devices in series
C — Three devices in series
D — Four devices in series

EXAMPLE 1M51Z5B1

(C) ZENER CLIPPERS: (Standard Tolerance $\pm 10\%$ and $\pm 5\%$).

Special clipper diodes with opposing Zener junctions built into the device are available by using the following nomenclature:

1	M	7.5	A	Z	Z	10
Device Description	Motorola	Nominal Voltage	1N3821 thru 1N3830 only	Zener Diodes	Clipper	Tolerance for each of the two Zener voltages (not a matching requirement)

Example: 1M7.5AZZ10

NOTE 3 – ZENER VOLTAGE (V_Z) MEASUREMENT

Motorola guarantees the zener voltage when measured at 90 seconds while maintaining the lead temperature (T_L) at $30^\circ\text{C} \pm 1^\circ\text{C}$, $3/8"$ from the diode body.

NOTE 4 – ZENER IMPEDANCE (Z_Z) DERIVATION

The zener impedance is derived from the 60 cycle ac voltage, which results when an ac current having an rms value equal to 10% of the dc zener current (I_{ZT} or I_{ZK}) is superimposed on I_{ZT} or I_{ZK} .

NOTE 5 – REVERSE LEAKAGE CURRENT (I_R)

Reverse leakage currents are guaranteed only for 5% and 10% zener diodes and are measured at V_R as shown in the Electrical Characteristics Table.

NOTE 6 – MAXIMUM ZENER CURRENT RATINGS (I_{ZM})

1N3821 thru 1N3830 – Maximum zener current ratings are based on maximum voltage of 10% tolerance units.

1N3016 thru 1N3051 – Maximum zener current ratings are based on maximum voltage of 5% tolerance units.

NOTE 7 – SURGE CURRENT (i_p)

Surge current is specified as the maximum allowable peak, non-recurrent square-wave current with a specified pulse width, PW. The data presented in Figures 8 and 9 may be used to find the maximum surge current for a square wave of any pulse width between 0.01 ms and 1000 ms.

APPLICATION NOTE

Since the actual voltage available from a given zener diode is temperature dependent, it is necessary to determine junction temperature under any set of operating conditions in order to calculate its value. The following procedure is recommended:

Lead Temperature, T_L , should be determined from:

$$T_L = \theta_{LA} P_D + T_A$$

θ_{LA} is the lead-to-ambient thermal resistance ($^\circ\text{C}/\text{W}$) and P_D is the power dissipation. The value for θ_{LA} will vary and depends on the device mounting method. θ_{LA} is generally $30\text{--}40^\circ\text{C}/\text{W}$ for the various clips and tie points in common use and for printed circuit board wiring.

The temperature of the lead can also be measured using a thermocouple placed on the lead as close as possible to the tie point. The thermal mass connected to the tie point is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady-state conditions are achieved. Using the measured value of T_L , the junction temperature may be determined by:

$$T_J = T_L + \Delta T_{JL}$$

ΔT_{JL} is the increase in junction temperature above the lead temperature and may be found from Figure 6 for a train of power pulses ($L = 3/8$ inch) or from Figure 7 for dc power.

$$\Delta T_{JL} = \theta_{JL} P_D$$

For worst-case design, using expected limits of I_Z , limits of P_D and the extremes of T_J (ΔT_J) may be estimated. Changes in voltage, V_Z , can then be found from:

$$\Delta V = \theta_{VZ} \Delta T_J$$

θ_{VZ} , the zener voltage temperature coefficient, is found from Figures 2 and 3.

Under high power-pulse operation, the zener voltage will vary with time and may also be affected significantly by the zener resistance. For best regulation, keep current excursions as low as possible.

Data of Figure 6 should not be used to compute surge capability. Surge limitations are given in Figure 8. They are lower than would be expected by considering only junction temperature, as current crowding effects cause temperatures to be extremely high in small spots resulting in device degradation should the limits of Figure 8 be exceeded.

TEMPERATURE COEFFICIENTS AND VOLTAGE REGULATION

(90% OF THE UNITS ARE IN THE RANGES INDICATED)

FIGURE 2 – TEMPERATURE COEFFICIENT-RANGE FOR UNITS TO 12 VOLTS

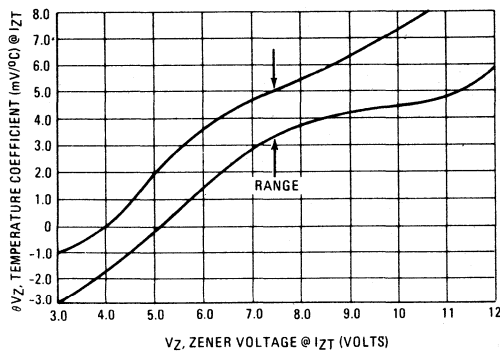


FIGURE 3 – TEMPERATURE COEFFICIENT-RANGE FOR UNITS 10 TO 220 VOLTS

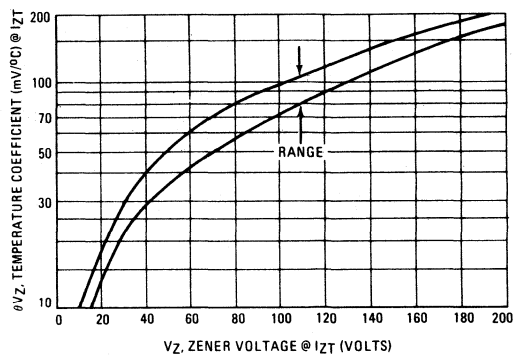


FIGURE 4 – TYPICAL VOLTAGE REGULATION

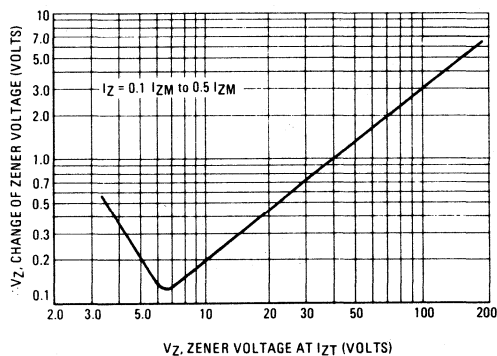


FIGURE 5 – MAXIMUM REVERSE LEAKAGE (95% OF THE UNITS ARE BELOW THE VALUES SHOWN)

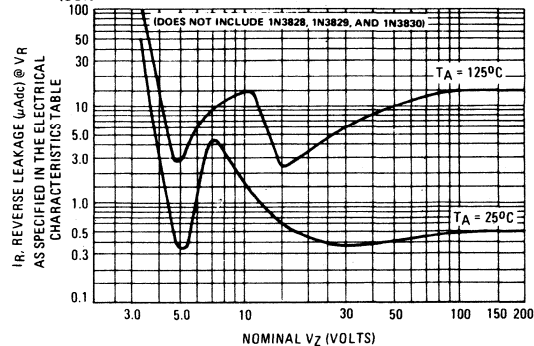


FIGURE 6 – TYPICAL THERMAL RESPONSE L, LEAD LENGTH = 3/8 INCH

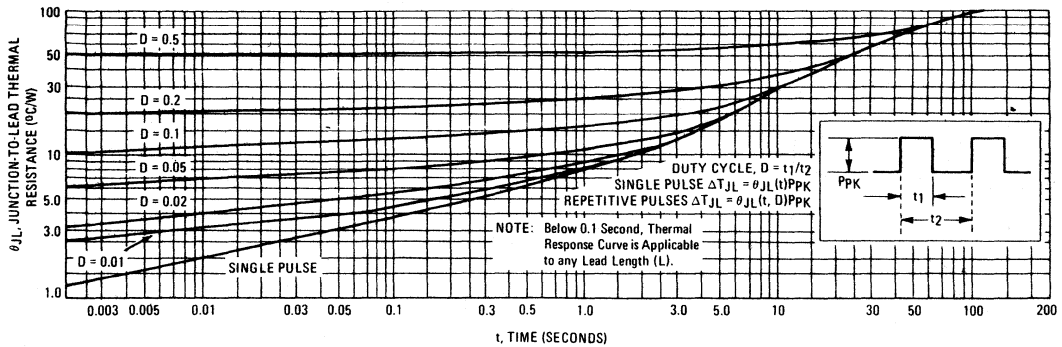


FIGURE 7 – TYPICAL THERMAL RESISTANCE

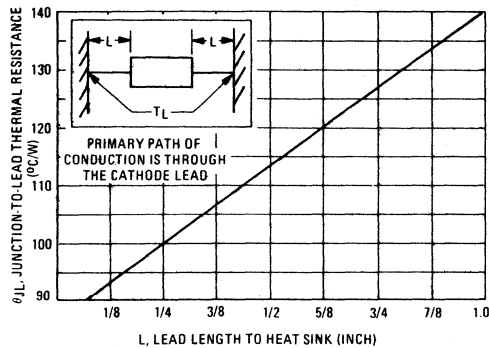


FIGURE 8 – MAXIMUM NON-REPETITIVE SURGE CURRENT

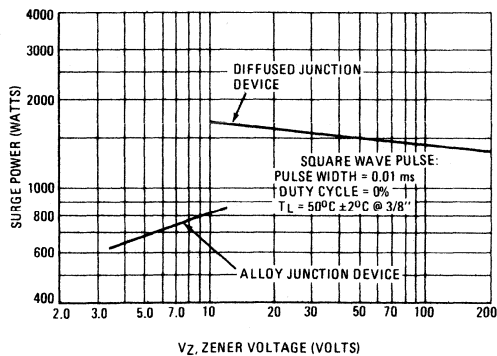


FIGURE 9 – SURGE POWER FACTOR

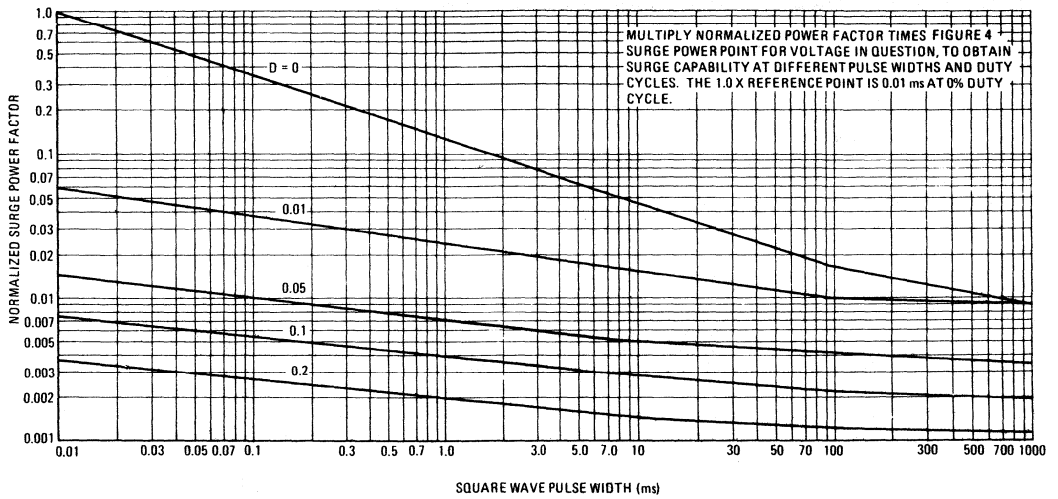
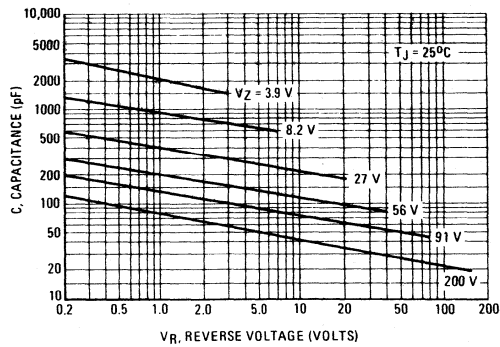


FIGURE 10 – TYPICAL CAPACITANCE



MR1366

Designers Data Sheet

STUD MOUNTED FAST RECOVERY POWER RECTIFIERS

... designed for special applications such as dc power supplies, inverters, converters, ultrasonic systems, choppers, low RF interference, sonar power supplies and free wheeling diodes. A complete line of fast recovery rectifiers having typical recovery time of 100 nanoseconds providing high efficiency at frequencies to 250 kHz.

Designer's Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

*MAXIMUM RATINGS

Rating	Symbol	1N3879	1N3880	1N3881	1N3882	1N3883	MR1366	Unit
Peak Repetitive Reverse Voltage	V_{RRM}	50	100	200	300	400	600	Volts
Working Peak Reverse Voltage	V_{RWM}							
DC Blocking Voltage	V_R							
Non-Repetitive Peak Reverse Voltage	V_{RSM}	75	150	250	350	450	650	Volts
RMS Reverse Voltage	$V_R(RMS)$	35	70	140	210	280	420	Volts
Average Rectified Forward Current (Single phase, resistive load, $T_C = 100^\circ C$)	I_O	← 6.0 →						Amps
Non-Repetitive Peak Surge Current (surge applied at rated load continuous)	I_{FSM}	← 150 (one cycle) →						Amps
Operating Junction Temperature Range	T_J	← -65 to +160 →						$^{\circ}C$
Storage Temperature Range	T_{stg}	← -65 to +175 →						$^{\circ}C$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	3.0	$^{\circ}\text{C/W}$

Motorola guarantees the listed value, although parts having higher values of thermal resistance will meet the current rating. Thermal resistance is not required by the JEDEC registration.

*ELECTRICAL CHARACTERISTICS

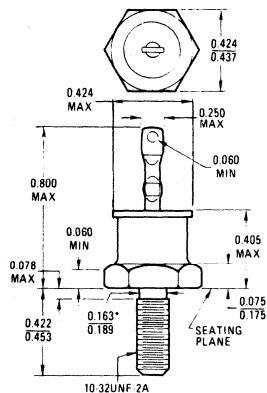
Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage ($I_F = 19 \text{ Amp}$, $T_J = 150^\circ\text{C}$)	V_F	—	1.2	1.5	Volts
Forward Voltage ($I_F = 6.0 \text{ Amp}$, $T_C = 25^\circ\text{C}$)	V_F	—	1.0	1.4	Volts
Reverse Current (rated dc voltage) $T_C = 25^\circ\text{C}$ $T_C = 100^\circ\text{C}$	I_R	—	10 0.5	15 1.0	μA mA

REVERSE RECOVERY CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Recovery Time *($I_{FM} = 1.0$ Amp to $V_R = 30$ Vdc, Figure 16) ($I_{FM} = 36$ Amp, $di/dt = 25$ A/ μ s, Figure 17)	t_{rr}	--	100 200	200 400	ns
Reverse Recovery Current *($I_F = 1.0$ Amp to $V_R = 30$ Vdc, Figure 16)	$I_{RM}(RE)$	--	--	2.0	Amp

* Indicates JEDEC Registered Data for 1N3879 Series.

**FAST RECOVERY
POWER RECTIFIERS
50-600 VOLTS
6 AMPERES**



*Dimension is a diameter
All JEDEC dimensions and notes apply

CASE 56B
DO-4

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

FINISH: All external surfaces corrosion resistant and readily solderable

POLARITY: Cathode to Case. Reverse Polarity available by adding Suffix "R" to type number.

WEIGHT: 5.6 Grams (approximately)

FIGURE 1 – FORWARD VOLTAGE

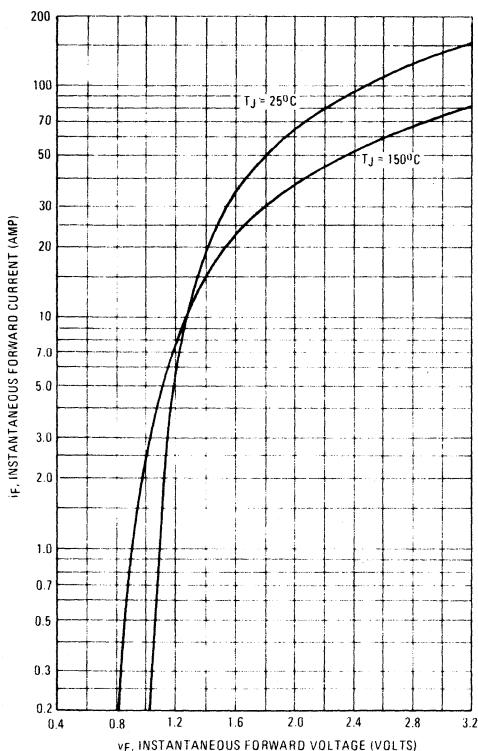
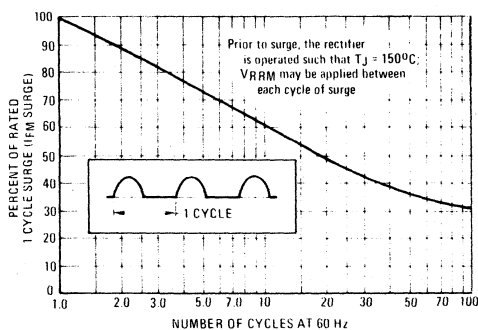


FIGURE 2 – MAXIMUM SURGE CAPABILITY



NOTE 1

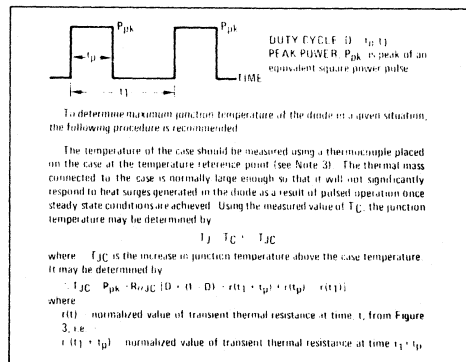
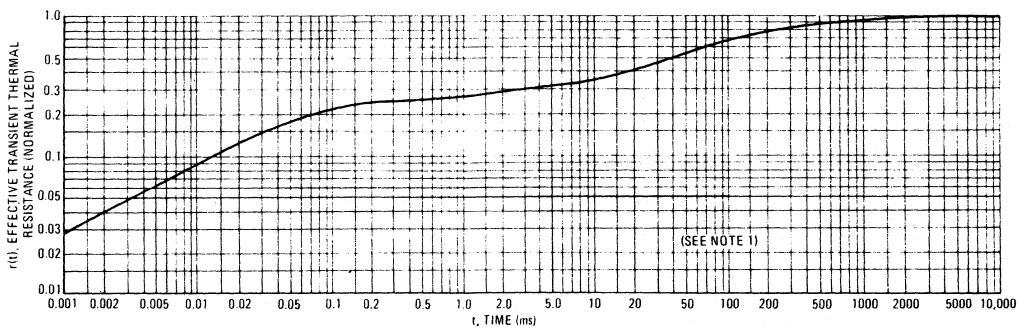
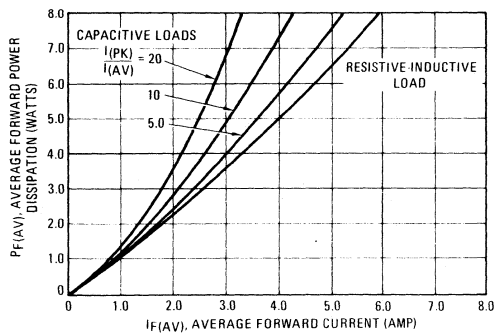


FIGURE 3 – THERMAL RESPONSE



SINE WAVE INPUT

FIGURE 4 – FORWARD POWER DISSIPATION



SQUARE WAVE INPUT

FIGURE 5 – FORWARD POWER DISSIPATION

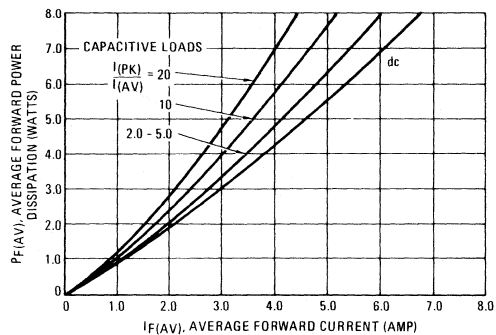


FIGURE 6 – CURRENT DERATING

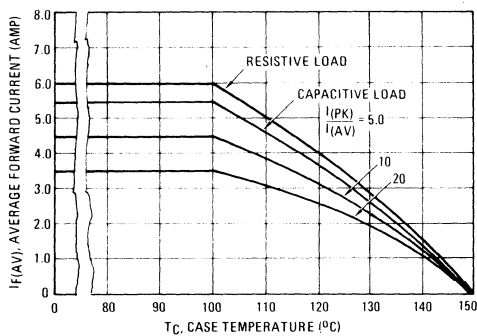


FIGURE 7 – CURRENT DERATING

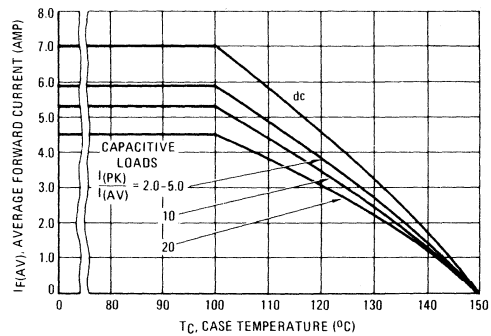


FIGURE 8 – TYPICAL REVERSE CURRENT

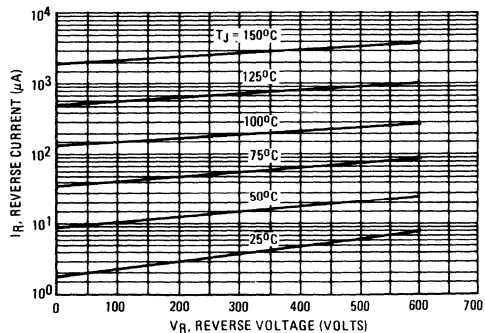
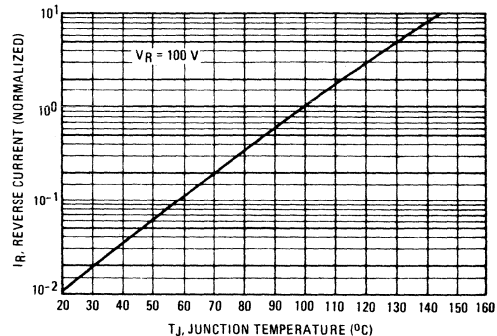


FIGURE 9 – NORMALIZED REVERSE CURRENT



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 10 – FORWARD RECOVERY TIME

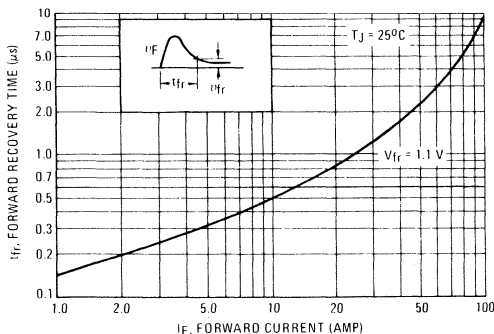
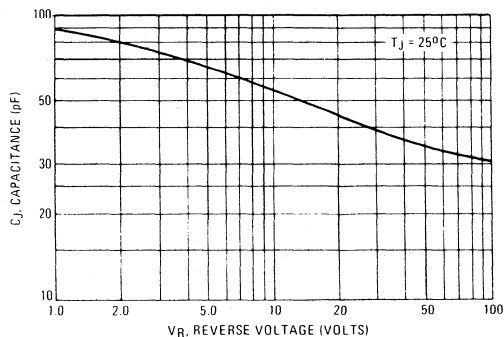


FIGURE 11 – JUNCTION CAPACITANCE



TYPICAL RECOVERED STORED CHARGE DATA

FIGURE 12 – $T_J = 25^\circ\text{C}$

(SEE NOTE 2)

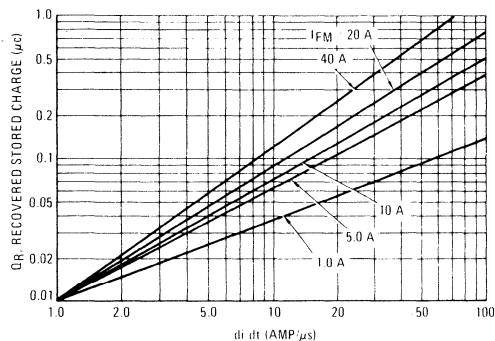
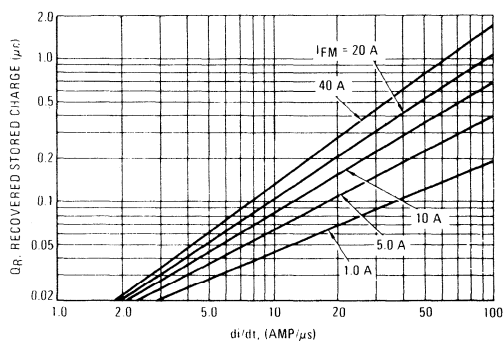
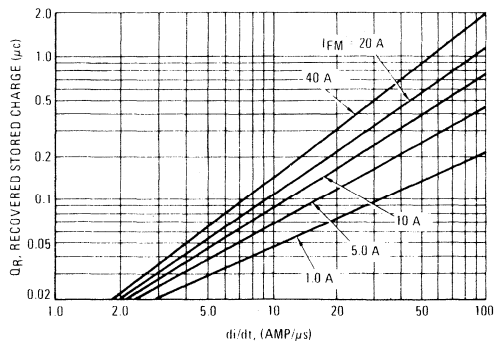
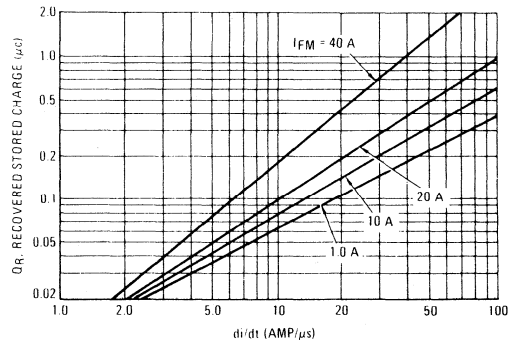

FIGURE 13 – $T_J = 75^\circ\text{C}$

FIGURE 14 – $T_J = 100^\circ\text{C}$

FIGURE 15 – $T_J = 150^\circ\text{C}$


FIGURE 16 – REVERSE RECOVERY CIRCUIT

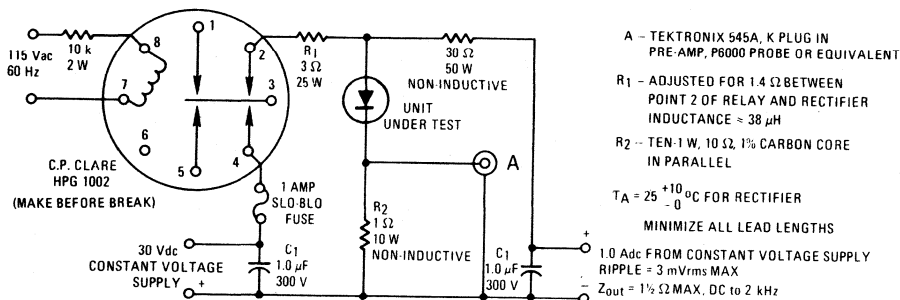
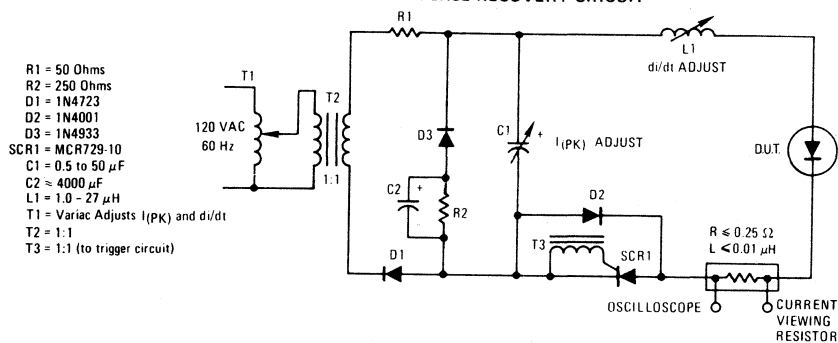


FIGURE 17 – JEDEC REVERSE RECOVERY CIRCUIT



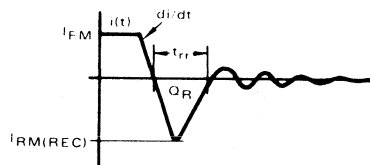
NOTE 2

Reverse recovery time is the period which elapses from the time that the current, thru a previously forward biased rectifier diode, passes thru zero going negatively until the reverse current recovers to a point which is less than 10% peak reverse current.

Reverse recovery time is a direct function of the forward current prior to the application of reverse voltage.

For any given rectifier, recovery time is very circuit dependent. Typical and maximum recovery time of all Motorola fast recovery power rectifiers are rated under a fixed set of conditions using $I_F = 1.0$ A, $V_R = 30$ V. In order to cover all circuit conditions, curves are given for typical recovered stored charge versus commutation di/dt for various levels of forward current and for junction temperatures of 25°C, 75°C, 100°C, and 150°C.

To use these curves, it is necessary to know the forward current level just before commutation, the circuit commutation di/dt , and the operating junction temperature. The reverse recovery test current waveform for all Motorola fast recovery rectifiers is shown.



From stored charge curves versus di/dt , recovery time (t_{rr}) and peak reverse recovery current ($I_{RM(REC)}$) can be closely approximated using the following formulas:

$$t_{rr} = 1.41 \times \left[\frac{Q_R}{di/dt} \right]^{1/2}$$

$$I_{RM(REC)} = 1.41 \times [Q_R \times di/dt]^{1/2}$$

1N3889 thru 1N3893

MR1376

Designers Data Sheet

STUD MOUNTED FAST RECOVERY POWER RECTIFIERS

... designed for special applications such as dc power supplies, inverters, converters, ultrasonic systems, choppers, low RF interference, sonar power supplies and free wheeling diodes. A complete line of fast recovery rectifiers having typical recovery time of 100 nanoseconds providing high efficiency at frequencies to 250 kHz.

Designer's Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

*MAXIMUM RATINGS

Rating	Symbol	1N3889	1N3890	1N3891	1N3892	1N3893	MR1376	Unit
Peak Repetitive Reverse Voltage	V _{RRM}	50	100	200	300	400	600	Volts
Working Peak Reverse Voltage	V _{RWM}							
DC Blocking Voltage	V _R							
Non-Repetitive Peak Reverse Voltage	V _{RSM}	75	150	250	350	450	650	Volts
RMS Reverse Voltage	V _{R(RMS)}	35	70	140	210	280	420	Volts
Average Rectified Forward Current (Single phase, resistive load, T _C = 100°C)	I _O	12						Amps
Non-Repetitive Peak Surge Current (Surge applied at rated load conditions)	I _{FSM}	200 (one cycle)						Amp
Operating Junction Temperature Range	T _J	-65 to +150						°C
Storage Temperature Range	T _{stg}	-65 to +175						°C

THERMAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit
Thermal Resistance, Junction to Case	R _{θJC}	2.0	°C/W

Motorola guarantees the listed value, although parts having higher values of thermal resistance will meet the current rating. Thermal resistance is not required by the JEDEC registration.

*ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage (I _F = 38 Amp, T _J = 150°C)	V _F	—	1.2	1.5	Volts
Forward Voltage (I _F = 12 Amp, T _C = 25°C)	V _F	—	1.0	1.4	Volts
Reverse Current (rated dc voltage) T _C = 25°C T _C = 100°C	I _R	—	10 0.5	25 3.0	μA mA

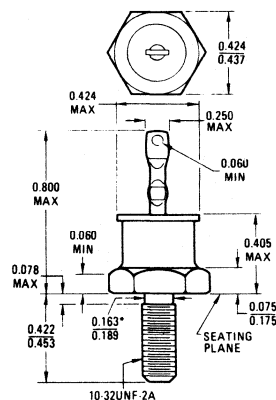
*REVERSE RECOVERY CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Recovery Time (I _F = 1.0 Amp to V _R = 30 Vdc, Figure 16) (I _{FM} = 38 Amp, di/dt = 25 A/μs, Figure 17)	t _{rr}	—	100 200	200 400	ns
Reverse Recovery Current (I _F = 1.0 Amp to V _R = 30 Vdc, Figure 16)	I _{RM(REC)}	—	—	2.0	Amp

*Indicates JEDEC Registered Data for 1N3889 Series.

FAST RECOVERY POWER RECTIFIERS

50-600 VOLTS
12 AMPERES



CASE 56B
DO-4

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

FINISH: All external surfaces corrosion resistant and readily solderable

POLARITY: Cathode to Case. Reverse Polarity available by adding Suffix "R" to type number.

WEIGHT: 5.6 grams (approximately)

FIGURE 1 – FORWARD VOLTAGE

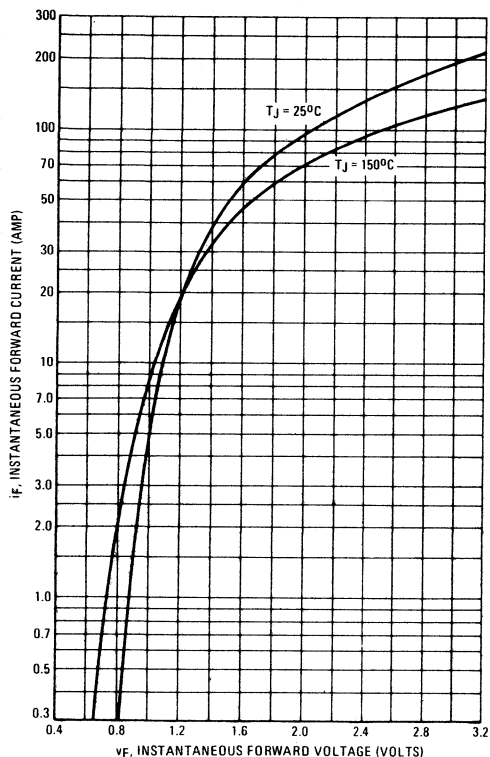
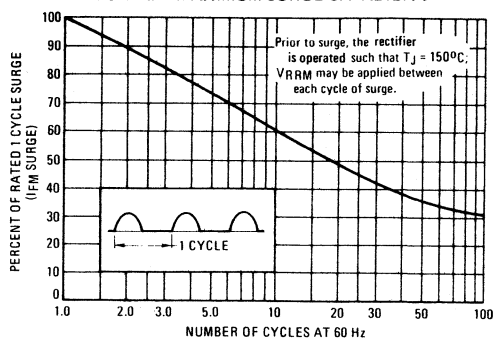
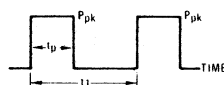


FIGURE 2 – MAXIMUM SURGE CAPABILITY



NOTE 1



DUTY CYCLE, $D = t_p / t_1$
PEAK POWER, P_{pk} , is peak of an equivalent square power pulse.

To determine maximum junction temperature of the diode in a given situation, the following procedure is recommended:

The temperature of the case should be measured using a thermocouple placed on the case at the temperature reference point (see Note 3). The thermal mass connected to the case is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady state conditions are achieved. Using the measured value of T_C , the junction temperature may be determined by:

$$T_J = T_C + \Delta T_{JC}$$

where ΔT_{JC} is the increase in junction temperature above the case temperature. It may be determined by:

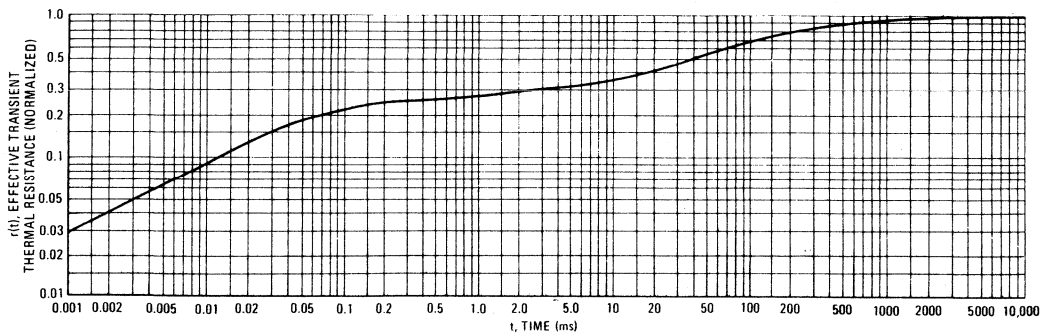
$$\Delta T_{JC} = P_{pk} \cdot R_{\theta JC} [D + (1 - D) \cdot r(t_1 + t_p) + r(t_p) \cdot r(t_1)]$$

where:

$r(t)$ = normalized value of transient thermal resistance at time, t , from Figure 3, i.e.,

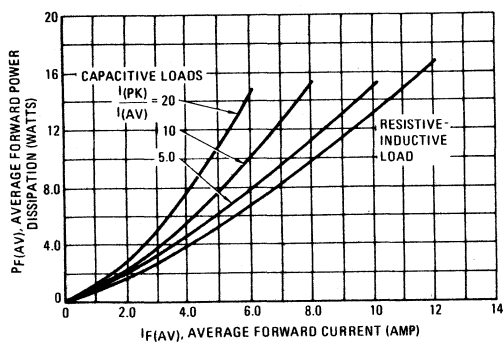
$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time $t_1 + t_p$

FIGURE 3 – THERMAL RESPONSE



SINE WAVE INPUT

FIGURE 4 – FORWARD POWER DISSIPATION



SQUARE WAVE INPUT

FIGURE 5 – FORWARD POWER DISSIPATION

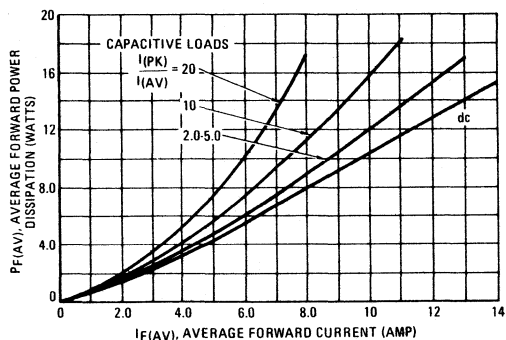


FIGURE 6 – CURRENT DERATING

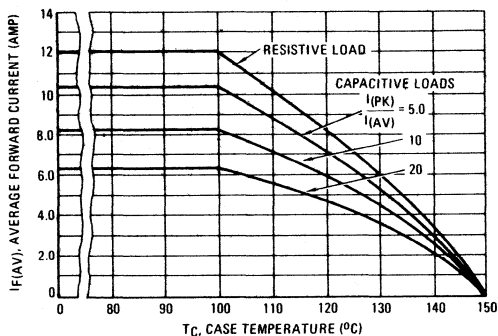


FIGURE 7 – CURRENT DERATING

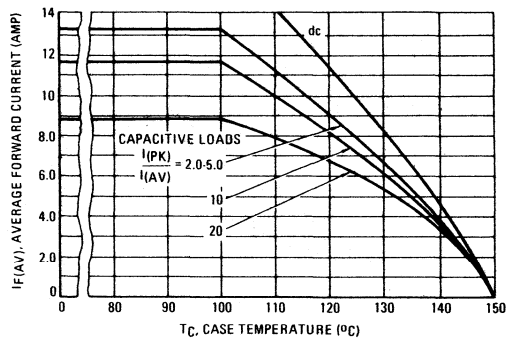


FIGURE 8 – TYPICAL REVERSE CURRENT

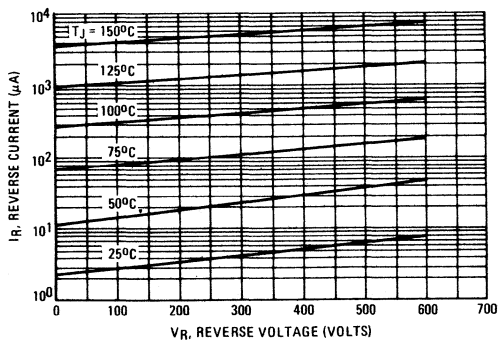
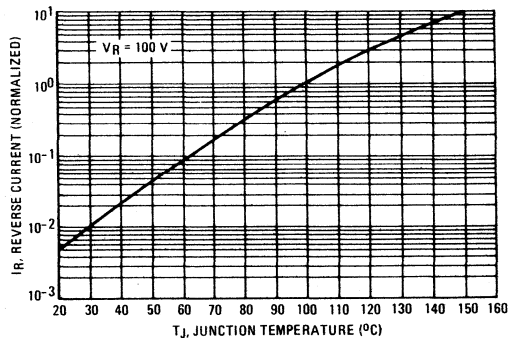


FIGURE 9 – NORMALIZED REVERSE CURRENT



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 10 – FORWARD RECOVERY TIME

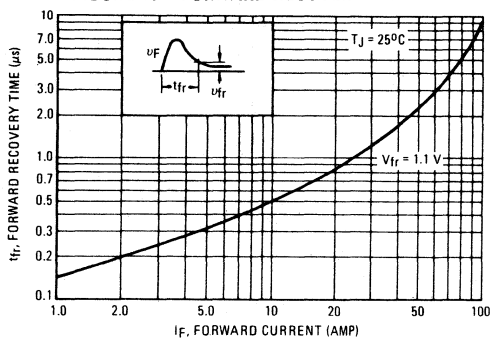
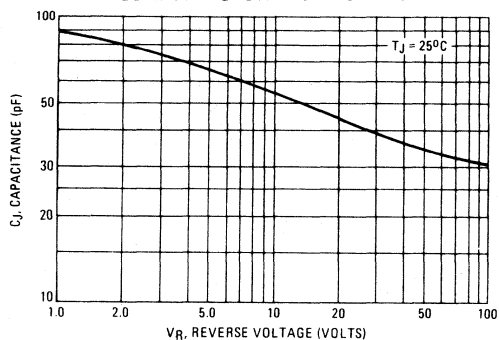


FIGURE 11 – JUNCTION CAPACITANCE



TYPICAL RECOVERED STORED CHARGE DATA

(See Note 2)

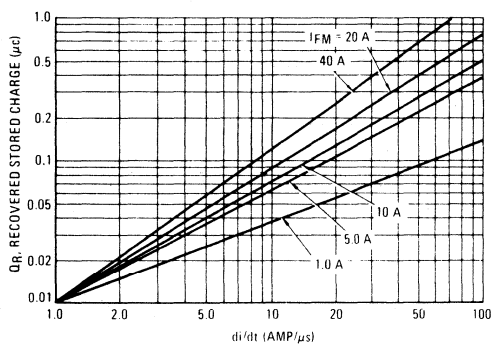
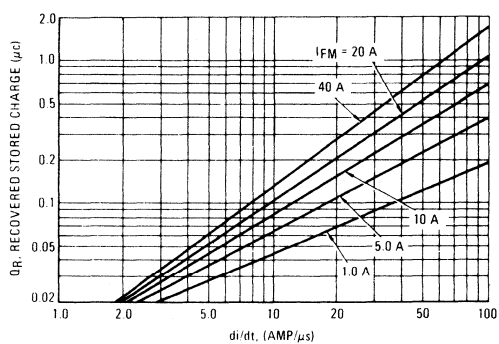
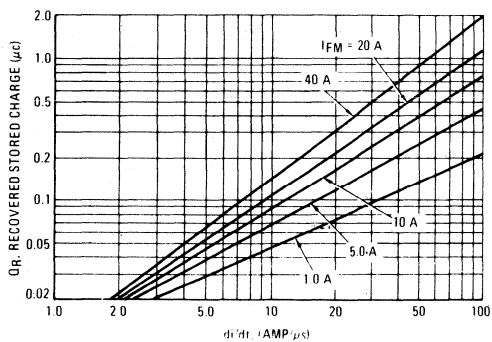
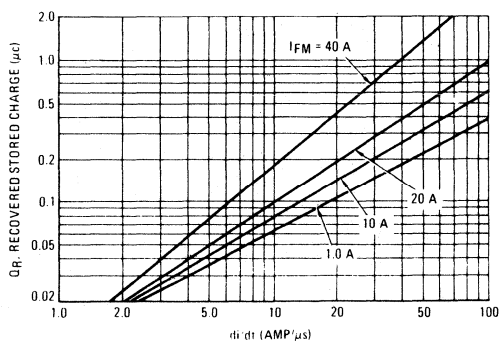
FIGURE 12 – $T_J = 25^\circ C$ FIGURE 13 – $T_J = 75^\circ C$ FIGURE 14 – $T_J = 100^\circ C$ FIGURE 15 – $T_J = 150^\circ C$ 

FIGURE 16 – REVERSE RECOVERY CIRCUIT

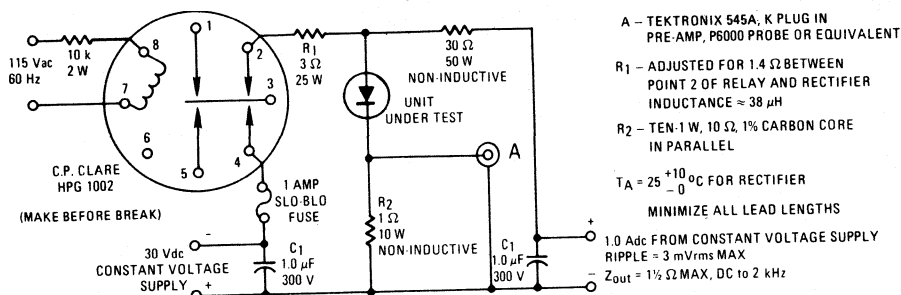
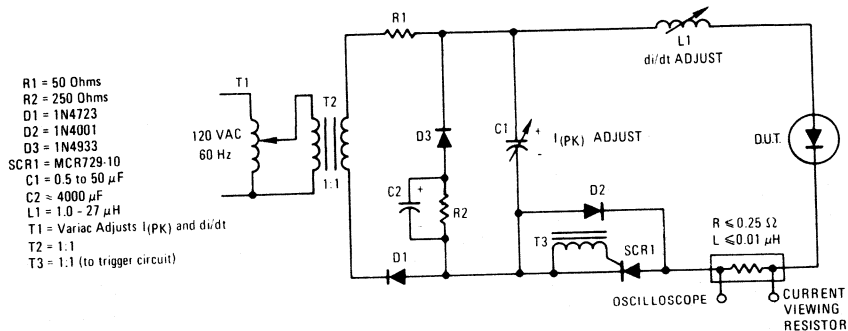


FIGURE 17 – JEDEC REVERSE RECOVERY CIRCUIT



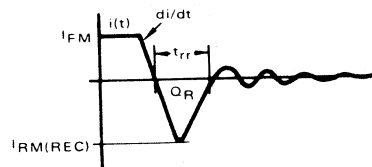
NOTE 2

Reverse recovery time is the period which elapses from the time that the current, thru a previously forward biased rectifier diode, passes thru zero going negatively until the reverse current recovers to a point which is less than 10% peak reverse current.

Reverse recovery time is a direct function of the forward current prior to the application of reverse voltage.

For any given rectifier, recovery time is very circuit dependent. Typical and maximum recovery time of all Motorola fast recovery power rectifiers are rated under a fixed set of conditions using $I_F = 1.0 \text{ A}$, $V_R = 30 \text{ V}$. In order to cover all circuit conditions, curves are given for typical recovered stored charge versus commutation di/dt for various levels of forward current and for junction temperatures of 25°C , 75°C , 100°C , and 150°C .

To use these curves, it is necessary to know the forward current level just before commutation, the circuit commutation di/dt , and the operating junction temperature. The reverse recovery test current waveform for all Motorola fast recovery rectifiers is shown.



From stored charge curves versus di/dt , recovery time (t_{rr}) and peak reverse recovery current ($I_{RM(REC)}$) can be closely approximated using the following formulas:

$$t_{rr} = 1.41 \times \left[\frac{Q_R}{di/dt} \right]^{1/2}$$

$$I_{RM(REC)} = 1.41 \times [Q_R \times di/dt]^{1/2}$$

1N3899 thru 1N3903

MR1386

Designers Data Sheet

STUD MOUNTED FAST RECOVERY POWER RECTIFIERS

... designed for special applications such as dc power supplies, inverters, converters, ultrasonic systems, choppers, low RF interference, sonar power supplies and free wheeling diodes. A complete line of fast recovery rectifiers having typical recovery time of 100 nanoseconds providing high efficiency at frequencies to 250 kHz.

Designers Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

*MAXIMUM RATINGS

Rating	Symbol	1N3899	1N3900	1N3901	1N3902	1N3903	MR1386	Unit
Peak Repetitive Reverse Voltage	V_{RRM}	50	100	200	300	400	600	Volts
Working Peak Reverse Voltage	V_{RWM}							
DC Blocking Voltage	V_R							
Non-Repetitive Peak Reverse Voltage	V_{RSM}	75	150	250	350	450	650	Volts
RMS Reverse Voltage	$V_R(RMS)$	35	70	140	210	280	420	Volts
Average Rectified Forward Current (Single phase, resistive load, $T_C = 100^\circ C$)	I_O	20						Amps
Non-Repetitive Peak Surge Current (surge applied at rated load conditions)	I_{FSM}	250 (one cycle)						Amps
Operating Junction Temperature Range	T_J	-65 to +150						$^\circ C$
Storage Temperature Range	T_{stg}	-65 to +175						$^\circ C$

*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.8	$^\circ C/W$

*ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage ($I_F = 63$ Amp, $T_J = 150^\circ C$)	V_F	—	1.2	1.5	Volts
Forward Voltage ($I_F = 20$ Amp, $T_C = 25^\circ C$)	V_F	—	1.1	1.4	Volts
Reverse Current (rated dc voltage) $T_C = 25^\circ C$	I_R	—	10	50	μA
$T_C = 100^\circ C$		—	0.5	6.0	mA

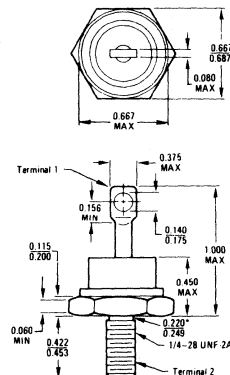
*REVERSE RECOVERY CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Recovery Time ($I_F = 1.0$ Amp to $V_R = 30$ Vdc, Figure 16)	t_{rr}	—	100	200	ns
($I_{FM} = 38$ Amp, $di/dt = 25$ A/ μs , Figure 17)		—	200	400	
Reverse Recovery Current ($I_F = 1.0$ Amp to $V_R = 30$ Vdc, Figure 16)	$I_{RM}(REC)$	—	—	3.0	Amp

*Indicates JEDEC Registered Data for 1N3899 Series.

FAST RECOVERY POWER RECTIFIERS

50-600 VOLTS
20 AMPERES



*Dimension is a diameter.
All JEDEC dimensions and notes apply

CASE 257
DO-5

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

FINISH: All external surfaces corrosion resistant and readily solderable

POLARITY: Cathode to Case. Reverse Polarity available by adding Suffix "R" to type number.

WEIGHT: 17 Grams (Approximately)

FIGURE 1 – FORWARD VOLTAGE

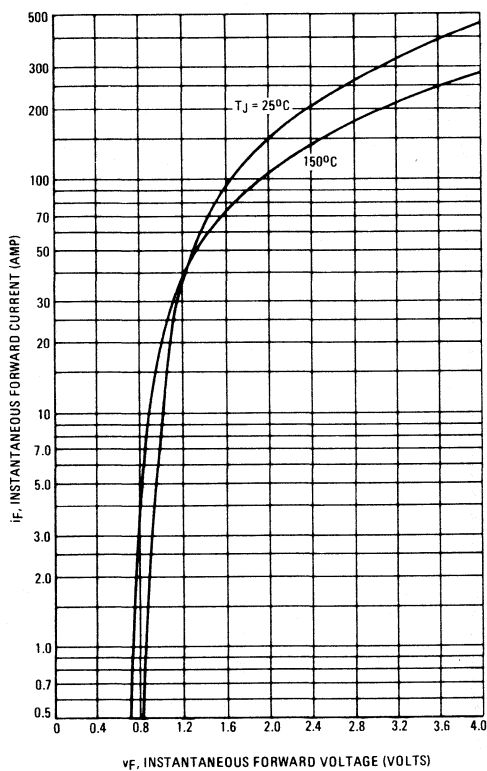
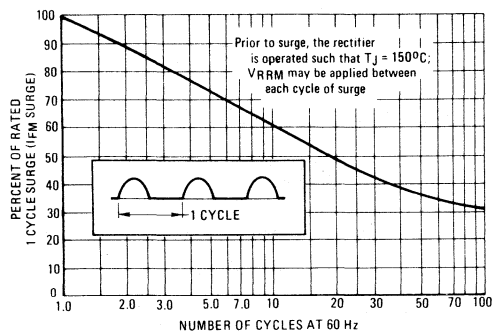


FIGURE 2 – MAXIMUM SURGE CAPABILITY



NOTE 1

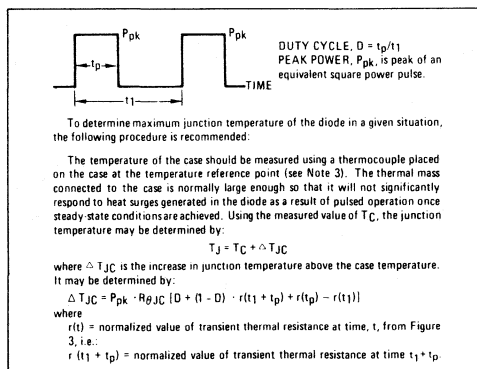
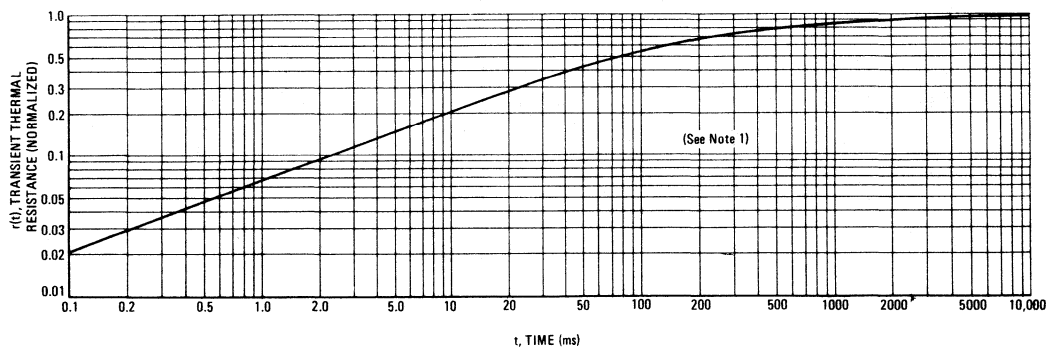
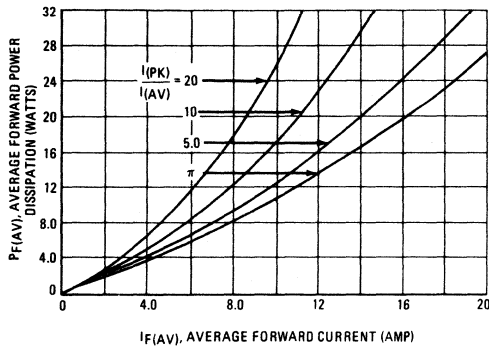


FIGURE 3 – THERMAL RESPONSE



SINE WAVE INPUT

FIGURE 4 – FORWARD POWER DISSIPATION



SQUARE WAVE INPUT

FIGURE 5 – FORWARD POWER DISSIPATION

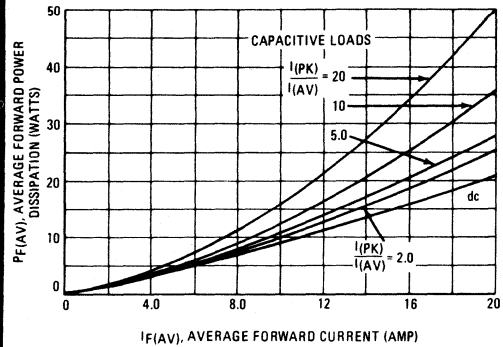


FIGURE 6 – CURRENT DERATING

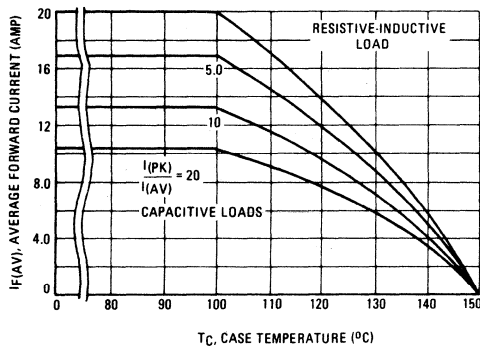


FIGURE 7 – CURRENT DERATING

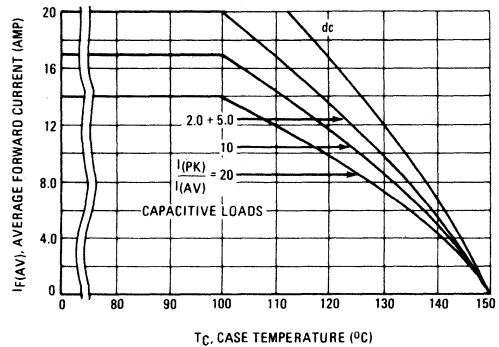


FIGURE 8 – TYPICAL REVERSE CURRENT

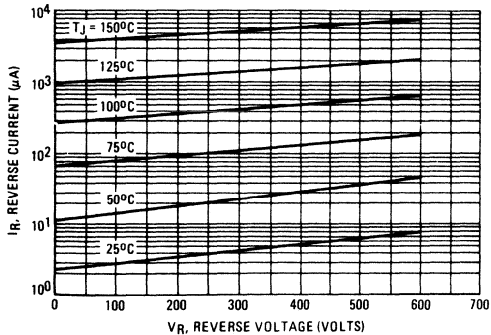
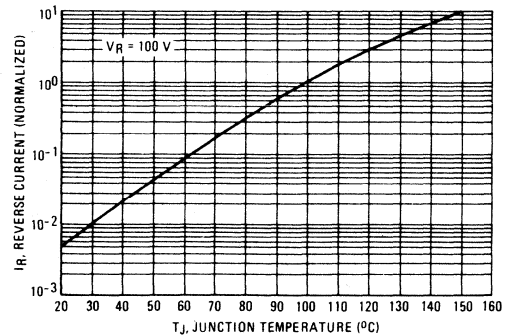


FIGURE 9 – NORMALIZED REVERSE CURRENT



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 10 – FORWARD RECOVERY TIME

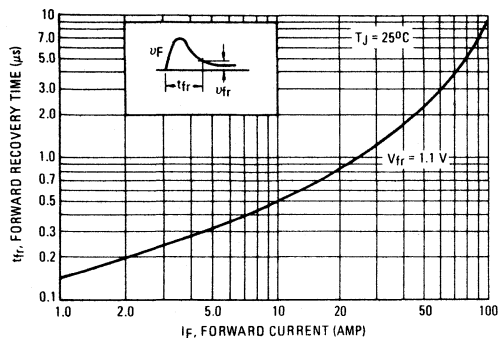
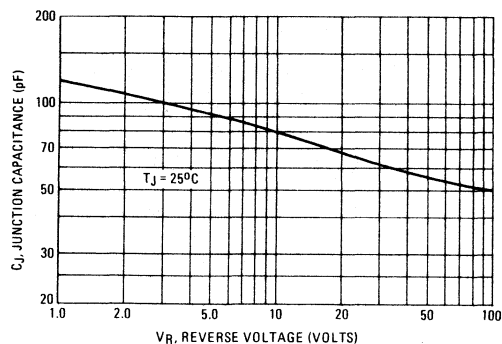
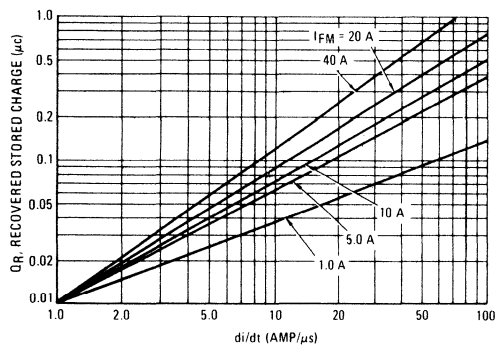
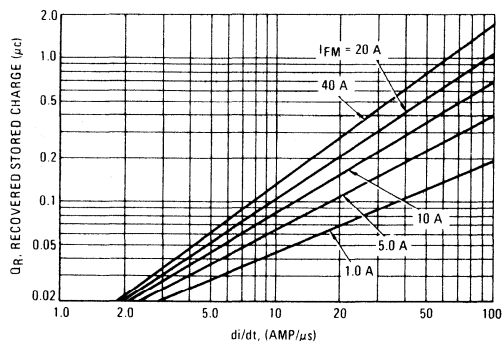


FIGURE 11 – JUNCTION CAPACITANCE

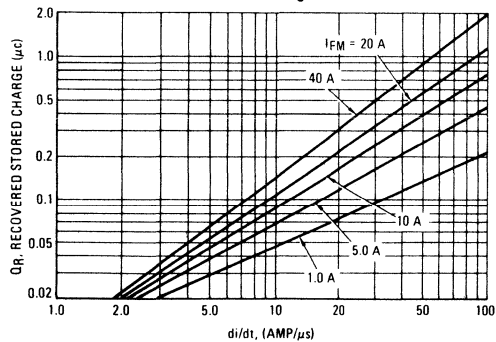
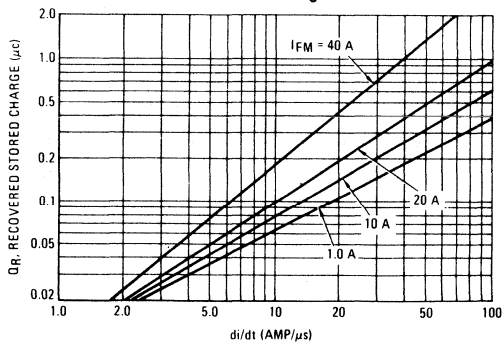


TYPICAL RECOVERED STORED CHARGE DATA

(See Note 2)

FIGURE 12 – $T_J = 25^\circ C$ FIGURE 13 – $T_J = 75^\circ C$ 

STORED CHARGE DATA

FIGURE 14 – $T_J = 100^\circ C$ FIGURE 15 – $T_J = 150^\circ C$ 

1N3909 thru 1N3913 MR1396

Designers Data Sheet

STUD MOUNTED FAST RECOVERY POWER RECTIFIERS

... designed for special applications such as dc power supplies, inverters, converters, ultrasonic systems, choppers, low RF interference, sonar power supplies and free wheeling diodes. A complete line of fast recovery rectifiers having typical recovery time of 100 nanoseconds providing high efficiency at frequencies to 250 kHz.

Designer's Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

*MAXIMUM RATINGS

Rating	Symbol	1N3909	1N3910	1N3911	1N3912	1N3913	MR1396	Unit
Peak Repetitive Reverse Voltage	V_{RRM}	50	100	200	300	400	600	Volts
Working Peak Reverse Voltage	V_{RWM}							
DC Blocking Voltage	V_R							
Non-Repetitive Peak Reverse Voltage	V_{RSM}	75	150	250	350	450	650	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	210	280	420	Volts
Average Rectified Forward Current (Single phase, resistive load, $T_C = 100^\circ\text{C}$)	I_O	30						Amps
Non-Repetitive Peak Surge Current (surge applied at rated load conditions)	I_{FSM}	300						Amp
Operating Junction Temperature Range	T_J	-65 to +150						$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +175						$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.2	$^\circ\text{C/W}$

*ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage ($I_F = 93 \text{ Amp}$, $T_J = 150^\circ\text{C}$)	V_F	—	1.2	1.5	Volts
Forward Voltage ($I_F = 30 \text{ Amp}$, $T_C = 25^\circ\text{C}$)	V_F	—	1.1	1.4	Volts
Reverse Current (rated dc voltage) $T_C = 25^\circ\text{C}$	I_R	—	10	80	μA
$T_C = 100^\circ\text{C}$		—	0.5	10	mA

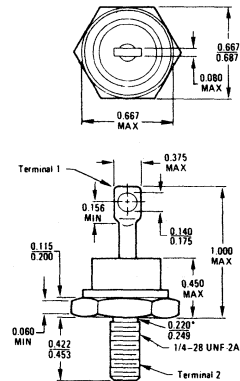
*REVERSE RECOVERY CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Recovery Time ($I_F = 1.0 \text{ Amp}$ to $V_R = 30 \text{ Vdc}$, Figure 16) ($I_{FM} = 36 \text{ Amp}$, $di/dt = 25 \text{ A}/\mu\text{s}$, Figure 17)	t_{rr}	—	100	200	ns
Reverse Recovery Current ($I_F = 1.0 \text{ Amp}$ to $V_R = 30 \text{ Vdc}$, Figure 16)	$I_{RM(REC)}$	—	1.5	3.0	Amp

*Indicates JEDEC Registered Data for 1N3909 Series.

FAST RECOVERY POWER RECTIFIERS

50-600 VOLTS
30 AMPERES



*Dimension is a diameter.
All JEDEC dimensions and notes apply

CASE 257
DO-5

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

FINISH: All external surfaces corrosion resistant and readily solderable

POLARITY: Cathode to Case. Reverse Polarity type available by adding Suffix "R" to type number.

WEIGHT: 17 Grams (Approximately)

FIGURE 1 — FORWARD VOLTAGE

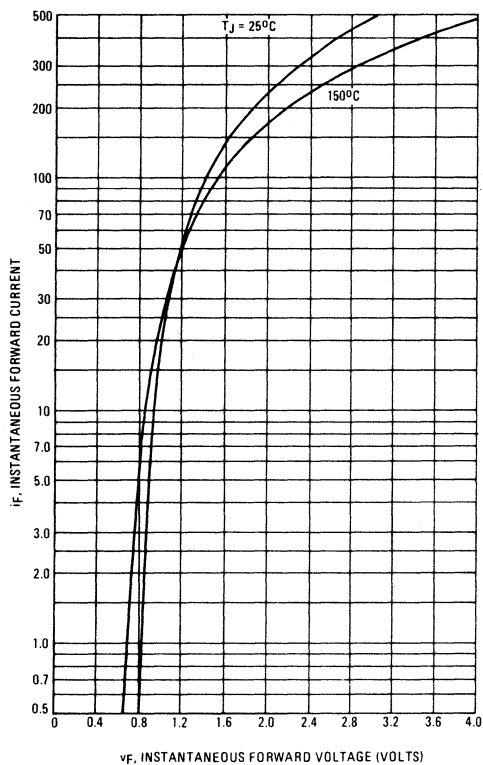
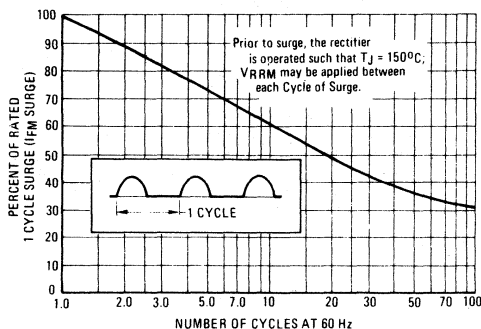
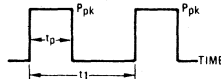


FIGURE 2 — MAXIMUM SURGE CAPABILITY



NOTE 1



DUTY CYCLE, $D = t_p/t_1$
PEAK POWER, P_{pk} , is peak of an equivalent square power pulse.

To determine maximum junction temperature of the diode in a given situation, the following procedure is recommended:

The temperature of the case should be measured using a thermocouple placed on the case at the temperature reference point (see Note 3). The thermal mass connected to the case is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady state conditions are achieved. Using the measured value of T_C , the junction temperature may be determined by:

$$T_J = T_C + \Delta T_{JC}$$

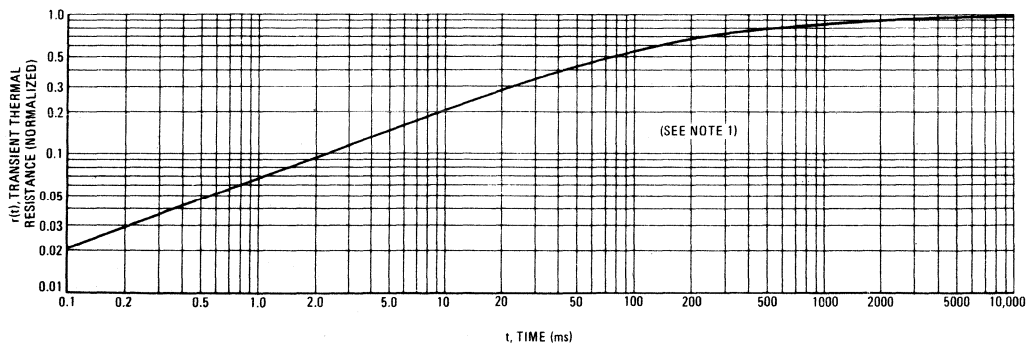
where T_{JC} is the increase in junction temperature above the case temperature. It may be determined by:

$$\Delta T_{JC} = P_{pk} \cdot R_{\theta JC} [D + (1 - D) \cdot r(t_1 + t_p) + r(t_1) - r(t_1)]$$

where

$r(t)$ = normalized value of transient thermal resistance at time, t , from Figure 3, i.e.,
 $r(t_1 + t_p)$ = normalized value of transient thermal resistance at time $t_1 + t_p$.

FIGURE 3 — THERMAL RESPONSE



SINE WAVE INPUT

FIGURE 4 – FORWARD POWER DISSIPATION

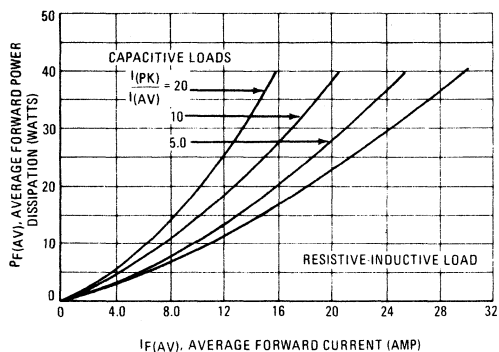


FIGURE 6 – CURRENT DERATING

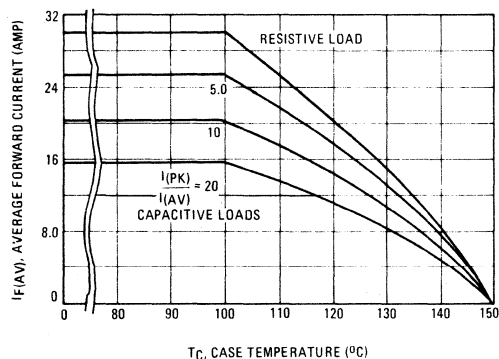
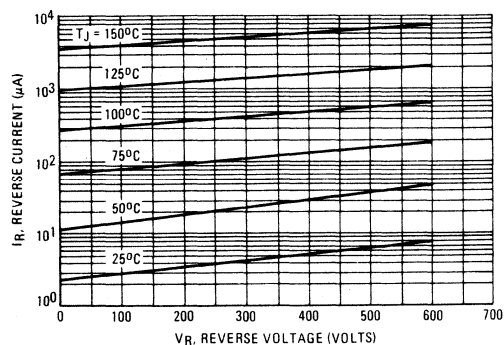


FIGURE 8 – TYPICAL REVERSE CURRENT



SQUARE WAVE INPUT

FIGURE 5 – FORWARD POWER DISSIPATION

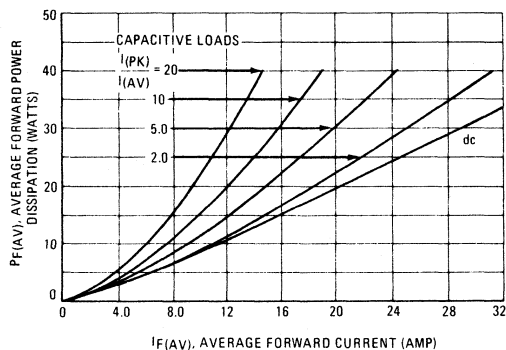


FIGURE 7 – CURRENT DERATING

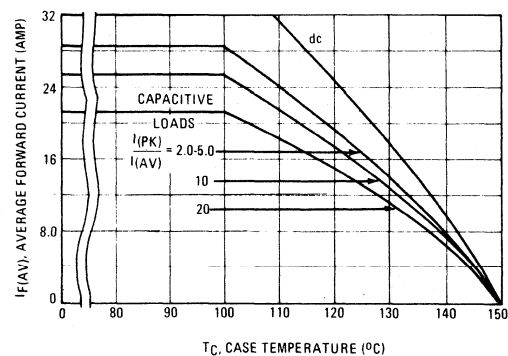
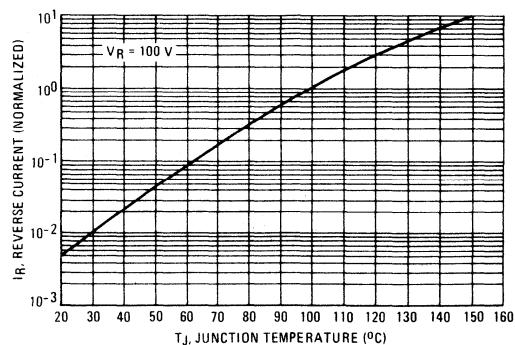


FIGURE 9 – NORMALIZED REVERSE CURRENT



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 10 – FORWARD RECOVERY TIME

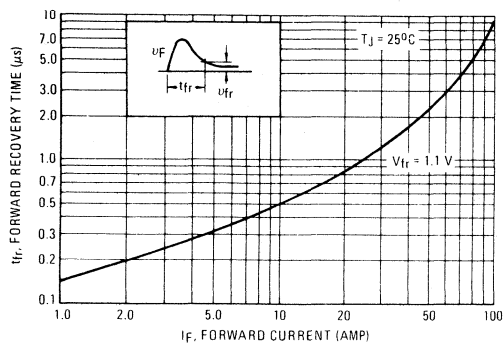
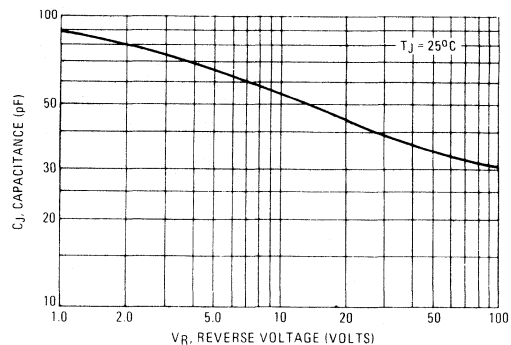


FIGURE 11 – JUNCTION CAPACITANCE



TYPICAL RECOVERED STORED CHARGE DATA

(See Note 2)

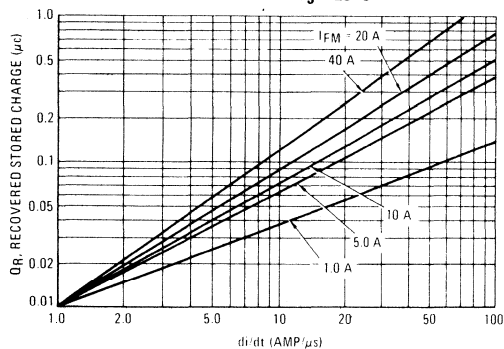
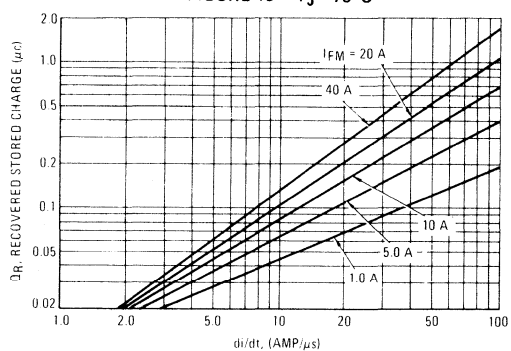
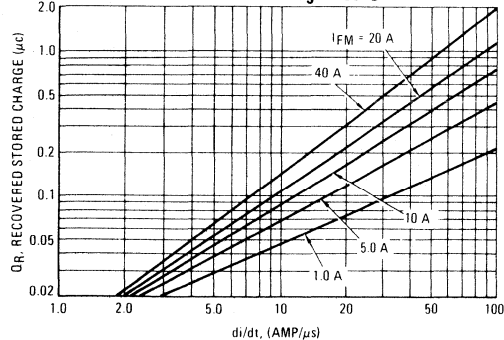
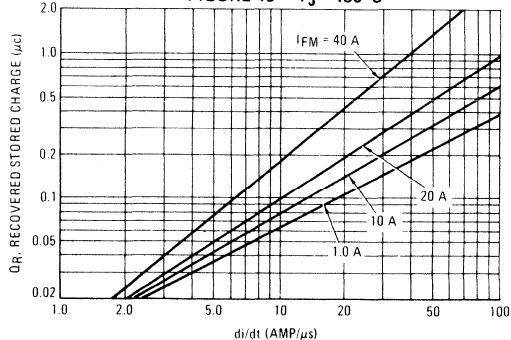
FIGURE 12 – $T_J = 25^\circ C$ FIGURE 13 – $T_J = 75^\circ C$ FIGURE 14 – $T_J = 100^\circ C$ FIGURE 15 – $T_J = 150^\circ C$ 

FIGURE 16 – REVERSE RECOVERY CIRCUIT

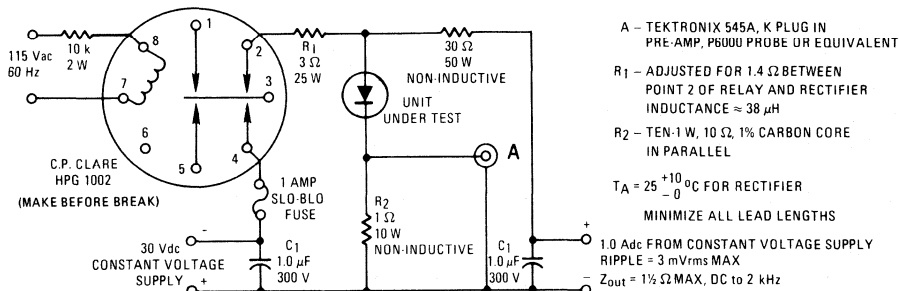
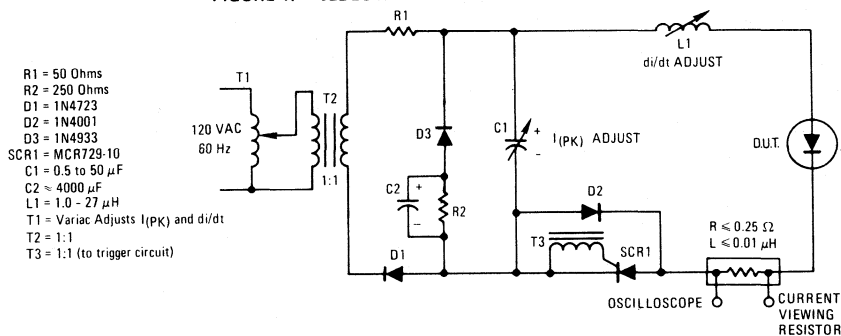


FIGURE 17 – JEDEC REVERSE RECOVERY CIRCUIT



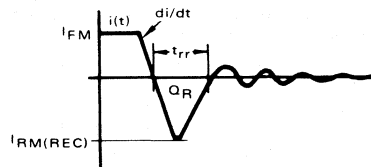
NOTE 2

Reverse recovery time is the period which elapses from the time that the current, thru a previously forward biased rectifier diode, passes thru zero going negatively until the reverse current recovers to a point which is less than 10% peak reverse current.

Reverse recovery time is a direct function of the forward current prior to the application of reverse voltage.

For any given rectifier, recovery time is very circuit dependent. Typical and maximum recovery time of all Motorola fast recovery power rectifiers are rated under a fixed set of conditions using $I_F = 1.0 \text{ A}$, $V_R = 30 \text{ V}$. In order to cover all circuit conditions, curves are given for typical recovered stored charge versus commutation di/dt for various levels of forward current and for junction temperatures of 25°C , 75°C , 100°C , and 150°C .

To use these curves, it is necessary to know the forward current level just before commutation, the circuit commutation di/dt , and the operating junction temperature. The reverse recovery test current waveform for all Motorola fast recovery rectifiers is shown.



From stored charge curves versus di/dt , recovery time (t_{rr}) and peak reverse recovery current ($I_{RM}(REC)$) can be closely approximated using the following formulas:

$$t_{rr} = 1.41 \times \left[\frac{Q_R}{di/dt} \right]^{1/2}$$

$$I_{RM(REC)} = 1.41 \times [Q_R \times di/dt]^{1/2}$$

1N3993 thru 1N4000 (ZENER DIODES)



CASE 56
(DO-4)



Low-voltage, alloy-junction zener diodes in hermetically sealed package with cathode connected to case. Supplied with mounting hardware.

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to $+175^{\circ}\text{C}$.

D C Power Dissipation: 10 Watts. (Derate 83.3 mW/ $^{\circ}\text{C}$ above 55°C).

The type numbers shown in the table have a standard tolerance on the nominal zener voltage of $\pm 10\%$. A standard tolerance of $\pm 5\%$ on individual units is also available and is indicated by suffixing "A" to the standard type number.

ELECTRICAL CHARACTERISTICS

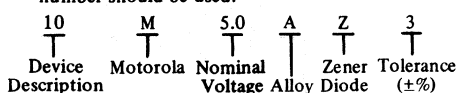
($T_j = 30^{\circ}\text{C} \pm 3$, $V_f = 1.5$ max @ $I_f = 2$ amp for all units)

Type No.	Nominal Zener Voltage V_z @ I_z , Volts	Test Current I_z , mA	Max Zener Impedance		Max DC Zener Current $I_{z\text{max}}$, mA	Reverse Leakage Current	
			Z_{zk} @ I_{zk} , Ohms	Z_{zk} @ $I_{zk} = 1.0$ mA, Ohms		$I_{r\text{max}}$, μA	V_r , Volts
1N3993	3.9	640	2.0	400	2380	100	0.5
1N3994	4.3	580	1.5	400	2130	100	0.5
1N3995	4.7	530	1.2	500	1940	50	1.0
1N3996	5.1	490	1.1	550	1780	10	1.0
1N3997	5.6	445	1.0	600	1620	10	1.0
1N3998	6.2	405	1.1	750	1460	10	2.0
1N3999	6.8	370	1.2	500	1330	10	2.0
1N4000	7.5	335	1.3	250	1210	10	3.0

SPECIAL SELECTIONS AVAILABLE INCLUDE: (See Selector Guide for details)

(A) NOMINAL ZENER VOLTAGES BETWEEN THE VOLTAGES SHOWN AND TIGHTER VOLTAGE TOLERANCES:

To designate units with zener voltages other than those assigned JEDEC numbers and/or tight voltage tolerances ($\pm 3\%$, $\pm 2\%$, $\pm 1\%$), the Motorola type number should be used.

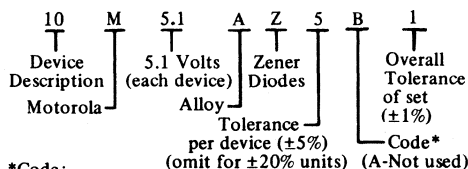


Example: 10M5.0AZ3

(B) MATCHED SETS: (Standard Tolerances are $\pm 5.0\%$, $\pm 2.0\%$, $\pm 1.0\%$).

Zener diodes can be obtained in sets consisting of two or more matched devices. The method for specifying such matched sets is similar to the one described in (A) for specifying units with a special voltage and/or tolerance except that two extra suffixes are added to the code number described.

These units are marked with code letters to identify the matched sets and, in addition, each unit in a set is marked with the same serial number, which is different for each set being ordered.



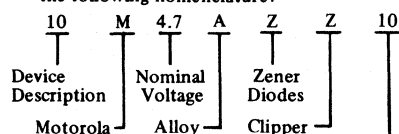
*Code:

- B - Two devices in series
- C - Three devices in series
- D - Four devices in series

Example: 10M5.1AZ5B1

(C) ZENER CLIPPERS: (Standard Tolerance $\pm 10\%$ and $\pm 5\%$).

Special clipper diodes with opposing Zener junctions built into the device are available by using the following nomenclature:



Example: 10M4.7AZZ10

1N4001 (SILICON)

thru

1N4007

Designers Data Sheet

"SURMETIC" RECTIFIERS

... subminiature size, axial lead mounted rectifiers for general-purpose low-power applications.

Designers Data for "Worst Case" Conditions

The Designers Data Sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

*MAXIMUM RATINGS

Rating	Symbol	1N4001	1N4002	1N4003	1N4004	1N4005	1N4006	1N4007	Unit
Peak Repetitive Reverse Voltage	V_{RRM}	50	100	200	400	600	800	1000	Volts
Working Peak Reverse Voltage	V_{RWM}								
DC Blocking Voltage	V_R								
Non-Repetitive Peak Reverse Voltage (halfwave, single phase, 60 Hz)	V_{RSM}	60	120	240	480	720	1000	1200	Volts
RMS Reverse Voltage	$V_R(RMS)$	35	70	140	280	420	560	700	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, see Figure 8, $T_A = 75^\circ C$)	I_O	1.0							Amp
Non-Repetitive Peak Surge Current (surge applied at rated load conditions, see Figure 2)	I_{FSM}	30 (for 1 cycle)							Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175							$^\circ C$

*ELECTRICAL CHARACTERISTICS

Characteristic and Conditions	Symbol	Typ	Max	Unit
Maximum Instantaneous Forward Voltage Drop ($I_F = 1.0$ Amp, $T_J = 25^\circ C$) Figure 1	v_F	0.93	1.1	Volts
Maximum Full-Cycle Average Forward Voltage Drop ($I_O = 1.0$ Amp, $T_L = 75^\circ C$, 1 inch leads)	$V_F(AV)$	—	0.8	Volts
Maximum Reverse Current (rated dc voltage) $T_J = 25^\circ C$ $T_J = 100^\circ C$	I_R	0.05 1.0	10 50	μA
Maximum Full-Cycle Average Reverse Current ($I_O = 1.0$ Amp, $T_L = 75^\circ C$, 1 inch leads)	$I_R(AV)$	—	30	μA

* Indicates JEDEC Registered Data.

MECHANICAL CHARACTERISTICS

CASE: Void free, Transfer Molded

MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: $350^\circ C$, 3/8" from case for 10 seconds at 5 lbs. tension

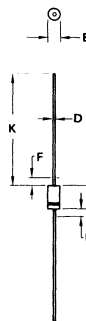
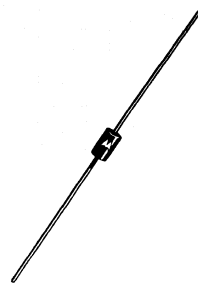
FINISH: All external surfaces are corrosion-resistant, leads are readily solderable

POLARITY: Cathode indicated by color band

WEIGHT: 0.40 Grams (approximately)

LEAD MOUNTED SILICON RECTIFIERS

50-1000 VOLTS
DIFFUSED JUNCTION



NOTE:
1. POLARITY DENOTED BY CATHODE BAND

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.07	5.20	0.160	0.205
B	2.04	2.71	0.080	0.107
D	0.71	0.86	0.028	0.034
F	—	1.27	—	0.050
K	27.94	—	1.100	—

All JEDEC dimensions and notes, apply.

CASE 59-03
DO-41

FIGURE 1 – FORWARD VOLTAGE

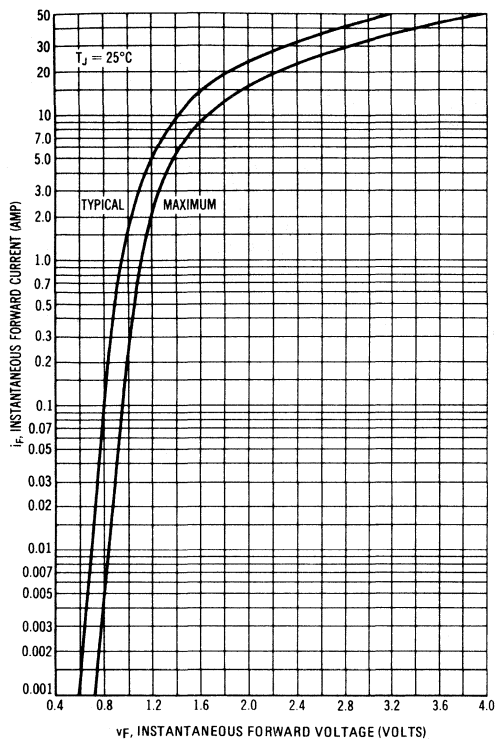


FIGURE 2 – NON-REPETITIVE SURGE CAPABILITY

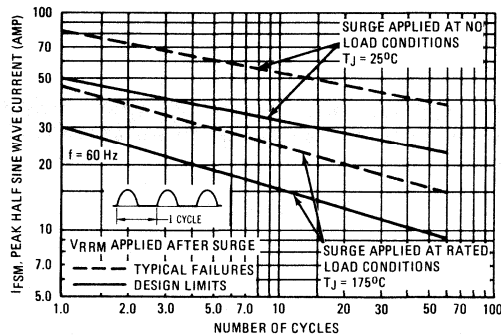


FIGURE 3 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT

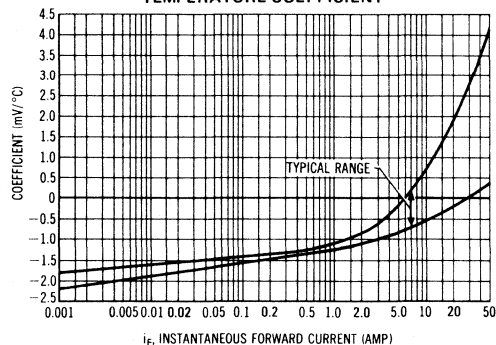
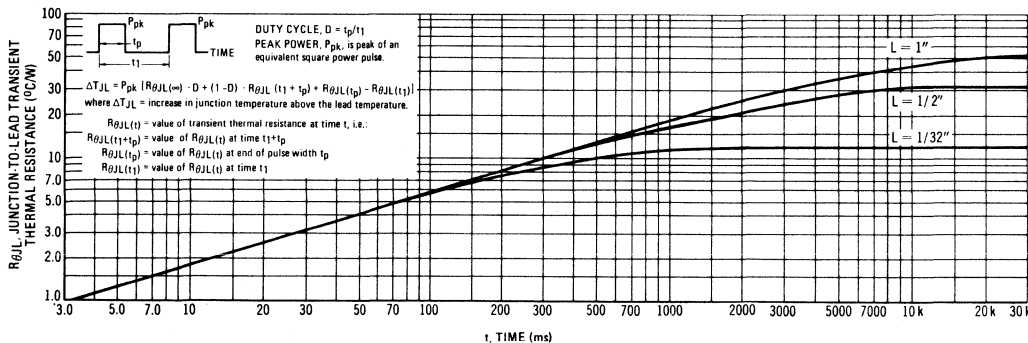


FIGURE 4 – TYPICAL TRANSIENT THERMAL RESISTANCE

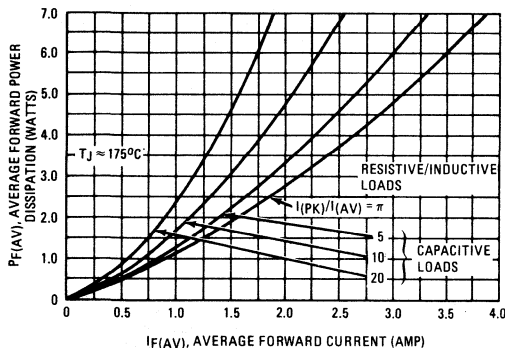
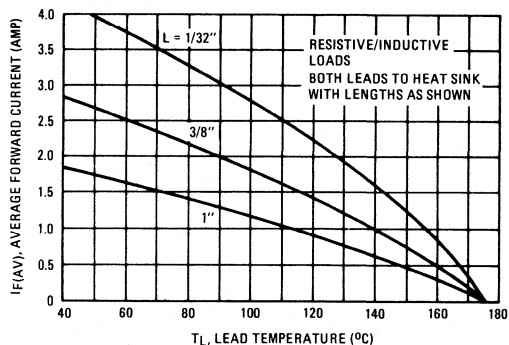
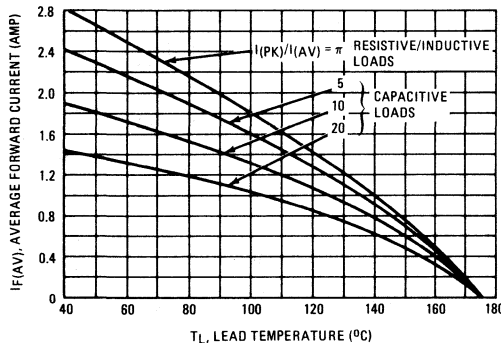
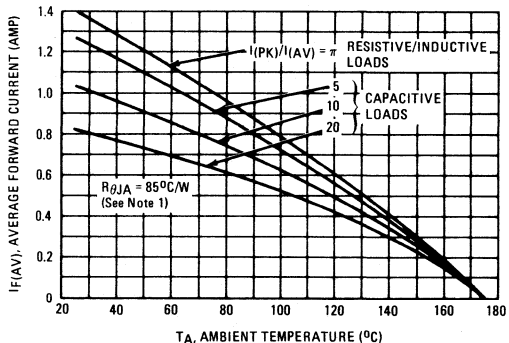
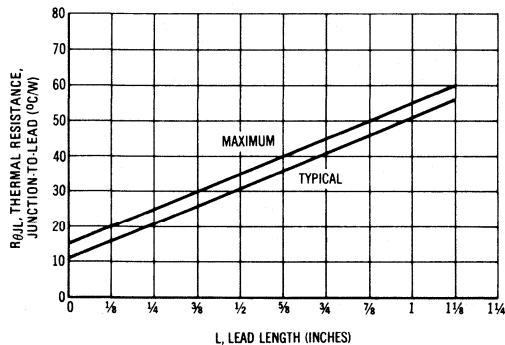


The temperature of the lead should be measured using a thermocouple placed on the lead as close as possible to the tie point. The thermal mass connected to the tie point is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady-

state conditions are achieved. Using the measured value of T_L , the junction temperature may be determined by:

$$T_J = T_L + \Delta T_{JL}$$

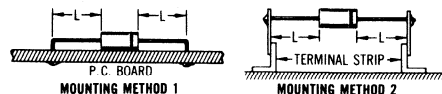
CURRENT DERATING DATA

FIGURE 5 – FORWARD POWER DISSIPATION

FIGURE 6 – EFFECT OF LEAD LENGTHS, RESISTIVE LOAD

FIGURE 7 – 3/8" LEAD LENGTH, VARIOUS LOADS

FIGURE 8 – PRINTED CIRCUIT BOARD MOUNTING – VARIOUS LOADS

FIGURE 9 – STEADY-STATE THERMAL RESISTANCE


NOTE 1

Data shown for thermal resistance junction-to-ambient ($R_{\theta JA}$) for the mountings shown is to be used as typical guideline values for preliminary engineering or in case the tie point temperature cannot be measured

TYPICAL VALUES FOR $R_{\theta JA}$ IN STILL AIR



MOUNTING METHOD	LEAD LENGTH, L (IN.)	$R_{\theta JA}$
1	1/32 3/8 1	75 85 °C/W
2	55 72 85	°C/W

TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 10 – FORWARD RECOVERY TIME

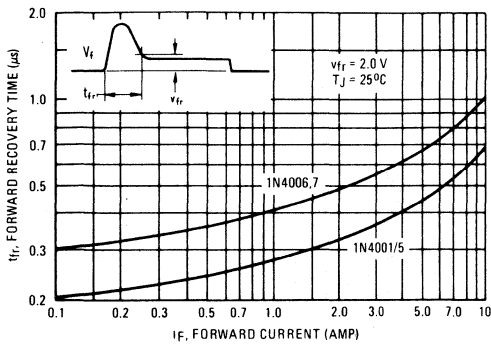


FIGURE 11 – REVERSE RECOVERY TIME

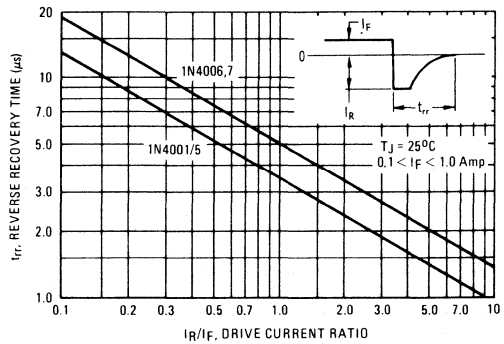


FIGURE 12 – JUNCTION CAPACITANCE

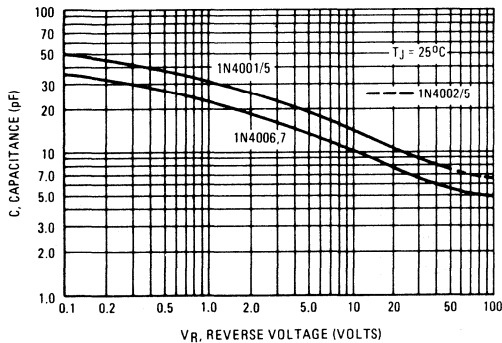


FIGURE 13 – RECTIFICATION WAVEFORM EFFICIENCY FOR SINE WAVE

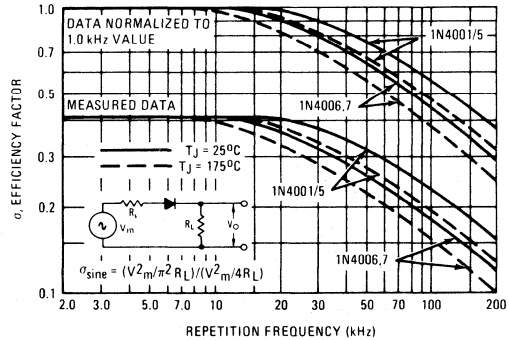
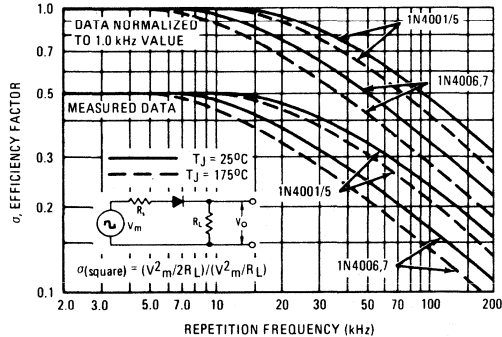


FIGURE 14 – RECTIFICATION WAVEFORM EFFICIENCY FOR SQUARE WAVE



RECTIFIER EFFICIENCY NOTE

The rectification efficiency factor σ shown in Figures 13 and 14 was calculated using the formula:

$$\sigma = \frac{P_{dc}}{P_{rms}} = \frac{\frac{V_O^2(dc)}{R_L}}{\frac{V_O^2(rms)}{R_L}} \cdot 100\% = \frac{V_O^2(dc)}{V_O^2(ac) + V_O^2(dc)} \cdot 100\% \quad (1)$$

For a sine wave input $V_m \sin(\omega t)$ to the diode, assumed lossless, the maximum theoretical efficiency factor becomes 40%; for a square wave input of amplitude V_m , the efficiency factor becomes 50%. (A full wave circuit has twice these efficiencies).

As the frequency of the input signal is increased, the reverse recovery time of the diode (Figure 11) becomes significant, resulting in an increasing ac voltage component across R_L which is opposite in polarity to the forward current thereby reducing the value of the efficiency factor σ , as shown in Figures 13 and 14.

It should be emphasized that Figures 13 and 14 show waveform efficiency only; they do not account for diode losses. Data was obtained by measuring the ac component of V_O with a true rms voltmeter and the dc component with a dc voltmeter. The data was used in Equation 1 to obtain points for the Figures.

1N4057 (Series)

For Specifications, See 1N429 Data

1N4099 thru 1N4135 (SILICON) (MZ4614 thru MZ4627) *

LOW-LEVEL SILICON PASSIVATED ZENER DIODES

... designed for 250 mW applications requiring low leakage, low impedance, and low noise.

- Voltage Range from 1.8 to 100 Volts
- First Zener Diode Series to Specify Noise—50% Lower than Conventional Diffused Zeners
- Zener Impedance and Zener Voltage Specified for Low-Level Operation at $I_{ZT} = 250 \mu A$
- Low Leakage Current —
 I_R from 0.01 to 10 μA over Voltage Range
- Expanded Temperature Range —
 $T_J = -65$ to $+200^\circ C$

MAXIMUM RATINGS

Rating	Value	Unit
DC Power Dissipation, $25^\circ C$ Ambient	250	mW
Derating Factor	1.43	mW/ $^\circ C$
Junction and Storage Temperature	-65 to +200	$^\circ C$

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, all-glass.

DIMENSIONS: See outline drawing.

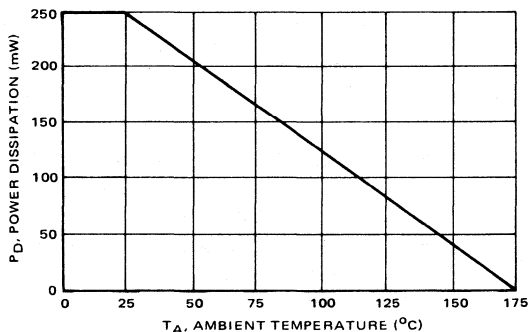
FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

POLARITY: Cathode indicated by polarity band.

WEIGHT: 0.2 gram (approx)

MOUNTING POSITION: Any

POWER TEMPERATURE DERATING CURVE

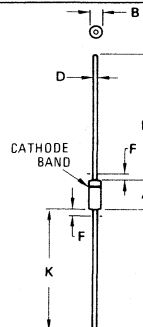
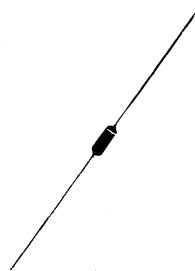


SILICON ZENER DIODES

($\pm 5.0\%$ TOLERANCE)

250 MILLIWATTS
1.8-100 VOLTS

SILICON OXIDE
PASSIVATED JUNCTION



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.84	7.62	0.230	0.300
B	2.16	2.72	0.085	0.107
D	0.46	0.56	0.018	0.022
F	-	1.27	-	0.050
K	25.40	-	1.000	-

All JEDEC dimensions and notes apply

CASE 51-02

DO-7

*Identical to 1N4614 registration, except registration has a minimum package diameter of 0.115 inches.

1N4099 thru 1N4135, MZ4614 thru MZ4627 (continued)

ELECTRICAL CHARACTERISTICS

($T_A = 25^\circ\text{C}$ unless otherwise noted) $I_{ZT} = 250\ \mu\text{A}$ and $V_F = 1.0\ \text{V}$ max @ $I_F = 200\ \text{mA}$ on all Types

Type Number (Note 1)	Nominal Zener Voltage V_Z (Note 1) (Volts)	Max Zener Impedance Z_{ZT} (Note 2) (Ohms)	Max Reverse Current I_R (μA) (Note 4)	Test Voltage V_R (Volts)	Max Noise Density At $I_{ZT} = 250\ \mu\text{A}$ N_D (Fig 1) (micro-volts per Square Root Cycle)	Max Zener Current I_{ZM} (Note 3) (mA)
MZ4614	1.8	1200	7.5	1.0	1.0	120
MZ4615	2.0	1250	5.0	1.0	1.0	110
MZ4616	2.2	1300	4.0	1.0	1.0	100
MZ4617	2.4	1400	2.0	1.0	1.0	95
MZ4618	2.7	1500	1.0	1.0	1.0	90
MZ4619	3.0	1600	0.8	1.0	1.0	85
MZ4620	3.3	1650	7.5	1.5	1.0	80
MZ4621	3.6	1700	7.5	2.0	1.0	75
MZ4622	3.9	1650	5.0	2.0	1.0	70
MZ4623	4.3	1600	4.0	2.0	1.0	65
MZ4624	4.7	1550	10	3.0	1.0	60
MZ4625	5.1	1500	10	3.0	2.0	55
MZ4626	5.6	1400	10	4.0	4.0	50
MZ4627	6.2	1200	10	5.0	5.0	45
1N4099	6.8	200	10	5.2	40	35
1N4100	7.5	200	10	5.7	40	31.8
1N4101	8.2	200	1.0	6.3	40	29.0
1N4102	8.7	200	1.0	6.7	40	27.4
1N4103	9.1	200	1.0	7.0	40	26.2
1N4104	10	200	1.0	7.6	40	24.8
1N4105	11	200	0.05	8.5	40	21.6
1N4106	12	200	0.05	9.2	40	20.4
1N4107	13	200	0.05	9.9	40	19.0
1N4108	14	200	0.05	10.7	40	17.5
1N4109	15	100	0.05	11.4	40	16.3
1N4110	16	100	0.05	12.2	40	15.4
1N4111	17	100	0.05	13.0	40	14.5
1N4112	18	100	0.05	13.7	40	13.2
1N4113	19	150	0.05	14.5	40	12.5
1N4114	20	150	0.01	15.2	40	11.9
1N4115	22	150	0.01	16.8	40	10.8
1N4116	24	150	0.01	18.3	40	9.9
1N4117	25	150	0.01	19.0	40	9.5
1N4118	27	150	0.01	20.5	40	8.8
1N4119	28	200	0.01	21.3	40	8.5
1N4120	30	200	0.01	22.8	40	7.9
1N4121	33	200	0.01	25.1	40	7.2
1N4122	36	200	0.01	27.4	40	6.6
1N4123	39	200	0.01	29.7	40	6.1
1N4124	43	250	0.01	32.7	40	5.5
1N4125	47	250	0.01	35.8	40	5.1
1N4126	51	300	0.01	38.8	40	4.6
1N4127	56	300	0.01	42.6	40	4.2
1N4128	60	400	0.01	45.6	40	4.0
1N4129	62	500	0.01	47.1	40	3.8
1N4130	68	700	0.01	51.7	40	3.5
1N4131	75	700	0.01	57.0	40	3.1
1N4132	82	800	0.01	62.4	40	2.9
1N4133	87	1000	0.01	66.2	40	2.7
1N4134	91	1200	0.01	69.2	40	2.6
1N4135	100	1500	0.01	76.0	40	2.3

NOTE 1: TOLERANCE AND VOLTAGE DESIGNATION

The type numbers shown have a standard tolerance of $\pm 5.0\%$ on the nominal zener voltage.

NOTE 2: ZENER IMPEDANCE (Z_{ZT}) DERIVATION

The zener impedance is derived from the 60 cycle ac voltage, which results when an ac current having an rms value equal to 10% of the dc zener current (I_{ZT}) is superimposed

on I_{ZT} .

NOTE 3: MAXIMUM ZENER CURRENT RATINGS (I_{ZM})

Maximum zener current ratings are based on maximum zener voltage of the individual units.

NOTE 4: REVERSE LEAKAGE CURRENT I_R

Reverse leakage currents are guaranteed and are measured at V_R as shown on the table.

ZENER NOISE DENSITY

A zener diode generates noise when it is biased in the zener direction. A small part of this noise is due to the internal resistance associated with the device. A larger part of zener noise is a result of the zener breakdown phenomenon and is called microplasma noise. This microplasma noise is generally considered "white" noise with equal amplitude for all frequencies from about zero cycles to approximately 200,000 cycles. To eliminate the higher frequency components of noise a small shunting capacitor can be used. The lower frequency noise generally must be tolerated since a capacitor required to eliminate the lower frequencies would degrade the regulation properties of the zener in many applications.

Motorola is rating this series with a maximum noise density at 250 microamperes. The rating of microvolts RMS per square root cycle enables calculation of the maximum

RMS noise for any bandwidth.

Noise density decreases as zener current increases. This can be seen by the graph in Figure 2 where a typical noise density is plotted as a function of zener current.

The junction temperature will also change the zener noise levels. Thus the noise rating must indicate bandwidth, current level and temperature.

The block diagram given in Figure 1 shows the method used to measure noise density. The input voltage and load resistance is high so that the zener is driven from a constant current source. The amplifier must be low noise so that the amplifier noise is negligible compared to the test zener. The filter bandpass is known so that the noise density in volts RMS per square root cycle can be calculated.

FIGURE 1 – NOISE DENSITY MEASUREMENT METHOD

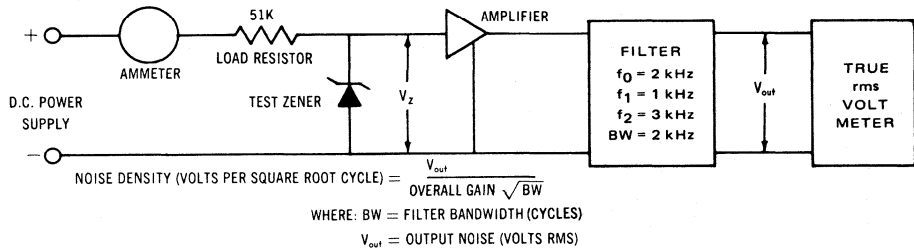


FIGURE 2 – TYPICAL NOISE DENSITY versus ZENER CURRENT

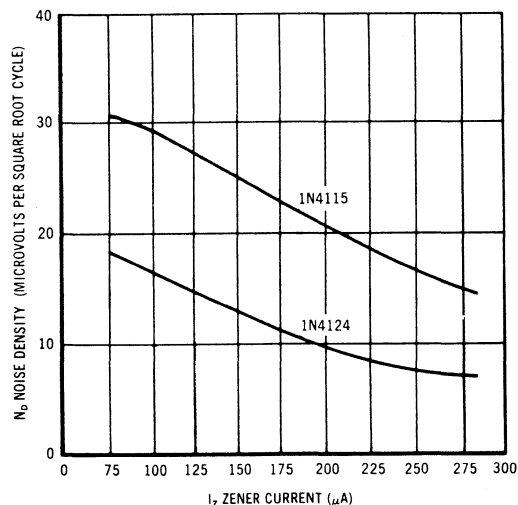


FIGURE 3 – TYPICAL CAPACITANCE

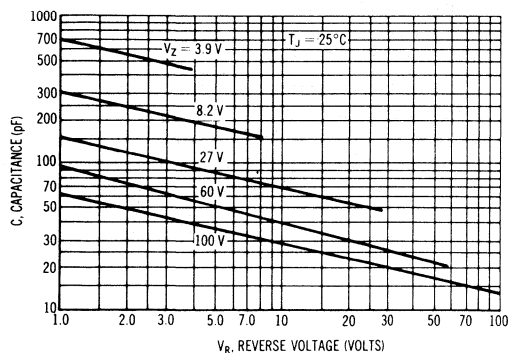
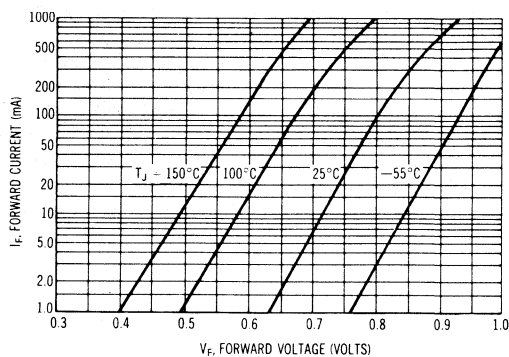


FIGURE 4 – TYPICAL FORWARD CHARACTERISTICS



1N4370 thru 1N4372

1N4370A thru 1N4372A

For Specifications, see 1N746 Data.

TN4387 (SILICON)

CASE 44
(DO-4)



Silicon varactor diode for high-power frequency multiplication applications.
cathode connected to stud

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	150	Vdc
RF Power Input	P_{in}	40	Watts
Total Device Dissipation @ $T_C = 75^\circ\text{C}$ Derate above 75°C	P_D	20 200	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	$^\circ\text{C}$

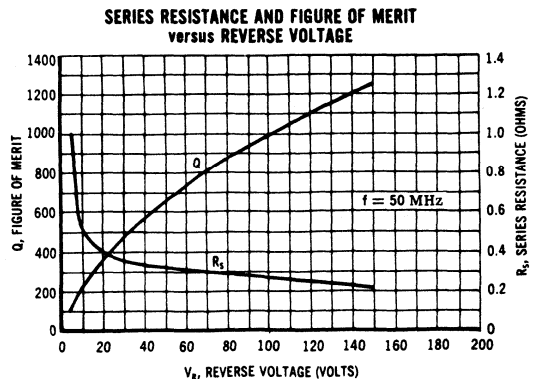
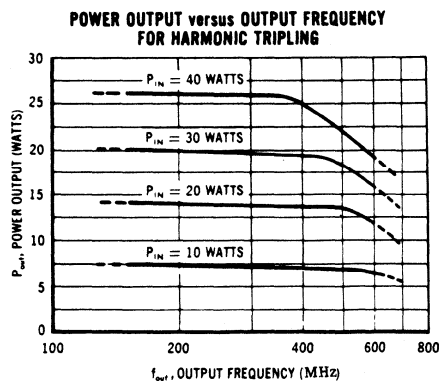
ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage ($I_R = 10 \mu\text{A dc}$)	BV_R	150	200	-	Vdc
Series Resistance ($V_R = 6.0 \text{ Vdc}$, $f = 50 \text{ MHz}$)	R_S	-	1.0	1.5	Ohms
Junction Capacitance * ($V_R = 6.0 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)	C_T	-	25	35	pF
Figure of Merit ($V_R = 10 \text{ Vdc}$, $f = 50 \text{ MHz}$)	Q	150	200	-	-

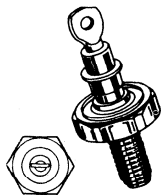
FUNCTIONAL TESTS

Power Output	Tripler Circuit $P_{in} = 30 \text{ W}$, $f_{in} = 150 \text{ MHz}$, $f_{out} = 450 \text{ MHz}$	P_{out}	15	18	-	Watts
Efficiency		η	50	60	-	%

$$*C_T = C_J + C_C$$



1N4388 (SILICON)



CASE 44
(DO-4)

cathode connected to stud

Silicon varactor diode for high-frequency harmonic generation applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	100	Vdc
Forward Current	I_F	1.0	Amp
RF Power Input	P_{in}	25	Watts
Total Device Dissipation @ $T_C = 75^\circ\text{C}$ Derate above 75°C	P_D	10 0.10	Watts W/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage ($I_R = 10 \mu\text{Adc}$)	BV_R	100	150	-	Vdc
Reverse Current ($V_R = 75 \text{ Vdc}$) ($V_R = 75 \text{ Vdc}, T_A = 150^\circ\text{C}$)	I_R	- -	0.5 -	2.0 100	μAdc
Diode Capacitance ($V_R = 6.0 \text{ Vdc}, f = 1.0 \text{ MHz}$) ($V_R = 90 \text{ Vdc}, f = 1.0 \text{ MHz}$)	C_T^*	- -	10 5.0	20 10	pF
Series Resistance ($V_R = 6.0 \text{ Vdc}, f = 50 \text{ MHz}$)	R_S	-	1.2	2.0	Ohms
Figure of Merit ($V_R = 10 \text{ Vdc}, f = 50 \text{ MHz}$) ($V_R = 90 \text{ Vdc}, f = 50 \text{ MHz}$)	Q	200 1000	300 -	- -	-

FUNCTIONAL TESTS

Power Output	Doubler Circuit (Figure 1) $P_{in} = 20 \text{ W}, f_{in} = 500 \text{ MHz},$ $f_{out} = 1000 \text{ MHz}$	P_{out}	11.0	12.0	-	Watts
Efficiency		η	55	60	-	%

$$*C_T = C_J + C_C$$

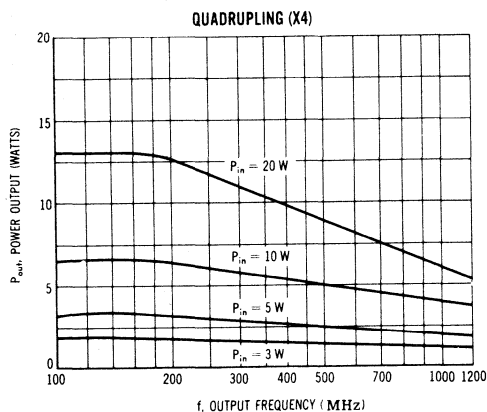
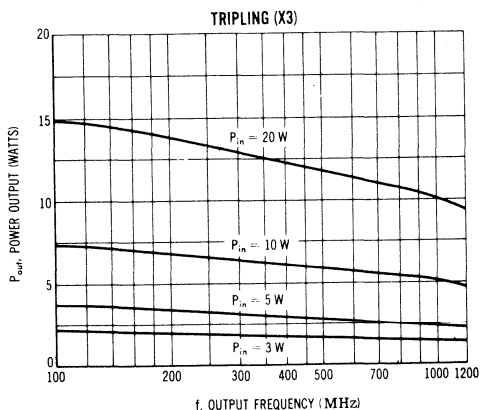
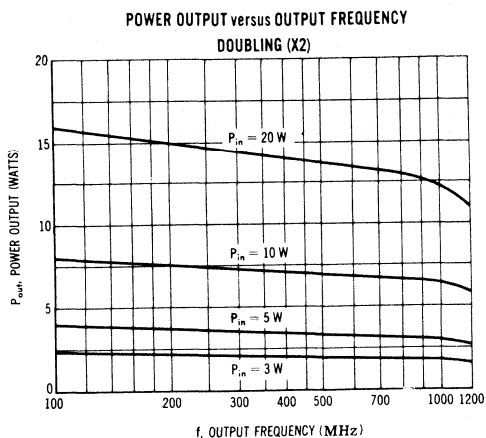
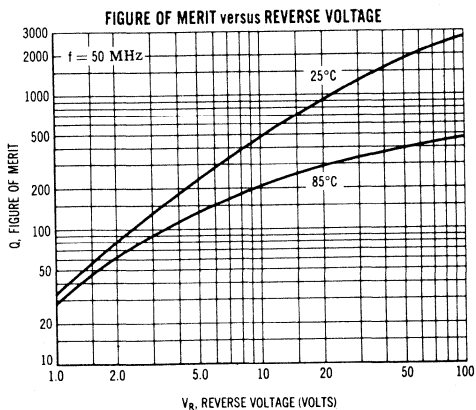
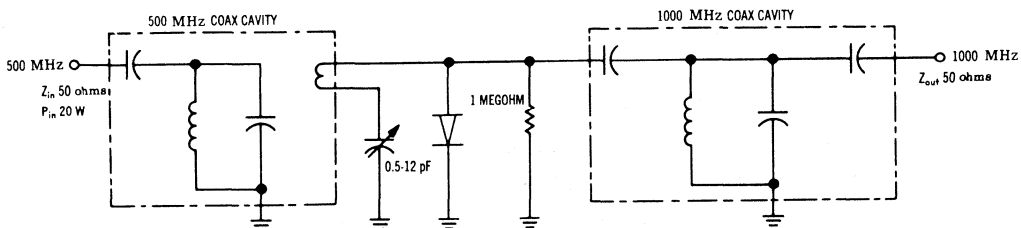


FIGURE 1 — HARMONIC DOUBLER EFFICIENCY TEST CIRCUIT



1N4549 thru 1N4556

1N4557 thru 1N4564

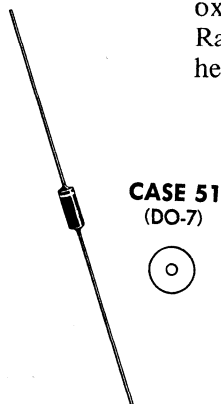
For Specifications, See 1N2804 Data

1N4565-1N4584

1N4775-1N4784

1N4765-1N4774

Low level temperature-compensated zener reference diodes—highly reliable reference sources utilizing an oxide-passivated junction for long-term voltage stability. RamRod construction provides a rugged, glass-enclosed, hermetically sealed structure.



MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to $+175^{\circ}\text{C}$

DC Power Dissipation: 400 Milliwatts at 50°C Ambient
(Derate 3.2 mW/ $^{\circ}\text{C}$ Above 50°C)

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, all-glass

DIMENSIONS: See outline drawing.

FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

POLARITY: Cathode indicated by polarity band.

WEIGHT: 0.2 Gram (approx)

MOUNTING POSITION: Any

1N4565-1N4584/1N4775-1N4784/1N4765-1N4774 (continued)

TYPE	ΔV_Z @ (Note 1)	Test Temperature	Temperature Coefficient for Reference %/°C (Note 1)	Dynamic Imped. Ohms Max (Note 2)
	Volts Max	°C		
V _Z = 6.4 Volts ± 5% (I _{ZT} = 0.5 mA)				
1N4565	0.048	0, +25, +75	0.01	200
1N4566	0.024		0.005	
1N4567	0.010		0.002	
1N4568	0.005		0.001	
1N4569	0.002		0.0005	
1N4565A	0.099	-55, 0, +25, +75, +100	0.01	200
1N4566A	0.050		0.005	
1N4567A	0.020		0.002	
1N4568A	0.010		0.001	
1N4569A	0.005		0.0005	
V _Z = 6.4 Volts ± 5% (I _{ZT} = 1.0 mA)				
1N4570	0.048	0, +25, +75	0.01	100
1N4571	0.024		0.005	
1N4572	0.010		0.002	
1N4573	0.005		0.001	
1N4574	0.002		0.0005	
1N4570A	0.099	-55, 0, +25, +75, +100	0.01	100
1N4571A	0.050		0.005	
1N4572A	0.020		0.002	
1N4573A	0.010		0.001	
1N4574A	0.005		0.0005	
V _Z = 6.4 Volts ± 5% (I _{ZT} = 2.0 mA)				
1N4575	0.048	0, +25, +75	0.01	50
1N4576	0.024		0.005	
1N4577	0.010		0.002	
1N4578	0.005		0.001	
1N4579	0.002		0.0005	
1N4575A	0.099	-55, 0, +25, +75, +100	0.01	50
1N4576A	0.050		0.005	
1N4577A	0.020		0.002	
1N4578A	0.010		0.001	
1N4579A	0.005		0.0005	
V _Z = 6.4 Volts ± 5% (I _{ZT} = 4.0 mA)				
1N4580	0.048	0, +25, +75	0.01	25
1N4581	0.024		0.005	
1N4582	0.010		0.002	
1N4583	0.005		0.001	
1N4584	0.002		0.0005	
1N4580A	0.099	-55, 0, +25, +75, +100	0.01	25
1N4581A	0.050		0.005	
1N4582A	0.020		0.002	
1N4583A	0.010		0.001	
1N4584A	0.005		0.0005	

NOTE 1:

Voltage Variation (ΔV_Z) and Temperature Coefficient.

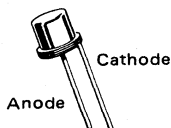
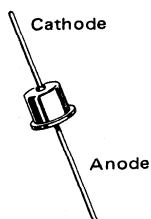
All reference diodes are characterized by the "box method". This guarantees a maximum voltage variation (ΔV_Z) over the specified temperature range, at the specified test current (I_{ZT}), verified by tests at indicated temperature points within the range. This method of indicating voltage stability is now used for JEDEC registration as well as for military qualification. The former method of indicating voltage stability — by means of temperature coefficient — accurately reflects the voltage deviation at the temperature extremes, but is not necessarily accurate within the temperature range because reference diodes have a nonlinear temperature relationship. The temperature coefficient, therefore, is given only as a reference.

TYPE	ΔV_Z @ (Note 1)	Test Temperature	Temperature Coefficient for Reference %/°C (Note 1)	Dynamic Imped. Ohms Max (Note 2)
	Volts Max	°C		
V _Z = 8.5 Volts ±5% (I _{ZT} = 0.5 mA)				
1N4775	0.064	0, +25, +75	0.01	200
1N4776	0.032		0.005	
1N4777	0.013		0.002	
1N4778	0.006		0.001	
1N4779	0.003		0.0005	
1N4775A	0.132	-55, 0, +25, +75, +100	0.01	200
1N4776A	0.066		0.005	
1N4777A	0.026		0.002	
1N4778A	0.013		0.001	
1N4779A	0.007		0.0005	
V _Z = 8.5 Volts ±5% (I _{ZT} = 1.0 mA)				
1N4780	0.064	0, +25, +75	0.01	100
1N4781	0.032		0.005	
1N4782	0.013		0.002	
1N4783	0.006		0.001	
1N4784	0.003		0.0005	
1N4780A	0.132	-55, 0, +25, +75, +100	0.01	100
1N4781A	0.066		0.005	
1N4782A	0.026		0.002	
1N4783A	0.013		0.001	
1N4784A	0.007		0.0005	
V _Z = 9.1 Volts ±5% (I _{ZT} = 0.5 mA)				
1N4765	0.068	0, +25, +75	0.01	350
1N4766	0.034		0.005	
1N4767	0.014		0.002	
1N4768	0.007		0.001	
1N4769	0.003		0.0005	
1N4765A	0.141	-55, 0, +25, +75, +100	0.01	350
1N4766A	0.070		0.005	
1N4767A	0.028		0.002	
1N4768A	0.014		0.001	
1N4769A	0.007		0.0005	
V _Z = 9.1 Volts ±5% (I _{ZT} = 1.0 mA)				
1N4770	0.068	0, +25, +75	0.01	200
1N4771	0.034		0.005	
1N4772	0.014		0.002	
1N4773	0.007		0.001	
1N4774	0.003		0.0005	
1N4770A	0.141	-55, 0, +25, +75, +100	0.01	200
1N4771A	0.070		0.005	
1N4772A	0.028		0.002	
1N4773A	0.014		0.001	
1N4774A	0.007		0.0005	

NOTE 2:

The dynamic zener impedance, Z_{ZT} , is derived from the 60-Hz ac voltage drop which results when an ac current with an rms value equal to 10% of the dc zener current, I_{ZT} , is superimposed on I_{ZT} . A cathode-ray tube curve-trace test on a sample basis is used to ensure that the zener has a sharp and stable knee region.

1N4719 thru 1N4725 (SILICON)
1N4997 thru 1N5003



CASE 60
1N4719 THRU 1N4725

CASE 70
1N4997 thru 1N5003

Silicon high-conductance rectifiers available in either axial-lead or single-ended packages. Type numbers shown have cathode connected to case. For anode-to-case connection, add suffix "R" to type number, i. e. 1N4719R

MAXIMUM RATINGS (Both Package Types) $T_A = 25^\circ\text{C}$ unless otherwise noted.

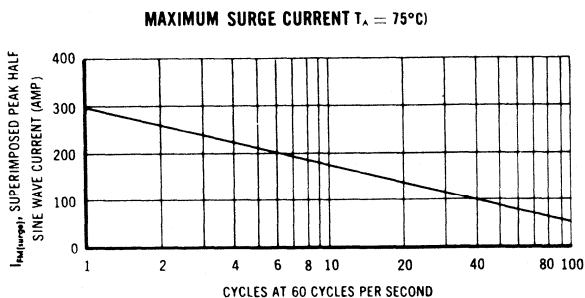
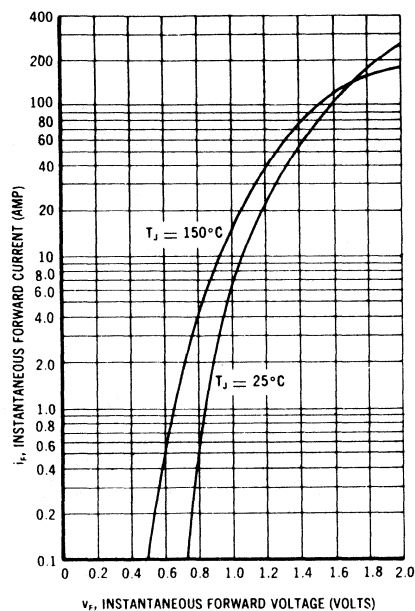
Rating	Symbol	1N 4719 1N 4997	1N 4720 1N 4998	1N 4721 1N 4999	1N 4722 1N 5000	1N 4723 1N 5001	1N 4724 1N 5002	1N 4725 1N 5003	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	800	1000	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single phase, 60 cycle peak)	V_{RSM}	100	200	300	500	720	1000	1200	Volts
RMS Reverse Voltage	$V_R(\text{RMS})$	35	70	140	280	420	560	700	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, $T_A = 75^\circ\text{C}$) see figure 4	I_O	3.0							Amp
Peak Repetitive Forward Current ($T_A = 75^\circ\text{C}$)	I_{FRM}	25							Amp
Non-Repetitive Peak Surge Current (superimposed on rated current at rated voltage, $T_A = 75^\circ\text{C}$) see figure 1	I_{FSM}	300 (for 1/2 cycle)							Amp
I^2t Rating (non-repetitive, 1 ms $< t < 8.3$ ms)	I^2t	185							$A_{(rms)}^2s$
Operating and Case Temperature	T_J, T_{stg}	-65 to +175							$^\circ\text{C}$
Thermal Resistance, Junction to Case (note 1)	$R_{\theta JA}$	30							$^\circ\text{C/W}$

1N4719 thru 1N4725 (Continued)
1N4997 thru 1N5003

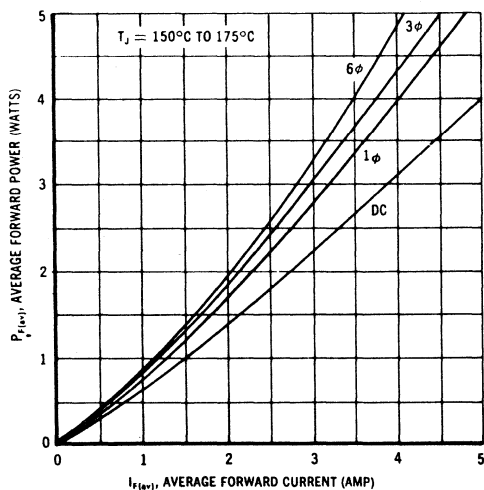
ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Max Limit	Unit
Instantaneous Forward Voltage ($i_F = 9.4 \text{ A}$, $T_J = 175^\circ\text{C}$, Half Wave Rectifier)	V_F	1.0	Volts
Full Cycle Average Reverse Current ($I_O = 3.0 \text{ Amps}$ and Rated V_R , $T_A = 75^\circ\text{C}$, Half Wave Rectifier)	$I_{R(AV)}$	1.5	mA
DC Reverse Current (Rated V_R , $T_A = 25^\circ\text{C}$)	I_R	0.5	mA

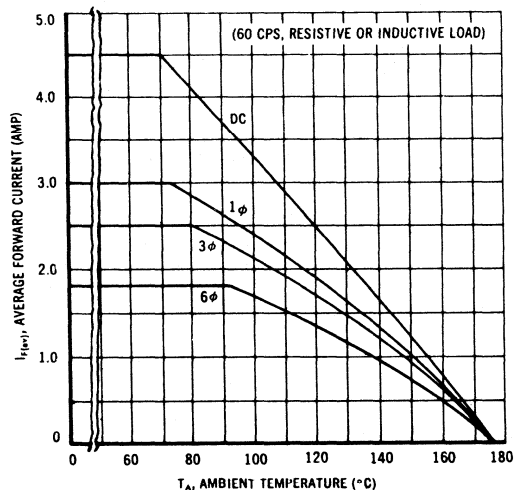
FORWARD VOLTAGE CHARACTERISTICS



MAXIMUM FORWARD POWER
DISSIPATION versus AVERAGE FORWARD CURRENT



MAXIMUM FORWARD CURRENT versus AMBIENT TEMPERATURE



1N4728 thru 1N4764 (SILICON)

1M3.3ZS10 thru 1M200ZS10

Designers Data Sheet

1.0 WATT SURMETIC 30 SILICON ZENER DIODES

... a complete series of 1.0 Watt Zener Diodes with limits and operating characteristics that reflect the superior capabilities of silicon-oxide-passivated junctions. All this in an axial-lead, transfer-molded plastic package offering protection in all common environmental conditions.

- To 80 Watts Surge Rating @ 1.0 ms
- Maximum Limits Guaranteed on Six Electrical Parameters
- Package No Larger Than the Conventional 400 mW Package

Designer's Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*DC Power Dissipation @ $T_A = 50^\circ\text{C}$ Derate above 50°C	P_D	1.0 6.67	Watt mW/ $^\circ\text{C}$
DC Power Dissipation @ $T_L = 75^\circ\text{C}$ Lead Length = 3/8" Derate above 75°C	P_D	3.0 24	Watts mW/ $^\circ\text{C}$
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

MECHANICAL CHARACTERISTICS

CASE: Void-free, transfer-molded, thermosetting plastic

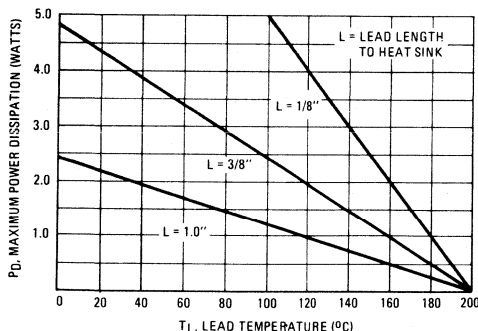
FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable

POLARITY: Cathode indicated by polarity band. When operated in zener mode, cathode will be positive with respect to anode

MOUNTING POSITION: Any

WEIGHT: 0.4 gram (approx)

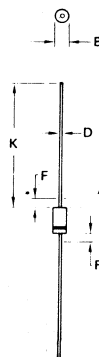
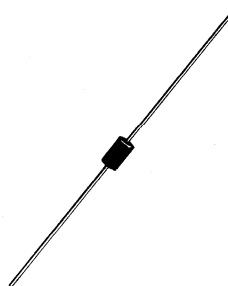
FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



* Indicates JEDEC Registered Data

1.0 WATT ZENER REGULATOR DIODES

3.3–200 VOLTS



NOTE:
1. POLARITY DENOTED BY
CATHODE BAND

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.07	5.20	0.160	0.205
B	2.04	2.71	0.080	0.107
D	0.71	0.86	0.028	0.034
F	—	1.27	—	0.050
K	27.94	—	1.100	—

All JEDEC dimensions and notes apply.

CASE 59-03
DO-41

1N4728 thru 1N4764 (continued)
1M3.3ZS10 thru 1M200ZS10

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted) * $V_F = 1.5\text{ V max}$, $I_F = 200\text{ mA}$ for all types

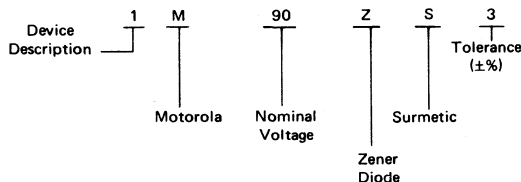
JEDEC Type No. (Note 1)	Motorola Type No. (Note 2)	*Nominal Zener Voltage $V_Z @ I_{ZT}$ Volts (Note 2 & 3)	*Test Current I_{ZT} mA	*Max Zener Impedance (Note 4)			*Leakage Current		*Surge Current $\text{at } T_A = 25^\circ\text{C}$ $i_T - \text{mA}$ (Note 5)
				$Z_{ZT} @ I_{ZT}$ Ohms	$Z_{ZK} @ I_{ZK}$ Ohms	I_{ZK} mA	I_R $\mu\text{A Max}$	V_R Volts	
1N4728	1M3.3ZS10	3.3	76	10	400	1.0	100	1.0	1980
1N4729	1M3.6ZS10	3.6	69	10	400	1.0	100	1.0	1260
1N4730	1M3.9ZS10	3.9	64	9.0	400	1.0	50	1.0	1190
1N4731	1M4.3ZS10	4.3	58	9.0	400	1.0	10	1.0	1070
1N4732	1M4.7ZS10	4.7	53	8.0	500	1.0	10	1.0	970
1N4733	1M5.1ZS10	5.1	49	7.0	550	1.0	10	1.0	890
1N4734	1M5.6ZS10	5.6	45	5.0	600	1.0	10	2.0	810
1N4735	1M6.2ZS10	6.2	41	2.0	700	1.0	10	3.0	730
1N4736	1M6.8ZS10	6.8	37	3.5	700	1.0	10	4.0	660
1N4737	1M7.5ZS10	7.5	34	4.0	700	0.5	10	5.0	605
1N4738	1M8.2ZS10	8.2	31	4.5	700	0.5	10	6.0	550
1N4739	1M9.1ZS10	9.1	28	5.0	700	0.5	10	7.0	500
1N4740	1M10ZS10	10	25	7.0	700	0.25	10	7.6	454
1N4741	1M11ZS10	11	23	8.0	700	0.25	5.0	8.4	414
1N4742	1M12ZS10	12	21	9.0	700	0.25	5.0	9.1	380
1N4743	1M13ZS10	13	19	10	700	0.25	5.0	9.9	344
1N4744	1M15ZS10	15	17	14	700	0.25	5.0	11.4	304
1N4745	1M16ZS10	16	15.5	16	700	0.25	5.0	12.2	285
1N4746	1M18ZS10	18	14	20	750	0.25	5.0	13.7	250
1N4747	1M20ZS10	20	12.5	22	750	0.25	5.0	15.2	225
1N4748	1M22ZS10	22	11.5	23	750	0.25	5.0	16.7	205
1N4749	1M24ZS10	24	10.5	25	750	0.25	5.0	18.2	190
1N4750	1M27ZS10	27	9.5	35	750	0.25	5.0	20.6	170
1N4751	1M30ZS10	30	8.5	40	1000	0.25	5.0	22.8	150
1N4752	1M33ZS10	33	7.5	45	1000	0.25	5.0	25.1	135
1N4753	1M36ZS10	36	7.0	50	1000	0.25	5.0	27.4	125
1N4754	1M39ZS10	39	6.5	60	1000	0.25	5.0	29.7	115
1N4755	1M43ZS10	43	6.0	70	1500	0.25	5.0	32.7	110
1N4756	1M47ZS10	47	5.5	80	1500	0.25	5.0	35.8	95
1N4757	1M51ZS10	51	5.0	95	1500	0.25	5.0	38.8	90
1N4758	1M56ZS10	56	4.5	110	2000	0.25	5.0	42.6	80
1N4759	1M62ZS10	62	4.0	125	2000	0.25	5.0	47.1	70
1N4760	1M68ZS10	68	3.7	150	2000	0.25	5.0	51.7	65
1N4761	1M75ZS10	75	3.3	175	2000	0.25	5.0	56.0	60
1N4762	1M82ZS10	82	3.0	200	3000	0.25	5.0	62.2	55
1N4763	1M91ZS10	91	2.8	250	3000	0.25	5.0	69.2	50
1N4764	1M100ZS10	100	2.5	350	3000	0.25	5.0	76.0	45
—	1M110ZS10	110	2.3	450	4000	0.25	5.0	83.6	—
—	1M120ZS10	120	2.0	550	4500	0.25	5.0	91.2	—
—	1M130ZS10	130	1.9	700	5000	0.25	5.0	98.8	—
—	1M150ZS10	150	1.7	1000	6000	0.25	5.0	114.0	—
—	1M160ZS10	160	1.6	1100	6500	0.25	5.0	121.6	—
—	1M180ZS10	180	1.4	1200	7000	0.25	5.0	136.8	—
—	1M200ZS10	200	1.2	1500	8000	0.25	5.0	152.0	—

NOTE 1 — TOLERANCE AND TYPE NUMBER DESIGNATION

The JEDEC type numbers listed have a standard tolerance on the nominal zener voltage of $\pm 10\%$. A standard tolerance of $\pm 5\%$ on individual units is also available and is indicated by suffixing "A" to the standard type number.

NOTE 2 — SPECIALS AVAILABLE INCLUDE:

(A) **NOMINAL ZENER VOLTAGES BETWEEN THE VOLTAGES SHOWN AND TIGHTER VOLTAGE TOLERANCES:** To designate units with zener voltages other than those assigned JEDEC numbers and/or tight voltage tolerances ($\pm 5\%$, $\pm 3\%$, $\pm 2\%$, $\pm 1\%$), the Motorola type number should be used.



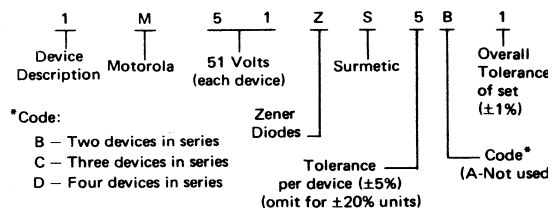
Example: **1M90ZS3**

*Indicates JEDEC Registered Data

(B) **MATCHED SETS:** (Standard Tolerances are $\pm 5.0\%$, $\pm 3.0\%$, $\pm 2.0\%$, $\pm 1.0\%$).

Zener diodes can be obtained in sets consisting of two or more matched devices. The method for specifying such matched sets is similar to the one described in (A), except that two extra suffixes are added to the code number described.

These units are marked with code letters to identify the matched sets and, in addition, each unit in a set is marked with the same serial number, which is different for each set being ordered.

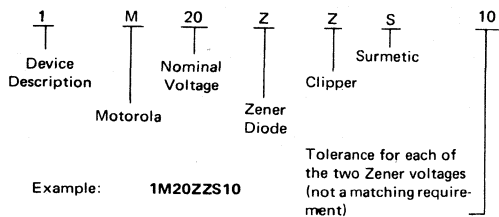


Example: **1M51ZS5B1**

1N4728 thru 1N4764 (continued) 1M3.3ZS10 thru 1M200ZS10

(C) ZENER CLIPPERS: (Standard Tolerance $\pm 10\%$ and $\pm 5\%$).

Special clipper diodes with opposing Zener junctions built into the device are available by using the following nomenclature:



NOTE 3 – ZENER VOLTAGE (V_Z) MEASUREMENT

Motorola guarantees the zener voltage when measured at 90 seconds while maintaining the lead temperature (T_L) at $30^\circ\text{C} \pm 1^\circ\text{C}$, $3/8''$ from the diode body.

NOTE 4 – ZENER IMPEDANCE (Z_Z) DERIVATION

The zener impedance is derived from the 60 cycle ac voltage, which results when an ac current having an rms value equal to 10% of the dc zener current (I_{ZT} or I_{ZK}) is superimposed on I_{ZT} or I_{ZK} .

NOTE 5 – SURGE CURRENT (i_p) NON-REPETITIVE

The rating listed in the electrical characteristics table is maximum peak, non-repetitive, reverse surge current of 1/2 square wave or equivalent sine wave pulse of 1/120 second duration superimposed on the test current, I_{ZT} , per JEDEC registration, however, actual device capability is as described in Figures 4 and 5.

APPLICATION NOTE

Since the actual voltage available from a given zener diode is temperature dependent, it is necessary to determine junction temperature under any set of operating conditions in order to calculate its value. The following procedure is recommended:

Lead Temperature, T_L , should be determined from:

$$T_L = \theta_{LA} P_D + T_A$$

θ_{LA} is the lead-to-ambient thermal resistance ($^\circ\text{C}/\text{W}$) and P_D is the power dissipation. The value for θ_{LA} will vary and depends on the device mounting method. θ_{LA} is generally $30\text{--}40^\circ\text{C}/\text{W}$ for the various clips and tie points in common use and for printed circuit board wiring.

The temperature of the lead can also be measured using a thermocouple placed on the lead as close as possible to the tie point. The thermal mass connected to the tie point is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady-state conditions are achieved. Using the measured value of T_L , the junction temperature may be determined by:

$$T_J = T_L + \Delta T_{JL}$$

ΔT_{JL} is the increase in junction temperature above the lead temperature and may be found from Figure 2 for a train of power pulses ($L = 3/8$ inch) or from Figure 3 for dc power.

$$\Delta T_{JL} = \theta_{JL} P_D$$

For worst-case design, using expected limits of I_Z , limits of P_D and the extremes of T_J (ΔT_J) may be estimated. Changes in voltage, V_Z , can then be found from:

$$\Delta V = \theta_{VZ} \Delta T_J$$

θ_{VZ} , the zener voltage temperature coefficient, is found from Figures 6 and 7.

Under high power-pulse operation, the zener voltage will vary with time and may also be affected significantly by the zener resistance. For best regulation, keep current excursions as low as possible.

Data of Figure 2 should not be used to compute surge capability. Surge limitations are given in Figure 4. They are lower than would be expected by considering only junction temperature, as current crowding effects cause temperatures to be extremely high in small spots resulting in device degradation should the limits of Figure 4 be exceeded.

1N4728 thru 1N4764 (continued)
1M3.3ZS10 thru 1M200ZS10

FIGURE 2 – TYPICAL THERMAL RESPONSE, LEAD LENGTH $L = 3/8$ INCH

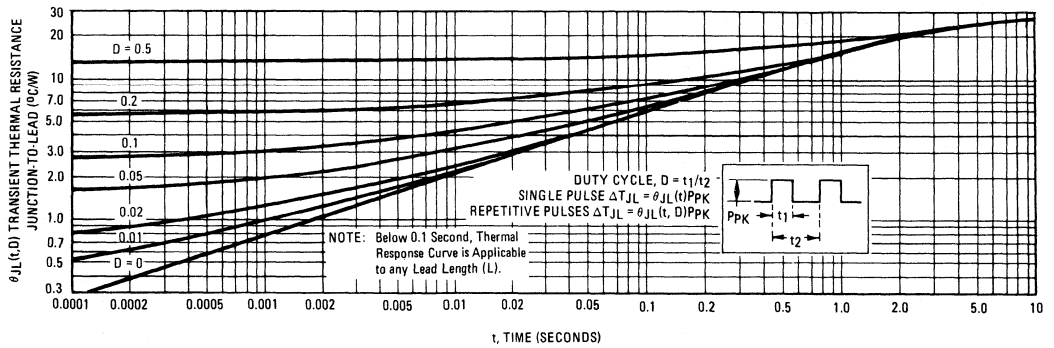


FIGURE 3 – TYPICAL THERMAL RESISTANCE

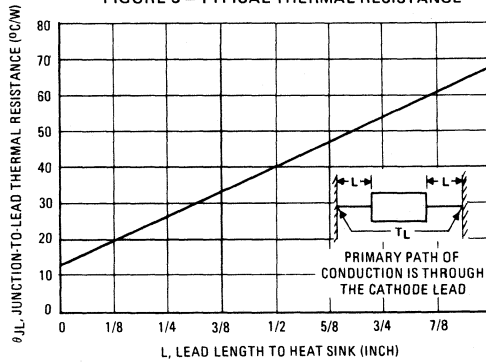


FIGURE 4 – MAXIMUM NON-REPETITIVE SURGE POWER

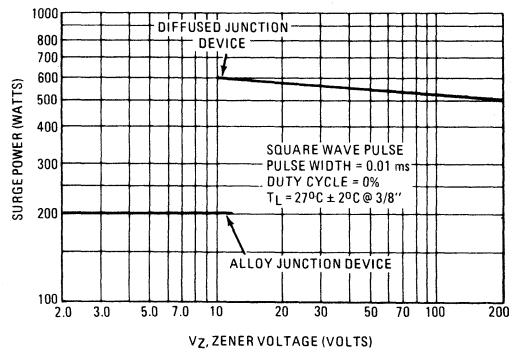
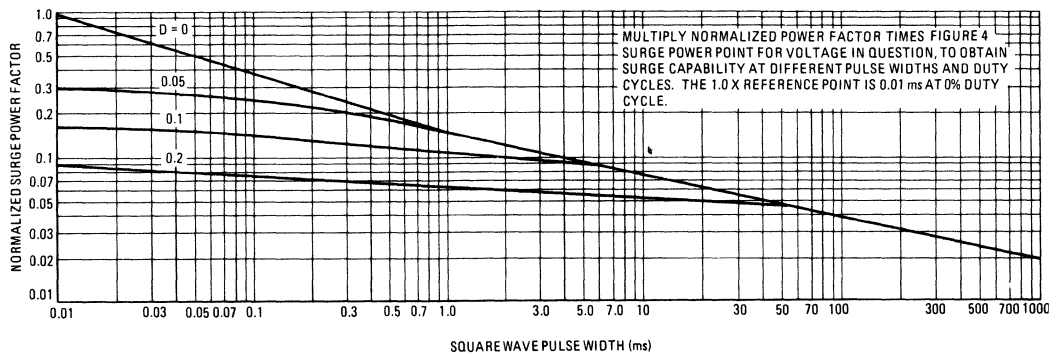


FIGURE 5 – SURGE POWER FACTOR



TEMPERATURE COEFFICIENTS AND VOLTAGE REGULATION

(90% OF THE UNITS ARE IN THE RANGES INDICATED)

FIGURE 6 — TEMPERATURE COEFFICIENT-RANGE
FOR UNITS TO 12 VOLTS

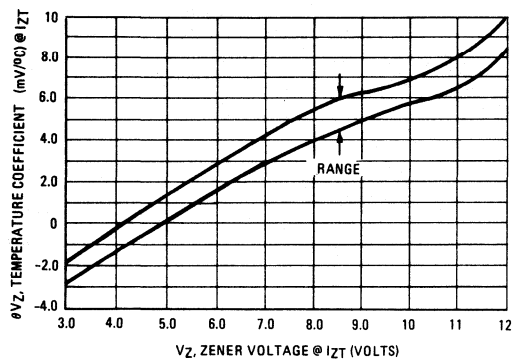


FIGURE 7 — TEMPERATURE COEFFICIENT-RANGE
FOR UNITS 10 TO 200 VOLTS

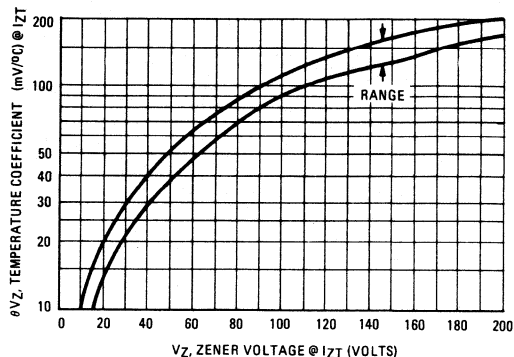


FIGURE 8 — VOLTAGE REGULATION

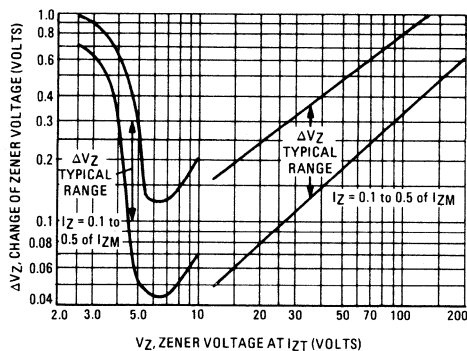
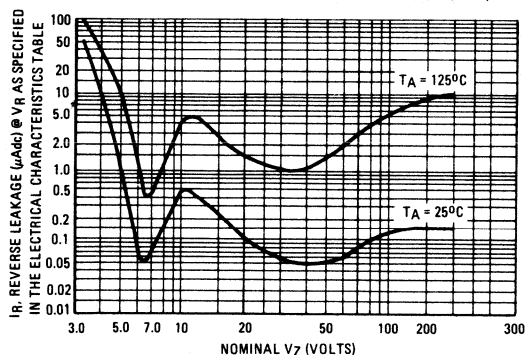


FIGURE 9 — MAXIMUM REVERSE LEAKAGE
(95% OF THE UNITS ARE BELOW THE VALUES SHOWN)



1N4765 thru 1N4774

1N4775 thru 1N4784

For Specifications, See 1N4565 Data.

1N4896, A thru 1N4915, A

1N4916, A thru 1N4932, A

**LOW NOISE
TEMPERATURE-COMPENSATED
ZENER REFERENCE DIODES**

Highly reliable reference sources utilizing an oxide-passivated junction for long-term voltage stability. RamRod construction provides a rugged, glass-enclosed, hermetically sealed structure.

- Low Noise Density Specified for Critical Applications
- Low Power Drain
Devices Specified @ 0.5 mA, 1.0 mA, 2.0 mA, 4.0 mA, and 7.5 mA
- Maximum Voltage Change Specified over Test Temperature Range
- Temperature Compensation Guaranteed over Two Standard Operating Temperature Ranges:
+25 to +100°C
-55 to +100°C

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to +175°C

DC Power Dissipation: 400 Milliwatts at 50°C Ambient
(Derate 3.2 mW/°C Above 50°C)

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, all-glass

DIMENSIONS: See outline drawing.

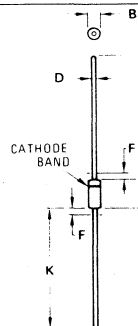
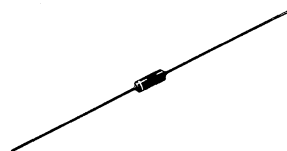
FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

POLARITY: Cathode indicated by polarity band.

WEIGHT: 0.2 Gram (approx)

MOUNTING POSITION: Any

**LOW NOISE
TEMPERATURE-COMPENSATED
ZENER
REFERENCE DIODES**



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.84	7.62	0.230	0.300
B	2.16	2.72	0.085	0.107
D	0.46	0.56	0.018	0.022
F	-	1.27	-	0.050
K	25.40	-	1.000	-

CASE 51
DO-7

Type Number	* ΔV_Z Volts (Note 1)	Temp. Coeff. for Ref. $\%/^{\circ}\text{C}$ (Note 1)	*Dynamic Imped. Ohms Max (Note 2)
-------------	-------------------------------	--	-----------------------------------

$$*I_{ZT} = 0.5 \text{ mA}^{(1)} N_D = 0.8 \frac{\mu\text{V}}{\sqrt{\text{Hz}}}$$

1N4896	0.096	0.01	400
1N4896A	0.198	0.01	
1N4897	0.048	0.005	
1N4897A	0.099	0.005	
1N4898	0.019	0.002	
1N4898A	0.040	0.002	
1N4899	0.010	0.001	200
1N4899A	0.010	0.001	
1N4900	0.096	0.01	

$$*I_{ZT} = 1.0 \text{ mA}^{(1)} N_D = 0.4 \frac{\mu\text{V}}{\sqrt{\text{Hz}}}$$

1N4900A	0.198	0.01	200
1N4901	0.048	0.005	
1N4901A	0.099	0.005	
1N4902	0.019	0.002	
1N4902A	0.040	0.002	
1N4903	0.010	0.001	
1N4903A	0.020	0.001	100
1N4904	0.096	0.01	
1N4904A	0.198	0.01	

$$*I_{ZT} = 2.0 \text{ mA}^{(1)} N_D = 0.25 \frac{\mu\text{V}}{\sqrt{\text{Hz}}}$$

1N4905A	0.099	0.005	100
1N4906	0.019	0.002	
1N4906A	0.040	0.002	
1N4907	0.010	0.001	
1N4907A	0.020	0.001	
1N4908	0.096	0.01	

$$*I_{ZT} = 4.0 \text{ mA}^{(1)} N_D = 0.22 \frac{\mu\text{V}}{\sqrt{\text{Hz}}}$$

1N4908A	0.198	0.01	50
1N4909	0.048	0.005	
1N4909A	0.099	0.005	
1N4910	0.019	0.002	
1N4910A	0.040	0.002	
1N4911	0.010	0.001	
1N4911A	0.020	0.001	25
1N4912	0.096	0.01	
1N4912A	0.198	0.01	

$$*I_{ZT} = 7.5 \text{ mA}^{(1)} N_D = 0.20 \frac{\mu\text{V}}{\sqrt{\text{Hz}}}$$

1N4913A	0.099	0.005	25
1N4914	0.019	0.002	
1N4914A	0.040	0.002	
1N4915	0.010	0.001	
1N4915A	0.020	0.001	
1N4916	0.144	0.01	

*Indicates JEDEC Registered Data.

NOTE 1:

Voltage Variation (ΔV_Z) and Temperature Coefficient.

All reference diodes are characterized by the "box method". This guarantees a maximum voltage variation (ΔV_Z) over the specified temperature range, at the specified test current (I_{ZT}), verified by tests at indicated temperature points within the range. V_Z is measured and recorded at each temperature specified. The ΔV_Z between the highest and lowest values must not exceed the max ΔV_Z given. This method of indicating voltage stability is now used for JEDEC registration as well as for military qualification. The former method of indicating voltage stability — by means of temperature coefficient — accurately reflects the voltage deviation at the temperature extremes, but is not necessarily accurate within the temperature range because reference diodes have a nonlinear temperature relationship. The temperature coefficient, therefore, is given only as a reference.

NOTE 2: Zener Impedance Derivation

The dynamic zener impedance, Z_{ZT} , is derived from the 60-Hz ac voltage drop which results when an ac current with an rms value equal to 10% of the dc zener current, I_{ZT} , is superimposed on I_{ZT} . A cathode-ray tube curve-trace test on a sample basis is used to ensure that the zener has a sharp and stable knee region.

Type Number	* ΔV_Z Volts (Note 1)	Temp. Coeff. for Ref. $\%/^{\circ}\text{C}$ (Note 1)	*Dynamic Imped. Ohms Max (Note 2)
-------------	-------------------------------	--	-----------------------------------

$$*I_{ZT} = 0.5 \text{ mA}^{(1)} N_D = 1.0 \frac{\mu\text{V}}{\sqrt{\text{Hz}}}$$

1N4916	0.144	0.01	600
1N4916A	0.298	0.01	
1N4917	0.072	0.005	
1N4917A	0.149	0.005	
1N4918	0.029	0.002	
1N4918A	0.060	0.002	

$$*I_{ZT} = 1.0 \text{ mA}^{(1)} N_D = 0.5 \frac{\mu\text{V}}{\sqrt{\text{Hz}}}$$

1N4919	0.144	0.01	300
1N4919A	0.298	0.01	
1N4920	0.072	0.005	
1N4920A	0.149	0.005	
1N4921	0.029	0.002	
1N4921A	0.060	0.002	

$$*I_{ZT} = 2.0 \text{ mA}^{(1)} N_D = 0.25 \frac{\mu\text{V}}{\sqrt{\text{Hz}}}$$

1N4922	0.144	0.01	150
1N4922A	0.298	0.01	
1N4923	0.072	0.005	
1N4923A	0.149	0.005	
1N4924	0.029	0.002	
1N4924A	0.060	0.002	

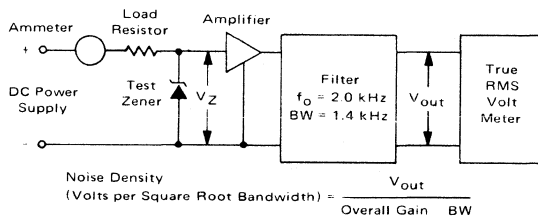
$$*I_{ZT} = 4.0 \text{ mA}^{(1)} N_D = 0.22 \frac{\mu\text{V}}{\sqrt{\text{Hz}}}$$

1N4925	0.144	0.01	75
1N4925A	0.298	0.01	
1N4926	0.072	0.005	
1N4926A	0.149	0.005	
1N4927	0.029	0.002	
1N4927A	0.060	0.002	
1N4928	0.014	0.001	36
1N4928A	0.030	0.001	
1N4929	0.144	0.01	

$$*I_{ZT} = 7.5 \text{ mA}^{(1)} N_D = 0.20 \frac{\mu\text{V}}{\sqrt{\text{Hz}}}$$

1N4930A	0.149	0.005	36
1N4931	0.029	0.002	
1N4931A	0.060	0.002	
1N4932	0.014	0.001	
1N4932A	0.030	0.001	
1N4933	0.144	0.01	

(1) NOISE DENSITY MEASUREMENT METHOD



Where BW = Filter Bandwidth (Hz)
 V_{out} = Output Noise (Volts RMS)

The input voltage and load resistance are high so that the zener diode is driven from a constant current source. The amplifier is low noise so that the amplifier noise is negligible compared to that of the test TC zener. The filter bandpass is known so that the noise density can be calculated from the formula shown.

1N4933 thru 1N4937

MR2271

Designers Data Sheet

SUBMINIATURE SIZE, AXIAL LEAD MOUNTED FAST RECOVERY RECTIFIERS

... designed for special applications such as dc power supplies, inverters, converters, ultrasonic systems, choppers, low RF interference and free wheeling diodes. A complete line of fast recovery rectifiers having typical recovery time of 100 nanoseconds providing high efficiency at frequencies to 250 kHz.

Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit curves — representing device characteristics boundaries — are given to facilitate "worst case" design.

*MAXIMUM RATINGS

Rating	Symbol	1N4933	1N4934	1N4935	MR2271	1N4936	1N4937	Unit
Peak Repetitive Reverse Voltage	V _{RRM}	50	100	200	300	400	600	Volts
Working Peak Reverse Voltage	V _{RWM}							
DC Blocking Voltage	V _R							
Non-Repetitive Peak Reverse Voltage	V _{RSM}	75	150	250	350	450	650	Volts
RMS Reverse Voltage	V _{R(RMS)}	35	70	140	210	280	420	Volts
Average Rectified Forward Current (Single phase, resistive load, T _A = 75°C)	I _O	1.0						Amp
Non-Repetitive Peak Surge Current (surge applied at rated load conditions)	I _{FSM}	30						Amps
Operating Junction Temperature Range	T _J	-65 to +150						°C
Storage Temperature Range	T _{stg}	-65 to +175						°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Typical Printed Circuit Board Mounting)	R _{θJA}	65	°C/W

ELECTRICAL CHARACTERISTICS

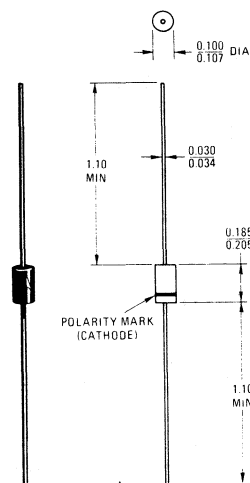
Characteristic	Symbol	Min	Typ	Max	Unit
*Instantaneous Forward Voltage (I _F = 3.14 Amp, T _J = 150°C)	V _F	—	1.0	1.2	Volts
Forward Voltage (I _F = 1.0 Amp, T _A = 25°C)	V _F	—	1.0	1.1	Volts
*Reverse Current (rated dc voltage) T _A = 25°C T _A = 100°C	I _R	—	1.0	5.0	µA
		—	50	100	

*REVERSE RECOVERY CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Recovery Time (I _F = 1.0 Amp to V _R = 30 Vdc) (Figure 21) (I _{FM} = 15 Amp, di/dt = 10 A/µs) (Figure 22)	t _{rr}	—	100	200	ns
		—	150	300	
Reverse Recovery Current (I _F = 1.0 Amp to V _R = 30 Vdc) (Figure 21)	I _{RM(REC)}	—	1.0	2.0	Amp

*Indicates JEDEC Registered Data for 1N4933 Series

FAST RECOVERY RECTIFIERS 50-600 VOLTS 1 AMPERE



All JEDEC dimensions and notes apply

CASE 59
DO-41

MECHANICAL CHARACTERISTICS

CASE: Void Free, Transfer Molded
FINISH: External leads are plated,
leads are readily solderable

POLARITY: Cathode indicated by
Polarity band.

WEIGHT: 0.4 Gram (Approximately)

FIGURE 1 – FORWARD VOLTAGE

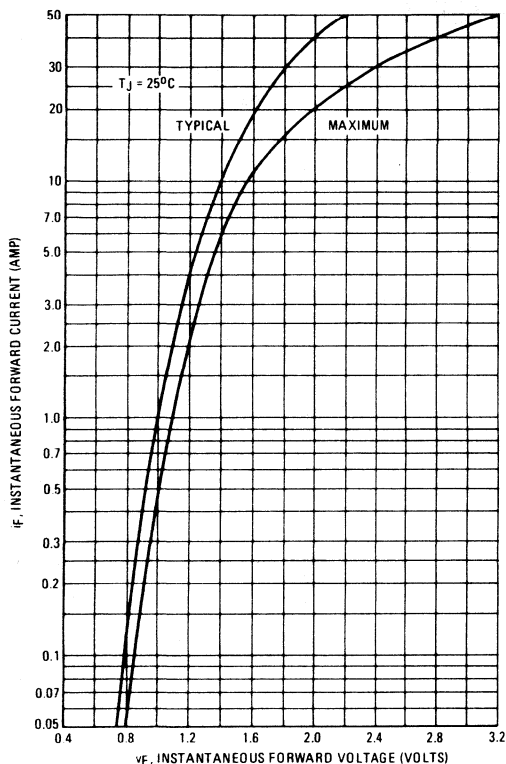


FIGURE 2 – MAXIMUM SURGE CAPABILITY

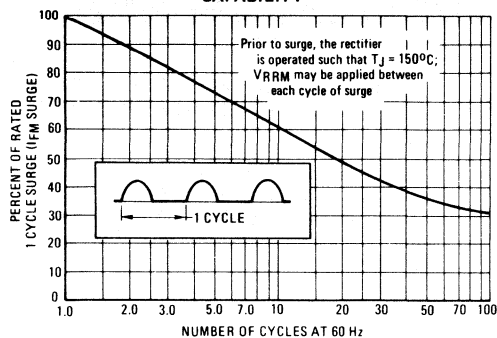
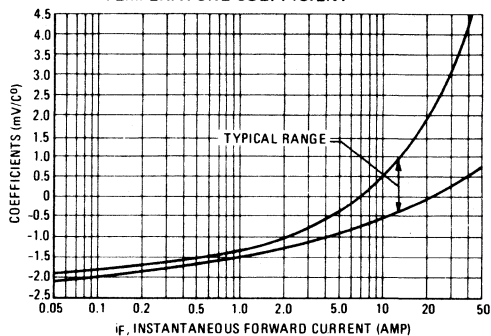
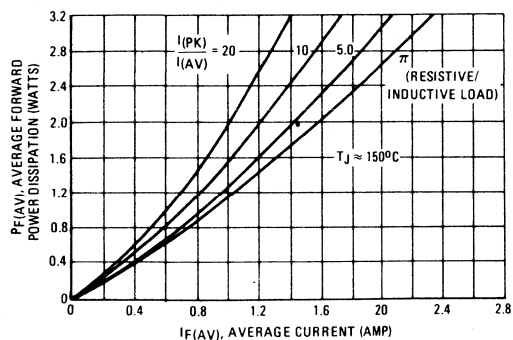
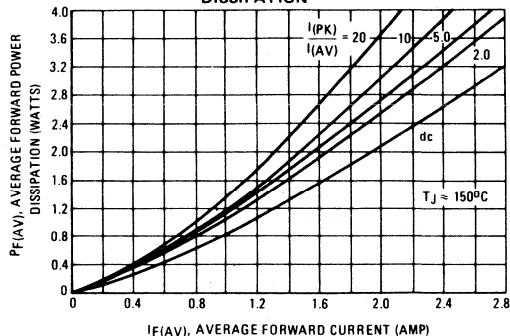
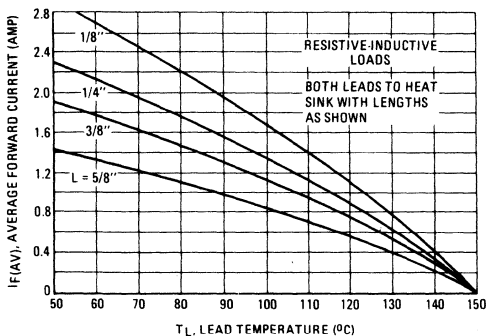


FIGURE 3 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT


SINE WAVE INPUT
FIGURE 4 – FORWARD POWER DISSIPATION

SQUARE WAVE INPUT
FIGURE 5 – FORWARD POWER DISSIPATION


MAXIMUM CURRENT RATINGS

SINE WAVE INPUT
FIGURE 6 – EFFECT OF LEAD LENGTHS,
RESISTIVE LOAD



SQUARE WAVE INPUT
FIGURE 7 – EFFECT OF LEAD LENGTHS,
RESISTIVE LOAD

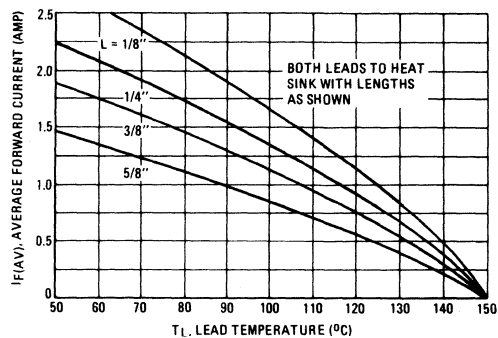


FIGURE 8 – 1/8\" LEAD LENGTH, VARIOUS LOADS

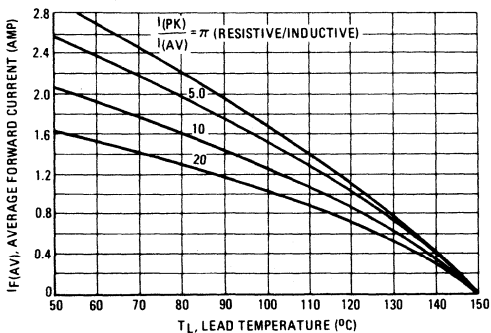


FIGURE 9 – 1/8\" LEAD LENGTHS, VARIOUS LOADS

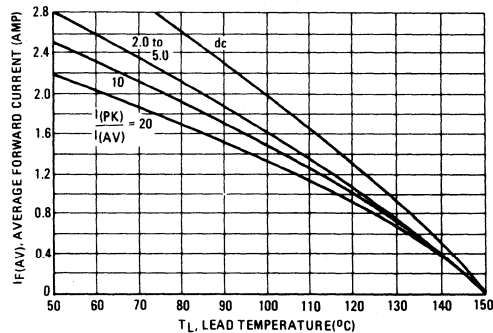


FIGURE 10 – PRINTED CIRCUIT BOARD MOUNTING,
VARIOUS LOADS

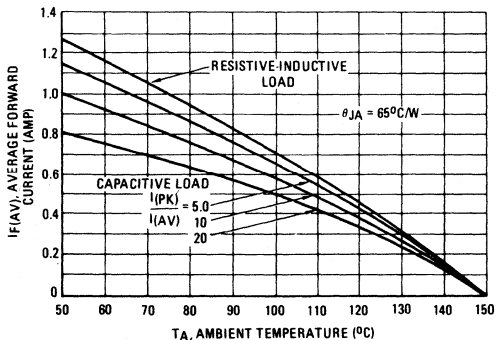


FIGURE 11 – PRINTED CIRCUIT BOARD MOUNTING,
VARIOUS LOADS

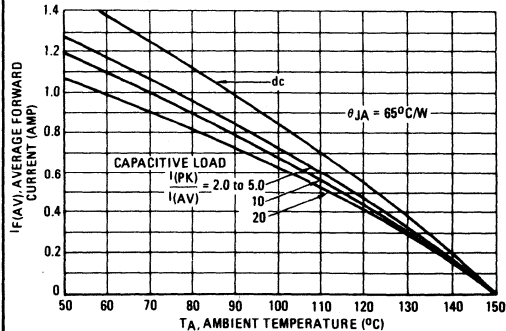


FIGURE 12 – THERMAL RESPONSE

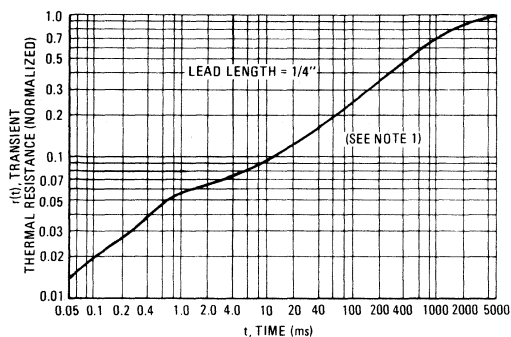
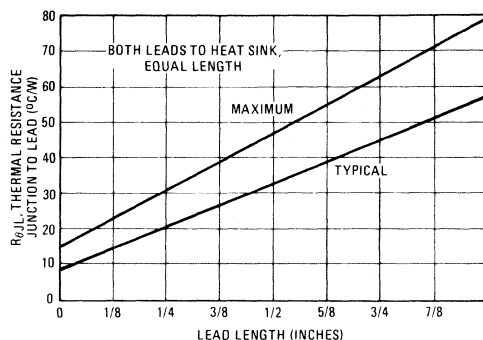
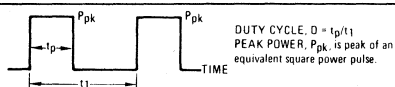


FIGURE 13 – THERMAL RESISTANCE



NOTE 1



DUTY CYCLE, $D = t_p/t_1$
PEAK POWER, P_{pk} , is peak of an equivalent square wave pulse.

To determine maximum junction temperature of the diode in a given situation, the following procedure is recommended:

The temperature of the case should be measured using a thermocouple placed on the case at the temperature reference point (see Note 3). The thermal mass connected to the case is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady-state conditions are achieved. Using the measured value of T_C , the junction temperature may be determined by:

$$T_J = T_C + \Delta T_{JC}$$

where ΔT_{JC} is the increase in junction temperature above the case temperature. It may be determined by:

$$\Delta T_{JC} = P_{pk} \cdot R_{\theta JC} [D + (1 - D) \cdot r(t_1 + t_p) + r(t_p) - r(t_1)]$$

where

$r(t)$ = normalized value of transient thermal resistance at time, t , from Figure 3, i.e.:

$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time $t_1 + t_p$

NOTE 2

Data shown for thermal resistance junction-to-ambient (θ_{JA}) for the mountings shown is to be used as typical guideline values for preliminary engineering or in case the tie point temperature cannot be measured.

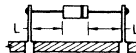
TYPICAL VALUES FOR θ_{JA} IN STILL AIR

MOUNTING METHOD	LEAD LENGTH, L (IN)				$R_{\theta JA}$
	1/8	1/4	1/2	3/4	
1	65	72	82	92	$^{\circ}\text{C/W}$
2	74	81	91	101	$^{\circ}\text{C/W}$
3			40		$^{\circ}\text{C/W}$

MOUNTING METHOD 1



MOUNTING METHOD 2



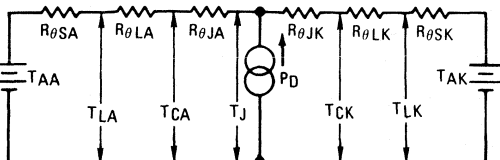
MOUNTING METHOD 3



P.C. Board with
1-1/2" x 1-1/2" copper surface

$L = 3/8"$

Board Ground Plane

FIGURE 14 – THERMAL CIRCUIT MODEL
(For Heat Conduction Through The Leads)


Use of the above model permits junction to lead thermal resistance for any mounting configuration to be found. For a given total lead length, lowest values occur when one side of the rectifier is brought as close as possible to the heat sink. Terms in the model signify:

T_A = Ambient Temperature $R_{\theta S}$ = Thermal Resistance, Heat Sink to Ambient
 T_L = Lead Temperature $R_{\theta L}$ = Thermal Resistance, Lead to Heat Sink
 T_C = Case Temperature $R_{\theta J}$ = Thermal Resistance, Junction to Case
 T_J = Junction Temperature P_D = Power Dissipation
(Subscripts A and K refer to anode and cathode sides respectively.)

Values for thermal resistance components are:
 $R_{\theta L} = 112^{\circ}\text{C/W/IN.}$ Typically and $128^{\circ}\text{C/W/IN.}$ Maximum
 $R_{\theta J} = 18^{\circ}\text{C/W}$ Typically and 30°C/W Maximum

The maximum lead temperature may be calculated as follows:

$$T_L = 150^{\circ} - \Delta T_{JL}$$

ΔT_{JL} can be calculated as shown in NOTE 1 or it may be approximated as follows:

$$\Delta T_{JL} \approx R_{\theta JL} \cdot P_F; P_F \text{ may be formulated for sine-wave operation from Figure 3 or from Figure 4 for square-wave operation.}$$

TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 15 – FORWARD RECOVERY TIME

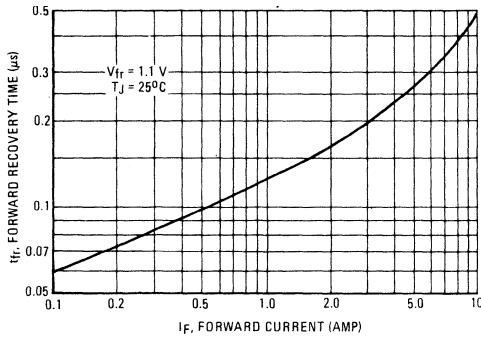
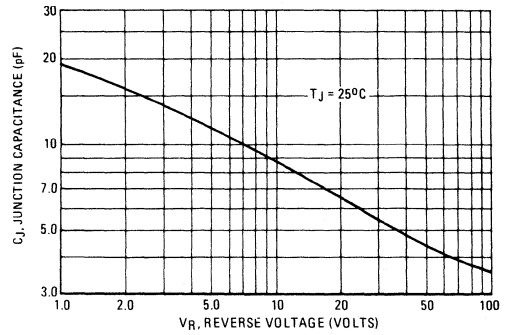


FIGURE 16 – JUNCTION CAPACITANCE



TYPICAL RECOVERED STORED CHARGE DATA

FIGURE 17 – $T_J = 25^\circ C$

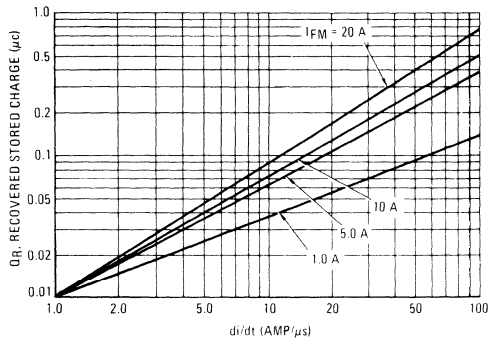


FIGURE 18 – $T_J = 75^\circ C$

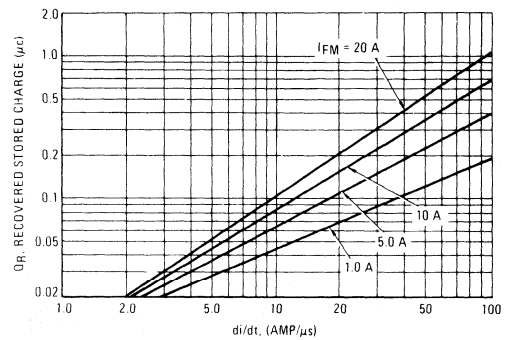


FIGURE 19 – $T_J = 100^\circ C$

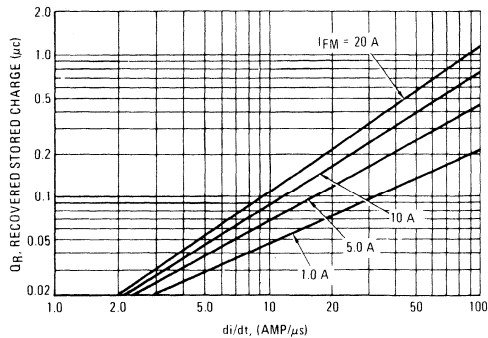
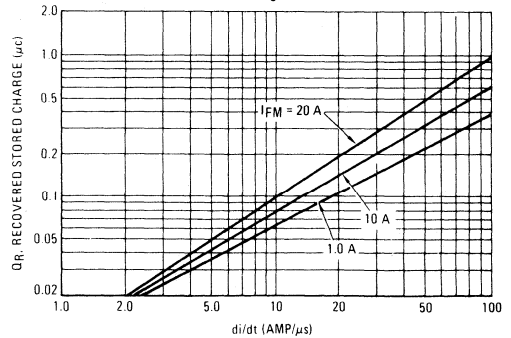


FIGURE 20 – $T_J = 150^\circ C$



RECOVERY TIME

FIGURE 21 — REVERSE RECOVERY CIRCUIT

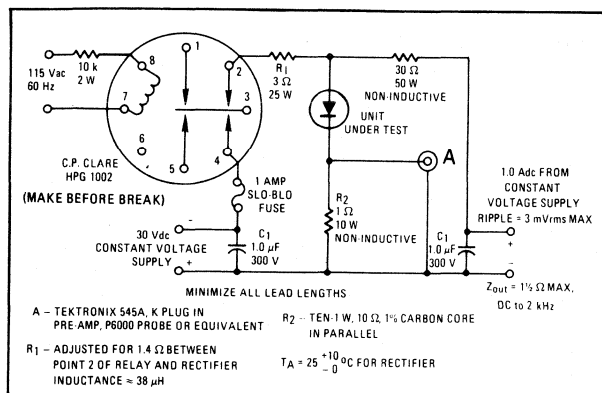


FIGURE 22 — JEDEC REVERSE RECOVERY CIRCUIT

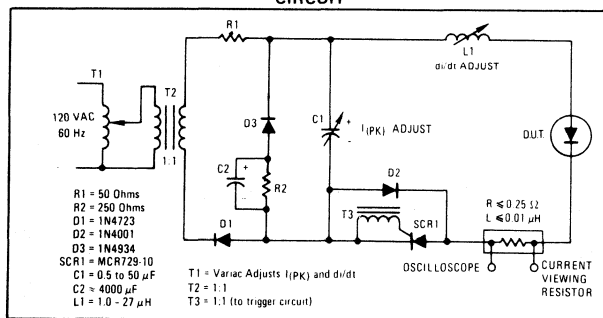


FIGURE 23 — TYPICAL REVERSE LEAKAGE

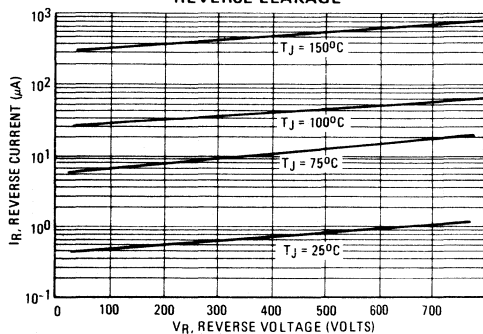
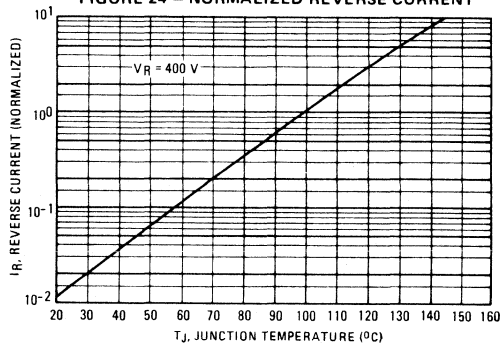


FIGURE 24 — NORMALIZED REVERSE CURRENT



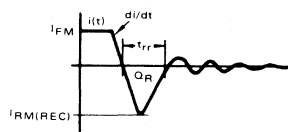
NOTE 3

Reverse recovery time is the period which elapses from the time that the current, thru a previously forward biased rectifier diode, passes thru zero going negatively until the reverse current recovers to a point which is less than 10% peak reverse current.

Reverse recovery time is a direct function of the forward current prior to the application of reverse voltage.

For any given rectifier, recovery time is very circuit dependent. Typical and maximum recovery time of all Motorola fast recovery power rectifiers are rated under a fixed set of conditions using $I_F = 1.0 A$, $V_R = 30 V$. In order to cover all circuit conditions, curves are given for typical recovered stored charge versus commutation di/dt for various levels of forward current and for junction temperatures of $25^\circ C$, $75^\circ C$, $100^\circ C$, and $150^\circ C$.

To use these curves, it is necessary to know the forward current level just before commutation, the circuit commutation di/dt , and the operating junction temperature. The reverse recovery test current waveform for all Motorola fast recovery rectifiers is shown.



From stored charge curves versus di/dt , recovery time (t_{rr}) and peak reverse recovery current ($I_{RM(REC)}$) can be closely approximated using the following formulas:

$$t_{rr} = 1.41 \times \left[\frac{Q_R}{di/dt} \right]^{1/2}$$

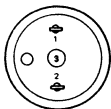
$$I_{RM(REC)} = 1.41 \times [Q_R \times di/dt]^{1/2}$$

2N... JEDEC REGISTERED DEVICE SPECIFICATIONS

2N173 (GERMANIUM)

For Specifications, See 2N277 Data.

2N174 (GERMANIUM) 2N1100 2N1358, A



STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

CASE 5
(TO-36)

PNP germanium power transistors. Power dissipation and junction temperature ratings exceed those of EIA registration.

MAXIMUM RATINGS

Rating	Symbol	2N174	2N1100	2N1358	Unit
Collector-Base Voltage	V_{CB}	80	100	80	Vdc
Emitter-Base Voltage	V_{EB}	60	80	60	Vdc
Emitter Current (Continuous)	I_E	15	15	15	Amp
Base Current (Continuous)	I_B	4.0	4.0	4.0	Amp
Junction and Storage Temperature	T_J, T_{stg}	-65 to +110			°C
Thermal Resistance, Junction to Case	θ_{JC}	0.5			°C/W

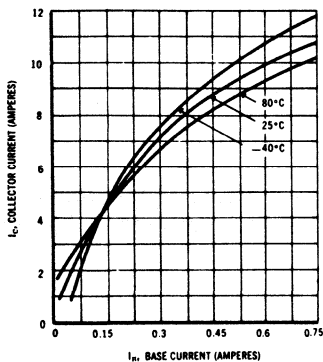
2N174, 2N1100, 2N1358 (continued)**ELECTRICAL CHARACTERISTICS**

Characteristic	Symbol	Minimum	Typical	Maximum	Unit
Collector-Base Cutoff Current ($V_{CB} = 2$ volts)	I_{CBO}	-	100	-	μA
2N174 2N1100 2N1358	- - -	100 100 100	- - 200		
Collector-Base Cutoff Current ($V_{EB} = 1.5$ volts, $V_{CB} = 80$ volts)	I_{CBO}	-	2.0	8.0	mA
2N174 2N1100 2N1358	- - -	2.0 2.0 2.0	8.0 8.0 8.0		
Emitter-Base Cutoff Current ($V_{EB} = 60$ volts)	I_{EBO}	-	1.0	8.0	mA
2N174 2N1100 2N1358	- - -	1.0 1.0 1.0	8.0 8.0 8.0		
Collector-Base Cutoff Current ($V_{CB} = 80$ volts, $71^{\circ}C$)	I_{CBO}	-	-	15	mA
2N174 2N1100 2N1358	- - -	- - 4.0	15 15 6.0		
Emitter-Base Cutoff Current ($V_{EB} = 30$ volts, $71^{\circ}C$)	I_{EBO}	-	4.0	6.0	mA
2N1358					
Collector-Emitter Voltage ($I_C = 300$ mA, $V_{EB} = 0$)	BV_{CES}^*	70	-	-	Vdc
2N174 2N1100 2N1358	80 80 70	- - -	- - -		
Collector-Emitter Voltage ($I_C = 1.0$ amp, $I_B = 0$)	BV_{CEO}^*	55	-	-	Vdc
2N174 2N1100 2N1358	65 65 40	- - -	- - -		
Floating Potential ($I_E = 0$, $V_{CB} = 80$ volts)	V_{EBF}	-	-	1.0	volt
2N174 2N1100 2N1358	- - -	- - 0.15	1.0 1.0 1.0		
Current Gain ($I_C = 1.2$ amp, $V_{CB} = 2$ volts)	h_{FE}	40	55	80	-
($I_C = 5$ amp, $V_{CB} = 2$ volts)		25	-	50	
2N174 2N1100 2N1358	25 25 25	- - 35	50 50 -		
($I_C = 12$ amp, $V_{CB} = 2$ volts)		-	20	-	
2N174 2N1100	- -	20 20	- -		
Base-Emitter Voltage ($I_C = 1.2$ amp, $V_{CB} = 2$ volts)	V_{BE}	-	0.35	0.5	Vdc
2N1358 2N174 2N1100 2N1358	- - - -	0.65 0.65 0.65 0.65	0.9 0.9 0.9 0.9		
Saturation Voltage ($I_C = 12$ amp, $I_B = 2$ amp)	$V_{CE(sat)}$	-	0.3	0.9	Vdc
2N174 2N1100 2N1358	- - -	0.3 0.3 0.3	0.7 0.7 0.7		
Common-Emitter Cutoff Frequency ($I_C = 5$ amp, $V_{CE} = 6$ volts)	$f_{\alpha e}$	-	10	-	kHz
2N174 2N1100					
Common-Base Cutoff Frequency ($I_E = 1$ amp, $V_{CB} = 12$ volts)	$f_{\alpha b}$	100	-	-	kHz
2N1358					
Rise Time ("on" $I_C = 12$ Adc, $I_B = 2$ Adc, $V_{CE} = 12$ volts)	t_r	-	15	-	μs
Fall Time ("off" $I_C = 0$, $V_{EB} = -6$ volts, $R_{EB} = 10$ ohms)	t_f	-	15	-	μs

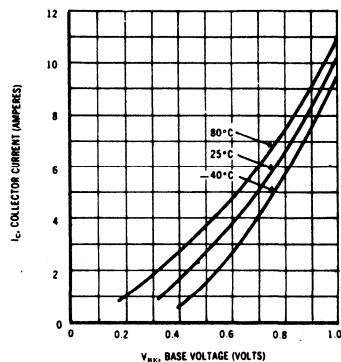
* In order to avoid excessive heating of the collector junction, perform test by the sweep method.

2N174, 2N1100, 2N1358 (continued)

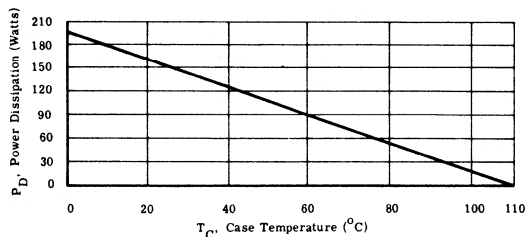
CURRENT TRANSFER CHARACTERISTICS



TRANSCONDUCTANCE CHARACTERISTICS



POWER-TEMPERATURE DERATING CURVE

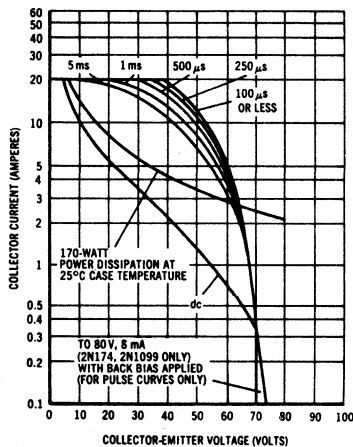


The maximum continuous power is related to maximum junction temperature by the thermal resistance factor.

This curve has a value of 150 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that:

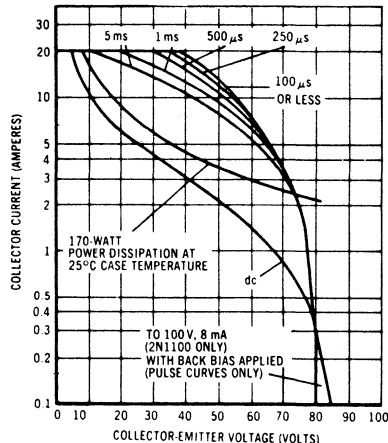
$$\text{allowable } P_D = \frac{110^\circ - T_C}{0.5}$$

2N174 AND 1358



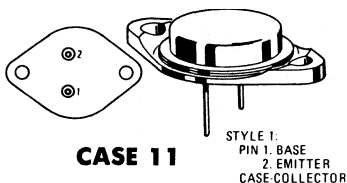
The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short.

2N1100



(Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J , the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N176 (GERMANIUM) 2N669



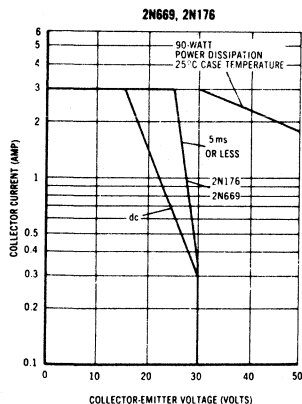
CASE 11

Collector connected to case

PNP germanium power transistors for economical power switching circuits and commercial grade power amplifier applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	40	Vdc
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector Current (Continuous)	I_C	3.0	Amp
Storage and Junction Temperature	T_J, T_{stg}	-65 to +100	°C
Total Device Dissipation (At 25°C Case Temperature)	P_D	90	Watts
Thermal Resistance (Junction to Case)	θ_{JC}	0.8	°C/W

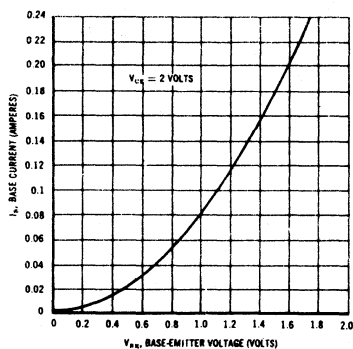
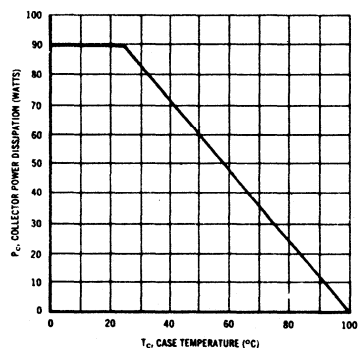


SAFE OPERATING AREAS

The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Case temperature and duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J , the power-temperature derating curve must be observed for both steady state and pulse power conditions.

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

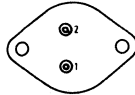
Characteristic	Symbol	Minimum	Typical	Maximum	Unit
Collector-Base Cutoff Current $V_{CB} = 30\text{ V}$, $I_E = 0$ $V_{CB} = 2.0\text{ V}$, $I_E = 0$ $V_{CB} = 30\text{ V}$, $I_E = 0$, $T_C = 90^\circ\text{C}$	I_{CBO}	— — —	— 50 —	3.0 — 20	mA μA mA
Emitter-Base Cutoff Current $V_{EB} = 10\text{ V}$, $I_C = 0$	I_{EBO}	—	—	2.0	mA
Collector-Emitter Breakdown Voltage $I_C = 330\text{ mA}$, $R_{BE} = 10\text{ Ohms}$	BV_{CER} BV_{CES}	30 30	— —	— —	Vdc
Collector-Emitter Saturation Voltage $I_C = 3\text{ A}$, $I_B = 300\text{ mA}$	$V_{CE(SAT)}$	—	—	0.4	Vdc
DC Forward Current Transfer Ratio $V_{CE} = 2.0\text{ V}$, $I_C = 0.5\text{ A}$	h_{FE}	25 75	— —	— 250	—
Power Gain $P_{out} = 2\text{ Watts}$, $V_{CE} = 12\text{ V}$, $I_C = 0.5\text{ Amp}$, $f = 1\text{ kHz}$, $R_S = 10\text{ Ohms}$, $R_L = 26.6\text{ Ohms}$	G_{PE}	34 38	— —	37 —	dB
Total Harmonic Distortion (under same conditions of power gain)		—	—	5.0	%
Small-Signal Current Gain Cutoff Frequency $V_{CE} = 12\text{ V}$, $I_C = 0.5\text{ Amp}$, $f = 1\text{ kHz}$ ref	$f_{\alpha e}$	4.0 3.0	7.0 5.0	— —	kHz
Small-Signal Forward-Current Transfer Ratio $V_{CE} = 2.0\text{ V}$, $I_C = 0.5\text{ Amp}$, $f = 1\text{ kHz}$	h_{fe}	— —	45 90	— —	—
Small-Signal Input Impedance $V_{CE} = 2.0\text{ V}$, $I_C = 0.5\text{ Amp}$, $f = 1\text{ kHz}$	h_{ie}	7.0 10	— —	25 50	Ohms

INPUT CURRENT versus EMITTER DRIVE VOLTAGE
(Both Types)

POWER-TEMPERATURE DERATING CURVE
(Both Types)


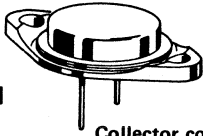
2N178 (GERMANIUM)

2N554

2N555



STYLE 1:
PIN 1: BASE
2: EMITTER
CASE: COLLECTOR



CASE 11

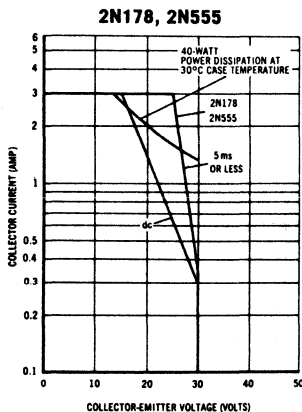
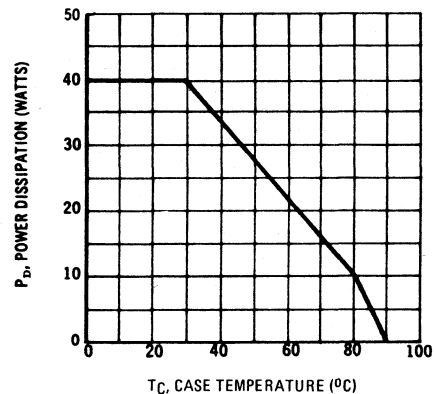
PNP germanium power transistor for non-critical power amplifier and power switching applications requiring economical components.

Collector connected to case

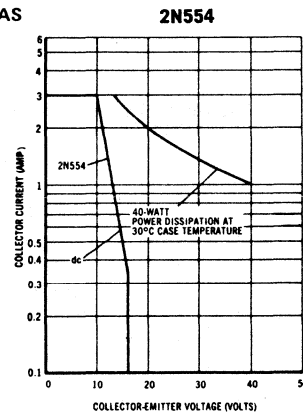
MAXIMUM RATINGS

Rating	Symbol	2N178	2N554	2N555	Unit
Collector-Emitter Voltage	V_{CER}	30	16	30	Vdc
Collector-Base Voltage	V_{CB}	30	15	30	Vdc
Emitter-Base Voltage	V_{EB}	20	15	15	Vdc
Collector Current	I_C	3.0			Ade
Total Device Dissipation @ $T_C = 80^\circ\text{C}$	P_D	10			Watts
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-40 to +90			$^\circ\text{C}$

POWER-TEMPERATURE DERATING CURVE



SAFE OPERATING AREAS



The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short.

(Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J , the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N178, 2N554, 2N555 (continued)

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 330 \text{ mAdc}$, $R_{BE} = 10\Omega$)	2N178 2N554 2N555	BV_{CER}	30 16 30	- - -	- - -	Vdc
Collector-Base Cutoff Current ($V_{CB} = 2.0 \text{ Vdc}$, $I_E = 0$)	2N178	I_{CBO}	-	0.05	-	mA
($V_{VB} = 30 \text{ Vdc}$, $I_E = 0$)	2N178		-	-	3.0	
($V_{CB} = 15 \text{ Vdc}$, $I_E = 0$)	2N554		-	-	10.0	
($V_{CB} = 30 \text{ Vdc}$, $I_E = 0$)	2N555		-	-	20.0	
($V_{CB} = 30 \text{ Vdc}$, $I_E = 0$, $T_C = 90^\circ\text{C}$)	2N178		-	-	20.0	
Emitter-Base Cutoff Current ($V_{BE} = 10 \text{ Vdc}$, $I_C = 0$)	2N178	I_{EBO}	-	-	2.0	mA

ON CHARACTERISTICS

DC Current Gain ($I_C = 0.5 \text{ Adc}$, $V_{CE} = 2.0 \text{ Vdc}$)	2N178 2N554 2N555	h_{FE}	15 - -	- 50 50	45 - -	-
Collector-Emitter Saturation Voltage ($I_C = 3.0 \text{ Adc}$, $I_B = 300 \text{ mAdc}$)		$V_{CE(sat)}$	-	0.6	-	Vdc

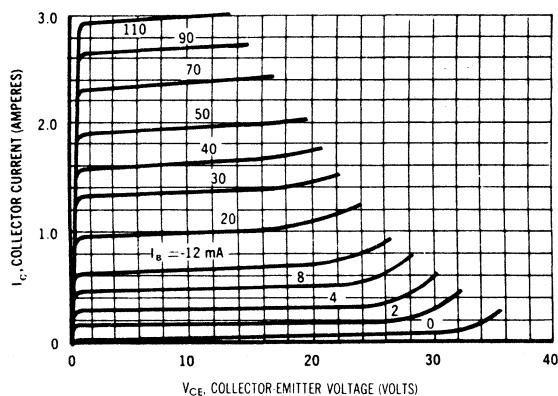
SMALL-SIGNAL CHARACTERISTICS

Common-Emitter Cutoff Frequency ($I_C = 0.5 \text{ Adc}$, $V_{CE} = 12 \text{ Vdc}$, $f = 1.0 \text{ kHz ref}$)	2N178 2N554 2N555	f_{oe}	5.0 - -	- 6.0 6.0	- - -	kHz
Small-Signal Current Gain ($I_C = 0.5 \text{ Adc}$, $V_{CE} = 2.0 \text{ Vdc}$, $f = 1.0 \text{ kHz ref}$)	2N178 2N554 2N555	h_{fe}	- - -	30 55 55	- - -	-
Input Impedance ($I_C = 0.5 \text{ Adc}$, $V_{CE} = 2.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	2N178 2N554 2N555	h_{ie}	8.0 - -	25 25 25	- - -	Ohms

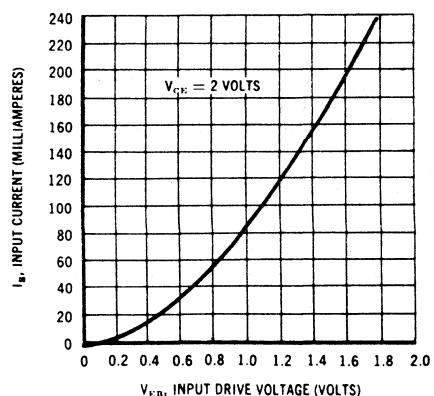
FUNCTIONAL TESTS

Power Gain ($V_{CE} = 12 \text{ Vdc}$, $I_C = 0.5 \text{ Adc}$, $P_{out} = 2.0$ Watts, $f = 1.0 \text{ kHz}$, $R_S = 10 \text{ Ohms}$, $R_L = 26.6 \text{ Ohms}$)	2N178 2N554 2N555	G_{PE}	28 20 25	- 35 35	33 - -	dB
Total Harmonic Distortion (Under same conditions as power gain)	2N178		-	-	5.0	%

COLLECTOR CHARACTERISTICS



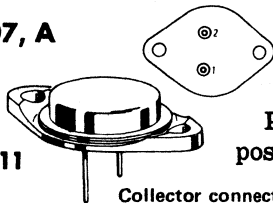
INPUT CURRENT versus INPUT DRIVE VOLTAGE



2N242 (GERMANIUM)

2N307, A

CASE 11



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE. COLLECTOR

PNP germanium power transistors for general purpose power amplifier and switching applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	2N242	2N307, 307A	Unit
Collector-Base Voltage	V_{CB}	45	35	Volts
Collector-Emitter Voltage ($R_{BE} = 30 \Omega$)	V_{CER}	45	—	Volts
Collector-Emitter Voltage	V_{CEO}	—	35	Volts
Emitter-Base Voltage	V_{EB}	—	10	Volts
Collector Current	I_C	5.0	5.0	Amp
Junction Temperature Range	T_J	-65 to +110	-65 to +110	$^{\circ}\text{C}$
Collector Dissipation (at $T_C = 25^{\circ}\text{C}$)	P_D	106	106	Watts

ELECTRICAL CHARACTERISTICS ($T_C = 25^{\circ}\text{C}$ unless otherwise noted)

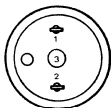
Characteristic	Symbol	Min	Max	Unit
Collector-Base Cutoff Current ($V_{CB} = 2 \text{ Vdc}$) ($V_{CB} = 25 \text{ Vdc}$) ($V_{CB} = 1 \text{ Vdc}$, $I_E = 0$, $T_C = 85^{\circ}\text{C}$)	I_{CBO} 2N307 2N307 2N307A 2N242	— — — —	0.5 5.0 2.0 5.0	mAdc
Emitter-Base Cutoff Current ($V_{EB} = 10 \text{ Vdc}$)	I_{EBO}	—	2.0	mAdc
Collector-Emitter Cutoff Current ($V_{CE} = 45 \text{ Vdc}$, $R_{BE} = 30 \Omega$) ($V_{CE} = 25 \text{ Vdc}$, $R_{BE} = 30 \Omega$) ($V_{CE} = 35 \text{ Vdc}$, $R_{BE} = 30 \Omega$)	I_{CER} 2N242 2N242 2N307 2N307A	— — — —	5.0 1.0 15 7.0	mAdc
Base-Emitter Voltage ($V_{CE} = 1.5 \text{ Vdc}$, $I_C = 1.0 \text{ Adc}$)	V_{BE} 2N242	0.3	0.8	Vdc
Collector-Emitter Saturation Voltage ($I_C = 2.0 \text{ Adc}$, $I_B = 200 \text{ mAdc}$) ($I_C = 0.2 \text{ Adc}$, $I_B = 20 \text{ mAdc}$) ($I_C = 1.0 \text{ Adc}$, $I_B = 100 \text{ mAdc}$)	$V_{CE(sat)}$ 2N242 2N307 2N307A	— — —	0.8 1.0 0.8	Vdc
DC Current Gain ($V_{CE} = 12 \text{ Vdc}$, $I_C = 500 \text{ mAdc}$) ($V_{CE} = 1 \text{ Vdc}$, $I_C = 200 \text{ mAdc}$)	h_{FE} 2N242 2N307 2N307A	30 20 30	120 — —	—
Common Emitter Cutoff Frequency ($V_{CE} = 12 \text{ V}$, $I_C = 0.5 \text{ A}$) ($V_{CE} = 6 \text{ V}$, $I_C = 1 \text{ A}$)	$f_{\alpha e}$ 2N242 2N307A 2N307	5.0 3.5 3.0	— — —	kHz
Power Gain ($I_C = 0.5 \text{ A}$, $V_{CE} = -14 \text{ V}$, $R_L = 30 \Omega$, $R_g = 10 \Omega$)	G_e 2N242	30	—	dB

2N277 (GERMANIUM)

2N278

2N173

2N1099



**CASE 5
(TO-36)**



STYLE 1:

PIN 1. BASE

2. EMITTER

3. COLLECTOR

Collector connected to case

PNP germanium power transistors for general purpose power amplifier and switching applications. Power and temperature ratings exceed EIA registration.

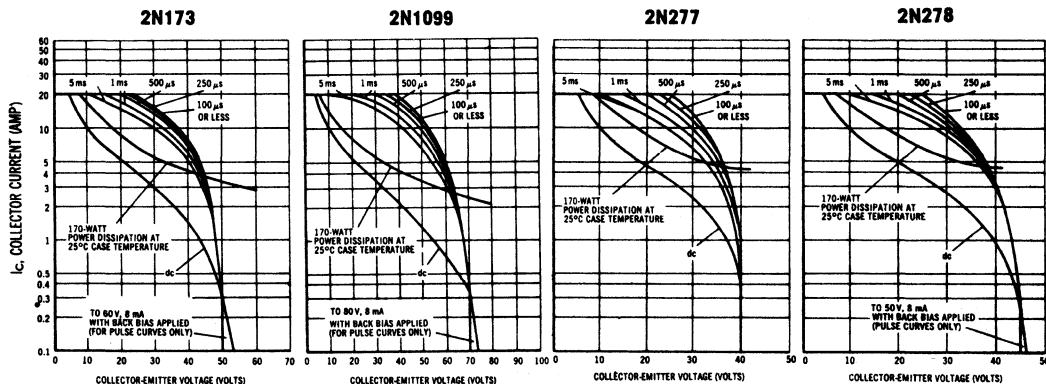
MAXIMUM RATINGS

Rating	Symbol	2N277	2N278	2N173	2N1099	Unit
Collector-Base Voltage	V_{CB}	40	50	60	80	Vdc
Emitter-Base Voltage	V_{EB}	20	30	40	40	Vdc
Emitter Current-Continuous	I_E	15				Adc
Base Current	I_B	4.0				Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	170 2.0				Watts $\text{W}/^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110				$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.5	$^\circ\text{C}/\text{W}$

SAFE OPERATING AREAS



The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short.

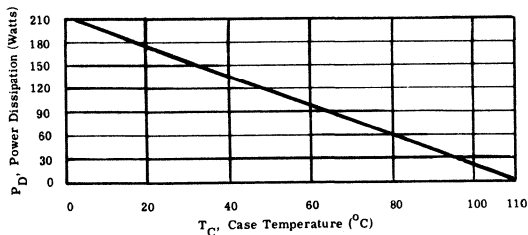
(Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J , the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N277, 2N278, 2N173, 2N1099 (continued)**ELECTRICAL CHARACTERISTICS** ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Minimum	Typical	Maximum	Unit
Collector-Base Cutoff Current $V_{CB0} = 2\text{ V}$	I_{CB0}	—	100	—	μA
Collector-Base Cutoff Current $V_{EB} = 1.5\text{ V}, V_{CB} = 40\text{ V}$	I_{CBX}	—	2.0	8.0	mA
2N277	—	2.0	8.0		
50	—	2.0	8.0		
60	—	2.0	8.0		
80	—	2.0	8.0		
2N1099					
Emitter-Base Cutoff Current $V_{EBO} = 20\text{ V}$	I_{EBO}	—	1.0	8.0	mA
2N277	—	1.0	8.0		
30	—	1.0	8.0		
40	—	1.0	8.0		
40	—	1.0	8.0		
2N1099					
Collector-Base Cutoff Current $V_{CB0} = 40\text{ V}, 71^\circ\text{C}$	I_{CB0}	—	—	15	mA
2N277	—	—	15		
50	—	—	15		
60	—	—	15		
80	—	—	15		
2N1099					
Collector-Emitter Voltage $I_C = 300\text{ mA}, V_{EB} = 0$	BV_{CES}^*	40	—	—	Vdc
2N277	45	—	—		
2N278	50	—	—		
2N173	70	—	—		
2N1099					
Collector-Emitter Voltage $I_C = 1\text{ Amp}, I_B = 0$	BV_{CEO}^*	25	—	—	Vdc
2N277	30	—	—		
2N278	45	—	—		
2N173	55	—	—		
2N1099					
Floating Potential $I_E = 0, V_{CB} = 40\text{ V}$	V_{fl}	—	0.15	1.0	volt
2N277	—	0.15	1.0		
50	—	0.15	1.0		
60	—	0.15	1.0		
80	—	0.15	1.0		
2N1099					
Current Gain $I_C = 5\text{ Amp}, V_{CB} = 2\text{ V}$ $I_C = 12\text{ Amp}, V_{CB} = 2\text{ V}$	h_{FE}	35	—	70	—
		—	25	—	
Base-Emitter Voltage $I_C = 5\text{ Amp}, V_{CB} = 2\text{ V}$	V_{BE}	—	0.65	—	Vdc
2N277	—	0.65	—		
2N278	—	0.65	—		
2N173	—	0.65	—		
2N1099	—	0.65	0.9		
Saturation Voltage $I_C = 12\text{ Amp}, I_B = 2\text{ Amp}$	$V_{CE(SAT)}$	—	0.3	—	Vdc
2N277	—	0.3	1.0		
2N278	—	0.3	1.0		
2N173	—	0.3	1.0		
2N1099	—	0.3	0.7		
Common-Emitter Current Amplification Cutoff Frequency $I_C = 5\text{ Amp}, V_{CE} = 6\text{ V}$	$f_{\alpha e}$	0.3	10	—	kHz
Rise Time "on" $I_C = 12\text{ Adc},$ $I_B = 2\text{ Adc}, V_{CE} = 12\text{ V}$	t_r	—	15	—	μs
Fall Time "off" $I_C = 0,$ $V_{EB} = 6\text{ V}, R_{EB} = 10\text{ Ohms}$	t_f	—	15	—	μs

* To avoid excessive heating of the collector junction, perform these tests with the sweep method.

POWER-TEMPERATURE DERATING CURVE

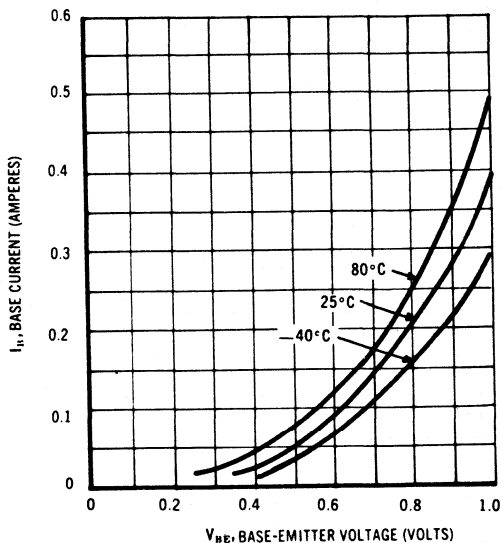


The maximum continuous power is related to maximum junction temperature by the thermal resistance factor.

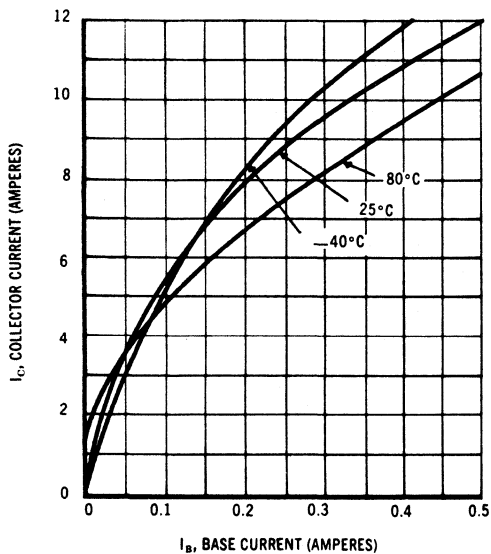
This curve has a value of 150 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that:

$$\text{allowable } P_D = \frac{110^\circ - T_C}{0.5}$$

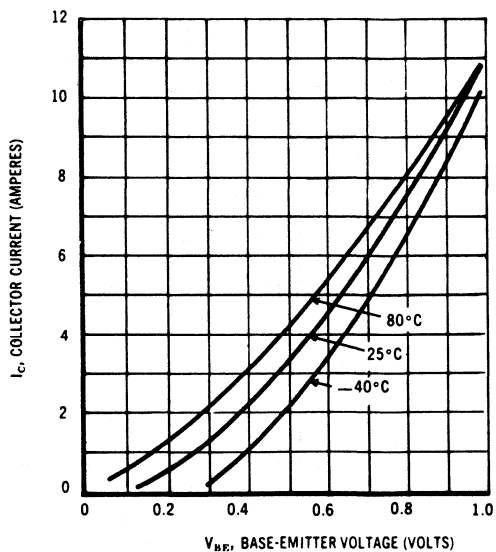
INPUT CHARACTERISTICS



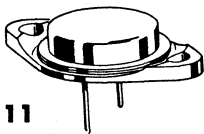
CURRENT TRANSFER CHARACTERISTICS



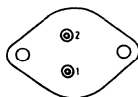
TRANSCONDUCTANCE CHARACTERISTICS



2N297A (GERMANIUM)



CASE 11



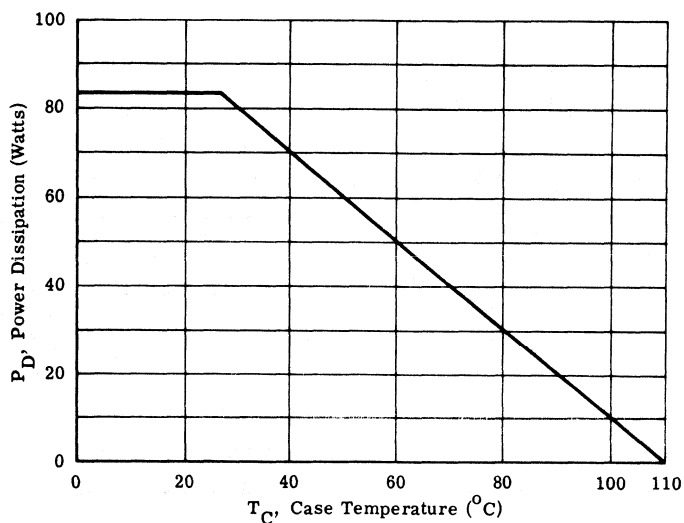
STYLE 1:
PIN 1. BASE
2. EMITTER
CASE-COLLECTOR

PNP germanium power transistor for military and industrial power switching and amplifier applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	60	Vdc
Collector-Emitter Voltage	V_{CES}	50	Vdc
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EB}	40	Vdc
Emitter Current	I_E	5.0	Amp
Operating Temperature Range	T_J	-65 to +110	°C
Collector Dissipation at 25°C Case Temperature ($\theta_{JC} = 1^\circ\text{C/W max}$)	P_D	85	Watts

POWER-TEMPERATURE DERATING CURVE



2N297 A (continued)**ELECTRICAL CHARACTERISTICS** ($T_C = 25^\circ\text{C}$ unless otherwise noted)

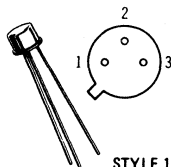
Characteristic	Symbol	Minimum	Maximum	Unit
DC Current Transfer Ratio $V_{CE} = 2 \text{ V}$ $I_C = 0.5 \text{ Adc}$	h_{FE}	40	100	—
DC Current Transfer Ratio $V_{CE} = 2 \text{ V}$ $I_C = 2.0 \text{ Adc}$	h_{FE}	20	—	—
Small-Signal Current Transfer Ratio Cutoff Frequency $V_{CE} = 14 \text{ Vdc}$ $I_C = 0.5 \text{ Amp}$	$f_{\alpha e}$	5.0	—	KHz
Emitter-Base Cutoff Current $V_{EB} = 40 \text{ Vdc}$ $I_C = 0$	I_{EBO}	—	3.0	mAdc
Collector-Base Cutoff Current $V_{CB} = 2 \text{ Vdc}$ $I_E = 0$	I_{CBO}	—	200	μAdc
Collector-Base Cutoff Current $V_{CB} = 60 \text{ Vdc}$ $I_E = 0$	I_{CBO}	—	3.0	mAdc
Base Current $V_{CE} = 2 \text{ Vdc}$ $I_C = 0.5 \text{ Adc}$	I_B	5.0	12.5	mAdc
Base Current $V_{CE} = 2 \text{ Vdc}$ $I_C = 2 \text{ Adc}$	I_B	—	100	mAdc
Emitter-Base Voltage $V_{CE} = 2 \text{ Vdc}$ $I_C = 2 \text{ Adc}$	V_{EB}	—	1.5	Vdc
Floating Potential $V_{CB} = 60 \text{ Vdc}$ (Voltmeter input resistance = 10 Megohm min)	V_{fl}	—	0.18	Vdc
Collector-Emitter Saturation Voltage $I_C = 2 \text{ Adc}$ $I_B = 200 \text{ mAdc}$	$V_{CE(SAT)}$	—	1.0	Vdc
Collector-Emitter Voltage $I_C = 300 \text{ mAdc}$ $I_B = 0$	BV_{CEO}	40	—	Vdc
Collector-Emitter Voltage $I_C = 300 \text{ mAdc}$ $V_{EB} = 0$	BV_{CES}	50	—	Vdc
High-Temperature Operation $T_C = +71^\circ\text{C min}$ Collector Cutoff Current $V_{CB} = 30 \text{ Vdc}$ $I_E = 0$	I_{CBO}	—	6.0	mAdc

2N307 (GERMANIUM)**2N307 A**

For Specifications, See 2N242 Data.

2N319 thru 2N321 (Germanium)

CASE 31 (TO-5)



PNP germanium transistors for audio amplifier
and low-frequency switching applications.

Base connected to case

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

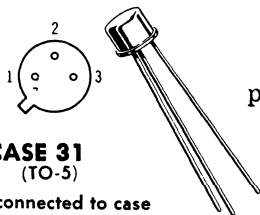
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	25	Vdc
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	500	mAdc
Junction and Storage Temperature	T_J, T_{stg}	-65 to + 100	°C
Power Dissipation at 25°C Ambient	P_D	225	mW

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
Collector Cutoff Current $V_{CB} = -25 \text{ Vdc}, I_E = 0$	I_{CBO}	-	16	μAdc
Emitter Cutoff Current $V_{EB} = -3.0 \text{ Vdc}, I_C = 0$	I_{EBO}	-	10	μAdc
Collector-Emitter Voltage $I_C = 0.6 \text{ mAdc}, R_{BE} = 10 \text{ K}$	BV_{CER}	20	-	Vdc
DC Current Gain $I_C = 20 \text{ mAdc}, V_{CE} = -1 \text{ Vdc}$ 2N319 2N320 2N321	h_{FE}	25 34 53	42 65 121	-
DC Current Gain $I_C = 100 \text{ mAdc}, V_{CE} = -1 \text{ Vdc}$ 2N319 2N320 2N321	h_{FE}	23 30 47	- - -	-
Base Input Voltage $V_{CE} = -1 \text{ Vdc}, I_C = 20 \text{ mAdc}$	V_{BE}	180	320	mVdc
Output Capacitance; Input AC Open Circuit $V_{CB} = -5 \text{ Vdc}, I_E = 1 \text{ mAdc}, f = 1 \text{ MHz}$	C_{ob}	-	35	pF
Frequency Cutoff $V_{CB} = -5 \text{ Vdc}, I_E = 1 \text{ mAdc}$ 2N319 2N320 2N321	$f_{\alpha b}$	1.0 1.5 2.0	- - -	MHz

2N322 thru 2N324 (GERMANIUM) 2N508



CASE 31
(TO-5)

Base connected to case

PNP germanium transistors for audio driver and low power output service in entertainment equipment.

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

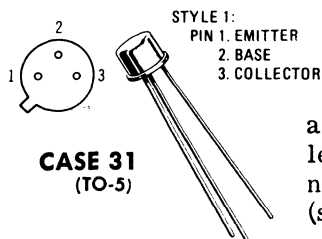
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	18	Vdc
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	500	mAdc
Junction and Storage Temperature	T_J, T_{stg}	-65 to + 100	°C
Power Dissipation at 25°C Ambient	P_D	225	mW

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
Collector Cutoff Current $V_{CB} = -16 \text{ Vdc}, I_E = 0$	I_{CBO}	—	16	μAdc
Emitter Cutoff Current $V_{EB} = -3 \text{ Vdc}, I_C = 0$	I_{EBO}	—	16	μAdc
Collector-Emitter Voltage $I_C = 0.6 \text{ mAdc}, R_{BE} = 5 \text{ K}$	BV_{CER}	18	—	Vdc
DC Current Gain $V_{CE} = -1 \text{ Vdc}, I_C = 20 \text{ mAdc}$ 2N322 2N323 2N324 2N508	h_{FE}	34 53 72 99	65 121 198 198	—
Base Input Voltage $V_{CE} = -1 \text{ Vdc}, I_C = 20 \text{ mAdc}$	V_{BE}	180	320	mVdc
Output Capacitance; Input AC Open Circuit $V_{CB} = -5 \text{ Vdc}, I_E = 1 \text{ mAdc}, f = 1 \text{ MHz}$	C_{ob}	—	35	pF
Frequency Cutoff $V_{CB} = -5 \text{ Vdc}, I_E = 1 \text{ mAdc}$ 2N322 2N323 2N324 2N508	$f_{\alpha b}$	1.0 1.5 2.0 2.5	— — — —	MHz

2N331 (Germanium)



PNP germanium transistor for audio range amplifier and switching service in military equipment. Have collector dissipation and storage temperature ratings significantly higher than those of the military specification (see maximum ratings table below).

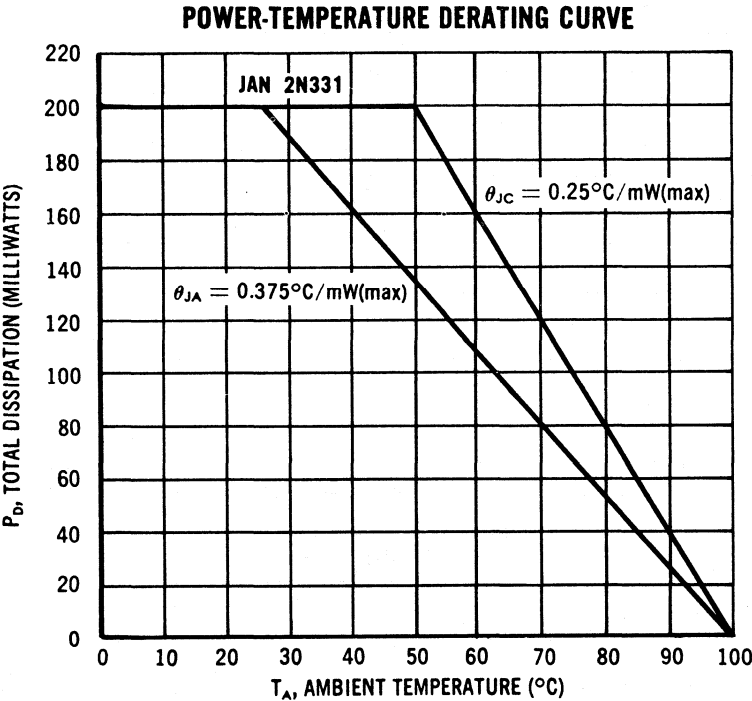
Base connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	30	Volts
Emitter-Base Voltage	V_{EB}	12	Volts
Storage Temperature	T_{stg}	-65 to + 85	°C
Storage Temperature	T_{stg}	-65 to + 100	°C
Collector Dissipation at $T_A = 25^\circ\text{C}$ (MIL-S-19500/4C) (Derate 1.25 mW/°C above 25°C)	P_D	75	mW
Collector Dissipation at $T_A = 25^\circ\text{C}$ (JAN 2N331) (Derate 2.67 mW/°C above 25°C)	P_D	200	mW

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

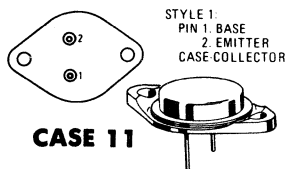
Characteristics	Symbol	Min	Max	Unit
Emitter Cutoff Current ($V_{EB} = -12\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	10	μAdc
Collector Cutoff Current ($V_{CB} = -30\text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	10	μAdc
Small-Signal Open-Circuit Output Admittance ($V_{CB} = -6\text{ Vdc}$, $I_E = 1.0\text{ mAdc}$, $f = 1\text{ kHz}$)	h_{ob}	—	1.0	μmho
Small-Signal Short-Circuit Input Impedance ($V_{CB} = -6\text{ Vdc}$, $I_E = 1.0\text{ mAdc}$, $f = 1\text{ kHz}$)	h_{ib}	—	50	Ohms
Small-Signal Short-Circuit Forward-Current Transfer Ratio ($V_{CE} = -6\text{ Vdc}$, $I_C = 1.0\text{ mAdc}$, $f = 1\text{ kHz}$)	h_{fe}	30	70	—
Small-Signal Short-Circuit Forward-Current Transfer Ratio Cutoff Frequency ($V_{CB} = -6\text{ Vdc}$, $I_E = 1\text{ mAdc}$)	$f_{\alpha b}$	0.4	—	MHz
Output Capacitance ($V_{CB} = -6\text{ Vdc}$, $I_E = 1\text{ mAdc}$)	C_{ob}	—	50	pF
Noise Figure ($V_{CB} = -6\text{ Vdc}$, $I_E = 1\text{ mAdc}$, $R_S = 1000\text{ ohms}$, $f = 1\text{ kHz}$, $f_{\Delta 1}\text{ Hz}$)	NF	—	20	dB



2N350A (GERMANIUM)

2N351A

2N376A

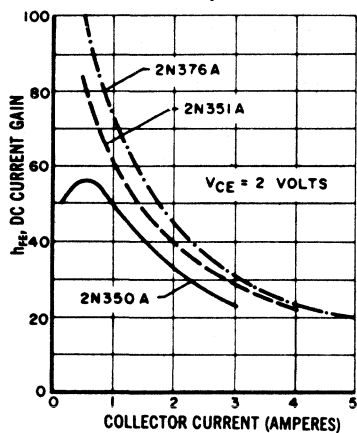


PNP germanium power transistors for economical power switching applications and for power amplifiers requiring up to 4 watts of output power at relatively low distortion.

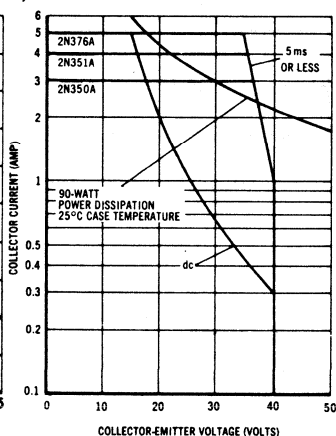
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	50	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector Dissipation at 25°C mounting base temperature	P_D	90	Watts
Collector Junction Temperature	T_J	-65 to +100	°C
Thermal Resistance (Junction to Case)	θ_{JC}	0.8	°C/W

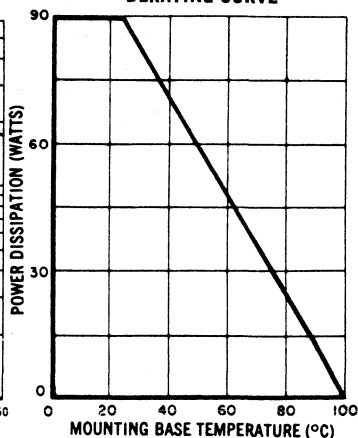
**CURRENT GAIN versus
COLLECTOR CURRENT (COMMON EMITTER)**



SAFE OPERATING AREAS



**POWER TEMPERATURE
DERATING CURVE**



The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short.

(Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J , the power-temperature derating curve must be observed for both steady state and pulse power conditions.

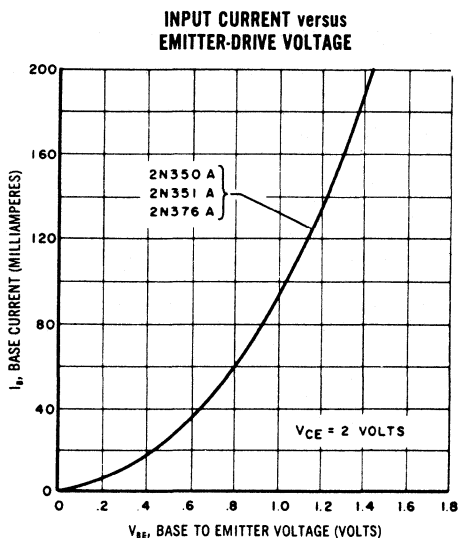
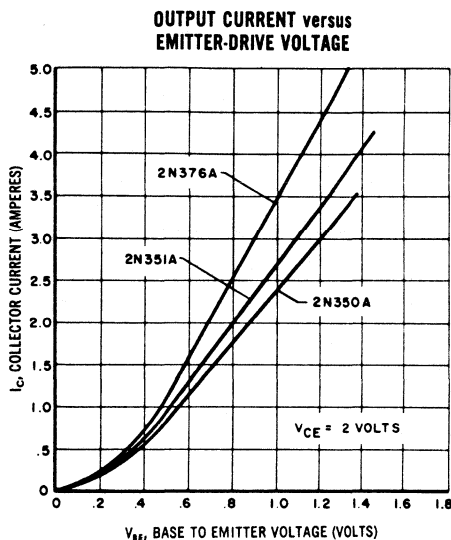
2N350A, 2N351A, 2N376A (continued)
ELECTRICAL CHARACTERISTICS (at mounting base temperature 25°C ± 3°C.)

GENERAL	Symbol	Minimum	Typical	Maximum	Unit
Collector Cutoff Current $V_{CB} = 30 \text{ V}$ $V_{CB} = 2 \text{ V}$ $V_{CB} = 30 \text{ V}, T = 100^\circ\text{C}$	I_{CBO}	— — —	— 50 —	3.0 — 30	mA μA mA
Emitter Cutoff Current $V_{EB} = 10 \text{ V}$	I_{EBO}	—	—	2.0	mA
Collector Breakdown Voltage $I_C = 1 \text{ A}$ ($R_{BE} = 10 \Omega$) $I_C = 330 \text{ mA}, R_{BE} = 0$ (This test should be made under dynamic conditions only)	BV_{CES}	40	—	—	Vdc

ELECTRICAL CHARACTERISTICS (at mounting base temperature 25°C ± 3°C.)

COMMON EMITTER		2N350A			2N351A			2N376A			Unit
	Sym	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Power Gain ($\pm 0.5 \text{ db}$) $P_{out} = 4 \text{ Watts}, V_{CE} = 12 \text{ V},$ $I_C = 0.7 \text{ A}, f = 1 \text{ kHz}$	G_{PE}	30	—	33	32	—	35	34	—	37	dB
Total Harmonic Distortion under same conditions as power gain		—	—	7.0	—	—	7.0	—	—	7.0	%
DC Forward Current Gain $V_{CE} = 2 \text{ V}, I_C = 0.7 \text{ A}$	h_{FE}	20	—	60	25	—	90	35	—	120	
Current Gain Frequency Cutoff $V_{CE} = 12 \text{ V}, I_C = 0.7 \text{ A},$ $f = 1 \text{ kHz}$ ref	$f_{\alpha e}$	5.0	—	—	5.0	—	—	5.0	—	—	kHz
Small-Signal Forward Current Gain $f = 1 \text{ kHz}, V_{CE} = 2 \text{ V}, I_C = 0.7 \text{ A}$	h_{fe}	—	30	—	—	45	—	—	60	—	
Small-Signal Input Impedance $f = 1 \text{ kHz}, V_{CE} = 2 \text{ V}, I_C = 0.7 \text{ A}$	h_{ie}	5.0	—	17	6.0	—	20	7.0	—	25	Ohms
Collector Saturation Voltage $I_C = 3 \text{ A}, I_B = 300 \text{ mA}$	$V_{CE(SAT)}$	—	0.8	1.75	—	—	—	—	—	—	Vdc
Base-Emitter Voltage $I_C = 3 \text{ A}, I_B = 300 \text{ mA}$	V_{BE}	—	1.0	2.00	—	—	—	—	—	—	Vdc
Collector Saturation Voltage $I_C = 4 \text{ A}, I_B = 400 \text{ mA}$	$V_{CE(SAT)}$	—	—	—	—	0.8	1.75	—	—	—	Vdc
Base-Emitter Voltage $I_C = 4 \text{ A}, I_B = 400 \text{ mA}$	V_{BE}	—	—	—	—	1.0	2.00	—	—	—	Vdc
Collector Saturation Voltage $I_C = 5 \text{ A}, I_B = 500 \text{ mA}$	$V_{CE(SAT)}$	—	—	—	—	—	—	—	0.8	1.75	Vdc
Base-Emitter Voltage $I_C = 5 \text{ A}, I_B = 500 \text{ mA}$	V_{BE}	—	—	—	—	—	—	—	1.0	2.00	Vdc

2N350A, 2N351A, 2N376A (continued)



2N375 (GERMANIUM)

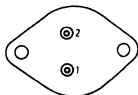
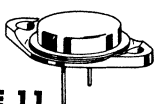
2N618

2N1359

2N1360

2N1362 thru 2N1365

PNP germanium power transistors for general purpose switching and amplifier applications.



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE. COLLECTOR

CASE 11

MAXIMUM RATINGS

Rating	Symbol	2N1359 2N1360	2N375 2N618	2N1362 2N1363	2N1364 2N1365	Unit
Collector-Emitter Voltage	V_{CES}	40	60	75	100	Vdc
Collector-Base Voltage	V_{CB}	50	80	100	120	Vdc
Emitter-Base Voltage	V_{EB}	25	40	50	60	Vdc
Collector Current-Continuous Peak	I_C	3.0 10				Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	106 1.25				Watts $\text{W}/^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110				$^\circ\text{C}$

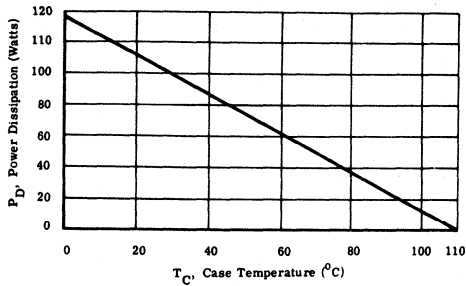
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.8	$^\circ\text{C}/\text{W}$

2N375, 2N618, 2N1359, 2N1360, 2N1362 thru 2N1365 (continued)
ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Types	Symbol	Minimum	Typical	Maximum	Unit
Collector-Base Cutoff Current ($V_{CB} = 40\text{ V}$, $I_E = 0$) ($V_{CB} = 50\text{ V}$, $I_E = 0$) ($V_{CB} = 60\text{ V}$, $I_E = 0$) ($V_{CB} = 80\text{ V}$, $I_E = 0$) ($V_{CB} = 75\text{ V}$, $I_E = 0$) ($V_{CB} = 100\text{ V}$, $I_E = 0$) ($V_{CB} = 100\text{ V}$, $I_E = 0$) ($V_{CB} = 120\text{ V}$, $I_E = 0$)	2N1359, 2N1360 2N375, 2N618 2N1362, 2N1363 2N1364, 2N1365	I_{CBO}	-- -- -- -- -- -- -- --	-- -- -- -- -- -- -- --	3.0 20.0 3.0 20.0 3.0 20.0 3.0 20.0	mA
Collector-Base Cutoff Current at $T_C = +90^\circ\text{C}$ $V_{CB} = 1/2\text{ BV}_{CES}\text{ rating}$		I_{CBO}	--	--	20	mA
Emitter-Base Cutoff Current ($V_{EB} = 12\text{ V}$, $I_C = 0$) ($V_{EB} = 25\text{ V}$, $I_C = 0$) ($V_{EB} = 50\text{ V}$, $I_C = 0$) ($V_{EB} = 60\text{ V}$, $I_C = 0$)	 2N1359, 2N1360 2N1362, 2N1363 2N1364, 2N1365	I_{EBO}	-- -- -- --	-- -- -- --	0.5 20 20 20	mA
Collector-Emitter Breakdown Voltage $I_C = 500\text{ mA}$, $V_{EB} = 0$	2N1359, 2N1360 2N375, 2N618 2N1362, 2N1363 2N1364, 2N1365	BV_{CES}	40 60 75 100	-- -- -- --	-- -- -- --	Vdc
DC Current Transfer Ratio ($V_{CE} = 4\text{ V}$, $I_C = 1.0\text{ A}$) ($V_{CE} = 4\text{ V}$, $I_C = 1.0\text{ A}$)	2N1359, 375, 1362, 64 2N1360, 618, 1363, 65 2N1359, 375, 1362, 64 2N1360, 618, 1363, 65	h_{FE}	35 60 15 20	55 90 22 35	90 140 -- --	--
Transconductance ($V_{CE} = 4\text{ V}$, $I_C = 1.0\text{ A}$)	2N375 2N618 2N1359, 2N1362, 2N1364 2N1360, 2N1363, 2N1365	g_{FE}	0.8 1.0 0.8 1.0	1.25 1.6 1.25 1.6	2.2 2.5 -- --	mhos
Frequency Cutoff ($V_{CE} = 4\text{ V}$, $I_C = 1\text{ A}$) ($V_{CE} = 4\text{ V}$, $I_C = 1\text{ A}$) ($V_{CE} = 4\text{ V}$, $I_C = 3\text{ A}$) ($V_{CE} = 4\text{ V}$, $I_C = 3\text{ A}$)	2N375 2N618 2N1359, 2N1362, 2N1364 2N1360, 2N1363, 2N1365	$f_{\alpha e}$	5.0 5.0 7.0 5.0	8.5 8.5 10 8.5	-- -- -- --	kHz
Collector Saturation Voltage ($I_C = 2.0\text{ A}$, $I_B = 200\text{ mA}$)	2N1359, 375, 1362, 64 2N1360, 618, 1363, 65	$V_{CE(sat)}$	-- --	0.4 0.3	1.0 0.8	Vdc
Base-Emitter Drive Voltage ($I_C = 2.0\text{ A}$, $I_B = 200\text{ mA}$)	2N1359, 375, 1362, 64 2N1360, 618, 1363, 65	V_{BE}	-- --	0.7 0.6	-- --	Vdc
Collector-Emitter Punch-Through Voltage ($V_{CB} = 50\text{ V}$, $I_C = 0$) ($V_{CB} = 100\text{ V}$, $I_C = 0$) ($V_{CB} = 120\text{ V}$, $I_C = 0$)	2N1359, 2N1360 2N1362, 2N1363 2N1364, 2N1365	V_{EBF}	-- -- --	-- -- --	1.25 1.25 1.25	Vdc

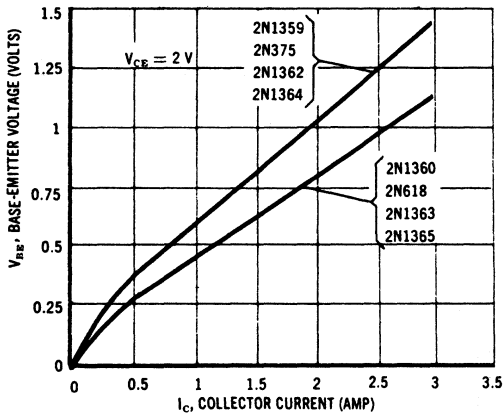
POWER-TEMPERATURE DERATING CURVE



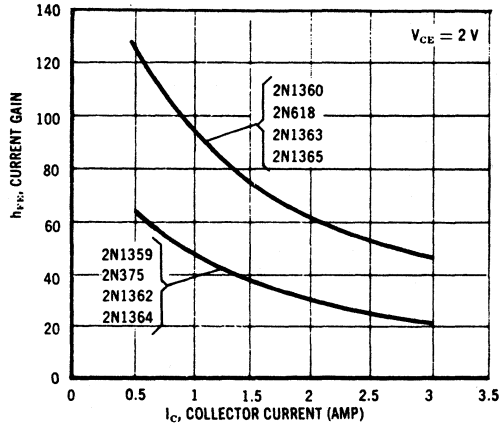
The maximum continuous power is related to maximum junction temperature, by the thermal resistance factor. For d.c. or frequencies below 25 cps the transistor must be operated within the constant $P_D = V_C \times I_C$ hyperbolic curve. This curve has a value of 106 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that

$$P_D \text{ allowable} = \frac{110^\circ - T_C}{0.8}$$

BASE-EMITTER VOLTAGE versus COLLECTOR CURRENT



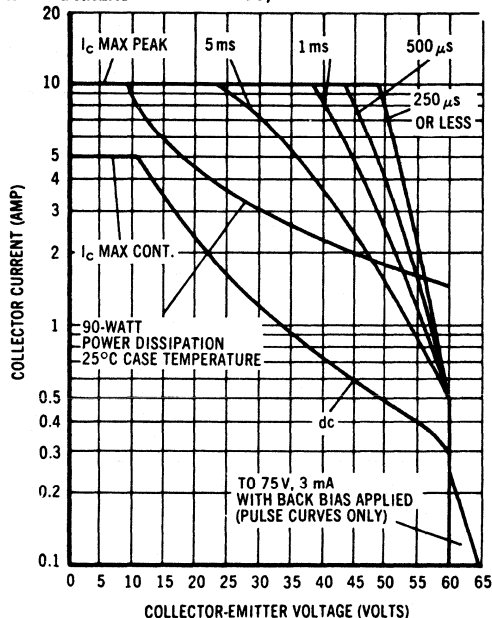
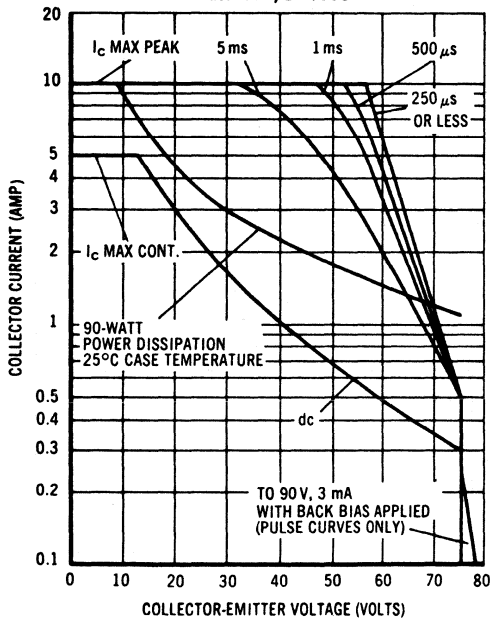
CURRENT GAIN versus COLLECTOR CURRENT



2N1362, 2N1363

SAFE OPERATING AREAS

2N375, 2N618



The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short.

(Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N376A (GERMANIUM)

For Specifications, See 2N350A Data.

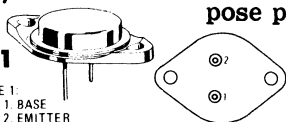
2N378 thru 2N380 (GERMANIUM)

2N459, A

PNP germanium power transistors for general purpose power amplifier and switching applications.

CASE 11

STYLE 1
PIN 1. BASE
2. EMITTER
CASE-COLLECTOR



MAXIMUM RATINGS

Rating	Symbol	2N378	2N379	2N380	2N459	2N459A	Unit
Collector-Emitter Voltage	V_{CEO}	20	40	30	60	60	Vdc
Collector-Emitter Voltage ($V_{BE} = 1.5 \text{ V}$) ($V_{BE} = 1.0 \text{ V}$)	V_{CEX}	40 -	80 -	60 -	- 105	- 105	Vdc
Collector-Emitter Voltage	V_{CES}	-	-	-	70	70	Vdc
Collector-Base Voltage	V_{CB}	-	-	-	-	105	Vdc
Emitter-Base Voltage	V_{EB}	-	-	-	10	25	Vdc
Collector Current	I_C	5.0					Adc
Operating Junction Temperature Range	T_J	-65 to +110					°C
Total Device Dissipation @ $T_C = 25^\circ \text{C}$	P_D	106					Watts

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ \text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 100 \text{ mAdc}$)	2N378 2N379 2N380 2N459, 2N459A	BV_{CEO}	20 40 30 60	- - - -	Vdc
Collector Cutoff Current ($V_{CE} = 40 \text{ Vdc}$, $V_{BE(off)} = 1.5 \text{ Vdc}$) ($V_{CE} = 60 \text{ Vdc}$, $V_{BE(off)} = 1.5 \text{ Vdc}$) ($V_{CE} = 80 \text{ Vdc}$, $V_{BE(off)} = 1.5 \text{ Vdc}$) ($V_{CE} = 105 \text{ Vdc}$, $V_{BE(off)} = 1.5 \text{ Vdc}$) ($V_{CE} = 105 \text{ Vdc}$, $V_{BE(off)} = 1.0 \text{ Vdc}$)	2N378 2N380 2N379 2N459 2N459A	I_{CEX}	- - - - -	10 10 10 10 10	mAdc
Collector Cutoff Current ($V_{CB} = 25 \text{ Vdc}$) ($V_{CB} = 25 \text{ Vdc}$, $T_C = 85^\circ \text{C}$)		I_{CBO}	- -	0.5 7.5	mAdc
Emitter Cutoff Current ($V_{BE} = 10 \text{ Vdc}$) ($V_{BE} = 25 \text{ Vdc}$)	2N380 2N459 2N459A	I_{EBO}	- - -	1.5 2.0 2.0	mAdc

2N378, thru 2N380 2N459, 2N459 A (continued)**ELECTRICAL CHARACTERISTICS (continued)**

Characteristic	Symbol	Min	Max	Unit
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ON CHARACTERISTICS

DC Current Gain ($I_C = 2.0 \text{ A dc}$, $V_{CE} = 2.0 \text{ V dc}$)	2N378 2N379, 2N459 2N380 2N459A 2N459A	h_{FE}	40 20 30 40 20	80 70 70 70 -	-
Collector-Emitter Saturation Voltage ($I_C = 2.0 \text{ A dc}$, $I_B = 0.2 \text{ A dc}$)	2N378-2N380, 2N459 2N459A	$V_{CE(sat)}$	- -	1.0 0.3	Vdc
Base-Emitter Voltage ($I_C = 2.0 \text{ A dc}$, $V_{CE} = 2.0 \text{ V dc}$)	2N378 2N379, 2N459, 2N459A 2N380	$V_{BE(on)}$	- - -	1.6 1.3 1.0	Vdc

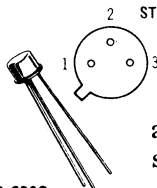
DYNAMIC CHARACTERISTICS

Common-Emitter Cutoff Frequency ($I_C = 1.0 \text{ A dc}$, $V_{CE} = 2.0 \text{ V dc}$)	2N378-2N380, 2N459	f_{ce}	5.0	-	kHz
($I_C = 2.0 \text{ A dc}$, $V_{CE} = 2.0 \text{ V dc}$)	2N459A		5.0	-	

2N381 thru 2N383 (GERMANIUM)

2N2171

CASE 31
(TO-5)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

PNP germanium transistors for small-signal audio amplifiers, Class B push-pull output stages and medium-speed switching circuits.

Base connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	50	Volts
Collector-Emitter Voltage ($R_{BE} = 10K$)	V_{CER}	25	Volts
Emitter-Base Voltage	V_{EB}	20	Volts
Collector Current	I_C	400	mA
Junction Temperature	T_J	-65 to +100	$^{\circ}C$
Collector Dissipation $T_A = 25^{\circ}C$ derate $T_C = 25^{\circ}C$ derate	P_D	225 3.0 500 6.7	mW mW/ $^{\circ}C$ mW mW/ $^{\circ}C$

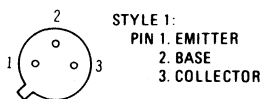
ELECTRICAL CHARACTERISTICS ($T_C = 25^{\circ}C$ unless otherwise noted)

Characteristics	Symbol	Min	Typical	Max	Unit
Collector-Base Cutoff Current ($V_{CB} = -25$ Vdc)	I_{CBO}	---	6.0	10	μA dc
Emitter-Base cutoff Current ($V_{EB} = -20$ Vdc)	I_{EBO}	---	5.0	10	μA dc
Collector-Emitter Voltage ($I_C = 500 \mu A$ dc, $R_{BE} = 10K$)	V_{CER}	25	---	---	Vdc
Collector-Emitter Voltage ($I_C = 50 \mu A$ dc, $V_{BE} = 1.0$ Vdc)	V_{CER}	---	50	---	Vdc
		---	45	---	
DC Current Gain ($I_C = 20$ mA, $V_{CE} = -1.0$ Vdc)	h_{FE}	35	---	65	---
		60	---	95	
		75	---	120	
		110	---	250	
($I_C = 100$ mA, $V_{CE} = -1.0$ Vdc)		30	---	---	
		50	---	---	
		65	---	---	
		90	---	---	

ELECTRICAL CHARACTERISTICS (continued)

Characteristics	Symbol	Min	Typical	Max	Unit
Small Signal Current Gain $(I_C = 10 \text{ mA}, V_{CE} = -5.0 \text{ V}, f = 1 \text{ kHz})$ 2N381 2N382 2N383 2N2171	h_{fe}	35 70 90 120	60 90 115 210	85 135 155 310	---
Voltage Feedback Ratio $(I_C = 10 \text{ mA}, V_{CE} = -5 \text{ V}, f = 1 \text{ kHz})$ 2N381 2N382 2N383 2N2171	h_{re}	--- --- --- ---	0.66 0.69 0.72 0.75	--- --- --- ---	$\times 10^{-3}$
Input Impedance $(I_C = 10 \text{ mA}, V_{CE} = -5.0 \text{ V}, f = 1 \text{ kHz})$ 2N381 2N382 2N382 2N2171	h_{ie}	--- --- --- ---	300 450 550 850	--- --- --- ---	ohms
Output Admittance $(I_C = 10 \text{ mA}, V_{CE} = -5.0 \text{ V}, f = 1 \text{ kHz})$ 2N381 2N382 2N383 2N2171	h_{oe}	--- --- --- ---	420 400 380 500	--- --- --- ---	μmhos
Transducer Gain $(R_g = 300 \Omega, R_L = 500 \Omega)$ $(R_g = 450 \Omega, R_L = 500 \Omega)$ $(R_g = 550 \Omega, R_L = 500 \Omega)$ $(R_g = 785 \Omega, R_L = 500 \Omega)$ 2N381 2N382 2N383 2N2171	G_T	--- --- --- ---	36 38 39.5 42.5	--- --- --- ---	dB
Output Capacitance $(I_C = 1 \text{ mA}, V_{CB} = -6\text{V})$	C_{ob}	---	20	---	pF
Noise Figure $(I_C = 1 \text{ mA}, V_{CE} = -6\text{V}, R_g = 1 \text{ kc}, f = 1 \text{ kHz})$ 2N381 2N382 2N383 2N2171	NF	--- --- --- ---	6.0 5.5 5.0 3.5	--- --- --- ---	dB
Cutoff Frequency $(I_C = 1 \text{ mA}, V_{CB} = -6\text{V})$ 2N381 2N382 2N383 2N2171	$f_{\alpha b}$	--- --- --- ---	3.0 4.0 5.0 7.5	--- --- --- ---	MHz

2N398, 2N398 A (GERMANIUM)



CASE 31
(TO-5)

All leads isolated



PNP germanium transistor for high-voltage, audio-frequency applications.

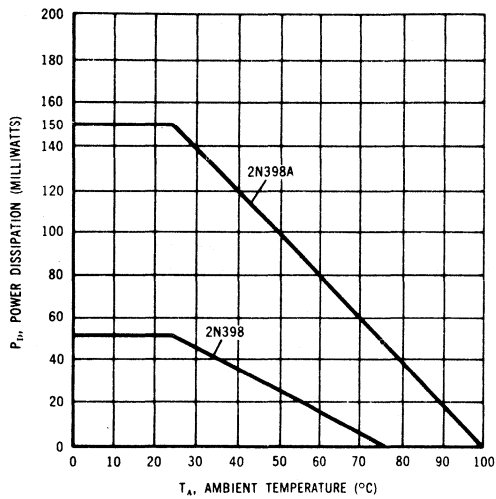
MAXIMUM RATINGS

Rating	Symbol	2N398A	2N398	Unit
Collector-Base Voltage	V_{CB}	105	105	Vdc
Collector-Emitter Voltage	V_{CEO}	105	105	Vdc
Emitter-Base Voltage	V_{EB}	50	50	Vdc
DC Collector Current	I_C	200	100	mA
Emitter Current	I_E	200	100	mA
Junction Temperature	T_J	-65 to +100	-65 to +85	°C
Storage Temperature	T_{stg}	-65 to +100	-65 to +85	°C
Collector Dissipation @ 25°C	P_D	150	50	mW
Thermal Resistance, Junction to Ambient	$\theta_{JA \text{ max}}$	0.5	1.2	°C/mW

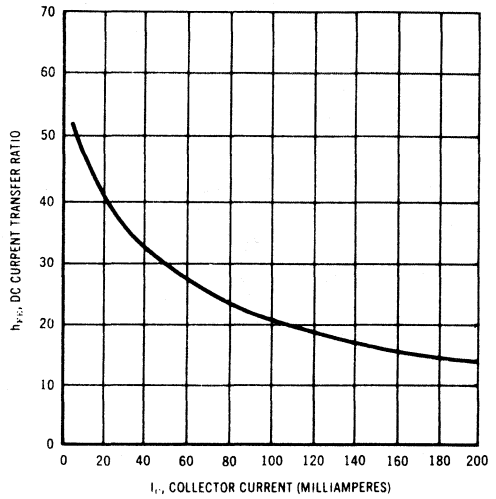
ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristics	Symbol	Min	Typical	Max	Unit
Collector-Base Cutoff Current ($V_{CB} = 105 \text{ V}$, $I_B = 0$)	I_{CBO}	-	12.0	50	μA
Collector-Base Cutoff Current ($V_{CB} = 2.5 \text{ V}$, $I_B = 0$)	I_{CBO}	-	5.0	14	μA
Emitter-Base Cutoff Current ($V_{EB} = 50 \text{ V}$, $I_C = 0$)	I_{EBO}	-	3.0	50	μA
Collector-Emitter Saturation Voltage ($I_C = 5 \text{ mAdc}$; $I_B = 0.25 \text{ mAdc}$)	$V_{CE \text{ (SAT)}}$	-	0.11	0.35	Vdc
Base-Emitter Saturation Voltage ($I_C = 5 \text{ mAdc}$; $I_B = 0.25 \text{ mAdc}$)	$V_{BE \text{ (SAT)}}$	-	0.22	0.40	Vdc
DC Current Transfer Ratio ($I_C = 5 \text{ mAdc}$; $V_{CE} = 0.35 \text{ Vdc}$)	h_{FE}	20	65	-	-
DC Collector-Emitter Punch-Through Voltage (V_{CB} necessary to obtain V_{EB} of -1 V max, using instrument with $Z_{in} > 11 \text{ megohm}$ to measure V_{BE})	V_{PT}	105	160	-	Vdc
Small-Signal Short-Circuit, Forward Current Transfer Ratio Cutoff Frequency ($V_{CB} = 6 \text{ Vdc}$; $I_E = 1 \text{ mAdc}$)	$f_{\alpha b}$	-	1.0	-	MHz

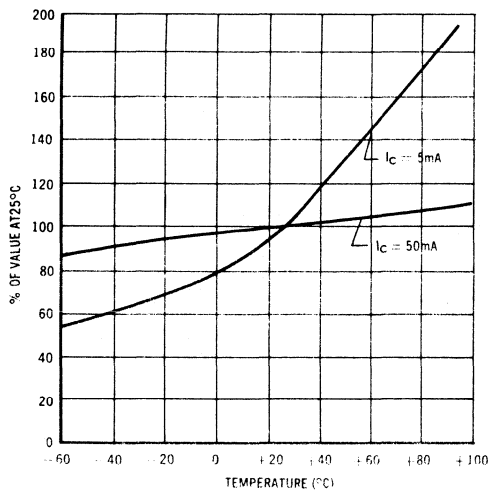
POWER — TEMPERATURE DERATING CURVE



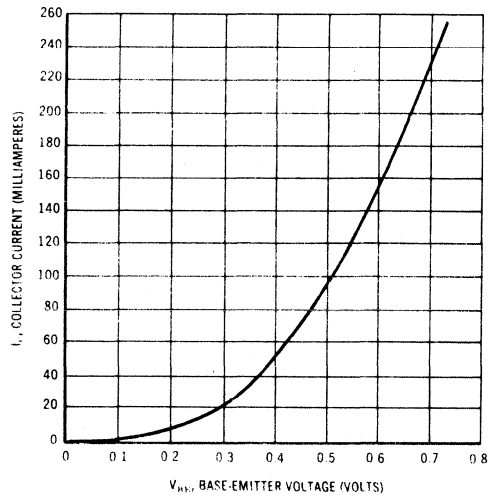
DC CURRENT TRANSFER RATIO versus COLLECTOR CURRENT
 $V_{CE} = 0.35V$



LARGE SIGNAL CURRENT GAIN (h_{FE}) versus TEMPERATURE
(Normalized to 25°C Value; $V_{CE} = 0.35V$)



OUTPUT CURRENT versus BASE-DRIVE VOLTAGE
($V_{CE} = -1V$)



2N441 (GERMANIUM)

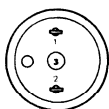
2N442

2N443

PNP germanium power transistors for power switching and amplifier applications. Power and temperature ratings exceed EIA registration.



CASE 5
(TO-36)



STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

Collector connected to case

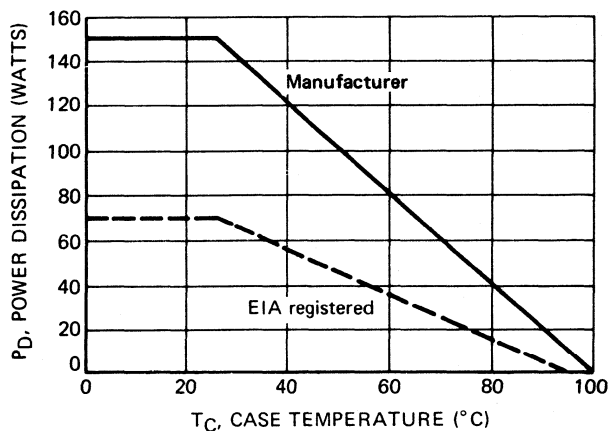
MAXIMUM RATINGS

Rating	Symbol	2N441	2N442	2N443	Unit
Collector-Emitter Voltage	V_{CES}	40	45	50	Vdc
Collector-Base Voltage	V_{CB}	40	50	60	Vdc
Emitter-Base Voltage	V_{EB}	20	30	40	Vdc
Base Current — Continuous	I_B	4.0			Adc
Emitter Current — Continuous	I_E	15			Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$	P_D	150			Watts
Operating Junction Temperature Range (EIA Registered)	T_J	-65 to +95			$^\circ\text{C}$
Operating Junction Temperature Range	T_J	-65 to +100			$^\circ\text{C}$

THERMAL CHARACTERISTICS

Thermal Resistance, Junction to Case (EIA Registered)	θ_{JC}	1.0	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Case	θ_{JC}	0.5	$^\circ\text{C}/\text{W}$

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



The maximum continuous power is related to maximum junction temperature, by the thermal resistance factor.

This curve has a value of 150Watts at case temperatures of 25°C and is 0 Watts at 100°C with a linear relation between the two temperatures such that

$$P_{D \text{ allowable}} = \frac{100^\circ - T_C}{0.5}$$

2N441 thru 2N443 (continued)

ELECTRICAL CHARACTERISTICS (T_c = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
----------------	--------	-----	-----	-----	------

OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage* (I _C = 1.0 Adc, I _B = 0)	2N441 2N442 2N443	BV _{CEO} *	25 30 45	- - -	- - -	Vdc
Collector-Emitter Breakdown Voltage* (I _C = 300 mAdc, V _{BE} = 0)	2N441 2N442 2N443	BV _{CES} *	40 45 50	- - -	- - -	Vdc
Floating Potential (V _{CB} = 40 Vdc, I _E = 0) (V _{CB} = 50 Vdc, I _E = 0) (V _{CB} = 60 Vdc, I _E = 0)	2N441 2N442 2N443	V _{EBF}	- - -	- - -	1.0 1.0 1.0	Vdc
Collector Cutoff Current (V _{CB} = 2.0 Vdc, I _E = 0) (V _{CB} = 40 Vdc, I _E = 0) (V _{CB} = 50 Vdc, I _E = 0) (V _{CB} = 60 Vdc, I _E = 0) (V _{CB} = 40 Vdc, I _E = 0, T _B = 71°C) (V _{CB} = 50 Vdc, I _E = 0, T _B = 71°C) (V _{CB} = 50 Vdc, I _E = 0, T _B = 71°C)	2N441 2N442 2N443 2N441 2N442 2N443	I _{CBO}	- - - - - - -	0.1 2.0 2.0 2.0 - - -	- 8.0 8.0 8.0 15 15 15	mAdc
Emitter Cutoff Current (V _{BE} = 20 Vdc, I _C = 0) (V _{BE} = 30 Vdc, I _C = 0) (V _{BE} = 40 Vdc, I _C = 0)	2N441 2N442 2N443	I _{EBO}	- - -	1.0 1.0 1.0	8.0 8.0 8.0	mAdc

ON CHARACTERISTICS

DC Current Gain (I _C = 5.0 Adc, V _{CE} = 2.0 Vdc) (I _C = 12 Adc, V _{CE} = 2.0 Vdc)		h _{FE}	20 -	- 20	40 -	-
Collector-Emitter Saturation Voltage (I _C = 12 Adc, I _B = 2.0 Adc)	2N441 2N442 2N443	V _{CE(sat)}	- - -	0.3 0.3 0.3	- - 1.0	Vdc
Base-Emitter Voltage (I _C = 5.0 Adc, V _{CE} = 2.0 Vdc)	2N441 2N442 2N443	V _{BE}	- - -	0.65 0.65 0.65	- - 0.9	Vdc

DYNAMIC CHARACTERISTICS

Common-Emitter Cutoff Frequency (I _C = 5.0 Adc, V _{CE} = 6.0 Vdc)		f _{ae}	-	10	-	kHz
--	--	-----------------	---	----	---	-----

SWITCHING CHARACTERISTICS

Rise Time (V _{CE} = 12 Vdc, I _C = 12 Adc, I _B = 2.0 Adc)		t _r	-	15	-	μs
Fall Time (I _C = 0, V _{BE} = 6.0 Vdc, R _{BE} = 10 ohms)		t _f	-	15	-	μs

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

TYPICAL COMMON-EMITTER CHARACTERISTICS

FIGURE 2 – OUTPUT CHARACTERISTICS

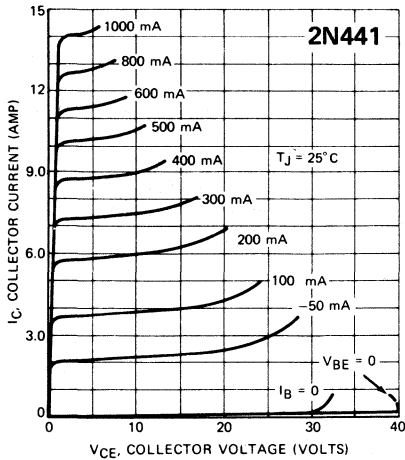


FIGURE 3 – OUTPUT CHARACTERISTICS

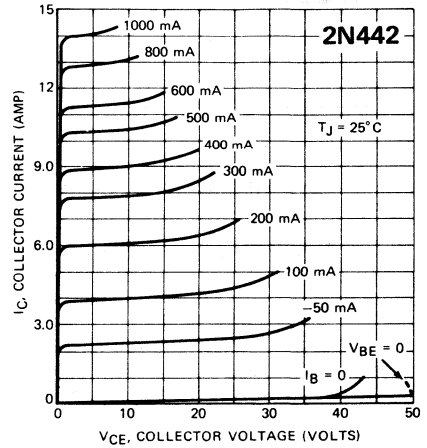


FIGURE 4 – OUTPUT CHARACTERISTICS

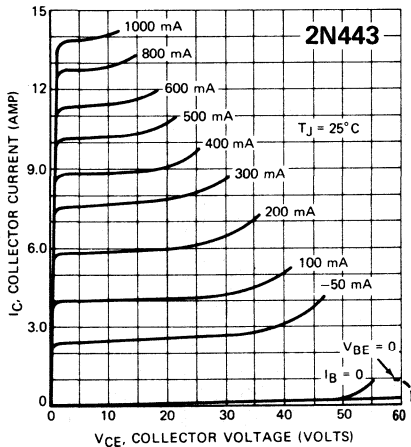


FIGURE 5 – INPUT CHARACTERISTICS

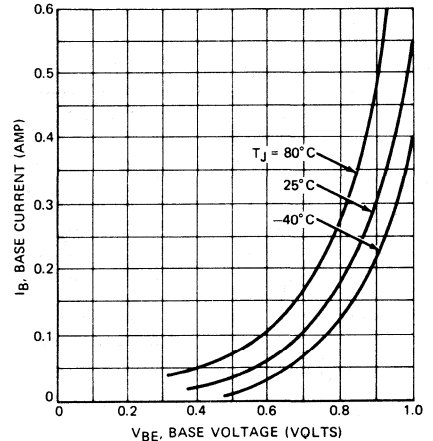


FIGURE 6 – DC CURRENT GAIN TRANSFER CHARACTERISTICS

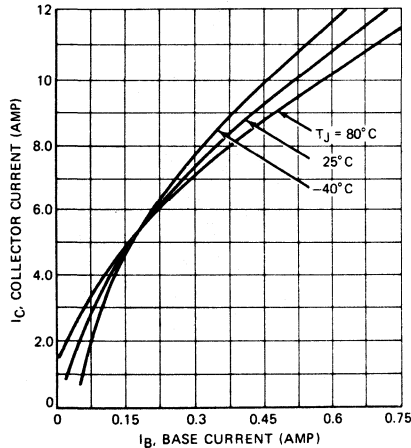
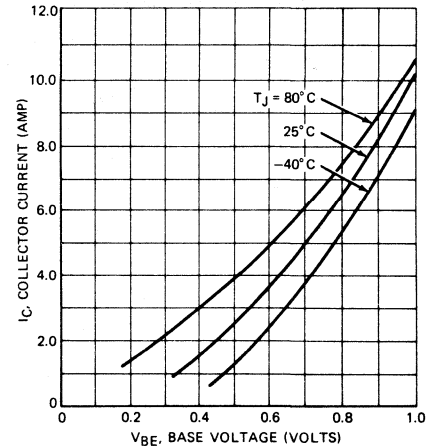


FIGURE 7 – TRANSCONDUCTANCE CHARACTERISTICS



2N456A (GERMANIUM)

2N457A

2N458A

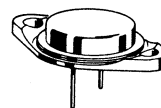
PNP GERMANIUM POWER TRANSISTORS

... designed for general-purpose power amplifier and switching applications.

- High DC Current Gain –
 $h_{FE} = 30\text{-}90$ @ $I_C = 5.0$ Adc
- Low Collector-Emitter Saturation Voltage –
 $V_{CE(sat)} = 0.5$ Vdc (Max) @ $I_C = 5.0$ Adc

7 AMPERE POWER TRANSISTORS PNP GERMANIUM

**40-60-80 VOLTS
85 WATTS**

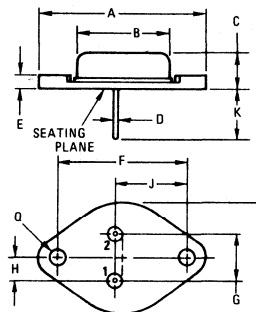
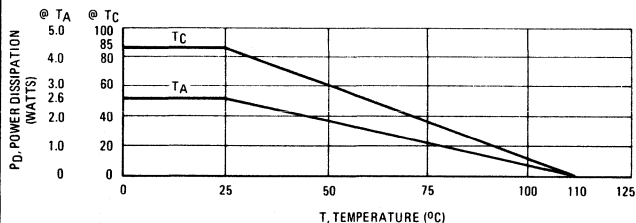


*MAXIMUM RATINGS

Rating	Symbol	2N456A	2N457A	2N458A	Unit
Collector-Emitter Voltage	V_{CEO}	20	30	40	Volts
Collector-Base Voltage	V_{CB}	40	60	80	Volts
Emitter-Base Voltage	V_{EB}	20			Volts
Collector Current	I_C	7.0			Adc
Base Current	I_B	3.0			Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	85 1.0			Watts W/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110			$^\circ\text{C}$

*Indicates JEDEC Registered Data.

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	—	39.37	—	1.550
B	—	21.08	—	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	—	3.43	—	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	—	26.67	—	1.050

Collector connected to case.
CASE 11

2N456A, 2N457A, 2N458A (continued)

*ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

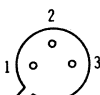
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 200\text{ mA dc}$, $I_B = 0$)	BV_{CEO}	20 30 40	— — —	Vdc
Collector-Base Cutoff Current ($V_{CB} = 20\text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	0.5	mAdc
($V_{CB} = 30\text{ Vdc}$, $I_E = 0$)		—	0.5	
($V_{CB} = 40\text{ Vdc}$, $I_E = 0$)		—	0.5	
($V_{CB} = 40\text{ Vdc}$, $I_E = 0$)		—	2.0	
($V_{CB} = 60\text{ Vdc}$, $I_E = 0$)		—	2.0	
($V_{CB} = 80\text{ Vdc}$, $I_E = 0$)		—	2.0	
($V_{CB} = 40\text{ Vdc}$, $I_E = 0$, $T_C = +71^\circ\text{C}$)		—	10	
($V_{CB} = 60\text{ Vdc}$, $I_E = 0$, $T_C = +71^\circ\text{C}$)		—	10	
($V_{CB} = 80\text{ Vdc}$, $I_E = 0$, $T_C = +71^\circ\text{C}$)		—	10	
Emitter-Base Cutoff Current ($V_{EB} = 20\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	2.0	mAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 1.0\text{ Adc}$, $V_{CE} = 1.5\text{ Vdc}$)	h_{FE}	40	—	—
($I_C = 3.0\text{ Adc}$, $V_{CE} = 1.5\text{ Vdc}$)		35	—	
($I_C = 5.0\text{ Adc}$, $V_{CE} = 1.5\text{ Vdc}$)		30	90	
($I_C = 7.0\text{ Adc}$, $V_{CE} = 1.5\text{ Vdc}$)		22	—	
Collector-Emitter Saturation Voltage ($I_C = 5.0\text{ Adc}$, $I_B = 500\text{ mA dc}$)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Voltage ($I_C = 5.0\text{ Adc}$, $V_{CE} = 1.5\text{ Vdc}$)	V_{BE}	—	1.5	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product ($I_C = 1.0\text{ Adc}$, $V_{CE} = 2.0\text{ Vdc}$)	f_T	200	—	kHz
Input Impedance ($I_C = 5.0\text{ Adc}$, $V_{CE} = 1.5\text{ Vdc}$)	h_{ie}	—	28	Ohms

*Indicates JEDEC Registered Data.

2N459, A (GERMANIUM)

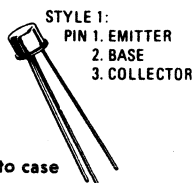
For Specifications, See 2N378 Data.

2N460, 2N461 (GERMANIUM)



CASE 31
(TO-5)

Base connected to case



PNP germanium transistor for general purpose industrial applications.

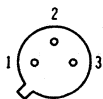
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	45	Volts
Collector-Emitter Voltage ($R_{BE} = 1 \text{ K}$)	V_{CER}	35	Volts
Emitter-Base Voltage	V_{EB}	10	Volts
Collector Current	I_C	400	mA
Collector Dissipation at 25° C Case Temperature Derate above 25° C at 25° C Ambient Temperature Derate above 25° C	P_D	500 6.7 225 3.0	mW mW/° C mW mW/° C
Junction Temperature Range	T_J	-65 to +100	° C

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristics	Symbol	Min	Typical	Max	Unit
Collector-Base Cutoff Current ($V_{CB} = 45 \text{ Vdc}$)	I_{CBO}	---	---	15	μAdc
Emitter-Base Cutoff Current ($V_{EB} = -10 \text{ Vdc}$)	I_{EBO}	---	---	10	μAdc
Collector-Emitter Voltage ($I_C = 1 \text{ mAdc}, R_{BE} = 1 \text{ K}$)	V_{CER}	35	---	---	Vdc
Small-Signal Current Gain ($V_{CB} = -6 \text{ Vdc}, I_E = 1 \text{ mAdc}, f = 1 \text{ kHz}$)	h_{fb}	0.94 0.955	0.96 0.968	0.972 0.988	---
Small-Signal Current Gain ($V_{CB} = -6 \text{ Vdc}, I_E = 1 \text{ mAdc}, f = 1 \text{ kHz}$)	h_{fe}	17 31	---	36 200	---
Reverse Voltage Ratio ($V_{CB} = -6 \text{ Vdc}, I_E = 1 \text{ mAdc}, f = 1 \text{ kHz}$)	h_{rb}	---	2.0 3.0	15 15	$\times 10^{-4}$
Input Resistance ($V_{CB} = -6 \text{ Vdc}, I_E = 1 \text{ mAdc}, f = 1 \text{ kHz}$)	h_{ib}	25 25	30 ---	40 40	Ohms
Output Admittance ($V_{CB} = -6 \text{ Vdc}, I_E = 1 \text{ mAdc}, f = 1 \text{ kHz}$)	h_{ob}	---	0.8 0.5	1.5 1.5	μmho
Frequency Cutoff ($V_{CE} = -5 \text{ Vdc}, I_E = 1 \text{ mAdc}$)	$f_{\alpha b}$	---	1.2 4.0	---	MHz
Output Capacitance ($V_{CB} = -10 \text{ Vdc}, I_E = 1 \text{ mAdc}, f = 1 \text{ MHz}$)	C_{ob}	---	20	---	pF
Noise Figure ($V_{CE} = -4.5 \text{ Vdc}, I_E = 0.5 \text{ mAdc}, R_g = 1 \text{ K}, f = 1 \text{ kHz}$)	NF	---	5.0 4.0	---	dB

2N464 thru 2N467 (GERMANIUM)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

PNP germanium transistor for general purpose applications in the audio-frequency range.

CASE 31
(TO-5)

Base connected to case

MAXIMUM RATINGS

Rating	Symbol	2N464	2N465	2N466	2N467	Unit
Collector-Base Voltage	V_{CB}	45	45	35	35	Volts
Collector-Emitter Voltage	V_{CER}	40	30	20	15	Volts
Emitter-Base Voltage	V_{EB}	12				Volts
DC Collector Current	I_C	500				mA
Max. Junction & Storage Temperature	T_J and T_{stg}	100				°C
Collector Dissipation, Ambient	P_D	200				mW
Derate above 25°C		2.67				mW/°C
Thermal Resistance, Junction to Ambient	θ_{JA}	0.375				°C/mW

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

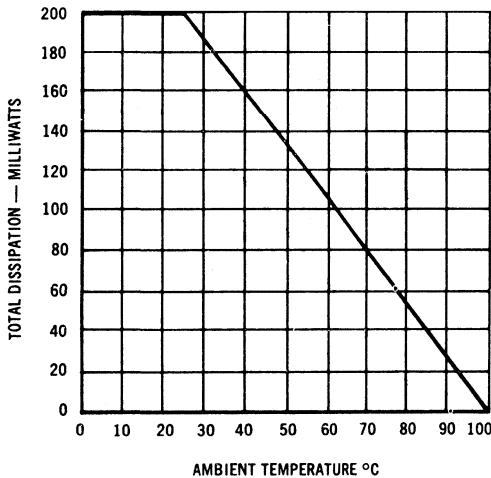
Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage ($I_C = 0.6 \text{ mAdc}$, $R_{BE} = 10 \text{ K ohms}$)	BV_{CER}	40 30 20 15	— — — —	— — — —	Vdc
Collector-Base Cutoff Current ($V_{CB} = 20 \text{ Vdc}$)	I_{CBO}	—	6.0	15	μAdc
Small Signal Current Gain Cutoff Frequency ($V_{CB} = 6 \text{ Vdc}$, $I_E = 1 \text{ mAdc}$)	$f_{\alpha b}$	— — — —	0.7 0.8 1.0 1.2	— — — —	MHz
Small Signal Current Gain ($V_{CE} = 6 \text{ Vdc}$, $I_E = 1.0 \text{ mAdc}$, $f = 1 \text{ kHz}$)	h_{fe}	14 27 56 112	26 45 90 180	— — — —	—

2N464 thru 2N467 (continued)

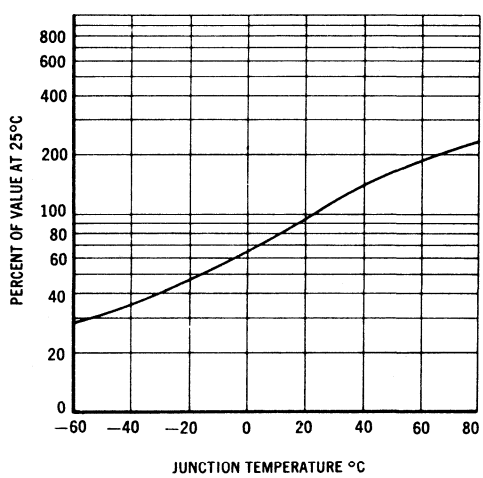
ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Typ	Max	Unit
Small Signal Input Impedance ($V_{CE} = 6 \text{ Vdc}$, $I_E = 1.0 \text{ mAdc}$, $f = 1 \text{ kHz}$)	h_{ie}	—	900	—	Ohms
2N464		—	1400	—	
2N465		—	3000	—	
2N466		—	5500	—	
2N467		—		—	
Small Signal Power Gain ($V_{CE} = 6 \text{ Vdc}$, $I_E = 1.0 \text{ mAdc}$, $f = 1 \text{ kHz}$, matched)	G_e	—	40	—	dB
2N464		—	42	—	
2N465		—	44	—	
2N466		—	45	—	
2N467		—		—	
Noise Figure ($V_{CE} = 2.5 \text{ Vdc}$, $I_E = 0.5 \text{ mAdc}$, $f = 1 \text{ kHz}$, $R_S = 10 \text{ Kohms}$, $\Delta f = 1 \text{ Hz}$)	NF	—	—	22	dB

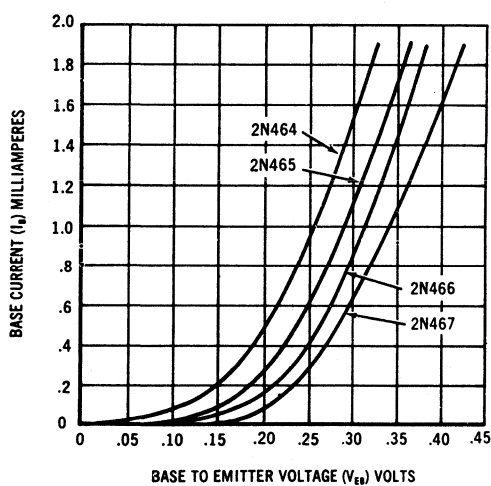
POWER-TEMPERATURE DERATING CURVE



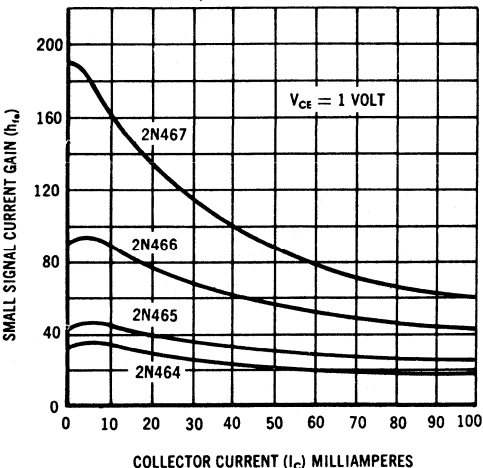
SMALL SIGNAL CURRENT GAIN versus TEMPERATURE



Input Current versus Emitter-Drive Voltage



Small Signal Current Gain versus Collector Current
(common emitter 1 kHz)



2N499 (Ge Mesa)
(2N499 JAN AVAILABLE)

2N499A
(2N499A JAN AVAILABLE)

2N502A JAN AVAILABLE

2N502B JAN AVAILABLE

PNP GERMANIUM HIGH-FREQUENCY TRANSISTORS

... designed for driver applications, small-signal amplification, wide band video amplifiers, and VHF/UHF oscillators.

*MAXIMUM RATINGS

Rating	Symbol	2N499 2N499JAN 2N499A 2N499AJAN	2N502AJAN 2N502BJAN	Unit
Collector-Base Voltage	V_{CB}	30		Vdc
Emitter-Base Voltage	V_{EB}	0.5		Vdc
Collector Current — Continuous	I_C	50		mA dc
Total Power Dissipation @ $T_A = 25^\circ\text{C}$	P_D	60	75	mW
Operating Junction Temperature Range	T_J	100		$^\circ\text{C}$

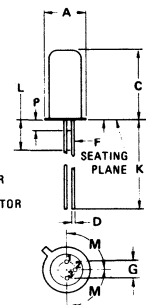
*Indicates JEDEC Registered Data.

PNP GERMANIUM AMPLIFIER TRANSISTORS

2N499, 2N499A
2N499JAN, 2N499AJAN



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR



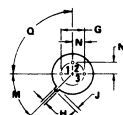
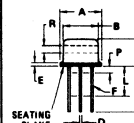
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	—	6.10	—	0.240
C	—	10.41	—	0.410
D	—	0.53	—	0.021
F	0.406	0.483	0.016	0.019
G	1.55	2.06	0.061	0.081
K	38.10	—	1.500	—
L	6.35	—	0.250	—
M	90° NOM		90° NOM	
P	—	1.27	—	0.050

All JEDEC notes and dimensions apply.

CASE 149-02
TO-1



2N502AJAN
2N502BJAN



STYLE 1
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° NOM		45° NOM	
P	—	1.27	—	0.050
Q	90° NOM		90° NOM	
R	2.54	—	0.100	—

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector Cutoff Current ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 15\text{ Vdc}$, $I_E = 0$)	I_{CBO}	— —	4.0 10	Adc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product ($I_C = 2.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 20\text{ MHz}$) 2N499,A, 2N499,AJAN ($I_C = 2.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$) 2N502A,BJAN	f_T	120 150	— 600	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 4.0\text{ MHz}$)	C_{ob}	— —	2.5 1.6	pF
Small-Signal Current Gain ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 9.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) 2N499,A, 2N499,AJAN ($I_C = 2.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$) 2N502AJAN 2N502BJAN	h_{fe}	20 15 25	80 200 80	—
Collector-Base Time Constant ($I_E = 2.0\text{ mAdc}$, $V_{CB} = 10\text{ Vdc}$, $f = 46\text{ MHz}$)	$r_b'C_c$	5.0 — 5.0 5.0	50 250 250 25	ps
Noise Figure ($I_E = 2.0\text{ mAdc}$, $V_{CB} = 10\text{ Vdc}$, $f = 200\text{ MHz}$) 2N502A,BJAN	NF	—	7.0	dB
FUNCTIONAL TEST				
Common-Emitter Amplifier Power Gain ($V_{CB} = 10\text{ Vdc}$, $I_E = 2.0\text{ mAdc}$, $f = 100\text{ MHz}$) 2N499,A,2N499,AJAN ($V_{CB} = 10\text{ Vdc}$, $I_E = 2.0\text{ mAdc}$, $f = 200\text{ MHz}$) 2N502A,BJAN	G_{pe}	7.5 10	— 20	dB

*Indicates JEDEC Registered Data.

2N508 (GERMANIUM)

For Specifications, See 2N322 Data

2N508A (GERMANIUM)

PNP Germanium Milliwatt transistor designed for low noise audio and switching applications.

- Small-Signal Current Gain –
 $h_{fe} = 180 \text{ (Max) @ } I_E = 1.0 \text{ mAdc}$
- Low Noise Figure Applications –
 $NF = 5.0 \text{ dB (Max) @ } I_C = 1.0 \text{ mAdc}$

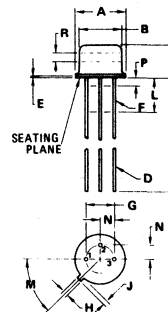
PNP GERMANIUM AUDIO AND SWITCHING TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*Collector-Emitter Voltage ($R_{BE} = 10 \text{ kohms}$)	V_{CER}	25	Vdc
*Collector-Emitter Voltage	V_{CES}	30	Vdc
*Collector-Base Voltage	V_{CB}	30	Vdc
*Emitter-Base Voltage	V_{EB}	10	Vdc
*Collector Current	I_C	200	mAdc
*Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	200 2.67	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100	$^\circ\text{C}$

*Indicates JEDEC Registered Data



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	5.08	BSC	0.200	BSC
H	0.711	0.864	0.028	0.034
J	0.734	1.14	0.029	0.045
K	38.10	—	1.500	—
L	6.35	—	0.250	—
M	45.0	BSC	45.0	BSC
N	2.54	BSC	0.100	BSC
P	—	1.27	—	0.050
R	2.54	—	0.100	—
S	—	0.179	—	0.007

All JEDEC dimensions and notes apply.

CASE 31-03
TO-5

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

*Collector-Emitter Breakdown Voltage ($I_C = 600\ \mu\text{Adc}$, $R_{BE} = 10\ \text{k ohms}$)	BV_{CER}	25	-	Vdc
*Collector Cutoff Current ($V_{CB} = 25\ \text{Vdc}$, $I_E = 0$)	I_{CBO}	-	7.0	μAdc
*Emitter Cutoff Current ($V_{BE} = 10\ \text{Vdc}$, $I_C = 0$)	I_{EBO}	-	7.0	μAdc

ON CHARACTERISTICS

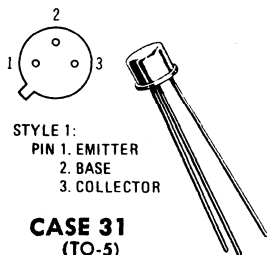
*DC Current Gain ($I_C = 20\ \text{mAdc}$, $V_{CE} = 1.0\ \text{Vdc}$)	h_{FE}	100	200	-
*Base-Emitter Voltage ($I_C = 20\ \text{mAdc}$, $V_{CE} = 1.0\ \text{Vdc}$)	V_{BE}	0.18	0.32	Vdc

SMALL-SIGNAL CHARACTERISTICS

*Cutoff Frequency ($I_E = 1.0\ \text{mAdc}$, $V_{CB} = 5.0\ \text{Vdc}$, $f = 1.0\ \text{kHz}$)	f_{ob}	2.5	-	MHz
*Output Capacitance ($V_{CB} = 5.0\ \text{Vdc}$, $I_E = 1.0\ \text{mAdc}$, $f = 1.0\ \text{MHz}$)	C_{ob}	-	35	pF
*Input Impedance ($I_E = 1.0\ \text{mAdc}$, $V_{CB} = 5.0\ \text{Vdc}$, $f = 1.0\ \text{kHz}$)	h_{ib}	26	31	Ohms
*Voltage Feedback Ratio ($I_E = 1.0\ \text{mAdc}$, $V_{CB} = 5.0\ \text{Vdc}$, $f = 1.0\ \text{kHz}$)	h_{rb}	1×10^{-4}	17×10^{-4}	-
*Small-Signal Current Gain ($I_E = 1.0\ \text{mAdc}$, $V_{CB} = 5.0\ \text{Vdc}$, $f = 1.0\ \text{kHz}$)	h_{fe}	75	180	-
*Output Admittance ($I_E = 1.0\ \text{mAdc}$, $V_{CB} = 5.0\ \text{Vdc}$, $f = 1.0\ \text{kHz}$)	h_{ob}	0.1	0.9	μmhos
Noise Figure ($I_C = 1.0\ \text{mAdc}$, $V_{CB} = 5.0\ \text{Vdc}$, $R_S = 500\ \text{ohms}$, $f = 1.0\ \text{kHz}$, $\Delta f = 1.0\ \text{Hz}$)	NF	-	5.0	dB

*Indicates JEDEC Registered Data.

2N524 thru 2N527 (GERMANIUM)



PNP germanium transistor for switching and amplifier applications in the audio-frequency range. Available for military and high-reliability industrial purposes.

Base connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	45	Vdc
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Emitter-Base Voltage	V_{EB}	15	Vdc
Collector Current	I_C	500	mAdc
Storage and Operating Temperature	T_{stg}, T_J	-65 to +100	°C
Collector Dissipation @ 25°C Ambient	P_D	225	mW
Thermal Resistance Junction to Ambient	θ_{JA}	0.333	°C/mW
Thermal Resistance (infinite heat sink)	θ_{JC}	0.15	°C/mW

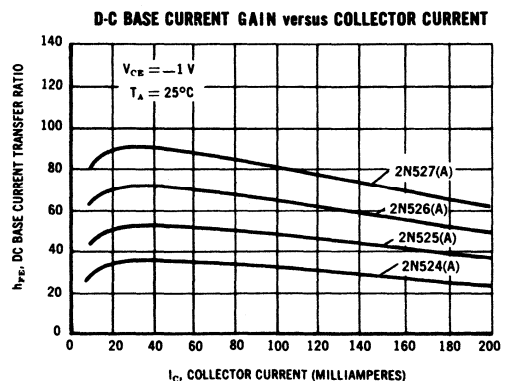
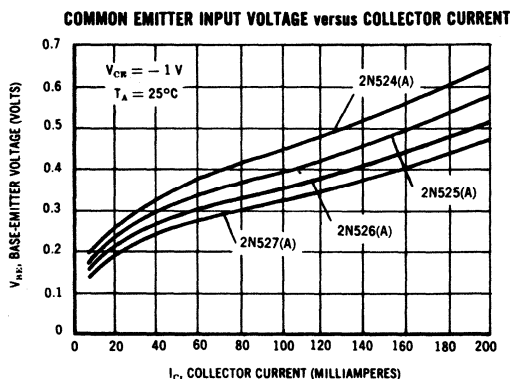
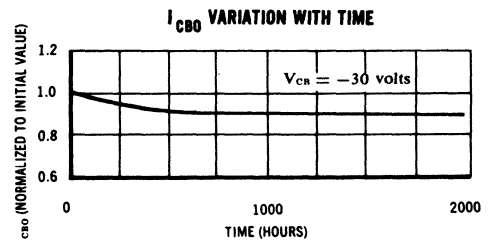
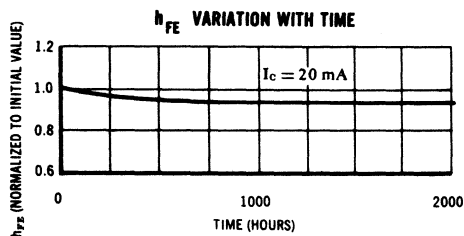
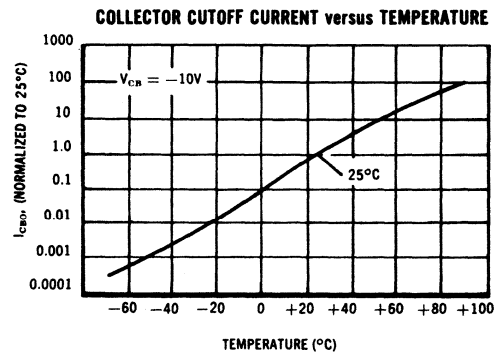
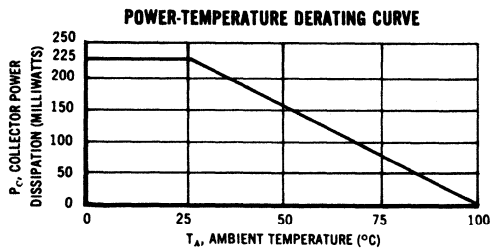
ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise specified)

Characteristics	Symbol	Min	Max	Unit
Collector Cutoff Current ($V_{CB} = 30 \text{ Vdc}$, $I_E = 0$)	I_{CBO}	-	10	μAdc
Emitter Cutoff Current ($V_{EB} = 15 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	-	10	μAdc
Collector-Emitter Breakdown Voltage ($I_C = 0.6 \text{ mAdc}$, $R_{BE} = 10\text{K}$)	BV_{CER}	30	-	Vdc
Collector-Emitter Reach Through (Punch-Thru) Voltage ($V_{EB} = 1 \text{ Vdc}$, $VTVM Z \geq 1 \text{ Megohm}$)	V_{RT}	30	-	Vdc
Static Forward-Current Transfer Ratio ($V_{CE} = 1 \text{ Vdc}$, $I_C = 20 \text{ mAdc}$)	h_{FE}	25	42	-
2N524		34	65	-
2N525		53	90	-
2N526		72	121	-
2N527				
Small-Signal Short-Circuit Forward Current Transfer Ratio Frequency Cutoff ($V_{CB} = 5 \text{ Vdc}$, $I_E = 1 \text{ mAdc}$)	$f_{\alpha b}$	0.8	5.0	MHz
2N524		1.0	5.5	
2N525		1.3	6.5	
2N526		1.5	7.0	
2N527				
Output Capacitance ($V_{CB} = 5 \text{ Vdc}$, $I_E = 1 \text{ mAdc}$, $f = 1 \text{ MHz}$)	C_{ob}	5.0	40	pF
Small-Signal Open Circuit Output Admittance ($V_{CB} = 5 \text{ Vdc}$, $I_E = 1 \text{ mAdc}$, $f = 1 \text{ kHz}$)	h_{ob}	0.10	1.3	μmho
2N524		0.10	1.2	
2N525		0.10	1.0	
2N526		0.10	0.9	
2N527				
Small-Signal Open Circuit Reverse Transfer Voltage Ratio ($V_{CB} = 5 \text{ Vdc}$, $I_E = 1 \text{ mAdc}$, $f = 1 \text{ kHz}$)	h_{rb}	1.0	10	$\times 10^{-4}$
2N524		1.0	11	
2N525		1.0	12	
2N526		1.0	14	
2N527				
Small-Signal Short Circuit Input Impedance ($V_{CB} = 5 \text{ Vdc}$, $I_E = 1 \text{ mAdc}$, $f = 1 \text{ kHz}$)	h_{ib}	26	36	ohms
2N524		26	35	
2N525		26	33	
2N526		26	31	
2N527				
Collector-Emitter Saturation Voltage ($I_B = 2 \text{ mAdc}$, $I_C = 20 \text{ mAdc}$)	$V_{CE(sat)}$	-	130	mVdc
2N524		-	130	
($I_B = 1.33 \text{ mAdc}$, $I_C = 20 \text{ mAdc}$)		-	130	
2N525		-	130	
($I_B = 1.0 \text{ mAdc}$, $I_C = 20 \text{ mAdc}$)		-	130	
2N526		-	130	
($I_B = 0.67 \text{ mAdc}$, $I_C = 20 \text{ mAdc}$)		-	130	
2N527		-	130	
Base Input Voltage ($V_{CE} = 1 \text{ Vdc}$, $I_C = 20 \text{ mAdc}$)	V_{BE}	220	320	mVdc
2N524		200	300	
2N525		190	280	
2N526		180	260	
2N527				

2N524 thru 2N527 (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristics	Symbol	Min	Max	Unit
Noise Figure ($V_{CB} = 5 \text{ Vdc}$, $I_E = 1 \text{ mAdc}$, $f = 1 \text{ kHz}$, $BW = 1 \text{ Hz}$)	NF	-	15	dB
Small-Signal Short-Circuit Forward-Current Transfer Ratio ($V_{CE} = 5 \text{ Vdc}$, $I_E = 1 \text{ mAdc}$, $f = 1 \text{ kHz}$)	h_{fe}			-
2N524		18	41	
2N525		30	64	
2N526		44	88	
2N527		60	120	



2N554 (GERMANIUM)

2N555

For Specifications, See 2N178 Data.

2N618 (GERMANIUM)

For Specifications, See 2N375 Data.

2N650A, 2N650 (GERMANIUM)

2N651A, 2N651

2N652A, 2N652

GERMANIUM PNP MILLIWATT TRANSISTORS

...designed primarily for low-power audio amplifier and medium-speed switching applications.

- Stabilization Bake at 100°C for 120 Hours for Greater Gain Stability
- Low Collector-Emitter Saturation Voltage – 0.2 Vdc Typ @ $I_C = 200$ mA

* MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage ($R_{BE} = 10$ k ohms)	V_{CE}	30	Vdc
Collector-Base Voltage	V_{CB}	45	Vdc
Emitter-Base Voltage	V_{EB}	30	Vdc
Collector Current – Continuous (1)	I_C	500	mA dc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$	P_D	200	mW
Derate above 25°C		2.67	mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100	$^\circ\text{C}$

Maximum lead temperature is 250°C for 3.0 seconds.

1/16" $\pm$ 1/32" from case.

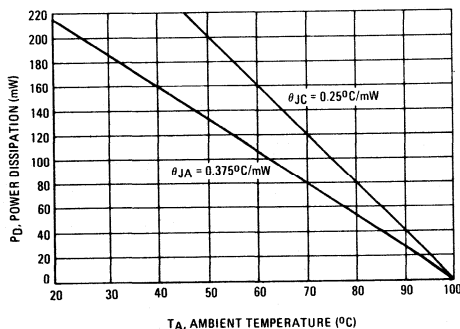
(1) Limited by power dissipation.

* THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.250	$^\circ\text{C}/\text{mW}$
Thermal Resistance, Junction to Ambient	θ_{JA}	0.375	$^\circ\text{C}/\text{mW}$

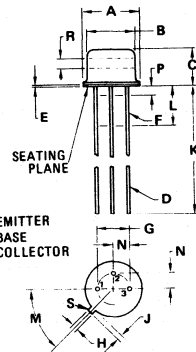
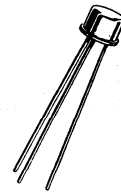
*Indicates JEDEC Registered Data.

FIGURE 1 – POWER-TEMPERATURE DERATING



AUDIO TRANSISTORS GERMANIUM PNP

45 VOLTS
200 MILLIWATTS



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	5.08	BSC	0.200	BSC
H	0.711	0.864	0.028	0.034
J	0.734	1.14	0.029	0.045
K	38.10	—	1.500	—
L	6.35	—	0.250	—
M	45.0	BSC	45.0	BSC
N	2.54	BSC	0.100	BSC
P	—	1.27	—	0.050
R	2.54	—	0.100	—
S	—	0.179	—	0.007

All JEDEC dimensions and notes apply.

CASE 31-03
TO-5

2N650A, 2N650/2N651A, 2N651/2N652A, 2N652 (continued)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Floating Potential (1) ($V_{CB} = .45 \text{ Vdc}$, $I_E = 0$, voltmeter input resistance $\geq 10 \text{ megohms}$)	V_{EBF}	—	1.0	Vdc
Collector Cutoff Current ($V_{CE} = 30 \text{ Vdc}$, $R_{BE} = 10 \text{ k ohms}$)	I_{CER}	—	600	μAdc
Collector Cutoff Current ($V_{CB} = 30 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 45 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $T_A = +71^\circ\text{C}$)	I_{CBO}	— — —	10 50 100	μAdc
Emitter Cutoff Current ($V_{EB} = 30 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	10	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 10 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$)	2N650 2N650A 2N651, A 2N652, A	h_{FE}	30 33 45 80	— — — —	—
Collector-Emitter Saturation Voltage ($I_C = 50 \text{ mAdc}$, $I_B = 2.5 \text{ mAdc}$) ($I_C = 50 \text{ mAdc}$, $I_B = 1.67 \text{ mAdc}$) ($I_C = 50 \text{ mAdc}$, $I_B = 1.25 \text{ mAdc}$) ($I_C = 100 \text{ mAdc}$, $I_B = 5.0 \text{ mAdc}$) ($I_C = 100 \text{ mAdc}$, $I_B = 3.33 \text{ mAdc}$) ($I_C = 100 \text{ mAdc}$, $I_B = 2.5 \text{ mAdc}$)	2N650, A 2N651, A 2N652, A 2N650, A 2N651, A 2N652, A	$V_{CE(sat)}$	— — — — — —	0.250 0.250 0.250 0.500 0.500 0.500	Vdc
Base-Emitter Voltage ($I_C = 10 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$)	2N650, A 2N651, A 2N652, A	V_{BE}	— — —	0.270 0.260 0.250	Vdc

SMALL-SIGNAL CHARACTERISTICS

Common-Base Cutoff Frequency ($I_E = 1.0 \text{ mAdc}$, $V_{CB} = 6.0 \text{ Vdc}$)	2N650, A 2N651, A 2N652, A	$f_{\alpha b}$	0.75 1.0 1.25	— — —	MHz
Output Capacitance (1) ($V_{CB} = 6.0 \text{ Vdc}$, $I_E = 0$, $f = 1.0 \text{ MHz}$)		C_{ob}	—	25	pF
Input Impedance ($I_E = 1.0 \text{ mAdc}$, $V_{CB} = 6.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)		h_{ib}	27	37	Ohms
Small-Signal Current Gain ($I_E = 1.0 \text{ mAdc}$, $V_{CE} = 6.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	2N650, A 2N651, A 2N652, A	h_{fe}	30 50 100	70 120 225	—
Output Admittance (1) ($I_E = 1.0 \text{ mAdc}$, $V_{CB} = 6.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)		h_{ob}	0.15	1.0	μmhos
Noise Figure ($I_E = 0.5 \text{ mAdc}$, $V_{CE} = 4.5 \text{ Vdc}$, $R_S = 1.0 \text{ k ohms}$, $f = 1.0 \text{ kHz}$, $\Delta f = 1.0 \text{ Hz}$)		NF	—	15	dB

(1) Applies only to 2N650A, 2N651A, and 2N652A Devices

*Indicates JEDEC Registered Data.

FIGURE 2 — DC CURRENT GAIN

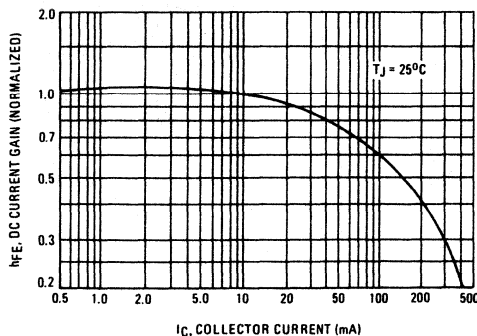
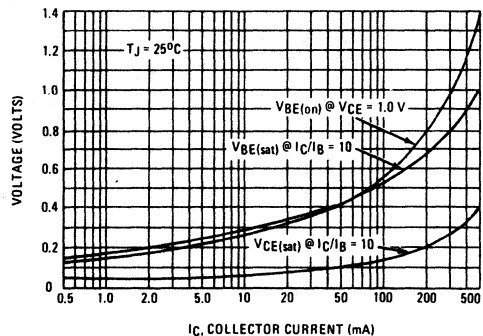


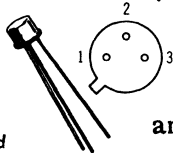
FIGURE 3 — "ON" VOLTAGES



2N653 thru 2N655 (GERMANIUM)

CASE 31 (TO-5)

All leads isolated



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

PNP germanium transistor, for high-gain amplifier and switching service in the audio frequency range.

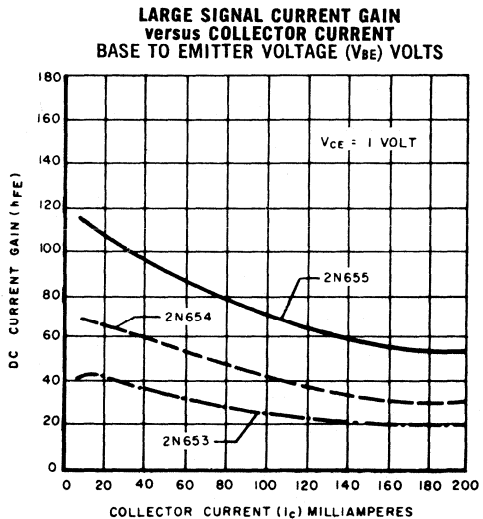
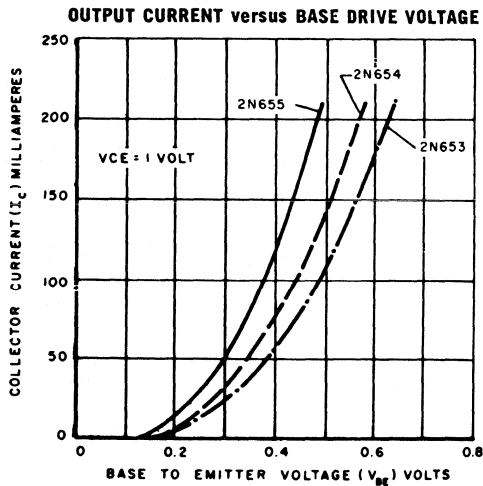
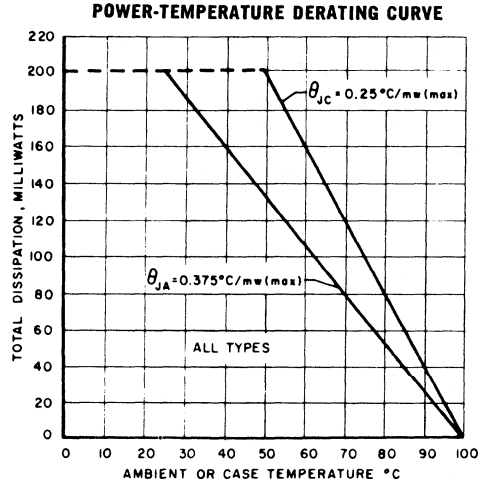
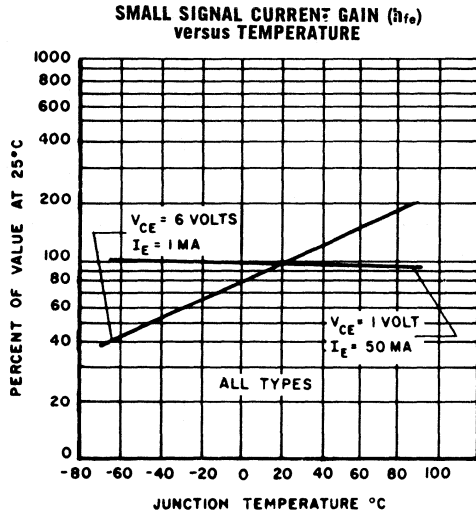
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector to Base Voltage	V_{CB}	30	Volts
Collector to Emitter Voltage	V_{CER}	25	Volts
Emitter to Base Voltage	V_{EB}	25	Volts
Collector D. C. Current *	I_C	250*	mA
Junction Temperature Limits	T_J	-65 to +100	°C
Storage Temperature Limits	T_{stg}	-65 to +100	°C
Collector Dissipation in, Ambient Derate 2.67 mW/°C above 25°C	P_D	200	mW
Thermal Resistance, Junction to Ambient	θ_{JA}	0.375	°C/mW

*Limited by power dissipation.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristics	Symbol	2N653			2N654			2N655			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Small Signal Current Gain $V_{CE} = 6\text{ V}, I_E = 1.0\text{ mA}, f = 1\text{ kHz}$	h_{fe}	30	49	70	50	80	125	100	130	250	-
Small Signal Input Impedance $V_{CE} = 6\text{ V}, I_E = 1.0\text{ mA}, f = 1\text{ kHz}$	h_{ie}	750	-	2900	1500	-	4700	3000	-	8500	ohms
Small Signal Current Gain Cutoff Frequency $V_{CB} = 6\text{ V}, I_E = 1.0\text{ mA}$	$f_{\alpha b}$		1.5			2.0			2.5		MHz
Output Capacity $V_{CB} = 6\text{ V}, I_E = 0\text{ mA}, f = 1\text{ MHz}$	C_{ob}		10			10			10		pF
Noise Figure $V_{CE} = 4.5\text{ V}, I_E = 0.5\text{ mA},$ $R_s = 1, f = \text{kHz}$ $\Delta f = 1\text{ Hz}$	NF		10			10			10		dB
Collector Reverse Current $V_{CB} = 25\text{ V}, I_E = 0$	I_{CBO}		5.0	15		5.0	15		5.0	15	μA
Emitter Reverse Current $V_{EB} = 25\text{ V}, I_C = 0$	I_{EBO}		5.0	15		5.0	15		5.0	15	μA
Collector-Emitter Reverse Current $V_{CE} = 25\text{ V}, R_{BE} = 10\text{ k}$	I_{CER}			600			600			600	μA
Base-Emitter Input Voltage $V_{CE} = 6\text{ V}, I_C = 1.0\text{ mA}$	V_{BE}			0.3			0.3			0.3	Vdc



2N656S (SILICON)

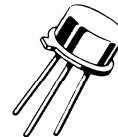
2N657S

NPN SILICON ANNULAR TRANSISTORS

... NPN silicon annular transistor designed for small-signal amplifier and general purpose switching applications.

- High Collector-Emitter Breakdown Voltage –
 $BV_{CEO} = 100 \text{ Vdc (Min) @ } I_C = 250 \mu\text{Adc} - 2N657$
- High Emitter-Base Breakdown Voltage –
 $BV_{EBO} = 8.0 \text{ Vdc (Min) @ } I_E = 250 \mu\text{Adc}$

NPN SILICON ANNULAR TRANSISTORS



*MAXIMUM RATINGS

Rating	Symbol	2N656	2N657	Unit
Collector-Emitter Voltage	V_{CEO}	60	100	Vdc
Collector-Base Voltage	V_{CB}	60	100	Vdc
Emitter-Base Voltage	V_{EB}	8.0		Vdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 5.7	4.0 22.8	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	4.0 22.8		Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 250 \mu\text{Adc}, I_B = 0$)	BV_{CEO}	60 100	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}, I_E = 0$)	BV_{CBO}	60 100	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 250 \mu\text{Adc}, I_C = 0$)	BV_{EBO}	8.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 30 \text{ Vdc}, I_E = 0$)	I_{CBO}	—	10	μAdc

ON CHARACTERISTICS

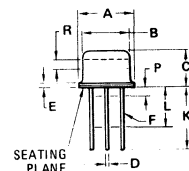
DC Current Gain(1) ($I_C = 200 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	h_{FE}	30	90	—
Collector-Emitter Saturation Voltage(1) ($I_C = 200 \text{ mAdc}, I_B = 40 \text{ mAdc}$)	$V_{CE(sat)}$	—	4.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

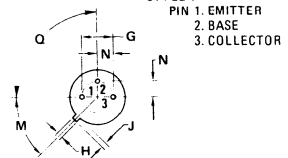
Input Impedance(1) ($I_B = 8.0 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}$)	h_{ie}	—	0.5	k ohm
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*Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Length = 300 μs , Duty Cycle $\leq 2.0\%$.



STYLE 1



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45°	NOM	45°	NOM
P	—	1.27	—	0.050
Q	90°	NOM	90°	NOM
R	2.54	—	0.100	—

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

2N665JAN (GERMANIUM)

GERMANIUM PNP POWER TRANSISTOR

... designed for driver, amplifier, and switching applications, with especially good high-temperature characteristics. These devices feature:

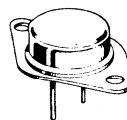
- Very Low Leakage Current — $I_{CBO} = 50 \mu A$ at $V_{CBO} = 2 V$
- High Frequency — 600 kc at $V_{CE} = 12 V$, $I_C = 0.5 A$

MIL-S-19500/58C

**5 AMPERE
POWER TRANSISTORS**

PNP GERMANIUM

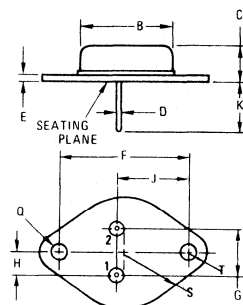
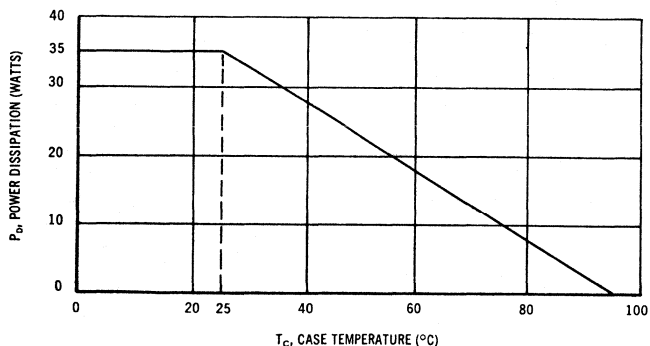
**80 VOLTS
35 WATTS**



MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	40	Vdc
DC Collector Current MIL-S-19500/58C Motorola Unit	I_C	2 3	Amps
DC Emitter Current	I_E	5	Amps
Collector Junction Temperature	T_J	-65 to +95	$^{\circ}C$
Collector Dissipation Derate above 25 $^{\circ}C$	P_C	35 0.5	Watts W/ $^{\circ}C$

FIGURE 1 — POWER DERATING CURVE



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE-COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
B	—	22.23	—	0.875
C	6.35	11.43	0.250	0.450
D	0.97	1.09	0.038	0.043
E	—	3.43	—	0.130
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	7.92	—	0.312	—
Q	3.84	4.09	0.151	0.161
S	—	13.34	—	0.525
T	—	4.78	—	0.188

All JEDEC dimensions and notes apply

CASE 1-03
(TO-3)

TABLE II — GROUP B INSPECTION

Examination or Test	Symbol	Limits		Unit	AQL (percent defective)	Inspection Level
		Min	Max			
SUBGROUP 1 Physical Dimensions	—	—	—	—	6.5	L7 Reduced: L5 Procedure R-1
SUBGROUP 2 Emitter Current ($I_E = 5 \text{ Adc}$, $V_{CB} = 0$, $T_C = 25^\circ \pm 5^\circ\text{C}$, $t = 1 \text{ hr}$) Temperature Cycling (Note 9) (5 cycles, $T = 95^\circ\text{min}$) Moisture Resistance (Note 6) End Points: (Subgroups 2, 3, 4, 6, 7) Emitter Cutoff Current ($V_{EBO} = -40 \text{ Vdc}$, $I_C = 0$) Collector Cutoff Current ($V_{CBO} = -60 \text{ Vdc}$, $I_E = 0$) DC Current Gain ($V_{CE} = -2 \text{ Vdc}$, $I_C = -2 \text{ Adc}$)	— — — — I_{EBO} I_{CBO} h_{FE}	— — — — — — 13	— — — — -4 -4 —	— — — — mAdc mAdc —	4	L4 Reduced: L2 Procedure R-1
SUBGROUP 3 Shock * † (500G, $t \approx 1 \text{ msec}$, 5 blows each in orientations X_1 , Y_1 , Y_2 , and Z_1 , total of 20 blows) Constant Acceleration* (10,000G) Vibration Fatigue * † (10G) Vibration, Variable Frequency (10G, 100 to 1000 cps) End Points: Same as Subgroup 2	— — — — —	— — — — —	— — — — —	— — — — —		
SUBGROUP 4 Barometric Pressure, Reduced (Altitude Operation) ($V_{CBO} = -60 \text{ Vdc}$, $I_{CBO} = -2 \text{ mAdc max}$, $I_E > 0$, 15 mm Hg, $t \approx 60 \text{ sec}$) Salt Spray (Corrosion) (Note 8) * (Test Condition A) End Points: Same as Subgroup 2	— —	— —	— —	— —		
SUBGROUP 5 Thermal Resistance	θ_{J-C}	—	2	$^\circ\text{C/W}$	4	L4 Reduced: L2 Procedure R-1

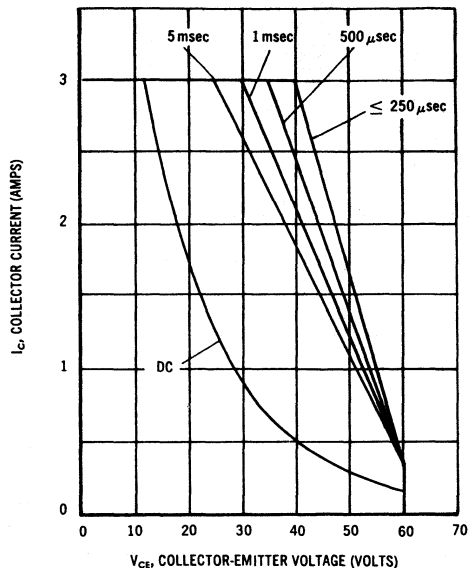
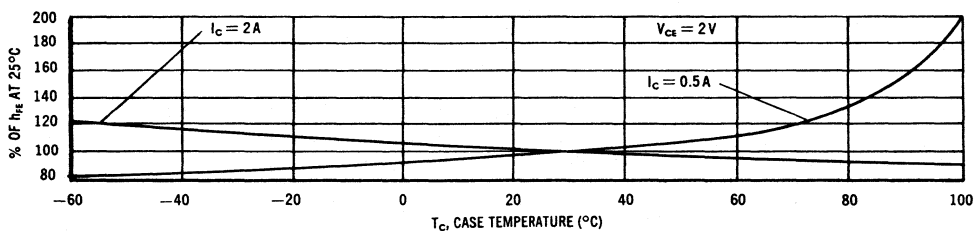
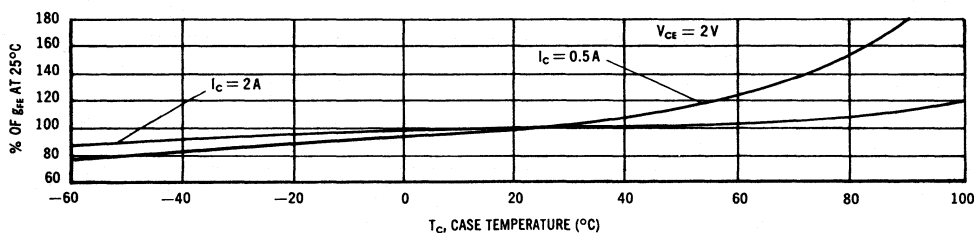
Examination or Test	Symbol	Limits		Unit	AQL (percent defective)					Inspection Level		
					1,000-Hour Life Test			Reduce-Hours Life-Test		1,000-hr Life Test	500 hr	250 hr
		Min	Max		250 hr	500 hr	1,000 hr	500 hr	250 hr			
SUBGROUP 6 Storage Life (Note 7) ($T_{stg} = +95^\circ\text{C min}$) End Points: Same as Subgroup 2	—	—	—	—	4	4	4	2.5	1.5	L8	I	II
SUBGROUP 7 Operation Life (Note 7) ($T_C = +75^\circ\text{C min}$, $P_C = 10 \begin{smallmatrix} +0 \\ -1 \end{smallmatrix} \text{ W}$) End Points: Same as Subgroup 2	—	—	—	—	4	4	4	2.5	1.5	L8	I	II

* Destructive tests

† No biases shall be applied during these tests.

FIGURE 2 — SAFE OPERATING AREA

The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J , the power-temperature de-rating curve must be observed for both steady state and pulse power conditions.

FIGURE 3 — h_{FE} versus TEMPERATUREFIGURE 4 — g_{FE} versus TEMPERATURE

2N669 (GERMANIUM)

For Specifications, See 2N176 Data.

2N681 thru 2N689 (SILICON)



CASE 263

STYLE 1:
PIN 1. CATHODE
2. GATE
3. ANODE



Industrial-type, silicon controlled rectifiers in a stud package with current handling capability to 25 amperes at junction temperatures to 125°C. MCR equivalents available in TO-48 package — i.e. — 2N681 available in TO-48 package as MCR681.

MAXIMUM RATINGS ($T_J = 125^\circ\text{C}$ unless otherwise noted)

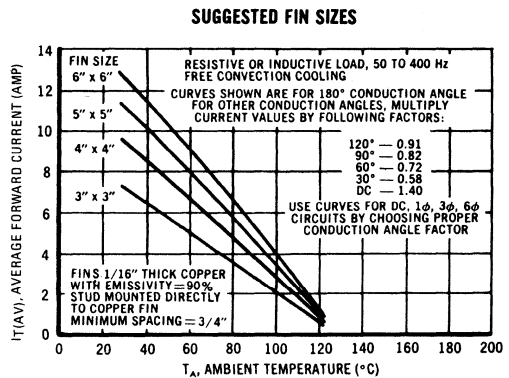
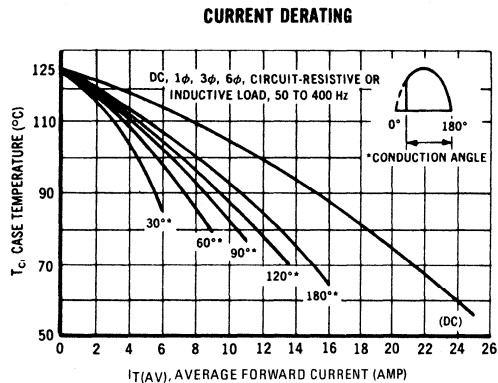
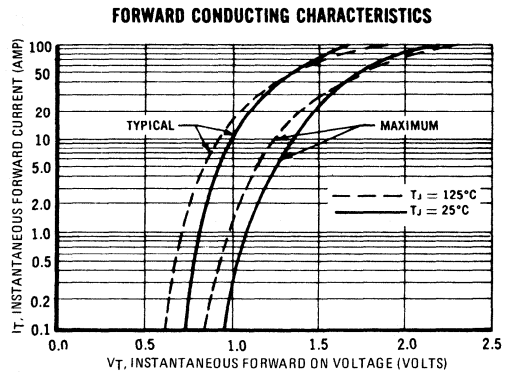
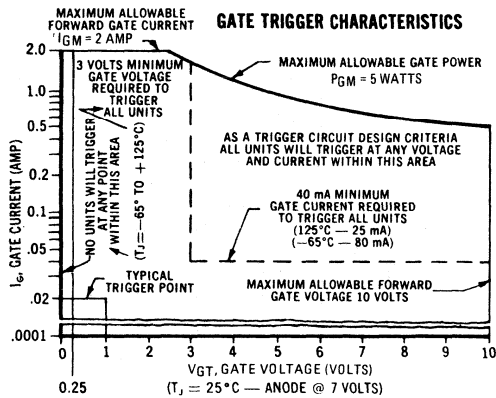
Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage* † 2N681 2N682 2N683 2N684 2N685 2N686 2N687 2N688 2N689	$V_{RSM(rep)}^{* \dagger}$	25 50 100 150 200 250 300 400 500	Volts
Peak Reverse Blocking Voltage* (Transient) (non-recurrent $t = 5 \text{ ms max.}$) 2N681 2N682 2N683 2N684 2N685 2N686 2N687 2N688 2N689	$V_{RSM(non-rep)}^{*}$	35 75 150 225 300 350 400 500 600	Volts
Forward Current RMS (all conduction angles)	I_T	25	Amp
Peak Forward Surge Current (One cycle, 60 Hz, $T_J = -65$ to $+125^\circ\text{C}$)	T_{TSM}	200	Amp
Circuit Fusing Considerations ($T_J = -65$ to $+125^\circ\text{C}$, $t \leq 8.3 \text{ ms}$)	I^2t	165	A^2s
Peak Gate Power-Forward	P_{GM}	5.0	Watts
Average Gate Power-Forward	$P_{G(AV)}$	0.5	Watt
Peak Gate Current-Forward	I_{GM}	2.0	Amp
Peak Gate Voltage-Forward Reverse	V_{GFM} V_{GRM}	10 5.0	Volts
Operating Junction Temperature Range	T_J	-65 to +125	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +150	$^\circ\text{C}$
Stud Torque	—	30	in. lb.

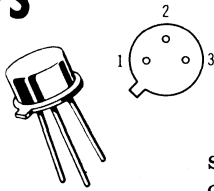
† V_{RSM} for all types can be applied on a continuous dc basis without incurring change.

* $V_{RSM(rep)}$ ratings apply for zero or negative gate voltage.

2N681 thru 2N689 (continued)
ELECTRICAL CHARACTERISTICS ($T_c = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage ($T_J = 125^\circ\text{C}$)	V_{DRM}	25 50 100 150 200 250 300 400 500	— — — — — — — — —	— — — — — — — — —	Volts
Peak Forward or Reverse Blocking Current ($T_J = 125^\circ\text{C}$)	I_{DRM} I_{RRM}	— — — — — — —	— — — — — — —	10.0 10.0 10.0 10.0 8.0 6.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, $R_L = 50\ \Omega$)	I_{GT}	—	10	25	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, $R_L = 50\ \Omega$)	V_{GT}	0.25	—	3.0	Volts
Holding Current (Anode Voltage = 7 Vdc, Gate Open)	I_{H}	—	20	—	mA
Forward On Voltage ($I_T = 20\ \text{Adc}$)	V_{TM}	—	1.1	1.5	Volts
Turn-On Time ($I_T = 10\ \text{A}$, $I_G = 200\ \text{mA}$)	t_{gt}	—	1.0	—	μs
Turn-Off Time ($I_T = 10\ \text{A}$; $I_R = 10\ \text{A}$, $dv/dt = 30\ \text{V}/\mu\text{s min}$, $T_J = 125^\circ\text{C}$) (V_{DRM} = rated voltage)	t_q	—	30	—	μs
Forward Voltage Application Rate (Gate open, $T_J = 125^\circ\text{C}$)	dv/dt	—	30	—	$\text{V}/\mu\text{s}$
Thermal Resistance (Junction to Case)	θ_{JC}	—	1.0	2.0	$^\circ\text{C}/\text{W}$



2N696S (SILICON)**2N697S**

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 79
(TO-39)

NPN silicon annular transistors designed for small-signal amplifier and general purpose switching applications.

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CER}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.6 13.3	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	2.0 13.3	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) ($I_C = 100 \text{ mAdc}$, $R_{BE} = 10 \text{ ohms}$)	BV_{CER}	40		Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \text{ } \mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	60		Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \text{ } \mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	5.0		Vdc
Collector Cutoff Current ($V_{CB} = 30 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 30 \text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	- -	1.0 100	μAdc

ON CHARACTERISTICS

DC Current Gain(1) ($I_C = 150 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$)	2N696 2N697	h_{FE}	20 40	60 120	-
Collector-Emitter Saturation Voltage(1) ($I_C = 150 \text{ mAdc}$, $I_B = 15 \text{ mAdc}$)		$V_{CE(sat)}$	-	1.5	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 150 \text{ mAdc}$, $I_B = 15 \text{ mAdc}$)		$V_{BE(sat)}$	-	1.3	Vdc

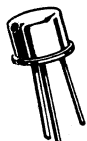
DYNAMIC CHARACTERISTICS

Current Gain-Bandwidth Product ($I_C = 50 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 20 \text{ MHz}$)	2N696 2N697	f_T	40 50	- -	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$)		C_{ob}	-	35	pF

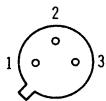
* Indicates JEDEC Registered Data

* Pulse Test: Pulse Length $\leq 12 \text{ ms}$, Duty Cycle $\leq 2.0\%$.

2N699 (SILICON)



CASE 79
(TO-39)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

Collector connected to case

NPN silicon annular transistor designed for medium-current switching and amplifier applications.

* MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CER}	80	Vdc
Collector-Base Voltage	V_{CB}	120	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation $T_A = 25^\circ\text{C}$	P_D	0.6	Watt
Derate above 25°C		4.0	mW/ $^\circ\text{C}$
Total Device Dissipation $T_C = 25^\circ\text{C}$	P_D	2.0	Watts
Derate above 25°C		13.3	mW/ $^\circ\text{C}$
Operating Junction Temperature	T_J	175	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

* Indicates JEDEC Registered Data

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	75	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	θ_{JA}	250	$^\circ\text{C/W}$

2N699 (continued)**ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage* ($I_C = 100\text{ mA dc}$, $R_{BE} \leq 10\text{ ohms}$)	BV_{CER}^*	80	-	Vdc
Collector Cutoff Current ($V_{CB} = 60\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 60\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	- -	2.0 200	$\mu\text{A dc}$
Emitter Cutoff Current ($V_{EB} = 2.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	-	100	$\mu\text{A dc}$

ON CHARACTERISTICS

DC Current Gain* ($I_C = 150\text{ mA dc}$, $V_{CE} = 10\text{ Vdc}$)	h_{FE}^*	40	120	-
Collector-Emitter Saturation Voltage* ($I_C = 150\text{ mA dc}$, $I_B = 15\text{ mA dc}$)	$V_{CE(sat)}^*$	-	5.0	Vdc
Base-Emitter Saturation Voltage* ($I_C = 150\text{ mA dc}$, $I_B = 15\text{ mA dc}$)	$V_{BE(sat)}^*$	-	1.3	Vdc

SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 50\text{ mA dc}$, $V_{CE} = 10\text{ Vdc}$, $f = 20\text{ MHz}$)	f_T	50	-	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)	C_{ob}	-	20	pF
Input Impedance ($I_C = 1.0\text{ mA dc}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 5.0\text{ mA dc}$, $V_{CB} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ib}	20 -	30 10	ohms
Voltage Feedback Ratio ($I_C = 1.0\text{ mA dc}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 5.0\text{ mA dc}$, $V_{CB} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{rb}	- -	2.5 3.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0\text{ mA dc}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 5.0\text{ mA dc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	35 45	100 -	-
Output Admittance ($I_C = 1.0\text{ mA dc}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 5.0\text{ mA dc}$, $V_{CB} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ob}	0.1 -	0.5 1.0	μmhos

* Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$; Duty Cycle $\leq 2\%$.

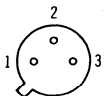
2N702 (SILICON)
2N703
 2N703 JAN AVAILABLE

NPN silicon annular transistors designed for low-level, high-speed switching applications.



CASE 22
(TO-18)

Collector connected to case



STYLE 1:
 PIN 1. EMITTER
 2. BASE
 3. COLLECTOR

***MAXIMUM RATINGS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	50	mA _{dc}
Total Device Dissipation @ $T_A = 25^\circ\text{C}$	P_D	300	mW
Derate above 25°C		2.0	mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$	P_D	600	mW
Derate above 25°C		4.0	mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_{stg}	-65 to +175	$^\circ\text{C}$

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 2.0 \text{ mA}_{dc}$, $I_B = 0$)	BV_{CEO}	25	-	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 5.0 \mu\text{A}_{dc}$, $I_E = 0$)	BV_{CBO}	25	-	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{A}_{dc}$, $I_C = 0$)	BV_{EBO}	5.0	-	-	Vdc
Collector Cutoff Current ($V_{CE} = 20 \text{ Vdc}$, $I_B = 0$)	I_{CEO}	-	-	10	μA_{dc}
Collector Cutoff Current ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $T_A = +150^\circ\text{C}$)	I_{CBO}	- -	- -	0.5 50	μA_{dc}

ON CHARACTERISTICS

DC Current Gain ⁽¹⁾ ($I_C = 10 \text{ mA}_{dc}$, $V_{CE} = 5.0 \text{ Vdc}$) ($I_C = 10 \text{ mA}_{dc}$, $V_{CE} = 5.0 \text{ Vdc}$, $T_A = -55^\circ\text{C}$)	2N702 2N703 2N702 2N703	h_{FE}	20 40 12 20	- - - -	60 100 - -	-
Collector-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 10 \text{ mA}_{dc}$, $I_B = 1.0 \text{ mA}_{dc}$)		$V_{CE(sat)}$	-	-	0.5	Vdc
Base-Emitter On Voltage ⁽¹⁾ ($I_C = 10 \text{ mA}_{dc}$, $V_{CE} = 5.0 \text{ Vdc}$)		$V_{BE(on)}$	0.7	-	0.95	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain - Bandwidth Product ($I_E = 10 \text{ mA}_{dc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	70	150		MHz
Output Capacitance ($V_{CB} = 5.0 \text{ Vdc}$, $I_E = 0$, $f = 1.0 \text{ MHz}$)	C_{ob}	-	3.0	6.0	pF

* Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width = 300 μs , Duty Cycle = 2.0%.

2N705 (Ge Mesa)

2N705 JAN AVAILABLE

CASE 22-03
(TO-18)



Collector connected to case

PNP germanium mesa transistor for high-speed switching applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

* MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	15	Vdc
Collector-Emitter Voltage	V_{CES}	15	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector Current - Continuous	I_C	50	mAdc
Emitter Current	I_E	50	mAdc
Junction Temperature	T_J	100	°C
Storage Temperature	T_{stg}	-65°C to +100	°C
Collector Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_C	300 4.0	mW mW/°C
Collector Dissipation @ $T_A = 25^\circ\text{C}$	P_C	150	mW

*Indicates JEDEC Registered Data

*** ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

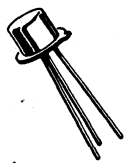
Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage ($I_C = 100\ \mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	15	—	Vdc
Collector-Emitter Breakdown Voltage ($I_{CE} = 100\ \mu\text{Adc}$, $V_{BE} = 0$)	BV_{CES}	15	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	3.5	—	Vdc
Collector Cutoff Current ($V_{CB} = 5\ \text{Vdc}$, $I_E = 0$)	I_{CBO}	—	3.0	μAdc
DC Forward Current Transfer Ratio ($V_{CE} = .3\ \text{Vdc}$, $I_C = 10\ \text{mAdc}$)	h_{FE}	25	—	—
Collector Saturation Voltage ($I_B = .4\ \text{mAdc}$, $I_C = 10\ \text{mAdc}$)	$V_{CE(sat)}$	—	0.3	Vdc
Base-Emitter Voltage ($I_B = .4\ \text{mAdc}$, $I_C = 10\ \text{mAdc}$)	V_{BE}	0.34	0.44	Vdc
Delay + Rise Time ($I_C = 10\ \text{mAdc}$, $I_B = 1\ \text{mAdc}$)	$t_d + t_r$	—	75	ns
Storage Time ($I_{B1} = 1.0\ \text{mAdc}$, $I_{B2} = .25\ \text{mAdc}$)	t_s	—	100	ns
Fall Time ($I_{B1} = 1.0\ \text{mAdc}$, $I_{B2} = .25\ \text{mAdc}$)	t_f	—	100	ns

*Indicates JEDEC Registered Data

2N706, A, B (SILICON)

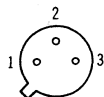
(2N706JAN AVAILABLE)

NPN silicon annular switching transistors for high-speed switching applications.



CASE 22 (TO-18)

Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	25	Volts
Collector-Emitter Voltage ⁽¹⁾	V_{CER}	20	Volts
Emitter-Base Voltage 2N706 2N706A 2N706B	V_{EB}	3.0 5.0 5.0	Volts
Junction Temperature	T_J	175	$^{\circ}C$
Storage Temperature	T_{stg}	-65 to +175	$^{\circ}C$
Total Device Dissipation at 25 $^{\circ}C$ Case Temperature. (Derate 6.67 mW/ $^{\circ}C$ above 25 $^{\circ}C$)	P_D	1.0	Watt
Total Device Dissipation at 25 $^{\circ}C$ Ambient Temperature (Derate 2 mW/ $^{\circ}C$ above 25 $^{\circ}C$)	P_D	0.3	Watt
Total Device Dissipation at 100 $^{\circ}C$ Case Temperature (Derate 6.67 mW/ $^{\circ}C$ above 100 $^{\circ}C$)	P_D	0.5	Watt

* Indicates JEDEC Registered Data

(1) Refers to collector breakdown voltage in the high current region when $R_{he} = 10\Omega$

2N706,A,B (continued)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}\text{C}$ unless otherwise noted)

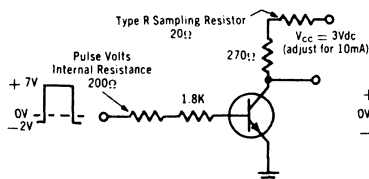
Characteristic	Type	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current ($V_{CB} = 15\text{Vdc}$, $I_E = 0$) ($V_{CB} = 15\text{Vdc}$, $I_E = 0$, $T_A = 150^{\circ}\text{C}$) ($V_{CB} = 25\text{Vdc}$, $I_E = 0$)	All Types All Types 2N706A, 2N706B,	I_{CBO}	- - -	0.005 3.0 -	0.5 30 10	μAdc
Collector-Emitter Cutoff Current ($V_{CE} = 20\text{Vdc}$, $R_{be} = 100\text{k}$)	2N706A, 2N706B,	I_{CER}	-	-	10	μAdc
Emitter Cutoff Current ($V_{EB} = 3\text{Vdc}$, $I_C = 0$) ($V_{EB} = 5\text{Vdc}$, $I_C = 0$)	2N706 2N706A, 2N706B,	I_{EBO}	- -	- -	10 10	μAdc
Collector-Emitter Breakdown Voltage(1) ($I_C = 10\text{mA}$, $I_B = 0$)		BV_{CEO}	15		-	Vdc
Collector-Emitter Breakdown Voltage(1) ($R = 10\text{ ohms}$, $I_C = 10\text{mA}$)		BV_{CER}	20		-	Vdc
Forward-Current Transfer Ratio(1) ($I_C = 10\text{mA}$, $V_{CE} = 1\text{Vdc}$)	2N706 2N706A, 2N706B,	h_{FE}	20 20	40 40	- 60	
Base-Emitter Voltage(1) ($I_C = 10\text{mA}$, $I_B = 1\text{mA}$)	2N706 2N706A, 2N706B,	$V_{BE}(\text{sat})$	- 0.7	0.75 0.75	0.9 0.9	Vdc
Collector Saturation Voltage(1) ($I_C = 10\text{mA}$, $I_B = 1\text{mA}$)	2N706, 2N706A 2N706B	$V_{CE}(\text{sat})$	- -	0.3 0.3	0.6 0.4	Vdc
Collector Capacitance ($V_{CB} = 5\text{Vdc}$, $I_E = 0$) ($V_{CB} = 10\text{Vdc}$, $I_E = 0$)	2N706A, 2N706B, 2N706	C_{ob}	- -	5.0 5.0	6.0 6.0	pF
Small-Signal Forward Current Transfer Ratio ($V_{CE} = 15\text{Vdc}$, $I_E = 10\text{mA}$, $f = 100\text{MHz}$)		h_{fe}	2.0	4.0	-	-
Current Gain-Bandwidth Product ($V_{CE} = 15\text{Vdc}$, $I_E = 10\text{mA}$, $f = 100\text{MHz}$)		f_T	-	400	-	MHz
Base Resistance ($V_{CE} = 15\text{Vdc}$, $I_E = 10\text{mA}$, $f = 300\text{MHz}$)		r_b'	-	39	50	ohms
Charge Storage Time Constant(2)	2N706 2N706A 2N753	τ_s	- - -	16 16 19	60 25 35	ns
Storage Time	2N706B	t_s	-	19	25	ns
Turn-On Time		t_{on}	-	30	40	ns
Turn-Off Time		t_{off}	-	50	75	ns

* Indicates JEDEC Registered Data

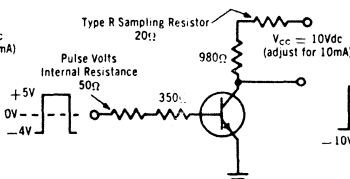
(1) Pulse Test: $PW \leq 12\text{ ms}$, Duty Cycle $\leq 2\%$

(2) Switching Times Measured with Tektronix Type R Plug-In (50 Ω Internal Impedance) and Circuits Shown Below.

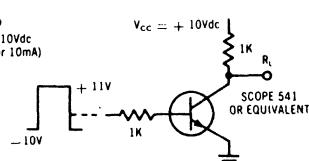
SWITCHING TIME TEST CIRCUIT



STORAGE TIME TEST CIRCUIT



MEASUREMENT CIRCUIT



2N708 (SILICON)
2N708
 JAN, JTX AVAILABLE



CASE 22
(TO-18)

Collector
 connected to case

STYLE 1:
 PIN 1. EMITTER
 2. BASE
 3. COLLECTOR

NPN silicon annular transistor for high-speed switching applications.

***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	360 2.0	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ $T_C = 100^\circ\text{C}$ Derate above 25°C Derate above 100°C	P_D	1.2 680 6.9 6.9	Watts mW mW/ $^\circ\text{C}$ mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

*Indicates JEDEC Registered Data.

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 30 \text{ mAdc}$, $I_E = 0$)	BV_{CEO}	15	-	-	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 30 \text{ mAdc}$, $R_{BE} \leq 10 \text{ ohms}$)	BV_{CER}	20	-	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 1.0 \text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	40	-	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	5.0	-	-	Vdc
Collector Cutoff Current ($V_{CE} = 20 \text{ Vdc}$, $V_{BE} = 0.25 \text{ Vdc}$, $T_A = +125^\circ\text{C}$)	I_{CEX}	-	-	10	μAdc
Collector Cutoff Current ($V_{CB} = 20 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 20 \text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	-	0.005 -	0.025 15	μAdc
Emitter Cutoff Current ($V_{BE} = 4.0 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	-	-	0.08	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 0.5 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$) (1) ($I_C = 10 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$, $T_A = -55^\circ\text{C}$) (1)	h_{FE}	15 30 15	- - -	- 120 -	-
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 1.0 \text{ mAdc}$) ($I_C = 7.0 \text{ mAdc}$, $I_B = 0.7 \text{ mAdc}$, $T_A = -55^\circ\text{C}$ to $+125^\circ\text{C}$)	$V_{CE(sat)}$	- -	0.2 -	0.4 0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 1.0 \text{ mAdc}$) ($I_C = 7.0 \text{ mAdc}$, $I_B = 0.7 \text{ mAdc}$, $T_A = -55^\circ\text{C}$)	$V_{BE(sat)}$	0.72 -	- -	0.80 0.90	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 10 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	300	450	-	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $100 \text{ kHz} \leq f \leq 1.0 \text{ MHz}$)	C_{ob}	-	3.0	6.0	pF
Extrinsic Base Resistance ($I_C = 10 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 300 \text{ MHz}$)	r_b'	-	-	50	ohms
Storage Time ($I_C = I_{B1} = I_{B2} = 10 \text{ mAdc}$)	t_s	-	15	25	ns

* Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width $< 300 \mu\text{s}$, Duty Cycle = 2.0 %

2N711A,B (Ge Mesa)

CASE 22-03
(TO-18)

Collector
connected to case



PNP germanium mesa transistors for high-speed switching applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

* MAXIMUM RATINGS

Rating	Symbol	2N711A	2N711B	Unit
Collector-Base Voltage	V_{CB}	15	18	Vdc
Collector-Emitter Voltage	V_{CES}	14	15	Vdc
Collector-Emitter Voltage	V_{CEO}	7.0	7.0	Vdc
Emitter-Base Voltage	V_{EB}	1.5	2.0	Vdc
Collector Current-Continuous	I_C	100	100	mAdc
Emitter Current-Continuous	I_E	100	100	mAdc
Junction Temperature	T_J	← 100 →		°C
Storage Temperature	T_{stg}	← -65 to +100 →		°C
Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	← 300 → ← 4.0 →		mW mW/°C
Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	← 150 → ← 2.0 →		mW mW/°C

*Indicates JEDEC Registered Data

2N711A,B (continued)

* ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Sym	Min	Max	Unit
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{A}$, $I_E = 0$)	BV_{CBO}	15	—	Vdc
($I_C = 20 \mu\text{A}$, $I_E = 0$)		18	—	
Collector-Emitter Breakdown Voltage ($I_C = 100 \mu\text{A}$)	BV_{CES}	14	—	Vdc
($I_C = 20 \mu\text{A}$)		15	—	
Collector-Emitter Breakdown Voltage ($I_C = 5 \text{mA}$, $I_B = 0$)	BV_{CEO}	7.0	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1 \text{mA}$, $I_C = 0$)	BV_{EBO}	1.5	—	Vdc
		2.0	—	
Collector-Base Cutoff Current ($V_{CB} = 5 \text{Vdc}$, $I_E = 0$)	I_{CBO}	—	1.5	μA
($V_{CB} = 10 \text{Vdc}$, $I_E = 0$)		—	1.5	
Emitter-Base Cutoff Current ($V_{EB} = 1 \text{Vdc}$)	I_{EBO}	—	100	μA
		—	20	
DC Current Gain ($I_C = 10 \text{mA}$, $V_{CE} = 0.5 \text{Vdc}$)	h_{FE}	25	150	—
		30	150	
($I_C = 50 \text{mA}$, $V_{CE} = 0.7 \text{Vdc}$)		40	—	
Collector Saturation Voltage ($I_C = 10 \text{mA}$, $I_B = 0.5 \text{mA}$)	$V_{CE(sat)}$	—	0.30	Vdc
($I_C = 10 \text{mA}$, $I_B = 0.4 \text{mA}$)		—	0.25	
($I_C = 50 \text{mA}$, $I_B = 2 \text{mA}$)		—	0.55	
		—	0.45	
Small-Signal Current Gain ($I_C = 10 \text{mA}$, $V_{CE} = 5 \text{Vdc}$, $f = 100 \text{MHz}$)	h_{fe}	1.5	—	—
($I_C = 10 \text{mA}$, $V_{CE} = 0.5 \text{Vdc}$, $f = 100 \text{MHz}$)		1.1	—	
		1.2	—	
Base-Emitter Voltage ($I_C = 10 \text{mA}$, $I_B = 0.4 \text{mA}$)	V_{BE}	0.30	0.44	Vdc
		0.30	0.44	
($I_C = 50 \text{mA}$, $I_B = 2 \text{mA}$)		0.40	0.65	
		0.40	0.65	
Collector Output Capacitance ($V_{CB} = 5 \text{Vdc}$, $I_E = 0$, $f = 1 \text{MHz}$)	C_{ob}	—	6.0	pF
Fall Time Figure 1: { 2N711A 2N711B Figure 2: { 2N711A 2N711B	t_f	— — — —	150 110 110 100	ns
Minority Carrier Storage Time Figure 1: { 2N711A 2N711B Figure 2: { 2N711A 2N711B	t_s	— — — —	150 140 120 100	ns
Delay Plus Rise Time Figure 1: 2N711A, 2N711B Figure 2: 2N711A, 2N711B	$t_d + t_r$	— —	100 75	ns

*Indicates JEDEC Registered Data

SWITCHING CIRCUITS

FIGURE 1

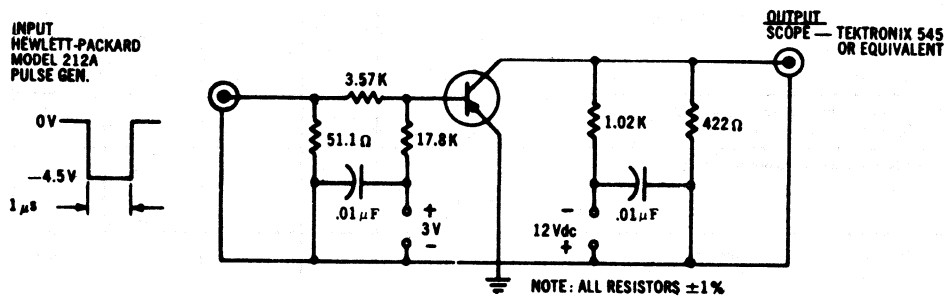
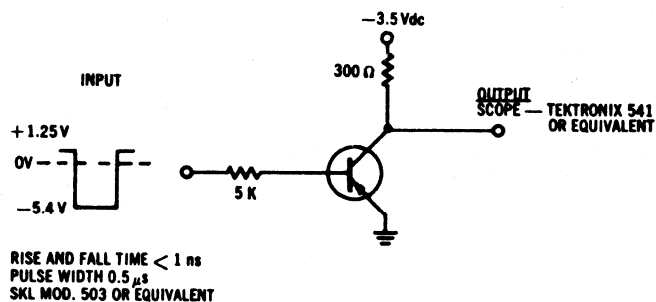


FIGURE 2

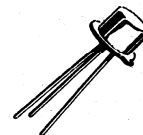


NPN SILICON ANNULAR AMPLIFIER TRANSISTOR

... designed for use as a general-purpose amplifier transistor in medium-voltage applications.

- Collector-Emitter Breakdown Voltage —
BV_{CER} = 40 Vdc (Min) @ I_C = 100 mA_{dc}
- High Current-Gain-Bandwidth Product —
f_T = 300 MHz (Typ) @ I_C = 50 mA_{dc}

NPN SILICON AMPLIFIER TRANSISTOR



*MAXIMUM RATINGS

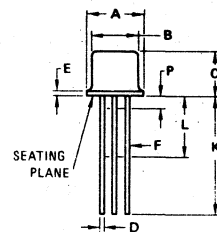
Rating	Symbol	Value	Unit
Collector-Emitter Voltage (R _{BE} ≤ 10 Ohms)	V _{CER}	40	Vdc
Collector-Base Voltage	V _{CB}	60	Vdc
Emitter-Base Voltage	V _{EB}	5.0	Vdc
Collector Current — Continuous	I _C	500	mA _{dc}
Total Power Dissipation @ T _A = 25°C Derate above 25°C	P _D	400 2.66	mW mW/°C
Total Power Dissipation @ T _C = 25°C Derate above 25°C	P _D	1.5 10	Watts mW/°C
Operating Junction Temperature Range	T _J	-65 to +175	°C
Storage Temperature Range	T _{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

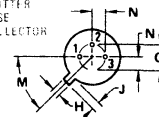
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	R _{θJA} (1)	376	°C/W
Thermal Resistance, Junction to Case	R _{θJC}	100	°C/W

*Indicates JEDEC Registered Data.

(1) R_{θJA} is measured with the device soldered into a typical printed circuit board.



STYLE 1
PIN 1
2
3
EMITTER
BASE
COLLECTOR



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	—	0.762	—	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC	—	0.100 BSC	—
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC	—	45° BSC	—
N	1.27 BSC	—	0.050 BSC	—
P	—	1.27	—	0.050

All JEDEC notes and dimensions apply.

CASE 22
TO-18

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (1) ($I_C = 100\text{ mAdc}$, $R_{BE} \leq 10\text{ Ohms}$)	BV_{CER}	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 1.0\text{ mAdc}$, $I_C = 0$)	BV_{EBO}	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 30\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 30\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	— —	1.0 100	μAdc

ON CHARACTERISTICS (1)

DC Current Gain ($I_C = 150\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$)	h_{FE}	20	55	60	—
Collector-Emitter Saturation Voltage ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$)	$V_{CE(sat)}$	—	0.15	1.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$)	$V_{BE(sat)}$	—	0.85	1.3	Vdc

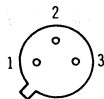
DYNAMIC CHARACTERISTICS

Current-Gain—Bandwidth Product ($I_C = 50\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 20\text{ MHz}$)	f_T	40	300	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)	C_{ob}	—	5.6	35	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)	C_{ib}	—	20	80	pF

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.

2N718(SILICON)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

NPN silicon annular transistors for medium-current switching and amplifier applications.

CASE 22 (TO-18)

Collector connected to case

* MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	60	Vdc
Collector-Emitter Voltage	V_{CER}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation at 25°C Case Temperature Derating Factor Above 25°C	P_D	1.5 10	Watts mW/°C
Total Device Dissipation at 25°C Ambient Temperatures Derating Factor Above 25°C	P_D	0.4 2.66	Watts mW/°C
Junction Temperature	T_J	+ 175	°C
Storage Temperature range	T_{stg}	-65 to + 200	°C

* ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current ($V_{CB} = 30 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 30 \text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	001 —	1.0 100	μAdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	60	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100 \text{ mAdc}$, pulsed; $R_B \leq 10 \text{ Ohms}$)	BV_{CER}	40	—	—	Vdc
Collector-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 150 \text{ mAdc}$, $I_B = 15 \text{ mAdc}$)	$V_{CE(sat)}$	—	0.3	1.5	Vdc
Base-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 150 \text{ mAdc}$, $I_B = 15 \text{ mAdc}$)	$V_{BE(sat)}$	—	—	1.3	Vdc

* Indicates JEDEC Registered Data

(1) Pulse Test: $PW \leq 300 \mu\text{s}$, Duty Cycle $\leq 2\%$

***ELECTRICAL CHARACTERISTICS (continued)**

Characteristic	Symbol	Min	Typ	Max	Unit
DC Forward Current Transfer Ratio(1) ($I_C = 1 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$)	h_{FE}	—	20	—	—
($I_C = 150 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$)		40	—	120	—
($I_C = 500 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$)		—	20	—	—
Small Signal Forward Current Transfer Ratio ($I_C = 50 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 20 \text{ MHz}$)	h_{fe}	2.5	15	—	—
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$)	C_{ob}	—	5.0	35	pF

* Indicates JEDEC Registered Data

(1) **Pulse Test:** $PW \leq 300 \mu s$, Duty Cycle $\leq 2\%$

2N718A(SILICON)

2N718A JAN, JTX AVAILABLE

2N956

2N1711S



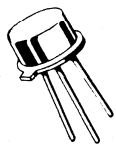
CASE 22

(TO-18)

2N718A

2N956

Collector connected to case



CASE 79

(TO-39)

2N1711



STYLE 1:

PIN 1. EMITTER

2. BASE

3. COLLECTOR

NPN silicon annular Star transistors for high-speed switching and DC to UHF amplifier applications.

*MAXIMUM RATINGS

Rating	Symbol	2N718A 2N956	2N1711	Unit
Collector-Emitter Voltage	V_{CER}	50		Vdc
Collector-Base Voltage	V_{CB}	75		Vdc
Emitter-Base Voltage	V_{EB}	7.0		Vdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	500 2.86	800 4.57	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.8 10.3	3.0 17.1	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

* Indicates JEDEC Registered Data

2N718A, 2N956, 2N1711S (continued)

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100\text{ mAdc}$, pulsed; $R_{BE} \leq 10\text{ ohms}$)	BV_{CER}	50	-	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\text{ }\mu\text{A}$, $I_E = 0$)	BV_{CBO}	75	-	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\text{ }\mu\text{A}$, $I_C = 0$)	BV_{EBO}	7.0	-	-	Vdc
Collector Cutoff Current ($V_{CB} = 60\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 60\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	- -	0.001 -	0.01 10	μA
Emitter Cutoff Current ($V_{BE} = 5.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	- -	- -	0.010 0.005	μA
2N718A, 2N956, 2N1711					

ON CHARACTERISTICS

DC Current Gain ($I_C = 0.01\text{ mA}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 0.1\text{ mA}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $T_A = -55^\circ\text{C}$) ($I_C = 150\text{ mA}$, $V_{CE} = 10\text{ Vdc}$)* ($I_C = 500\text{ mA}$, $V_{CE} = 10\text{ Vdc}$)*	2N956, 2N1711 2N718A, 2N956, 2N1711 2N718A, 2N956, 2N1711 2N718A, 2N956, 2N1711 2N718A, 2N956, 2N1711 2N718A, 2N956, 2N1711	h_{FE}	20 20 35 35 75 35 20 30 40 100 20 40	- - - - - - - - - - - -	- - - - - - - - 120 300 - - -	-
Collector-Emitter Saturation Voltage(1) ($I_C = 150\text{ mA}$, $I_B = 15\text{ mA}$)		$V_{CE(sat)}$	-	0.24	1.5	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 150\text{ mA}$, $I_B = 15\text{ mA}$)		$V_{BE(sat)}$	-	1.0	1.3	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 50\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 20\text{ MHz}$)	2N718A, 2N956, 2N1711	f_T	60 70	300 300	-	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)		C_{ob}	-	4.0	25	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)		C_{ib}	-	20	80	pF
Input Impedance ($I_C = 1.0\text{ mA}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 5.0\text{ mA}$, $V_{CB} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)		h_{ib}	24 4.0	- -	34 8.0	ohms
Voltage Feedback Ratio ($I_C = 1.0\text{ mA}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 5.0\text{ mA}$, $V_{CB} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N718A, 2N956, 2N1711 2N718A, 2N956, 2N1711	h_{rb}	- - - -	- - - -	3.0 5.0 3.0 5.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0\text{ mA}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 5.0\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N718A, 2N956, 2N1711 2N718A, 2N956, 2N1711	h_{fe}	30 50 35 70	- - - -	100 200 150 300	-
Output Admittance ($I_C = 1.0\text{ mA}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 5.0\text{ mA}$, $V_{CB} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)		h_{ob}	0.1 0.1	- -	0.5 1.0	μmho
Noise Figure ($I_C = 300\text{ }\mu\text{A}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N718A, 2N956, 2N1711	NF	- -	- -	12 8.0	dB

* Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.

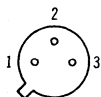
2N720A (SILICON)



NPN silicon annular transistor designed for small-signal amplifier and general purpose switching applications.

CASE 22 (TO-18)

Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Emitter Voltage	V_{CER}	100	Vdc
Collector-Base Voltage	V_{CB}	120	Vdc
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.5 2.86	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.8 10.3	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	97	$^\circ\text{C}/\text{W}$

*Indicates JEDEC Registered Data

2N720A (continued)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage(1) ($I_C = 30 \text{ mA}$, $I_B = 0$)	$BV_{CEO(sus)}$	80	-	Vdc
Collector-Emitter Sustaining Voltage(1) ($I_C = 100 \text{ mA}$, $R_{BE} = 10 \text{ ohms}$)	$BV_{CER(sus)}$	100	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \text{ }\mu\text{A}$, $I_E = 0$)	BV_{CBO}	120	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \text{ }\mu\text{A}$, $I_C = 0$)	BV_{EBO}	7.0	-	Vdc
Collector Cutoff Current ($V_{CB} = 90 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 90 \text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	-	0.10 15	μA μA
Emitter Cutoff Current ($V_{BE} = 5.0 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	-	0.10	μA

ON CHARACTERISTICS

DC Current Gain ($I_C = 0.1 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$) ($I_C = 10 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$)(1) ($I_C = 10 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$, $T_A = -55^\circ\text{C}$) ($I_C = 150 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$)(1)	h_{FE}	20 35 20 40	- - - 120	-
Collector-Emitter Saturation Voltage (1) ($I_C = 50 \text{ mA}$, $I_B = 5.0 \text{ mA}$) ($I_C = 150 \text{ mA}$, $I_B = 15 \text{ mA}$)	$V_{CE(sat)}$	- -	1.2 5.0	Vdc
Base-Emitter Saturation Voltage (1) ($I_C = 50 \text{ mA}$, $I_B = 5.0 \text{ mA}$) ($I_C = 150 \text{ mA}$, $I_B = 15 \text{ mA}$)	$V_{BE(sat)}$	- -	0.9 1.3	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 50 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$, $f = 20 \text{ MHz}$)	f_T	50	-	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)	C_{ob}	-	15	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 100 \text{ kHz}$)	C_{ib}	-	85	pF
Input Impedance ($I_C = 1.0 \text{ mA}$, $V_{CB} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mA}$, $V_{CB} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{ib}	20 4.0	30 8.0	Ohms
Voltage Feedback Ratio ($I_C = 1.0 \text{ mA}$, $V_{CB} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mA}$, $V_{CB} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{rb}	- -	1.25 1.50	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0 \text{ mA}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) ($I_C = 1.0 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{fe}	30 45	100 -	-
Output Admittance ($I_C = 1.0 \text{ mA}$, $V_{CB} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mA}$, $V_{CB} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{ob}	- -	0.5 0.5	μmhos

*Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

2N727 (SILICON)

PNP SILICON ANNULAR TRANSISTORS

... designed for general purpose audio amplifier applications.

- Collector-Emitter Breakdown Voltage —
 $BV_{CEO} = 20 \text{ Vdc (Min) @ } I_C = 10 \text{ mAdc}$
- Low Output Capacitance —
 $C_{ob} = 5.0 \text{ pF (Max) @ } V_{CB} = 5.0 \text{ Vdc}$

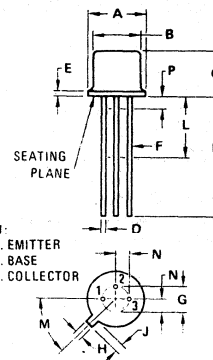
PNP SILICON AMPLIFIER TRANSISTORS



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 2.0	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 6.67	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

*Indicates JEDEC Registered Data



STYLE 1:

PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	—	0.762	—	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC	—	0.100 BSC	—
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC	—	45° BSC	—
N	1.27 BSC	—	0.050 BSC	—
P	—	1.27	—	0.050

All JEDEC notes and dimensions apply.

CASE 22-03
(TO-18)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 10\text{ mAdc}$, $I_B = 0$)	BV_{CEO}	20	—	Vdc
Collector Cutoff Current ($V_{CE} = 15\text{ Vdc}$, $I_B = 0$)	I_{CEO}	—	5.0	μAdc
Collector Cutoff Current ($V_{CB} = 25\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 25\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	—	1.0 25	μAdc
Emitter Cutoff Current ($V_{EB} = 5.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	0.5	μAdc
ON CHARACTERISTICS				
DC Current Gain ⁽¹⁾ ($I_C = 10\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$, $T_A = -55^\circ\text{C}$)	h_{FE}	30 12	120 —	—
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$)	$V_{CE(sat)}$	—	0.6	Vdc
Base-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$)	$V_{BE(sat)}$	—	1.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product ⁽²⁾ ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	140	—	MHz
Output Capacitance ($V_{CB} = 5.0\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{ob}	—	5.0	pF
Small-Signal Current Gain ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	30	240	—

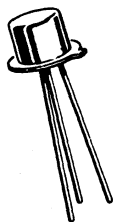
*Indicates JEDEC Registered Data.

⁽¹⁾Pulse Test: Pulse Width = 300 μs , Duty Cycle $\leq 2.0\%$.⁽²⁾ f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

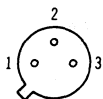
2N736 (SILICON)

2N739

2N740



NPN silicon annular transistors designed for small-signal amplifier and general purpose switching applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 22
(TO-18)

Collector connected to case

*MAXIMUM RATINGS

Rating	Symbol	2N736	2N739 2N740	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	80	125	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	1.0		Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	500 2.86		mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

* Indicates JEDEC Registered Data

Lead Temperature, $1/16'' \pm 1/32''$ from case for 10 s.

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 10\text{ mAdc}$, $I_B = 0$)	2N736 2N739, 2N740	BV_{CEO}	60 80	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $I_E = 0$)	2N736 2N739, 2N740	BV_{CBO}	80 125	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{Adc}$, $I_C = 0$)		BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current ($V_{CB} = 40\text{ Vdc}$, $I_E = 0$)		I_{CBO}	-	1.0	μAdc
Emitter Cutoff Current ($V_{BE} = 5.0\text{ Vdc}$, $I_C = 0$)		I_{EBO}	-	10	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 5.0\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$)	2N739 2N736, 2N740	h_{FE}	30 60	100 200	-
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 2.0\text{ mAdc}$)		$V_{CE(sat)}$	-	1.0	Vdc
Base-Emitter Voltage ($I_C = 10\text{ mAdc}$, $I_B = 2.0\text{ mAdc}$)		V_{BE}	0.35	1.5	Vdc

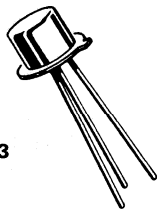
SMALL-SIGNAL CHARACTERISTICS

Output Capacitance ($V_{CB} = 5.0\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)		C_{ob}	-	10	pF
Input Impedance ($I_C = 5.0\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N739 2N736, 2N740	h_{ie}	- -	1500 1800	Ohm
Small-Signal Current Gain ($I_C = 5.0\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 1.0\text{ Hz}$)	2N739 2N736, 2N740	h_{fe}	40 80	100 200	-

* Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.

2N741, A (Ge Mesa)



CASE 22-03
(TO-18)

Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

PNP germanium mesa transistors for oscillator, frequency multiplier and amplifier applications.

*MAXIMUM RATINGS

Rating	Symbol	2N741	2N741A	Unit
Collector-Emitter Voltage	V_{CE}	15	20	Vdc
Collector-Base Voltage	V_{CB}	15	20	Vdc
Emitter-Base Voltage	V_{EB}	1.0		Vdc
Collector Current - Continuous	I_C	100		mA dc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	150 2.0		mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	300 4.0		mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100		$^\circ\text{C}$

*Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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ON CHARACTERISTICS

Collector-Base Breakdown Voltage ($I_C = 100\ \mu\text{A}$, $I_E = 0$)	2N741 2N741A	BV_{CBO}	15 20	- -	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu\text{A}$, $I_C = 0$)		BV_{EBO}	1.0	-	Vdc
Collector Cutoff Current ($V_{CE} = 15\ \text{Vdc}$, $V_{BE} = 0$) ($V_{CE} = 20\ \text{Vdc}$, $V_{BE} = 0$)	2N741 2N741A	I_{CES}	- -	100 100	μA
Collector Cutoff Current ($V_{CB} = 6\ \text{Vdc}$, $I_E = 0$)		I_{CBO}	-	3.0	μA

ON CHARACTERISTICS

DC Current Gain ($I_C = 5\ \text{mA}$, $V_{CE} = 6\ \text{Vdc}$)		h_{FE}	10	-	-
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SMALL-SIGNAL CHARACTERISTICS

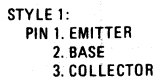
Current-Gain — Bandwidth Product ($I_E = 5\ \text{mA}$, $V_{CB} = 6\ \text{Vdc}$, $f = 100\ \text{MHz}$)	2N741 2N741A	f_T	- 300	- -	MHz
Output Capacitance ($V_{CB} = 6\ \text{Vdc}$, $I_E = 0$, $f = 100\ \text{kHz}$)		C_{ob}	-	10	pF
Small-Signal Current Gain ($I_C = 5\ \text{mA}$, $V_{CE} = 6\ \text{Vdc}$, $f = 1\ \text{kHz}$)		h_{fe}	20	-	-
Input Impedance ($I_E = 5\ \text{mA}$, $V_{CB} = 6\ \text{Vdc}$, $f = 1\ \text{kHz}$)		h_{ib}	-	15	Ohms
Power Gain, Matched, Neutralized ($V_{CB} = 6\ \text{Vdc}$, $I_E = 5\ \text{mA}$, $f = 30\ \text{MHz}$)		G_{pe}	16	-	dB

*Indicates JEDEC Registered Data

2N744 (SILICON)



Collector connected to case



NPN silicon annular transistor for high-speed switching applications.

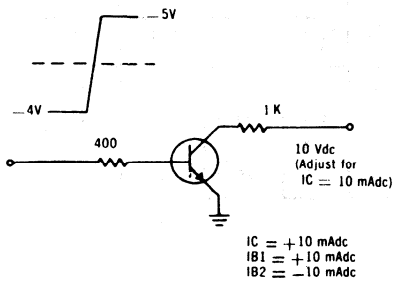
***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	20	Vdc
Collector-Emitter Voltage(1)	V_{CEO}	12*	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector DC Current	I_C	200	mA _{dc}
Total Device Dissipation at 25°C Case Temperature (Derate 6.67 mW/°C above 25°C)	P_D	1.0	Watt
Total Device Dissipation at 25°C Ambient Temperature Derate above 25°C	P_D	0.3 2.0	Watt mW/°C
Junction Temperature	T_J	+175	°C
Storage Temperature	T_{stg}	-65 to +200	°C

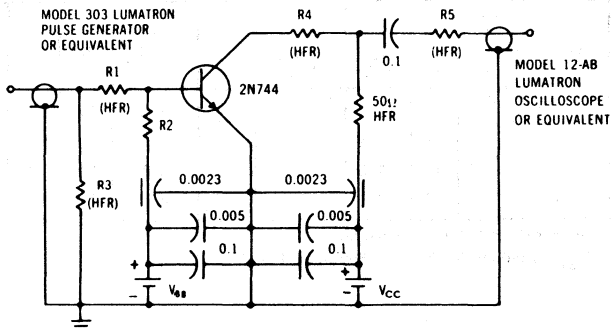
* Indicates JEDEC Registered Data

(1) Refers to the voltage at which the magnitude of h_{FE} approaches one when the emitter-base diode is open-circuited.

SWITCHING TIME TEST CIRCUIT



CHARGE STORAGE TEST CIRCUIT



***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current ($V_{CE} = 20 \text{ Vdc}$, $I_E = 0$) ($V_{CE} = 20 \text{ Vdc}$, $I_B = 0$, $T_A = 170^\circ\text{C}$)	I_{CES}	— —	005 —	1.0 100	μAdc
Collector Cutoff Current ($V_{CE} = 10 \text{ Vdc}$, $V_{BE} = 0.35 \text{ Vdc}$, $T_A = 100^\circ\text{C}$)	I_{CEX}	—	—	30	μAdc
Emitter Cutoff Current ($V_{EB} = 5 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	—	10	μAdc
Collector-Emitter Breakdown Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 0$)*	BV_{CEO}	12	30	—	Vdc
Forward Current Transfer Ratio ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 0.25 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}$, $V_{CE} = 0.35 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}$, $V_{CE} = 0.35 \text{ Vdc}$, $T_A = -55^\circ\text{C}$) ($I_C = 100 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$)(1)	h_{FE}	20 40 20 20	— — — —	— 120 — —	—
Small Signal Forward Current Transfer Ratio ($I_C = 10 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 100 \text{ MHz}$)	h_{fe}	2.8	4.5	—	—
Base-Emitter Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 1 \text{ mAdc}$) ($I_C = 10 \text{ mAdc}$, $I_B = 1 \text{ mAdc}$, $T_A = -55^\circ\text{C}$) ($I_C = 100 \text{ mAdc}$, $I_B = 10 \text{ mAdc}$)(1) ($I_C = 100 \text{ mAdc}$, $I_B = 10 \text{ mAdc}$, $T_A = -55^\circ\text{C}$)(1)	V_{BE}	0.7 — — —	— — — —	0.85 1.1 1.5 1.6	Vdc
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 1 \text{ mAdc}$, $T_A = 170^\circ\text{C}$) ($I_C = 100 \text{ mAdc}$, $I_B = 10 \text{ mAdc}$, $T_A = 170^\circ\text{C}$)(1)	$V_{CE(sat)}$	— —	— —	0.35 1.0	Vdc
Output Capacitance ($V_{CB} = 5 \text{ Vdc}$, $I_E = 0$)	C_{ob}	—	3.0	5.0	pF
Turn-on Time (Condition 1) (Condition 2) (Condition 3) (Condition 4)	t_{on}	— — — —	26 10 7.0 6.0	— 16 — 12	ns
Turn-off Time (Condition 1) (Condition 2) (Condition 3) (Condition 4)	t_{off}	— — — —	30 17 18 23	— 24 — 45	ns
Charge Storage Time Constant ($I_C = 10 \text{ mAdc}$, $I_{B1} = -I_{B2} = 10 \text{ mAdc}$)	τ_s	—	—	18	ns

(1) Pulse Test: Pulse width $\leq 300 \mu\text{s}$, duty cycle $\leq 2\%$

CONDITION	I_C mA	I_{B1} mA	I_{B2} mA	$V_{BE(off)}$ Vdc	V_{CC} Vdc	$R_1 = R_2$ Ω	R_3 Ω	R_4 Ω	R_5 Ω	t_{on}		t_{off}	
										V_{BB} V	V_{IN} V	V_{BB} V	V_{IN} V
1	3	1	-0.5	-0.9	3.4	6.8 K	50	1 K	0	-1.8	10.2	8.4	-10.2
2	10	3	-1.5	-1.5	3.0	3.3 K	50	220	0	-3.0	15.0	12.0	-15.0
3	50	15	-7.5	-1.8	4.0	680	50	18	1 K	-3.5	15.3	** 1.7	-15.3
4	100	40	-20.0	-2.4	6.0	330	56	0	1 K	-4.5	20.0	** 5.3	-20.0

* Indicates JEDEC Registered Data

** V_{BB} is pulsed for 1.5 s @ less than 10% duty cycle

NPN SILICON ANNULAR SWITCHING TRANSISTOR

... designed for use in high-speed saturated switching applications.

- Collector-Emitter Breakdown Voltage –
 $V_{CE0} = 20 \text{ Vdc (Min) @ } I_C = 10 \text{ mAdc}$
- Low Collector-Emitter Saturation Voltage –
 $V_{CE(sat)} = 0.3 \text{ Vdc (Typ) @ } I_C = 10 \text{ mAdc}$
- High Current-Gain-Bandwidth Product –
 $f_T = 400 \text{ MHz (Typ) @ } I_C = 10 \text{ mAdc}$
- Fast Switching Times –
 $t_{on} = 40 \text{ ns (Max)}$
 $t_{off} = 75 \text{ ns (Max)}$

*MAXIMUM RATINGS

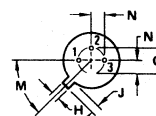
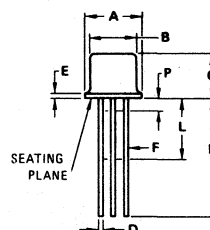
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	15	Vdc
Collector-Emitter Voltage ($R_{BE} = 10 \text{ Ohms}$)	V_{CER}	20	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	50	mA dc
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 2.0	mW mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 6.67	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}(1)$	150	$^\circ\text{C/W}$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	500	$^\circ\text{C/W}$

* Indicates JEDEC Registered Data.
(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

NPN SILICON SWITCHING TRANSISTOR



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

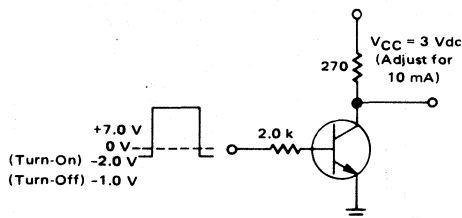
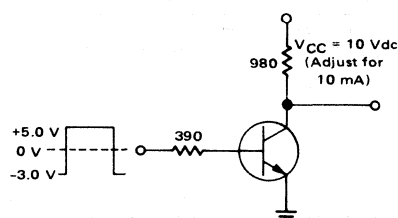
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	—	0.762	—	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC	—	0.100 BSC	—
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC	—	45° BSC	—
N	1.27 BSC	—	0.050 BSC	—
P	—	1.27	—	0.050

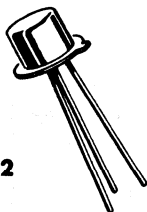
CASE 22-03
(TO-18)

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 10\text{ mA}$, $I_E = 0$)	BV_{CEO}	15	—	—	Vdc
Collector-Emitter Breakdown Voltage (1) ($I_C = 10\text{ mA}$, $R_{BE} = 10\text{ Ohms}$)	BV_{CER}	20	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\text{ }\mu\text{A}$, $I_E = 0$)	BV_{CBO}	25	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\text{ }\mu\text{A}$, $I_C = 0$)	BV_{EBO}	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 15\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$) ($V_{CB} = 25\text{ Vdc}$, $I_E = 0$)	I_{CBO}	— — —	— — —	0.5 30 10	μA
Collector-Emitter Cutoff Current ($V_{CE} = 20\text{ Vdc}$, $R_{BE} = 100\text{ k Ohms}$)	I_{CER}	—	—	10	μA
Emitter-Cutoff Current ($V_{BE} = 5.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	—	10	μA
ON CHARACTERISTICS					
DC Current Gain ($I_C = 10\text{ mA}$, $V_{CE} = 1.0\text{ Vdc}$)	h_{FE}	40	70	120	—
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mA}$, $I_E = 1.0\text{ mA}$) ($I_C = 50\text{ mA}$, $I_E = 5.0\text{ mA}$)	$V_{CE(sat)}$	— —	0.3 0.3	0.6 —	Vdc
Base-Emitter Saturation Voltage ($I_C = 10\text{ mA}$, $I_E = 1.0\text{ mA}$)	$V_{BE(sat)}$	0.7	0.8	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	200	400	—	MHz
Output Capacitance ($V_{CB} = 5.0\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{ob}	—	4.0	5.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (Figure 1) ($V_{CC} = 3.0\text{ Vdc}$, $I_C = 10\text{ mA}$, $V_{BE(off)} = 2.0\text{ Vdc}$, $I_{B1} = 1.2\text{ mA}$)	t_{on}	—	30	40	ns
Turn-Off Time (Figure 1) ($V_{CC} = 3.0\text{ Vdc}$, $I_C = 10\text{ mA}$, $I_{B1} = 1.2\text{ mA}$, $I_{B2} = 0.5\text{ mA}$)	t_{off}	—	60	75	ns
Storage Time (Figure 2) ($V_{CC} = 10\text{ Vdc}$, $I_C = 10\text{ mA}$, $I_{B1} = I_{B2} = 10\text{ mA}$)	t_s	—	19	35	ns

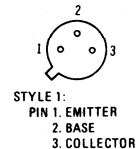
*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.**FIGURE 1 — SWITCHING TIME TEST CIRCUIT****FIGURE 2 — STORAGE TIME TEST CIRCUIT**



CASE 22
(TO-18)

Collector connected to case



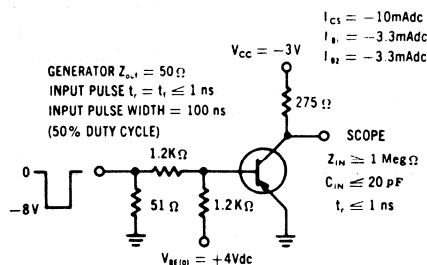
PNP germanium mesa transistor for high-speed switching applications.

* MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	20	Vdc
Collector-Emitter Voltage	V_{CES}	20	Vdc
Collector-Emitter Voltage	V_{CEX}	10	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current-Continuous	I_C	100	mAdc
Junction Temperature	T_J	+100	°C
Storage Temperature	T_{stg}	-65 to +100	°C
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	150 2.0	mW mW/°C

*Indicates JEDEC Registered Data

FIGURE 1 - SWITCHING TIME TEST CIRCUIT



* ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{A}$, $I_E = 0$)	BV_{CBO}	20	---	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100 \mu\text{A}$, $V_{EB} = 0$)	BV_{CES}	20	---	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{A}$, $I_C = 0$)	BV_{EBO}	4	---	Vdc
Collector Latch-up Voltage	LV_{CEX}	10	---	Vdc
Collector-Emitter Cutoff Current ($V_{CE} = 15 \text{ Vdc}$, $V_{EB} = 0$)	I_{CES}	---	5.0	μA
Collector-Base Cutoff Current ($V_{CB} = 15 \text{ Vdc}$)	I_{CBO}	---	5.0	μA
DC Forward Current Transfer Ratio ($I_C = 10 \text{ mA}$, $V_{CE} = 0.3 \text{ Vdc}$)	h_{FE}	100	---	---
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mA}$, $I_B = 3.3 \text{ mA}$)	$V_{CE(sat)}$	---	0.25	Vdc
Base-Emitter Voltage ($I_C = 10 \text{ mA}$, $I_B = 3.3 \text{ mA}$)	V_{BE}	---	0.5	Vdc
Small-Signal Forward Current Transfer Ratio ($I_C = 10 \text{ mA}$, $V_{CE} = 1 \text{ V}$, $f = 100 \text{ MHz}$)	h_{fe}	2.5	---	---
Collector Output Capacitance ($V_{CB} = 10 \text{ V}$, $I_E = 0$, $f = 1 \text{ MHz}$)	C_{ob}	---	9.0	pF
Delay Time (Figure 1)	t_d	---	15	ns
Rise Time (Figure 1)	t_r	---	20	ns
Storage Time (Figure 1)	t_s	---	30	ns
Fall Time (Figure 1)	t_f	---	30	ns

*Indicates JEDEC Registered Data

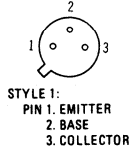
2N828 (Ge Mesa)

CASE 22-03
(TO-18)

Collector
connected to case



PNP germanium epitaxial mesa transistor for high-speed switching applications.



* MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	15	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	2.5	Vdc
Collector Current - Continuous	I_C	200	mA dc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	150 2.0	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	300 4.0	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100	$^\circ\text{C}$

*Indicates JEDEC Registered Data

FIGURE 1 — SWITCHING TIME TEST CIRCUIT

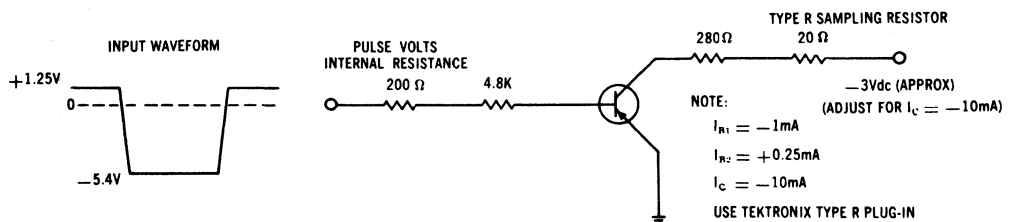
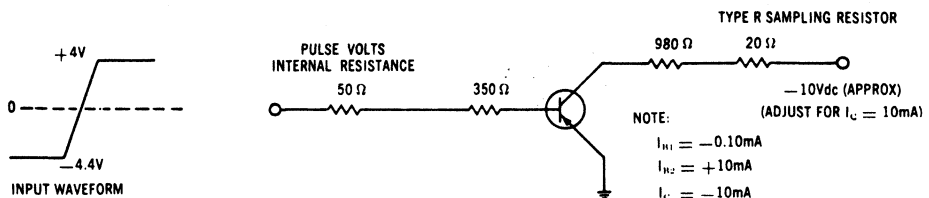


FIGURE 2 — CHARGE STORAGE TIME TEST CIRCUIT



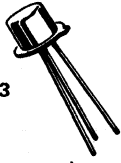
***ELECTRICAL CHARACTERISTICS** ($T_C = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu\text{Adc}$, $V_{BE} = 0$)	BV_{CES}	15	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	15	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	2.5	—	Vdc
Collector Cutoff Current ($V_{CB} = 6\ \text{Vdc}$, $I_E = 0$)	I_{CBO}	—	3.0	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 10\ \text{mAdc}$, $V_{CE} = 0.3\ \text{Vdc}$)	h_{FE}	25	—	—
Collector-Emitter Saturation Voltage ($I_C = 10\ \text{mAdc}$, $I_B = 1\ \text{mAdc}$) ($I_C = 50\ \text{mAdc}$, $I_B = 5\ \text{mAdc}$)	$V_{CE(sat)}$	— —	0.2 0.25	Vdc
Base-Emitter Saturation Voltage ($I_C = 10\ \text{mAdc}$, $I_B = 1\ \text{mAdc}$)	$V_{BE(sat)}$	0.34	0.44	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product ($I_C = 10\ \text{mAdc}$, $V_{CE} = 1\ \text{Vdc}$, $f = 100\ \text{MHz}$)	f_T	300	—	MHz
Output Capacitance ($V_{CB} = 10\ \text{Vdc}$, $I_E = 0$)	C_{ob}	—	—	pF
Small Signal Current Gain ($I_C = 10\ \text{mAdc}$, $V_{CE} = 1\ \text{Vdc}$, $f = 100\ \text{MHz}$)	h_{fe}	3.0	—	—
Delay Plus Rise Time (Figure 1)	$t_d + t_r$	—	70	ns
Storage Time (Figure 1)	t_s	—	50	ns
Fall Time (Figure 1)	t_f	—	50	ns
Charge Storage Time Constant (Figure 2)	τ_s	—	25	ns
Rise Time	t_r	—	—	ns
Storage Time	t_s	—	—	ns
Fall Time	t_f	—	—	ns

*Indicates JEDEC Registered Data.

2N828A (Ge Mesa)

CASE 22-03
(TO-18)



Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

PNP germanium mesa transistors for high- speed switching applications

* MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector to Base Voltage	V_{CB}	15	Vdc
Collector to Emitter Voltage	V_{CES}	15	Vdc
Emitter to Base Voltage	V_{EB}	2.5	Vdc
Collector Current - Continuous	I_C	200	mA dc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	300 4.0	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	150 2.0	mW mW/ $^\circ\text{C}$
Junction Temperature	T_J	+100	$^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +100	$^\circ\text{C}$

*Indicates JEDEC Registered Data

*** ELECTRICAL CHARACTERISTICS** ($T_A = 25^{\circ}\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector to Base Breakdown Voltage $I_E = 0, I_C = 100\mu\text{Adc}$	BV_{CBO}	15	--	Vdc
Collector to Emitter Breakdown Voltage $V_{EB} = 0, I_C = 100\mu\text{Adc}$	BV_{CES}	15	--	Vdc
Emitter to Base Breakdown Voltage $I_C = 0, I_E = 100\mu\text{Adc}$	BV_{EBO}	2.5	--	Vdc
Collector Cutoff Current $I_E = 0, V_{CB} = 6\text{Vdc}$	I_{CBO}	--	3.0	μAdc
Forward Current Transfer Ratio $I_C = 10\text{mAdc}, V_{CE} = 0.3\text{Vdc}$	h_{FE}	25	--	--
Forward Current Transfer Ratio $I_C = 150\text{mAdc}, V_{CE} = 1\text{Vdc}$	h_{fe}	25	--	--
Collector Saturation Voltage $I_C = 10\text{mAdc}, I_B = 1.0\text{mAdc}$	$V_{CE(sat)}$	--	0.20	Vdc
Collector Saturation Voltage $I_C = 50\text{mAdc}, I_B = 5.0\text{mAdc}$	$V_{CE(sat)}$	--	0.25	Vdc
Collector Saturation Voltage $I_C = 150\text{mAdc}, I_B = 15\text{mAdc}$	$V_{CE(sat)}$	--	0.50	Vdc
Base to Emitter Voltage $I_C = 10\text{mAdc}, I_B = 1\text{mAdc}$	V_{BE}	0.34	0.44	Vdc
Base to Emitter Voltage $I_C = 150\text{mAdc}, I_B = 15\text{mAdc}$	V_{BE}	--	0.85	Vdc
Collector Capacitance $I_E = 0, V_{CB} = 6\text{Vdc}, f = 100\text{ kHz}$	C_{ob}	--	4.0	pF

*Indicates JEDEC Registered Data

2N828A (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Max	Unit
Input Capacitance $V_{BE} = 1Vdc, I_E = 0, f = 100 \text{ kHz}$	C_{ib}	--	3.5	pF
Small Signal Forward Current Transfer Ratio $I_C = 10mA_{dc}, V_{CE} = -1Vdc, f = 100 \text{ MHz}$	h_{fe}	3.0	--	--
Current Gain Bandwidth Product $V_{CE} = 1Vdc, I_C = -10mA_{dc}, f = 100 \text{ MHz}$	f_T	300	--	MHz
Delay Plus Rise Time (Fig. 1) $I_C = 10mA_{dc}$	t_{on}	--	50	ns
Storage Time (Fig. 1) $I_C = 10mA_{dc}$	t_s	--	50	ns
Fall Time (Fig. 1) $I_C = 10mA_{dc}$	t_f	--	50	ns
Total Control Charge (Fig. 3) $I_C = 10mA_{dc}$	Q_T	--	80	pC
Delay Plus Rise Time (Fig. 2) $I_C = 150mA_{dc}$	t_{on}	--	50	ns
Turn Off Time (Fig. 2) $I_C = 150mA_{dc}$	t_{off}	--	100	ns
Total Control Charge (Fig. 4) $I_C = 150mA_{dc}$	Q_T	--	175	pC

*Indicates JEDEC Registered Data

FIGURE 1 — 10mA SWITCHING TIME TEST CIRCUIT

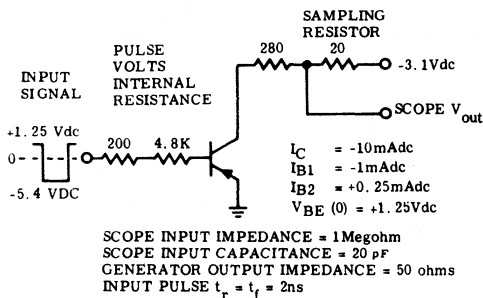


FIGURE 2 — 150mA SWITCHING TIME TEST CIRCUIT

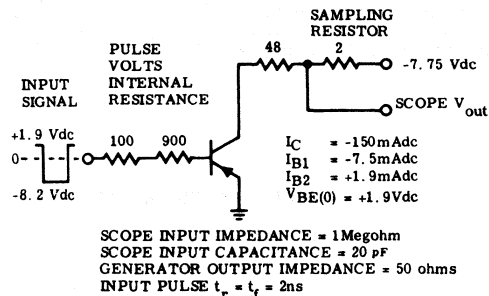


FIGURE 3 — 10mA TOTAL CONTROL CHARGE TEST CIRCUIT

*ADJUST V_{BB} FOR -5.4 VOLT PULSE AT POINT A

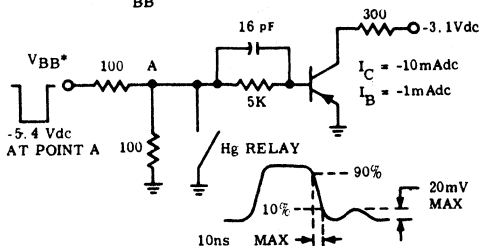
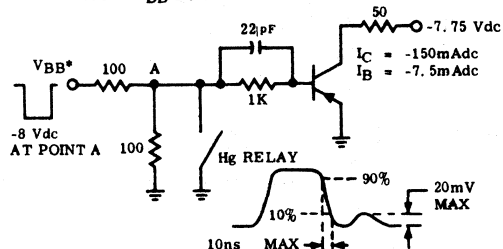


FIGURE 4 — 150mA TOTAL CONTROL CHARGE TEST CIRCUIT

*ADJUST V_{BB} FOR -8 VOLT PULSE AT POINT A



2N834 (SILICON)

2N835



NPN silicon epitaxial transistors for high-speed switching applications.

CASE 22
(TO-18)

Collector connected to case



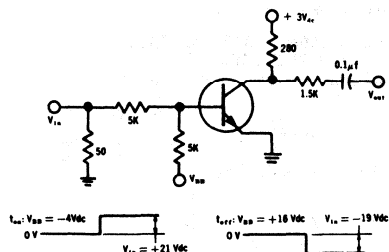
STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

***MAXIMUM RATINGS**

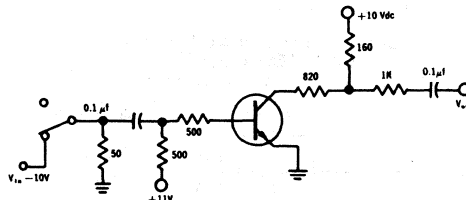
Rating	Symbol	2N834	2N835	Unit
Collector-Emitter Voltage	V_{CES}	30	20	Vdc
Collector-Base Voltage	V_{CB}	40	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	3.0	Vdc
Collector Current-Continuous Peak	I_C	200		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.3 2.0		Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 6.67		Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 100^\circ\text{C}$ Derate above 100°C	P_D	0.5 6.67		Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175		$^\circ\text{C}$

* Indicates JEDEC Registered Data

**FIGURE 1 — TURN-ON AND TURN-OFF
TIME MEASUREMENT CIRCUIT**



**FIGURE 2 — CHARGE STORAGE TIME
CONSTANT MEASUREMENT CIRCUIT**



NOTE: ALL SWITCHING TIMES MEASURED WITH LUMATRON MODEL 420 SWITCHING TIME TEST SET OR EQUIVALENT.

2N834, 2N835 (continued)

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Base Breakdown Voltage ($I_C = 10\ \mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	40 25	- -	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	5.0 3.0	- -	Vdc
Collector Cutoff Current ($V_{CE} = 30\ \text{Vdc}$, $V_{BE} = 0$)	I_{CES}	-	10	μAdc
($V_{CE} = 20\ \text{Vdc}$, $V_{BE} = 0$)		-	10	
Collector Cutoff Current ($V_{CB} = 20\ \text{Vdc}$, $I_E = 0$)	I_{CBO}	-	0.5	μAdc
($V_{CB} = 20\ \text{Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)		-	30	

ON CHARACTERISTICS

DC Current Gain(1) ($I_C = 10\ \text{mAdc}$, $V_{CE} = 1\ \text{Vdc}$)	h_{FE}	25 20	- -	-
Collector-Emitter Saturation Voltage ($I_C = 10\ \text{mAdc}$, $I_B = 1\ \text{mAdc}$)	$(V_{CE(sat)})$	- -	0.25 0.30	Vdc
($I_C = 50\ \text{mAdc}$, $I_B = 5\ \text{mAdc}$)(1)		- -	0.4 -	
Base-Emitter Saturation Voltage(1) ($I_C = 10\ \text{mAdc}$, $I_B = 1\ \text{mAdc}$)	$V_{BE(sat)}$	-	0.9	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 10\ \text{mAdc}$, $V_{CE} = 20\ \text{Vdc}$, $f = 100\ \text{MHz}$)	f_T	350	-	MHz
($I_C = 10\ \text{mAdc}$, $V_{CE} = 15\ \text{Vdc}$, $f = 100\ \text{MHz}$)		300	-	
High-Frequency Current Gain ($I_C = 10\ \text{mAdc}$, $V_{CE} = 20\ \text{Vdc}$, $f = 100\ \text{MHz}$)	$ h_{fe} $	3.5	-	-
($I_C = 10\ \text{mAdc}$, $V_{CE} = 15\ \text{Vdc}$, $f = 100\ \text{MHz}$)		3.0	-	
Output Capacitance ($V_{CB} = 10\ \text{Vdc}$, $I_E = 0$, $f = 100\ \text{kHz}$)	C_{ob}	-	4.0	pF
Charge-Storage Time Constant (Figure 2) ($I_C = 10\ \text{mAdc}$, $I_{B1} = I_{B2} = 10\ \text{mAdc}$)	t_s	- -	25 35	ns
Turn-On Time (Figure 1) ($I_C = 10\ \text{mAdc}$, $I_{B1} = 3\ \text{mAdc}$, $I_{B2} = 1\ \text{mAdc}$)	t_{on}	- -	33 20	ns
Turn-Off Time (Figure 1) ($I_C = 10\ \text{mAdc}$, $I_{B1} = 3\ \text{mAdc}$, $I_{B2} = 1\ \text{mAdc}$)	t_{off}	- -	75 35	ns

* Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width $\leq 12\ \text{ms}$, Duty Cycle $\leq 2\%$

2N838 (Ge Mesa)



CASE 22-03
(TO-18)

PNP germanium mesa transistor for high-speed switching applications.

Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	30	Vdc
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Emitter Voltage	V_{CEX}	15	Vdc
Emitter-Base Voltage	V_{EB}	2.5	Vdc
Collector Current - Continuous	I_C	100	mAdc
Junction Temperature	T_J	+100	$^{\circ}\text{C}$
Storage Temperature	T_{stg}	-65 to + 100	$^{\circ}\text{C}$
Device Dissipation @ $T_A = 25^{\circ}\text{C}$ (Derate 2mW/ $^{\circ}\text{C}$ above 25°C)	P_D	150 2.0	mW mW/ $^{\circ}\text{C}$

*Indicates JEDEC Registered Data

FIGURE 1 — SWITCHING TIME TEST CIRCUIT

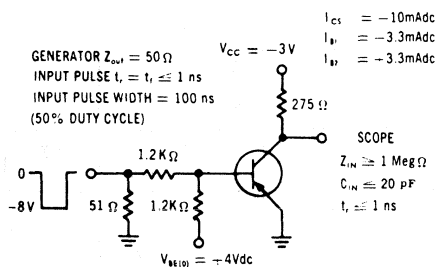
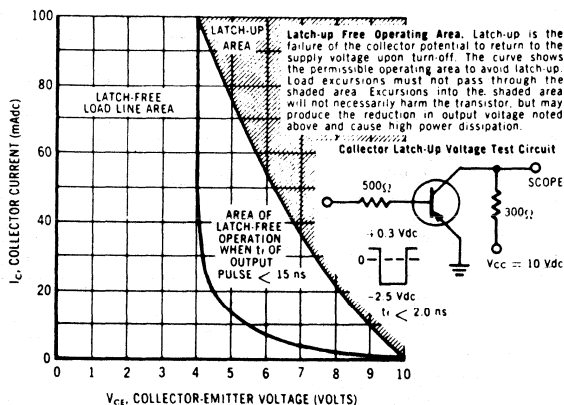


FIGURE 2 — AREA OF PERMISSIBLE LOAD LOC

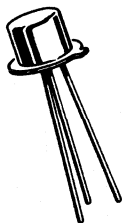


*** ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{A}$, $I_E = 0$)	BV_{CBO}	30	---	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100 \mu\text{A}$, $V_{EB} = 0$)	BV_{CES}	30	---	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{A}$, $I_C = 0$)	BV_{EBO}	2.5	---	Vdc
Collector Latch-up Voltage (see Figure 2)	LV_{CEX}	15	---	Vdc
Collector-Emitter Cutoff Current ($V_{CE} = 15 \text{ Vdc}$, $V_{EB} = 0$)	I_{CES}	---	10	μA
Collector-Base Cutoff Current ($V_{CB} = 15 \text{ V}$, $I_E = 0$)	I_{CBO}	---	10	μA
DC Forward Current Transfer Ratio ($I_C = 10 \text{ mA}$, $V_{CE} = 0.3 \text{ Vdc}$)	h_{FE}	30	---	---
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mA}$, $I_B = 3.3 \text{ mA}$)	$V_{CE(sat)}$	---	0.18	Vdc
Base-Emitter Voltage ($I_C = 10 \text{ mA}$, $I_B = 3.3 \text{ mA}$)	V_{BE}	---	0.5	Vdc
Small-Signal Forward Current Transfer Ratio ($I_C = 10 \text{ mA}$, $V_{CE} = 1 \text{ V}$, $f = 100 \text{ MHz}$)	h_{fe}	3.0	---	---
Collector Output Capacitance ($V_{CB} = 10 \text{ V}$, $I_E = 0$, $f = 1 \text{ MHz}$)	C_{ob}	---	4.0	pF
Delay Time (Figure 1)	t_d	---	15	ns
Rise Time (Figure 1)	t_r	---	15	ns
Storage Time (Figure 1)	t_s	---	20	ns
Fall Time (Figure 1)	t_f	---	20	ns

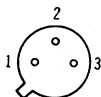
*Indicates JEDEC Registered Data

2N841 (SILICON)



NPN silicon annular transistor designed for small-signal amplifier and general purpose switching applications.

CASE 22
(TO-18)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

Collector connected to case

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Emitter Voltage	V_{CES}	45	Vdc
Collector-Base Voltage	V_{CB}	45	Vdc
Emitter-Base Voltage	V_{EB}	2.0	Vdc
Collector Current	I_C	1.0	Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	500 2.86	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

*Indicates JEDEC Registered Data

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 10 \text{ mAdc}$, $I_E = 0$)	BV_{CEO}	45	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \text{ } \mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	45	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \text{ } \mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	2.0	-	Vdc
Collector Cutoff Current ($V_{CE} = 45 \text{ Vdc}$, $V_{BE} = 0$, $R_{BE} = 5.0 \text{ k ohms}$)	I_{CER}	-	20	μAdc
Collector Cutoff Current ($V_{CB} = 45 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 45 \text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	- -	1.0 50	μAdc
Emitter Cutoff Current ($V_{BE} = 2.0 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	-	50	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 10 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	60	400	-
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 2.2 \text{ mAdc}$)	$V_{CE(sat)}$	-	2.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 20 \text{ MHz}$)	f_T	2.0	-	MHz
Output Capacitance ($V_{CB} = 5.0 \text{ Vdc}$, $I_E = 0$, $f = 1.0 \text{ MHz}$)	C_{ob}	-	15	pF
Small-Signal Current Gain ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$, $T_A = -55^\circ\text{C}$)	h_{fe}	80 25	330 -	-
Output Admittance ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{oe}	-	1.2	μmhos
Input Resistance ($I_C = 1.0 \text{ mAdc}$, $V_{CB} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{ib}	-	80	Ohms
Output Conductance ($I_C = 1.0 \text{ mAdc}$, $V_{CB} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{ob}	-	1.2	μmhos
Real Part of Input Impedance ($I_C = 10 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 20 \text{ MHz}$)	$\text{Re}(h_{ie})$	-	500	Ohms

*Indicates JEDEC Registered Data

2N 843(SILICON)

NPN SILICON ANNULAR AMPLIFIER TRANSISTOR

... designed for use in general-purpose amplifier applications.

- Collector-Emitter Breakdown Voltage – $V_{CEO} = 45 \text{ Vdc (Min) @ } I_C = 10 \text{ mAdc}$
- High Current-Gain-Bandwidth Product – $f_T = 250 \text{ MHz (Typ) @ } I_C = 10 \text{ mAdc}$

NPN SILICON AMPLIFIER TRANSISTOR



MAXIMUM RATINGS

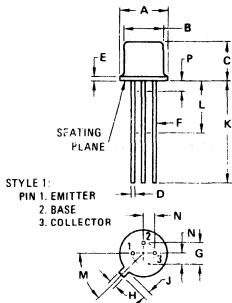
Rating	Symbol	Value	Unit
*Collector-Emitter Voltage	V_{CEO}	45	Vdc
*Collector-Base Voltage	V_{CB}	45	Vdc
*Emitter-Base Voltage	V_{EB}	2.0	Vdc
*Collector Current – Continuous	I_C	800	mAdc
*Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate Above 25°C	P_D	300 2.0	mW mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate Above 25°C	P_D	1.3 8.7	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Thermal Resistance, Junction to Ambient	$R_{\theta JA}(1)$	500	$^\circ\text{C/W}$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	115	$^\circ\text{C/W}$

*Indicates JEDEC Registered Data

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	—	0.762	—	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC	—	0.100 BSC	—
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC	—	45° BSC	—
N	1.27 BSC	—	0.050 BSC	—
P	—	1.27	—	0.050

All JEDEC notes and dimensions apply.

CASE 22 03
(TO-18)

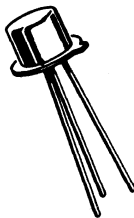
***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 10\text{ mA}$, $I_B = 0$)	BV_{CEO}	45	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\text{ }\mu\text{A}$, $I_E = 0$)	BV_{CBO}	45	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\text{ }\mu\text{A}$, $I_C = 0$)	BV_{EBO}	2.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 45\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 45\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	— —	1.0 50	μA
Collector Cutoff Current ($V_{CE} = 45\text{ Vdc}$, $R_{BE} \leq 5.0\text{ k}\Omega$)	I_{CER}	—	—	20	μA
Emitter Cutoff Current ($V_{BE} = 2.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	—	50	μA
ON CHARACTERISTICS					
DC Current Gain (1) ($I_C = 1.0\text{ mA}$, $V_{CE} = 5.0\text{ Vdc}$)	h_{FE}	45	100	150	—
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mA}$, $I_B = 2.2\text{ mA}$)	$V_{CE(sat)}$	—	0.3	1.2	Vdc
Base-Emitter Saturation Voltage ($I_C = 10\text{ mA}$, $I_B = 2.2\text{ mA}$)	$V_{BE(sat)}$	—	0.78	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 20\text{ MHz}$)	f_T	40	250	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{ob}	—	4.0	10	pF
Small-Signal Current Gain ($I_C = 1.0\text{ mA}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	40	—	—	—

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.

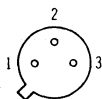
2N869 (SILICON)



CASE 22 (TO-18)

Collector connected to case

PNP silicon annular transistor for high-frequency general-purpose amplifier applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Base Voltage	V_{CB}	25	Vdc
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation at 25°C Case Temperature at 100°C Case Temperature Derate above 25°C	P_D	1.2 0.68 6.86	Watts Watt mW/°C
Total Device Dissipation at 25°C Ambient Temperature Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Storage Temperature	T_{stg}	-65 to +200	°C
Junction Temperature	T_J	+200	°C

* Indicates JEDEC Registered Data

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{A}$, $I_E = 0$)	BV_{CBO}	25	---	---	Vdc
Collector-Emitter Sustaining Voltage(1) ($I_C = 10 \text{ mA}$, $I_B = 0$)	$V_{CEO(sust)}$	18	---	---	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{A}$, $I_C = 0$)	BV_{EBO}	5.0	---	---	Vdc
Collector Cutoff Current ($V_{CB} = 15 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 15 \text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	---	---	010 25	μA
Emitter Current ($V_{EB} = 4.0 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	---	---	10	μA
Collector Saturation Voltage ($I_C = 10 \text{ mA}$, $I_B = 1.0 \text{ mA}$)	$V_{CE(sat)}$	---	0.17	1.0	Vdc
Base Saturation Voltage ($I_C = 10 \text{ mA}$, $I_B = 1.0 \text{ mA}$)	$V_{BE(sat)}$	---	0.78	1.0	Vdc
DC Forward-Current Transfer Ratio(1) ($I_C = 10 \text{ mA}$, $V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	20	---	120	---
Open-Circuit Output Capacitance ($V_{CB} = 10 \text{ V}$, $I_E = 0$)	C_{ob}	---	3.0	9	pF
Open-Circuit Input Capacitance ($V_{BE} = 0.5 \text{ V}$, $I_C = 0$) Both Types	C_{ib}	---	7.0	11	pF
Small-Signal Forward-Current Transfer Ratio ($I_C = 10 \text{ mA}$, $V_{CE} = 15 \text{ V}$, $f = 100 \text{ MHz}$)	h_{fe}	1.0	3.0	---	---

* Indicates JEDEC Registered Data

(1) Pulse Note: Pulse Width = 300 μs , Duty Cycle = 1%

2N869A (SILICON)

2N4453

PNP SILICON ANNULAR TRANSISTORS

...designed for high speed, low power, saturated switching applications.

- Collector-Emitter Sustaining Voltage –
 $V_{CEO(sus)} = 18 \text{ Vdc (Min)} - 2N869A, 2N4453$
- JAN/JANTX/JANTXV Available for 2N869A and 2N4453
- Glass Passivated Die
- Collector-Emitter Breakdown Voltage –
 $BV_{CEO} = 30 \text{ Vdc} - \text{Available as a Special}$
- Switching Times @ $I_C = 30 \text{ mAdc}$, $I_C/I_B = 10$
 $t_{on} = 9.0 \text{ ns (Typ)}$
 $t_{off} = 44 \text{ ns (Typ)}$

MAXIMUM RATINGS

Rating	Symbol	2N869A	2N4453	Unit
*Collector-Emitter Voltage	V_{CEO}	18	18	Vdc
*Collector-Base Voltage	V_{CB}	25	25	Vdc
*Emitter-Base Voltage	V_{EB}	5.0		Vdc
*Collector Current – Continuous	I_C	200		mAdc
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	360* 2.06	300* 1.71	mW mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ $T_C = 100^\circ\text{C}$ Derate above 25°C	P_D	1.2* 0.686* 6.86	1.8* 1.03 10.3	Watts mW/ $^\circ\text{C}$
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

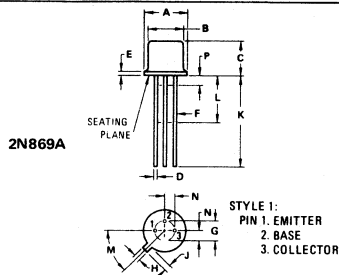
THERMAL CHARACTERISTICS

Characteristic	Symbol	2N869A	2N4453	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	486	585	$^\circ\text{C/W}$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	146	97.5	$^\circ\text{C/W}$

* Indicates JEDEC Registered Data.

SWITCHING TRANSISTORS

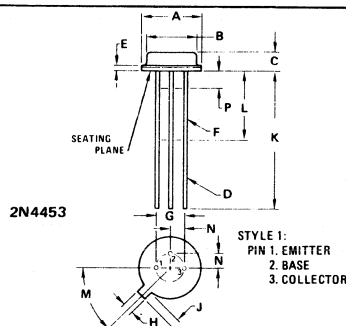
PNP SILICON



CASE 22-03
(TO-18)

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	—	0.762	—	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC	—	0.100 BSC	—
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	46° BSC	—	45° BSC	—
N	1.27 BSC	—	0.050 BSC	—
P	—	1.27	—	0.050

All JEDEC notes and dimensions apply.



CASE 26-03
TO-46

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	1.65	2.16	0.065	0.085
D	0.406	0.533	0.016	0.021
E	—	1.02	—	0.040
F	0.305	0.483	0.012	0.019
G	2.54 BSC	—	0.100 BSC	—
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC	—	45° BSC	—
N	1.27 BSC	—	0.050 BSC	—
P	—	1.27	—	0.050

All JEDEC dimensions and notes apply.

2N869A, 2N4453 (continued)

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I _C = 10 mA _{dc} , I _B = 0)	V _{CEO(sus)}	18	—	—	V _{dc}
Collector-Emitter Breakdown Voltage (I _C = 10 μA _{dc} , V _{BE} = 0)	BV _{CES}	25	—	—	V _{dc}
Collector-Base Breakdown Voltage (I _C = 10 μA _{dc} , I _E = 0)	BV _{CBO}	25	—	—	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 10 μA _{dc} , I _C = 0)	BV _{EBO}	5.0	—	—	V _{dc}
Collector Cutoff Current (V _{CE} = 15 V _{dc} , V _{BE} = 0)	I _{CES}	—	—	10	nA _{dc}
Collector Cutoff Current (V _{CB} = 15 V _{dc} , I _E = 0, T _A = 150°C)	I _{CBO}	—	—	25	μA _{dc}
Emitter Cutoff Current (V _{EB} = 4.5 V _{dc} , I _C = 0)	I _{EBO}	—	—	10	μA _{dc}
Base Current (V _{CE} = 15 V _{dc} , V _{BE} = 0)	I _B	—	—	10	nA _{dc}

ON CHARACTERISTICS (1)

DC Current Gain (I _C = 10 mA _{dc} , V _{CE} = 0.3 V _{dc}) (I _C = 10 mA _{dc} , V _{CE} = 5.0 V _{dc}) (I _C = 30 mA _{dc} , V _{CE} = 0.5 V _{dc}) (I _C = 30 mA _{dc} , V _{CE} = 0.5 V _{dc} , T _A = -55°C) (I _C = 100 mA _{dc} , V _{CE} = 1.0 V _{dc})	2N869A 2N869A 2N869A 2N4453 2N869A 2N869A	h _{FE}	30 40 40 40 17 25	— — — — — —	— 120 120 — — —	—
Collector-Emitter Saturation Voltage (I _C = 10 mA _{dc} , I _B = 1.0 mA _{dc}) (I _C = 30 mA _{dc} , I _B = 1.5 mA _{dc}) (I _C = 30 mA _{dc} , I _B = 3.0 mA _{dc}) (I _C = 100 mA _{dc} , I _B = 10 mA _{dc})	2N869A 2N4453 2N869A 2N869A	V _{CE(sat)}	— — — —	— — — —	0.15 0.25 0.2 0.5	V _{dc}
Base-Emitter Saturation Voltage (I _C = 10 mA _{dc} , I _B = 1.0 mA _{dc}) (I _C = 30 mA _{dc} , I _B = 1.5 mA _{dc}) (I _C = 30 mA _{dc} , I _B = 3.0 mA _{dc}) (I _C = 100 mA _{dc} , I _B = 10 mA _{dc})	2N869A 2N4453 2N869A 2N869A	V _{BE(sat)}	0.78 0.8 0.85 —	— — — —	0.98 1.1 1.2 1.7	V _{dc}

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product (1)(2) (I _C = 10 mA _{dc} , V _{CE} = 15 V _{dc} , f = 100 MHz)	f _T	400	—	—	MHz
Emitter-Base Capacitance (V _{BE} = 0.5 V _{dc} , I _C = 0, f = 1.0 MHz)	C _{eb}	—	—	6.0	pF
Collector-Base Capacitance (V _{CB} = 5.0 V _{dc} , I _E = 0, f = 1.0 MHz)	C _{cb}	—	—	6.0	pF
Output Capacitance (V _{CB} = 5.0 V _{dc} , I _E = 0, f = 140 kHz)	C _{ob}	—	—	6.0	pF
Input Capacitance (V _{BE} = 0.5 V _{dc} , I _C = 0, f = 150 kHz)	C _{ib}	—	—	6.0	pF

SWITCHING CHARACTERISTICS (Figure 3)

Turn-On Time	V _{CC} = 2.0 V _{dc} , 2N869A	t _{on}	—	30	50	ns
Delay Time	I _C = 30 mA _{dc} , V _{CC} = 3.0 V _{dc} { 2N4453	t _d	—	13	35	ns
Rise Time	I _{B1} = 1.5 mA _{dc} { 2N4453	t _r	—	17	20	ns
Turn-Off Time	I _C = 30 mA _{dc} , V _{CC} = 2.0 V _{dc} 2N869A	t _{off}	—	60	80	ns
Storage Time	I _{B1} = I _{B2} = V _{CC} = 3.0 V _{dc} { 2N4453	t _s	—	43	65	ns
Fall Time	1.5 mA _{dc} { 2N4453	t _f	—	17	20	ns

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 1.0%.

(2) f_T is defined as the frequency at which |h_{fe}| extrapolates to unity.

TYPICAL SWITCHING CHARACTERISTICS

FIGURE 1 – TURN-ON TIME

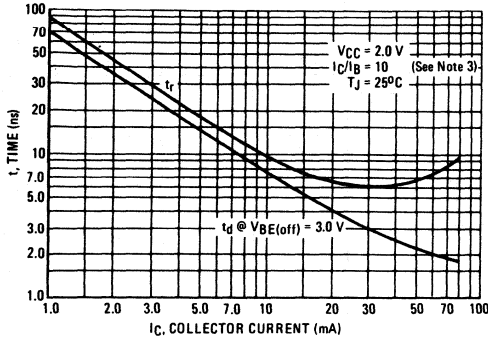


FIGURE 2 – TURN-OFF TIME

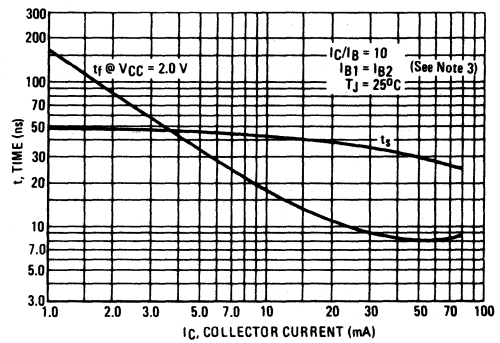


FIGURE 3 – SWITCHING TIME TEST CIRCUIT

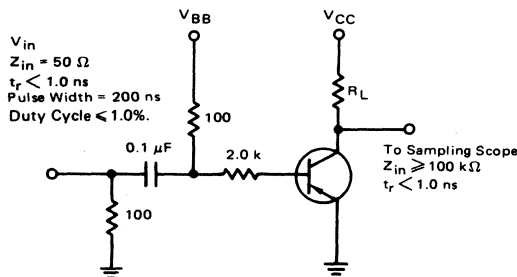


FIGURE 4 – CAPACITANCE

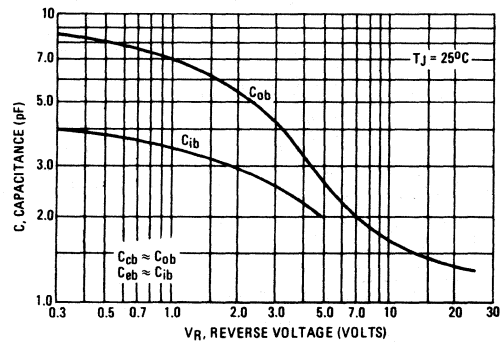


FIGURE 5 – SWITCHING TEST CIRCUIT VALUES

		V_{in} Volts	V_{BB} Volts	V_{CC} Volts	R_L Ohms	I_C mA	$I_{B1}^{(4)}$ mA	$I_{B2}^{(4)}$ mA
t_{on}, t_r, t_d	2N869A	-7.0	3.0	2.0	62	30	1.5	—
	2N4453	-7.0	3.0	3.0	91	30	1.5	—
t_{off}, t_s, t_f	2N869A	+6.0	-4.0	2.0	62	30	1.5	1.5
	2N4453	+6.0	-4.0	3.0	91	30	1.5	1.5

(3) $I_C/I_B = 10$. Switching is shown to reflect current industry practices. Compare the values shown in Figures 1 and 2 @ $I_C = 30$ mA to the typical values in the Electrical Characteristics table @ $I_C/I_B = 20$.

(4) $I_{B1} = I_{B2} = 3.0$ mA @ $I_C/I_B = 10$

FIGURE 6 – DC CURRENT GAIN

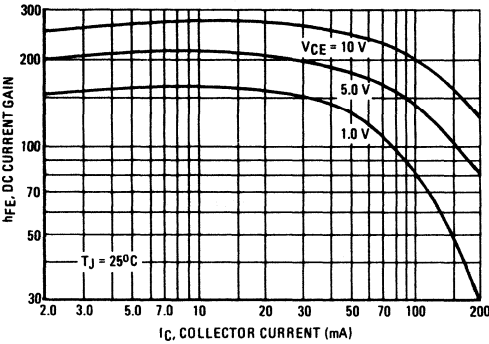


FIGURE 7 – “ON” VOLTAGES

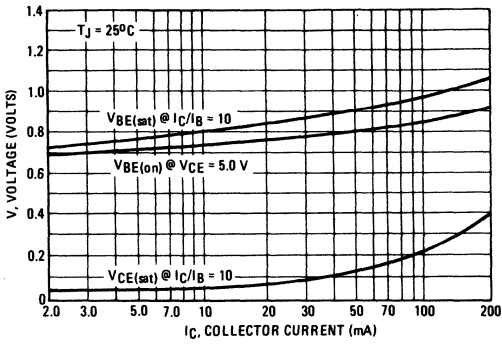
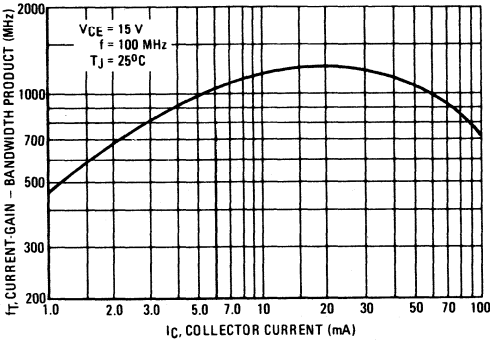


FIGURE 8 – CURRENT-GAIN – BANDWIDTH PRODUCT



NPN SILICON ANNULAR TRANSISTOR

... designed for small-signal amplifier applications.

- High Collector-Emitter Sustaining Voltage –
 $V_{CEO(sus)} \geq 60 \text{ Vdc (Min) @ } I_C = 30 \text{ mAdc}$

NPN SILICON AMPLIFIER TRANSISTOR



MAXIMUM RATINGS

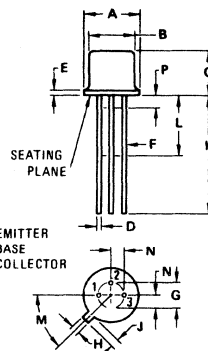
Rating	Symbol	Value	Unit
*Collector-Emitter Voltage	V_{CEO}	60	Vdc
*Collector-Emitter Voltage ($R_{BE} = 10 \text{ Ohms}$)	V_{CER}	80	Vdc
*Collector-Base Voltage	V_{CB}	100	Vdc
*Emitter-Base Voltage	V_{EB}	7.0	Vdc
Collector Current – Continuous	I_C	1.0	Adc
*Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.5 2.86	Watt mW/ $^\circ\text{C}$
*Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C $T_C = 100^\circ\text{C}$	P_D	1.8 1.0 10.3	Watt mW/ $^\circ\text{C}$
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	350	$^\circ\text{C/W}$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97.4	$^\circ\text{C/W}$

*Indicates JEDEC Registered Data.

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	—	0.762	—	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC	—	0.100 BSC	—
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	48.0 BSC	—	48.0 BSC	—
N	1.27 BSC	—	0.050 BSC	—
P	—	1.27	—	0.050

All JEDEC notes and dimensions apply.

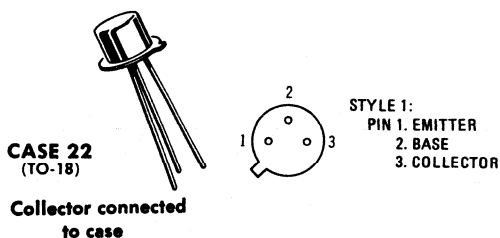
CASE 22-03
(TO-18)

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) ($I_C = 30\text{ mA}$, $I_B = 0$)	$V_{CE(sus)}$	60	—	Vdc
Collector-Emitter Sustaining Voltage (1) ($I_C = 100\text{ mA}$, $R_{BE} \leq 10\text{ ohms}$)	$V_{CER(sus)}$	80	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\text{ }\mu\text{A}$, $I_E = 0$)	BV_{CBO}	100	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\text{ }\mu\text{A}$, $I_C = 0$)	BV_{EBO}	7.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 75\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 75\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	25 15	nAdc μAdc
Emitter Cutoff Current ($V_{BE} = 5.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	25	nAdc
ON CHARACTERISTICS (1)				
DC Current Gain ($I_C = 0.1\text{ mA}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $T_A = -55^\circ\text{C}$)	h_{FE}	35 75 30	— — —	—
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mA}$, $I_B = 1.0\text{ mA}$) ($I_C = 50\text{ mA}$, $I_B = 5.0\text{ mA}$)	$V_{CE(sat)}$	— —	0.4 1.2	Vdc
Base-Emitter Saturation Voltage ($I_C = 10\text{ mA}$, $I_B = 1.0\text{ mA}$) ($I_C = 50\text{ mA}$, $I_B = 5.0\text{ mA}$)	$V_{BE(sat)}$	0.6 —	0.8 0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain-Bandwidth Product ($I_C = 50\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 20\text{ MHz}$)	f_T	60	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)	C_{ob}	—	15	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)	C_{ib}	—	85	pF
Input Impedance ($I_C = 5.0\text{ mA}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ie}	—	1800	Ohms
Small-Signal Current Gain ($I_C = 1.0\text{ mA}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	76	200	—
Output Admittance ($I_C = 5.0\text{ mA}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{oe}	—	100	μhos
Input Resistance ($I_C = 1.0\text{ mA}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 5.0\text{ mA}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ib}	20 4.0	30 8.0	Ohms
Voltage Feedback Ratio ($I_C = 1.0\text{ mA}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{rb}	—	3.0	$\times 10^{-4}$
Output Conductance ($I_C = 1.0\text{ mA}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 5.0\text{ mA}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ob}	— —	0.5 1.0	μmho
Noise Figure ($I_C = 0.3\text{ mA}$, $V_{CB} = 10\text{ Vdc}$, $R_G = 510\text{ ohms}$, $f = 1.0\text{ kHz}$, B. W. = 200 Hz)	NF	—	12	dB

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle = 2.0%.



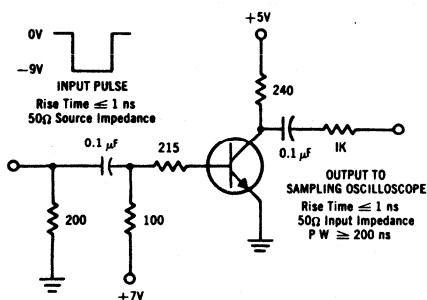
NPN silicon annular transistor for high-speed switching applications.

*** MAXIMUM RATINGS**

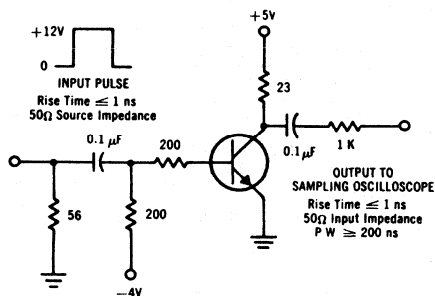
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage ($R_{BE} \leq 10$ ohms)	V_{CER}	20	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current (Note 1)	I_C	150	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	360 2.06	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.2 6.9	Watts mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 100^\circ\text{C}$	P_D	0.68	Watt
Operating Junction Temperature Range	T_J	200	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

*Indicates JEDEC Registered Data.
Note 1: Limited by Power Dissipation

CHARGE STORAGE TIME CONSTANT TEST CIRCUIT



t_{on} and t_{off} TEST CIRCUIT



2N914 (continued)***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage (Note 1) ($I_C = 30 \text{ mAdc}$, $I_B = 0$)	$BV_{CEO(sus)}$	15	-	Vdc
Collector-Emitter Sustaining Voltage (Note 1) ($I_C = 30 \text{ mAdc}$, $R_{BE} \leq 10 \text{ ohms}$)	$BV_{CER(sus)}$	20	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 1.0 \text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current ($V_{CE} = 20 \text{ Vdc}$, $V_{EB(off)} = 0.25 \text{ Vdc}$, $T_A = 125^\circ\text{C}$)	I_{CEX}	-	10	μAdc
Collector Cutoff Current ($V_{CB} = 20 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 20 \text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	- -	0.025 15	μAdc
Emitter Cutoff Current ($V_{BE} = 4.0 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	-	0.1	μAdc

ON CHARACTERISTICS

DC Current Gain (Note 1) ($I_C = 10 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$, $T_A = -55^\circ\text{C}$) ($I_C = 500 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	30 12 10	120 - -	-
Collector-Emitter Saturation Voltage (Note 1) ($I_C = 200 \text{ mAdc}$, $I_B = 20 \text{ mAdc}$) ($I_C = 10 \text{ mAdc}$, $I_B = 1.0$ thru 20 mAdc , $T_A = -55$ to $+125^\circ\text{C}$)	$V_{CE(sat)}$	- -	0.70 0.25	Vdc
Base-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 1.0 \text{ mAdc}$)	$V_{BE(sat)}$	0.70	0.80	Vdc

DYNAMIC CHARACTERISTICS

[†] Current-Gain — Bandwidth Product ($I_C = 20 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	300	-	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 1.0 \text{ MHz}$)	C_{ob}	-	6.0	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 1.0 \text{ MHz}$)	C_{ib}	-	9.0	pF
Charge Storage Time Constant (Note 2) ($I_C = I_{B1} = I_{B2} = 20 \text{ mAdc}$)	τ_s	-	20	ns
Turn-On Time (Note 2) ($I_C = 200 \text{ mAdc}$, $I_{B1} = 40 \text{ mAdc}$, $I_{B2} = 20 \text{ mAdc}$)	t_{on}	-	40	ns
Turn-Off Time (Note 2) ($I_C = 200 \text{ mAdc}$, $I_{B1} = 40 \text{ mAdc}$, $I_{B2} = 20 \text{ mAdc}$)	t_{off}	-	40	ns

Note 1: Pulse Test: Pulse Width = 300 μs , Duty Cycle $\leq 1.0\%$.Note 2: Measured on Sampling Scope: Pulse Width $\geq 200 \text{ ns}$.

*Indicates JEDEC Registered Data.

[†]JEDEC Registration Defined as h_{fe} .

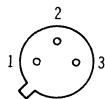
2N915 (SILICON)

CASE 22 (TO-18)



NPN silicon annular transistor for high-frequency amplifier, oscillator and switching applications.

Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	70	Vdc
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation @ 25°C Case Temperature Derating Factor Above 25°C	P_D	1.2 6.9	W mW/°C
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor Above 25°C	P_D	0.36 2.06	W mW/°C
Junction Temperature, Operating	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to + 200	°C

* Indicates JEDEC Registered Data

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current $I_E = 0 \quad V_{CB} = 60\text{V}$	I_{CBO}		10	nA
Collector Cutoff Current @ 150°C $I_E = 0 \quad V_{CB} = 60\text{V}$	I_{CBO}		30	μA
Collector Breakdown Voltage $I_C = 100 \mu\text{A} \quad I_E = 0$	BV_{CBO}	70		Volts
Collector to Emitter Sustaining Voltage(1) $I_C = 10\text{mA} \quad I_B = 0$	V_{CEO}	50		Volts
Emitter Breakdown Voltage $I_C = 0 \quad I_E = 100 \mu\text{A}$	BV_{EBO}	5.0		Volts
Base Saturation Voltage $I_C = 10\text{mA} \quad I_B = 1.0\text{mA}$	$V_{BE(\text{sat})}$		0.9	Volts
Collector Saturation Voltage $I_C = 10\text{mA} \quad I_B = 1.0\text{mA}$	$V_{CE(\text{sat})}$		1.0	Volts
DC Pulse Current Gain $I_C = 10\text{mA} \quad V_{CE} = 5.0\text{V}$	h_{FE}	50	200	
Output Capacitance $I_E = 0 \quad V_{CB} = 10\text{V}$	C_{ob}		3.5	pF
Emitter Transition Capacitance $I_C = 0 \quad V_{EB} = 0.5\text{V}$	C_{TE}		10	pF
High Frequency Current Gain $f = 100\text{ MHz}$ $I_C = 10\text{mA} \quad V_{CE} = 15\text{V}$	h_{fe}	2.5		
Small Signal Current Gain $f = 1\text{ kHz}$ $I_C = 1.0\text{mA} \quad V_{CE} = 5.0\text{V}$ $I_C = 5.0\text{mA} \quad V_{CE} = 5.0\text{V}$	h_{fe}	40	200	
		50	250	
Input Resistance $f = 1\text{ kHz}$ $I_C = 1.0\text{mA} \quad V_{CE} = 5.0\text{V}$ $I_C = 5.0\text{mA} \quad V_{CE} = 5.0\text{V}$	h_{ie}		6000	ohms
			2000	ohms
Output Conductance $f = 1\text{ kHz}$ $I_C = 1.0\text{mA} \quad V_{CE} = 5.0\text{V}$ $I_C = 5.0\text{mA} \quad V_{CE} = 5.0\text{V}$	h_{oe}		75	μmho
			125	μmho

* Indicates JEDEC Registered Data

(1) Pulse Test: $PW \leq 300 \mu\text{s}$, Duty Cycle $\leq 1.0\%$

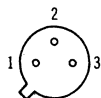
2N916 (SILICON)

2N916 JAN Available

CASE 22
(TO-18)



Collector
connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

NPN silicon annular transistor for high-frequency amplifier, oscillator and switching applications.

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	45	Vdc
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Total Device Dissipation @ 25°C Case Temperature Derating Factor Above 25°C	P_D	1.2 6.9	W mW/°C
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor Above 25°C	P_D	.36 2.06	W mW/°C
Junction Temperature, Operating	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +300	°C

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current $I_E = 0 \quad V_{CB} = 30\text{V}$	I_{CBO}		10	nAdc
Collector Cutoff Current @150°C $I_E = 0 \quad V_{CB} = 30\text{V}$	I_{CBO}		10	μAdc
Collector Breakdown Voltage $I_C = 10\mu\text{A} \quad I_E = 0$	BV_{CBO}	45		Vdc
Collector to Emitter Sustaining Voltage (1) $I_C = 30\text{mA} \quad I_B = 0$	V_{CEO}	25		Vdc
Emitter Breakdown Voltage $I_C = 0 \quad I_E = 10\mu\text{A}$	BV_{EBO}	5.0		Vdc
Base Saturation Voltage $I_C = 10\text{mA} \quad I_B = 1.0\text{mA}$	$V_{BE(sat)}$		0.9	Vdc
Collector Saturation Voltage $I_C = 10\text{mA} \quad I_B = 1.0\text{mA}$	$V_{CE(sat)}$		0.5	Vdc
DC Pulse Current Gain (1) $I_C = 10\text{mA} \quad V_{CE} = 1.0\text{V}$	h_{FE}	50	200	—
Output Capacitance $I_E = 0 \quad V_{CB} = 5.0\text{V}$	C_{ob}		6.0	pF
Emitter Transition Capacitance $I_C = 0 \quad V_{EB} = 0.5\text{V}$	C_{TE}		10	pF
High Frequency Current Gain $f = 100\text{ MHz}$ $I_C = 10\text{mA} \quad V_{CE} = 15\text{V}$	h_{fe}	3.0		—
Small Signal Current Gain $f = 1\text{ kHz}$ $I_C = 1.0\text{mA} \quad V_{CE} = 5.0\text{V}$ $I_C = 5.0\text{mA} \quad V_{CE} = 5.0\text{V}$	h_{fe}	40 50	200 250	
Input Resistance $f = 1\text{ kHz}$ $I_C = 1.0\text{mA} \quad V_{CE} = 5.0\text{V}$ $I_C = 5.0\text{mA} \quad V_{CE} = 5.0\text{V}$	h_{ie}		6000 2000	ohms ohms
Output Conductance $f = 1\text{ kHz}$ $I_C = 1.0\text{mA} \quad V_{CE} = 5.0\text{V}$ $I_C = 5.0\text{mA} \quad V_{CE} = 5.0\text{V}$	h_{oe}		75 125	μmho μmho

* Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width $\approx 300\mu\text{s}$, Duty Cycle $\leq 1.0\%$

NPN SILICON ANNULAR VHF/UHF OSCILLATOR AMPLIFIER TRANSISTOR

... designed for use as both oscillator and amplifier at UHF and VHF frequencies.

- Collector-Emitter Breakdown Voltage —
 $BV_{CEO} = 15 \text{ Vdc (Min) @ } I_C = 3.0 \text{ mAdc}$
- High Current-Gain-Bandwidth Product —
 $f_T = 900 \text{ MHz (Typ) @ } I_C = 4.0 \text{ mAdc}$
- Low Output Capacitance —
 $C_{ob} = 0.8 \text{ pF (Typ) @ } V_{CB} = 10 \text{ Vdc}$
- Excellent Noise Figure —
 $NF = 3.0 \text{ dB (Typ) @ } I_C = 1.0 \text{ mAdc, } f = 60 \text{ MHz}$
- High Power Output —
 $P_{out} = 10 \text{ mW @ } V_{CE} = 15 \text{ Volts}$

NPN SILICON VHF/UHF OSCILLATOR AMPLIFIER TRANSISTOR



MAXIMUM RATINGS

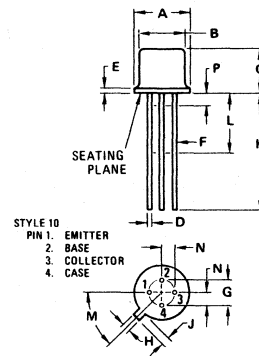
Rating	Symbol	Value	Unit
*Collector-Emitter Voltage	V_{CEO}	15	Vdc
*Collector-Base Voltage	V_{CB}	30	Vdc
*Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector-Current — Continuous	I_C	50	mAdc
*Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	200 1.14	mW mW/ $^\circ\text{C}$
*Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	300 1.72	mW mW/ $^\circ\text{C}$
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}(1)$	875	$^\circ\text{C/W}$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	583	$^\circ\text{C/W}$
Lead Temperature 1/16" From Case for 60 Seconds	T_L	300	$^\circ\text{C}$

*Indicates JEDEC Registered Data.

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.34	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	—	0.76	—	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC	—	0.100 BSC	—
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC	—	45° BSC	—
N	1.27 BSC	—	0.050 BSC	—
P	—	1.27	—	0.050

ALL JEDEC dimensions and notes apply

CASE 20-03
TO-72

(1) Pulse Test: Pulse Width $\leq 300 \mu s$, Duty Cycle $\leq 2.0\%$.

$V_{CB} = 10 \text{ V}$
 $I_C = 5.0 \text{ mA}$
 $f = 200 \text{ MHz}$
 $R_G = 50 \Omega$

Components and values:
 - $25 \mu\text{F}$ capacitor
 - $0.05 \mu\text{F}$ capacitor
 - $R.F.C. f_r = 200 \text{ MHz}$ (1000 pF)
 - L_2 inductor
 - 15 pF capacitor
 - Output
 - 15 pF capacitor
 - 11 pF capacitor
 - 1000 pF capacitor
 - $R.F.C. f_r = 200 \text{ MHz}$ (1000 pF)
 - 2.2 k resistor
 - 5.0 mA resistor
 - $0.05 \mu\text{F}$ capacitor
 - V_{BB}

Dimensions:
 - L_1 - 1 Loop = 12 ga 10 = 2 cm
 - L_2 - 1/2 Loop = 12 ga 10 = 3 cm

$I_C = 8.0 \text{ mA}$
 $V_{CB} = 15 \text{ V}$
 $f = 500 \text{ MHz}$

1. Coax plumbing consists of the following GR air lines:
 - 2 Type 874 TEE
 - 1 Type 874-D20 Adjustable Stub
 - 1 Type 874-LA Adjustable Line
 - 1 Type 874-WN3 Short-Circuit Termination
2. 2 turns #16 AWG wire, 3/8 inch OD, 1-1/4 inch long
(or the equivalent)

2N918 (SILICON)

2N918 JAN, JTX AVAILABLE

NPN SILICON ANNULAR TRANSISTORS

... designed for use in VHF and UHF amplifier, mixer and oscillator applications.

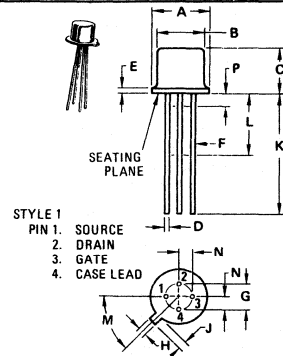
- High Current-Gain – Bandwidth Product –
 $f_T = 600 \text{ MHz (Min) @ } f = 100 \text{ MHz}$
- Low Output Capacitance –
 $C_{ob} = 1.7 \text{ pF (Max) @ } V_{CB} = 10 \text{ Vdc}$
- Collector-Emitter Sustaining Voltage –
 $V_{CE(sus)} = 15 \text{ Vdc (Min) @ } I_C = 3.0 \text{ mAdc}$
- JAN/JANTX Also Available

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE}	15	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current – Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	200	mW
		1.14	mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	300	mW
		1.71	mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

*Indicates JEDEC Registered Data

NPN SILICON AMPLIFIER TRANSISTORS

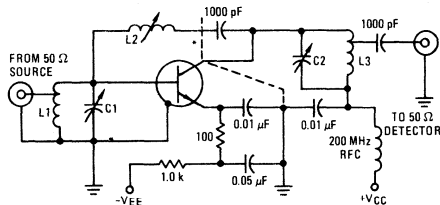


DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	—	0.76	—	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC	—	0.100 BSC	—
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC	—	45° BSC	—
N	1.27 BSC	—	0.050 BSC	—
P	—	1.27	—	0.050

ALL JEDEC dimensions and notes apply

CASE 20-03
TO-72

FIGURE 1 – NEUTRALIZED 200 MHz POWER AMPLIFIER GAIN TEST CIRCUIT

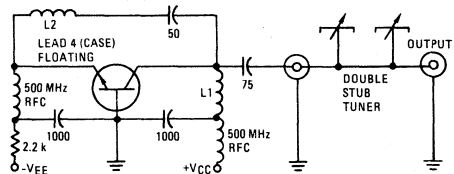


CIRCUIT COMPONENT INFORMATION:

- C1: 3.0-12 pF
C2: 1.5-7.5 pF
L1: 3 1/2 turns #16 AWG 5/16" ID, 7/16" length, turns ratio -2 to 1
L2: 0.4-0.65 μH Miller #4303 (or equal)
L3: 8 turns #16 AWG 1/8" ID, 7/8" length, turns ratio -8 to 1

*External interlead shield to isolate collector lead from emitter and base leads.

FIGURE 2 – 500 MHz OSCILLATOR TEST CIRCUIT



CIRCUIT COMPONENT INFORMATION:

- L1: 2 turns #16 AWG, 3/8" OD, 1 1/4" length
L2: 9 turns #22 AWG, 3/16" OD, 1/2" length
Capacitance values are in pF.
Double Stub Tuner consists of the following commercially available components.
2 GR Type 874 TEE
1 GR Type 874-D20 Adjustable Stub
1 GR Type 874-LA Adjustable Line
1 GR Type 874-WN3 Short-Circuit Termination
(or equivalents)

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage ($I_C = 3.0\text{ mAdc}$, $I_B = 0$)	$V_{CE(sus)}$	15	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 1.0\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	30	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	3.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 15\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 15\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	.010 1.0	μAdc μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 3.0\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$)	h_{FE}	20	—	—
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$)	$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$)	$V_{BE(sat)}$	—	1.0	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain — Bandwidth Product (1) ($I_C = 4.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	600	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 140\text{ kHz}$) ($V_{CB} = 0$, $I_E = 0$, $f = 140\text{ kHz}$)	C_{ob}	— —	1.7 3.0	pF
Input Capacitance ($V_{EB} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 140\text{ kHz}$)	C_{ib}	—	2.0	pF
Noise Figure ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 6.0\text{ Vdc}$, $R_G = 400\text{ Ohms}$, $f = 60\text{ MHz}$)	NF	—	6.0	dB

FUNCTIONAL TEST

Amplifier Power Gain (Figure 1) ($V_{CB} = 12\text{ Vdc}$, $I_C = 6.0\text{ mAdc}$, $f = 200\text{ MHz}$)	G_{pe}	15	—	dB
Power Output (Figure 2) ($V_{CB} = 15\text{ Vdc}$, $I_C = 8.0\text{ mAdc}$, $f = 500\text{ MHz}$)	P_{out}	30	—	mW
Collector Efficiency (Figure 2) ($V_{CB} = 15\text{ Vdc}$, $I_C = 8.0\text{ mAdc}$, $f = 500\text{ MHz}$)	η	25	—	%

*Indicates JEDEC Registered Data.

(1) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

2N929, A (SILICON)

2N930, A

2N929 JAN, JTX AVAILABLE

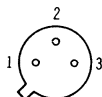
2N930 JAN, JTX AVAILABLE



NPN silicon annular transistors for low-level, low-noise amplifier applications.

CASE 22
(TO-18)

Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	2N929 2N930	2N929A 2N930A	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	Vdc
Collector-Base Voltage	V_{CB}	45	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	6.0	Vdc
Collector Current	I_C	30		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.5 3.33		W mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.8 12		Watt mW/ $^\circ\text{C}$
Operating Junction Temperature Range	T_J	-65to + 175		$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200		$^\circ\text{C}$

* Indicates JEDEC Registered Data

2N929, A, 2N930, A (continued)

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ⁽¹⁾ (I _C = 10 mA, I _B = 0)	BV _{CEO}	45	-	Vdc
Collector-Base Breakdown Voltage (I _C = 10 mA, I _E = 0) 2N929A, 2N930A	BV _{CBO}	60	-	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 mA, I _C = 0) 2N929, 2N930 2N929A, 2N930A	BV _{EBO}	5.0 6.0	-	Vdc
Collector Cutoff Current (V _{CE} = 5.0 Vdc, I _B = 0)	I _{CEO}	-	2.0	nA
Collector Cutoff Current (V _{CE} = 45 Vdc, V _{BE} = 0) 2N929, 2N930 2N929A, 2N930A	I _{CES}	-	10 2.0	nA
(V _{CE} = 45 Vdc, V _{BE} = 0, T _A = 170°C) 2N929, 2N930 2N929A, 2N930A		-	10 2.0	μA
Collector Cutoff Current (V _{CE} = 45 Vdc, I _E = 0) 2N929, 2N930 2N929A, 2N930A	I _{CBO}	-	10 2.0	nA
Emitter Cutoff Current (V _{BE} = 5.0 Vdc, I _C = 0) 2N929, 2N930 2N929A, 2N930A	I _{EBO}	-	10 2.0	nA

ON CHARACTERISTICS

DC Current Gain (I _C = 1.0 mA, V _{CE} = 5.0 Vdc) 2N929A 2N930A	h _{FE}	25 60	-	-
(I _C = 10 mA, V _{CE} = 5.0 Vdc) 2N929, 2N929A 2N930, 2N930A		40 100	120 300	
(I _C = 10 mA, V _{CE} = 5.0 Vdc, T _A = -55°C) 2N929 2N929A 2N930 2N930A		10 15 20 30	- - - -	
(I _C = 500 mA, V _{CE} = 5.0 Vdc) 2N929, 2N929A 2N930, 2N930A		60 150	- -	
(I _C = 10 mA, V _{CE} = 5.0 Vdc) ⁽¹⁾ 2N929, 2N929A 2N930, 2N930A		- -	350 600	
Collector-Emitter Saturation Voltage ⁽¹⁾ (I _C = 10 mA, I _B = 0.5 mA) 2N929, 2N930 2N929A, 2N930A	V _{CE(sat)}	- -	1.0 0.5	Vdc
Base-Emitter Saturation Voltage ⁽¹⁾ (I _C = 10 mA, I _B = 0.5 mA) 2N929, 2N930 2N929A, 2N930A	V _{BE(sat)}	0.6	1.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product (I _C = 500 mA, V _{CE} = 5.0 Vdc, f = 30 MHz) 2N929, 2N930 2N929A, 2N930A	f _T	30 45	- -	MHz
Output Capacitance (V _{CB} = 5.0 Vdc, I _E = 0, f = 1.0 MHz) 2N929, 2N930 2N929A, 2N930A	C _{ob}	- -	8.0 6.0	pF
Input Impedance (I _E = 1.0 mA, V _{CB} = 5.0 Vdc, f = 1.0 kHz)	h _{ib}	25	32	ohms
Voltage Feedback Ratio (I _E = 1.0 mA, V _{CB} = 5.0 Vdc, f = 1.0 kHz)	h _{rb}	-	600	X 10 ⁻⁶
Small-Signal Current Gain (I _C = 1.0 mA, V _{CE} = 5.0 Vdc, f = 1.0 kHz) 2N929, 2N929A 2N930, 2N930A	h _{fe}	60 150	350 600	-
Output Admittance (I _E = 1.0 mA, V _{CB} = 5.0 Vdc, f = 1.0 kHz)	h _{ob}	-	1.0	μmho
Noise Figure (I _C = 10 mA, V _{CE} = 5.0 Vdc, 2N929, 2N929A R _S = 10 k ohms, f = 10 Hz to 15.7 kHz) 2N930, 2N930A	NF	- -	4.0 3.0	dB

* Indicates JEDEC Registered Data

⁽¹⁾ Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N956

For Specifications, See 2N718A Data

2N960 (Ge Mesa)**2N961****2N962**

2N962JAN AVAILABLE

2N964

2N964JAN AVAILABLE

2N965**2N966**CASE 22-03
(TO-18)

Collector connected to case

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

PNP germanium mesa transistors for high-speed switching applications.

*** MAXIMUM RATINGS**

Characteristic	Symbol	2N960 2N964	2N961 2N965	2N962 2N966	Unit
Collector-Emitter Voltage	V_{CE}	15	12	12	Vdc
Collector-Base Voltage	V_{CB}	15	12	12	Vdc
Emitter-Base Voltage	V_{EB}	2.5	2.0	1.25	Vdc
Total Device Dissipation @ $T_A = 25^{\circ}\text{C}$ Derate above 25°C	P_D	150 2.0			mW mW/ $^{\circ}\text{C}$
Total Device Dissipation @ $T_C = 25^{\circ}\text{C}$ Derate above 25°C	P_D	300 4.0			mW mW/ $^{\circ}\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100			$^{\circ}\text{C}$

*Indicates JEDEC Registered Data

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}$, $I_E = 0$) 2N960, 2N964 2N961, 2N962, 2N965, 2N966	BV_{CBO}	15 12	- -	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}$, $I_C = 0$) 2N960, 2N964 2N961, 2N965 2N962, 2N966	BV_{EBO}	2.5 2.0 1.25	- - -	Vdc
Collector-Latch-up Voltage $V_{CC} = 11.5 \text{ Vdc}$	LV_{CEX}	11.5	-	Vdc
Collector-Emitter Cutoff Current ($V_{CE} = 15 \text{ Vdc}$) ($V_{CE} = 12 \text{ Vdc}$) 2N960, 2N964 2N961, 2N962, 2N965, 2N966	I_{CES}	- -	100 100	μAdc
Collector-Base Cutoff Current ($V_{CB} = 6 \text{ Vdc}$, $I_E = 0$)	I_{CBO}	-	3.0	μAdc
DC Current Gain ($I_C = 10 \text{ mAdc}$, $V_{CE} = 0.3 \text{ Vdc}$) ($I_C = 50 \text{ mAdc}$, $V_{CE} = 1 \text{ Vdc}$) ($I_C = 100 \text{ mAdc}$, $V_{CE} = 1 \text{ Vdc}$) 2N960, 2N961, 2N962 2N964, 2N965, 2N966 2N960, 2N961, 2N962 2N964, 2N965, 2N966 2N960, 2N961, 2N962 2N964, 2N965, 2N966	h_{FE}	20 40 20 40 20 40	- - - - - -	-
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 1 \text{ mAdc}$) ($I_C = 50 \text{ mAdc}$, $I_B = 5 \text{ mAdc}$) ($I_C = 100 \text{ mAdc}$, $I_B = 10 \text{ mAdc}$) 2N964, 2N965, 2N966 2N960, 2N961, 2N962 2N964, 2N965, 2N966 2N960, 2N961, 2N962 2N964, 2N965, 2N966 2N960, 2N961, 2N962	$V_{CE(sat)}$	- - - - -	0.18 0.20 0.35 0.40 0.60 0.70	Vdc
Base-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 1 \text{ mAdc}$) ($I_C = 50 \text{ mAdc}$, $I_B = 5 \text{ mAdc}$) ($I_C = 100 \text{ mAdc}$, $I_B = 10 \text{ mAdc}$) All Types All Types 2N960, 2N961, 2N964, 2N965 2N962, 2N966	$V_{BE(sat)}$	0.30 0.40 0.40 0.40	0.50 0.75 1.00 1.25	Vdc
Current-Gain - Bandwidth Product ($I_E = 20 \text{ mAdc}$, $V_{CB} = 1.0 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	300	-	MHz

*Indicates JEDEC Registered Data

2N960 SERIES (continued)

* ELECTRICAL CHARACTERISTICS (continued)

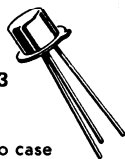
Characteristic	Symbol	Min	Max	Unit
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 1 \text{ MHz}$)	C_{ob}	-	4.0	pF
Emitter Transition Capacitance ($V_{EB} = 1 \text{ Vdc}$)	C_{Te}	-	3.5	pF
Turn-On Time ($I_C = 10 \text{ mAdc}$, $I_{B1} = 5 \text{ mAdc}$, $V_{BE(off)} = 1.25 \text{ Vdc}$) ($I_C = 100 \text{ mAdc}$, $I_{B1} = 5 \text{ mAdc}$, $V_{BE(off)} = 1.25 \text{ Vdc}$)	t_{on}	-	50	ns
Turn-Off Time ($I_C = 10 \text{ mAdc}$, $I_{B1} = 1 \text{ mAdc}$, $I_{B2} = 0.25 \text{ mAdc}$) 2N960, 2N961, 2N964, 2N965 2N962, 2N966 ($I_C = 100 \text{ mAdc}$, $I_{B1} = 5 \text{ mAdc}$, $I_{B2} = 1.25 \text{ mAdc}$) 2N960, 2N961, 2N964, 2N965 2N962, 2N966	t_{off}	-	85 100	ns
Total Control Charge ($I_C = 10 \text{ mAdc}$, $I_B = 1 \text{ mAdc}$) 2N960, 2N961, 2N964, 2N965 2N962, 2N966 ($I_C = 100 \text{ mAdc}$, $I_B = 5 \text{ mAdc}$) 2N960, 2N961, 2N964, 2N965 2N962, 2N966	Q_T	-	80 90 125 150	pC

*Indicates JEDEC Registered Data

2N963 (Ge Mesa) 2N967

CASE 22-03
(TO-18)

Collector
connected to case



PNP germanium epitaxial mesa transistors for high-speed switching applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	12	Vdc
Collector-Base Voltage	V_{CB}	12	Vdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	150 2.0	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	300 4.0	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	100	$^\circ\text{C}$

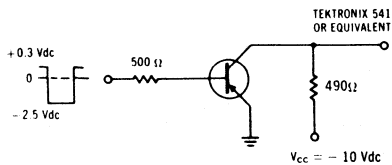
*Indicates JEDEC Registered Data

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

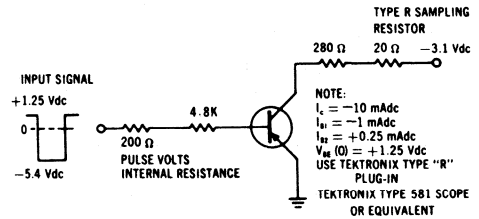
Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage ($I_C = 100\ \mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	12	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	2.0	-	Vdc
Collector-Latch-up Voltage ($V_{CC} = 10\ \text{Vdc}$)	LV_{CEX}	10	-	Vdc
Collector Cutoff Current ($V_{CE} = 12\ \text{Vdc}$, $V_{BE} = 0$)	I_{CES}	-	100	μAdc
Collector Cutoff Current ($V_{CE} = 10\ \text{Vdc}$, $V_{BE} = 0.3\ \text{Vdc}$, $T_A = 55^\circ\text{C}$)	I_{CEX}	-	20	μAdc
Collector Cutoff Current ($V_{CB} = 6\ \text{Vdc}$, $I_E = 0$)	I_{CBO}	-	5.0	μAdc
Emitter Cutoff Current ($V_{BE} = 5\ \text{Vdc}$, $I_C = 0$)	I_{EBO}	-	1.0	mAdc
Base Cutoff Current ($V_{CE} = 10\ \text{Vdc}$, $V_{BE} = 0.3\ \text{Vdc}$, $T_A = 55^\circ\text{C}$)	I_{BL}	-	20	μAdc
DC Current Gain ($I_C = 10\ \text{mAdc}$, $V_{CE} = 0.3\ \text{Vdc}$)	h_{FE}	20 40	- -	-
Collector Saturation Voltage ($I_C = 10\ \text{mAdc}$, $I_B = 1\ \text{mAdc}$)	$V_{CE(sat)}$	-	0.2	Vdc
Base-Emitter Saturation Voltage ($I_C = 10\ \text{mAdc}$, $I_B = 1\ \text{mAdc}$)	$V_{BE(sat)}$	0.3	0.5	Vdc
Current-Gain – Bandwidth Product ($I_C = 20\ \text{mAdc}$, $V_{CE} = 1\ \text{Vdc}$, $f = 100\ \text{MHz}$)	f_T	300	-	MHz
Output Capacitance ($V_{CB} = 5\ \text{Vdc}$, $I_E = 0$, $f = 1\ \text{MHz}$)	C_{ob}	-	5.0	pF
Input Capacitance ($V_{BE} = 1\ \text{Vdc}$, $I_C = 0$, $f = 100\ \text{kHz}$)	C_{ib}	-	4.0	pF
Turn-On Time ($I_C = 10\ \text{mAdc}$, $I_{B1} = 1\ \text{mAdc}$, $V_{BE(off)} = 1.25\ \text{Vdc}$)	t_{on}	-	60	ns
Turn-Off Time ($I_C = 10\ \text{mAdc}$, $I_{B1} = 1\ \text{mAdc}$, $I_{B2} = 1.25\ \text{mAdc}$)	t_{off}	-	120	ns
Total Control Charge ($I_C = 10\ \text{mAdc}$, $I_B = 1\ \text{mAdc}$)	Q_T	-	120	pC

*Indicates JEDEC Registered Data

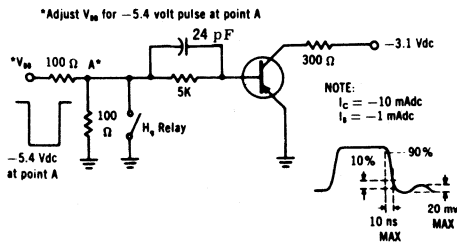
COLLECTOR LATCH-UP VOLTAGE TEST CIRCUIT



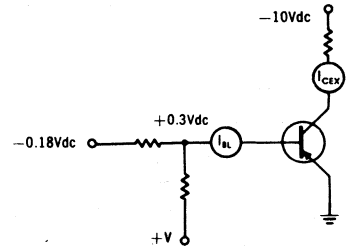
10-mA (I_C) SWITCHING TIME TEST CIRCUIT



BASE AND COLLECTOR CUTOFF CURRENT TEST CIRCUIT



10-mA (I_C) TOTAL CONTROL CHARGE TEST CIRCUIT



2N964 (Ge Mesa)

For Specifications, See 2N960 Data.

2N964A (Ge Mesa)



CASE 22-03
(TO-18)
Collector Connected to Case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

PNP germanium mesa transistor for high- speed switching applications.

* MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	7.0	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	2.5	Vdc
Collector Current - Continuous	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25^{\circ}\text{C}$ Derate above 25°C	P_D	150 2.0	mW mW/ $^{\circ}\text{C}$
Total Device Dissipation @ $T_C = 25^{\circ}\text{C}$ Derate above 25°C	P_D	300 4.0	mW mW/ $^{\circ}\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100	$^{\circ}\text{C}$

*Indicates JEDEC Registered Data

FIGURE 1

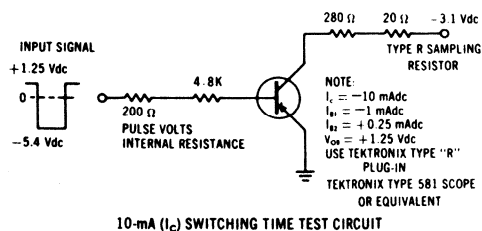
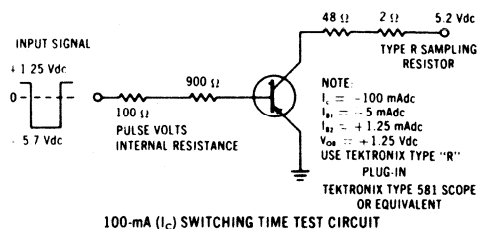


FIGURE 2



* ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 10\text{ mAdc}$, $I_B = 0$)	BV_{CEO}	7.0	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	15	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	2.5	-	Vdc
Collector Latch-up Voltage	LV_{CEX}	11.5	-	Vdc
Collector-Emitter Cutoff Current ($V_{CE} = 15\text{ Vdc}$, $V_{BE} = 0$)	I_{CES}	-	100	μAdc
Collector Cutoff Current ($V_{CB} = 6\text{ Vdc}$, $I_E = 0$)	I_{CBO}	-	3.0	μAdc
Base Leakage Current ($V_{CE} = 6\text{ Vdc}$, $V_{BE(off)} = 0.5\text{ Vdc}$) ($V_{CE} = 6\text{ Vdc}$, $V_{BE(off)} = 0.5\text{ Vdc}$, $T_J = 85^\circ\text{C}$)	I_{BL}	- -	4.0 140	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 10\text{ mAdc}$, $V_{CE} = 0.3\text{ Vdc}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 0.3\text{ Vdc}$, $T_J = -55^\circ\text{C}$) ($I_C = 50\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$) ($I_C = 100\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$) ($I_C = 100\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$, $T_J = 85^\circ\text{C}$)	h_{FE}	40 20 48 40 35	- - - - -	
Collector Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 1\text{ mAdc}$) ($I_C = 50\text{ mAdc}$, $I_B = 5\text{ mAdc}$) ($I_C = 100\text{ mAdc}$, $I_B = 10\text{ mAdc}$)	$V_{CE(sat)}$	- - -	0.18 0.28 0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 1\text{ mAdc}$) ($I_C = 50\text{ mAdc}$, $I_B = 5\text{ mAdc}$) ($I_C = 100\text{ mAdc}$, $I_B = 10\text{ mAdc}$)	$V_{BE(sat)}$	0.3 0.4 0.4	0.44 0.58 0.72	Vdc

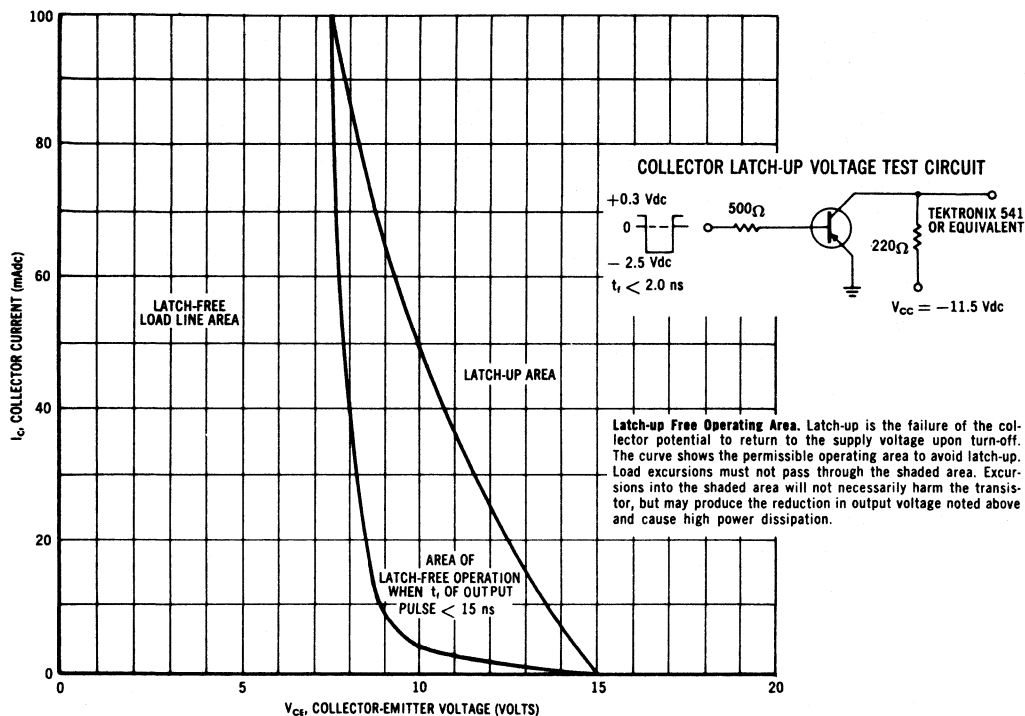
DYNAMIC CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_E = 20\text{ mAdc}$, $V_{CB} = 1\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	300	-	MHz
High-Frequency Current Gain ($I_C = 20\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$, $f = 100\text{ MHz}$)	h_{fe}	3.0	-	-
Output Capacitance ($V_{CB} = 1\text{ Vdc}$, $I_E = 0$, $f = 1\text{ MHz}$) ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1\text{ MHz}$)	C_{ob}	- -	5.0 4.0	pF
Input Capacitance ($V_{BE} = 1\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)	C_{ib}	-	3.5	pF
Delay Time Plus Rise Time ($I_C = 10\text{ mAdc}$) ($I_C = 100\text{ mAdc}$)	$t_d + t_r$	- -	50 50	ns
Storage Time Plus Fall Time ($I_C = 10\text{ mAdc}$) ($I_C = 100\text{ mAdc}$)	$t_s + t_f$	- -	85 85	ns
Active Region Time Constant ($I_C = 10\text{ mAdc}$)	τ_A	-	1.5	ns
Total Control Charge ($I_C = 10\text{ mAdc}$, $I_B = 1\text{ mAdc}$)	Q_T	-	75	pC

*Indicates JEDEC Registered Data

2N964A LIMIT CURVES

FIGURE 3—AREA OF PERMISSIBLE LOAD LOC

**2N965** (Ge Mesa)**2N966**

For Specifications, See 2N960 Data.

2N967 (Ge Mesa)

For Specifications, See 2N963 Data.

PNP SILICON ANNULAR TRANSISTOR

... designed for general-purpose amplifier applications.

- Collector-Emitter Sustaining Voltage –
 $V_{CEO(sus)} = 20\text{ Vdc (Min) @ } I_C = 100\text{ mAdc}$

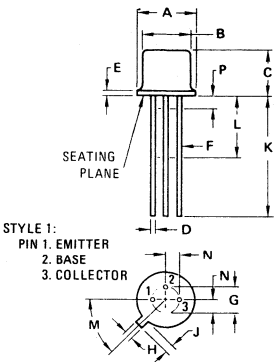
PNP SILICON
AMPLIFIER
TRANSISTOR



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	600	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.33 2.64	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.25 10	Watts mW/ $^\circ\text{C}$
Operating Junction Temperature	T_J	150	$^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

* Indicates JEDEC Registered Data.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	—	0.762	—	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45.0 BSC		45.0 BSC	
N	1.27 BSC		0.050 BSC	
P	—	1.27	—	0.050

All JEDEC notes and dimensions apply.

CASE 22-03
(TO-18)

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage ⁽¹⁾ ($I_C = 100\text{ mA}$, $I_B = 0$)	$V_{CE(sus)}$	20	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 1.0\text{ mA}$, $I_E = 0$)	BV_{CBO}	30	—	Vdc
Collector Cutoff Current ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$ ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	5.0 200	μAdc
Emitter Cutoff Current ($V_{EB} = 1.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	200	μAdc

ON CHARACTERISTICS

DC Current Gain ⁽¹⁾ ($I_C = 30\text{ mA}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 150\text{ mA}$, $V_{CE} = 10\text{ Vdc}$)	h_{FE}	15 15	— 60	—
Collector-Emitter Saturation Voltage ($I_C = 150\text{ mA}$, $I_B = 15\text{ mA}$)	$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 150\text{ mA}$, $I_B = 15\text{ mA}$)	$V_{BE(sat)}$	—	1.5	Vdc

SMALL-SIGNAL CHARACTERISTICS

Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{ob}	—	45	pF
Small-Signal Current Gain ($I_C = 50\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 20\text{ MHz}$)	h_{fe}	2.0	—	—

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width = 300 μs , Duty Cycle = 1.0%.

2N985 (Ge Mesa)



CASE 22-03
(TO-18)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

PNP germanium mesa transistor for high-speed switching applications.

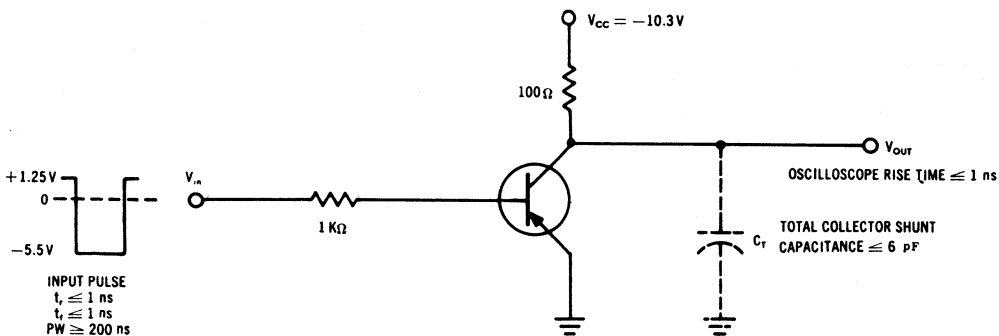
Collector connected to case

* MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	15	Vdc
Collector-Emitter Voltage	V_{CEO}	7.0	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current - Continuous	I_C	200	mA dc
Junction Temperature	T_J	100	$^{\circ}\text{C}$
Storage Temperature	T_{stg}	-65 to +100	$^{\circ}\text{C}$
Device Dissipation @ $T_C = 25^{\circ}\text{C}$ Derate above 25°C	P_D	300 4.0	mW mW/ $^{\circ}\text{C}$
Device Dissipation @ $T_A = 25^{\circ}\text{C}$ Derate above 25°C	P_D	150 2.0	mW mW/ $^{\circ}\text{C}$

*Indicates JEDEC Registered Data

SWITCHING TIME TEST CIRCUIT



*** ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage ($I_C = 100\ \mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	15	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 5\ \text{mAdc}$, $I_B = 0$)	BV_{CEO}	7.0	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu\text{Adc}$, $R_{BE} = 0$)	BV_{CES}	15	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	3.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 5\ \text{Vdc}$, $I_E = 0$)	I_{CBO}	—	3.0	μAdc
Emitter Cutoff Current ($V_{EB} = 3\ \text{Vdc}$, $I_C = 0$)	I_{EBO}	—	100	μAdc
DC Current Gain ($I_C = 10\ \text{mAdc}$, $V_{CE} = 0.25\ \text{Vdc}$) ($I_C = 100\ \text{mAdc}$, $V_{CE} = 0.5\ \text{Vdc}$)	h_{FE}	40 60	— —	—
Collector Saturation Voltage ($I_C = 10\ \text{mAdc}$, $I_B = 0.5\ \text{mAdc}$) ($I_C = 100\ \text{mAdc}$, $I_B = 5\ \text{mAdc}$)	$V_{CE(sat)}$	— —	0.15 0.30	Vdc
Base-Emitter Voltage ($I_C = 10\ \text{mAdc}$, $I_B = 0.5\ \text{mAdc}$) ($I_C = 100\ \text{mAdc}$, $I_B = 5\ \text{mAdc}$)	V_{BE}	0.28 0.40	0.40 0.60	Vdc
Small Signal Current Gain ($V_{CE} = 2\ \text{Vdc}$, $I_C = 30\ \text{mAdc}$, $f = 100\ \text{MHz}$)	$ h_{fe} $	3.0	—	—
Collector Output Capacitance ($V_{CB} = 5\ \text{Vdc}$, $I_E = 0$, $f = 1\ \text{MHz}$)	C_{ob}	—	6.0	pF
Turn-on Time ($I_C = 10\ \text{mAdc}$, $I_{B1} = 5\ \text{mAdc}$, $V_{BE(0)} = 1.25\ \text{Vdc}$)	t_{on}	—	35	ns
Turn-off Time ($I_C = 10\ \text{mAdc}$, $I_{B1} = 5\ \text{mAdc}$, $I_{B2} = 1.25\ \text{mA}$)	t_{off}	—	80	ns

*Indicates JEDEC Registered Data

PNP SILICON ANNULAR TRANSISTOR

... designed for general-purpose amplifier applications.

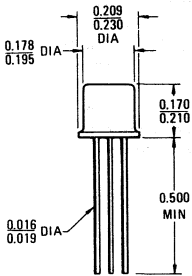
- Collector-Emitter Sustaining Voltage –
 $V_{CEO(sus)} = 12 \text{ Vdc (Min) @ } I_C = 10 \text{ mA}$
- Collector-Base Breakdown Voltage –
 $BVCBO = 15 \text{ Vdc (Min) @ } I_C = 10 \mu\text{A}$
- Emitter-Base Breakdown Voltage –
 $BVEBO = 4.0 \text{ Vdc (Min) @ } I_E = 10 \mu\text{A}$

*MAXIMUM RATINGS

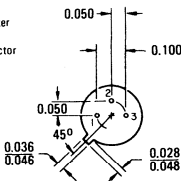
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	200	mA
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	360 2.06	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.2 6.86	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

*Indicates JEDEC Registered Data.

PNP SILICON TRANSISTOR



STYLE 1
Pin 1: Emitter
2: Base
3: Collector



Collector Connected to Case
CASE 22(1)
(TO-18)

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage ⁽¹⁾ ($I_C = 10\text{ mAdc}$, $I_B = 0$)	$V_{CE(sus)}$	12	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	15	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	4.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	0.005 15	μAdc μAdc
Emitter Cutoff Current ($V_{BE} = 4.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	10	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 20\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$)	h_{FE}	35	—	—
Collector-Emitter Saturation Voltage ($I_C = 60\text{ mAdc}$, $I_B = 2.0\text{ mAdc}$)	$V_{CE(sat)}$	—	0.3	Vdc
Base-Emitter Saturation Voltage ($I_C = 20\text{ mAdc}$, $I_B = 2.0\text{ mAdc}$)	$V_{BE(sat)}$	—	0.95	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product ⁽²⁾ ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	100	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$ to 1.0 MHz)	C_{ob}	—	10	pF

*Indicates JEDEC Registered Data.

⁽¹⁾Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.⁽²⁾ f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

NPN SILICON ANNULAR DARLINGTON TRANSISTORS

... containing two NPN silicon annular transistors in a darlington connection, and designed for applications requiring:

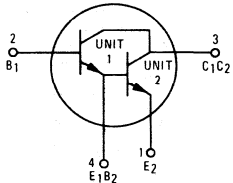
- High DC Current Gain —
 $h_{FE} = 2000$ (Min) @ $I_C = 100$ mAdc
- Guaranteed DC Current Gain from 1.0 mAdc to 100 mAdc
- Low Noise Figure —
 $NF = 6.0$ dB (Max) @ $I_C = 0.1$ mAdc
- Low Leakage Current —
 $I_{CBO} = 0.01$ μ Adc (Max) @ $V_{CB} = 90$ Vdc
 $I_{EBO} = 0.01$ μ Adc (Max) @ $V_{BE} = 10$ Vdc

*MAXIMUM RATINGS(Numerical subscripts refer to unit number.)

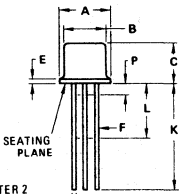
Rating	Symbol	Value	Unit
Collector-Emitter Voltage (Base 1 and Base 2 open)	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	15	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.5 2.86	Watt mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.8 10.3	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

*Indicates JEDEC Registered Data

NPN SILICON
DARLINGTON
TRANSISTORS



The input unit is identified as Unit 1 regardless of terminal numbering.



STYLE B
PIN 1. EMITTER 2
2. BASE 1
3. COLLECTOR
4. EMITTER 1
BASE 2

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	—	0.76	—	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45 $^\circ$ BSC		45 $^\circ$ BSC	
N	1.27 BSC		0.050 BSC	
P	—	1.27	—	0.050

ALL JEDEC dimensions and notes apply

CASE 20-03
TO-72

* ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage ⁽¹⁾ ($I_C = 30\text{ mAdc}$, $I_E = 0$)	$BV_{CEO(sus)}$	60	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	100	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	15	—	Vdc
Collector Cutoff Current ($V_{CB} = 90\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 90\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	0.01 15	μAdc
Emitter Cutoff Current ($V_{BE} = 10\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	0.01	μAdc

ON CHARACTERISTICS

DC Current Gain ⁽¹⁾ ($I_C = 1\text{ mAdc}$, $V_{CE} = 5\text{ Vdc}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 5\text{ Vdc}$) ($I_C = 100\text{ mAdc}$, $V_{CE} = 5\text{ Vdc}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 5\text{ Vdc}$, measured across each transistor within the device)	h_{FE}	800 1,600 2,000 25	— 8,000 — —	—
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DYNAMIC CHARACTERISTICS

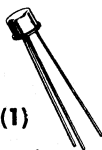
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)	C_{ob}	—	30	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)	C_{ib}	—	50	pF
Small-Signal Current Gain ($I_C = 1\text{ mAdc}$, $V_{CE} = 5\text{ Vdc}$, $f = 1\text{ kHz}$)	h_{fe}	1,000	—	—
Noise Figure** ($I_C = 0.1\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $R_S = 5\text{ kohms}$, $f = 1\text{ kHz}$, Bandwidth = 200 Hz)	NF**	—	6.0	dB

* Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$ **Measured with constant current supply of $20\text{ }\mu\text{Adc}$ connected to the emitter of the input transistor. (See Figure 1)

2N1008, A, B (GERMANIUM)

2N1008B JAN AVAILABLE



PNP germanium transistor for audio driver and medium speed switching applications.

CASE 31(1)

(TO-5)

All leads isolated

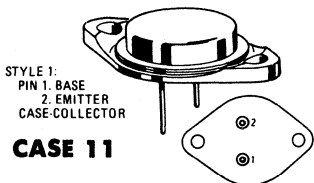
MAXIMUM RATINGS

Rating	Symbol	2N1008	2N1008A	2N1008B	Unit
Collector-Base Voltage	V_{CB}	20	40	60	Vdc
Collector-Emitter Voltage	V_{CEO}	20	40	60	Vdc
Emitter-Base Voltage	V_{EB}	15			Vdc
Collector Current	I_C	300			mAdc
Base Current	I_B	30			mAdc
Collector Dissipation $T_A = 25^\circ\text{C}$ derate $T_C = 25^\circ\text{C}$ derate	P_D	200 2.78 300 4.0			mW mW/ $^\circ\text{C}$ mW mW/ $^\circ\text{C}$
Junction and Storage Temperature Range	T_J, T_{stg}	-65 to +100			$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristics	Symbol	Min	Typ	Max	UNIT
Collector Leakage Current ($V_{CB} = 10$ Vdc) 2N1008 ($V_{CB} = 10$ Vdc, $T_A = 85^\circ\text{C}$) 2N1008 ($V_{CB} = 25$ Vdc) 2N1008A ($V_{CB} = 25$ Vdc, $T_A = 85^\circ\text{C}$) 2N1008A ($V_{CB} = 45$ Vdc) 2N1008B ($V_{CB} = 45$ Vdc, $T_A = 85^\circ\text{C}$) 2N1008B	I_{CBO}	---	5.0 --- 5.0 --- 7.0 ---	10 500 10 500 15 750	μAdc
Emitter Leakage Current ($V_{EB} = 10$ Vdc) 2N1008 2N1008A 2N1008B	I_{EBO}	---	5.0 --- ---	10 10 10	μAdc
Collector-Emitter Breakdown Voltage ($I_C = 1.0$ mAdc, $R_{BE} = 10$ K) 2N1008 2N1008A 2N1008B	BV_{CER}	15 35 55	--- --- ---	--- --- ---	Vdc
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 10$ mAdc)	$V_{CE}(\text{sat})$	---	---	0.25	Vdc
Small Signal Current Gain ($I_C = -10$ mAdc, $V_{CE} = 5.0$ Vdc, $f = 1$ kHz)	h_{fe}	40	---	150	---
Input Resistance ($V_{CB} = 6$ V, $I_E = 1$ mA)	h_{ie}	200	---	1000	ohms

2N1011 (GERMANIUM)



Collector connected to case

PNP germanium power transistor for general purpose power amplifier and switching applications in military and industrial equipment. Operating temperature range and power dissipation exceed military specifications.

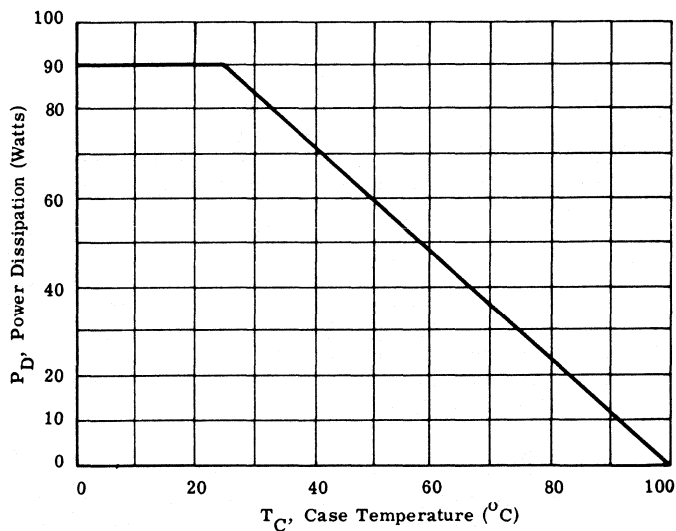
MAXIMUM RATINGS

Rating	Symbol	2N1011	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Emitter Voltage	V_{CES}	80	Vdc
Collector-Base Voltage	V_{CB}	80	Vdc
Emitter-Base Voltage	V_{EB}	40	Vdc
Collector Current	I_C	5.0	Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$	P_D	90	Watts
Derate above 25°C		1.2	W/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.8	$^\circ\text{C}/\text{W}$

POWER-TEMPERATURE DERATING CURVE



ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted).

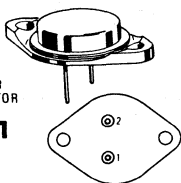
Characteristic	Symbol	Minimum	Maximum	Unit
DC Current Transfer Ratio $V_{CE} = 2\text{ V}$ $I_C = 1.0\text{ Adc}$	h_{FE}	—	150	—
DC Current Transfer Ratio $V_{CE} = 2\text{ V}$ $I_C = 3.0\text{ Adc}$	h_{FE}	30	75	—
Small-Signal Current Transfer Ratio Cutoff Frequency $V_{CE} = 2\text{ Vdc}$ $I_C = 3\text{ Amp}$	f_{ae}	5.0	—	kHz
Emitter-Base Cutoff Current $V_{EB} = 40\text{ Vdc}$ $I_C = 0$	I_{EBO}	—	3.0	mAdc
Collector-Base Cutoff Current $V_{CB} = 2\text{ Vdc}$ $I_E = 0$	I_{CBO}	—	200	μAdc
Collector-Base Cutoff Current $V_{CB} = 80\text{ Vdc}$ $I_E = 0$	I_{CBO}	—	15.0	mAdc
Base Current $V_{CE} = 2\text{ Vdc}$ $I_C = 1\text{ Adc}$	I_B	6.7	—	mAdc
Base Current $V_{CE} = 2\text{ Vdc}$ $I_C = 3\text{ Adc}$	I_B	40	100	mAdc
Emitter-Base Voltage $V_{CE} = 2\text{ Vdc}$ $I_C = 3\text{ Adc}$	V_{EB}	—	2.0	Vdc
Floating Potential $V_{CB} = 50\text{ Vdc}$ (Voltmeter input resistance = 10 Megohm min)	V_{fl}	—	1.0	Vdc
Collector-Emitter Saturation Voltage $I_C = 3\text{ Adc}$ $I_B = 200\text{ mAdc}$	$V_{CE(SAT)}$	—	1.5	Vdc
Collector-Emitter Voltage $I_C = 300\text{ mAdc}$ $I_B = 0$	BV_{CEO}	40	—	Vdc
Collector-Emitter Voltage $I_C = 300\text{ mAdc}$ $V_{EB} = 0$	BV_{CES}	80	—	Vdc
High-Temperature Operation $T_C = +90^\circ\text{C min}$ Collector Cutoff Current $V_{CB} = 30\text{ Vdc}$ $I_E = 0$	I_{CBO}	—	20	mAdc

2N1021 (GERMANIUM)

2N1022

STYLE 1:
PIN 1. BASE
2. EMITTER
CASE-COLLECTOR

CASE 11

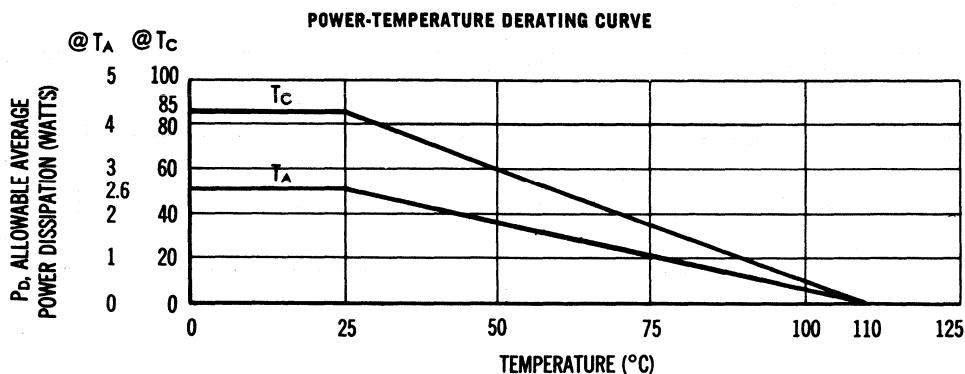


PNP germanium power transistors for industrial and general purpose power amplifier and switching applications.

Collector connected to case

MAXIMUM RATINGS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Rating	Symbol	2N1021	2N1022	Unit
Collector-Base Voltage	V_{CB}	100	120	Volts
Collector-Emitter Voltage	V_{CEX}	100	120	Volts
Collector-Emitter Voltage	V_{CEO}	50		Volts
Emitter-Base Voltage	V_{EB}	30		Volts
Collector Current	I_C	5.0		Amp
Operating Junction and Storage Temperature Range	T_J, T_{stg}	-65 to +110		$^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	85 1.0		Watts $\text{W}/^\circ\text{C}$



ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Cutoff Current $(V_{CB} = 50 \text{ Vdc})$ 2N1021 $(V_{CB} = 60 \text{ Vdc})$ 2N1022 $(V_{CB} = 100 \text{ Vdc})$ 2N1021 $(V_{CB} = 120 \text{ Vdc})$ 2N1022 $(V_{CB} = 50 \text{ Vdc}, T_C = +55^\circ\text{C})$ 2N1021 $(V_{CB} = 60 \text{ Vdc}, T_C = +55^\circ\text{C})$ 2N1022	I_{CBO}	— — — — — —	0.5 0.5 2.0 2.0 8.0 8.0	mAdc
Collector-Emitter Breakdown Voltage* $(I_C = 200 \text{ mAdc})$	BV_{CEO}^*	50	—	Vdc
Emitter-Base Cutoff Current $(V_{EB} = 10 \text{ Vdc})$ $(V_{EB} = 30 \text{ Vdc})$	I_{EBO}	— —	0.5 2.0	mAdc
Base-Emitter Voltage $(V_{CE} = -1.5 \text{ Vdc}, I_C = 1.0 \text{ Adc})$	V_{BE}	—	3.0	Vdc
Collector-Emitter Saturation Voltage $(I_C = 5 \text{ Adc}, I_B = 500 \text{ mAdc})$	$V_{CE(sat)}$	—	0.5	Vdc
DC Current Gain $(I_C = 1 \text{ Adc}, V_{CE} = 1.5 \text{ Vdc})$ $(I_C = 3 \text{ Adc}, V_{CE} = 1.5 \text{ Vdc})$ $(I_C = 5 \text{ Adc}, V_{CE} = 1.5 \text{ Vdc})$ $(I_C = 7 \text{ Adc}, V_{CE} = 1.5 \text{ Vdc})$	h_{FE}	40 35 30 22	— — 90 —	—
Input Impedance $(I_C = 1.0 \text{ Adc}, V_{CE} = 1.5 \text{ Vdc})$	h_{ie}	—	28	ohms
Current Gain-Bandwidth Product $(I_C = 1.0 \text{ Adc}, V_{CE} = 2 \text{ Vdc})$	f_T	200	—	kHz

*Sweep Test: 1/2 sine wave, 60 Hz .

2N1038 thru 2N1041 (GERMANIUM) 2N2552 thru 2N2559

PNP GERMANIUM MEDIUM POWER TRANSISTORS

... designed for relay drivers, pulse amplifiers, audio amplifiers and high-current switching applications.

- High Current Capability — $I_C = 3.0$ Amperes
- Guaranteed Excellent Collector-Emitter Sustaining Voltage
- 20-Watt Power Dissipation at 25°C Case Temperature
- 100°C Maximum Junction Temperature

PNP GERMANIUM POWER TRANSISTORS

40–100 VOLTS
20 WATTS

*MAXIMUM RATINGS

Rating	Symbol	2N1038 2N2552 2N2556	2N1039 2N2553 2N2557	2N1040 2N2554 2N2558	2N1041 2N2555 2N2559	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	50	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	100	Vdc
Emitter-Base Voltage	V_{EB}	20				Vdc
Collector Current — Continuous	I_C	3.0				Adc
Base Current — Continuous	I_B	1.0				Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	450 6.0				mW mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C (Note 1)	P_D	20 0.267				Watts W/°C
* Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100				°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.75	°C/W

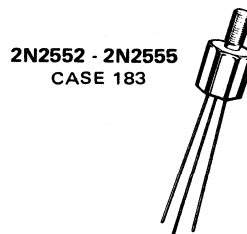
* Indicates JEDEC Registered Data.

Note 1: Case Temperature shall be measured 0.100 ± 0.010 inches above the seating plane.

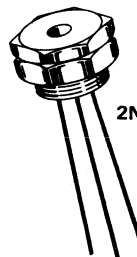
** Motorola guarantees this data in addition to the JEDEC Registered Data shown.



2N1038 - 2N1041
CASE 180



2N2552 - 2N2555
CASE 183



2N2556 - 2N2559
CASE 184

2N1038 thru 2N1041/2N2552 thru 2N2559 (continued)

*ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage ($I_C = 100 \text{ mA}$, $I_B = 0$)	2N1038, 2N2552, 2N2556 2N1039, 2N2553, 2N2557 2N1040, 2N2554, 2N2558 2N1041, 2N2555, 2N2559	$V_{CEO(sus)}$	30 40 50 60	- - - -	Vdc
Collector Cutoff Current ($V_{CE} = 15 \text{ Vdc}$, $I_B = 0$) ($V_{CE} = 20 \text{ Vdc}$, $I_B = 0$) ($V_{CE} = 25 \text{ Vdc}$, $I_B = 0$) ($V_{CE} = 30 \text{ Vdc}$, $I_B = 0$)	2N1038, 2N2552, 2N2556 2N1039, 2N2553, 2N2557 2N1040, 2N2554, 2N2558 2N1041, 2N2555, 2N2559	I_{CEO}	- - - -	25 20 20 20	mA
Collector-Emitter Cutoff Current ($V_{CE} = 40 \text{ Vdc}$, $V_{BE(off)} = 0.2 \text{ Vdc}$) ($V_{CE} = 60 \text{ Vdc}$, $V_{BE(off)} = 0.2 \text{ Vdc}$) ($V_{CE} = 80 \text{ Vdc}$, $V_{BE(off)} = 0.2 \text{ Vdc}$) ($V_{CE} = 100 \text{ Vdc}$, $V_{BE(off)} = 0.2 \text{ Vdc}$) ($V_{CE} = 20 \text{ Vdc}$, $V_{BE(off)} = 0.2 \text{ Vdc}$, $T_C = 85^\circ\text{C}$) ($V_{CE} = 30 \text{ Vdc}$, $V_{BE(off)} = 0.2 \text{ Vdc}$, $T_C = 85^\circ\text{C}$) ($V_{CE} = 40 \text{ Vdc}$, $V_{BE(off)} = 0.2 \text{ Vdc}$, $T_C = 85^\circ\text{C}$) ($V_{CE} = 50 \text{ Vdc}$, $V_{BE(off)} = 0.2 \text{ Vdc}$, $T_C = 85^\circ\text{C}$)	2N1038, 2N2552, 2N2556 2N1039, 2N2553, 2N2557 2N1040, 2N2554, 2N2558 2N1041, 2N2555, 2N2559 2N1038, 2N2552, 2N2556 2N1039, 2N2553, 2N2557 2N1040, 2N2554, 2N2558 2N1041, 2N2555, 2N2559	I_{CEX}	- - - - - - - -	0.65 0.65 0.65 0.65 5.0 5.0 5.0 5.0	mA
Collector Cutoff Current ($V_{CB} = 20 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 30 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 40 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 50 \text{ Vdc}$, $I_E = 0$) **($V_{CB} = 40 \text{ Vdc}$, $I_E = 0$) **($V_{CB} = 60 \text{ Vdc}$, $I_E = 0$) **($V_{CB} = 80 \text{ Vdc}$, $I_E = 0$) **($V_{CB} = 100 \text{ Vdc}$, $I_E = 0$)	2N1038, 2N2552, 2N2556 2N1039, 2N2553, 2N2557 2N1040, 2N2554, 2N2558 2N1041, 2N2555, 2N2559 2N1038, 2N2552, 2N2556 2N1039, 2N2553, 2N2557 2N1040, 2N2554, 2N2558 2N1041, 2N2555, 2N2559	I_{CBO}	- - - - - - - -	125 125 125 125 750 750 750 750	μA
Emitter Cutoff Current ($V_{BE} = 20 \text{ Vdc}$, $I_C = 0$)		I_{EBO}	-	650	μA

ON CHARACTERISTICS

DC Current Gain ($I_C = 50 \text{ mA}$, $V_{CE} = 0.5 \text{ Vdc}$) ($I_C = 1.0 \text{ A}$, $V_{CE} = 0.5 \text{ Vdc}$)	h_{FE}	33 20	200 60	-
Collector-Emitter Saturation Voltage ($I_C = 1.0 \text{ A}$, $I_B = 100 \text{ mA}$)	$V_{CE(sat)}$	-	0.25	Vdc
Base-Emitter Input Voltage ($I_C = 1.0 \text{ A}$, $V_{CE} = 0.5 \text{ Vdc}$)	V_{BE}	-	1.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

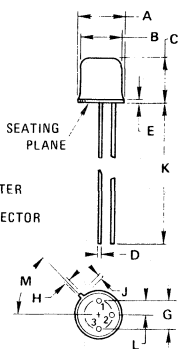
Small-Signal Current Gain ($I_C = 500 \text{ mA}$, $V_{CE} = 1.5 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{fe}	18	72	-
Small-Signal Current Gain ($I_C = 500 \text{ mA}$, $V_{CE} = 1.5 \text{ Vdc}$, $f = 112.5 \text{ kHz}$)	$ h_{fe} $	2.0	-	-

*Indicates JEDEC Registered Data.

**Motorola Guarantees this data in addition to the JEDEC Registered Data Shown.

2N1038
2N1041

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

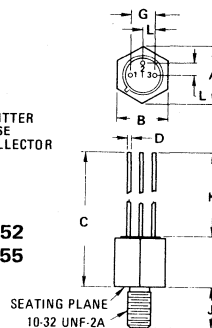


DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.87	8.64	0.310	0.340
C	6.10	9.91	0.240	0.390
D	0.56	0.71	0.022	0.028
E	0.23	3.18	0.009	0.125
G	5.08 BSC		0.200 BSC	
H	0.64	0.89	0.025	0.035
J	0.74	1.14	0.029	0.045
K	38.10		1.500	
L	2.54 BSC		0.100 BSC	
M	45° BSC		45° BSC	

CASE 180

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

2N2552
2N2555



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	12.45	12.95	0.490	0.510
B	10.85	11.35	0.427	0.447
C	49.35	—	1.943	—
D	0.56	0.71	0.022	0.028
G	4.83	5.33	0.190	0.210
J	8.76	9.27	0.345	0.365
K	38.10	—	1.500	—
L	2.41	2.67	0.095	0.105

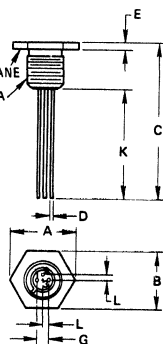
NOTE:
1. COLLECTOR CONNECTED TO CASE

CASE 183

2N2556
2N2559

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

SEATING PLANE
1/2-20 UNF-2A



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	—	22.23	—	0.875
B	18.80	19.30	0.740	0.760
C	52.53	—	2.068	—
D	0.56	0.71	0.022	0.028
E	2.11	2.62	0.083	0.103
G	4.57	5.59	0.180	0.220
K	38.10	—	1.500	—
L	2.29	2.79	0.090	0.110

CASE 184

2N1042 thru 2N1045 (GERMANIUM)
2N2560 thru 2N2567

PNP GERMANIUM MEDIUM POWER TRANSISTORS

... designed for relay drivers, pulse amplifiers, audio amplifiers and high-current switching applications.

- High Current Capability — $I_C = 3.5$ Amperes
- Guaranteed Excellent Collector-Emitter Sustaining Voltage
- 20-Watt Power Dissipation at 25°C Case Temperature
- 100°C Maximum Junction Temperature

* MAXIMUM RATINGS

Rating	Symbol	2N1042	2N1043	2N1044	2N1045	Unit
		2N2560	2N2561	2N2562	2N2563	
Collector-Emitter Voltage	V_{CEO}	30	40	50	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	100	Vdc
Emitter-Base Voltage	V_{EB}	20				Vdc
Collector Current — Continuous	I_C	3.5				Adc
Base Current — Continuous	I_B	1.0				Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	450				mW
		6.0				mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C (Note 1)	P_D	20				Watts
		0.267				W/°C
** Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100				°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.75	°C/W

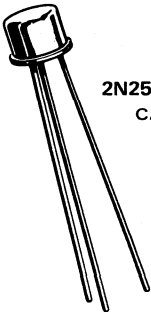
*Indicates JEDEC Registered Data.

Note 1: Case Temperature shall be measured 0.100 ± 0.010 inches above the seating plane.

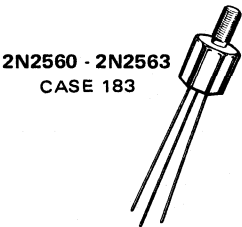
** Motorola guarantees this data in addition to the JEDEC Registered Data shown.

PNP GERMANIUM
POWER TRANSISTORS

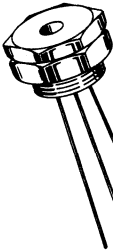
40–100 VOLTS
20 WATTS



2N2564 - 2N2567
CASE 180



2N2560 - 2N2563
CASE 183



2N1042 - 2N1045
CASE 184

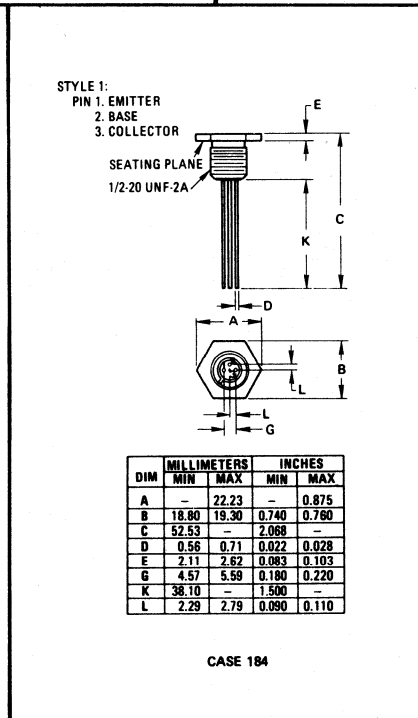
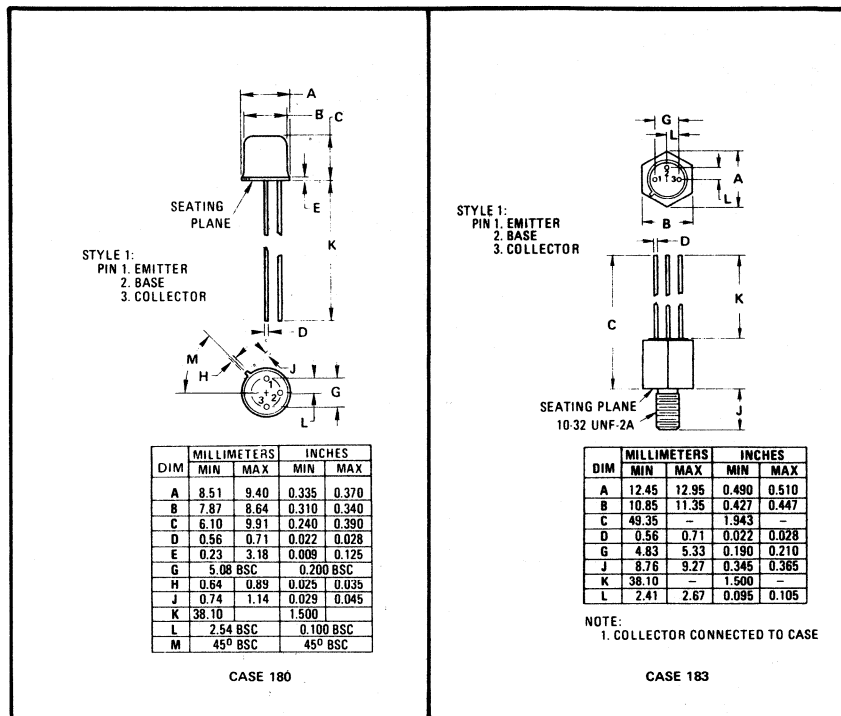
2N1042 thru 2N1045/2N2560 thru 2N2567 (continued)

*ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

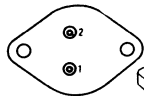
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage ($I_C = 100\text{ mA}$, $I_B = 0$)	$V_{CE(sus)}$	30 40 50 60	— — — —	Vdc
Collector Cutoff Current ($V_{CE} = 15\text{ Vdc}$, $I_B = 0$) ($V_{CE} = 20\text{ Vdc}$, $I_B = 0$) ($V_{CE} = 25\text{ Vdc}$, $I_B = 0$) ($V_{CE} = 30\text{ Vdc}$, $I_B = 0$)	I_{CEO}	— — — —	25 20 20 20	mA
Collector-Emitter Cutoff Current ($V_{CE} = 40\text{ Vdc}$, $V_{BE(off)} = 0.2\text{ Vdc}$) ($V_{CE} = 60\text{ Vdc}$, $V_{BE(off)} = 0.2\text{ Vdc}$) ($V_{CE} = 80\text{ Vdc}$, $V_{BE(off)} = 0.2\text{ Vdc}$) ($V_{CE} = 100\text{ Vdc}$, $V_{BE(off)} = 0.2\text{ Vdc}$) ($V_{CE} = 20\text{ Vdc}$, $V_{BE(off)} = 0.2\text{ Vdc}$, $T_C = 85^\circ\text{C}$) ($V_{CE} = 30\text{ Vdc}$, $V_{BE(off)} = 0.2\text{ Vdc}$, $T_C = 85^\circ\text{C}$) ($V_{CE} = 40\text{ Vdc}$, $V_{BE(off)} = 0.2\text{ Vdc}$, $T_C = 85^\circ\text{C}$) ($V_{CE} = 50\text{ Vdc}$, $V_{BE(off)} = 0.2\text{ Vdc}$, $T_C = 85^\circ\text{C}$)	I_{CEX}	— — — — — — — —	0.65 0.65 0.65 0.65 5.0 5.0 5.0 5.0	mA
Collector Cutoff Current ($V_{CB} = 20\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 30\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 40\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 50\text{ Vdc}$, $I_E = 0$) **($V_{CB} = 40\text{ Vdc}$, $I_E = 0$) **($V_{CB} = 60\text{ Vdc}$, $I_E = 0$) **($V_{CB} = 80\text{ Vdc}$, $I_E = 0$) **($V_{CB} = 100\text{ Vdc}$, $I_E = 0$)	I_{CBO}	— — — — — — — —	125 125 125 125 750 750 750 750	μA
Emitter Cutoff Current ($V_{BE} = 20\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	650	μA
ON CHARACTERISTICS				
DC Current Gain ($I_C = 50\text{ mA}$, $V_{CE} = 0.5\text{ Vdc}$) ($I_C = 1.0\text{ A}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 3.0\text{ A}$, $V_{CE} = 1.0\text{ Vdc}$)	h_{FE}	50 — 20	— 150 60	—
Collector-Emitter Saturation Voltage ($I_C = 1.0\text{ A}$, $I_B = 100\text{ mA}$) ($I_C = 3.0\text{ A}$, $I_B = 300\text{ mA}$)	$V_{CE(sat)}$	— —	0.25 0.75	Vdc
Base-Emitter Input Voltage ($I_C = 3.0\text{ A}$, $V_{CE} = 1.0\text{ Vdc}$)	V_{BE}	—	1.5	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Small-Signal Current Gain ($I_C = 500\text{ mA}$, $V_{CE} = 1.5\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	25	100	—
Small-Signal Current Gain ($I_C = 500\text{ mA}$, $V_{CE} = 1.5\text{ Vdc}$, $f = 125\text{ kHz}$)	$ h_{fe} $	2.0	—	—

*Indicates JEDEC Registered Data.

**Motorola Guarantees this data in addition to the JEDEC Registered Data Shown.

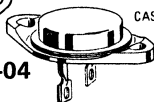


2N1073, A, B (GERMANIUM)



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE-COLLECTOR

CASE 4-04

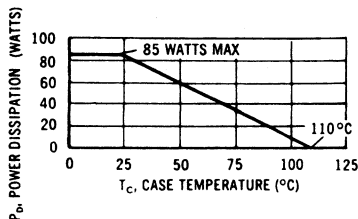


PNP germanium power transistors for high-voltage power switching applications.

MAXIMUM RATINGS

Rating	Symbol	2N1073	2N1073A	2N1073B	Unit
Collector-Emitter Voltage	V_{CE}	40	80	120	Vdc
Collector-Base Voltage	V_{CB}	40	80	120	Vdc
Emitter-Base Voltage	V_{EB}	1.5	1.5	1.5	Vdc
Collector Current (Cont)	I_C	10	10	10	Amp
Base Current (Cont)	I_B	5.0			Amp
Emitter Reverse Current (Surge 60 cps Recurrent)	I_E	1.5			Amp
Storage and Operating Temperature	T_{stg} T_J	-65 to +110			$^{\circ}\text{C}$
Collector Dissipation (25 $^{\circ}\text{C}$ Mtg. Case Temp.)	P_D	85			Watts

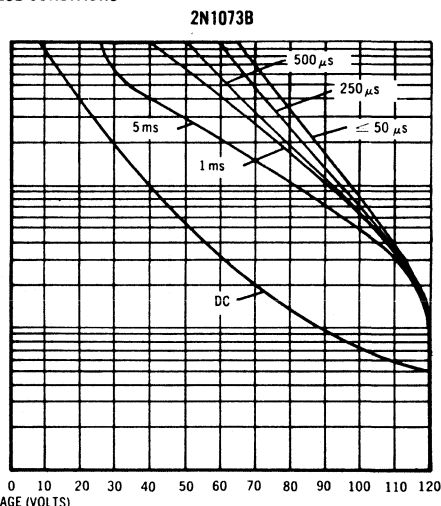
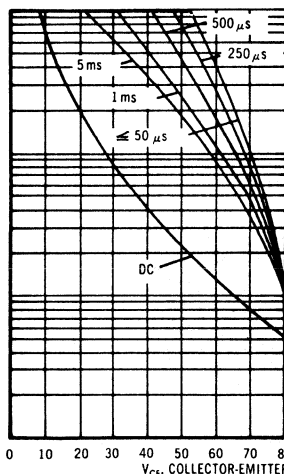
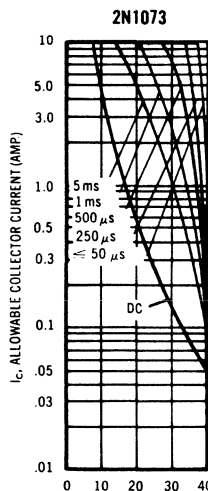
POWER-TEMPERATURE DERATING CURVE



The maximum continuous power is related to maximum junction temperature by the thermal resistance factor. This curve has a value of 85 watts at a case temperature of 25 $^{\circ}\text{C}$ and is 0 watts at 110 $^{\circ}\text{C}$ with a linear relation between the two temperatures such that:

$$\text{Allowable } P_D = \frac{110 - T_C}{1.0} \text{ Watts}$$

SAFE OPERATING AREAS — PULSE CONDITIONS



The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short.

(Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J , the power-temperature derating curve must be observed for both steady state and pulse power conditions.

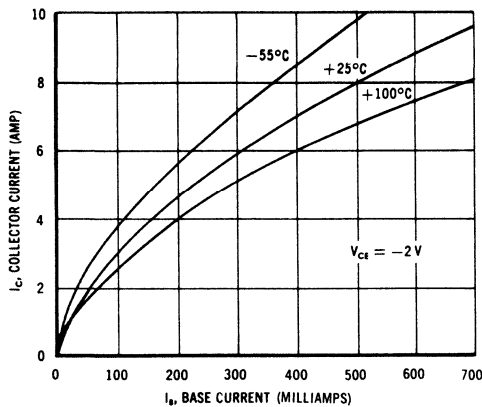
2N1073, A, B (continued)

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

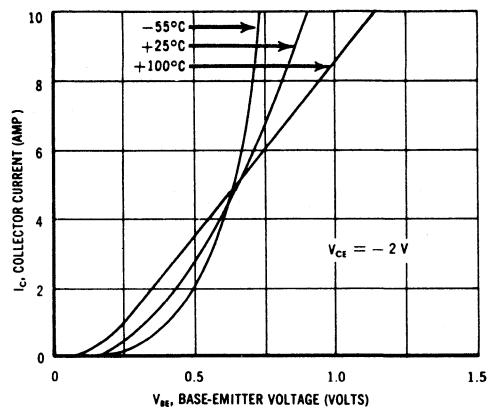
Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current ($V_{CB} = 25\text{ Vdc}$, $I_E = 0$)	2N1073	I_{CBO}	-	-	1.0	mAdc
($V_{CB} = 25\text{ Vdc}$, $I_E = 0$, $T_C = 85^\circ\text{C}$)	2N1073		-	-	15	
($V_{CB} = 40\text{ Vdc}$, $I_E = 0$)	2N1073		-	-	20	
($V_{CB} = 60\text{ Vdc}$, $I_E = 0$)	2N1073A		-	-	1.0	
($V_{CB} = 60\text{ Vdc}$, $I_E = 0$, $T_C = 85^\circ\text{C}$)	2N1073A		-	-	15	
($V_{CB} = 80\text{ Vdc}$, $I_E = 0$)	2N1073A		-	-	20	
($V_{CB} = 100\text{ Vdc}$, $I_E = 0$)	2N1073B		-	-	2.0	
($V_{CB} = 100\text{ Vdc}$, $I_E = 0$, $T_C = 85^\circ\text{C}$)	2N1073B		-	-	20	
($V_{CB} = 120\text{ Vdc}$, $I_E = 0$)	2N1073B		-	-	20	
($V_{CB} = 2.0\text{ Vdc}$, $I_E = 0$)			-	-	0.3	
Emitter-Base Leakage Current ($V_{EB} = 0.75\text{ Vdc}$)		I_{EBO}	-	-	50	mAdc
Emitter Floating Potential ($V_{CE} = 40\text{ Vdc}$)	2N1073	V_{EBF}	-	-	1.0	Vdc
($V_{CE} = 80\text{ Vdc}$)	2N1073A		-	-	1.0	
($V_{CE} = 120\text{ Vdc}$)	2N1073B		-	-	1.0	
Collector-Emitter Breakdown Voltage* ($I_C = 5.0\text{ mAdc}$, $R_{BE} = 100\Omega$)	2N1073 2N1073A 2N1073B	BV_{CER}^*	40 80 120	- - -	- - -	Vdc
DC Current Gain ($I_C = 5.0\text{ Adc}$, $V_{CE} = 2.0\text{ Vdc}$)		h_{FE}	20	-	60	-
Small-Signal Current Gain ($I_C = 0.5\text{ Adc}$, $V_{CE} = 12\text{ Vdc}$, $f = 30\text{ kHz}$)		h_{fe}	-	15	-	-
Base Input Voltage ($V_{CE} = 2.0\text{ Vdc}$, $I_C = 5.0\text{ Adc}$)		V_{BE}	-	-	1.0	Vdc
Collector-Emitter Saturation Voltage ($I_C = 5.0\text{ Adc}$, $I_B = 0.5\text{ Adc}$)		$V_{CE(sat)}$	-	0.5	1.0	Vdc
Rise Time		t_r	-	5.5	-	μs
Storage Time		t_s	-	1.2	-	μs
Fall Time		t_f	-	2.0	-	μs

*To avoid excessive heating of collector junction, perform this test with a sweep method.

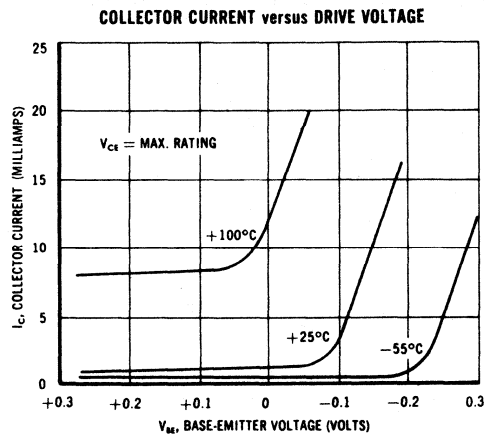
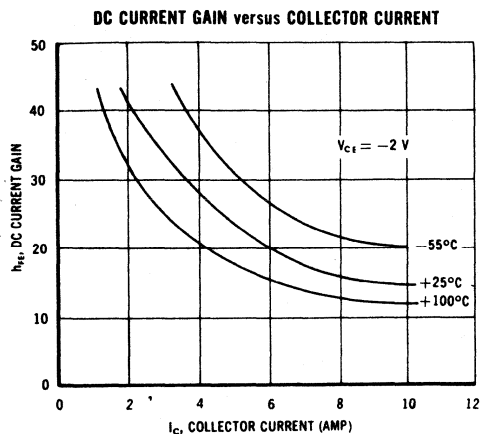
COLLECTOR CURRENT versus BASE CURRENT



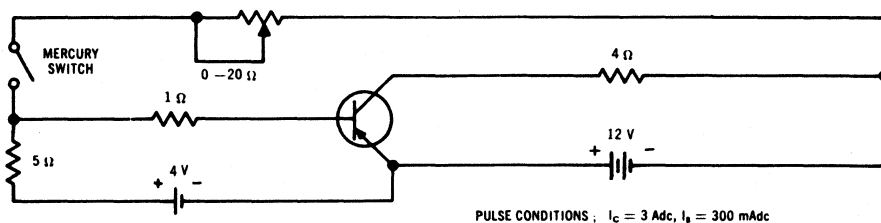
COLLECTOR CURRENT versus DRIVE VOLTAGE



2N1073, A, B (continued)



SWITCHING TEST CIRCUIT



2N1099 (GERMANIUM)

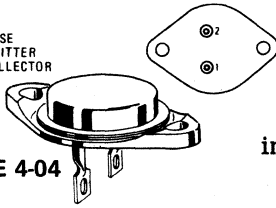
For Specifications, See 2N277 Data.

2N1100 (GERMANIUM)

For Specifications, See 2N174 Data.

2N1120 (GERMANIUM)

STYLE 1:
PIN 1: BASE
2: EMITTER
CASE: COLLECTOR



CASE 4-04

PNP germanium power transistor for military and industrial power applications.

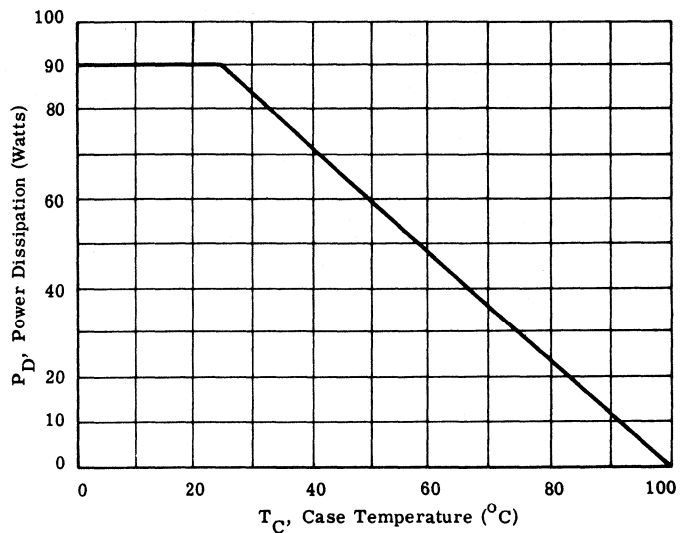
MAXIMUM RATINGS

Rating	Symbol	2N1120	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Emitter Voltage	V_{CES}	70	Vdc
Collector-Base Voltage	V_{CB}	80	Vdc
Emitter-Base Voltage	V_{EB}	40	Vdc
Emitter Current	I_E	15	Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	90 1.2	Watts W/ $^\circ\text{C}$
Operating Junction Temperature Range	T_J	-65 to +100	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.8	$^\circ\text{C}/\text{W}$

POWER-TEMPERATURE
DERATING CURVE



ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 300 \text{ mAdc}$, $I_B = 0$)	BV_{CEO}	40	-	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 300 \text{ mAdc}$, $V_{BE} = 0$)	BV_{CES}	70	-	Vdc
Floating Potential ($V_{CB} = 80 \text{ Vdc}$, $I_E = 0$) (Voltmeter Input Resistance = 10 meg. min.)	V_{EBF}	-	1.0	Vdc
Collector Cutoff Current ($V_{CB} = 2 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 30 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 80 \text{ Vdc}$, $I_E = 0$)	I_{CBO}	- - -	0.3 20 15	mAdc
Emitter Cutoff Current ($V_{BE} = 40 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	-	5.0	mAdc
Base Current ($V_{CE} = 2 \text{ Vdc}$, $I_C = 5 \text{ Adc}$) ($V_{CE} = 2 \text{ Vdc}$, $I_C = 10 \text{ Adc}$)	I_B	50 200	- 500	mAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 5.0 \text{ Adc}$, $V_{CE} = 2.0 \text{ Vdc}$) ($I_C = 10.0 \text{ Adc}$, $V_{CE} = 2.0 \text{ Vdc}$)	h_{FE}	- 20	100 50	-
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ Adc}$, $I_B = 1.0 \text{ Adc}$)	$V_{CE(sat)}$	-	1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 10 \text{ Adc}$, $I_B = 1.0 \text{ Adc}$)	$V_{BE(sat)}$	-	1.5	Vdc
Base-Emitter On Voltage ($I_C = 10 \text{ Adc}$, $V_{CE} = 2 \text{ Vdc}$)	$V_{BE(on)}$	-	2.0	Vdc

SMALL SIGNAL CHARACTERISTICS

Common-Emitter Cutoff Frequency ($I_C = 5.0 \text{ Adc}$, $V_{CE} = 2.0 \text{ Vdc}$)	$f_{\alpha e}$	3.0	-	kHz
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2N1131S (SILICON)

2N1131 JAN AVAILABLE

2N1131AS

2N1991S

PNP SILICON ANNULAR TRANSISTORS

... designed for medium-speed switching and amplifier applications where low DC current gain is essential.

- Low DC Current Gain –
 $h_{FE} = 45$ (Max) @ $I_C = 150$ mAdc – 2N1131,A
- Turn-On Time – $t_{ON} = 45$ ns (Max) – 2N1131A
- Turn-Off Time – $t_{OFF} = 35$ ns (Max) – 2N1131A

*MAXIMUM RATINGS

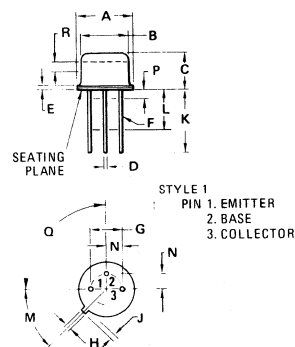
Rating	Symbol	2N1131	2N1131A	2N1991	Unit
Collector-Emitter Voltage	V_{CEO}	35	40	20	Vdc
Collector-Emitter Voltage	V_{CER}	50	50	—	Vdc
Collector-Base Voltage	V_{CB}	50	60	30	Vdc
Emitter-Base Voltage	V_{EB}	5.0	5.0	5.0	Vdc
Collector Current – Continuous	I_C	600	600	600	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.6 4.0	0.6 4.0	0.6 4.8	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ @ $T_C = 100^\circ\text{C}$ Derate above 25°C	P_D	2.0 1.0 13.3	2.0 1.0 13.3	2.0 1.0 16	Watts Watt mW/ $^\circ\text{C}$
Operating Junction Temperature Range	T_J	175	175	150	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	—	—65 to +200	—65 to +150	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N1131,A	2N1991	Unit
Thermal Resistance, Junction to Case	θ_{JC}	75	62.5	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	θ_{JA}	250	208	$^\circ\text{C}/\text{W}$

*Indicates JEDEC Registered Data.

PNP SILICON AMPLIFIER AND SWITCHING TRANSISTORS

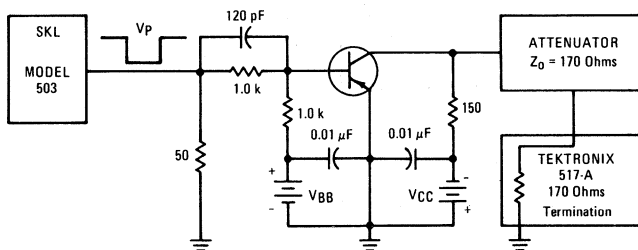


DIM	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° NOM	—	45° NOM	—
P	—	1.27	—	0.050
Q	90° NOM	—	90° NOM	—
R	2.54	—	0.100	—

All JEDEC dimensions and notes apply.

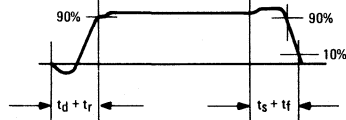
CASE 79-02
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FIGURE 1 – SWITCHING TIME TEST CIRCUIT – 2N1131A



CONDITIONS:

$V_{CC} = -15$ Volts $V_p = -7.5$ Volts
 $V_{BB} = 1.5$ Volts Pulse Width = 150 ns



2N1131S, 2N1131AS, 2N1991S (continued)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage(1) ($I_C = 100 \text{ mA}$, $I_B = 0$)	2N1131 2N1131A 2N1991	$V_{CEO(sus)}$	35 40 20	— — —	Vdc
Collector-Emitter Sustaining Voltage(1) ($I_C = 100 \text{ mA}$, $R_{BE} \leq 10 \text{ ohms}$)	2N1131, 2N1131A	$V_{CER(sus)}$	50	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{A}$, $I_E = 0$) ($I_C = 1.0 \text{ mA}$, $I_E = 0$)	2N1131A 2N1991	BV_{CBO}	60 30	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 1.0 \text{ mA}$, $I_C = 0$)	2N1131A	BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 30 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 30 \text{ Vdc}$, $I_E = 0$, $T_A = +150^\circ\text{C}$) ($V_{CB} = 50 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 45 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 45 \text{ Vdc}$, $I_E = 0$, $T_A = +150^\circ\text{C}$) ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $T_A = +150^\circ\text{C}$)	2N1131 2N1131 2N1131 2N1131A 2N1131A 2N1991 2N1991	I_{CBO}	— — — — — — —	1.0 100 100 0.5 50 5.0 200	μA
Emitter Cutoff Current ($V_{BE} = 2.0 \text{ Vdc}$, $I_C = 0$) ($V_{BE} = 5.0 \text{ Vdc}$, $I_C = 0$) ($V_{BE} = 1.0 \text{ Vdc}$, $I_C = 0$)	2N1131 2N1131A 2N1991	I_{EBO}	— — —	100 100 200	μA

ON CHARACTERISTICS

DC Current Gain ($I_C = 5.0 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$) ($I_C = 30 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$) ($I_C = 150 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$)	2N1131, 2N1131A 2N1991 2N1131, 2N1131A 2N1991	h_{FE}	15 15 20 15	— — 45 60	—
Collector-Emitter Saturation Voltage ($I_C = 150 \text{ mA}$, $I_B = 15 \text{ mA}$)		$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 150 \text{ mA}$, $I_B = 15 \text{ mA}$)	2N1131, 2N1131A 2N1991	$V_{BE(sat)}$	— —	1.3 1.5	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product(2) ($I_C = 50 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$, $f = 20 \text{ MHz}$)	2N1131, 2N1131A 2N1991	f_T	50 40	— —	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 140 \text{ kHz}$) ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 1.0 \text{ MHz}$)	2N1131, 2N1991 2N1131A	C_{ob}	— —	45 30	pF
Input Capacitance ($V_{EB} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 140 \text{ kHz}$) ($V_{EB} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 1.0 \text{ MHz}$)	2N1131 2N1131A	C_{ib}	— —	80 80	pF
Input Impedance ($I_C = 1.0 \text{ mA}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	2N1131, 2N1131A 2N1131, 2N1131A	h_{ib}	25 —	35 10	ohms
Voltage Feedback Ratio ($I_C = 1.0 \text{ mA}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	2N1131, 2N1131A 2N1131, 2N1131A	h_{rb}	— —	8.0 8.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0 \text{ mA}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	2N1131, 2N1131A 2N1131, 2N1131A	h_{fe}	15 20	50 —	—
Output Admittance ($I_C = 1.0 \text{ mA}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	2N1131, 2N1131A 2N1131, 2N1131A	h_{ob}	— —	1.0 5.0	μmhos

SWITCHING CHARACTERISTICS (Figure 1)

Turn-On Time	2N1131A	t_{on}	—	45	ns
Turn-Off Time	2N1131A	t_{off}	—	35	ns

*Indicates JEDEC Registered Data.

(1)Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

2N1132, A

PNP SILICON ANNULAR TRANSISTORS

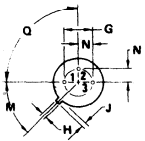
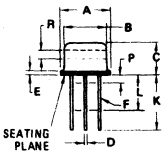
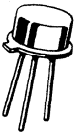
... designed for medium-current switching and amplifier applications.

PNP SILICON SWITCHING TRANSISTORS

*MAXIMUM RATINGS

Rating	Symbol	2N1132	2N1132A	Unit
Collector-Emitter Voltage	V_{CEO}	35	40	Vdc
Collector-Emitter Voltage ($R_{BE} \leq 10$ Ohms)	V_{CER}	50		Vdc
Collector-Base Voltage	V_{CB}	50	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	600		Vdc
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	600		mW
		4.0		mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	2.0		Watts
		13.3		mW/ $^\circ\text{C}$
Operating Junction Temperature Range	T_J	-65 to +175		$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200		$^\circ\text{C}$

*Indicates JEDEC Registered Data



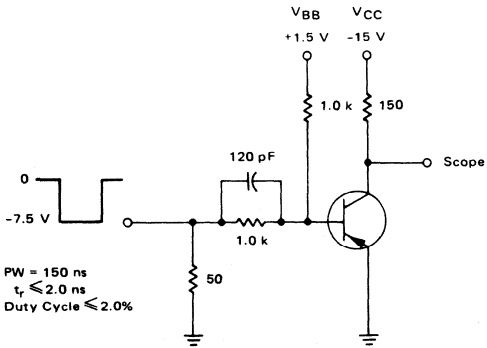
STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.408	0.533	0.016	0.021
E	0.225	3.18	0.009	0.125
F	0.408	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° NOM	—	45° NOM	—
P	—	1.27	—	0.060
Q	90° NOM	—	90° NOM	—
R	2.54	—	0.100	—

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



2N1132, 2N1132A (continued)

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) ($I_C = 10\text{ mAdc}$, $I_B = 0$)	$V_{CE(sus)}$	35 40	— —	Vdc
Collector-Emitter Sustaining Voltage (1) ($I_C = 10\text{ mAdc}$, $R_{BE} \leq 10\text{ Ohms}$)	$V_{CER(sus)}$	50	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	50 60	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\text{ }\mu\text{Adc}$, $I_C = 0$) ($I_C = 1.0\text{ mAdc}$, $I_C = 0$)	BV_{EBO}	5.0 5.0	— —	Vdc
Collector Cutoff Current ($V_{CB} = 30\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 30\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$) ($V_{CB} = 45\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 45\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— — — —	1.0 100 0.5 50	μAdc
Emitter Cutoff Current ($V_{BE} = 5.0\text{ Vdc}$, $I_C = 0$) ($V_{BE} = 2.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	— —	100 100	μAdc
ON CHARACTERISTICS (1)				
DC Current Gain ($I_C = 5.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 150\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$)	h_{FE}	25 30	— 90	—
Collector-Emitter Saturation Voltage ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$)	$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$)	$V_{BE(sat)}$	—	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain-Bandwidth Product ($I_C = 50\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 20\text{ MHz}$)	f_T	60	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 140\text{ kHz}$) ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{ob}	— —	45 30	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 140\text{ kHz}$) ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 1.0\text{ MHz}$)	C_{ib}	— —	80 80	pF
Input Resistance ($I_C = 1.0\text{ mAdc}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 5.0\text{ mAdc}$, $V_{CB} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ib}	25 —	35 10	Ohms
Voltage Feedback Ratio ($I_C = 1.0\text{ Adc}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 5.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{rb}	— —	8.0 8.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 5.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	25 25 30	100 75 —	—
Output Admittance ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 5.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ob}	— —	1.0 5.0	μmhos
SWITCHING CHARACTERISTICS (Figure 1)				
Turn-On Time	t_{on}	—	45	ns
Turn-Off Time	t_{off}	—	35	ns

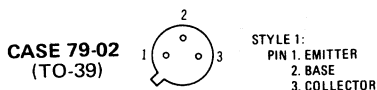
*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$

2N1141 thru 2N1143 (Ge Mesa)
2N1142 JAN AVAILABLE
2N1195
2N1195 JAN AVAILABLE



PNP germanium mesa transistors for amplifier, driver, oscillator and doubler applications.



Collector connected to case

*** MAXIMUM RATINGS**

Rating	Symbol	2N1141	2N1142	2N1143	2N1195	Unit
Collector-Base Voltage	V_{CB}	35	30	25	30	Vdc
Emitter-Base Voltage	V_{EB}	1.0	0.7	0.5	1.0	Vdc
Collector Current-Continuous	I_C	100	100	100	40	mAdc
Base Current-Continuous	I_B	50	50	50	-	mAdc
Emitter Current-Continuous	I_E	100	100	100	-	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 4.0	300 4.0	300 4.0	- -	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	750 10	750 10	750 10	- -	mW mW/ $^\circ\text{C}$
Collector Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_C	- -	- -	- -	225 3.0	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100				$^\circ\text{C}$

*Indicates JEDEC Registered Data

2N1141 thru 2N1143, 2N1195 (continued)

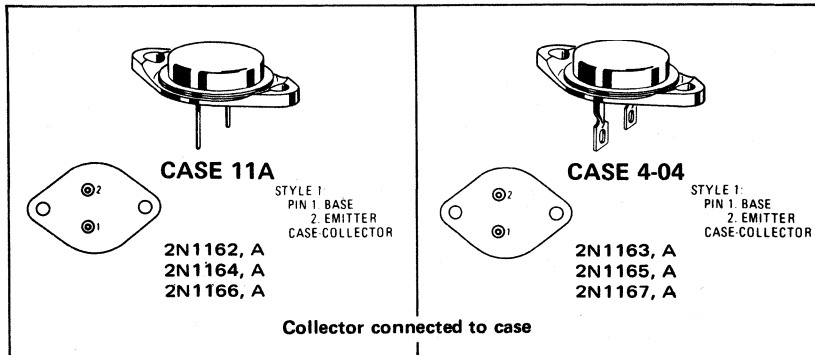
*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Base Breakdown Voltage ($I_C = 100\ \mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	35 30 25 30	— — — —	Vdc
2N1141 2N1142 2N1143 2N1195				
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	1.0 0.7 0.5 1.0	— — — —	Vdc
2N1141 2N1142 2N1143 2N1195				
Collector Cutoff Current ($V_{CB} = 15\ \text{Vdc}$, $I_E = 0$) ($V_{CB} = 20\ \text{Vdc}$, $I_E = 0$)	I_{CBO}	— —	5.0 5.0	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 10\ \text{mAdc}$, $V_{CE} = 10\ \text{Vdc}$)	h_{FE}	10	—	—
2N1141, 2N1142, 2N1143				
Collector-Emitter Saturation Voltage ($I_C = 50\ \text{mAdc}$, $I_B = 10\ \text{mAdc}$)	$V_{CE(sat)}$	—	2.0	Vdc
2N1141, 2N1142, 2N1143				
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain-Bandwidth Product ($I_C = 10\ \text{mAdc}$, $V_{CE} = 10\ \text{Vdc}$, $f = 100\ \text{MHz}$)	f_T	1200 1000 800	— — —	MHz
2N1141, 2N1195 2N1142 2N1143				
Collector Transition Capacitance ($V_{CB} = 10\ \text{Vdc}$, $I_E = 0$, $f = 1.0\ \text{MHz}$)	C_{TC}	—	1.5	pF
Input Impedance ($I_C = 10\ \text{mAdc}$, $V_{CE} = 10\ \text{Vdc}$, $f = 1.0\ \text{kHz}$)	h_{ib}	—	10	k Ohm
2N1195				
Voltage Feedback Ratio ($I_C = 10\ \text{mAdc}$, $V_{CE} = 10\ \text{Vdc}$, $f = 1.0\ \text{kHz}$)	h_{rb}	—	0.003	$\times 10^{-4}$
2N1195				
Small-Signal Current Gain ($I_C = 10\ \text{mAdc}$, $V_{CE} = 10\ \text{Vdc}$, $f = 1.0\ \text{kHz}$)	h_{fb}	0.96	0.995	—
2N1195				
Output Admittance ($I_C = 10\ \text{mAdc}$, $V_{CE} = 10\ \text{Vdc}$, $f = 1.0\ \text{kHz}$)	h_{ob}	—	20	μmhos
2N1195				
Extrinsic Base Resistance ($I_C = 10\ \text{mAdc}$, $V_{CE} = 10\ \text{Vdc}$, $f = 250\ \text{MHz}$)	r_b	— —	70 80	Ohms
2N1141 2N1195				

*Indicates JEDEC Registered Data.

2N1162 thru 2N1167 (GERMANIUM) **2N1162A thru 2N1167A**

PNP germanium power transistors for switching and amplifier applications in high reliability equipment.



MAXIMUM RATINGS

Apply also to standard, non-A series

Rating	Symbol	2N1162A 2N1163A	2N1164A 2N1165A	2N1166A 2N1167A	Units
Collector-Base Voltage	V_{CB}	50	80	100	Vdc
Collector-Emitter Voltage	V_{CES}	35	60	75	Vdc
Emitter-Base Voltage	V_{EB}	25	40	50	Vdc
Total Device Dissipation @ 25°C Derate above 25°C	P_D	106 1.25			Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110			°C

GROUP A ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current ($V_{CB} = V_{CB(\text{max})}$, $I_E = 0$)	I_{CBO1}	—	3.0	15	mA
Collector Cutoff Current ($V_{CB} = 2\text{ V}$, $I_E = 0$)	I_{CBO}	—	125	225	μA
($V_{CB} = 15\text{ V}$, $I_E = 0$, $T_C = 90^\circ\text{C}$) 2N1162A-3A*		—	10	20	mA
($V_{CB} = 30\text{ V}$, $I_E = 0$, $T_C = 90^\circ\text{C}$) 2N1164A-7A*		—	10	20	mA
Collector-Emitter Breakdown Voltage** ($I_C = 500\text{ mA}$, $V_{EB} = 0$)	BV_{CES}^{**}	35 60 75	— — —	— — —	Vdc
2N1162A-3A* 2N1164A-5A* 2N1166A-7A*					
Emitter Cutoff Current ($V_{EB} = 12\text{ V}$, $I_C = 0$)	I_{EBO}	—	0.5	1.2	mA
DC Forward Current Gain ($V_{CE} = 1\text{ V}$, $I_C = 25\text{ A}$)	h_{FE1}	15	25	—	—
($V_{CE} = 2\text{ V}$, $I_C = 5\text{ A}$)	h_{FE}	—	65	125	—
Collector-Emitter Saturation Voltage ($I_C = 25\text{ A}$, $I_B = 1.6\text{ A}$)	$V_{CE(\text{sat})}$	—	0.3	0.8	volts
Base-Emitter Saturation Voltage ($I_C = 25\text{ A}$, $I_B = 1.6\text{ A}$)	$V_{BE(\text{sat})}$	—	0.7	1.7	volts
Common Emitter-Cutoff Frequency ($V_{CE} = 2\text{ V}$, $I_C = 2\text{ A}$)	$f_{\alpha e}$	—	4.0	—	kHz

*Characteristics apply also to corresponding, non-A type numbers

**Sweep Method: 1/2 cycle sine wave, 60 Hz

SWITCHING CHARACTERISTICS (Typical)

Saturated Collector Current	Pulsed Drive Base Current		Response times in μs		
	On	Off	$t_d + t_r$	t_s	t_f
5 amp	330 mA	100 mA	11	5.0	17
10 amp	660 mA	200 mA	15	4.0	20
25 amp	1650 mA	500 mA	19	3.0	18

FIGURE 1 — POWER TEMPERATURE DERATING CURVE

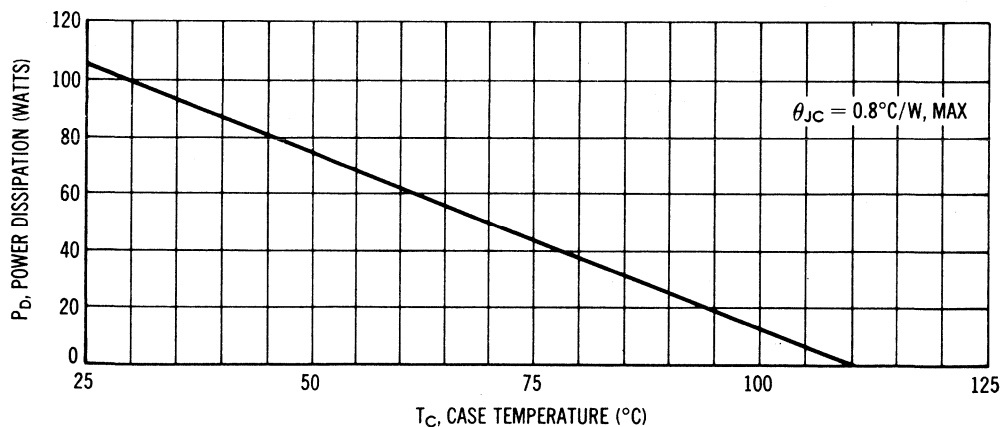
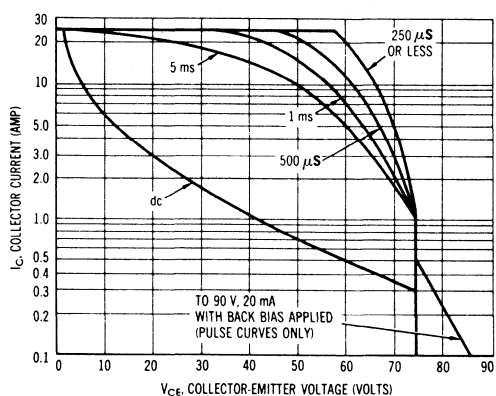
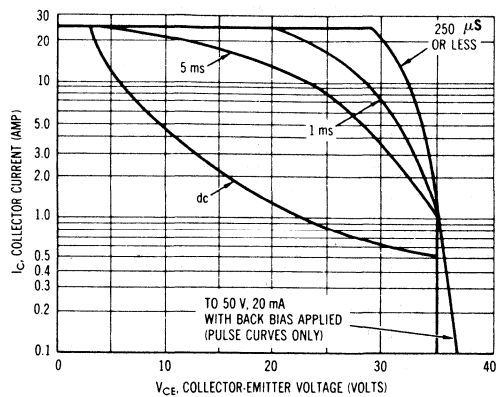
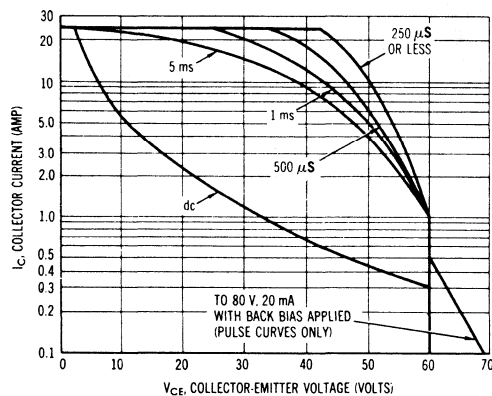


FIGURE 2 — ACTIVE REGION SAFE OPERATING AREAS

The active region safe operating area curves indicate $I_C V_{CE}$ limits to be observed in order to avoid secondary breakdown. (Secondary breakdown is independent of temperature and duty cycle.) These curves do not define operation in the avalanche region. To insure operation below the maximum junction temperature, power derating must be observed for both steady state and pulse conditions.



LARGE SIGNAL CHARACTERISTICS

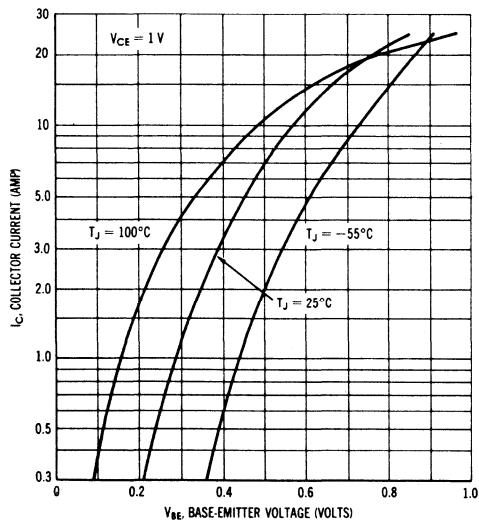
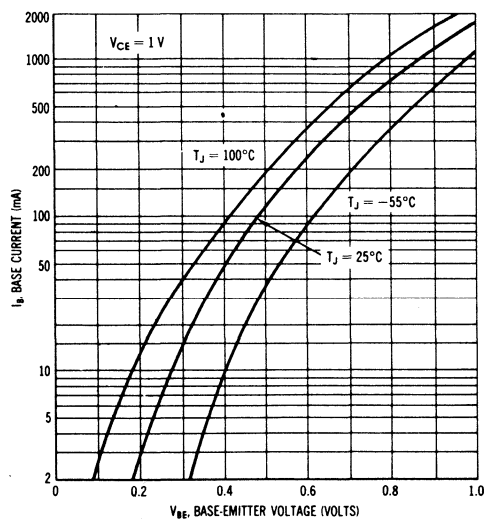
FIGURE 3 — TRANSCONDUCTANCE

FIGURE 4 — INPUT ADMITTANCE


FIGURE 5 — CURRENT GAIN

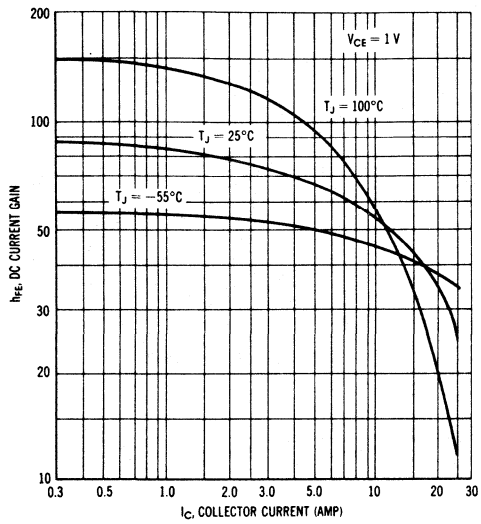
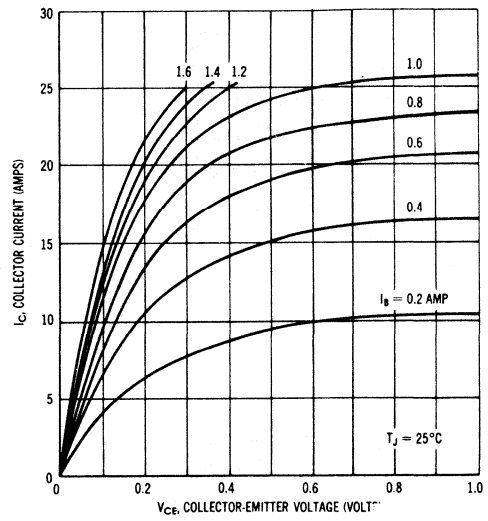


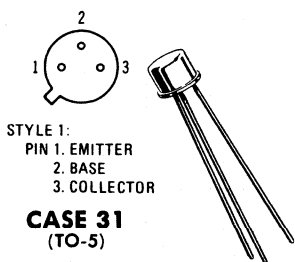
FIGURE 6 — SATURATION REGION



2N1175

For Specifications, See 2N1413-2N1415 Data

2N1185 thru 2N1188 (GERMANIUM)



PNP germanium transistors for high-gain audio amplifier and switching applications.

All leads isolated from case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage 2N1185 2N1186-2N1188	V_{CB}	45 60	Vdc
Collector-Emitter Voltage 2N1185 2N1186-2N1188	V_{CER}	30 45	Vdc
Emitter-Base Voltage	V_{EB}	30	Vdc
Collector Current* (Continuous)	I_C	500*	mAdc
Storage and Operating Temperature	T_{stg}, T_J	-65 to +100	°C
Collector Dissipation in, Ambient (Derate 2.67 mW/°C above 25°C)	P_D	200	mW
Thermal Resistance Junction to Ambient	θ_{JA}	0.375	°C/mW
Thermal Resistance (Junction to Case)	θ_{JC}	0.250	°C/mW

*Limited by power dissipation

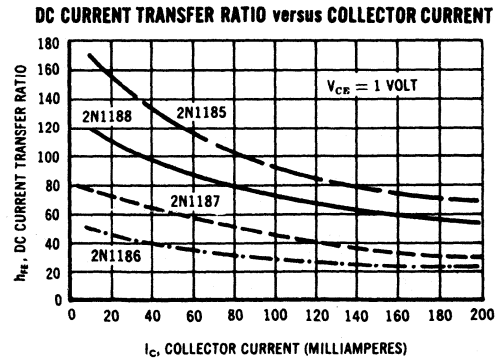
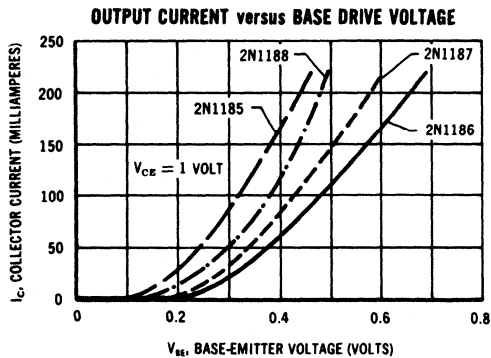
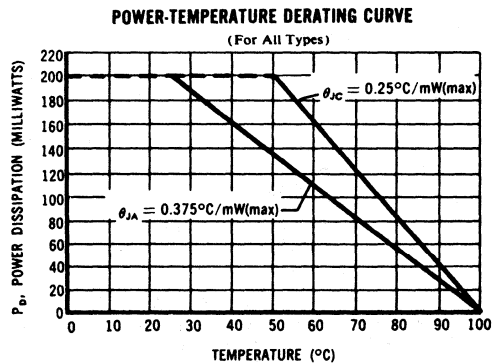
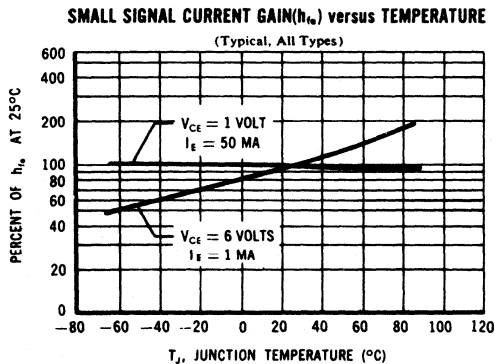
2N1185 thru 2N1188 (continued)
ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current ($V_{CB} = 30\text{ V}$, $I_E = 0$) ($V_{CB} = 45\text{ V}$, $I_E = 0$) ($V_{CB} = 60\text{ V}$, $I_E = 0$) ($V_{CB} = 10\text{ V}$, $I_E = 0$, $T_A = +71^\circ\text{C}$)	I_{CBO}	- - - -	3.0 5.0 - 55	10 10 50 100	μA
Emitter-Base Cutoff Current ($V_{EB} = 30\text{ V}$, $I_C = 0$)	I_{EBO}	-	3.0	10	μA
Collector-Emitter Leakage Current ($V_{CE} = 30\text{ V}$, $R_{BE} = 10\text{ K}$) ($V_{CE} = 45\text{ V}$, $R_{BE} = 10\text{ K}$)	I_{CER}	- -	- -	600 600	μA
Collector-Emitter Punch-Thru Voltage ($V_F = 1.0\text{ V}$, VTVM Impedance $\geq 1\text{ M ohm}$)	V_{pt}	45 60	- -	- -	Vdc
Output Capacitance ($V_{CB} = 6\text{ V}$, $I_E = 0$)	C_{ob}	-	10	25	pF
Noise Figure ($V_{CE} = 4.5\text{ V}$, $I_E = 0.5\text{ mA}$, $R_g = 1\text{ K}$, $f = 1\text{ kHz}$, $\Delta f = 1\text{ Hz}$)	NF	-	5.0	15	dB
Small Signal Current Gain Cutoff Frequency ($V_{CB} = 6\text{ V}$, $I_E = 1\text{ mA}$)	$f_{\alpha b}$	1.75 0.75 1.0 1.25	3.0 1.5 2.0 2.5	- - - -	MHz
Input Impedance ($V_{CB} = 6\text{ V}$, $I_E = 1\text{ mA}$, $f = 1\text{ kHz}$)	h_{ib}	27 27 27 27	35 31 34 35	37 37 37 37	Ohms
Output Admittance ($V_{CB} = 6\text{ V}$, $I_E = 1\text{ mA}$, $f = 1\text{ kHz}$)	h_{ob}	0.2 0.2 0.2 0.2	0.50 0.65 0.60 0.55	0.7 1.0 0.9 0.8	μmho
Small Signal Current Gain ($V_{CE} = 6\text{ V}$, $I_E = 1\text{ mA}$, $f = 1\text{ kHz}$)	h_{fe}	190 30 50 100	260 49 80 130	400 70 120 225	-
DC Current Transfer Ratio ($V_{CE} = 1.0\text{ V}$, $I_C = 10\text{ mA}$)	h_{FE}	130 33 45 80	170 44 75 115	- - - -	-

2N1185 thru 2N1188 (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristics	Symbol	Min	Typ	Max	Unit
Base-Emitter Input Voltage ($V_{CE} = 1.0 \text{ V}$, $I_C = 10 \text{ mA}$)	V_{BE}	-	0.215	0.240	Vdc
2N1185	-	-	0.245	0.270	
2N1186	-	-	0.235	0.260	
2N1187	-	-	0.225	0.250	
2N1188	-	-			
Collector-Emitter Saturation Voltage ($I_C = 50 \text{ mA}$, $I_B = 1.0 \text{ mA}$)	$V_{CE}(\text{sat})$	-	0.175	0.250	Vdc
2N1185	-	-	0.175	0.250	
2N1186	-	-	0.175	0.250	
2N1187	-	-	0.175	0.250	
2N1188	-	-	0.175	0.250	
Collector-Emitter Saturation Voltage ($I_C = 100 \text{ mA}$, $I_B = 2.0 \text{ mA}$)	$V_{CE}(\text{sat})$	-	0.250	0.500	Vdc
2N1185	-	-	0.250	0.500	
2N1186	-	-	0.250	0.500	
2N1187	-	-	0.250	0.500	
2N1188	-	-	0.250	0.500	



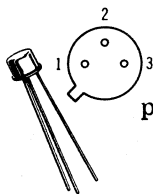
2N1189 2N1190(GERMANIUM)

STYLE 1:

PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 31
(TO-5)

All leads isolated



PNP germanium transistors for high-gain audio amplifier and switching applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	45	Vdc
Collector-Emitter Voltage	V_{CER}	30	Vdc
Emitter-Base Voltage	V_{EB}	15	Vdc
Collector Current (Continuous)	I_C	500*	mAdc
Junction, Storage Temperature	T_J, T_{stg}	-65 to +100	°C
Collector Dissipation, Ambient (Derate 2.67 mW/°C above 25°C)	P_D	200	mW
Thermal Resistance (Junction to Ambient)	θ_{JA}	0.375	°C/mW
Thermal Resistance (Junction to Case)	θ_{JC}	0.250	°C/mW

*Limited by power dissipation.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

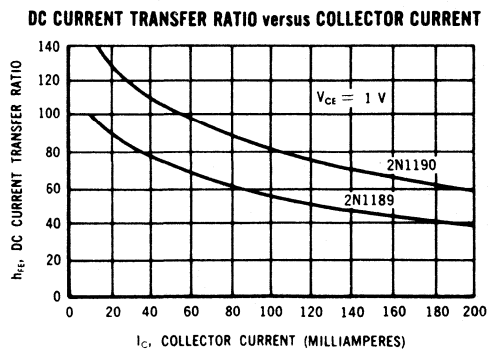
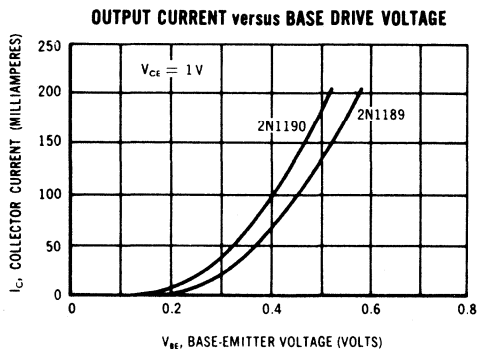
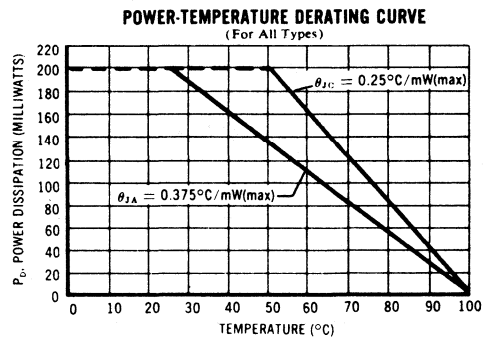
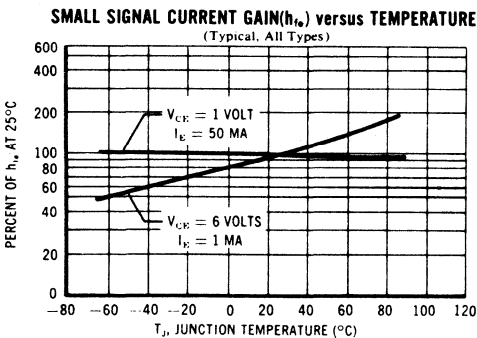
Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$) ($V_{CB} = 45$ Vdc, $I_E = 0$) ($V_{CB} = 10$ Vdc, $I_E = 0$, $T_A = +71^\circ\text{C}$)	I_{CBO}	— — —	3.0 — 55	10 50 100	μAdc
Emitter-Base Cutoff Current ($V_{EB} = 15$ Vdc, $I_C = 0$)	I_{EBO}	—	3.0	10	μAdc
Collector-Emitter Leakage Current ($V_{CE} = 30$ Vdc, $R_{BE} = 10\text{K}$)	I_{CER}	—	—	600	μAdc
Collector-Emitter Punch-Thru Voltage ($V_{EB} = 1$ Vdc, VTVM Impedance ≥ 1 M ohm)	V_{pt}	45	—	—	Vdc
Output Capacitance ($V_{CB} = 6$ Vdc, $I_E = 0$, $f = 1$ MHz)	C_{ob}	—	12.0	25	pF
Noise Figure ($V_{CE} = 4.5$ Vdc, $I_E = 0.5$ mAdc $R_g = 1$ K, $f = 1$ kHz $\Delta f = 1$ Hz)	NF	—	5.0	15	dB
Small-Signal Current-Gain Cutoff Frequency ($V_{CB} = 6$ Vdc, $I_E = 1$ mAdc)	$f_{\alpha b}$	1.75 2.25	3.5 4.5	— —	MHz

2N1189
2N1190

2N1189, 2N1190 (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Typ	Max	Unit
Input Impedance ($V_{CB} = 6 \text{ Vdc}$, $I_E = 1 \text{ mAdc}$, $f = 1 \text{ kHz}$)	h_{ib}	27	31	37	Ohms
Output Admittance ($V_{CB} = 6 \text{ Vdc}$, $I_E = 1 \text{ mAdc}$, $f = 1 \text{ kHz}$)	h_{ob}	0.1	—	0.9	μmho
Small Signal Current Gain ($V_{CE} = 6 \text{ Vdc}$, $I_E = 1 \text{ mAdc}$, $f = 1 \text{ kHz}$)	h_{fe}				—
2N1189		75	120	175	
2N1190		125	190	300	
DC Current Transfer Ratio ($V_{CE} = 1.0 \text{ Vdc}$, $I_E = 10 \text{ mAdc}$)	h_{FE}				—
2N1189		60	115	—	
2N1190		100	170	—	
Base-Emitter Drive Voltage ($V_{CE} = 1.0 \text{ Vdc}$, $I_E = 10 \text{ mAdc}$)	V_{BE}				Vdc
2N1189		—	0.24	0.26	
2N1190		—	0.22	0.25	
Collector-Emitter Saturation Voltage ($I_C = 50 \text{ mAdc}$, $I_B = 1.5 \text{ mA}$) ($I_C = 50 \text{ mAdc}$, $I_B = 1.0 \text{ mA}$) ($I_C = 100 \text{ mAdc}$, $I_B = 3.0 \text{ mA}$) ($I_C = 100 \text{ mAdc}$, $I_B = 2.0 \text{ mA}$)	$V_{CE}(\text{sat})$				Vdc
2N1189		—	0.14	0.22	
2N1190		—	0.15	0.22	
2N1189		—	0.17	0.3	
2N1190		—	0.19	0.3	



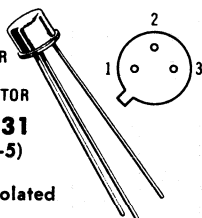
2N1191 thru 2N1194 (GERMANIUM)

STYLE 1:

PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 31
(TO-5)

All leads isolated



PNP germanium transistors for high-gain audio amplifier and switching applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	40	Vdc
Collector-Emitter Voltage	V_{CER}	25	Vdc
Emitter-Base Voltage	V_{EB}	25	Vdc
Collector Current (Continuous)	I_C	200	mAdc
Storage and Operating Temperature	T_{stg}, T_J	-65 to +100	°C
Collector Dissipation in, Ambient (Derate 2.67 mW/°C above 25°C)	P_D	200	mW
Thermal Resistance (Junction to Ambient)	θ_{JA}	0.375	°C/mW
Thermal Resistance (Junction to Case)	θ_{JC}	0.250	°C/mW

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

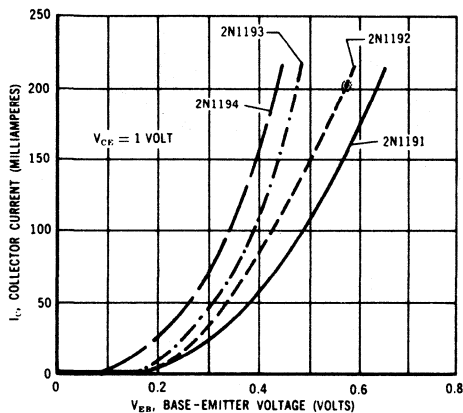
Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current ($V_{CB} = 25\text{ V}, I_E = 0$) ($V_{CB} = 1.0\text{ V}, I_E = 0$)	I_{CBO}	—	—	15	μAdc
		—	2.0	—	μAdc
Emitter-Base Cutoff Current ($V_{EB} = 25\text{ V}, I_C = 0$)	I_{EBO}	—	—	15	μAdc
Collector-Emitter Leakage Current ($V_{CB} = 25\text{ V}, R_{BE} = 10\text{ K}$)	I_{CER}	—	—	600	μAdc
Output Capacitance ($V_{CE} = 6\text{ V}, I_E = 1.0\text{ mA}$)	C_{ob}	—	20	—	pF
Noise Figure ($V_{CE} = 4.5\text{ V}, I_E = 0.5\text{ mA}$, $f = 1\text{ kHz}, R_s = 100\text{ ohms}$)	NF	—	10	—	dB
Small Signal Current Gain Cutoff Frequency ($V_{CB} = 6\text{ V}, I_E = 1.0\text{ mA}$)	$f_{\alpha b}$	—	1.5	—	MHz
		—	2.0	—	
		—	2.5	—	
		—	3.0	—	
		—	—	—	

2N1191 thru 2N1194 (continued)

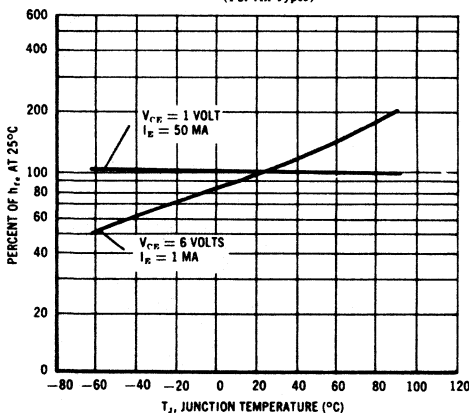
ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Typ	Max	Unit
Small Signal Current Gain ($V_{CE} = 6 \text{ V}$, $I_E = 1.0 \text{ mA}$, $f = 1 \text{ kHz}$)	2N1191	h_{fe}	30	40	70	—
	2N1192		50	75	125	
	2N1193		100	160	250	
	2N1194		190	280	500	
DC Current Gain ($V_{CE} = 1 \text{ V}$, $I_C = 10 \text{ mA}$)	2N1191	h_{FE}	20	—	80	—
	2N1192		40	—	135	
	2N1193		70	—	300	
	2N1194		125	—	600	
Small Signal Power Gain ($V_{CE} = 6 \text{ V}$, $I_E = 1.0 \text{ mA}$, $f = 1 \text{ kHz}$, matched)	2N1191	G_e	—	42	—	dB
	2N1192		—	44	—	
	2N1193		—	46	—	
	2N1194		—	48	—	
Base-Emitter Input Voltage ($V_{CE} = 6 \text{ V}$, $I_C = 1.0 \text{ mA}$)		V_{BE}	—	—	0.3	Vdc

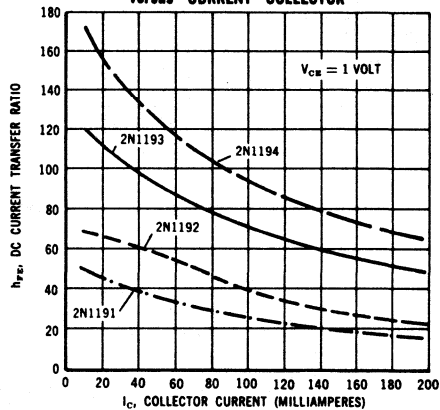
OUTPUT CURRENT versus BASE DRIVE VOLTAGE



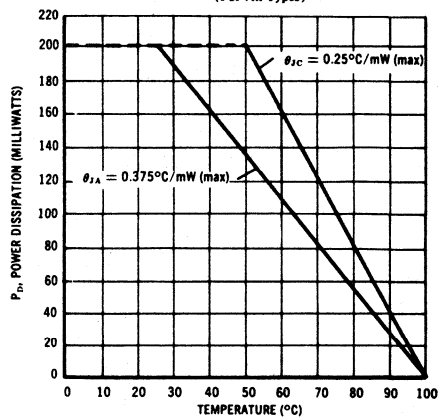
SMALL SIGNAL CURRENT GAIN
versus TEMPERATURE
(For All Types)



DC CURRENT TRANSFER RATIO
versus CURRENT COLLECTOR



POWER-TEMPERATURE DERATING CURVE
(For All Types)



2N1195, 2N1195JAN

For Specifications, See 2N1141 Data

2N1204A (Ge Mesa)

2N1495

PNP GERMANIUM SWITCHING TRANSISTORS

... designed for high-speed, high-current switching applications.

*MAXIMUM RATINGS

Rating	Symbol	2N1204A	2N1495	Unit
Collector-Emitter Voltage	V_{CE0}	15	25	Vdc
Collector-Emitter Voltage	V_{CES}	20	40	Vdc
Collector-Base Voltage	V_{CB}	20	40	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current — Continuous	I_C	500		mA dc
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300	4.0	mW mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	750	10	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100		$^\circ\text{C}$

*Indicates JEDEC Registered Data.

FIGURE 1 — CARRIER STORAGE TIME CONSTANT
TEST CIRCUIT

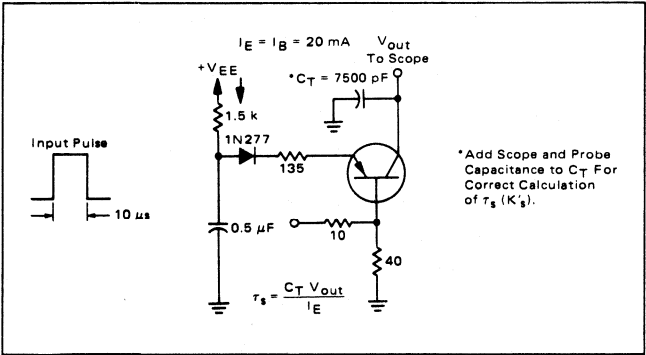
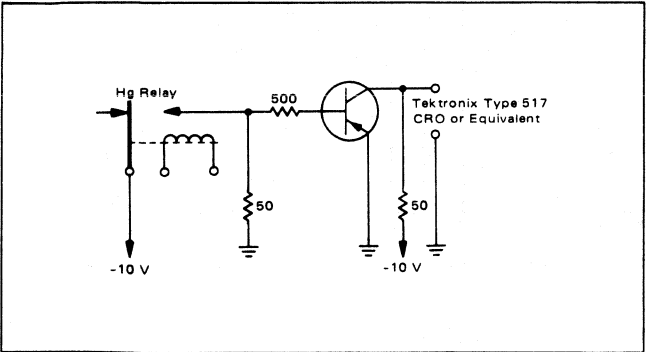
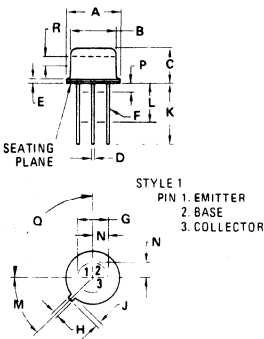
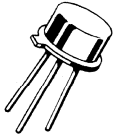


FIGURE 2 — RISE TIME TEST CIRCUIT



PNP GERMANIUM
SWITCHING
TRANSISTORS



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45°	NOM	45°	NOM
P	—	1.27	—	0.050
Q	90°	NOM	90°	NOM
R	2.54	—	0.100	—

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 2.0\text{ mAdc}$, $I_B = 0$) ($I_C = 10\text{ mAdc}$, $I_B = 0$)	BV_{CEO}	15 25	— —	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100\text{ }\mu\text{A}$, $V_{BE} = 0$)	BV_{CES}	20 40	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\text{ }\mu\text{A}$, $I_E = 0$)	BV_{CBO}	20 40	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 1.0\text{ mAdc}$, $I_C = 0$)	BV_{EBO}	4.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 5.0\text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	7.0	μA
Emitter Cutoff Current ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	50	μA
ON CHARACTERISTICS				
DC Current Gain ($I_C = 200\text{ mAdc}$, $V_{CE} = 0.5\text{ Vdc}$)	h_{FE}	25	—	—
Collector-Emitter Saturation Voltage ($I_C = 200\text{ mAdc}$, $I_B = 10\text{ mAdc}$) ($I_C = 200\text{ mAdc}$, $I_B = 20\text{ mAdc}$)	$V_{CE(sat)}$	— —	0.4 0.3	Vdc
Base-Emitter Saturation Voltage ($I_C = 200\text{ mAdc}$, $I_B = 10\text{ mAdc}$)	$V_{BE(sat)}$	0.40	0.72	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 4.0\text{ MHz}$)	C_{ob}	—	6.5	pF
Input Capacitance ($V_{BE} = 1.0\text{ Vdc}$, $I_C = 0$, $f = 4.0\text{ MHz}$)	C_{ib}	—	50	pF
Small-Signal Current Gain ($I_C = 20\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	h_{fe}	1.1 1.5	— —	—
SWITCHING CHARACTERISTICS				
Rise Time (Figure 2)	t_r	— —	35 55	ns
Storage Time (Figure 1)	t_s	— —	75 90	ns

*Indicates JEDEC Registered Data.

PNP GERMANIUM POWER TRANSISTOR

... designed for military applications requiring h_{FE} of 25-50 at $I_C = 5$ Amps.

- 0.5°C/Watt Maximum Thermal Resistance
- 150-Watt Power Dissipation at 25°C Case Temperature

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CB}	80	Vdc
Collector-Emitter Voltage	V_{CES}	70	Vdc
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	40	Vdc
Emitter Current (Continuous)	I_E	15	Amps
Base Current (Continuous)	I_B	4	Amps
Power Dissipation (per MIL-S-19500/122A Derate 1.25 W/°C above 25°C)	P_C	94	Watts
Power Dissipation (MOTOROLA JAN 2N1358) Derate 2 W/°C above 25°C	P_C	150	Watts
Junction Temperature Range	T_J	-65 to +100	°C

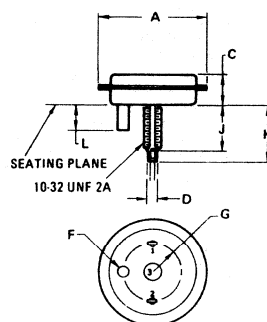
THERMAL CHARACTERISTICS

Characteristic	Symbol	Typ	Max	Unit
Thermal Resistance, Junction to Case (per MIL-S-19500/122A)	θ_{JC}	—	0.8	°C/W
Actual Thermal Resistance, Junction to Case (MOTOROLA JAN 2N1358)	θ_{JC}	0.35	0.5	°C/W

15 AMPERE POWER TRANSISTOR

PNP GERMANIUM

80 VOLTS
150 WATTS



STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR
(CONNECTED TO CASE)

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	—	31.75	—	1.250
C	—	13.21	—	0.520
D	—	4.83	—	0.190
F	—	3.56	—	0.140
G	8.76	NOM	0.346	NOM
J	9.53	12.70	0.375	0.500
K	15.49	18.03	0.610	0.710
L	—	7.92	—	0.312

All JEDEC dimensions and notes apply

CASE 5-03
TO-36

TABLE I — GROUP A INSPECTION

Examination or Test	MIL-STD-750 Method	Symbol	Limits		Unit	LTPD	Min Rej. Number
			Min	Max			
SUBGROUP 1							
Visual and Mechanical Examination	2071	—	—	—	—	10	5
SUBGROUP 2							
Emitter-Base Cutoff Current ($V_{EB} = -2.0$ Vdc, $I_C = 0$) ($V_{EB} = -40$ Vdc, $I_C = 0$)	3061 Condition D	I_{EBO}	— —	-0.2 -4	mAdc	5	4
Collector-Base Cutoff Current ($V_{CB} = -2.0$ Vdc, $I_E = 0$) ($V_{CB} = -80$ Vdc, $I_E = 0$)	3036 Condition D	I_{CBO}	— —	-0.2 -4	mAdc		
Collector-Emitter Breakdown Voltage* ($I_C = -300$ mAdc, $I_B = 0$)	3030	BV_{CEO}^*	-40	—	Vdc		
Collector-Emitter Breakdown Voltage ($I_C = -300$ mAdc, $V_{BE} = 0$)	3030	BV_{CES}	-70	—	Vdc		
Emitter-Base Voltage ($I_C = -1.2$ Adc, $V_{CE} = -2$ Vdc) ($I_C = -5$ Adc, $V_{CE} = -2$ Vdc)	3066 Condition B	V_{EB}	— —	0.5 0.9	Vdc		
Floating Potential ($V_{CB} = -80$ Vdc, $I_E = 0$, voltmeter input resistance = 10 megohm min)	3020	V_{EBF}	—	-0.5	Vdc		
Collector-Emitter Saturation Voltage ($I_C = 12$ Adc, $I_B = -2$ Adc)	3071	$V_{CE}(\text{sat})$	—	-0.7	Vdc		
DC Forward Current Transfer Ratio ($I_C = -1.2$ Adc, $V_{CE} = -2$ Vdc) ($I_C = -5$ Adc, $V_{CE} = -2$ Vdc)	3076	h_{FE}	— 25	80 50	—		
Base Current ($I_C = -1.2$ Adc, $V_{CE} = -2$ Vdc) ($I_C = -5$ Adc, $V_{CE} = -2$ Vdc)	3076	I_B	-15 -100	— -200	mAdc		
SUBGROUP 3							
Small-Signal Short-Circuit Forward-Current Transfer Ratio Cutoff Frequency ($V_{CE} = -6$ Vdc, $I_C = -5$ Adc)	3301	f_{at}	5	—	kc	5	4
SUBGROUP 4							
Emitter-Base Cutoff Current ($V_{EB} = -30$ Vdc, $T_C = 71^\circ\text{C}$)	3061 Condition D	I_{EBO}	—	-6	mAdc	10	5
Collector-Base Cutoff Current ($V_{CB} = -30$ Vdc, $T_C = 71^\circ\text{C}$)	3036 Condition D	I_{CBO}	—	-6	mAdc		

*Test by sweep method to avoid excessive heating.

TABLE II — GROUP B INSPECTION (Subgroups 2, 3, 5, 6, and 7 are destructive tests.)

Examination or Test	MIL-STD-750 Method	Symbol	Limits		Unit	LTPD	Min Rej. Number
			Min	Max			
SUBGROUP 1							
Physical Dimensions	2066	—	—	—	—	20	4
SUBGROUP 2							
Temperature Cycling	1051 Condition B, Except T (high) = 100°C	—	—	—	—	15	5
Moisture Resistance	1021 omit initial conditioning	—	—	—	—		
End Points: (Subgroups 2, 3, 5)							
Emitter-Base Cutoff Current (V _{EB} = -40 Vdc)	3061 Condition D	I _{EBO}	—	-8	mAdc		
Collector-Base Cutoff Current (V _{CB} = -80 Vdc)	3036 Condition D	I _{CBO}	—	-8	mAdc		
Base Current (I _C = -5Adc, V _{CE} = -2 Vdc)	3076	I _B	-90	-250	mAdc		

TABLE II — GROUP B INSPECTION (Continued)

Examination or Test	MIL-STD-750 Method	Symbol	Limits		Unit	LTPD	Min Req. Number
			Min	Max			
SUBGROUP 3							
Shock (500G, 1 msec, 5 blows each in orientations X ₁ , X ₂ , Y ₁ , and Y ₂ , total of 20 blows)	2016 Non-operating	—	—	—	—	15	5
Vibration Fatigue	2046 Non-operating	—	—	—	—		
Vibration, Variable Frequency	2056 Non-operating	—	—	—	—		
Constant Acceleration (2000G)	2006	—	—	—	—		
End Points: Same as Subgroup 2							
SUBGROUP 4							
Terminal Strength (Tension) (10 lb ± 1 oz, 10 sec to each lead)	2036 Condition A	—	—	—	—	15	5
Terminal Strength (Torque) (lead torque = 24 oz-in. , applied to flat of each lead; stud torque = 12 lb.-in)	2036 Condition D	—	—	—	—		
SUBGROUP 5							
Salt Spray (Corrosion)	1046 Condition A	—	—	—	—	20	4
End Points: Same as Subgroup 2 (See Note 4)							
SUBGROUP 6							
High Temperature Life (T _A = 100°C)	1031 Non-operating	—	—	—	—	λ = 10	—
End Points (Subgroups 6, 7)							
Emitter-Base Cutoff Current (V _{EB} = -40 Vdc)	3061 Condition D	I _{EBO}	—	-10	mAdc	λ = 10	—
Collector-Base Cutoff Current (V _{CB} = -80 Vdc)	3036 Condition D	I _{CBO}	—	-10	mAdc		
Base Current (I _C = -5 Adc, V _{CE} = -2 Vdc)	3076	I _B	-85	-250	mAdc		
SUBGROUP 7							
Steady State Operation Life (P _C = 18 W min, T _C = 80°C)	1026	—	—	—	—	λ = 15	—
End Points: Same as Subgroup 6							

TABLE III — GROUP C INSPECTION (See note 6)

Examination or Test	MIL-STD-750 Method	Symbol	Limits		Unit	LTPD	Min Req. Number
			Min	Max			
Thermal Resistance	3151	θ_{JC}	—	0.8	$^\circ\text{C/W}$	20	4
Barometric Pressure, Reduced (15 $\pm$ 2 mm Hg, $t = 60$ sec min, $V_{CB} = -80$ Vdc)	1001 (See Note 5)	I_{CBO}	—	-5	mAdc		

NOTE 1. Sampling and inspection shall be in accordance with Specification MIL-S-19500, and as specified herein.

NOTE 2. Acceptance inspection shall consist of the examinations and tests specified in Tables I, II, and III.

NOTE 3. Marking shall be as specified in MIL-S-19500, except omit polarity and color band identification.

NOTE 4. The transistor shall be examined for legibility of

marking before end-point measurements.

NOTE 5. The transistor shall operate satisfactorily without voltage derating.

NOTE 6. These tests shall be conducted on the initial lot, and thereafter once every 6 months.

NOTE 7. In addition to the notes specified herein, the notes specified in Specification MIL-S-19500 are applicable.

2N1358 JAN (continued)

FIGURE 1 — INPUT CHARACTERISTICS

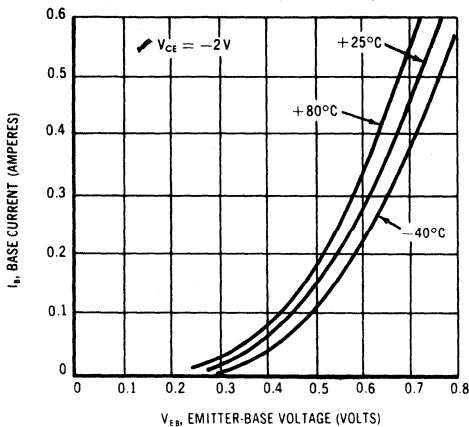


FIGURE 2 — OUTPUT CHARACTERISTICS

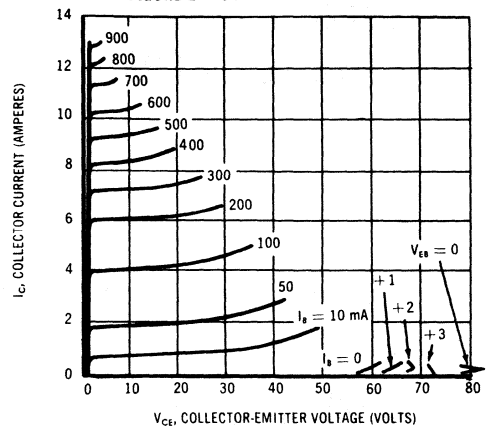


FIGURE 3 — CURRENT TRANSFER CHARACTERISTICS

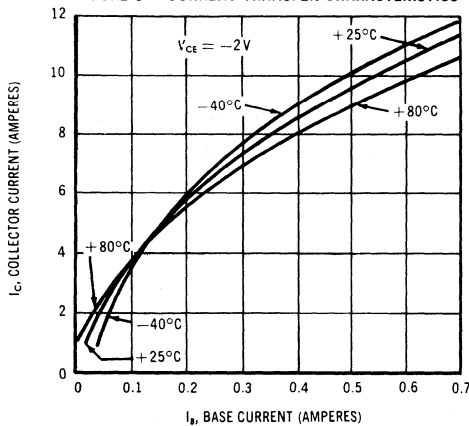


FIGURE 4 — TRANSCONDUCTANCE CHARACTERISTICS

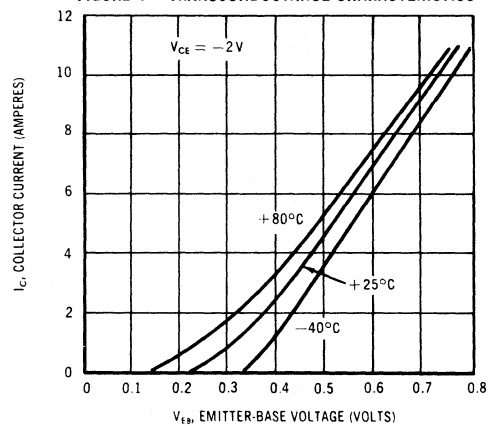
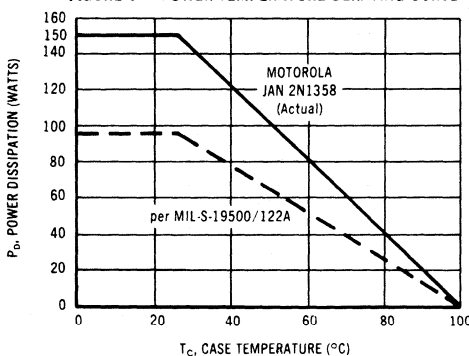


FIGURE 5 — POWER-TEMPERATURE DERATING CURVE



The maximum continuous power is related to maximum junction temperature by the thermal resistance factor.

This curve has a value of 150 Watts at case temperatures of 25°C and is 0 Watts at 100°C with a linear relation between the two temperatures such that

$$\text{allowable } P_D = \frac{100 - T_{\text{case}}}{0.5}$$

2N1358, A (GERMANIUM)

For Specifications, See 2N174 DATA.

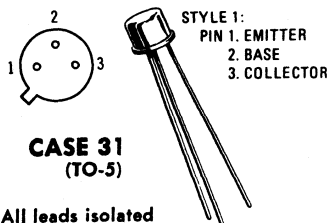
2N1359 (GERMANIUM)

2N1360

2N1362 thru **2N1365**

For Specifications, See 2N375 Data.

2N1408 (GERMANIUM)



PNP germanium transistor for high voltage neon driver, solenoid and relay driver circuits.

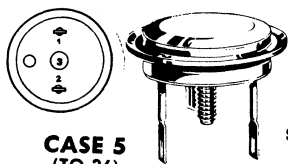
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	50	Vdc
Collector-Emitter Voltage	V_{CES}	50	Vdc
Emitter-Base Voltage	V_{EB}	10	Vdc
Collector Current	I_C	200	mA
Collector Dissipation at $T_A = 25^\circ\text{C}$	P_D	150	mW
derating factor		2.0	mW/ $^\circ\text{C}$
Junction Temperature Range	T_J	-65 to +100	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Cutoff Current ($V_{CB} = 5 \text{ Vdc}$, $I_E = 0$)	I_{CBO}	---	7.0	μAdc
Emitter-Base Cutoff Current ($V_{EB} = 5 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	---	7.0	μAdc
Collector-Emitter Leakage Current ($V_{CB} = 50 \text{ Vdc}$, $R_{BE} = 0$)	I_{CES}	---	150	μAdc
Collector-Base Breakdown Voltage ($I_C = 25 \mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	50	---	Vdc
Emitter-Base Breakdown Voltage ($I_E = 25 \mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	10	---	Vdc
Collector-Emitter Punch-Thru Voltage ($I_E = 25 \mu\text{Adc}$)	V_{pt}	50	---	Vdc
Base-Emitter Input Voltage ($I_B = 1.0 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$)	V_{BE}	---	0.6	Vdc
DC Current Gain ($V_{CE} = 1 \text{ Vdc}$, $I_B = 1 \text{ mAdc}$)	h_{FE}	10	---	---
Small Signal Current Gain ($V_{CE} = 5.0 \text{ Vdc}$, $I_E = 1.0 \text{ mA}$, $f = 1 \text{ kHz}$)	h_{fe}	10	---	---
Output Admittance ($V_{CB} = 5.0 \text{ Vdc}$, $I_E = 1.0 \text{ mA}$, $f = 1 \text{ kHz}$)	h_{ob}	---	2.0	μmhos

2N1412 (GERMANIUM) 2N1412A



**CASE 5
(TO-36)**

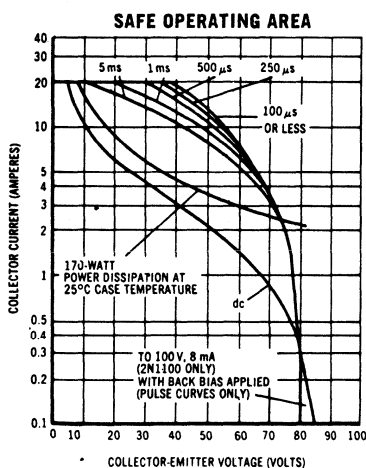
Collector connected to case

STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

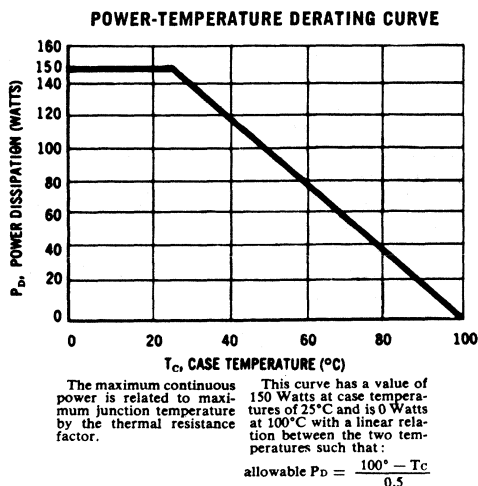
PNP germanium power transistors for high-voltage power amplifier and switching applications in military and industrial equipment.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	100	Vdc
Collector-Emitter Voltage	V_{CES}	80	Vdc
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Emitter-Base Voltage	V_{EB}	60	Vdc
Emitter Current (Continuous)	I_E	15	Amp
Base Current (Continuous)	I_B	4.0	Amp
Junction & Storage Temperature	T_{stg}	-65 to +100	$^{\circ}\text{C}$
Thermal Resistance	θ_{JC}	0.5	$^{\circ}\text{C/W}$



The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short.



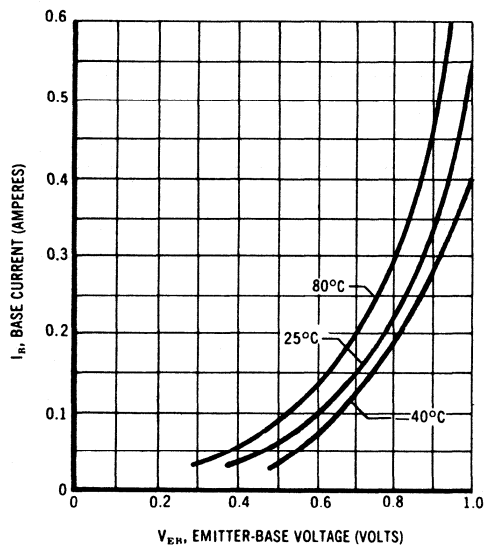
(Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J , the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N1412 (continued)**ELECTRICAL CHARACTERISTICS**

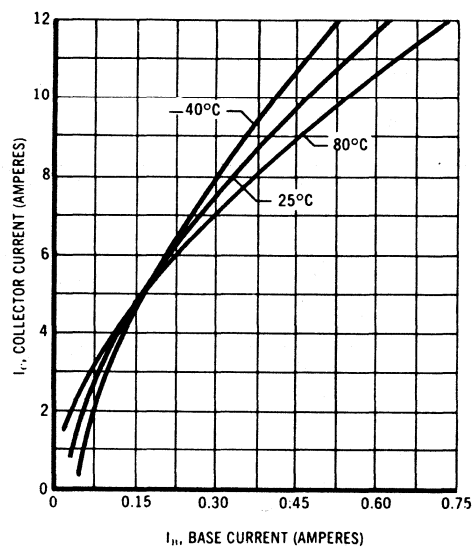
Characteristic	Symbol	Minimum	Maximum	Unit
Emitter Cutoff Current $V_{EB} = -2.0 \text{ Vdc}$ $I_C = 0$	I_{EBO}	—	200	μAdc
Emitter Cutoff Current $V_{EB} = -60 \text{ Vdc}$ $I_C = 0$	I_{EBO}	—	10	mAdc
Collector Cutoff Current $V_{CB} = -2.0 \text{ Vdc}$ $I_E = 0$	I_{CBO}	—	200	μAdc
Collector Cutoff Current $V_{CB} = -100 \text{ Vdc}$ $I_E = 0$	I_{CBO}	—	10	mAdc
Emitter-Base Voltage $V_{CE} = -2.0 \text{ Vdc}$ $I_C = -1.2 \text{ Adc}$	V_{EB}	—	0.5	Vdc
Emitter-Base Voltage $V_{CE} = -2.0 \text{ Vdc}$ $I_C = -5.0 \text{ Adc}$	V_{EB}	—	0.9	Vdc
Floating Potential $V_{CB} = -100 \text{ Vdc}$ $I_E = 0$ (Voltmeter input resistance = 10 Megohm min)	V_{fl}	—	1.0	Vdc
Collector-Emitter Saturation Voltage $I_C = -12 \text{ Adc}$ $I_B = -2.0 \text{ Adc}$	$V_{CE(\text{SAT})}$	—	0.7	Vdc
Forward Current Transfer Ratio* $V_{CE} = -2.0 \text{ Vdc}$ $I_C = -15 \text{ Adc}$	h_{FE}	10	—	—
Forward Current Transfer Ratio $V_{CE} = -2.0 \text{ Vdc}$ $I_C = -5.0 \text{ Adc}$	h_{FE}	25	50	—
Collector-Emitter Breakdown Voltage* $I_C = -1 \text{ Adc}$ $I_B = 0$	BV_{CEO}	60	—	Vdc
Collector-Emitter Breakdown Voltage* $V_{EB} = 0$ $I_C = 300 \text{ mA}$	BV_{CES}	80	—	Vdc
Small-Signal Short-Circuit Forward-Current Transfer Ratio Cutoff Frequency $V_{CE} = -12 \text{ Vdc}$ $I_C = -5.0 \text{ Adc}$	f_{ae}	5.0	—	kHz
High-Temperature Operation Emitter Cutoff Current $T_C = +71^\circ\text{C min}$ $V_{EB} = -30 \text{ Vdc}$	I_{EBO}	—	6.0	mAdc
Collector Cutoff Current $V_{CB} = -30 \text{ Vdc}$ $I_E = 0$	I_{CBO}	—	6.0	mAdc

*Test by sweep method with a short duty cycle (about 1%) to avoid excessive heating.

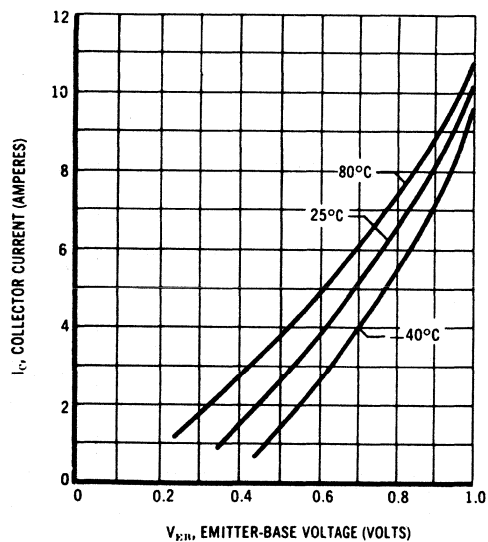
INPUT CHARACTERISTICS



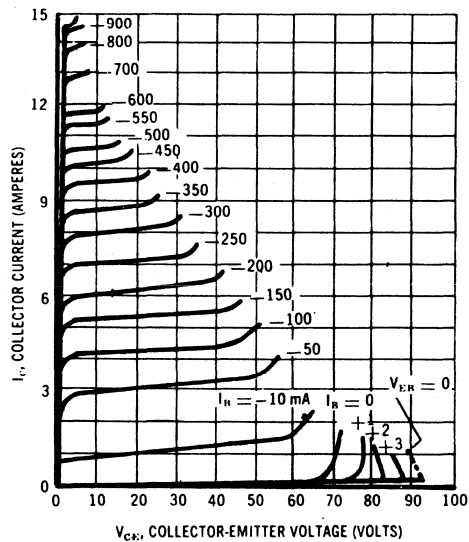
CURRENT TRANSFER CHARACTERISTICS



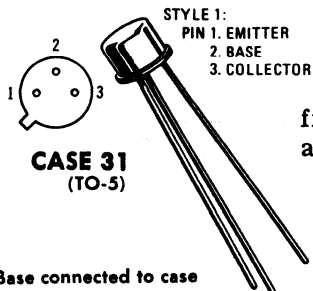
TRANSCONDUCTANCE CHARACTERISTICS



OUTPUT CHARACTERISTICS



2N1413 thru 2N1415 (GERMANIUM) 2N1175



PNP germanium transistors for general-purpose low-frequency amplifier and switching applications. Characteristic curves similar to 2N524-2N527 series.

Base connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	35	Vdc
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Emitter-Base Voltage	V_{EB}	10	Vdc
Collector Current	I_C	500	mAdc
Junction and Storage Temperature	T_j & T_{stg}	-65 to +100	°C
Power Dissipation at 25°C Ambient	P_D	225	mW

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
Collector Cutoff Current $V_{CB} = 30 \text{ Vdc}, I_E = 0$	I_{CBO}	—	12	μAdc
Emitter Cutoff Current $V_{EB} = 10 \text{ Vdc}, I_C = 0$	I_{EBO}	—	10	μAdc
Collector-Emitter Voltage $I_C = 0.6 \text{ mAdc}, R_{BE} = 10 \text{ K}$	BV_{CER}	25	—	Vdc
Punch-Thru Voltage	V_{pt}	25	—	Vdc
DC Current Gain $I_C = 20 \text{ mAdc}, V_{CE} = 1 \text{ Vdc}$	h_{FE}	25 34 53 70	42 65 90 140	—

2N1413 thru 2N1415, 2N1175 (continued)

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
DC Current Gain $I_C = 100 \text{ mAdc}$, $V_{CE} = 1 \text{ Vdc}$ 2N1413 2N1414 2N1415 2N1175	h_{FE}	23 30 47 62	— — — —	—
Base Input Voltage $V_{CE} = 1 \text{ Vdc}$, $I_C = 20 \text{ mAdc}$ 2N1175	V_{BE}	—	260	mVdc
Output Capacitance; Input AC Open Circuit $V_{CB} = 5 \text{ Vdc}$, $I_E = 1 \text{ mAdc}$, $f = 1 \text{ MHz}$	C_{ob}	—	40	pF
Frequency Cutoff $V_{CE} = 5 \text{ Vdc}$, $I_E = 1 \text{ mAdc}$ 2N1413 2N1414 2N1415 2N1175	$f_{\alpha b}$	0.8 1.0 1.3 1.5	— — — —	MHz
Small-Signal Short-Circuit Forward-Transfer Current Ratio $V_{CE} = 5 \text{ Vdc}$, $I_E = 1 \text{ mAdc}$, $f = 1 \text{ kHz}$ 2N1413 2N1414 2N1415 2N1175	h_{fe}	20 30 44 60	41 64 88 120	—
Small-Signal Open Circuit Output Admittance $V_{CB} = 5 \text{ Vdc}$, $I_E = 1 \text{ mAdc}$, $f = 1 \text{ kHz}$ 2N1413 2N1414 2N1415 2N1175	h_{ob}	0.10 0.10 0.10 0.10	1.3 1.2 1.0 0.9	μmh
Small-Signal Open-Circuit Reverse-Transfer Voltate Ratio $V_{CB} = 5 \text{ Vdc}$, $I_E = 1 \text{ mAdc}$, $f = 1 \text{ kHz}$ 2N1413 2N1414 2N1415 2N1175	h_{rb}	1.0 1.0 1.0 1.0	10 11 12 14	$\times 10^{-4}$
Small-Signal Short-Circuit Input Impedance $V_{CB} = 5 \text{ Vdc}$, $I_E = 1 \text{ mAdc}$, $f = 1 \text{ kHz}$ 2N1413 2N1414 2N1415 2N1175	h_{ib}	26 26 26 26	36 35 33 31	μmhos

2N1495

For Specifications, See 2N1204A Data

2N1518 thru 2N1523

PNP GERMANIUM HIGH POWER SWITCHING TRANSISTORS

...designed featuring low saturation voltage capability for high efficiency performance in motor drive controls and low loss regulators.

- Collector-Base Voltage –
 $V_{CB} = 50 \text{ Vdc (Min)} - 2N1518, 2N1520, 2N1522$
 $= 80 \text{ Vdc (Min)} - 2N1519, 2N1521, 2N1523$
- Collector Current –
 $I_C = 25 \text{ Adc} - 2N1518, 2N1519$
 $= 35 \text{ Adc} - 2N1520, 2N1521$
 $= 50 \text{ Adc} - 2N1522, 2N1523$

*MAXIMUM RATINGS

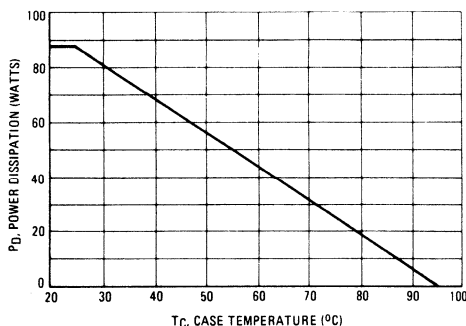
Rating	Symbol	2N1518 2N1520 2N1522		2N1519 2N1521 2N1523	Unit
Collector-Emitter Voltage	V_{CE0}	40		60	Vdc
Collector-Base Voltage	V_{CB}	50		80	Vdc
Emitter-Base Voltage	V_{EB}	30			Vdc
		2N1518 2N1519	2N1520 2N1521	2N1522 2N1523	
Collector Current – Continuous	I_C	25	35	50	Adc
Base Current – Continuous	I_B	4.0	6.0	8.0	Adc
Total Power Dissipation @ $T_C = 25^{\circ}\text{C}$ Derate above 25°C	P_D	$\longleftrightarrow 87.5 \longleftrightarrow$ $\longleftrightarrow 1.17 \longleftrightarrow$			Watts W/ $^{\circ}\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	$\longleftrightarrow -65 \text{ to } +95 \longleftrightarrow$			$^{\circ}\text{C}$

*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.8	$^\circ\text{C/W}$

*Indicates JEDEC Registered Data.

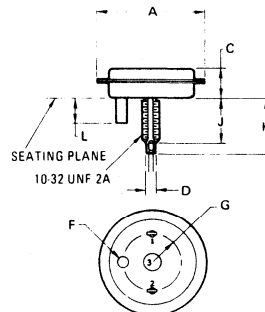
FIGURE 1 – POWER DERATING



25, 35, 50 AMPERE POWER TRANSISTORS

PNP GERMANIUM

50, 80 VOLTS
87.5 WATTS



STYLE 1:
 PIN 1. BASE
 2. EMITTER
 3. COLLECTOR
 (CONNECTED TO CASE)

DIM	MIN	MAX	MIN	MAX
A	—	31.75	—	1.250
C	—	13.21	—	0.520
D	—	4.83	—	0.190
F	—	3.56	—	0.140
G	8.76	NOM	0.345	NOM
J	9.53	12.70	0.375	0.500
K	15.49	18.03	0.610	0.710
L	—	7.92	—	0.312

All JEDEC dimensions and notes apply

CASE 5-03
TO-36

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

*Collector-Emitter Breakdown Voltage ($I_C = 1.0 \text{ Adc}$, $I_B = 0$)	2N1518, 2N1520, 2N1522 2N1519, 2N1521, 2N1523	BV_{CEO}	40 60	— —	— —	Vdc
*Floating Potential ($V_{CB} = 50 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 80 \text{ Vdc}$, $I_E = 0$)	2N1518, 2N1520, 2N1522 2N1519, 2N1521, 2N1523	V_{EBF}	— —	— —	1.0 1.0	Vdc
Collector Cutoff Current ($V_{CB} = 2.0 \text{ Vdc}$, $I_E = 0$)	All Devices	I_{CBO}	—	—	300	μAdc
*($V_{CB} = 50 \text{ Vdc}$, $I_E = 0$)	2N1518, 2N1520, 2N1522		—	—	4.0	mAdc
*($V_{CB} = 80 \text{ Vdc}$, $I_E = 0$)	2N1519, 2N1521, 2N1523		—	—	4.0	
*($V_{CB} = 50 \text{ Vdc}$, $I_E = 0$, $T_C = 85^\circ\text{C}$)	2N1518, 2N1520, 2N1522		—	—	15	
*($V_{CB} = 80 \text{ Vdc}$, $I_E = 0$, $T_C = 85^\circ\text{C}$)	2N1519, 2N1521, 2N1523		—	—	15	
*Emitter Cutoff Current ($V_{EB} = 30 \text{ Vdc}$, $I_C = 0$)		I_{EBO}	—	—	8.0	mAdc

ON CHARACTERISTICS

*DC Current Gain ($I_C = 15 \text{ Adc}$, $V_{CE} = 4.0 \text{ Vdc}$)	2N1518, 2N1519 2N1520, 2N1521 2N1522, 2N1523	h_{FE}	15 17 25	— — —	60 68 100	—
($I_C = 25 \text{ Adc}$, $V_{CE} = 4.0 \text{ Vdc}$)	2N1518, 2N1519		12	—	—	
($I_C = 35 \text{ Adc}$, $V_{CE} = 4.0 \text{ Vdc}$)	2N1520, 2N1521		12	—	—	
($I_C = 50 \text{ Adc}$, $V_{CE} = 4.0 \text{ Vdc}$)	2N1522, 2N1523		12	17	—	
*Collector-Emitter Saturation Voltage ($I_C = 25 \text{ Adc}$, $I_B = 4.0 \text{ Adc}$)	2N1518, 2N1519	$V_{CE(sat)}$	—	—	0.7	Vdc
($I_C = 35 \text{ Adc}$, $I_B = 4.0 \text{ Adc}$)	2N1520, 2N1521		—	—	0.6	
($I_C = 50 \text{ Adc}$, $I_B = 5.0 \text{ Adc}$)	2N1522, 2N1523		—	—	0.5	
Base-Emitter Saturation Voltage ($I_C = 25 \text{ Adc}$, $I_B = 3.0 \text{ Adc}$)	2N1518, 2N1519	$V_{BE(sat)}$	—	—	1.5	Vdc
($I_C = 35 \text{ Adc}$, $I_B = 4.0 \text{ Adc}$)	2N1520, 2N1521		—	—	1.5	
($I_C = 50 \text{ Adc}$, $I_B = 5.0 \text{ Adc}$)	2N1522, 2N1523		—	—	1.5	

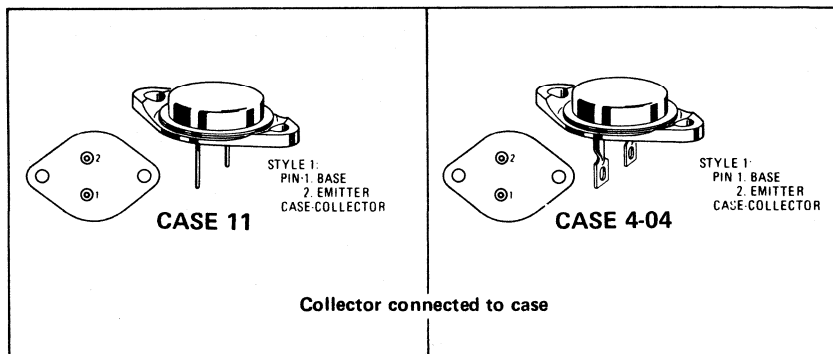
SMALL-SIGNAL CHARACTERISTICS

Common-Emitter Amplification Cutoff Frequency ($I_C = 5.0 \text{ Adc}$, $V_{CE} = 6.0 \text{ Vdc}$)	$h_{f_{fe}}$	—	4.0	—	—	kHz
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*Indicates JEDEC Registered Data.

2N1529 thru 2N1538 (GERMANIUM)
2N1529A thru 2N1532A, 2N1534A thru 2N1537A

PNP germanium power transistors for switching and amplifier applications in high-reliability equipment.



units with solder lugs attached, specify
ces MP1529, A etc. (Case 4-04)

MAXIMUM RATINGS

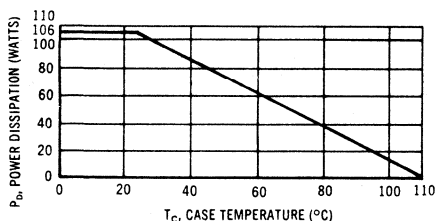
Rating	Symbol	2N1529 2N1534	2N1530 2N1535	2N1531 2N1536	2N1532 2N1537	2N1533 2N1538	Units
Collector-Emitter Voltage	V_{CEX}	40	60	80	100	120	Vdc
Collector-Emitter Voltage	V_{CES}	30	45	60	75	90	Vdc
Collector-Emitter Voltage	V_{CEO}	20	30	40	50	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	100	120	Vdc
Emitter-Base Voltage	V_{EB}	20	30	40	50	60	Vdc
Collector Current (Continuous)	I_C	5.0					Amp
Collector Current (Peak)	I_C	10					Amp
Junction Temperature Range	T_J	-65 to +110					°C
Total Device Dissipation (25°C Case Temperature)	P_D	106					Watts
Thermal Resistance	θ_{JC}	0.8					°C/W

2N1529 thru 2N1538 (continued)
ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise specified.)

Characteristics apply to corresponding "A" type numbers also.

Characteristic		Symbol	Min	Max	Unit
Collector-Base Cutoff Current ($V_{CB} = 25\text{V}$) ($V_{CB} = 40\text{V}$) ($V_{CB} = 55\text{V}$) ($V_{CB} = 65\text{V}$) ($V_{CB} = 80\text{V}$)	2N1529, 2N1534 2N1530, 2N1535 2N1531, 2N1536 2N1532, 2N1537 2N1533, 2N1538	I_{CBO1}	— — — — —	2.0 2.0 2.0 2.0 2.0	mA
Collector-Base Cutoff Current ($V_{CB} = 2\text{V}$) ($V_{CB} = 1\ 2\ BV_{CES}$ rating; $T_C = +90^\circ\text{C}$)		I_{CBO}	— —	0.2 20	mA
Emitter-Base Cutoff Current ($V_{EB} = 12\text{V}$)		I_{EBO}	—	0.5	mA
Collector-Emitter Breakdown Voltage ($I_C = 500\text{ mA}$, $V_{EB} = 0$)	2N1529, 2N1534 2N1530, 2N1535 2N1531, 2N1536 2N1532, 2N1537 2N1533, 2N1538	BV_{CES}	30 45 60 75 90	— — — — —	volts
Collector-Emitter Leakage Current ($V_{BE} = 1\text{V}$, V_{CE} @ rated BV_{CBO})		I_{CEX}	—	20	mA
Collector-Emitter Breakdown Voltage ($I_C = 500\text{ mA}$, $I_B = 0$)	2N1529, 2N1534 2N1530, 2N1535 2N1531, 2N1536 2N1532, 2N1537 2N1533, 2N1538	BV_{CEO}	20 30 40 50 60	— — — — —	volts
Collector-Base Breakdown Voltage ($I_C = 20\text{ mA}$)	2N1529, 2N1534 2N1530, 2N1535 2N1531, 2N1536 2N1532, 2N1537 2N1533, 2N1538	BV_{CBO}	40 60 80 100 120	— — — — —	volts
Current Gain ($V_{CE} = 2\text{V}$, $I_C = 3\text{A}$)	2N1529 - 2N1533 2N1534 - 2N1538	h_{FE1}	20 35	40 70	—
Base-Emitter Saturation Voltage ($I_C = 3\text{A}$, $I_B = 300\text{ mA}$)	2N1529 - 2N1533 2N1534 - 2N1538	$V_{BE(sat)}$	— —	1.7 1.5	volts
Collector-Emitter Saturation Voltage ($I_C = 3\text{A}$, $I_B = 300\text{ mA}$)	2N1529 - 2N1533 2N1534 - 2N1538	$V_{CE(sat)}$	— —	1.5 1.2	volts
Transconductance ($V_{CE} = 2\text{V}$, $I_C = 3\text{A}$)	2N1529 - 2N1533 2N1534 - 2N1538	g_{FE}	1.2 1.5	— —	mhos

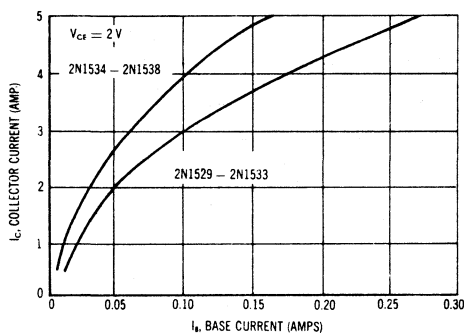
POWER-TEMPERATURE DERATING CURVE



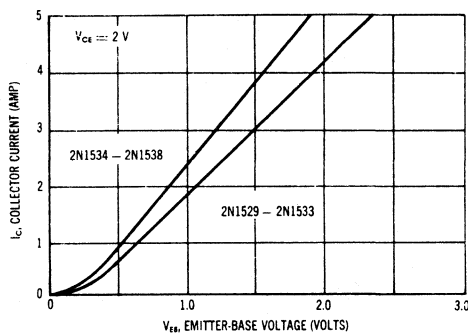
The maximum continuous power is related to maximum junction temperature, by the thermal resistance factor. For dc or frequencies below 25 Hz the transistor must be operated within the constant $P_D = V_C \times I_C$ hyperbolic curve. This curve has a value of 106 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that

$$P_{D \text{ allowable}} = \frac{110^\circ - T_c}{0.8}$$

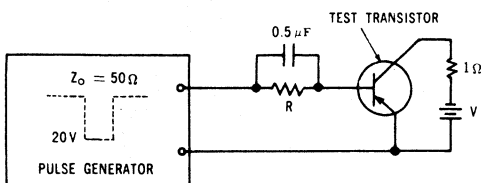
COLLECTOR CURRENT versus BASE CURRENT



COLLECTOR CURRENT versus EMITTER BASE VOLTAGE



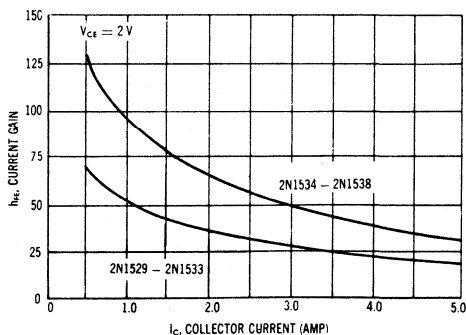
SWITCHING TIME MEASURING CIRCUIT



TYPICAL SWITCHING CHARACTERISTICS

	I_C (AMP)	V (VOLTS)	R (ohms)	$t_d + t_r$ (μS)	t_s (μS)	t_f (μS)
2N1529-33	3	3	65	10	2	5
2N1534-38	3	3	100	8	3	5

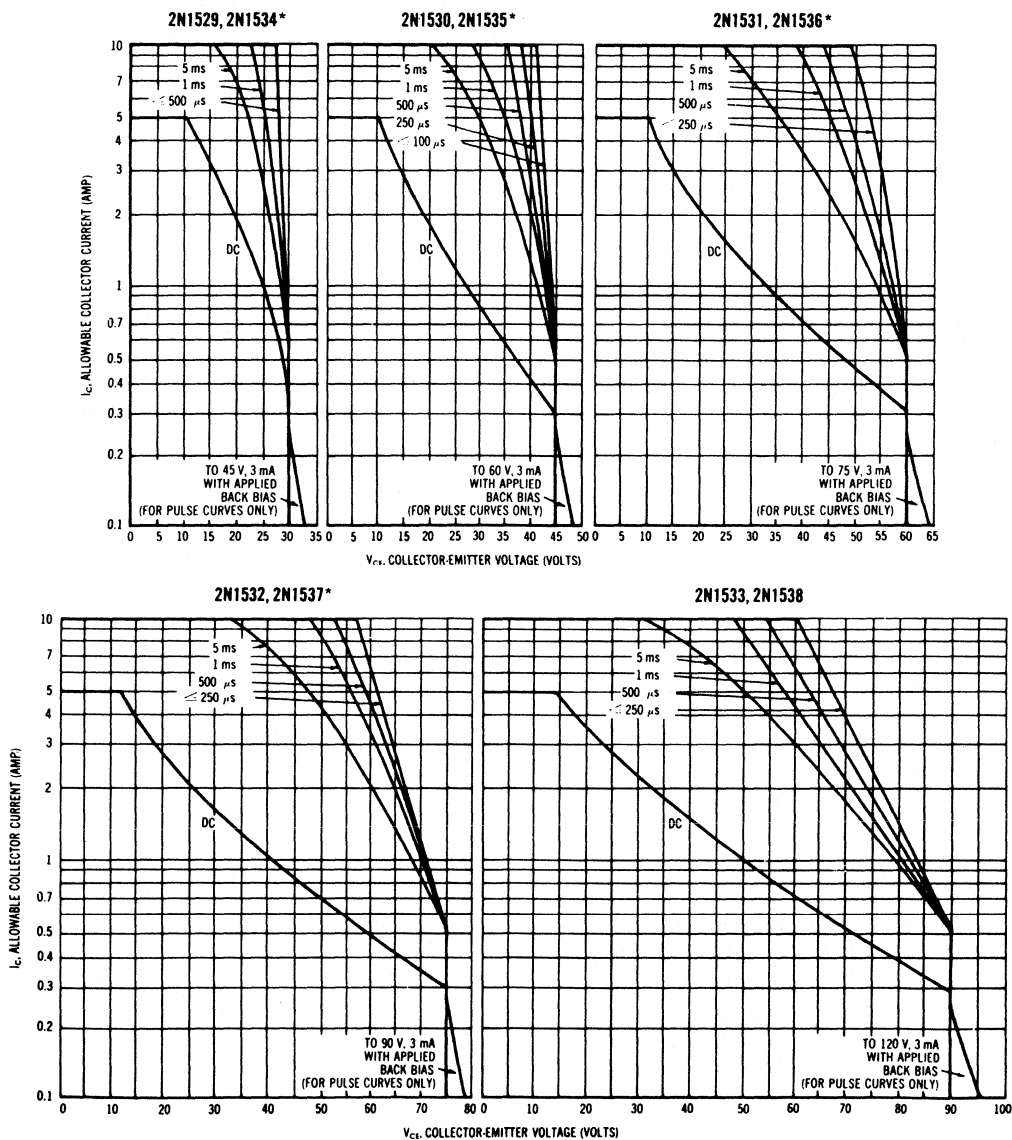
DC CURRENT GAIN versus
COLLECTOR CURRENT



SAFE OPERATING AREAS — PULSE CONDITIONS

The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short.

(Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J , the power-temperature derating curve must be observed for both steady state and pulse power conditions.

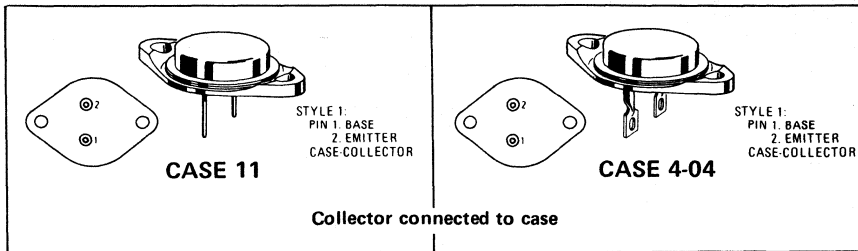


*Characteristics apply to corresponding *A* type numbers also.

2N1539 thru 2N1548 (GERMANIUM)

2N1539A thru 2N1542A, 2N1544A thru 2N1547A

PNP germanium power transistors for switching and amplifier applications in high-reliability equipment.



For units with solder lugs attached, specify devices MP1539, A etc. (Case 4-04)

MAXIMUM RATINGS

Rating	Symbol	2N1539 2N1544	2N1540 2N1545	2N1541 2N1546	2N1542 2N1547	2N1543 2N1548	Unit
Collector-Emitter Voltage	V_{CEO}	20	30	40	50	60	Vdc
Collector-Emitter Voltage	V_{CES}	30	45	60	75	90	Vdc
Collector-Emitter Voltage	V_{CEX}	40	60	80	100	120	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	100	120	Vdc
Emitter-Base Voltage	V_{EB}	20	30	40	50	60	Vdc
Collector Current-Continuous Peak	I_C	5.0					Adc
	I_C	10					Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$	P_D	106					Watts
Operating Junction Temperature Range	T_J	-65 to +110					$^\circ\text{C}$

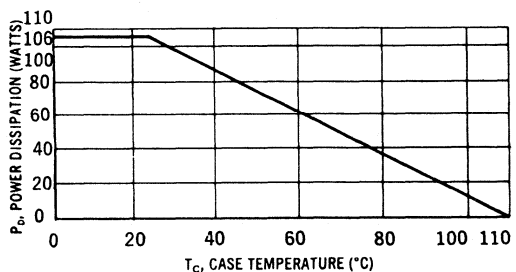
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.8	$^\circ\text{C}/\text{W}$

The maximum continuous power is related to maximum junction temperature, by the thermal resistance factor. For d.c. or frequencies below 25 cps the transistor must be operated within the constant $P_D = V_c \times I_c$ hyperbolic curve. This curve has a value of 106 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that

$$P_D \text{ allowable} = \frac{110^\circ - T_c}{0.8}$$

POWER-TEMPERATURE DERATING CURVE



2N1539 thru 2N1548 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25 °C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage† (I _C = 500 mA _{dc} , I _B = 0)	BV _{CEO} †	20 30 40 50 60	- - - - -	volts
Collector-Emitter Breakdown Voltage† (I _C = 500 mA _{dc} , V _{BE} = 0)	BV _{CES} †	30 45 60 75 90	- - - - -	volts
Collector-Base Breakdown Voltage (I _C = 20 mA _{dc} , I _E = 0)	BV _{CBO}	40 60 80 100 120	- - - - -	volts
Collector Cutoff Current (V _{CE} @ rated V _{CB} , V _{BE} = 1.0 V _{dc})	I _{CEX}	-	20	mA
Collector Cutoff Current (V _{CB} = 2.0 V _{dc} , I _E = 0) (V _{CB} = 1/2 V _{CES} rating, T _C = 90 °C)	I _{CBO}	- -	0.2 20	mA
Collector Cutoff Current (V _{CB} = 25 V _{dc} , I _E = 0) (V _{CB} = 40 V _{dc} , I _E = 0) (V _{CB} = 55 V _{dc} , I _E = 0) (V _{CB} = 65 V _{dc} , I _E = 0) (V _{CB} = 80 V _{dc} , I _E = 0)	I _{CBO1}	- - - - -	2.0 2.0 2.0 2.0 2.0	mA

ON CHARACTERISTICS

DC Current Gain (I _C = 3.0 A _{dc} , V _{CE} = 2.0 V _{dc})	2N1539-2N1543 2N1544-2N1548	h _{FE1}	50 75	100 150	-
DC Transconductance (I _C = 3.0 A _{dc} , V _{CE} = 2.0 V _{dc})	2N1539-2N1543 2N1544-2N1548	g _{FE}	3.0 5.0	- -	mhos
Collector-Emitter Saturation Voltage (I _C = 3.0 A _{dc} , I _B = 300 mA _{dc})	2N1539-2N1543 2N1544-2N1548	V _{CE(sat)}	- -	0.3 0.2	volts
Base-Emitter Saturation Voltage (I _C = 3.0 A _{dc} , I _B = 300 mA _{dc})	2N1539-2N1543 2N1544-2N1548	V _{BE(sat)}	- -	0.7 0.5	volts

DYNAMIC CHARACTERISTICS

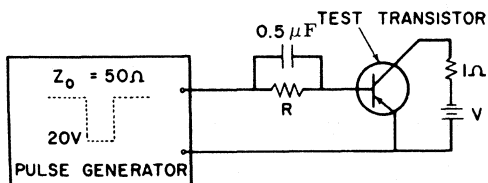
Common-Emitter Cutoff Frequency (I _C = 3.0 A _{dc} , V _{CE} = 2.0 V _{dc})	f _{αe}	Typ 4.0	kHz
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Characteristics apply to corresponding A type numbers also.

†To avoid excessive heating of collector junction, perform this test with a sweep method.

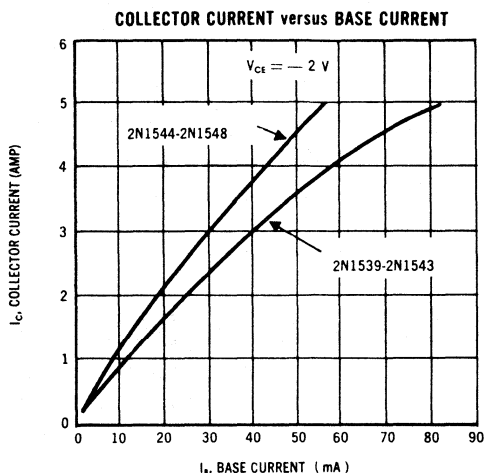
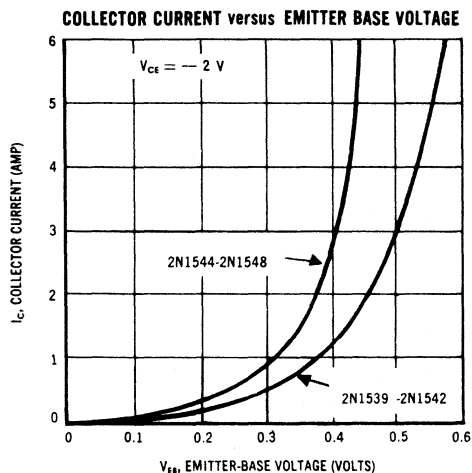
2N1539 thru 2N1548 (continued)

SWITCHING TIME MEASURING UNIT



Devices	Conditions*			Typical Switching Times		
	I_C (Amp)	V (Volts)	R (ohms)	$t_d + t_r$ (μs)	t_f (μs)	t_r (μs)
2N1539-43	3	3	165	5	3	5
2N1544-48	3	3	250	5	3	8

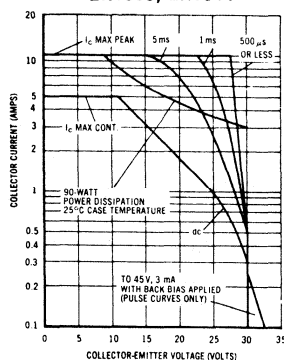
*Input Pulse Repetition Rate = 2 kHz,
Pulse Width = 50 μs



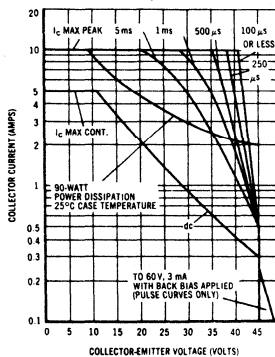
SAFE OPERATING AREAS

The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Case temperature and duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J , the power-temperature derating curve must be observed for both steady state and pulse power conditions.

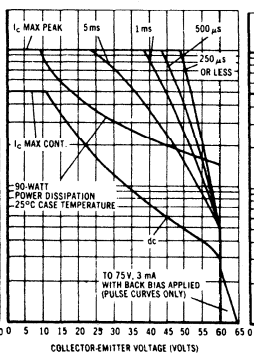
2N1539, 2N1544



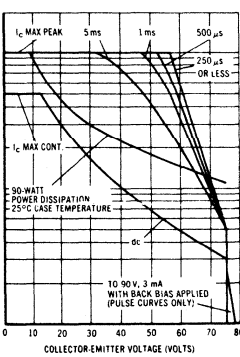
2N1540, 2N1545



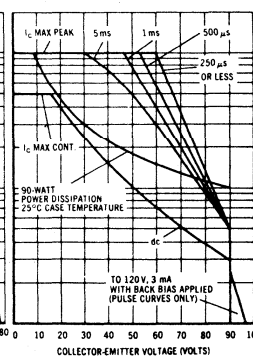
2N1541, 2N1546



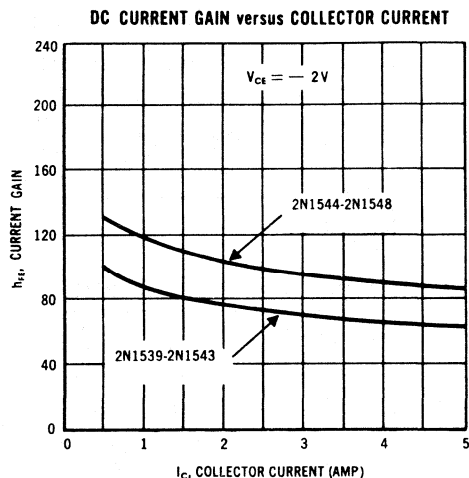
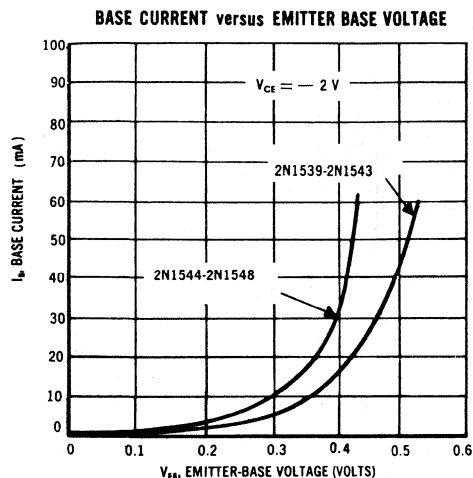
2N1542, 2N1547



2N1543, 2N1548

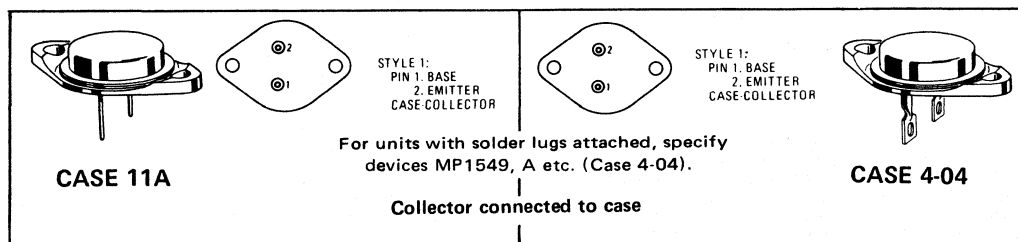


2N1539 thru 2N1548 (continued)



2N1549, A thru 2N1560, A (GERMANIUM)

PNP germanium power transistors for switching and amplifier applications in high-reliability equipment.



MAXIMUM RATINGS Apply to corresponding "Hi-Rel" Series also

Rating	Symbol	2N1549 2N1553 2N1557	2N1550 2N1554 2N1558	2N1551 2N1555 2N1559	2N1552 2N1556 2N1560	Units
Collector-Emitter Voltage	V_{CEX}	40	60	80	100	Vdc
Collector-Emitter Voltage	V_{CES}^*	30	45	60	75	Vdc
Collector-Emitter Voltage	V_{CEO}^*	20	30	40	50	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	100	Vdc
Emitter-Base Voltage	V_{EB}	20	30	40	50	Vdc
Collector Current (Continuous)	I_C	15				Amp
Collector Current (Peak)	I_C	20				Amp
Collector Junction Temperature	T_J	-65 to +110				$^{\circ}C$
Collector Dissipation (25 $^{\circ}C$ Case Temp.)	P_D	106				Watts
Thermal Resistance	θ_{JC}	0.8				$^{\circ}C/W$

*To avoid excessive heating of collector junction, perform this test with a sweep method.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

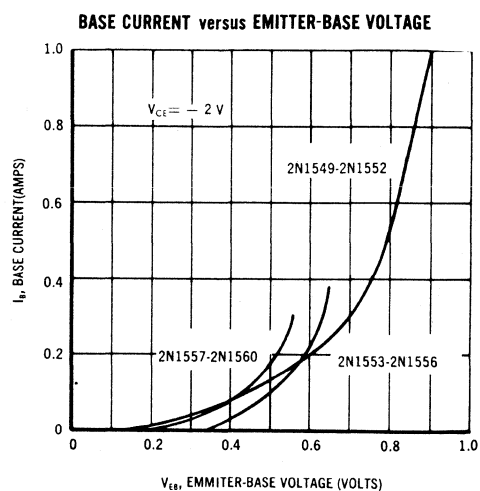
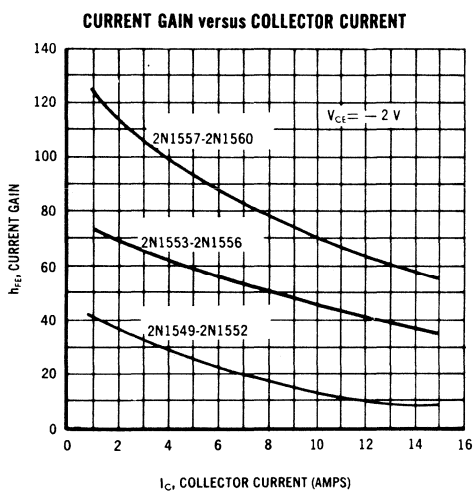
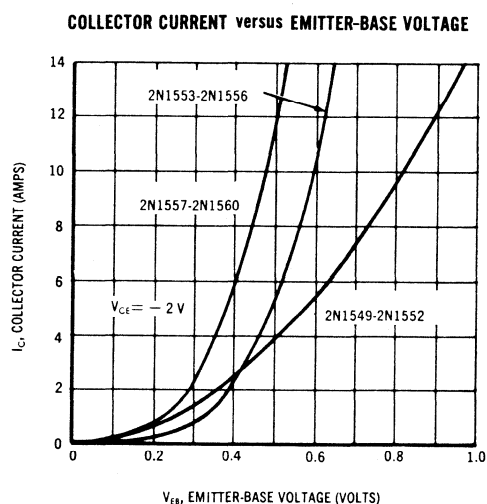
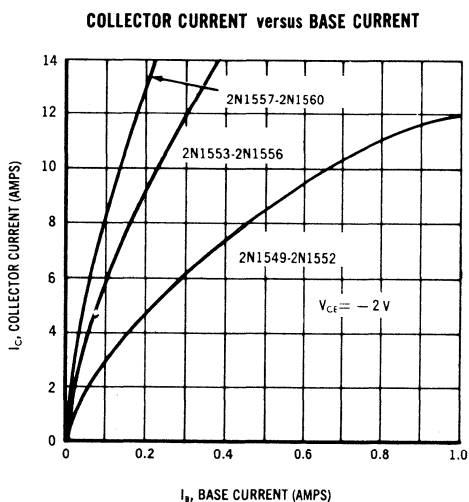
Characteristics apply to corresponding A type numbers also.

Characteristic	Symbol	Min	Max	Unit
Collector-Base Cutoff Current ($V_{CB} = 25\text{ V}$) 2N1549, 2N1553, 2N1557 ($V_{CB} = 40\text{ V}$) 2N1550, 2N1554, 2N1558 ($V_{CB} = 55\text{ V}$) 2N1551, 2N1555, 2N1559 ($V_{CB} = 65\text{ V}$) 2N1552, 2N1556, 2N1560	I_{CBO1}	- - - -	3.0 3.0 3.0 3.0	mA
Collector-Base Cutoff Current ($V_{CB} = 2\text{ V}$) ($V_{CB} = 1/2\text{ BV}_{CES}$ rating; $T_C = +90^\circ\text{C}$)	I_{CBO}	- -	0.2 20	mA
Emitter-Base Cutoff Current ($V_{EB} = 12\text{ V}$)	I_{EBO}	-	0.5	mA
Collector-Emitter Breakdown Voltage ($I_C = 300\text{ mA}$) 2N1549, 2N1553, 2N1557 2N1550, 2N1554, 2N1558 2N1551, 2N1555, 2N1559 2N1552, 2N1556, 2N1560	BV_{CES}	30 45 60 75	- - - -	volts
Collector-Emitter Leakage Current ($V_{BE} = 1.0\text{ V}$, V_{CE} @ rated BV_{CBO})	I_{CEX}	-	20	mA
Collector-Emitter Breakdown Voltage* ($I_C = 300\text{ mA}$, $I_B = 0$) 2N1549, 2N1553, 2N1557 2N1550, 2N1554, 2N1558 2N1551, 2N1555, 2N1559 2N1552, 2N1556, 2N1560	BV_{CEO}^*	20 30 40 50	- - - -	volts
Collector-Base Breakdown Voltage ($I_C = 20\text{ mA}$) 2N1549, 2N1553, 2N1557 2N1550, 2N1554, 2N1558 2N1551, 2N1555, 2N1559 2N1552, 2N1556, 2N1560	BV_{CBO}	40 60 80 100	- - - -	volts
Current Gain ($V_{CE} = 2.0\text{ V}$, $I_C = 10\text{ A}$) 2N1549 - 2N1552 2N1553 - 2N1556 2N1557 - 2N1560	h_{FE1}	10 30 50	30 60 100	
Base-Emitter Drive Voltage ($I_C = 10\text{ A}$, $I_B = 1.0\text{ A}$) 2N1549 - 2N1552 2N1553 - 2N1556 2N1557 - 2N1560	V_{BE}	- - -	1.3 1.0 0.85	volts
Collector Saturation Voltage ($I_C = 10\text{ A}$, $I_B = 1.0\text{ A}$) 2N1549 - 2N1552 2N1553 - 2N1556 2N1557 - 2N1560	$V_{CE(sat)}$	- - -	1.0 0.7 0.5	volts

*To avoid excessive heating of collector junction, perform this test with a sweep method.

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Max	Unit
Transconductance ($V_{CE} = 2.0 \text{ V}$, $I_C = 10 \text{ A}$)	g_{FE}	6.0 8.0 12	18 30 40	mhos
Frequency Cutoff	f_{ac}	Typ 10 6.0 5.0		kHz
2N1549 - 2N1552				
2N1553 - 2N1556				
2N1557 - 2N1560				

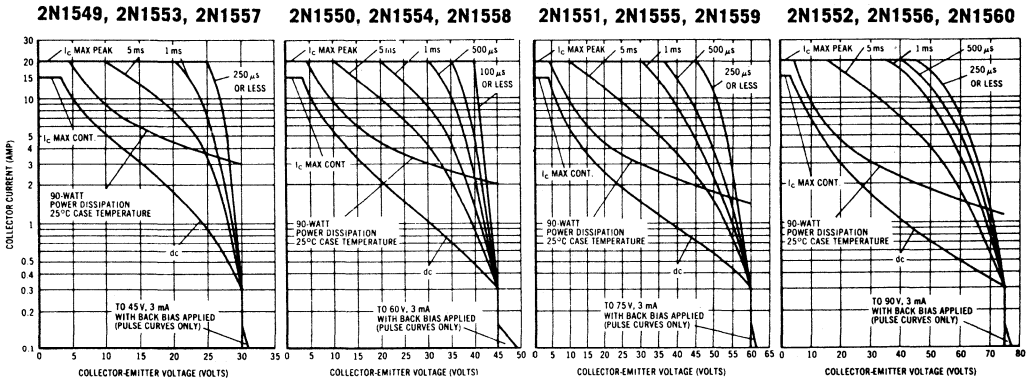


2N1549 thru 2N1560 (continued)

SAFE OPERATING AREAS

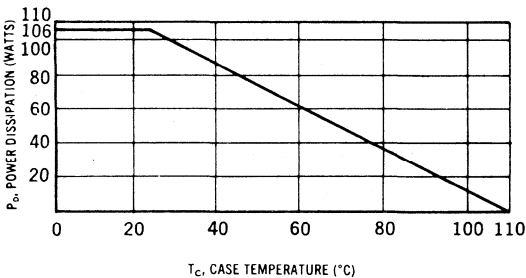
The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short.

(Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J , the power-temperature derating curve must be observed for both steady state and pulse power conditions.



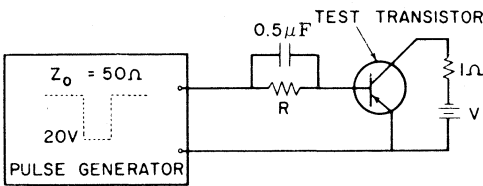
POWER-TEMPERATURE DERATING CURVE

The maximum continuous power is related to maximum junction temperature, by the thermal resistance factor. For dc or frequencies below 25 Hz the transistor must be operated within the constant $P_D = V_c \times I_c$ hyperbolic curve. This curve has a value of 106 watts at case temperatures of 25°C and is 0 watts at 110°C with a linear relation between the two temperatures such that P_D allowable = $110^\circ - T_c$



$$0.8$$

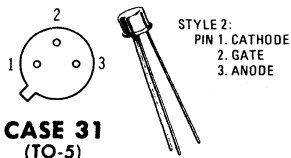
SWITCHING TIME MEASURING UNIT



Devices	Conditions*			Typical Switching Times		
	I_C (Amp)	V (Volts)	R (ohms)	$t_r + t_f$ (µs)	t_r (µs)	t_f (µs)
2N1549 -52	10	10	10	5	2	10
2N1553 -56	10	10	30	10	5	25
2N1557 -60	10	10	50	10	5	25

* Input Pulse Repetition Rate = 2 kHz,
Pulse Width = 50 µs

2N1595 thru 2N1599 (SILICON)

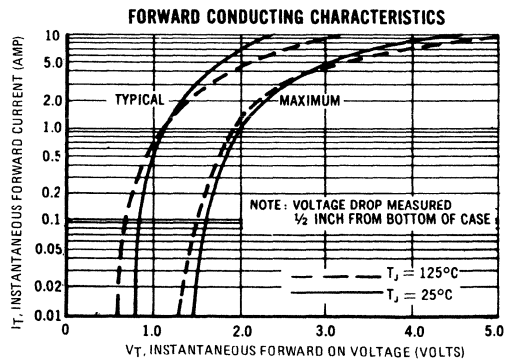
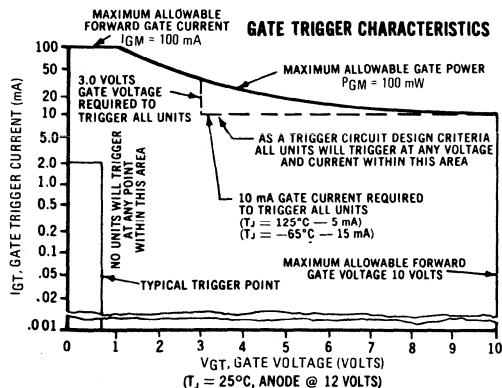


Industrial-type, low-current silicon controlled rectifiers in a three-lead package ideal for printed-circuit applications. Current handling capability of 1.6 amperes at junction temperatures to 125°C.

MAXIMUM RATINGS ($T_J = 125^\circ\text{C}$ unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage*	$V_{RSM(rep)}$ *	50 100 200 300 400	Volts
Forward Current RMS (All Conduction Angles)	$I_T(RMS)$	1.6	Amp
Peak Forward Surge Current (One Cycle, 60 Hz, $T_J = -65$ to $+125^\circ\text{C}$)	I_{TSM}	15	Amp
Peak Gate Power - Forward	P_{GM}	0.1	Watt
Average Gate Power - Forward	$P_{G(AV)}$	0.01	Watt
Peak Gate Current - Forward	I_{GM}	0.1	Amp
Peak Gate Voltage - Forward	V_{GFM}	10	Volts
Reverse	V_{GRM}	10	Volts
Operating Junction Temperature Range	T_J	-65 to +125	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +150	$^\circ\text{C}$

* V_{RSM} for all types can be applied on a continuous dc basis without incurring damage.



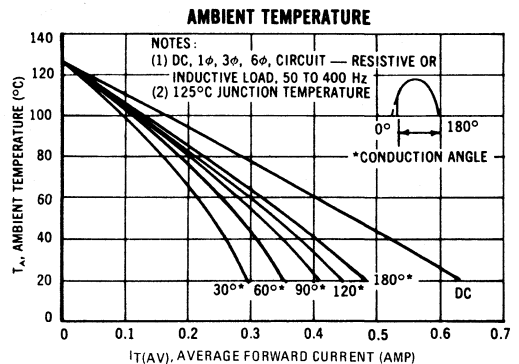
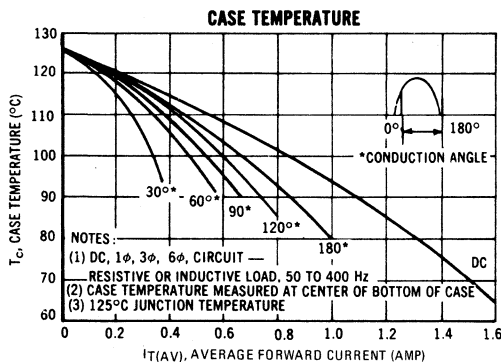
2N1595 thru 2N1599 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage* (T _J = 125°C) 2N1595 2N1596 2N1597 2N1598 2N1599	V _{DRM} *	50 100 200 300 400	— — — — —	— — — — —	Volts
Peak Forward Blocking Current (Rated V _{DRM} with gate open, T _J = 125°C)	I _{DRM}	—	—	1.0	mA
Peak Reverse Blocking Current (Rated V _{RSM} , T _J = 125°C)	I _{RRM}	—	—	1.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, R _L = 12 Ω)	I _{GT}	—	2.0	10.0	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, R _L = 12 Ω) (V _{DRM} = Rated, R _L = 12 Ω, T _J = 125°C)	V _{GT} V _{GNT}	— 0.2	0.7 —	3.0 —	Volts
Holding Current (Anode Voltage = 7 Vdc, Gate Open)	I _H	—	5.0	—	mA
Forward On Voltage (I _T = 1 Adc)	V _{TM}	—	1.1	2.0	Volts
Turn-On Time (t _d + t _r) (I _{GT} = 10 mA, I _T = 1A)	t _{gt}	—	0.8	—	μs
Turn-Off Time (I _T = 1 A, I _R = 1 A, dv/dt = 20 V/μs, T _J = 125°C) (V _{DRM} = rated voltage)	t _q	—	10	—	μs

*V_{DRM} for all types can be applied on a continuous dc basis without incurring damage.

CURRENT DERATING



2N1613S(SILICON)

2N1613SJAN AVAILABLE

NPN SILICON ANNULAR AMPLIFIER TRANSISTOR

... designed for use in general purpose amplifier and switching applications.

- Collector-Emitter Breakdown Voltage —
BV_{CE} = 50 Vdc (Min) @ I_C = 100 mAdc
- DC Current Gain — 100 μAdc to 500 mAdc

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage (R _{BE} ≤ 10 Ohms)	V _{CE}	50	Vdc
Collector-Base Voltage	V _{CB}	75	Vdc
Emitter-Base Voltage	V _{EB}	7.0	Vdc
Collector Current — Continuous	I _C	500	mAdc
Total Power Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.8 4.57	Watt mW/°C
Total Power Dissipation @ T _C = 25°C Derate above 25°C	P _D	3.0 17.15	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200	°C

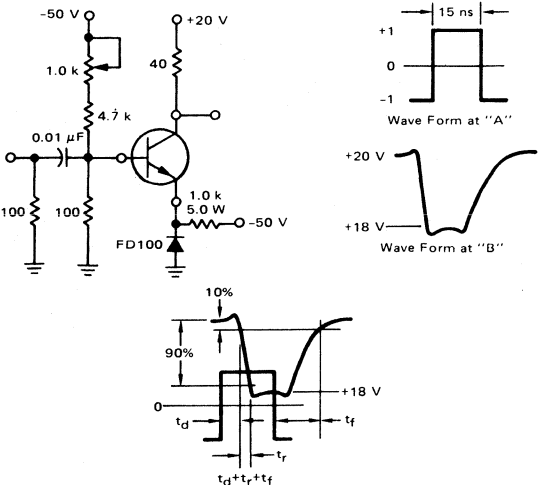
*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	R _{θJA} (1)		°C/W
Thermal Resistance, Junction to Case	R _{θJC}	58.3	°C/W

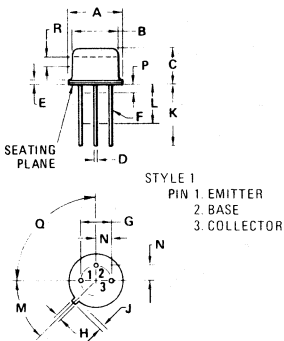
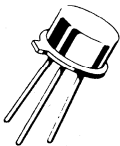
*Indicates JEDEC Registered Data.

(1) R_{θJA} is measured with the device soldered into a typical printed circuit board.

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



NPN SILICON AMPLIFIER TRANSISTOR



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° NOM	—	45° NOM	—
P	—	1.27	—	0.050
Q	90° NOM	—	90° NOM	—
R	2.54	—	0.100	—

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted).

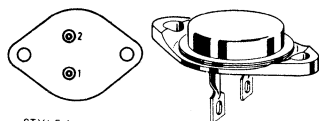
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage ⁽¹⁾ ($I_C = 100\text{ mAdc}$, $R_{BE} \leq 10\text{ Ohms}$)	$BV_{CER(sus)}$	50	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	75	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	7.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 60\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 60\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	— —	10 10	nAdc μAdc
Emitter Cutoff Current ($V_{EB} = 5.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	—	10	nAdc
ON CHARACTERISTICS⁽¹⁾					
DC Current Gain ($I_C = 100\text{ }\mu\text{Adc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $T_A = -55^\circ\text{C}$) ($I_C = 150\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 500\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$)	h_{FE}	20 35 20 40 20	35 50 — 80 30	— — — 120 —	—
Collector-Emitter Saturation Voltage ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$)	$V_{CE(sat)}$	—	0.3	1.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$)	$V_{BE(sat)}$	—	0.78	1.3	Vdc
DYNAMIC CHARACTERISTICS/SMALL-SIGNAL CHARACTERISTICS					
Current-Gain – Bandwidth Product ⁽¹⁾ ($I_C = 50\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 20\text{ MHz}$)	f_T	60	—	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)	C_{ob}	—	10	25	pF
Input Capacitance ($V_{EB} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)	C_{ib}	—	50	80	pF
Input Impedance ($I_C = 1.0\text{ mAdc}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 5.0\text{ mAdc}$, $V_{CB} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ib}	24 4.0	— —	34 8.0	Ohms
Voltage Feedback Ratio ($I_C = 1.0\text{ mAdc}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 5.0\text{ mAdc}$, $V_{CB} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{rb}	— —	— —	3.0 3.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 5.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	30 35	— —	100 150	—
Output Admittance ($I_C = 1.0\text{ mAdc}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 5.0\text{ mAdc}$, $V_{CB} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ob}	0.05 0.1	— —	0.5 1.0	μmhos
Noise Figure ($I_C = 0.3\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $R_S = 510\text{ Ohms}$, $f = 1.0\text{ kHz}$, Bandwidth = 1.0 Hz)	NF	—	—	12	dB
SWITCHING CHARACTERISTICS					
Switching Time (Figure 1)	$t_d + t_r + t_f$	—	—	30	ns

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.

2N1651 thru 2N1653 (Germanium)

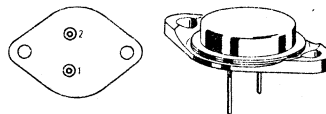
2N2285 thru 2N2287 (Germanium)



STYLE 1:
PIN 1: BASE
2: EMITTER
CASE: COLLECTOR

CASE 161

2N1651 thru 2N1653



STYLE 1:
PIN 1: BASE
2: EMITTER
CASE: COLLECTOR

CASE 3-04

2N2285 thru 2N2287

PNP Germanium power transistors designed for high-current switching applications requiring low saturation voltages and fast switching times in addition to good safe operating area.

MAXIMUM RATINGS

Rating	Symbol	2N1651 2N2285	2N1652 2N2286	2N1653 2N2287	Unit
Collector-Emitter Voltage	V _{CEO}	30	60	80	Vdc
Collector-Base Voltage	V _{CB}	60	100	120	Vdc
Emitter-Base Voltage	V _{EB}	← 1.5 →			Vdc
Collector Current - Continuous	I _C	← 25 →			Adc
Base Current - Continuous	I _B	← 5.0 →			Adc
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	← 106 1.25 →			Watts W/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	← -65 to +110 →			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.8	$^\circ\text{C/W}$

FIGURE 1 – SUSTAINING VOLTAGE TEST CIRCUIT

$R_1 = 1.0 \text{ Ohm, } 20 \text{ Watts}$
 $R_2 = 7.5 \text{ Ohms, } 2.0 \text{ Watts}$
 $R_3 = 0.1 \text{ Ohm, } 1.0 \text{ W}$
 $R_4 = 0.04 \text{ Ohm}$

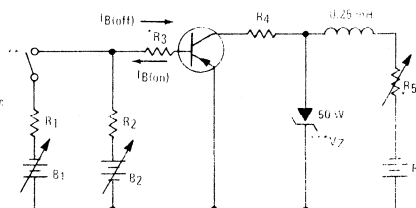
$R_5 = I_C \text{ Adjust @ } V_{CE} = V_Z$
 $B_1 = \text{Adjust for } I_{B(on)} = \frac{I_C}{10}$
 $B_2 = 1.5 \text{ Vdc, Adjust for } I_{B(off)} = 0.2 \text{ Adc}$
 $B_3 = 12 \text{ Vdc}$

*Not required if current probe is used to read I_B

**PRF 50 Hz

***Zener selected to establish Sustaining Voltage

NOTE: Series impedance and inductance must be kept to a minimum.



2N1651 thru 2N1653/2N2285 thru 2N2287 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I _C = 100 mAdc, I _B = 0)	BV _{CEO}	30 60 80	- - -	Vdc
Collector-Emitter Sustaining Voltage (See Figure 1) (I _C = 25 Adc)	V _{CE(sus)}	40 45 50	- - -	Vdc
Collector Cutoff Current (V _{CB} = 2.0 Vdc, I _E = 0)	I _{CBO1}	-	200	μAdc
Collector Cutoff Current (V _{CB} = 40 Vdc, I _E = 0)	I _{CBO2}	-	5.0	mAcd
(V _{CB} = 80 Vdc, I _E = 0)		-	5.0	
(V _{CB} = 100 Vdc, I _E = 0)		-	5.0	
Collector Cutoff Current (V _{CB} = 40 Vdc, I _E = 0, T _C = 100°C) (+0, -3.0°C)	I _{CBO3}	-	35	mAcd
(V _{CB} = 80 Vdc, I _E = 0, T _C = 100°C) (+0, -3.0°C)		-	35	
(V _{CB} = 100 Vdc, I _E = 0, T _C = 100°C) (+0, -3.0°C)		-	35	
Collector Cutoff Current (V _{CB} = 60 Vdc, I _E = 0)	I _{CBO4}	-	20	mAcd
(V _{CB} = 100 Vdc, I _E = 0)		-	20	
(V _{CB} = 120 Vdc, I _E = 0)		-	20	
Emitter Cutoff Current (V _{EB} = 1.5 Vdc, I _C = 0)	I _{EBO}	-	50	mAcd

ON CHARACTERISTICS

DC Current Gain (I _C = 10 Adc, V _{CE} = 2.0 Vdc)	h _{FE}	35	140	-
(I _C = 25 Adc, V _{CE} = 1.5 Vdc)		20	-	
Collector-Emitter Saturation Voltage (I _C = 25 Adc, I _B = 2.5 Adc)	V _{CE(sat)}	-	0.30	Vdc
Base-Emitter Saturation Voltage (I _C = 25 Adc, I _B = 2.5 Adc)	V _{BE(sat)}	-	0.65	Vdc

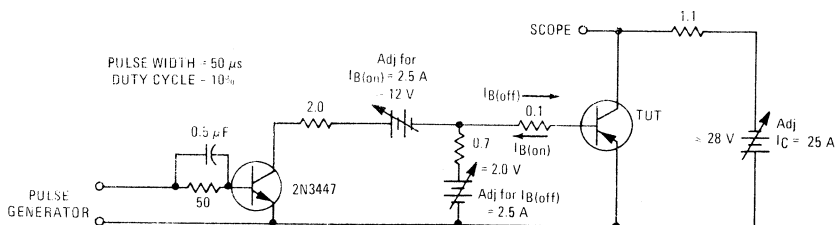
SMALL-SIGNAL CHARACTERISTICS

Small-Signal Current Gain (I _C = 0.5 Adc, V _{CE} = 6.0 Vdc, f = 30 kHz)	h _{ie}	20	-	-
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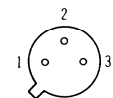
SWITCHING CHARACTERISTICS

Rise Time	(I _C = 25 Adc, I _{B(on)} = 2.5 Adc, I _{B(off)} = 2.5 Adc)	t _r	-	12	μs
Storage Time		t _s	-	10	μs
Fall Time		t _f	-	8.0	μs

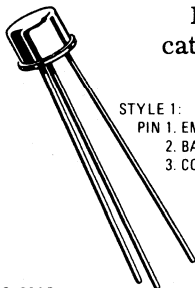
FIGURE 2 – SWITCHING TIME TEST CIRCUIT



2N1705 thru 2N1707 (GERMANIUM)



CASE 31
(TO-5)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

PNP germanium transistors for audio driver applications in transistorized radio receivers.

Base connected to case

MAXIMUM RATINGS

Rating	Symbol	2N1705	2N1706	2N1707	Unit
Collector-Base Voltage	V_{CB}	18	25	30	Vdc
Collector-Emitter Voltage ($R_{BE} = 1\text{ K}$)	V_{CER}	12	18	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	5.0	10	Vdc
Collector Current	I_C	400			mA
Collector Dissipation at $T_C = 25^\circ\text{C}$	P_D	200			mW
Junction Temperature Range	T_J	-65 to +100			$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

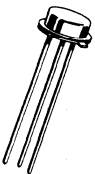
Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current ($V_{CB} = -10\text{ Vdc}$) ($V_{CB} = -25\text{ Vdc}$)	2N1705	I_{CBO}	---	5.0	10	μAdc
	2N1706		---	---	10	
	2N1707		---	---	15	
Emitter-Base Cutoff Current ($V_{EB} = -5\text{ Vdc}$) ($V_{EB} = -10\text{ Vdc}$)	2N1705	I_{EBO}	---	4.0	20	μAdc
	2N1706		---	---	20	
	2N1707		---	---	10	
Collector-Emitter Voltage ($I_C = 1\text{ mAdc}$, $R_{BE} = 1\text{ K}$)	2N1705	V_{CER}	12	---	---	Vdc
	2N1706		18	---	---	
	2N1707		25	---	---	
Base-Emitter Voltage ($I_C = 10\text{ mA}$, $V_{CE} = 5\text{ V}$) ($I_C = 20\text{ mA}$, $V_{CE} = 1\text{ V}$)	2N1706	V_{BE}	0.15	---	0.35	Vdc
	2N1705		0.2	---	0.4	
DC Current Gain ($I_C = 10\text{ mAdc}$, $V_{CE} = -5\text{ V}$) ($I_C = 20\text{ mAdc}$, $V_{CE} = -1\text{ V}$)	2N1707	h_{FE}	40	90	150	---
	2N1706		60	---	120	
Small Signal Current Gain ($I_C = 1\text{ mA}$, $V_{CE} = -6\text{ V}$, $f = 1\text{ kHz}$) ($I_C = 10\text{ mA}$, $V_{CE} = -5\text{ V}$, $f = 1\text{ kHz}$)	2N1705	h_{fe}	70	110	150	---
	2N1706		50	90	150	
	2N1707		30	---	150	
Output Admittance Conductance ($I_C = 1\text{ mA}$, $V_{CB} = -6\text{ V}$, $f = 1\text{ kHz}$) ($I_C = 10\text{ mA}$, $V_{CE} = -5\text{ V}$, $f = 1\text{ kHz}$)	2N1705	h_{ob}	---	0.5	---	μmhos
	2N1706, 2N1707		---	3.0	---	
Input Impedance ($I_C = 1\text{ mA}$, $V_{CE} = -6\text{ V}$, $f = 1\text{ kHz}$) ($I_C = 10\text{ mA}$, $V_{CE} = -5\text{ V}$, $f = 1\text{ kHz}$)	2N1705	h_{ib}	---	30	---	ohms
	2N1706, 2N1707		---	4.0	---	
Voltage Feedback Ratio ($I_C = 1\text{ mA}$, $V_{CB} = -6\text{ V}$, $f = 1\text{ kHz}$) ($I_C = 10\text{ mA}$, $V_C = -5\text{ V}$, $f = 1\text{ kHz}$)	2N1705	h_{rb}	---	3.0	---	$\times 10^{-4}$
	2N1706	h_{re}	---	0.69	---	$\times 10^{-3}$
	2N1707	h_{rb}	---	4.5	---	$\times 10^{-4}$
Frequency Cutoff ($I_C = 1\text{ mA}$, $V_C = -6\text{ V}$)	2N1706, 2N1707 2N1705	f_{ob}	---	3.0	---	MHz
			---	4.0	---	
Output Capacitance ($I_C = 1\text{ mA}$, $V_{CB} = -6\text{ V}$, $f = 1\text{ MHz}$)		C_{ob}	---	20	---	pF
Noise Figure ($I_C = 1\text{ mA}$, $V_{CB} = -6\text{ V}$, $R_s = 1\text{ K}$, $f = 1\text{ kHz}$)	2N1705	NF	---	6.0	---	dB

NPN SILICON SWITCHING TRANSISTOR

... designed for high-speed, low-power saturated switching applications for computers in military and industrial service.

- Turn-On Time — $t_{on} = 40 \text{ ns (Max) @ } I_C = 10 \text{ mAdc}$
- Turn-Off Time — $t_{off} = 75 \text{ ns (Max) @ } I_C = 10 \text{ mAdc}$

NPN SILICON SWITCHING TRANSISTOR



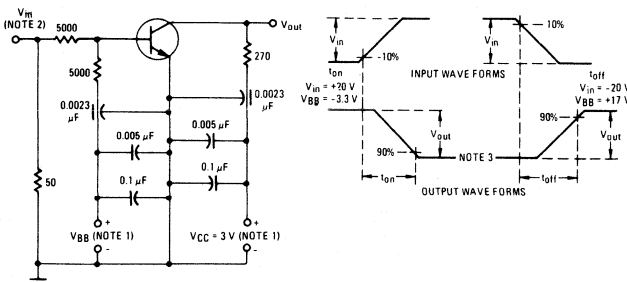
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current	I_C	200	mAdc
**Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.0	mW mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 5.71	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$
Lead Temperature 1/16" $\pm$ 1/32" from case, 10 s	T_L	+235	$^\circ\text{C}$

*Indicates JEDEC Registered Data.

**Motorola Guarantees this data in addition to JEDEC Registered Data

FIGURE 1 — TURN-ON AND TURN-OFF TIME TEST CIRCUIT



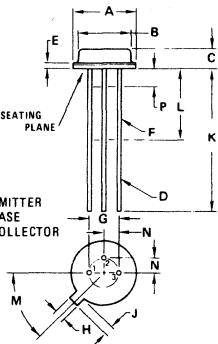
NOTE 1: With certain types of power supplies, it may be necessary to connect 25 μF decoupling capacitors across the power supply terminals for V_{CC} and V_{BB} .

NOTE 2: Input voltage (V_{in}) obtained from a pulse generator having an output impedance of 50 ohms. V_{in} rise time $\leq 1.0 \text{ ns}$, pulse duration $\geq 300 \text{ ns}$, and duty factor $\leq 2.0\%$.

NOTE 3: Input and output waveforms, shown above, monitored by means of an oscilloscope having a rise time $\leq 0.5 \text{ ns}$, input capacitance of probe $\leq 2.5 \text{ pF}$ with shunt resistance $\geq 3000 \text{ ohms}$.

STYLE 1:

- PIN 1. EMITTER
- 2. BASE
- 3. COLLECTOR



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	1.85	2.16	0.065	0.085
D	0.406	0.533	0.016	0.021
E	—	1.02	—	0.040
F	0.305	0.483	0.012	0.019
G	2.94 BSC	—	0.100 BSC	—
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC	—	45° BSC	—
N	1.27 BSC	—	0.050 BSC	—
P	—	1.27	—	0.050

All JEDEC dimensions and notes apply

CASE 26
TO-46

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) ($I_C = 10\text{ mAdc}$, $I_E = 0$)	$V_{CEO(sus)}$	12	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	25	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	3.0	—	Vdc
Collector-Cutoff Current ($V_{CE} = 10\text{ Vdc}$, $V_{BE} = 0.25\text{ Vdc}$, $T_A = 100^\circ\text{C}$)	I_{CEX}	—	15	μAdc
Collector Cutoff Current ($V_{CB} = 15\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 15\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	0.025 15	μAdc

ON CHARACTERISTICS

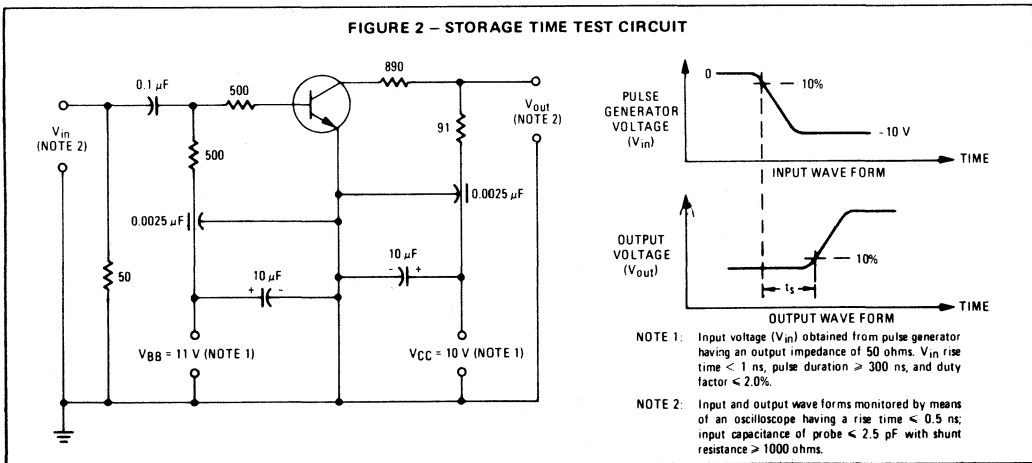
DC Current Gain (1) ($I_C = 10\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$)	h_{FE}	20	—	—
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$) ($I_C = 50\text{ mAdc}$, $I_B = 5.0\text{ mAdc}$)	$V_{CE(sat)}$	— —	0.22 0.35	Vdc
Base-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$)	$V_{BE(sat)}$	0.7	0.9	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	200	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 140\text{ kHz}$)	C_{ob}	—	6.0	pF
Turn-On Time (Figure 1) ($V_{CC} = 3.0\text{ Vdc}$, $I_C = 10\text{ mAdc}$, $I_{B1} = 3.0\text{ mAdc}$, $I_{B2} = 1.0\text{ mAdc}$)	t_{on}	—	40	ns
Turn-Off Time (Figure 1) ($V_{CC} = 3.0\text{ Vdc}$, $I_C = 10\text{ mAdc}$, $I_{B1} = 3.0\text{ mAdc}$, $I_{B2} = 1.0\text{ mAdc}$)	t_{off}	—	75	ns
Storage Time (Figure 2) ($I_C = 10\text{ mAdc}$, $I_{B1} = I_{B2} = 10\text{ mAdc}$)	t_s	—	25	ns

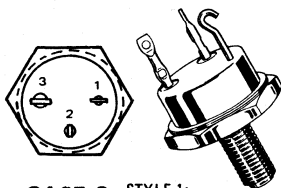
* Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 1.0\%$.



2N1724 (SILICON)

2N1725



CASE 9
(TO-18)

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

NPN silicon power transistors designed for switching and amplifier applications.

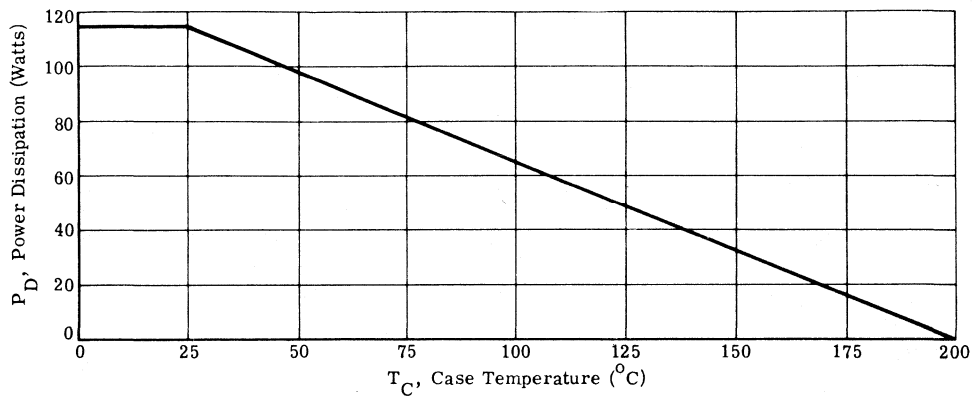
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	120	Vdc
Collector-Emitter Voltage	V_{CE}	80	Vdc
Emitter-Base Voltage	V_{EB}	10	Vdc
Collector Current (Continuous)	I_C	5.0	Adc
Power Dissipation	P_D	117	Watts
Thermal Resistance, Junction to Case	θ_{JC}	1.5	$^{\circ}\text{C}/\text{W}$
Junction Operating Temperature Range	T_J	-65 to +200	$^{\circ}\text{C}$

2N1724, 2N1725 (continued)
ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Emitter-Base Cutoff Current ($V_{EB} = 9 \text{ Vdc}$) ($V_{EB} = 10 \text{ Vdc}$) 2N1725	I_{EBO}	- -	- -	0.5 10.0	mAdc
Collector-Emitter Cutoff Current ($V_{CE} = 60 \text{ Vdc}$, $V_{BE} = 0$) ($V_{CE} = 60 \text{ Vdc}$, $V_{BE} = 0$, $T_C = 150^\circ\text{C}$) ($V_{CE} = 120 \text{ Vdc}$, $V_{BE} = 0$, $T_C = 150^\circ\text{C}$)	I_{CES}	- - -	- - -	1.0 2.0 10.0	mAdc
Collector-Base Cutoff Current ($V_{CB} = 3 \text{ Vdc}$, $I_E = 0$)	I_{CBO}	-	-	0.1	mAdc
Collector-Emitter Sustaining Voltage ($I_C = 200 \text{ mAdc}$, $I_B = 0$)	$V_{CEO(sus)}$	80	-	-	Vdc
DC Current Gain ($V_{CE} = 15 \text{ Vdc}$, $I_C = 2 \text{ Adc}$) ($V_{CE} = 15 \text{ Vdc}$, $I_C = 2 \text{ Adc}$, $T_A = -55^\circ\text{C}$) ($V_{CE} = 15 \text{ Vdc}$, $I_C = 0.1 \text{ Adc}$) 2N1724 2N1725 2N1724 2N1725 2N1724 2N1725	h_{FE}	20 50 12 25 20 50	40 90 - - - -	90 150 - - - -	
Collector-Emitter Saturation Voltage ($I_C = 2 \text{ Adc}$, $I_B = 200 \text{ mAdc}$)	$V_{CE(sat)}$		0.5	1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 2 \text{ Adc}$, $I_B = 200 \text{ mAdc}$)	$V_{BE(sat)}$		1.2	2.0	Vdc
High Frequency Current Gain ($V_{CE} = 15 \text{ Vdc}$, $I_C = 0.5 \text{ Adc}$, $f = 10 \text{ MHz}$)	h_{fe}	1.0	1.6	-	
Common Base Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $f = 0.1 \text{ MHz}$)	C_{ob}		260	550	pF
Switching Times ($I_C = 2 \text{ Adc}$, $I_{B1} = -I_{B2} = 0.2 \text{ Adc}$) Delay time plus Rise time Storage time Fall time	$t_d + t_r$ t_s t_f	- - -	0.15 1.3 0.14	- - -	μs

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



SAFE OPERATING AREAS

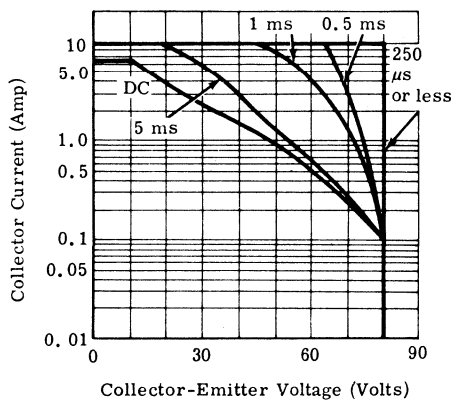
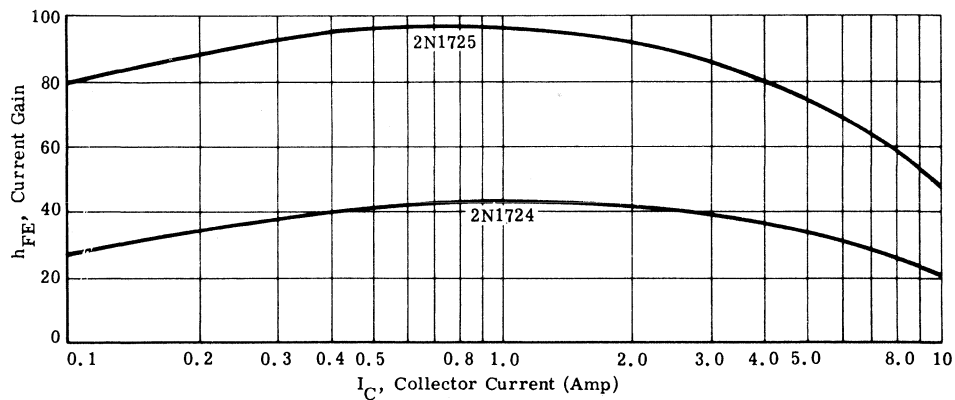


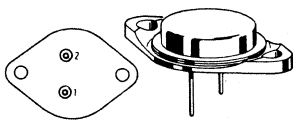
FIGURE 2 — 2N1724, 2N1725

In using these curves the average power derating curve (Fig. 1) must be observed to ensure operation below the maximum junction temperature.

FIGURE 3 — DC CURRENT GAIN versus COLLECTOR CURRENT



2N1751 (GERMANIUM)



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE. COLLECTOR

CASE 3-04
(TO-3 modified)

PNP Germanium power transistor designed for high-current switching applications requiring low saturation voltages, short switching times and good sustaining voltage capability.

- Alloy-Diffused Epitaxial Construction
- Low Saturation Voltages –
 $V_{CE(sat)} = 0.3 \text{ Vdc (Max) @ } I_C = 20 \text{ Adc}$
 $V_{BE(sat)} = 0.7 \text{ Vdc (Max) @ } I_C = 20 \text{ Adc}$

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
*Collector-Base Voltage	V_{CB}	80	Vdc
*Emitter-Base Voltage	V_{EB}	2.5	Vdc
*Collector Current - Continuous	I_C	25	Adc
Base Current - Continuous	I_B	5.0	Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	106 1.25	Watts W/ $^\circ\text{C}$
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Thermal Resistance, Junction to Case	θ_{JC}	0.8	$^\circ\text{C/W}$

* Indicates JEDEC Registered Data.

FIGURE 1 – SUSTAINING VOLTAGE TEST CIRCUIT

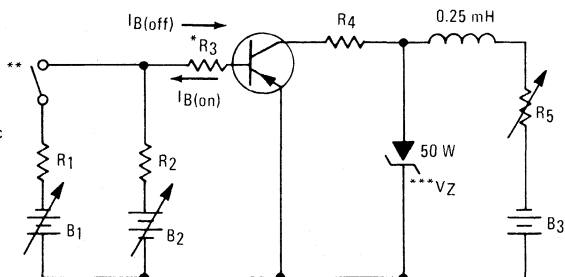
$R_1 = 1.0 \text{ Ohm, 20 Watts}$ $R_5: I_C \text{ Adjust @ } V_{CE} = V_Z$
 $R_2 = 10.0 \text{ Ohms, 2.0 Watts}$ $B_1: \text{ Adjust for } I_{B(on)} = \frac{I_C}{10}$
 $R_3 = 0.1 \text{ Ohm, 1.0\%}$ $B_2 = 2.0 \text{ Vdc, Adjust for } I_{B(off)} = 0.2 \text{ Adc}$
 $R_4 \leq 0.04 \text{ Ohm}$ $B_3 = 12 \text{ Vdc}$

*Not required if current probe is used to read I_B

**PRF $\approx 60 \text{ Hz}$

***Zener selected to establish Sustaining Voltage.

NOTE: Series impedance and inductance must be kept to a minimum.
Adjust input pulse width for $I_C = 25 \text{ A}$ condition.



2N1751 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I _C = 100 mA, I _B = 0)	BV _{CEO}	60	-	Vdc
Collector-Emitter Sustaining Voltage (See Figure 1) (I _C = 25 A)	V _{CE(sus)}	45	-	Vdc
* Floating Potential (V _{CB} = 80 Vdc, I _E = 0)	V _{EBF}	-	1.0	Vdc
Collector-Emitter Cutoff Current (V _{CE} = 80 Vdc, R _{BE} = 50 Ohms)	I _{CER}	-	50	mA
Collector Cutoff Current (V _{CE} = 80 Vdc, V _{BE} = 0)	I _{CES}	-	5.0	mA
Collector Cutoff Current (V _{CB} = 2.0 Vdc, I _E = 0)	I _{CBO1}	-	200	μA
Collector Cutoff Current *(V _{CB} = 80 Vdc, I _E = 0) (V _{CB} = 80 Vdc, I _E = 0, T _C = 100°C, +0, -3°C)	I _{CBO2}	-	5.0 25	mA
* Emitter Cutoff Current (V _{EB} = 2.5 Vdc, I _C = 0)	I _{EBO}	-	50	mA

ON CHARACTERISTICS

* DC Current Gain (I _C = 20 A, V _{CE} = 1.5 Vdc)	h _{FE}	30	90	-
Collector-Emitter Saturation Voltage (I _C = 20 A, I _B = 2.5 A)	V _{CE(sat)}	-	0.3	Vdc
Base-Emitter Saturation Voltage (I _C = 20 A, I _B = 2.5 A)	V _{BE(sat)}	-	0.7	Vdc

SMALL-SIGNAL CHARACTERISTICS

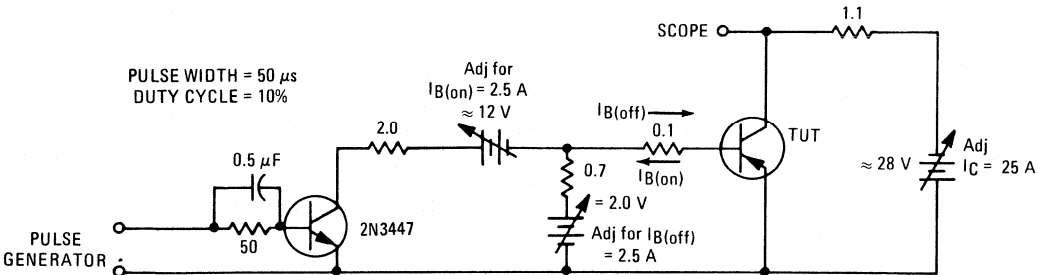
* Common-Base Cutoff Frequency (I _C = 0.5 A, V _{CB} = 10 Vdc)	f _{αb}	1.5	-	MHz
* Small-Signal Current Gain (I _C = 0.5 A, V _{CE} = 6.0 Vdc, f = 30 kHz)	h _{fe}	20	-	-

SWITCHING CHARACTERISTICS

Rise Time	(I _C = 25 A, I _{B(on)} = 2.5 A, I _{B(off)} = 2.5 A) (See Figure 2)	t _r	-	12	μs
Storage Time		t _s	-	10	μs
Fall Time		t _f	-	8.0	μs

*Indicates JEDEC Registered Data.

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



2N1842 thru 2N1850 (SILICON)



CASE 263

STYLE 1:
PIN 1. CATHODE
2. GATE
3. ANODE

Industrial-type, silicon controlled rectifiers in a stud package with current handling capability to 16 amperes at junction temperatures to 100°C. MCR equivalents available in TO-48 package — i.e. — 2N1842 available in TO-48 package as MCR1842.

MAXIMUM RATINGS ($T_J = 100^\circ\text{C}$ unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage*	$V_{RSM(rep)}^*$		Volts
2N1842		25	
2N1843		50	
2N1844		100	
2N1845		150	
2N1846		200	
2N1847		250	
2N1848		300	
2N1849		400	
2N1850		500	
Peak Reverse Blocking Voltage (Transient) (Non-Recurrent 5 ms max.)	$V_{RSM(non-rep)}$		Volts
2N1842		35	
2N1843		75	
2N1844		150	
2N1845		225	
2N1846		300	
2N1847		350	
2N1848		400	
2N1849		500	
2N1850		600	
Forward Current RMS (All Conduction Angles)	$I_T(RMS)$	16	Amp
Circuit Fusing Considerations ($T_J = -40$ to $+100^\circ\text{C}$, $t \leq 8.3$ ms)	I^2t	60	A^2s
Peak Forward Surge Current (One Cycle, 60 Hz, $T_J = -40$ to $+100^\circ\text{C}$)	I_{TSM}	125	Amp
Peak Gate Power	P_{GM}	5.0	Watts
Average Gate Power	$P_{G(AV)}$	0.5	Watt
Peak Gate Current	I_{GM}	2.0	Amp
Peak Gate Voltage - Forward	V_{GFM}	10	Volts
Reverse	V_{GRM}	5.0	
Operating Junction Temperature Range	T_J	-40 to +100	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-40 to +125	$^\circ\text{C}$
Stud Torque	—	30	in. lb.

* $V_{RSM(rep)}$ for all types can be applied on a continuous dc basis without incurring damage.

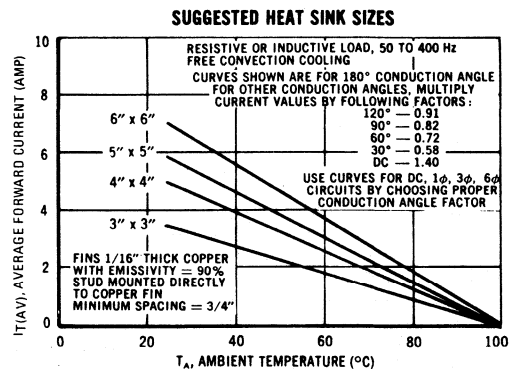
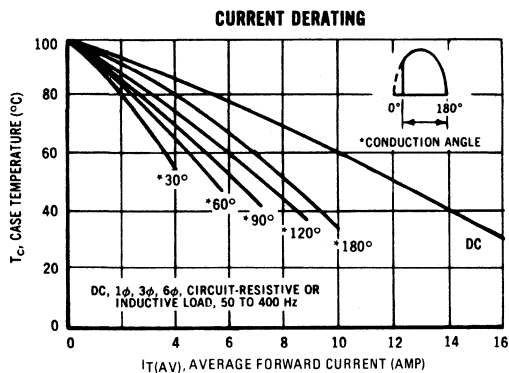
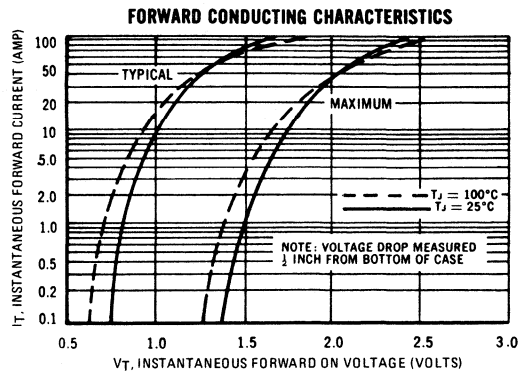
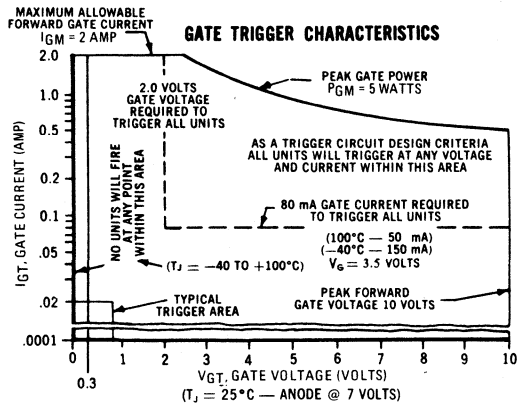
Ratings apply for zero or negative gate voltage.

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage* ($T_J = 100^\circ\text{C}$)	V_{DRM}^*	25 50 100 150 200 250 300 400 500	— — — — — — — — —	— — — — — — — — —	Volts
Peak Forward or Reverse Blocking Current (Rated V_{FOM} or V_{ROM} gate open, $T_J = 100^\circ\text{C}$)	I_{DRM} I_{RRM}	—	—	6.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, $R_L = 50\ \Omega$)	I_{GT}	—	15	80	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, $R_L = 50\ \Omega$) ($V_{\text{DRM}} = \text{Rated V}$, $R_L = 50\ \Omega$, $T_J = 100^\circ\text{C}$)	V_{GT} V_{GNT}	— 0.3	0.8 —	2.0 —	Volts
Holding Current (Anode Voltage = 7 Vdc, Gate Open)	I_{H}	—	20	—	mA
Forward On Voltage ($I_{\text{F}} = 16\ \text{Adc}$)	V_{TM}	—	1.1	1.8	Volts
Turn-On Time ($t_d + t_r$) ($I_{\text{G}} = 50\ \text{mA}$, $I_{\text{F}} = 10\ \text{A}$)	t_{gt}	—	1.0	—	μs
Turn-Off Time ($I_{\text{F}} = 10\ \text{A}$, $I_{\text{R}} = 10\ \text{A}$; $dv/dt = 20\ \text{V}/\mu\text{s}$, $T_J = 100^\circ\text{C}$) ($V_{\text{DRM}} = \text{rated voltage}$)	t_q	—	25	—	μs
Forward Voltage Application Rate (Gate open, $T_J = 100^\circ\text{C}$)	dv/dt	—	30	—	$\text{V}/\mu\text{s}$
Thermal Resistance (Junction to Case)	θ_{JC}	—	1.0	2.0	$^\circ\text{C}/\text{W}$

* V_{DRM} for all types can be applied on a continuous dc basis without incurring damage.

Ratings apply for zero or negative voltage.



2N1842A thru 2N1850A (SILICON)



CASE 263



STYLE 1:
PIN 1. CATHODE
2. GATE
3. ANODE

Industrial-type, silicon controlled rectifiers in a stud package with current handling capability to 16 amperes at junction temperatures to 125°C.

MAXIMUM RATINGS ($T_J = 125^\circ\text{C}$ unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage* 2N1842A 2N1843A 2N1844A 2N1845A 2N1846A 2N1847A 2N1848A 2N1849A 2N1850A	$V_{RSM(rep)}$ *	25 50 100 150 200 250 300 400 500	Volts
Peak Reverse Blocking Voltage (Transient) (Non-Recurrent 5 ms max.) 2N1842A 2N1843A 2N1844A 2N1845A 2N1846A 2N1847A 2N1848A 2N1849A 2N1850A	$V_{RSM(non-rep)}$	35 75 150 225 300 350 400 500 600	Volts
Forward Current RMS	$I_T(RMS)$	16	Amp
Peak Forward Surge Current (One Cycle, 60 Hz, $T_J = -65$ to $+125^\circ\text{C}$)	I_{TSM}	125	Amp
Circuit Fusing Considerations ($T_J = -65$ to $+125^\circ\text{C}$, $t \leq 8.3$ ms)	I^2t	60	A^2s
Peak Gate Power - Forward	P_{GM}	5.0	Watts
Average Gate Power - Forward	$P_{G(AV)}$	0.5	Watt
Peak Gate Current - Forward	I_{GM}	2.0	Amp
Peak Gate Voltage - Forward Reverse	V_{GFM} V_{GRM}	10 5.0	Volts
Operating Junction Temperature Range	T_J	-65 to $+125$	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to $+150$	$^\circ\text{C}$
Stud Torque	—	30	in. lb.

* $V_{RSM(rep)}$ for all types can be applied on a continuous dc basis without incurring damage.

Ratings apply for zero or negative gate voltage.

2N1842 A thru 2N1850A (continued)

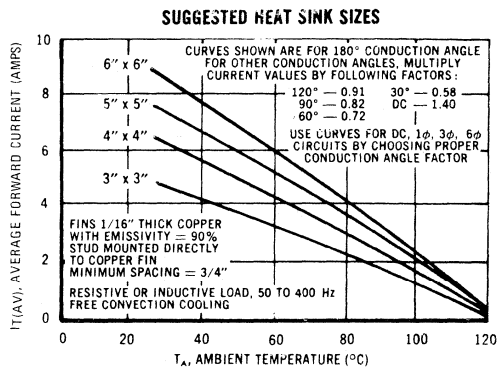
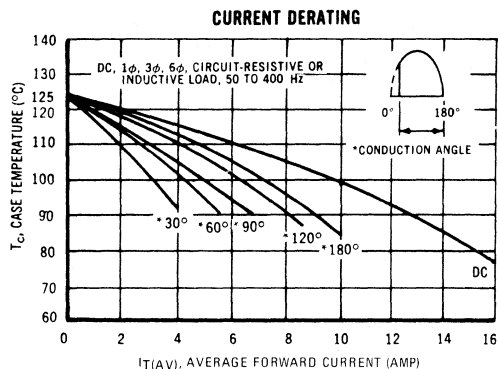
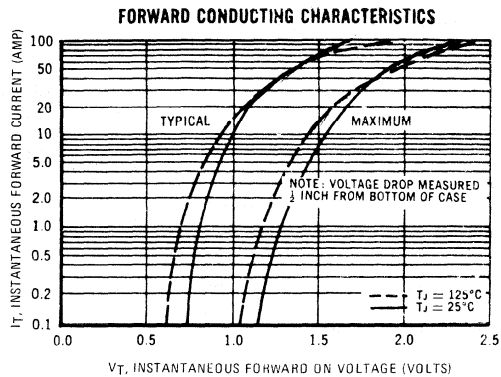
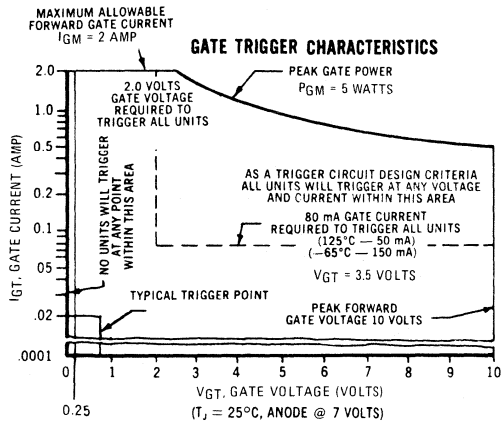
ELECTRICAL CHARACTERISTICS ($T_c = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage* ($T_J = 125^\circ\text{C}$)	V_{DRM}^*	25 50 100 150 200 250 300 400 500	— — — — — — — — —	— — — — — — — — —	Volts
Peak Forward or Reverse Blocking Current (V_{DRM} , OR V_{RSM} , gate open, $T_J = 125^\circ\text{C}$)	I_{DRM} I_{RRM}	—	—	6.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, $R_L = 50\ \Omega$)	I_{GT}	—	15	80	mA
Gate Trigger Voltage (Anode Voltage = 7 Vdc, $R_L = 50\ \Omega$) ($V_{\text{DRM}} = \text{Rated } V$, $R_L = 50\ \Omega$, $T_J = 125^\circ\text{C}$)	V_{GT} V_{GNT}	— 0.25	0.8 —	2.0 —	Volts
Holding Current (Anode Voltage = 7 Vdc, Gate Open)	I_H	—	20	—	mA
Forward On Voltage ($I_T = 16\ \text{Adc}$)	V_T	—	1.1	1.6	Volts
Turn-On Time ($t_d + t_r$) ($I_{\text{GT}} = 50\ \text{mA}$, $I_T = 10\ \text{A}$)	t_{gt}	—	1.0	—	μs
Turn-Off Time ($I_T = 10\ \text{A}$, $I_R = 10\ \text{A}$, $dv/dt = 20\ \text{V}/\mu\text{s}$, $T_J = 125^\circ\text{C}$)	t_q	—	30	—	μs
Forward Voltage Application Rate (Gate Open, $T_J = 125^\circ\text{C}$)	dv/dt	—	30	—	$\text{V}/\mu\text{s}$
Thermal Resistance (Junction to Case)	θ_{JC}	—	1.0	2.0	$^\circ\text{C}/\text{W}$

* V_{DRM} for all types can be applied on a continuous dc basis without incurring damage.

Ratings apply for zero or negative gate voltage.

2N1842A thru 2N1850A (continued)



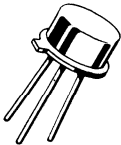
2N 1890S (SILICON)

NPN SILICON ANNULAR AMPLIFIER TRANSISTOR

... designed for use in medium-current, general-purpose amplifier applications.

- Collector-Emitter Sustaining Voltage —
 $V_{CEO(sus)} = 60 \text{ Vdc (Min) @ } I_C = 30 \text{ mAdc}$

NPN SILICON AMPLIFIER TRANSISTOR



*MAXIMUM RATINGS

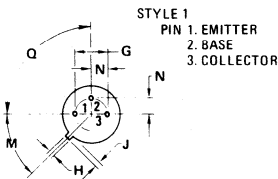
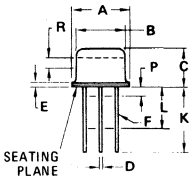
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Emitter Voltage $R_{BE} \leq 10 \text{ Ohms}$	V_{CER}	80	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	800	mW
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	3.0 17.2	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}^{(1)}$	219	$^\circ\text{C/W}$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	58.3	$^\circ\text{C/W}$
Lead Temperature 1/16" from Case for 10 Seconds	T_L	80	Vdc

*Indicates JEDEC Registered Data.

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° NOM	—	45° NOM	—
P	—	1.27	—	0.050
Q	90° NOM	—	90° NOM	—
R	2.54	—	0.100	—

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

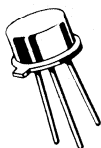
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage ⁽¹⁾ ($I_C = 100\text{ mA}$, $I_B = 0$, $R_{BE} = 10\text{ Ohms}$)	$BV_{CER(sus)}$	80	—	—	Vdc
Collector-Emitter Sustaining Voltage ⁽¹⁾ ($I_C = 30\text{ mA}$, $I_B = 0$)	$BV_{CEO(sus)}$	60	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\text{ }\mu\text{A}$, $I_E = 0$)	BV_{CBO}	100	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\text{ }\mu\text{A}$, $I_C = 0$)	BV_{EBO}	7.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 75\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 75\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	— —	10 15	nAdc μAdc
Emitter Cutoff Current ($V_{EB} = 5.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	—	10	nAdc
ON CHARACTERISTICS⁽¹⁾					
DC Current Gain ($I_C = 150\text{ mA}$, $V_{CE} = 10\text{ Vdc}$)	h_{FE}	100	180	300	—
Collector-Emitter Saturation ($I_C = 50\text{ mA}$, $I_B = 5.0\text{ mA}$) ($I_C = 150\text{ mA}$, $I_B = 15\text{ mA}$)	$V_{CE(sat)}$	— —	0.4 0.8	1.2 5.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 50\text{ mA}$, $I_B = 5.0\text{ mA}$) ($I_C = 150\text{ mA}$, $I_B = 15\text{ mA}$)	$V_{BE(sat)}$	— —	0.78 0.9	0.9 1.3	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product ($I_C = 50\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 20\text{ MHz}$)	f_T	60	—	—	—
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)	C_{ob}	—	10	15	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)	C_{ib}	—	55	85	pF
Input Impedance ($I_C = 1.0\text{ mA}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 5.0\text{ mA}$, $V_{CB} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ib}	20 4.0	— —	30 8.0	Ohms
Voltage Feedback Ratio ($I_C = 1.0\text{ mA}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 5.0\text{ mA}$, $V_{CB} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{rb}	— —	— —	1.5 1.5	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0\text{ mA}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 5.0\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	50 70	— —	200 300	—
Output Admittance ($I_C = 1.0\text{ mA}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 5.0\text{ mA}$, $V_{CB} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ob}	— —	— —	0.3 0.3	μmhos

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.

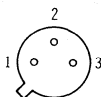
2N1893S (SILICON) 2N2405S

NPN silicon annular transistors designed for medium-power amplifier and switching applications.



**CASE 79
(TO-39)**

Collector connected
to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

* MAXIMUM RATINGS

Rating	Symbol	2N1893	2N2405	Unit
Collector-Emitter Voltage	V_{CEO}	80	90	Vdc
Collector-Emitter Voltage	V_{CER}	100	140	Vdc
Collector-Base Voltage	V_{CB}	120		Vdc
Emitter-Base Voltage	V_{EB}	7.0		Vdc
Collector Current	I_C	0.5	1.0	Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$	P_D	0.8	1.0	Watt
Derate above 25°C		4.57	5.72	mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$	P_D	3.0	5.0	Watts
Derate above 25°C		17.2	28.6	mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N1893	2N2405	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	219	175	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	58.3	35	$^\circ\text{C}/\text{W}$

* ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) ($I_C = 30 \text{ mA dc}, I_B = 0$) 2N1893 2N2405 2N2405	$BV_{CEO(sus)}$	80 90 90	- - -	Vdc
Collector-Emitter Sustaining Voltage ($I_C = 100 \text{ mA dc}, R_{BE} = 10 \text{ ohms}$) 2N1893 2N2405	$BV_{CER(sus)}$	100 140	- -	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{A dc}, I_E = 0$)	BV_{CBO}	120	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{A dc}, I_C = 0$)	BV_{EBO}	7.0	-	Vdc
Collector Cutoff Current ($V_{CB} = 90 \text{ Vdc}, I_E = 0$) ($V_{CB} = 90 \text{ Vdc}, I_E = 0, T_A = 150^\circ\text{C}$) 2N1893 2N2405	I_{CBO}	- - -	0.01 15 10	$\mu\text{A dc}$
Emitter Cutoff Current ($V_{BE} = 5.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	-	0.01	$\mu\text{A dc}$

* Indicates JEDEC Registered Data

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Max	Unit
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ON CHARACTERISTICS

DC Current Gain(1) ($I_C = 0.1 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $T_A = -55^\circ\text{C}$) ($I_C = 150 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$)	2N1893 Both Types 2N1893 2N1893 2N2405	h_{FE}	20 35 20 40 60	- - - 120 200	-
Collector-Emitter Saturation Voltage ($I_C = 50 \text{ mAdc}$, $I_B = 5.0 \text{ mAdc}$) ($I_C = 150 \text{ mAdc}$, $I_B = 15 \text{ mAdc}$)	2N1893 2N1893 2N2405	$V_{CE(sat)}$	- - -	1.2 5.0 0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 50 \text{ mAdc}$, $I_B = 5.0 \text{ mAdc}$) ($I_C = 150 \text{ mAdc}$, $I_B = 15 \text{ mAdc}$)	2N1893 2N1893 2N2405	$V_{BE(sat)}$	- - -	0.9 1.3 1.1	Vdc

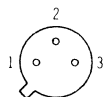
SMALL-SIGNAL CHARACTERISTICS

Current-Gain—Bandwidth Product ($I_C = 50 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 20 \text{ MHz}$)	2N1893	f_T	50	-	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $100 \text{ kHz} \leq f \leq 1.0 \text{ MHz}$)		C_{ob}	-	15	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}$, $I_C = 0$, $100 \text{ kHz} \leq f \leq 1.0 \text{ MHz}$)	2N1893 2N2405	C_{ib}	- -	85 80	pF
Input Impedance ($I_C = 1.0 \text{ mAdc}$, $V_{CB} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mAdc}$, $V_{CB} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	2N1893 2N1893, 2N2405	h_{ib}	20 4.0	30 8.0	ohms
Voltage Feedback Ratio ($I_C = 1.0 \text{ mAdc}$, $V_{CB} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mAdc}$, $V_{CB} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	2N1893 2N1893 2N2405	h_{rb}	- - -	1.25 1.5 3.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	2N1893 2N2405 2N1893	h_{fe}	30 50 45	100 275 -	-
Output Admittance ($I_C = 1.0 \text{ mAdc}$, $V_{CB} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mAdc}$, $V_{CB} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	2N1893 2N1893, 2N2405	h_{ob}	- -	0.5 0.5	μmho

* Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

2N1924 thru 2N1926 (GERMANIUM)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 31
(TO-5)

Base connected to case



PNP germanium transistors for general purpose, low-frequency applications. Characteristics curves similar to 2N524-2N527 series.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	60	Vdc
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EB}	25	Vdc
Collector Current	I_C	500	mAdc
Junction and Storage Temperature	T_J & T_{stg}	-65 to +100	°C
Power Dissipation at 25°C Ambient	P_D	225	mW

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

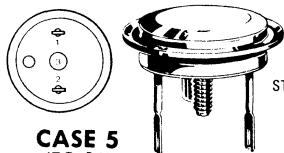
Characteristics	Symbol	Min	Max	Unit
Collector Cutoff Current $V_{CB} = -45 \text{ Vdc}, I_E = 0$	I_{CBO}	—	10	μAdc
Emitter Cutoff Current $V_{EB} = -25 \text{ Vdc}, I_C = 0$	I_{EBO}	—	10	μAdc
Collector-Base Voltage $I_C = 200 \mu\text{Adc}, I_E = 0$	V_{CBO}	60	—	Vdc
Collector-Emitter Voltage $I_C = 50 \mu\text{Adc}, V_{BE} = +1.5 \text{ Vdc}, R_{BE} = 10 \text{ K}$	V_{CEX}	50	—	Vdc
Collector-Emitter Voltage $I_C = 0.6 \text{ mAdc}, R_{BE} = 10 \text{ K}$	V_{CER}	40	—	Vdc
Punch-Thru Voltage ($V_{EB} = 1 \text{ Vdc}, V_{TVM} Z \geq 1 \text{ Megohm}$)	V_{pt}	50	—	Vdc

ELECTRICAL CHARACTERISTICS (continued)

Characteristics	Symbol	Min	Max	Unit
DC Current Gain $I_C = 20 \text{ mAdc}, V_{CE} = -1 \text{ Vdc}$ 2N1924 2N1925 2N1926	h_{FE}	34 53 72	65 90 121	—
DC Current Gain $I_C = 100 \text{ mAdc}, V_{CE} = -1 \text{ Vdc}$ 2N1924 2N1925 2N1926	h_{FE}	30 47 65	— — —	—
Collector-Emitter Saturation Voltage $I_B = 1.33 \text{ mAdc}, I_C = 20 \text{ mAdc}$ 2N1924 $I_B = 1.0 \text{ mAdc}, I_C = 20 \text{ mAdc}$ 2N1925 $I_B = 0.67 \text{ mAdc}, I_C = 20 \text{ mAdc}$ 2N1926	$V_{CE(SAT)}$	50 55 60	110 110 110	mVdc
Base Input Voltage $V_{CE} = -1 \text{ Vdc}, I_C = 20 \text{ mAdc}$ 2N1924 2N1925 2N1926	V_{BE}	200 190 180	300 290 280	mVdc
Output Capacitance; Input AC Open Circuit $V_{CB} = -5 \text{ Vdc}, I_E = 1 \text{ mAdc}, f = 1 \text{ MHz}$	C_{ob}	—	30	pF
Frequency Cutoff $V_{CB} = -5 \text{ Vdc}, I_E = 1 \text{ mAdc}$ 2N1924 2N1925 2N1926	f_{ob}	1.0 1.3 1.5	— — —	MHz
Small-Signal Short-Circuit Forward-Transfer Current Ratio $V_{CE} = -5 \text{ Vdc}, I_E = 1 \text{ mAdc}, f = 1 \text{ kHz}$ 2N1924 2N1925 2N1926	h_{fe}	30 44 60	64 88 120	—
Small-Signal Open Circuit Output Admittance $V_{CE} = -5 \text{ Vdc}, I_E = 1 \text{ mAdc}, f = 1 \text{ kHz}$ 2N1924 2N1925 2N1926	h_{oe}	15 20 25	60 65 70	μmho
Small-Signal Open-Circuit Reverse-Transfer Voltage Ratio $V_{CE} = -5 \text{ Vdc}, I_E = 1 \text{ mAdc}, f = 1 \text{ kHz}$ 2N1924 2N1925 2N1926	h_{re}	2.0 3.0 4.0	8.0 9.0 10	$\times 10^{-4}$
Small-Signal Short-Circuit Input Impedance $V_{CE} = -5 \text{ Vdc}, I_E = 1 \text{ mAdc}, f = 1 \text{ kHz}$ 2N1924 2N1925 2N1926	h_{ie}	700 1200 1500	2200 3200 4200	ohms

2N1970 (GERMANIUM)

2N1980 thru 2N1982



CASE 5
(TO-36)

Collector connected to case

STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

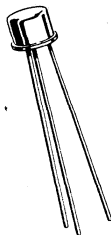
PNP germanium power transistors for general purpose amplifier and switching applications.

MAXIMUM RATINGS

Rating	Symbol	2N1970	2N1980	2N1981	2N1982	Unit
Collector-Base Voltage	V_{CB}	100	50	70	90	Volts
Collector-Emitter Voltage	V_{CEO}	50	30	40	50	Volts
Emitter-Base Voltage	V_{EB}	40	20	20	20	Volts
Collector Current	I_C	15				Amp
Power Dissipation at $T_C = 25^\circ\text{C}$	P_D	170				Watts
Junction Temperature Range	T_J	-65 to +110				$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Cutoff Current ($V_{CB} = -100 \text{ Vdc}$) ($V_{CB} = -50 \text{ Vdc}$) ($V_{CB} = -70 \text{ Vdc}$) ($V_{CB} = -90 \text{ Vdc}$) ($V_{CB} = -2 \text{ Vdc}$)	I_{CBO} 2N1970 2N1980 2N1981 2N1982 2N1980-2N1982	— — — — —	4.0 6.0 6.0 6.0 0.3	mAdc
Emitter-Base Cutoff Current ($V_{EB} = -40 \text{ Vdc}$) ($V_{EB} = -20 \text{ Vdc}$) ($V_{EB} = -2 \text{ Vdc}$)	I_{EBO} 2N1970 2N1980-2N1982 2N1980-2N1982	— — —	4.0 5.0 0.3	mAdc
Collector-Emitter Breakdown Voltage ($I_C = 1 \text{ Adc}$, $I_B = 0$)	BV_{CEO} 2N1970 2N1980 2N1981 2N1982	50 30 40 50	— — — —	Vdc
Base-Emitter Voltage ($V_{CE} = -2 \text{ Vdc}$, $I_C = 5 \text{ Adc}$)	V_{BE} 2N1970	—	0.9	Vdc
Emitter Floating Potential ($V_{CB} = -50 \text{ Vdc}$) ($V_{CB} = -70 \text{ Vdc}$) ($V_{CB} = -90 \text{ Vdc}$)	V_{EBF} 2N1980 2N1981 2N1982	— — —	1.0 1.0 1.0	Vdc
Collector-Emitter Saturation Voltage ($I_C = 12 \text{ Adc}$, $I_B = 2 \text{ Adc}$) ($I_C = 5 \text{ Adc}$, $I_B = 0.5 \text{ Adc}$)	$V_{CE(sat)}$ 2N1970 2N1980-2N1982	— —	1.0 0.5	Vdc
DC Current Gain ($I_C = 5 \text{ Adc}$, $V_{CE} = -2 \text{ Vdc}$) ($I_C = 12 \text{ Adc}$, $V_{CE} = -2 \text{ Vdc}$)	h_{FE} 2N1970 2N1980-2N1982 2N1970	17 50 10	40 100 —	—
Common Emitter Cutoff Frequency ($V_{CE} = -4 \text{ V}$, $I_C = 5 \text{ A}$) ($V_{CE} = -5 \text{ V}$, $I_C = 2 \text{ A}$)	$f_{\alpha e}$ 2N1970 2N1980-2N1982	5.0 3.0	— —	kHz

2N1983 (SILICON)**2N1984**

NPN silicon annular small-signal transistor.

CASE 31
(TO-5)

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	50	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	1.0	Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.6 4.8	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	2.0 16	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	62.5	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	θ_{JA}	208	$^\circ\text{C/W}$

2N1983, 2N1984 (continued)

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage ⁽¹⁾ ($I_C = 100 \text{ mAdc}$, $I_B = 0$)	$BV_{CEO(sus)}$	25	-	Vdc
Collector-Emitter Sustaining Voltage ⁽¹⁾ ($I_C = 100 \text{ mAdc}$, $R_{BE} \leq 10 \text{ ohms}$)	$BV_{CER(sus)}$	30	-	Vdc
Collector Cutoff Current ($V_{CB} = 30 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 30 \text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	- -	5.0 200	μAdc
Emitter-Cutoff Current ($V_{EB(off)} = 2.0 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	-	100	μAdc

ON CHARACTERISTICS

Collector-Emitter Saturation Voltage ($I_C = 5.0 \text{ mAdc}$, $I_B = 0.5 \text{ mAdc}$)	$V_{CE(sat)}$	-	0.25	Vdc
Base-Emitter On Voltage ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)	$V_{BE(on)}$	-	0.85	Vdc

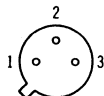
SMALL-SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 50 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 20 \text{ MHz}$)	f_T	40	-	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$)	C_{ob}	-	45	pF
Input Impedance ($I_C = 5.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)	h_{ie}	- -	2.0 1.2	k ohm
Input Resistance ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{ib}	20 4.0	30 8.0	ohm
Voltage Feedback Ratio ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{rb}	- - - -	7.0 5.0 7.0 5.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{fe}	70 35 80 40	210 100 240 120	-
Output Admittance ($I_C = 5.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)	h_{oe}	- -	200 100	-
Output Admittance ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{ob}	- -	1.0 1.5	μmho

⁽¹⁾ Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

2N1990S(SILICON)

CASE 79
(TO-39)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

NPN silicon transistor designed for driving neon display tubes.

Collector Connected to Case

* MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current-Continuous	I_C	1.0	Adc
Total Device Dissipation $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.6 4.8	W mW/ $^\circ\text{C}$
Total Device Dissipation $T_C = 2.5^\circ\text{C}$ @ $T_C = 100^\circ\text{C}$	P_D	2.0 1.0	W
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	62.5	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	θ_{JA}	208	$^\circ\text{C/W}$

* ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector Cutoff Current ($V_{CE} = 75\text{ Vdc}, I_B = 10\text{ }\mu\text{Adc}$) ($V_{CE} = 75\text{ Vdc}, I_B = 250\text{ }\mu\text{Adc}, T_A = 150^\circ\text{C}$)	I_{CEX}	- -	10 250	μAdc
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ON CHARACTERISTICS

DC Current Gain ($I_C = 30\text{ mAdc}, V_{CE} = 10\text{ Vdc}$)	h_{FE}	20	-	-
Collector-Emitter Saturation Voltage ($I_C = 2.0\text{ mAdc}, I_B = 0.2\text{ mAdc}$)	$V_{CE(sat)}$	-	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 2.0\text{ mAdc}, I_B = 0.2\text{ mAdc}$)	$V_{BE(sat)}$	-	1.0	Vdc

* Indicates JEDEC Registered Data

2N1991S(SILICON)

For Specifications, See 2N1131 Data.

2N2042, 2N2043 (GERMANIUM)

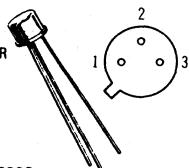
STYLE 1:

PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 31
(TO-5)

All leads

isolated from case



PNP germanium transistors suitable for high-voltage audio switching and amplifier applications. Suitable for high-reliability projects.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	105	Vdc
Collector-Emitter Voltage	V_{CES}	105	Vdc
Emitter-Base Voltage	V_{EB}	75	Vdc
Collector Current (Continuous)	I_C	200	mAdc
Operating Junction Temperature Range	T_J	-65 to +100	°C
Storage Temperature Range	T_{stg}	-65 to +100	°C
Collector Dissipation, Ambient Derate above 25°C	P_D	200 2.67	mW mW/°C
Thermal Resistance (Junction to Ambient)	θ_{JA}	0.375	°C/mW
Thermal Resistance (Junction to Case)	θ_{JC}	0.250	°C/mW

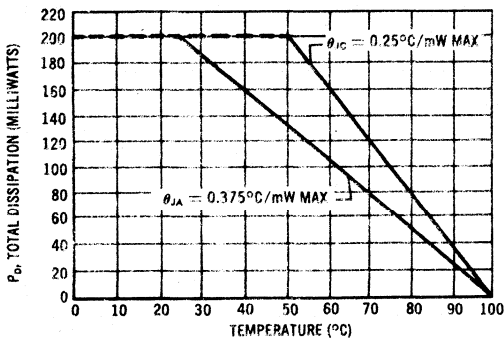
ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Cutoff Current ($V_{CB} = 105\text{ V}$, $I_E = 0$) ($V_{CB} = 2.5\text{ V}$, $I_E = 0$) ($V_{CB} = 105\text{ V}$, $I_E = 0$, $T_A = +71^\circ\text{C}$)	I_{CBO}	— — —	25 10 500	μAdc
Emitter-Base Cutoff Current ($V_{EB} = 75\text{ V}$, $I_C = 0$) ($V_{EB} = 2.5\text{ V}$, $I_C = 0$)	I_{EBO}	— —	50 10	μAdc
Collector-Emitter Cutoff Current ($V_{CE} = 55\text{ V}$, $R_{BE} = 10\text{ K}$)	I_{CER}	—	600	μAdc
Collector-Emitter Cutoff Current ($V_{CE} = 105\text{ V}$, $V_{BE} = 0$)	I_{CES}	—	1.0	mAdc
DC Collector-Emitter Punch-Through Voltage ($V_{fl} = 1.0\text{ V}$, VTVM R_{in} 10-12 megohm)	V_{pt}	105	—	Vdc
DC Current Gain ($I_C = 5\text{ mA}$, $V_{CE} = 0.35\text{ V}$)	h_{FE}	20 40	50 100	—
Common Base, Small-Signal Input Impedance ($V_{CB} = 6\text{ V}$, $I_E = 1\text{ mA}$, $f = 1\text{ kHz}$)	h_{ib}	30	50	Ohms

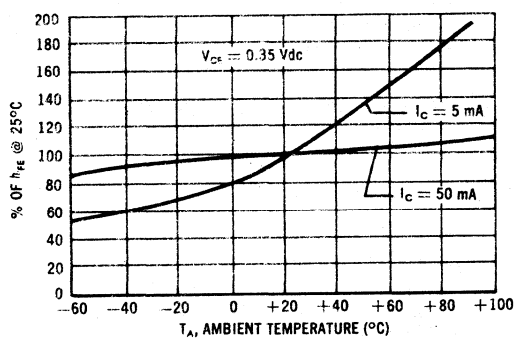
ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Max	Unit
Common Base, Small-Signal Output Admittance ($V_{CB} = 6 \text{ V}$, $I_E = 1 \text{ mA}$, $f = 1 \text{ kHz}$)	h_{ob}	0.1	1.0	μmho
Common Emitter, Small-Signal Current Transfer Ratio ($V_{CE} = 6 \text{ V}$, $I_C = 1 \text{ mA}$, $f = 1 \text{ kHz}$)	h_{fe}	20 45	80 180	—
Base-Emitter Saturation Voltage ($I_C = 5 \text{ mA}$, $I_B = 0.25 \text{ mA}$)	$V_{BE(sat)}$	—	0.30	Vdc
Collector-Emitter Saturation Voltage ($I_C = 5 \text{ mA}$, $I_B = 0.25 \text{ mA}$) ($I_C = 100 \text{ mA}$, $I_B = 10 \text{ mA}$)	$V_{CE(sat)}$	— —	0.25 0.75	Vdc
Collector Output Capacitance ($V_{CB} = 6 \text{ V}$, $I_E = 0$)	C_{ob}	—	25	pF
Common-Base, Small-Signal Forward Current Transfer Ratio Cutoff Frequency ($V_{CB} = 6 \text{ V}$, $I_E = 1 \text{ mA}$)	$f_{\alpha b}$	0.50 0.75	— —	MHz

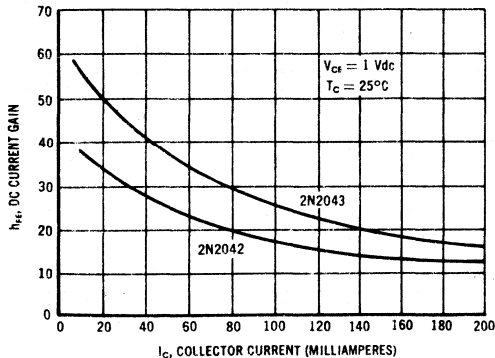
POWER-TEMPERATURE DERATING CURVE



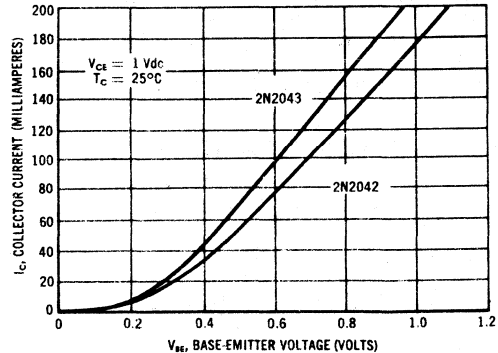
LARGE SIGNAL CURRENT GAIN versus TEMPERATURE



DC CURRENT GAIN versus COLLECTOR CURRENT



COLLECTOR CURRENT versus BASE-DRIVE VOLTAGE



2N2060, A (SILICON)

2N2060 JAN, JTX, JTXV Available

2N2223, A

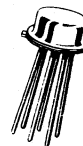
2N2480, A

MULTIPLE SILICON ANNULAR TRANSISTORS

... designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Excellent Temperature Tracking — Dual Devices — 2N2223, A
 $\Delta|V_{BE1} - V_{BE2}| = 2.0 \text{ mVdc (Max) @ } -55 \text{ to } +25^\circ\text{C}$
 $= 2.5 \text{ mVdc (Max) @ } +25 \text{ to } +125^\circ\text{C}$
- Low Collector-Emitter Saturation Voltage — 2N2480
 $V_{CE(sat)} = 1.3 \text{ Vdc (Max) @ } I_C = 50 \text{ mAdc}$
- DC Current Gain Specified — $10 \mu\text{Adc}$ to 10 mAdc
- High Current-Gain-Bandwidth Product —
 $f_T = 60 \text{ MHz @ } I_C = 50 \text{ mAdc}$

NPN SILICON MULTIPLE TRANSISTORS

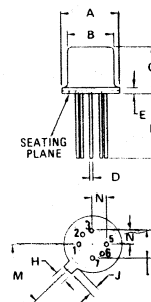


*MAXIMUM RATINGS

Rating	Symbol	2N2060, A 2N2223, A	2N2480	2N2480A	Unit
Collector-Emitter Voltage	V_{CEO}	60	35	40	Vdc
Collector-Emitter Voltage	V_{CER}	80	—	—	Vdc
Collector-Base Voltage	V_{CB}	100	75	80	Vdc
Emitter-Base Voltage	V_{EB}	7.0	5.0	5.0	Vdc
Collector Current — Continuous	I_C	500			mAdc
		One Die		All Die Equal Power	
Total Power Dissipation @ $T_A = 25^\circ\text{C}$	P_D	0.5	0.6		mW
		0.3	0.6		
		0.5	0.6		
		0.5	0.6		
Derate above 25°C	P_D	2.86	3.43		mW/ $^\circ\text{C}$
		1.72	3.43		
		2.86	3.43		
		2.86	3.43		
Total Power Dissipation @ $T_C = 25^\circ\text{C}$	P_D	1.5	3.0		Watts
		1.0	2.0		
		1.6	3.0		
		1.6	3.0		
Derate above 25°C	P_D	8.6	17.2		mW/ $^\circ\text{C}$
		5.7	11.4		
		9.1	17.2		
		9.1	17.2		
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			$^\circ\text{C}$

*Indicates JEDEC Registered Data.

STYLE 1:
 PIN 1. COLLECTOR 5. EMITTER
 2. BASE 6. BASE
 3. EMITTER 7. COLLECTOR
 4. OMITTED 8. OMITTED



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC	—	0.200 BSC	—
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	—	0.500	—
M	45° BSC	—	45° BSC	—
N	2.54 BSC	—	0.100 BSC	—

CASE 654-07

2N2060, A, 2N2223, A, 2N2480, A (continued)

* ELECTRICAL CHARACTERISTICS (each side) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 20\text{ mA}$, $I_B = 0$) ($I_C = 30\text{ mA}$, $I_B = 0$)	BV_{CEO}	35 40 60	- - -	Vdc
Collector-Emitter Breakdown Voltage(1) ($I_C = 100\text{ mA}$, $R_{BE} \leq 10\text{ ohms}$)	BV_{CER}	80	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\text{ }\mu\text{A}$, $I_E = 0$)	BV_{CBO}	100 75 80	- - -	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\text{ }\mu\text{A}$, $I_C = 0$)	BV_{EBO}	7.0 5.0	- -	Vdc
Collector Cutoff Current ($V_{CB} = 30\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$) ($V_{CB} = 60\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 80\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 80\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	- - - -	15 0.050 0.020 0.010	μA
Emitter Cutoff Current ($V_{BE} = 5.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	- - - -	2.0 10 50 20	nA

ON CHARACTERISTICS

DC Current Gain ($I_C = 10\text{ }\mu\text{A}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 100\text{ }\mu\text{A}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 1.0\text{ mA}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 10\text{ mA}$, $V_{CE} = 5.0\text{ Vdc}$)*	2N2060, 2N2060A 2N2223, 2N2223A 2N2060, 2N2060A 2N2223, 2N2223A 2N2480 2N2480A 2N2060, 2N2060A 2N2480 2N2480A 2N2060, 2N2060A 2N2223, 2N2223A	h_{FE}	25 15 30 25 20 15 40 30 50 50 50	75 - 90 150 - - 120 350 200 150 200	-
Collector-Emitter Saturation Voltage ($I_C = 50\text{ mA}$, $I_B = 5.0\text{ mA}$)	2N2060A 2N2060, 2N2223, 2N2223A, 2N2480A 2N2480	$V_{CE(sat)}$	- - -	0.6 1.2 1.3	Vdc
Base-Emitter Saturation Voltage ($I_C = 50\text{ mA}$, $I_B = 5.0\text{ mA}$)	2N2060, 2N2060A, 2N2223, 2N2223A, 2N2480A 2N2480	$V_{BE(sat)}$	- -	0.9 1.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 50\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 20\text{ MHz}$)	2N2223, 2N2223A, 2N2480, 2N2480A 2N2060, 2N2060A	f_T	50 60	- -	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	2N2060, 2N2060A, 2N2223, 2N2223A 2N2480A 2N2480	C_{ob}	- - -	15 18 20	pF

* Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.

(2) Motorola Guarantees this Data in Addition to JEDEC Registered Data.

2N2060, A, 2N2223, A, 2N2480, A (continued)
*** ELECTRICAL CHARACTERISTICS (continued)**

Characteristic	Symbol	Min	Max	Unit
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 1.0 \text{ MHz}$) 2N2060, 2N2060A, 2N2223, 2N2223A, 2N2480A	C_{ib}	-	85	pF
Input Impedance ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) 2N2060, 2N2060A, 2N2480A	h_{ie}	1000 1000	4000 5000	ohms
Input Impedance ($I_C = 1.0 \text{ mAdc}$, $V_{CB} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) 2N2060, 2N2060A, 2N2223, 2N2223A, 2N2480A	h_{ib}	20 20	30 35	ohms
Voltage Feedback Ratio ($I_C = 1.0 \text{ mAdc}$, $V_{CB} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) 2N2223, 2N2223A	h_{rb}	-	3.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) 2N2060, 2N2060A, 2N2223, 2N2223A, 2N2480A	h_{fe}	50 40 50	150 200 300	-
Output Admittance ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) 2N2060, 2N2060A, 2N2480A	h_{oe}	4.0	16	μmhos
Output Admittance ($I_C = 1.0 \text{ mAdc}$, $V_{CB} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$) 2N2223, 2N2223A	h_{ob}	-	0.5	μmhos
Noise Figure ($I_C = 0.3 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $R_S = 510 \text{ ohms}$, $f = 1.0 \text{ kHz}$, $BW = 1.0 \text{ Hz}$) 2N2480, 2N2480A ($I_C = 0.3 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $R_S = 510 \text{ ohms}$, $f = 1.0 \text{ kHz}$, $BW = 200 \text{ Hz}$) 2N2060, 2N2060A ($I_C = 0.3 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $R_S = 1.0 \text{ k ohm}$, $f = 1.0 \text{ kHz}$, $BW = 15.7 \text{ kHz}$) (3)	NF	- - -	8.0 8.0 8.0	dB

MATCHING CHARACTERISTICS

DC Current Gain Ratio ⁽⁴⁾ ($I_C = 100 \mu\text{A}$, $V_{CE} = 5.0 \text{ Vdc}$) 2N2060, 2N2060A, 2N2223A, 2N2223, 2N2480, 2N2480A ($I_C = 1.0 \text{ mA}$, $V_{CE} = 5.0 \text{ Vdc}$) 2N2060, 2N2060A, 2N2480, 2N2480A	h_{FE1}/h_{FE2}	0.9 0.8 0.9 0.8	1.0 1.0 1.0 1.0	-
Base-Emitter Voltage Differential ($I_C = 100 \mu\text{A}$, $V_{CE} = 5.0 \text{ Vdc}$) 2N2060A, 2N2060, 2N2223A, 2N2480A, 2N2480, 2N2223 ($I_C = 1.0 \text{ mA}$, $V_{CE} = 5.0 \text{ Vdc}$) 2N2060, 2N2060A, 2N2480A, 2N2480	$ V_{BE1} - V_{BE2} $	- - - - - -	3.0 5.0 10 15 5.0 10	mVdc
Base-Emitter Voltage Differential Change Due to Temperature ($I_C = 100 \mu\text{A}$, $V_{CE} = 5.0 \text{ Vdc}$, $T_A = -55 \text{ to } +25^\circ\text{C}$) 2N2060A, 2N2060, 2N2223, 2N2223A, 2N2480, 2N2480A ($I_C = 100 \mu\text{A}$, $V_{CE} = 5.0 \text{ Vdc}$, $T_A = +25 \text{ to } +125^\circ\text{C}$) 2N2060, 2N2060A, 2N2223, 2N2223A, 2N2480, 2N2480A	$\Delta(V_{BE1} - V_{BE2})$	- - - - - - - - -	0.4 0.8 2.0 1.2 1.0 0.5 2.5 1.5	mVdc

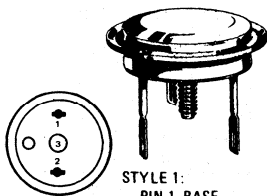
* Indicates JEDEC Registered Data

(3) Amplifier: 3.0 dB points at 25 Hz and 10 kHz with a roll-off of 6.0 dB per octave.

(4) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

2N2075 thru 2N2082 (GERMANIUM)

2N2075A thru 2N2082A



STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

PNP germanium power transistors for high-power applications in high-reliability equipment.

Collector connected to case

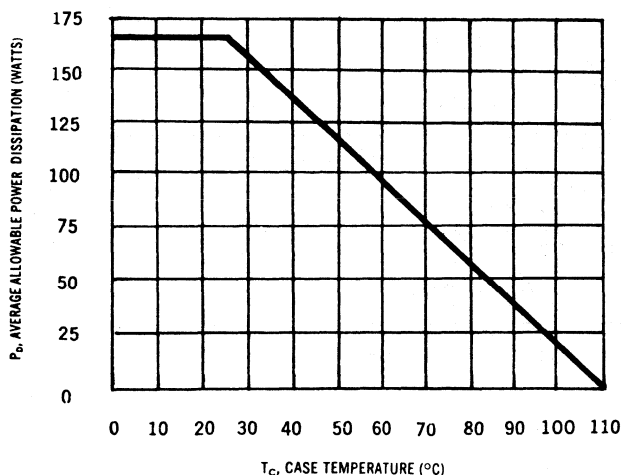
CASE 5 (TO-36)

MAXIMUM RATINGS

Rating	Symbol	2N2078 2N2082	2N2077 2N2081	2N2076 2N2080	2N2075 2N2079	Unit
Collector-Emitter Voltage	V_{CEO}	25	45	55	65	Vdc
Collector-Emitter Voltage	V_{CES}	40	50	70	80	Vdc
Collector-Base Voltage	V_{CB}	40	50	70	80	Vdc
Emitter-Base Voltage	V_{EB}	20	25	35	40	Vdc
Collector Current	I_C	15				Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$	P_D	170				Watts
Operating Junction Temperature Range	T_J	-65 to +110				$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.5	$^\circ\text{C}/\text{W}$



POWER-TEMPERATURE DERATING CURVE

The maximum average power is related to maximum junction temperature by the thermal resistance factor.

This curve has a value of 170 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that:

$$\text{allowable } P_D = \frac{110^\circ - T_C}{0.5}$$

2N2075 thru 2N2082 (continued)

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 1.0 \text{ Adc}$, $I_B = 0$)	BV_{CEO}	25 45 55 65	- - - -	Vdc
Collector-Emitter Breakdown Voltage* ($I_C = 300 \text{ mAdc}$, $V_{BE} = 0$)	BV_{CES}	40 50 70 80	- - - -	Vdc
Floating Potential ($V_{CB} = 40 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 50 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 70 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 80 \text{ Vdc}$, $I_E = 0$)	V_{EBF}	- - - -	1.0 1.0 1.0 1.0	Vdc
Collector Cutoff Current ($V_{CB} = 2.0 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = V_{CB(max)}$, $V_{EB} = 1.5 \text{ Vdc}$) ($V_{CB} = V_{CB(max)}$, $I_E = 0$, $T_C = +71^\circ\text{C}$)	I_{CBO}	- - -	0.2 4.0 15	mAdc
Emitter Cutoff Current ($V_{BE} = V_{BE(max)}$, $I_C = 0$) ($V_{BE} = V_{BE(max)}$, $I_C = 0$, $T_C = +71^\circ\text{C}$)	I_{EBO}	- -	4.0 15	mAdc

ON CHARACTERISTICS

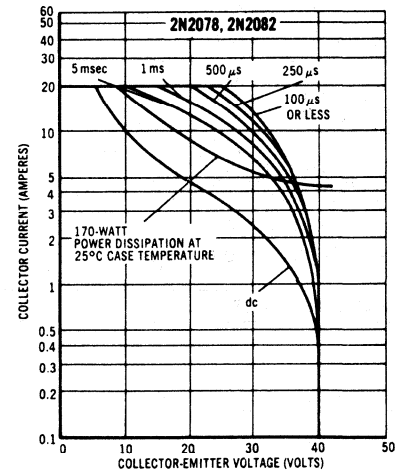
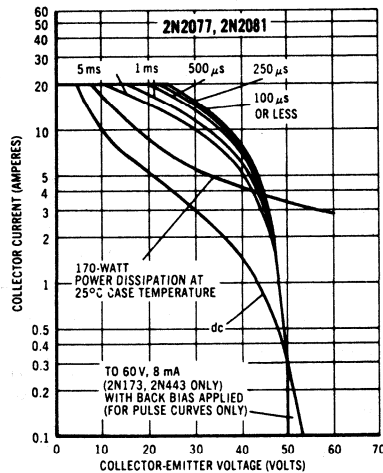
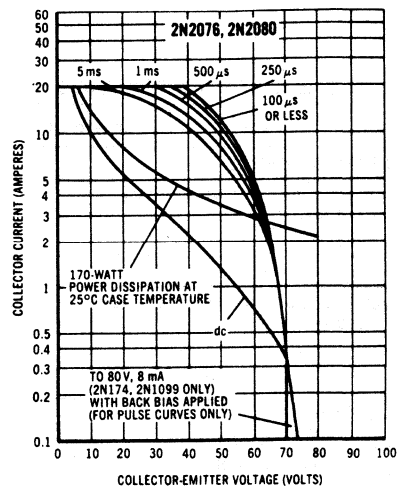
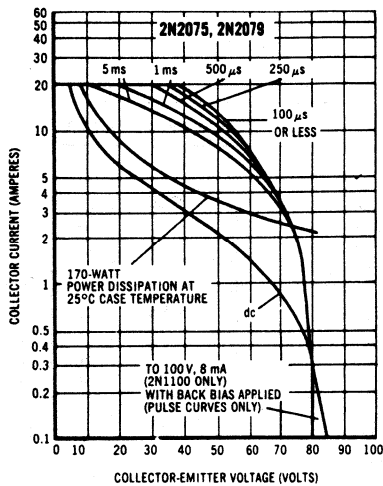
DC Current Gain ($I_C = 1.2 \text{ Adc}$, $V_{CE} = 2.0 \text{ Vdc}$) ($I_C = 5.0 \text{ Adc}$, $V_{CE} = 2.0 \text{ Vdc}$) ($I_C = 5.0 \text{ Adc}$, $V_{CE} = 2.0 \text{ Vdc}$, $T_C = -55^\circ\text{C}$) ($I_C = 12 \text{ Adc}$, $V_{CE} = 2.0 \text{ Vdc}$)	2N2075 thru 2N2078 2N2079 thru 2N2082 2N2075 thru 2N2078 2N2079 thru 2N2082 2N2075 thru 2N2078 2N2079 thru 2N2082 2N2075 thru 2N2078 2N2079 thru 2N2082	h_{FE}	25 40 20 35 15 25 8 12	100 160 40 70 - - - -	-
Collector-Emitter Saturation Voltage ($I_C = 13 \text{ Adc}$, $I_B = 2.0 \text{ Adc}$)	2N2075 & 76, 2N2079 & 80 2N2077 & 78, 2N2081 & 82	$V_{CE(sat)}$	- -	0.7 0.9	Vdc
Base-Emitter On Voltage ($I_C = 5.0 \text{ Adc}$, $V_{CE} = 12 \text{ Vdc}$)		$V_{BE(on)}$	-	0.9	Vdc

DYNAMIC CHARACTERISTICS

Common-Emitter Cutoff Frequency ($I_C = 5.0 \text{ Adc}$, $V_{CE} = 6.0 \text{ Vdc}$)		$f_{\alpha e}$	5.0	-	kHz
Rise Time ($V_{CE} = 12 \text{ Vdc}$, $I_{C(on)} = 12 \text{ Adc}$, $I_B = 2.0 \text{ Adc}$)	2N2075 thru 2N2078 2N2079 thru 2N2082	t_r	Typ		μs
			9.0 6.0		
Fall Time ($V_{BE} = 6.0 \text{ Vdc}$, $I_{C(off)} = 0$, $R_{BE} = 10 \text{ ohms}$)	2N2075 thru 2N2078 2N2079 thru 2N2082	t_f	12 13		μs

*To avoid excessive heating of collector junction, perform this test with a sweep method.

SAFE OPERATING AREAS

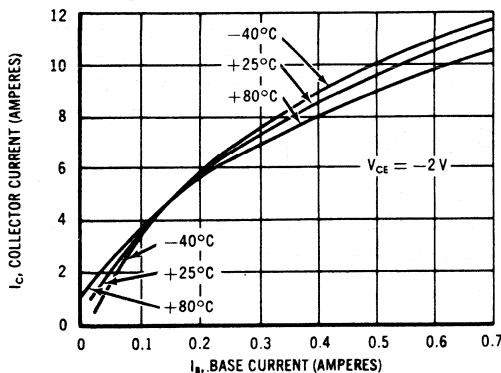


The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short.

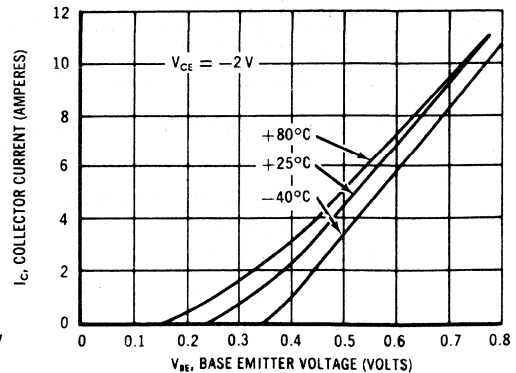
(Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J , the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N2075-2N2078

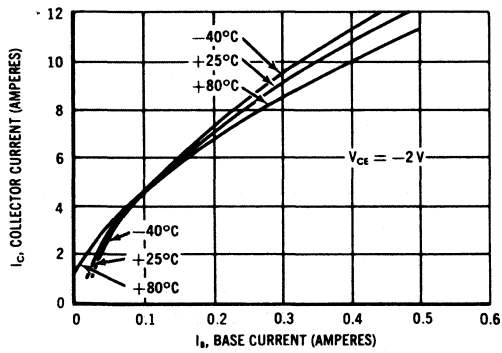
CURRENT TRANSFER CHARACTERISTICS



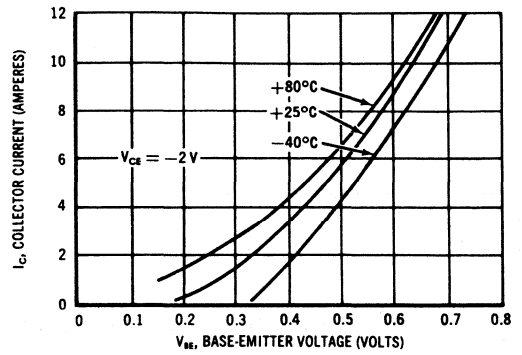
TRANSCONDUCTANCE CHARACTERISTICS



CURRENT TRANSFER CHARACTERISTICS



TRANSCONDUCTANCE CHARACTERISTICS

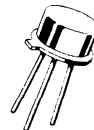


NPN SILICON ANNULAR AMPLIFIER TRANSISTOR

... designed for use in general-purpose amplifier applications.

- Collector-Emitter Sustaining Voltage —
 $V_{CEO(sus)} = 65 \text{ Vdc (Min) @ } I_C = 100 \text{ mAdc}$
- DC Current Gain — $10 \mu\text{Adc to } 1.0 \text{ mAdc}$
- Low Noise Figure —
 $NF = 4.0 \text{ dB (Typ) @ } I_C = 300 \mu\text{Adc}$

NPN SILICON AMPLIFIER TRANSISTOR



*MAXIMUM RATINGS

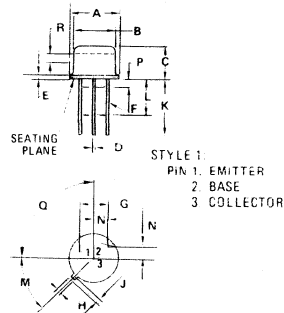
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	65	Vdc
Collector-Emitter Voltage, $R_{BE} \leq 10 \text{ Ohms}$	V_{CER}	80	Vdc
Collector-Base Voltage	V_{CB}	120	Vdc
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 5.71	Watt $\text{mW}/^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	5.0 28.6	Watts $\text{mW}/^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA(1)}$	175	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	$^\circ\text{C}/\text{W}$

*Indicates JEDEC Registered Data.

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.225	3.12	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.664	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° NOM	45° NOM	—	—
P	—	1.27	—	0.050
Q	90° NOM	90° NOM	—	—
R	2.54	—	0.100	—

CASE 79-02

TO-39

2N2102S (continued)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) ($I_C = 100 \text{ mA}$, $I_B = 0$)	$V_{CE(sus)}$	65	—	—	Vdc
Collector-Emitter Sustaining Voltage ($I_C = 100 \text{ mA}$, $R_{FE} \leq 100 \text{ Ohms}$)	$V_{CE(sus)}$	80	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100 \mu\text{A}$, $V_{EB} = 1.5 \text{ Vdc}$)	BV_{CEX}	120	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{A}$, $I_E = 0$)	BV_{CBO}	120	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{A}$, $I_C = 0$)	BV_{EBO}	7.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 60 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 60 \text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	—	—	2.0 2.0	nA μA
Emitter Cutoff Current ($V_{RE} = 5.0 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	—	2.0	nA

ON CHARACTERISTICS

DC CHARACTERISTICS		h_{FE}				
DC Current Gain ($I_C = 10 \mu A$ dc, $V_{CE} = 10$ Vdc) ($I_C = 0.1$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc) ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, $T_A = -55^\circ C$) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc) (1) ($I_C = 500$ mAdc, $V_{CE} = 10$ Vdc) (1) ($I_C = 1.0$ Adc, $V_{CE} = 10$ Vdc) (1)		10	—	—	—	—
		20	—	—	—	—
		35	—	—	—	—
		20	—	—	—	—
		40	—	—	120	—
		25	—	—	—	—
		10	—	—	—	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{CE(sat)}$	—	0.3	0.5		Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{BE(sat)}$	—	0.78	1.1		Vdc

DYNAMIC CHARACTERISTICS

DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product ($I_C = 50 \text{ mA dc}$, $V_{CE} = 10 \text{ V dc}$, $f = 20 \text{ MHz}$)	f_T	60	—	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ V dc}$, $I_E = 0$, $f = 100 \text{ kHz}$)	C_{ob}	—	8.0	15	pF
Input Capacitance ($V_{BE} = 0.5 \text{ V dc}$, $I_C = 0$, $f = 100 \text{ kHz}$)	C_{ib}	—	60	80	pF
Input Impedance ($I_C = 1.0 \text{ mA dc}$, $V_{CE} = 5.0 \text{ V dc}$, $f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mA dc}$, $V_{CE} = 10 \text{ V dc}$, $f = 1.0 \text{ kHz}$)	h_{ib}	24 4.0	— —	34 8.0	Ohms
Voltage Feedback Ratio ($I_C = 1.0 \text{ mA dc}$, $V_{CE} = 5.0 \text{ V dc}$, $f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mA dc}$, $V_{CE} = 10 \text{ V dc}$, $f = 1.0 \text{ kHz}$)	h_{rb}	— —	— —	3.0 3.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0 \text{ mA dc}$, $V_{CE} = 5.0 \text{ V dc}$, $f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mA dc}$, $V_{CE} = 10 \text{ V dc}$, $f = 1.0 \text{ kHz}$)	h_{fe}	30 35	— —	100 150	—
Output Admittance ($I_C = 1.0 \text{ mA dc}$, $V_{CE} = 5.0 \text{ V dc}$, $f = 1.0 \text{ kHz}$) ($I_C = 5.0 \text{ mA dc}$, $V_{CE} = 10 \text{ V dc}$, $f = 1.0 \text{ kHz}$)	h_{ob}	0.01 0.01	— —	0.5 1.0	μmho
Noise Figure ($I_C = 300 \mu\text{A dc}$, $V_{CE} = 10 \text{ V dc}$, $R_S = 1.0 \text{ k Ohm}$, $f = 1.0 \text{ kHz}$, Bandwidth = 1.0 Hz)	NF	—	4.0	6.0	dB

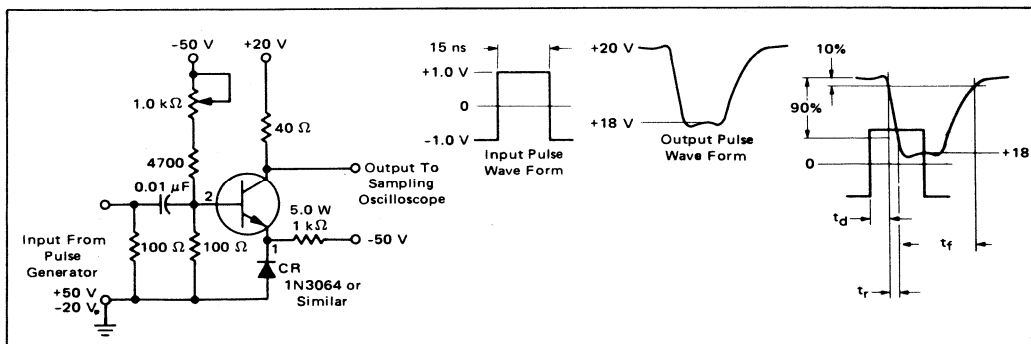
SWITCHING CHARACTERISTICS

Switching Time (Figure 1)	$t_d + t_r + t_f$	—	—	30	ns
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*Indicates JEDEC Registered Data.

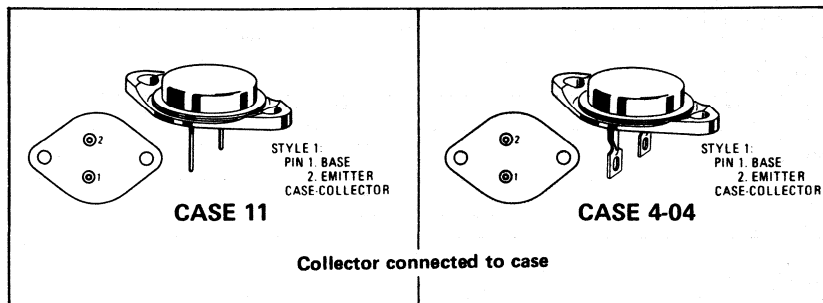
(1) Pulse Test: Pulse Width $\leq 300 \mu s$, Duty Cycle $\leq 2.0\%$.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT



2N2137 thru **2N2146** (GERMANIUM) **2N2137A** thru **2N2146A**

PNP germanium industrial power transistors for driver applications in high reliability equipment.



For units with solder lugs attached, specify devices MP2137,A etc. (Case 4-04)

MAXIMUM RATINGS

Apply also to standard, non-A series

Rating	Symbol	2N2137A 2N2142A	2N2138A 2N2143A	2N2139A 2N2144A	2N2140A 2N2145A	2N2141A 2N2146A	Unit
Collector-Base Voltage	V_{CB}	30	45	60	75	90	Vdc
Collector-Emitter Voltage	V_{CES}	30	45	60	75	90	Vdc
Collector-Emitter Voltage	V_{CEO}	20	30	45	60	65	Vdc
Emitter-Base Voltage	V_{EB}	15	25	30	40	45	Vdc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	70 0.833					Watts W/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110					$^\circ\text{C}$

2N2137 thru 2N2146 (continued)

ELECTRICAL CHARACTERISTICS

*Characteristics apply also to corresponding, non-A type numbers.

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage** ($I_C = 500 \text{ mAdc}$, $I_B = 0$)	BV_{CEO}^{**}	20 30 45 60 65	- - - - -	- - - - -	Vdc
Collector-Emitter Breakdown Voltage** ($I_C = 300 \text{ mAdc}$, $V_{BE} = 0$)	BV_{CES}^{**}	30 45 60 75 90	- - - - -	- - - - -	Vdc
Floating Potential ($V_{CB} = 30 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 45 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 60 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 75 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 90 \text{ Vdc}$, $I_E = 0$)	V_{EBF}	- - - - -	- - - - -	1.0 1.0 1.0 1.0 1.0	Vdc
Collector-Base Cutoff Current ($V_{CB} = 2.0 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = V_{CB(max)}$, $I_C = 0$, $T_C = +71^\circ\text{C}$)	I_{CBO}	- -	0.018 0.75	0.05 5.0	mAdc
Collector-Base Cutoff Current† ($V_{CB} = V_{CB(max)}$, $I_E = 0$)	I_{CBO1}	-	0.1	2.0	mAdc
Emitter-Base Cutoff Current ($V_{BE} = V_{BE(max)}$, $I_C = 0$) ($V_{BE} = V_{BE(max)}$, $I_C = 0$, $T_C = +71^\circ\text{C}$)	I_{EBO}	- -	0.08 0.5	2.0 5.0	mAdc

ON CHARACTERISTICS

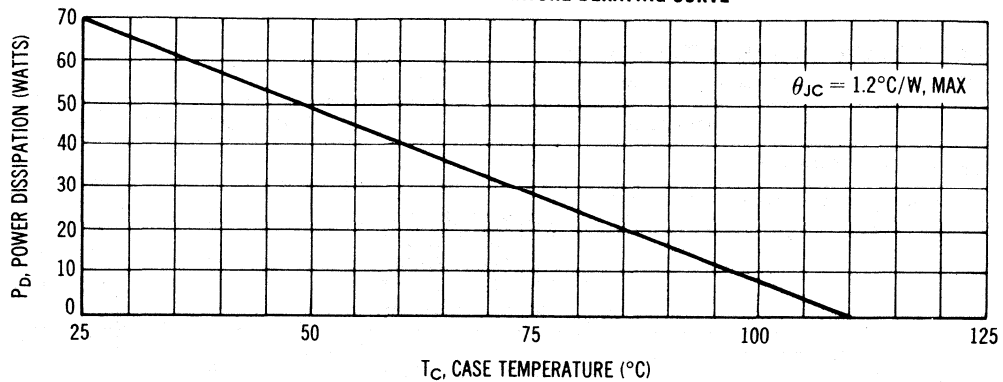
DC Current Gain ($I_C = 0.5 \text{ Adc}$, $V_{CE} = 2.0 \text{ Vdc}$)† ($I_C = 2.0 \text{ Adc}$, $V_{CE} = 2.0 \text{ Vdc}$)	h_{FE1} h_{FE}	30 50 15 25	45 70 22 33	60 100 - -	-
Collector-Emitter Saturation Voltage ($I_C = 2.0 \text{ Adc}$, $I_B = 200 \text{ mAdc}$)	$V_{CE(sat)}$	-	0.12	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 2.0 \text{ Adc}$, $I_B = 200 \text{ mAdc}$)	$V_{BE(sat)}$	-	0.75	1.2	Vdc

DYNAMIC CHARACTERISTICS

Common Emitter Cutoff Frequency ($I_C = 2.0 \text{ Adc}$, $V_{CE} = 6.0 \text{ Vdc}$)	f_{oe}	12	20	-	kHz
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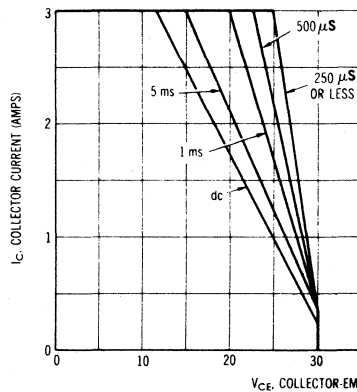
**Sweep method: 1/2 cycle sine wave, 60 Hz .

FIGURE 1 — POWER TEMPERATURE DERATING CURVE

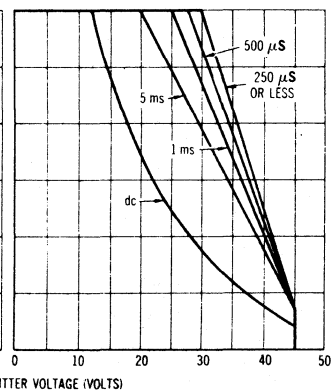
FIGURE 2 — ACTIVE REGION
SAFE OPERATING AREAS

The active region safe operating area curves indicate I_C - V_{CE} limits to be observed in order to avoid secondary breakdown. (Secondary breakdown is independent of temperature and duty cycle.) These curves do not define operation in the avalanche region. To insure operation below the maximum junction temperature, power derating must be observed for both steady state and pulse conditions.

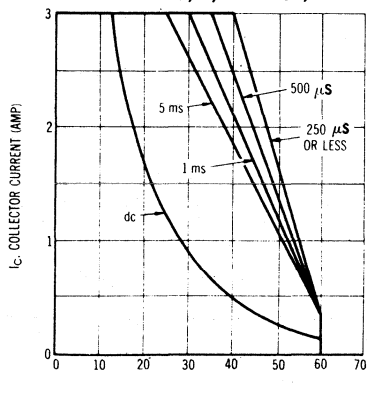
2N2137, A; 2N2142, A



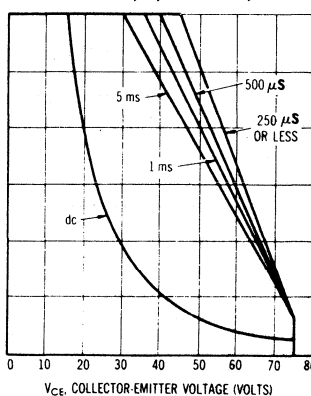
2N2138, A; 2N2143, A



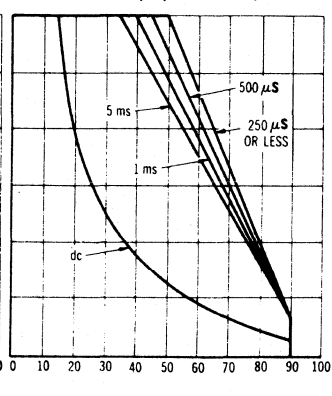
2N2139, A; 2N2144, A



2N2140, A; 2N2145, A



2N2141, A; 2N2146, A



LARGE SIGNAL CHARACTERISTICS

FIGURE 3 — TRANSCONDUCTANCE
(ALL TYPES)

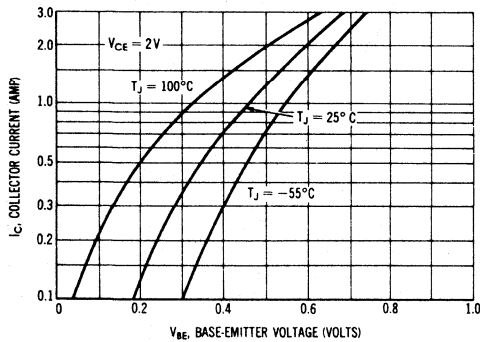


FIGURE 4 — INPUT ADMITTANCE
(2N2137A-2N2141A, 2N2137-2N2141)

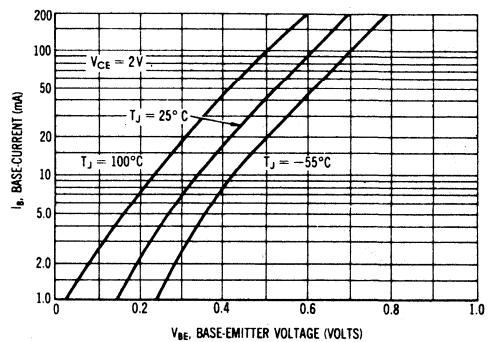


FIGURE 5 — INPUT ADMITTANCE
(2N2142A-2N2146A, 2N2142-2N2146)

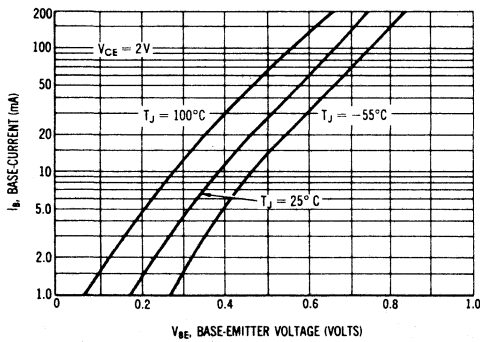


FIGURE 6 — NORMALIZED DC CURRENT GAIN
(ALL TYPES)

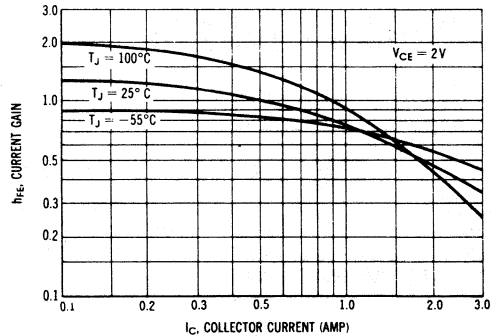


FIGURE 7 — SATURATION REGION
(2N2137A-2N2141A, 2N2137-2N2141)

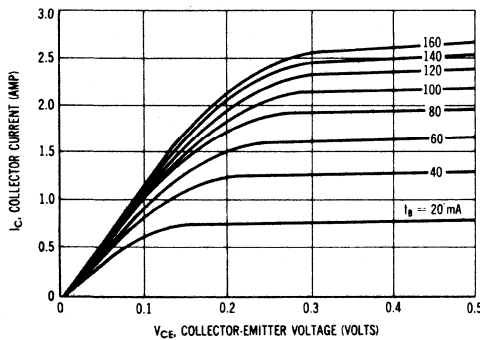
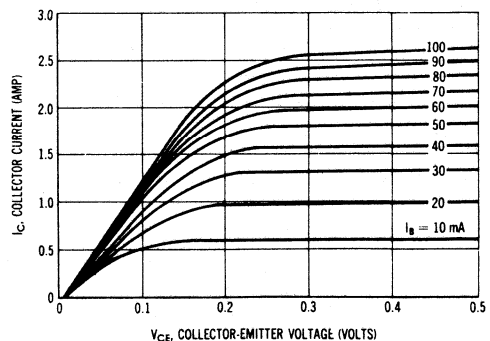


FIGURE 8 — SATURATION REGION
(2N2142A-2N2146A, 2N2142-2N2146)

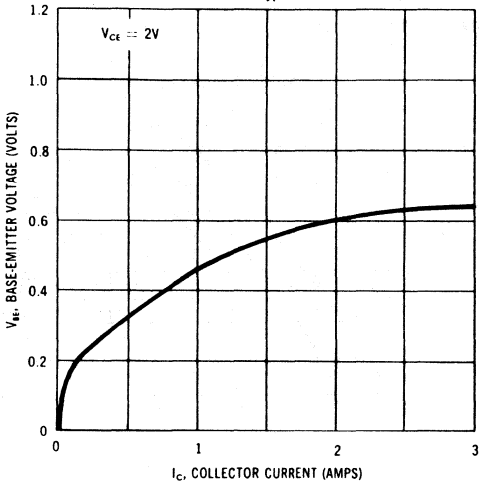


2N2137 thru 2N2146 (continued)

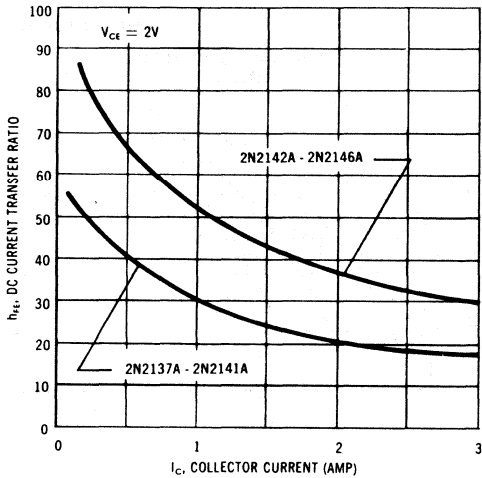
INPUT & TRANSFER CHARACTERISTICS

BASE-EMITTER VOLTAGE versus COLLECTOR CURRENT

All Types

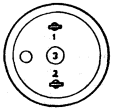


DC CURRENT TRANSFER RATIO versus COLLECTOR CURRENT



2N2152 thru 2N2154 (GERMANIUM)

2N2156 thru 2N2158



STYLE 1:
PIN 1, BASE
2, EMITTER
3, COLLECTOR



CASE 5
(TO-36)

Collector connected to case
MAXIMUM RATINGS

PNP germanium power transistors for high-power, high-gain applications in high-reliability industrial equipment.

Rating	Symbol	2N2152 2N2156	2N2153 2N2157	2N2154 2N2158	Unit
Collector-Emitter Voltage	V_{CEO}	30	45	60	Vdc
Collector-Emitter Voltage	V_{CES}	45	60	75	Vdc
Collector-Base Voltage	V_{CB}	45	60	75	Vdc
Emitter-Base Voltage	V_{EB}	25	30	40	Vdc
Collector Current	I_C	30			Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	170 0.5			Watts W/ $^\circ\text{C}$
Operating Junction Temperature Range	T_J	-65 to +110			$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.5	$^\circ\text{C}/\text{W}$

2N2152 thru 2N2154 2N2156 thru 2N2158 (continued)
ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage* ($I_C = 1.0 \text{ A dc}$, $I_B = 0$) 2N2152, 2N2156 2N2153, 2N2157 2N2154, 2N2158	BV_{CEO}^*	30 45 60	- - -	- - -	Vdc
Collector-Emitter Breakdown Voltage* ($I_C = 300 \text{ mAdc}$, $V_{BE} = 0$) 2N2152, 2N2156 2N2153, 2N2157 2N2154, 2N2158	BV_{CES}^*	45 60 75	- - -	- - -	Vdc
Floating Potential ($V_{CB} = 45 \text{ Vdc}$, $I_E = 0$) 2N2152, 2N2156 ($V_{CB} = 60 \text{ Vdc}$, $I_E = 0$) 2N2153, 2N2157 ($V_{CB} = 75 \text{ Vdc}$, $I_E = 0$) 2N2154, 2N2158	V_{EBF}	- - -	- - -	1.0 1.0 1.0	Vdc
Collector Cutoff Current ($V_{CB} = 2\text{V}$, $I_E = 0$) 2N2152, 2N2156 ($V_{CB} = 45 \text{ Vdc}$, $I_E = 0$) 2N2153, 2N2157 ($V_{CB} = 60 \text{ Vdc}$, $I_E = 0$) 2N2154, 2N2158 ($V_{CB} = 75 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = V_{CB(max)}$, $I_E = 0$, $T_C = 71^\circ\text{C}$)	I_{CBO}	- - - - -	0.08 0.9 0.9 0.9 4.0	0.2 4.0 4.0 4.0 15	mAdc
Emitter Cutoff Current ($V_{BE} = 25 \text{ Vdc}$, $I_C = 0$) ($V_{BE} = 30 \text{ Vdc}$, $I_C = 0$) ($V_{BE} = 40 \text{ Vdc}$, $I_C = 0$) ($V_{BE} = V_{EB(max)}$, $I_C = 0$, $T_C = 71^\circ\text{C}$)	I_{EBO}	- - - -	0.2 0.2 0.2 2.7	4.0 4.0 4.0 15	mAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 5.0 \text{ A dc}$, $V_{CB} = 2 \text{ Vdc}$) 2N2152, 2N2153, 2N2154 2N2156, 2N2157, 2N2158 ($I_C = 15 \text{ A dc}$, $V_{CB} = 2 \text{ Vdc}$) 2N2152, 2N2153, 2N2154 2N2156, 2N2157, 2N2158 ($I_C = 25 \text{ A dc}$, $V_{CB} = 2 \text{ Vdc}$)	h_{FE}	50 80 25 40 15	75 105 47 63 38	100 160 - - -	-
Collector-Emitter Saturation Voltage ($I_C = 5.0 \text{ A dc}$, $I_B = 500 \text{ mAdc}$) ($I_C = 25 \text{ A dc}$, $I_B = 2 \text{ A dc}$)	$V_{CE(sat)}$	- -	0.06 0.2	0.1 0.3	Vdc
Base-Emitter On Voltage ($I_C = 5.0 \text{ A dc}$, $I_B = 500 \text{ mAdc}$) ($I_C = 25 \text{ A dc}$, $I_B = 2 \text{ A dc}$)	$V_{BE(on)}$	- -	0.65 1.0	1.0 2.0	Vdc

SMALL SIGNAL CHARACTERISTICS

Common-Emitter Cutoff Frequency ($I_C = 5.0 \text{ A dc}$, $V_{CE} = 6.0 \text{ Vdc}$)	f_{ae}	2.0	2.7	-	kHz
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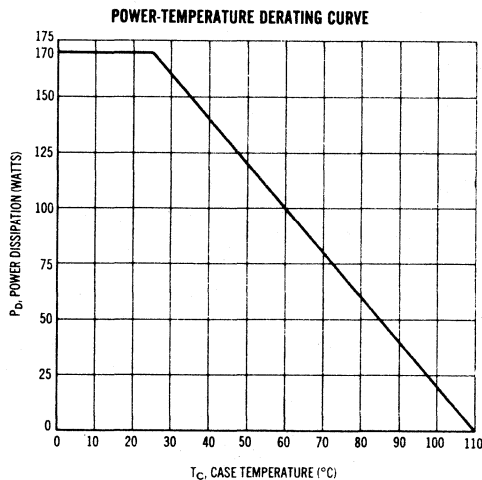
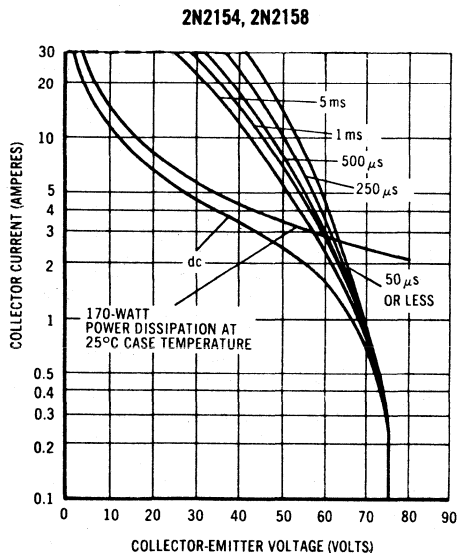
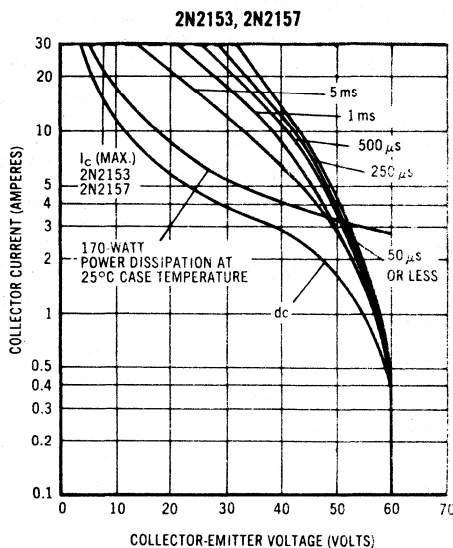
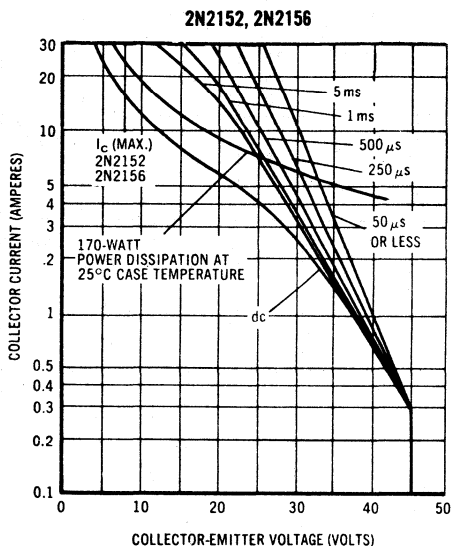
*To avoid excessive heating of the collector junction, perform these tests with an oscilloscope.

2N2152 thru 2N2154, 2N2156 thru 2N2158 (continued)

SAFE OPERATING AREAS

The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short.

(Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J , the power-temperature derating curve must be observed for both steady state and pulse power conditions.

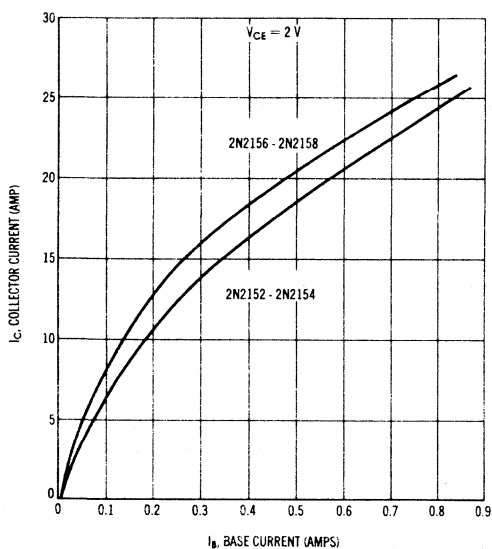


The maximum continuous power is related to maximum junction temperature by the thermal resistance factor. This curve has a value of 170 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that:

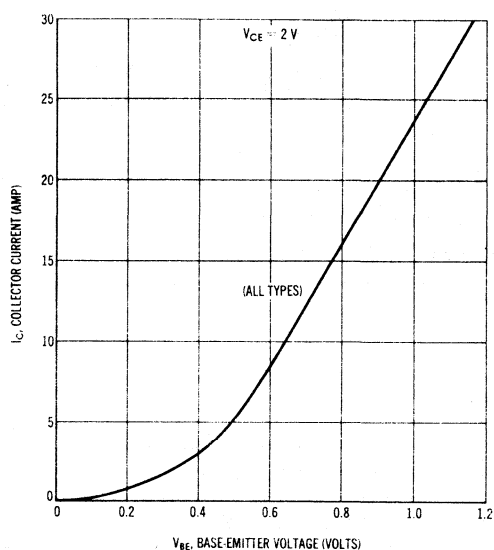
$$\text{allowable } P_D = \frac{110^\circ - T_C}{0.5}$$

TYPICAL INPUT AND TRANSFER CHARACTERISTICS

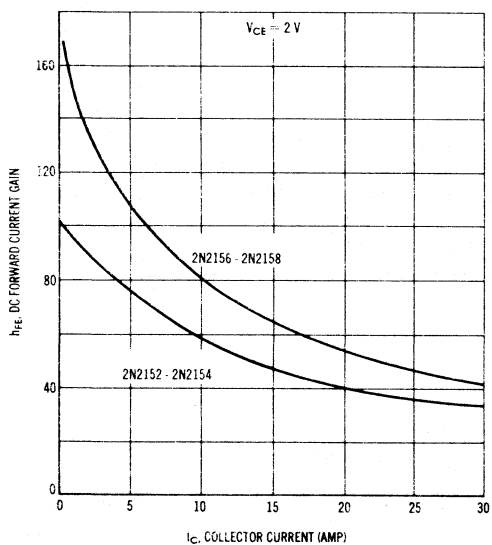
COLLECTOR CURRENT
versus BASE CURRENT



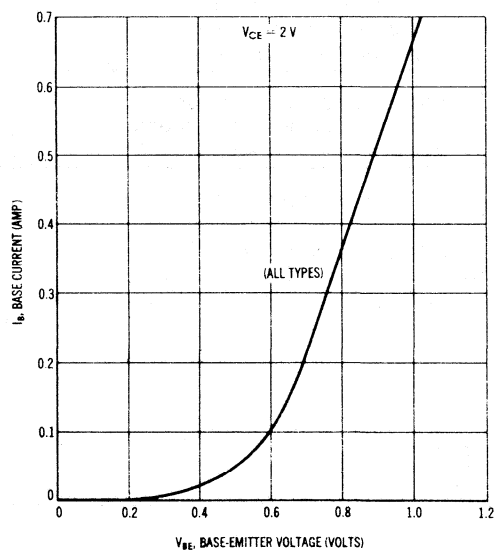
COLLECTOR CURRENT
versus BASE-EMITTER VOLTAGE



DC CURRENT GAIN
versus COLLECTOR CURRENT



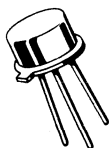
BASE CURRENT versus
BASE-EMITTER VOLTAGE



2N2171

For Specifications, See 2N381 Data.

2N2193AS (SILICON)

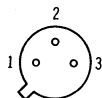


NPN silicon annular transistors for high-current switching and amplifier applications.

CASE 79

(TO-39)

Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

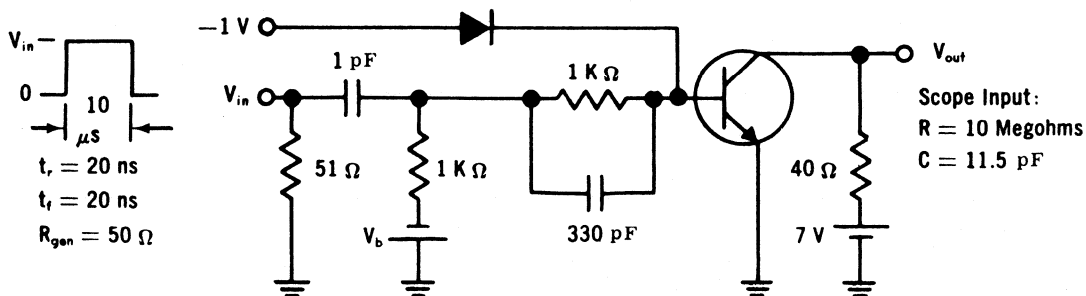
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	80	Vdc
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Emitter-Base Voltage	V_{EB}	8.0	Vdc
Collector Current	I_C	1.0	Adc
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor Above 25°C	P_D	0.8 4.56	Watt mW/°C
Total Device Dissipation @ 25°C Case Temperature Derating Factor Above 25°C	P_D	2.8 16	Watts mW/°C
Junction Temperature, Operating	T_J	-65 to +200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

* Indicates JEDEC Registered Data

FIGURE 1

$V_{in} = 15 \text{ V}$, $V_b = 15 \text{ V}$



2N2193AS (continued)*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage ($I_C = 100\ \mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	80	-	Vdc
Collector-Emitter-Open Base Sustain Voltage ⁽¹⁾ ($I_C = 25\ \text{mA}$ pulsed, $I_B = 0$)	$V_{CEO(sus)}$	50	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	8.0	-	Vdc
Collector Cutoff Current ($V_{CB} = 60\ \text{Vdc}$, $I_E = 0$) ($V_{CB} = 60\ \text{Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	- -	0.010 25	μAdc
Emitter Cutoff Current ($V_{EB} = 5\ \text{Vdc}$, $I_C = 0$)	I_{EBO}	-	0.050	μAdc
Collector-Emitter Saturation Voltage ($I_C = 150\ \text{mAdc}$, $I_B = 15\ \text{mAdc}$)	$V_{CE(sat)}$	-	0.25	Vdc
Base-Emitter Saturation Voltage ($I_C = 150\ \text{mAdc}$, $I_B = 15\ \text{mAdc}$)	$V_{BE(sat)}$	-	1.3	Vdc
DC Current Gain ⁽¹⁾ ($I_C = 0.1\ \text{mAdc}$, $V_{CE} = 10\ \text{Vdc}$) ($I_C = 10\ \text{mAdc}$, $V_{CE} = 10\ \text{Vdc}$) ($I_C = 10\ \text{mAdc}$, $V_{CE} = 10\ \text{Vdc}$, $T_A = -55^\circ\text{C}$) ($I_C = 150\ \text{mAdc}$, $V_{CE} = 10\ \text{Vdc}$) ($I_C = 150\ \text{mAdc}$, $V_{CE} = 1.0\ \text{Vdc}$) ($I_C = 500\ \text{mAdc}$, $V_{CE} = 10\ \text{Vdc}$) ($I_C = 1.0\ \text{Adc}$, $V_{CE} = 10\ \text{Vdc}$)	h_{FE}	30 20 40 30 20	- - 120 -	-
Output Capacitance ($V_{CB} = 10\ \text{Vdc}$, $I_E = 0$, $f = 1.0\ \text{MHz}$)	C_{ob}	-	20	pF
Small Signal Current Gain ($I_C = 50\ \text{mA}$, $V_{CE} = 10\ \text{V}$, $f = 20\ \text{MHz}$)	h_{fe}	2.5	-	-
Rise Time	t_r	-	70	ns
Storage Time	t_s	-	150	ns
Fall Time	t_f	-	50	ns

* Indicates JEDEC Registered Data

⁽¹⁾ Pulse Test: $PW \leq 300\ \mu\text{s}$ Duty Cycle $\leq 2\%$

NPN SILICON ANNULAR TRANSISTOR

... designed for high-speed, low-current switching applications requiring TO-46 package configurations.

- Collector-Emitter Sustaining Voltage —
 $V_{CE(sus)} = 12 \text{ Vdc (Min) @ } I_C = 10 \text{ mAdc}$
- Collector-Emitter Saturation Voltage —
 $V_{CE(sat)} = 0.2 \text{ Vdc (Typ) @ } I_C = 50 \text{ mAdc}$
- High Current-Gain-Bandwidth Product —
 $f_T = 250 \text{ MHz (Typ) @ } I_C = 10 \text{ mAdc}$
- Fast Switching Time (Figure 2) @ $I_C = 10 \text{ mAdc}$
 $t_{on} = 35 \text{ ns (Typ)}$
 $t_{off} = 60 \text{ ns (Typ)}$

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 2.0	mW mW/°C
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 0.66	Watt mW/°C
Operating Junction Temperature Range	T_J	-65 to +175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

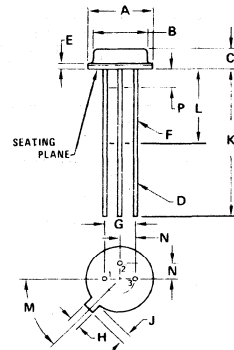
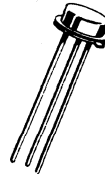
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA(1)}$	500	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	150	°C/W
Lead Temperature 1/16" $\pm$ 1/32" from Case for 10 seconds	T_L	235	°C

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

*Indicates JEDEC Registered Data.

NPN SILICON SWITCHING TRANSISTOR



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	1.65	2.16	0.065	0.085
D	0.406	0.533	0.016	0.021
E	—	1.02	—	0.040
F	0.305	0.483	0.012	0.019
G	2.54 BSC	—	0.100 BSC	—
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC	—	45° BSC	—
N	1.27 BSC	—	0.050 BSC	—
P	—	1.27	—	0.050

All JEDEC dimensions and notes apply

CASE 26-03
TO-46

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) ($I_C = 10\text{ mAdc}$, $I_B = 0$)	$BV_{CEO(sus)}$	12	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	25	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 15\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	— —	25 15	nAdc μAdc
Emitter Cutoff Current ($V_{EB} = 3.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	—	100	μAdc
Collector Cutoff Current ($V_{CE} = 10\text{ Vdc}$, $V_{BE} = 250\text{ mVdc}$, $T_A = 100^\circ\text{C}$)	I_{CEV}	—	—	15	μAdc

ON CHARACTERISTICS

DC Current Gain (1) ($I_C = 10\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$)	h_{FE}	40	100	120	—
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$) ($I_C = 50\text{ mAdc}$, $I_B = 5.0\text{ mAdc}$) (1)	$V_{CE(sat)}$	— —	150 200	220 350	mVdc
Base-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$)	$V_{BE(sat)}$	700	800	900	mVdc

DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product (1) ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	200	250	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 140\text{ kHz}$)	C_{ob}	—	4.0	6.0	pF

SWITCHING CHARACTERISTICS

Turn-On Time ($V_{CC} = 3.0\text{ Vdc}$, $I_C = 10\text{ mAdc}$, $I_{B1} = 3.0\text{ mAdc}$) (Figure 2)	t_{on}	—	35	40	ns
Turn-Off Time ($V_{CC} = 3.0\text{ Vdc}$, $I_C = 10\text{ mAdc}$, $I_{B1} = I_{B2} = 1.0\text{ mAdc}$) (Figure 2)	t_{off}	—	60	75	ns
Storage Time ($V_{CC} = 10\text{ Vdc}$, $I_C = 10\text{ mAdc}$, $I_{B1} = I_{B2} = 10\text{ mAdc}$)	t_s	—	—	35	ns

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.

FIGURE 1 – STORAGE TIME TEST CIRCUIT

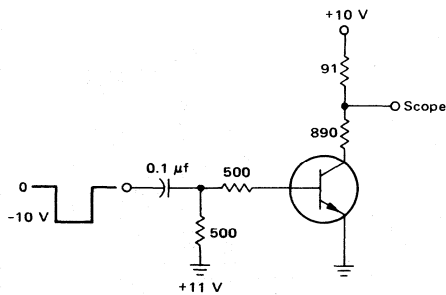
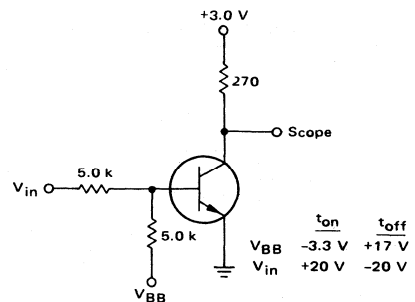


FIGURE 2 – TURN-ON AND TURN-OFF TIMES TEST CIRCUIT



PNP GERMANIUM POWER TRANSISTORS

... designed for high-current switching applications requiring low saturation voltages, short switching times and good collector-emitter sustaining capability.

- Alloy-Diffused Epitaxial Construction
- Low Saturation Voltage –
 $V_{CE(SAT)} = 0.5 \text{ Vdc (Max) @ } I_C = 5.0 \text{ Adc}$

MAXIMUM RATINGS

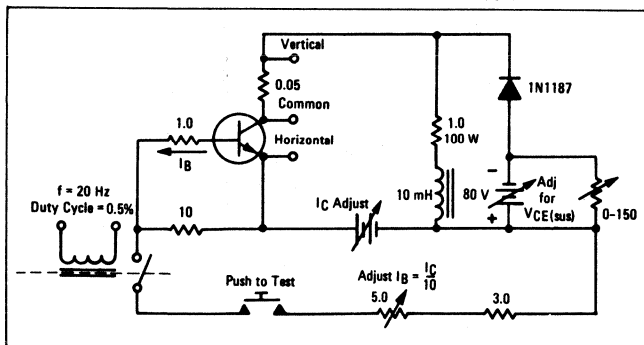
Rating	Symbol	Value	Unit
*Collector-Emitter Voltage	V_{CER}	120	Vdc
*Collector-Base Voltage	V_{CB}	120	Vdc
*Emitter-Base Voltage	V_{EB}	1.5	Vdc
*Collector Current - Continuous	I_C	10	Adc
*Base Current - Continuous	I_B	3.0	Adc
Total Device Dissipation @ $T_C = 25^\circ C$ Derate above $25^\circ C$	P_D	102 1.2	Watts W/ $^\circ C$
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110	$^\circ C$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Thermal Resistance, Junction to Case	θ_{JC}	0.83	°C/W

*Indicates JEDEC Registered Data.

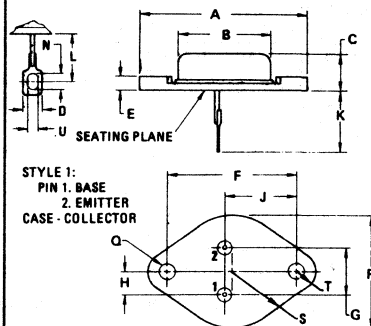
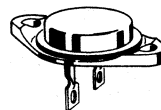
FIGURE 1 – SUSTAINING VOLTAGE TEST CIRCUIT



10 AMPERE

PNP ADE GERMANIUM POWER TRANSISTORS

120 VOLTS
102 WATTS



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	—	39.37	—	1.550
B	—	21.08	—	0.830
C	—	7.62	—	0.300
D	4.32	4.83	0.170	0.190
E	—	3.43	—	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	—	17.27	—	0.680
N	3.30	4.32	0.130	0.170
Q	3.84	4.09	0.151	0.161
R	—	26.67	—	1.050
U	2.03	3.05	0.080	0.120

CASE 4-04

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 100\text{ mAdc}$, $I_B = 0$)	BV_{CEO}	60	-	Vdc
Collector-Emitter Sustaining Voltage (See Figure 1) ($I_C = 5.0\text{ Adc}$, $I_B = 0$)	$V_{CE(sus)}$	60	-	Vdc
Collector-Emitter Cutoff Current ($V_{CE} = 120\text{ Vdc}$, $R_{BE} = 100\text{ Ohms}$)	I_{CER}	-	50	mAdc
*Collector Cutoff Current ($V_{CE} = 100\text{ Vdc}$, $V_{BE(off)} = 0.2\text{ Vdc}$, $T_C = 85^\circ\text{C}$)	I_{CEX}	-	20	mAdc
Collector Cutoff Current ($V_{CB} = 2.0\text{ Vdc}$, $I_E = 0$)	I_{CBO}	-	200	μAdc
*($V_{CB} = 100\text{ Vdc}$, $I_E = 0$)		-	2.0	mAdc
Emitter Cutoff Current ($V_{EB} = 0.75\text{ Vdc}$, $I_C = 0$)	I_{EBO}	-	25	mAdc

ON CHARACTERISTICS

*DC Current Gain ($I_C = 0.6\text{ Adc}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 1.2\text{ Adc}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 5.0\text{ Adc}$, $V_{CE} = 2.0\text{ Vdc}$)	h_{FE}	50 60 50	200 200 120	-
Collector-Emitter Saturation Voltage ($I_C = 5.0\text{ Adc}$, $I_B = 0.5\text{ Adc}$)	$V_{CE(sat)}$	-	0.5	Vdc
*Base-Emitter On Voltage ($I_C = 5.0\text{ Adc}$, $V_{CE} = 2.0\text{ Vdc}$)	$V_{BE(on)}$	-	1.0	Vdc

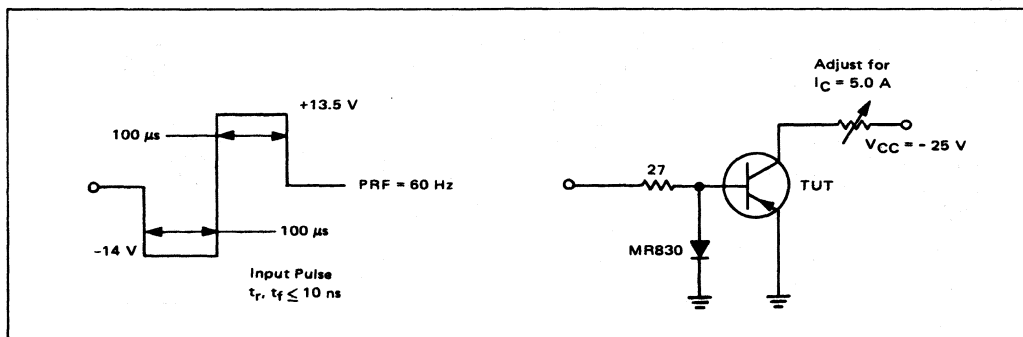
SMALL-SIGNAL CHARACTERISTICS

*Small-Signal Current Gain ($I_C = 0.5\text{ Adc}$, $V_{CE} = 6.0\text{ Vdc}$, $f = 30\text{ kHz}$)	h_{fe}	15	-	-
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SWITCHING CHARACTERISTICS

Rise Time	($I_C = 5.0\text{ Adc}$, $I_{B1} = 0.5\text{ Adc}$, $I_{B2} = 0.5\text{ Adc}$) (See Figure 2)	t_r	-	7.0	μs
Storage Time		t_s	-	10	μs
Fall Time		t_f	-	8.0	μs

*Indicates JEDEC Registered Data.

FIGURE 2 – SWITCHING TIME TEST CIRCUIT

2N2218S, AS, 2N2219S, AS, 2N2221, A(SILICON) 2N2222, A, 2N5581, 2N5582

NPN SILICON ANNULAR HERMETIC TRANSISTORS

... widely used "Industry Standard" transistors for applications as medium-speed switches and as amplifiers from audio to VHF frequencies.

- DC Current Gain Specified — 1.0 to 500 mAdc
- Low Collector-Emitter Saturation Voltage —
 $V_{CE(sat)}$ @ $I_C = 500$ mAdc
 = 1.6 Vdc (Max) — Non-A Suffix
 = 1.0 Vdc (Max) — A-Suffix
- High Current-Gain-Bandwidth Product —
 $f_T = 250$ MHz (Min) @ $I_C = 20$ mAdc — All Types Except
 = 300 MHz (Min) @ $I_C = 20$ mAdc — 2N2219A, 2N2222A, 2N5582
- Complements to PNP 2N2904, A thru 2N2907, A
- JAN, JTX Available in all devices
- JTXV Available on 2N2222, A Series
- 2N2218 and 2N2219 available in TO-39 Package With 1/2" Leads (1)

NPN SILICON SWITCHING AND AMPLIFIER TRANSISTORS

SELECTION GUIDE

Device Type	Characteristic			Package
	BV_{CEO} $I_C = 10$ mAdc Volts	$I_C = 150$ mAdc Min/Max	h_{FE} $I_C = 500$ mAdc Min	
2N2218 2N2219	30	40/120 100/300	20 30	TO-5
2N2221 2N2222	30	40/120 100/300	20 30	TO-18
2N5581 2N5582	40	40/120 100/300	25 40	TO-46
2N2218A 2N2219A	40	40/120 100/300	25 40	TO-5
2N2221A 2N2222A	40	40/120 100/300	25 40	TO-18

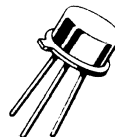
*MAXIMUM RATINGS

Rating	Symbol	2N2218 2N2219 2N2221 2N2222	2N2218A 2N2219A 2N2221A 2N2222A	2N5581 2N5582	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	40	Vdc
Collector-Base Voltage	V_{CB}	60	75	75	Vdc
Emitter-Base Voltage	V_{EB}	5.0	6.0	6.0	Vdc
Collector Current — Continuous	I_C	800	800	800**	mAdc
		2N2218, A 2N2219, A	2N2221, A 2N2222, A	2N5581 2N5582	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.8 5.33	0.5 3.33	0.5 3.33	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	3.0 20	1.8 12	2.0 11.43	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			$^\circ\text{C}$

*Indicates JEDEC Registered Data.

**Motorola Guarantees this Data in Addition to JEDEC Registered Data.

CASE 79 02
TO-39
2N2218, A
2N2219, A



CASE 22 03
TO-18
2N2221, A
2N2222, A



CASE 26-03
TO-46
2N5581
2N5582



***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 10\text{ mA}$, $I_B = 0$)	BV_{CEO}	30 40	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ mA}$, $I_E = 0$)	BV_{CBO}	60 75	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ mA}$, $I_C = 0$)	BV_{EBO}	5.0 6.0	— —	Vdc
Collector Cutoff Current ($V_{CE} = 60\text{ Vdc}$, $V_{EB(\text{off})} = 3.0\text{ Vdc}$)	I_{CEX}	—	10	nAdc
Collector Cutoff Current ($V_{CB} = 50\text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	0.01	μAdc
($V_{CB} = 60\text{ Vdc}$, $I_E = 0$)		—	0.01	
($V_{CB} = 50\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)		—	10	
($V_{CB} = 60\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)		—	10	
Emitter Cutoff Current ($V_{EB} = 3.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	10	nAdc
Base Cutoff Current ($V_{CE} = 60\text{ Vdc}$, $V_{EB(\text{off})} = 3.0\text{ Vdc}$)	I_{BL}	—	20	nAdc
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			
($I_C = 0.1\text{ mA}$, $V_{CE} = 10\text{ Vdc}$)		20	—	
		35	—	
($I_C = 1.0\text{ mA}$, $V_{CE} = 10\text{ Vdc}$)		25	—	
		50	—	
($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ Vdc}$)		35	—	
		75	—	
($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $T_A = -55^\circ\text{C}$)		15	—	
		35	—	
($I_C = 150\text{ mA}$, $V_{CE} = 10\text{ Vdc}$)(1)		40	120	
		100	300	
($I_C = 150\text{ mA}$, $V_{CE} = 1.0\text{ Vdc}$)(1)		20	—	
		50	—	
($I_C = 500\text{ mA}$, $V_{CE} = 10\text{ Vdc}$)(1)		20	—	
		30	—	
		25	—	
		40	—	
Collector-Emitter Saturation Voltage(1) ($I_C = 150\text{ mA}$, $I_B = 15\text{ mA}$)	$V_{CE(\text{sat})}$	— —	0.4 0.3	Vdc
($I_C = 500\text{ mA}$, $I_B = 50\text{ mA}$)		— —	1.6 1.0	
Base-Emitter Saturation Voltage(1) ($I_C = 150\text{ mA}$, $I_B = 15\text{ mA}$)	$V_{BE(\text{sat})}$	0.6 0.6	2.0 1.2	Vdc
($I_C = 500\text{ mA}$, $I_B = 50\text{ mA}$)		— —	2.6 2.0	

* Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS (Continued)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product(2) ($I_C = 20$ mAdc, $V_{CE} = 20$ Vdc, $f = 100$ MHz)	All Types, Except 2N2219A, 2N2222A, 2N5582	f_T	250 300	—	MHz
Output Capacitance(3) ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 100$ kHz)		C_{ob}	—	8.0	pF
Input Capacitance(3) ($V_{EB} = 0.5$ Vdc, $I_C = 0$, $f = 100$ kHz)	Non-A Suffix A-Suffix, 2N5581, 2N5582	C_{ib}	— —	30 25	pF
Input Impedance ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 1.0$ kHz)	2N2218A, 2N2221A, 2N5581 2N2219A, 2N2222A, 2N5582	h_{ie}	1.0 2.0	3.5 8.0	k ohms
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, $f = 1.0$ kHz)	2N2218A, 2N2221A, 2N5581 2N2219A, 2N2222A, 2N5582		0.2 0.25	1.0 1.25	
Voltage Feedback Ratio ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 1.0$ kHz)	2N2218A, 2N2221A, 2N5581 2N2219A, 2N2222A, 2N5582	h_{re}	— —	5.0 8.0	$\times 10^{-4}$
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, $f = 1.0$ kHz)	2N2218A, 2N2221A, 2N5581 2N2219A, 2N2222A, 2N5582		— —	2.5 4.0	
Small-Signal Current Gain ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 1.0$ kHz)	2N2218A, 2N2221A, 2N5581 2N2219A, 2N2222A, 2N5582	h_{fe}	30 50	150 300	—
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, $f = 1.0$ kHz)	2N2218A, 2N2221A, 2N5581 2N2219A, 2N2222A, 2N5582		50 75	300 375	
Output Admittance ($I_C = 1.0$ mAdc, $V_{CE} = 10$ Vdc, $f = 1.0$ kHz)	2N2218A, 2N2221A, 2N5581 2N2219A, 2N2222A, 2N5582	h_{oe}	3.0 5.0	15 35	μ mhos
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, $f = 1.0$ kHz)	2N2218A, 2N2221A, 2N5581 2N2219A, 2N2222A, 2N5582		10 25	100 200	
Collector-Base Time Constant ($I_E = 20$ mAdc, $V_{CB} = 20$ Vdc, $f = 31.8$ MHz)	A-Suffix, 2N5581, 2N5582	$r_b' C_c$	—	150	ps
Noise Figure ($I_C = 100$ μ Adc, $V_{CE} = 10$ Vdc, $R_S = 1.0$ k ohm, $f = 1.0$ kHz)	2N2219A, 2N2222A	NF	—	4.0	dB

SWITCHING CHARACTERISTICS (A-Suffix, 2N5581 and 2N5582)

Delay Time	(VCC = 30 Vdc, $V_{BE}(\text{off}) = 0.5$ Vdc, $I_C = 150$ mAdc, $I_{B1} = 15$ mAdc) (Figure 14)	t_d	—	10	ns
Rise Time		t_r	—	25	ns
Storage Time	(VCC = 30 Vdc, $I_C = 150$ mAdc, $I_{B1} = I_{B2} = 15$ mAdc) (Figure 15)	t_s	—	225	ns
Fall Time		t_f	—	60	ns
Active Region Time Constant** ($I_C = 150$ mAdc, $V_{CE} = 30$ Vdc)		T_A	—	2.5	ns

* Indicates JEDEC Registered Data.

** Motorola Guarantees this Data in Addition to JEDEC Registered Data.

(1) Pulse Test: Pulse Width ≤ 300 μ s, Duty Cycle $\leq 2.0\%$.(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.(3) 2N5581 and 2N5582 are Listed C_{cb} and C_{eb} for these conditions and values.

FIGURE 1 – NORMALIZED DC CURRENT GAIN

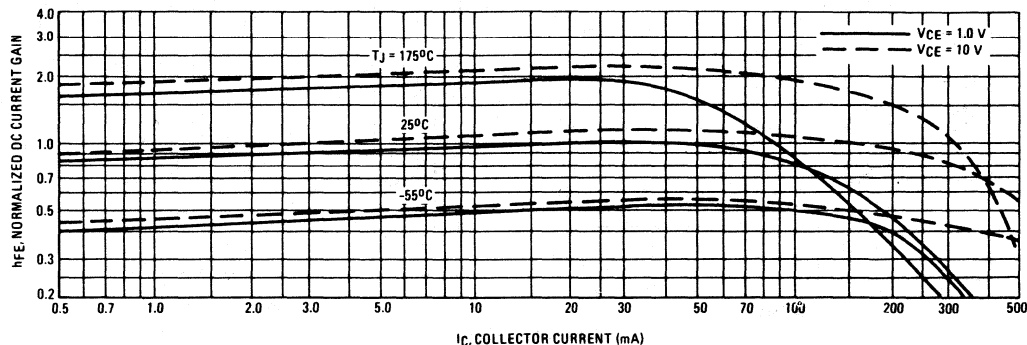
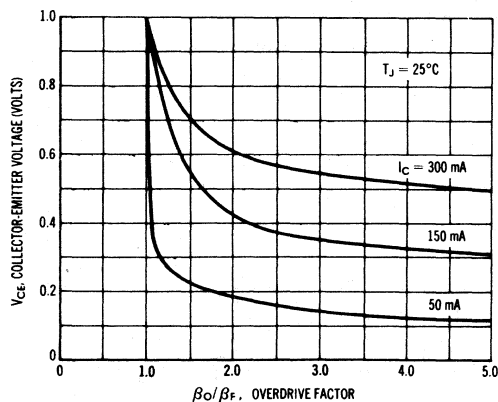


FIGURE 2 – COLLECTOR CHARACTERISTICS IN SATURATION REGION



This graph shows the effect of base current on collector current. β_o (current gain at the edge of saturation) is the current gain of the transistor at 1 volt, and β_f (forced gain) is the ratio of I_c/I_B in a circuit.

EXAMPLE: For type 2N2219, estimate a base current (I_B) to insure saturation at a temperature of 25°C and a collector current of 150 mA.

Observe that at $I_c = 150$ mA an overdrive factor of at least 2.5 is required to drive the transistor well into the saturation region. From Figure 1, it is seen that h_{FE} @ 1 volt is approximately 0.62 of h_{FE} @ 10 volts. Using the guaranteed minimum gain of 100 @ 150 mA and 10 V, $\beta_o = 62$ and substituting values in the overdrive equation, we find:

$$\frac{\beta_o}{\beta_f} = \frac{h_{FE} @ 1.0 \text{ V}}{I_c / I_B} \quad 2.5 = \frac{62}{150 / I_B} \quad I_B \approx 6.0 \text{ mA}$$

FIGURE 3 – "ON" VOLTAGES

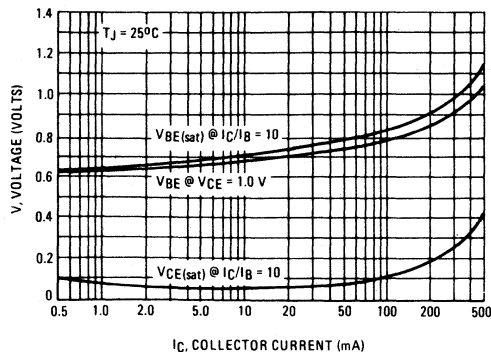
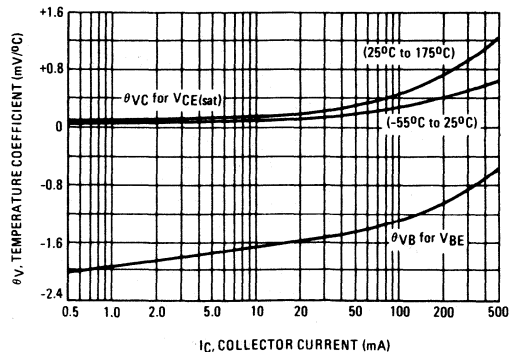


FIGURE 4 – TEMPERATURE COEFFICIENTS



NOISE FIGURE

$V_{CE} = 10 \text{ V}$, $T_A = 25^\circ\text{C}$

FIGURE 5 – FREQUENCY EFFECTS

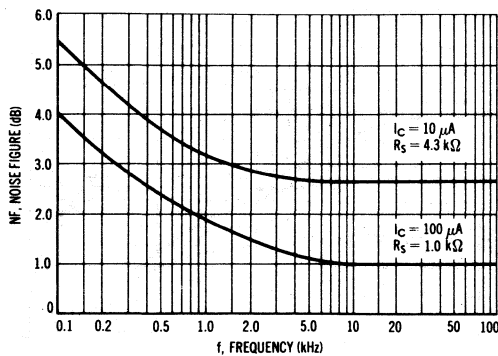
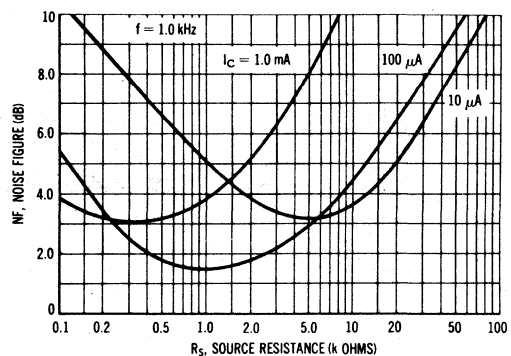


FIGURE 6 – SOURCE RESISTANCE EFFECTS



h PARAMETERS

$V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$, $T_A = 25^\circ\text{C}$

This group of graphs illustrates the relationship between h_{fe} and other "h" parameters for this series of transistors. To obtain these curves, a high-gain and a low-gain unit were selected and the same units were used to develop the correspondingly numbered curves on each graph.

FIGURE 7 – INPUT IMPEDANCE

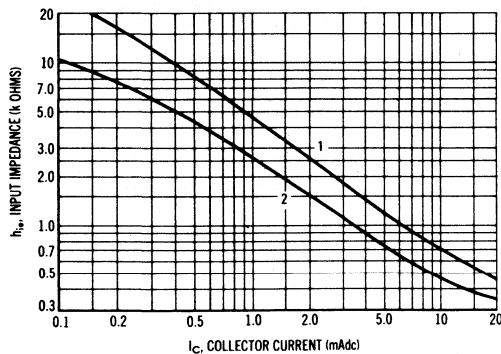


FIGURE 8 – VOLTAGE FEEDBACK RATIO

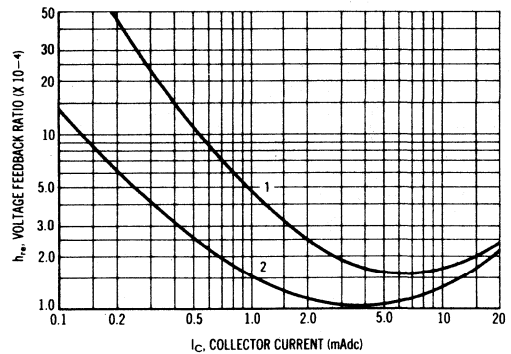


FIGURE 9 – CURRENT GAIN

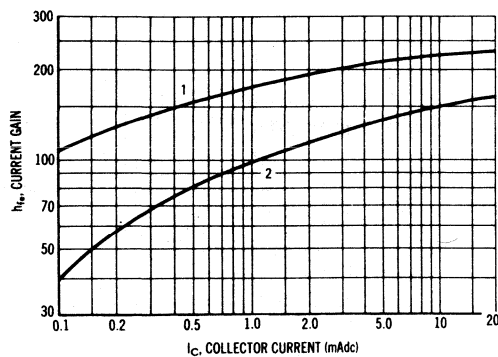
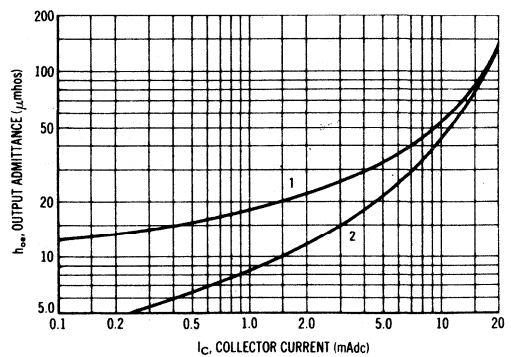


FIGURE 10 – OUTPUT ADMITTANCE



SWITCHING TIME CHARACTERISTICS

FIGURE 11 – TURN-ON TIME

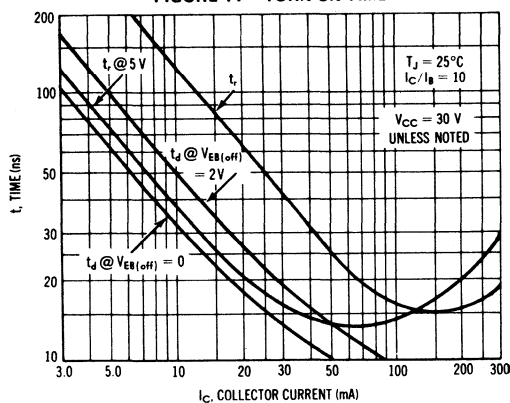


FIGURE 12 – CHARGE DATA

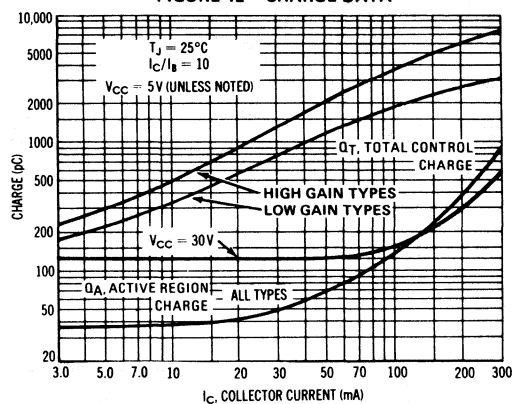


FIGURE 13 – TURN OFF BEHAVIOR

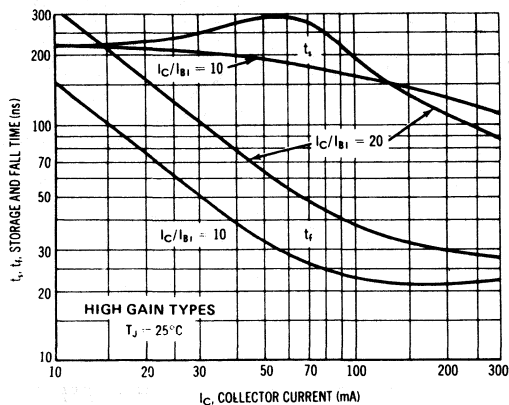
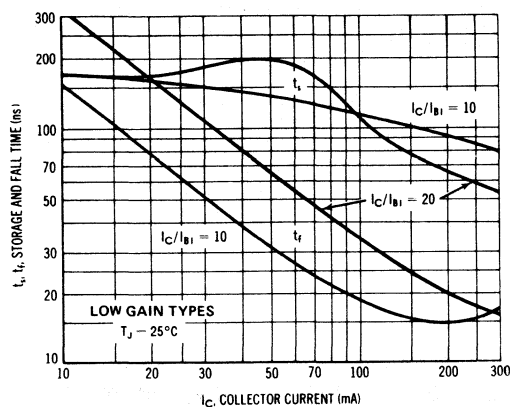


FIGURE 14 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

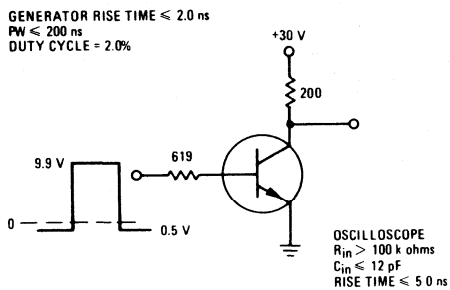


FIGURE 15 – STORAGE TIME AND FALL TIME EQUIVALENT TEST CIRCUIT

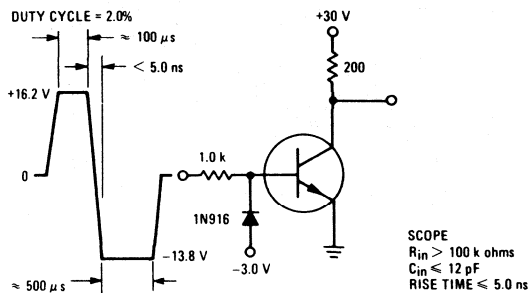


FIGURE 16 – CURRENT-GAIN-BANDWIDTH PRODUCT AND COLLECTOR-BASE TIME CONSTANT DATA

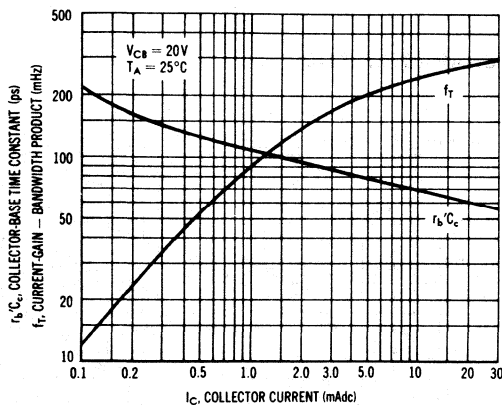


FIGURE 17 – CAPACITANCES

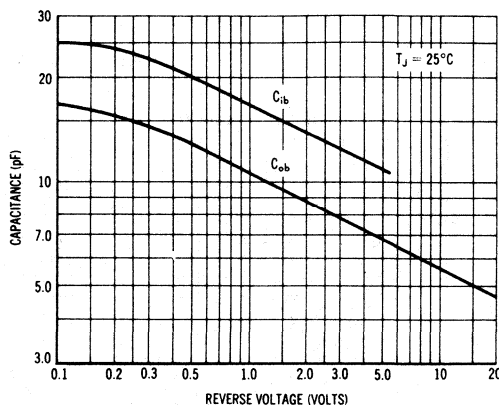
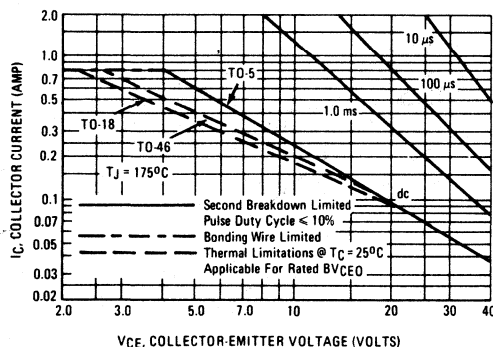


FIGURE 18 – ACTIVE-REGION SAFE OPERATING AREAS

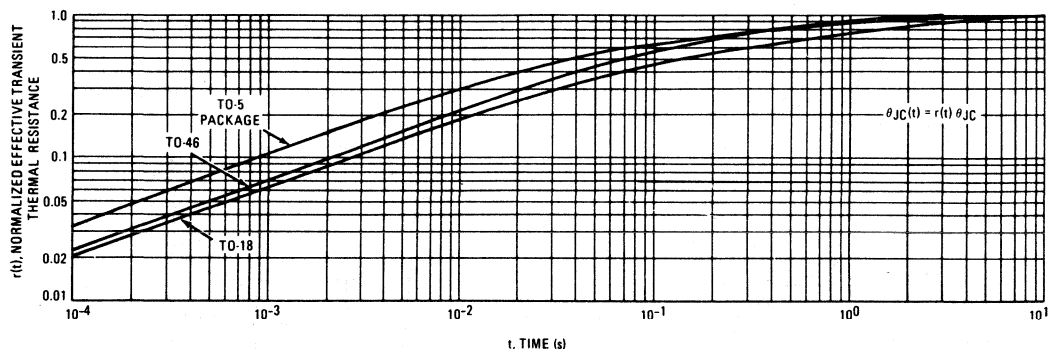


This graph shows the maximum I_C - V_{CE} limits of the device both from the standpoint of thermal dissipation (at 25°C case temperature), and secondary breakdown. For case temperatures other than 25°C, the thermal dissipation curve must be modified in accordance with the derating factor in the Maximum Ratings table.

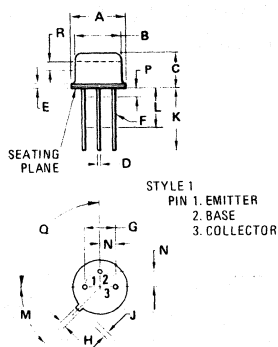
To avoid possible device failure, the collector load line must fall below the limits indicated by the applicable curve. Thus, for certain operating conditions the device is thermally limited, and for others it is limited by secondary breakdown.

For pulse applications, the maximum I_C - V_{CE} product indicated by the dc thermal limits can be exceeded. Pulse thermal limits may be calculated by using the transient thermal resistance curve of Figure 19.

FIGURE 19 – THERMAL RESPONSE



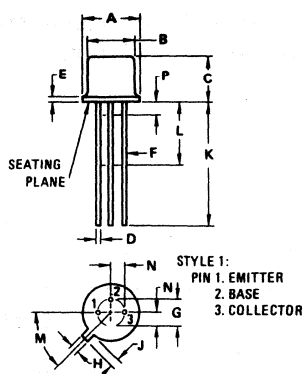
OUTLINE DIMENSIONS



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° NOM	45° NOM	—	—
P	—	1.27	—	0.050
Q	90° NOM	90° NOM	—	—
R	2.54	—	0.100	—

All JEDEC dimensions and notes apply.

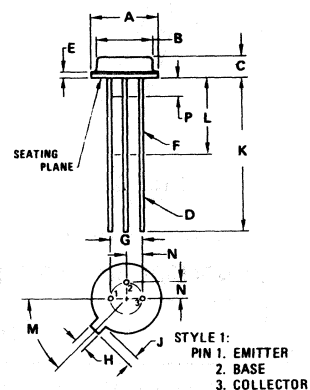
CASE 79-02
TO-39



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	—	0.762	—	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC	—	0.100 BSC	—
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC	45° BSC	—	—
N	1.27 BSC	—	0.050 BSC	—
P	—	1.27	—	0.050

All JEDEC notes and dimensions apply.

CASE 22
TO-18



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	1.65	2.16	0.065	0.085
D	0.406	0.533	0.016	0.021
E	—	1.02	—	0.040
F	0.305	0.483	0.012	0.019
G	2.54 BSC	—	0.100 BSC	—
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC	45° BSC	—	—
N	1.27 BSC	—	0.050 BSC	—
P	—	1.27	—	0.050

All JEDEC dimensions and notes apply.

CASE 26
TO-46

2N2223, A

For Specifications, See 2N2060 Data.

2N2224 (SILICON)



NPN silicon annular transistor designed primarily for high speed switching applications.

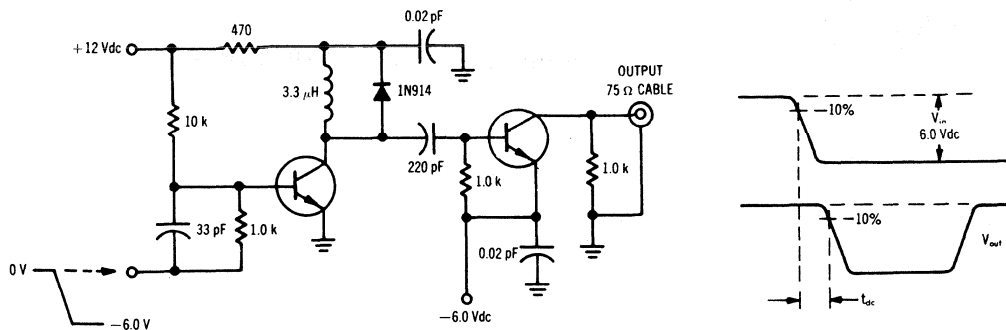
CASE 31 (TO-5)

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	65	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current-Continuous	I_C	0.5	Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.8 5.33	W mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	3.0 20	Watts mW/ $^\circ\text{C}$
Operating Junction Temperature	T_J	+175	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

FIGURE 1



ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
----------------	--------	-----	-----	------

OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage ($I_C = 10\text{ mAdc}$, $I_B = 0$)	BV_{CEO}	40	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	65	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	5.0	-	Vdc
Collector-Cutoff Current ($V_{CB} = 50\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 50\text{ Vdc}$, $I_E = 0$, $T_A = +150^\circ\text{C}$)	I_{CBO}	- -	0.01 10	μAdc
Emitter Cutoff Current ($V_{EB} = 4.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	-	1.0	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 0.1\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 100\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$)	h_{FE}	20 25 35 40	- - 115 120	-
Collector-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$)	$V_{CE(sat)}$	-	0.4	Vdc
Base-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$)	$V_{BE(sat)}$	-	1.3	Vdc

DYNAMIC CHARACTERISTICS

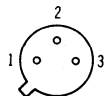
Current-Gain-Bandwidth Product ($I_C = 20\text{ mAdc}$, $V_{CE} = 20\text{ Vdc}$, $f = 100\text{ MHz}$) ($I_C = 80\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	250 160	- -	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$)	C_{ob}	-	8.0	pF
Circuit Delay (Figure 1) ($T_A = 25^\circ\text{C}$)	t_{dc}	-	15	ns
Circuit Delay - Total Change (Figure 1) ($T_A = +10^\circ\text{C}$ to $T_A = +25^\circ\text{C}$)	Δt_{dc}	-	15	ns

⁽¹⁾ Pulse Test: $PW < 300\text{ }\mu\text{s}$, Duty Cycle $< 2.0\%$

2N2242 (SILICON)



CASE 22
(TO-18)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

NPN silicon annular transistor designed for high-speed, low-power saturated switching applications.

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	225	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	360 2.06	mWatts mW/ $^\circ\text{C}$
Junction Temperature — Operating	T_J	-65 to +200	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

* Indicates JEDEC Registered Data

FIGURE 1 — SWITCHING TIME TEST CIRCUIT

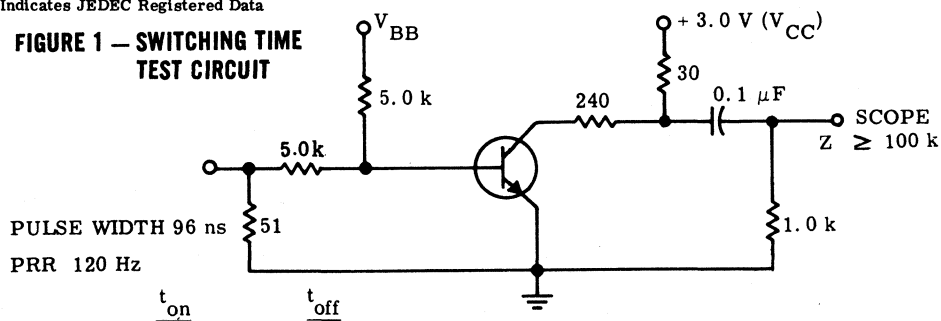
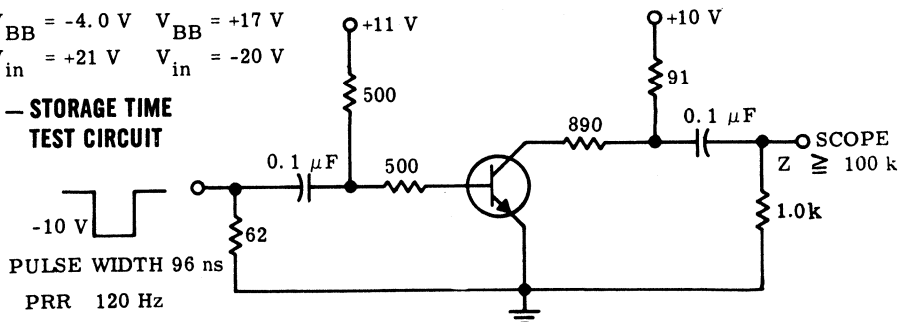


FIGURE 2 — STORAGE TIME TEST CIRCUIT



***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 30\text{ mAdc}$, $I_E = 0$)	BV_{CEO}	15	-	Vdc
Collector-Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 30\text{ mAdc}$, $R_{BE} = \sim 10\text{ ohms}$)	BV_{CER}	20	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 1.0\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current ($V_{CE} = 20\text{ Vdc}$, $V_{EB(off)} = 0.25\text{ Vdc}$, $T_A = 125^\circ\text{C}$)	I_{CEX}	-	10	μAdc
Collector Cutoff Current ($V_{CB} = 20\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 20\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	- -	0.1 15	μAdc
Emitter Cutoff Current ($V_{EB(off)} = 4.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	-	0.1	μAdc

ON CHARACTERISTICS

DC Current Gain ⁽¹⁾ ($I_C = 10\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$, $T_A = -55^\circ\text{C}$)	h_{FE}	40 20	120 -	-
Collector-Emitter Saturation Voltage ($I_C = 100\text{ mAdc}$, $I_B = 10\text{ mAdc}$) ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$, $T_A = -55\text{ to }+125^\circ\text{C}$)	$V_{CE(sat)}$	- -	0.7 0.3	Vdc
Base-Emitter Saturation Voltage ($I_C = 100\text{ mAdc}$, $I_B = 10\text{ mAdc}$) ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$, $T_A = 125^\circ\text{C}$)	$V_{BE(sat)}$	- -	1.5 0.8	Vdc

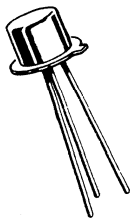
DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 20\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	250	-	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{ob}	-	6.0	pF
Turn-On Time (Figure 1) ($V_{CC} = 3.0\text{ Vdc}$, $V_{BE(off)} = -2.0\text{ Vdc}$, $I_{B1} = 3.0\text{ mAdc}$, $I_C = 10\text{ mAdc}$)	t_{on}	-	30	ns
Turn-Off Time (Figure 1) ($V_{CC} = 3.0\text{ Vdc}$, $I_C = 10\text{ mAdc}$, $I_{B1} = 3.0\text{ mAdc}$, $I_{B2} = 1.0\text{ mAdc}$)	t_{off}	-	50	ns
Storage Time (Figure 2) ($I_C = 10\text{ mAdc}$, $I_{B1} = I_{B2} = 10\text{ mAdc}$)	t_s	-	25	ns

*Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width = $300\text{ }\mu\text{s}$; Duty Cycle = $\sim 2\%$

2N2256, 2N2257 (SILICON)



NPN silicon and PNP germanium mesa complementary transistors for high-speed non-saturated switching applications.

CASE 22
(TO-18)

Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	2N2256 2N2257	Unit
Collector-Emitter Voltage	V_{CEO}	7.0	Vdc
Collector-Base Voltage	V_{CB}	7.0	Vdc
Emitter-Base Voltage	V_{EB}	1.0	Vdc
Collector Current-Continuous	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25^{\circ}\text{C}$ Derate above 25°C	P_D	300 2.0	mW mW/ $^{\circ}\text{C}$
Total Device Dissipation @ $T_C = 25^{\circ}\text{C}$ Derate above 25°C	P_D	1000 6.67	mW mW/ $^{\circ}\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	$^{\circ}\text{C}$

* Indicates JEDEC Registered Data

TRANSISTOR SELECTION CHART

TYPE	TYPE		$h_{FE} @ I_C = 25 \text{ mA}$	
	NPN	PNP	20	40
2N2256	X		X	
2N2257	X			X

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu\text{Adc}$, $V_{BE} = 0$)	BV_{CES}	7.0	15	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	7.0	15	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	1.0	-	-	Vdc
Collector Cutoff Current ($V_{CB} = 6\ \text{Vdc}$, $I_E = 0$) ($V_{CB} = 6\ \text{Vdc}$, $I_E = 0$, $T_A = 65^\circ\text{C}$)	I_{CBO}	- -	3.0 30	10 100	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 10\ \text{mAdc}$, $V_{CE} = 1\ \text{Vdc}$) ($I_C = 25\ \text{mAdc}$, $V_{CE} = 1\ \text{Vdc}$)	2N2256 2N2257 2N2256 2N2257	h_{FE}	17 40 20 40	30 50 35 55	- - - -	-
Base-Emitter On Voltage ($I_C = 10\ \text{mAdc}$, $V_{CE} = 1\ \text{Vdc}$) ($I_C = 25\ \text{mAdc}$, $V_{CE} = 1\ \text{Vdc}$)		$V_{BE(on)}$	- -	0.70 0.8	0.8 0.9	Vdc
Conduction Threshold Base-Emitter Voltage(1) ($I_C = 200\ \mu\text{Adc}$, $V_{CE} = 1\ \text{Vdc}$)		V_T	0.5	-	-	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 10\ \text{mAdc}$, $V_{CE} = 15\ \text{Vdc}$, $f = 100\ \text{MHz}$)	f_T	250	320	-	MHz
Output Capacitance ($V_{CB} = 5\ \text{Vdc}$, $I_E = 0$, $f = 4\ \text{MHz}$)	C_{ob}	-	4.0	5.0	pF
Base Resistance ($I_E = 5\ \text{mAdc}$, $V_{CB} = 2\ \text{Vdc}$, $f = 300\ \text{MHz}$)	r'_b	-	50	100	Ohms
Turn-On Time(1)	t_{on}	-	3.0	7.0	ns
Turn-Off Time(1)	t_{off}	-	4.0	7.0	ns

(1) Base-to-emitter forward bias voltage at which transistor will be at the threshold of conduction; i. e. that base-to-emitter voltage at which the collector current is less than or equal to the specified amount under a given collector-to-emitter voltage condition.

* Indicates JEDEC Registered Data

FIGURE 1 — NPN SWITCHING TIME TEST CIRCUIT

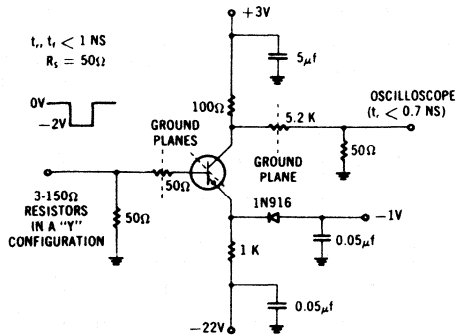


FIGURE 2 — CASCADE COMPLEMENTARY GATE

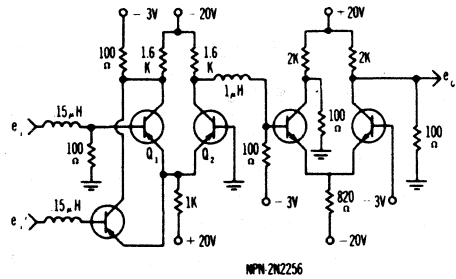


FIGURE 3 — CURRENT MODE INVERTER FOR USE WITH DIODE LOGIC PROPAGATION DELAY TIME 10 ns

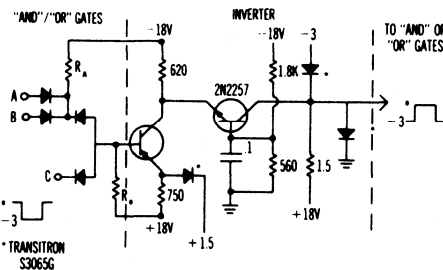


FIGURE 4 — CURRENT GAIN CHARACTERISTICS

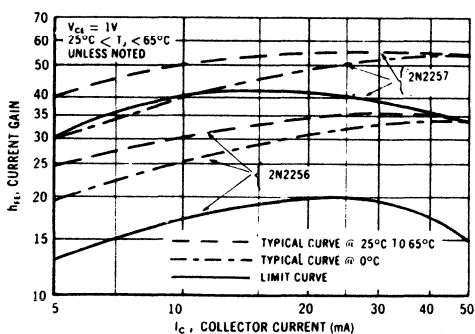
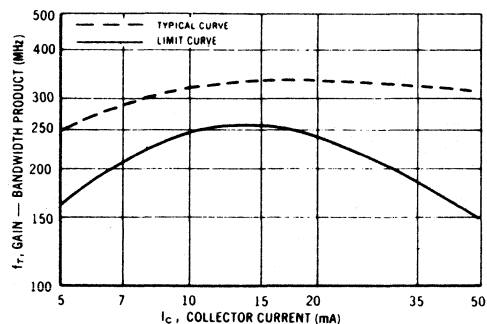


FIGURE 5 — CURRENT GAIN-BANDWIDTH PRODUCT CHARACTERISTICS

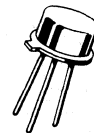


NPN SILICON ANNULAR HIGH-CURRENT AMPLIFIER TRANSISTOR

... designed for use in amplifier applications.

- Collector-Emitter Sustaining Voltage –
 $BV_{CEO(sus)} = 45 \text{ Vdc (Min) @ } I_C = 100 \text{ mAdc}$
- High-Current-Gain–Bandwidth Product –
 $f_T = 250 \text{ MHz (Typ) @ } I_C = 50 \text{ mAdc}$

NPN SILICON AMPLIFIER TRANSISTOR



*MAXIMUM RATINGS

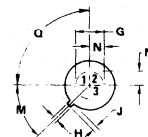
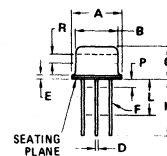
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Emitter Voltage, $R_{BE} \leq 10 \text{ Ohms}$	V_{CER}	60	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Collector Current – Continuous	I_C	1.0	Adc
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 5.71	Watt mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	5.0 28.6	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}(1)$	175	$^\circ\text{C/W}$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	$^\circ\text{C/W}$

*Indicates JEDEC Registered Data.

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	46°	NOM	45°	NOM
P	—	1.27	—	0.050
Q	90°	NOM	90°	NOM
R	2.54	—	0.100	—

CASE 79-02
TO-39

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) ($I_C = 100\text{ mAdc}$, $I_B = 0$)	$V_{CEO(sus)}$	45	—	—	Vdc
Collector-Emitter Breakdown Voltage (1) ($I_C = 100\text{ mAdc}$, $R_{BE} \leq 10\text{ Ohms}$)	BV_{CER}	60	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.05\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1\text{ mAdc}$, $I_C = 0$)	BV_{EBO}	7.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 60\text{ Vdc}$, $I_E = 0$, $T_L = 25^\circ\text{C}$) ($V_{CB} = 60\text{ Vdc}$, $I_E = 0$, $T_C = 150^\circ\text{C}$)	I_{CBO}	—	—	0.05 50	μAdc
Emitter Cutoff Current ($V_{BE} = 5.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	—	100	nAdc

ON CHARACTERISTICS

DC Current Gain (1) ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 150\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$)	h_{FE}	30 50	90 135	— 200	—
Collector-Emitter Saturation Voltage ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$)	$V_{CE(sat)}$	—	0.3	0.9	Vdc
Base-Emitter Saturation Voltage ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$)	$V_{BE(sat)}$	—	0.75	1.2	Vdc

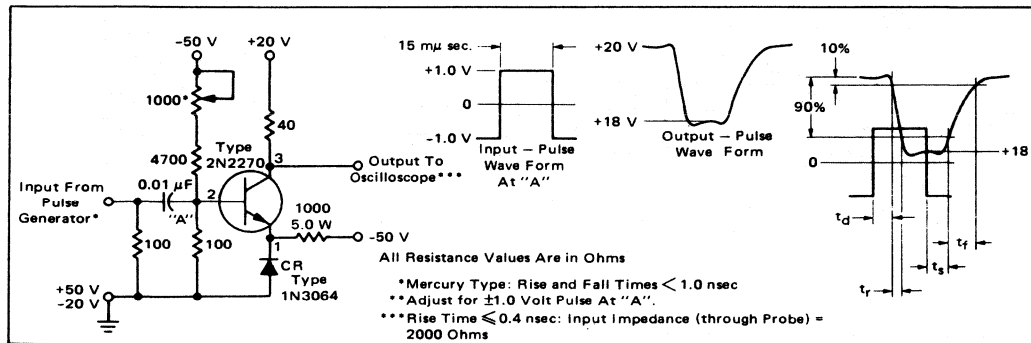
DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 50\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 20\text{ MHz}$)	f_T	100	250	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)	C_{ob}	—	10	15	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)	C_{ib}	—	60	80	pF
Small-Signal Current Gain ($I_C = 5.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	50	—	275	—
Noise Figure ($I_C = 0.3\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $R_S = 1.0\text{ k Ohm}$, $f = 1.0\text{ kHz}$, B.W. = 1.0 Hz)	NF	—	7.0	10	dB

SWITCHING CHARACTERISTICS

Total Switching Time (Figure 1)	$t_{on} + t_{off}$	—	—	30	ns
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*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.**FIGURE 1 – SWITCHING TIME TEST CIRCUIT**

PNP GERMANIUM AMPLIFIER TRANSISTOR

... designed for military VHF amplifier applications.

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	15	Vdc
Collector-Emitter Voltage	V_{CES}	25	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	1.0	Vdc
Collector Current — Continuous	I_C	100	mA dc
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	150 2.0	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100	$^\circ\text{C}$

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 200 \mu\text{A dc}$, $V_{BE} = 0$)	BV_{CES}	25	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{A dc}$, $I_E = 0$)	BV_{CBO}	25	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{A dc}$, $I_C = 0$)	BV_{EBO}	1.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 12 \text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	10	$\mu\text{A dc}$

ON CHARACTERISTICS

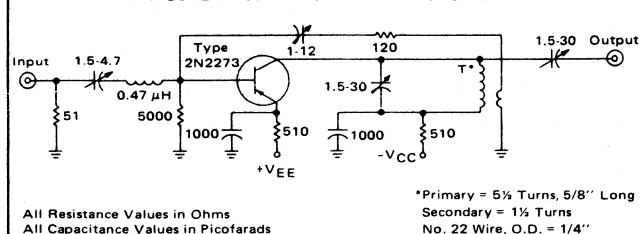
DC Current Gain ($I_C = 1.0 \text{ mA dc}$, $V_{CE} = 10 \text{ Vdc}$)	h_{FE}	20	75	—
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DYNAMIC CHARACTERISTICS

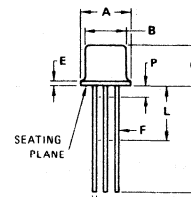
Current Gain—Bandwidth Product ($I_C = 1.0 \text{ mA dc}$, $V_{CE} = 6.0 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	250	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 1.0 \text{ MHz}$)	C_{ob}	—	3.5	pF
Small-Signal Current Gain ($I_C = 1.0 \text{ mA dc}$, $V_{CE} = 6.0 \text{ Vdc}$, $f = 10 \text{ MHz}$)	h_{fe}	20	28	—
Extrinsic Base Resistance ($I_C = 1.0 \text{ mA dc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 250 \text{ MHz}$)	r_b	—	250	Ohms
Noise Figure ($I_C = 1.0 \text{ mA dc}$, $V_{CB} = 10 \text{ Vdc}$, $R_G = 50 \text{ Ohms}$, $f = 10 \text{ MHz}$)	NF	—	12	dB

*Indicates JEDEC Registered Data.

FIGURE 1 — 30 MHz POWER GAIN TEST CIRCUIT



PNP GERMANIUM AMPLIFIER TRANSISTOR



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	—	0.762	—	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC	—	0.100 BSC	—
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC	—	45° BSC	—
N	1.27 BSC	—	0.050 BSC	—
P	—	1.27	—	0.050

All JEDEC notes and dimensions apply.

CASE 22-03
(TO-18)

2N2285 thru 2N2287

For Specifications, See 2N1651 Data.

2N2288, 2N2289 (GERMANIUM)
2N2290

PNP GERMANIUM POWER SWITCHING
TRANSISTORS

... designed for fast-switching applications requiring low saturation
voltage and excellent collector-emitter sustaining voltage capability.

- Alloy-Diffused Epitaxial Construction
- Low Saturation Voltages –
 $V_{CE(sat)} = 0.5 \text{ Vdc (Max) @ } I_C = 5.0 \text{ Adc}$
 $V_{BE(sat)} = 1.0 \text{ Vdc (Max) @ } I_C = 5.0 \text{ Adc}$

10 AMPERE
POWER TRANSISTORS
PNP ADE GERMANIUM

40-120 VOLTS
70 WATTS

MAXIMUM RATINGS

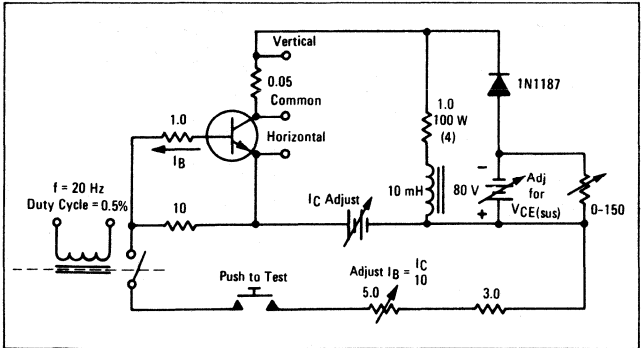
Rating	Symbol	2N2288	2N2289	2N2290	Unit
*Collector-Emitter Voltage ($R_{BE} = 100 \text{ Ohms}$)	V_{CER}	40	80	120	Vdc
*Collector-Base Voltage	V_{CB}	40	80	120	Vdc
*Emitter-Base Voltage	V_{EB}	$\longleftrightarrow 0.75 \longleftrightarrow$			Vdc
*Collector Current - Continuous	I_C	$\longleftrightarrow 10 \longleftrightarrow$			Adc
Base Current - Continuous	I_B	$\longleftrightarrow 3.0 \longleftrightarrow$			Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ *Derate above 25°C	P_D	$\longleftrightarrow 70 \text{ or } 0.833 \longleftrightarrow$			Watts W. $^\circ\text{C}$
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	$\longleftrightarrow -65 \text{ to } +110 \longleftrightarrow$			$^\circ\text{C}$

THERMAL CHARACTERISTICS

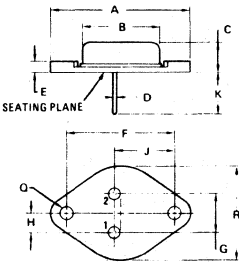
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.2	$^\circ\text{C/W}$

*Indicates JEDEC Registered Data.

FIGURE 1 – SUSTAINING VOLTAGE TEST CIRCUIT



STYLE 1
PIN 1 BASE
2 EMITTER
CASE COLLECTOR



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	—	39.37	—	1.550
B	—	21.08	—	0.830
C	—	7.62	—	0.300
D	1.22	1.32	0.048	0.052
E	—	3.43	—	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	8.13	10.67	0.320	0.420
L	3.84	4.09	0.151	0.161
R	—	26.67	—	1.050

Collector connected to case
CASE 11A

2N2288, 2N2289, 2N2290 (continued)

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 100\text{ mA}$, $I_B = 0$)	BV_{CEO}	30 50 70	- - -	Vdc
Collector-Emitter Sustaining Voltage (See Figure 1) ($I_C = 5.0\text{ A}$)	$V_{CE(sus)}$	30 50 70	- - -	Vdc
*Collector-Emitter Breakdown Voltage ($I_C = 50\text{ mA}$, $R_{BE} = 100\text{ Ohms}$)	BV_{CER}	40 80 120	- - -	Vdc
*Collector Cutoff Current ($V_{CE} = 15\text{ Vdc}$, $I_B = 0$) ($V_{CE} = 25\text{ Vdc}$, $I_B = 0$) ($V_{CE} = 35\text{ Vdc}$, $I_B = 0$)	I_{CEO}	- - -	50 50 50	mA
*Collector Cutoff Current ($V_{CE} = 40\text{ Vdc}$, $V_{BE(off)} = 0.1\text{ Vdc}$, $T_C = 100^\circ\text{C}, +0, -3.0^\circ\text{C}$) ($V_{CE} = 80\text{ Vdc}$, $V_{BE(off)} = 0.1\text{ Vdc}$, $T_C = 100^\circ\text{C}, +0, -3.0^\circ\text{C}$) ($V_{CE} = 120\text{ Vdc}$, $V_{BE(off)} = 0.1\text{ Vdc}$, $T_C = 100^\circ\text{C}, +0, -3.0^\circ\text{C}$)	I_{CEX}	- - -	35 35 35	mA
Collector Cutoff Current ($V_{CB} = 2.0\text{ Vdc}$, $I_E = 0$) *($V_{CB} = 40\text{ Vdc}$, $I_E = 0$) *($V_{CB} = 80\text{ Vdc}$, $I_E = 0$) *($V_{CB} = 120\text{ Vdc}$, $I_E = 0$)	I_{CBO}	- - - -	200 5.0 5.0 5.0	μA mA
Emitter Cutoff Current ($V_{EB} = 0.75\text{ Vdc}$, $I_C = 0$)	I_{EBO}	-	25	mA

ON CHARACTERISTICS

*DC Current Gain ($I_C = 2.0\text{ A}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 5.0\text{ A}$, $V_{CE} = 2.0\text{ Vdc}$)	h_{FE}	20 20	- 60	-
Collector-Emitter Saturation Voltage ($I_C = 5.0\text{ A}$, $I_B = 0.5\text{ A}$)	$V_{CE(sat)}$	-	0.5	Vdc
*Base-Emitter Saturation Voltage ($I_C = 5.0\text{ A}$, $I_B = 0.5\text{ A}$)	$V_{BE(sat)}$	-	1.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

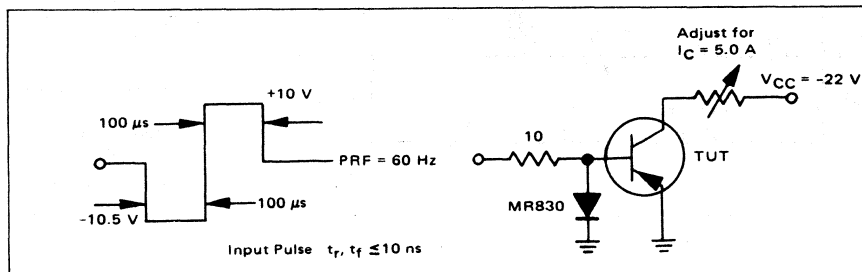
*Small-Signal Current Gain ($I_C = 0.5\text{ A}$, $V_{CE} = 14\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 0.5\text{ A}$, $V_{CE} = 6.0\text{ Vdc}$, $f = 30\text{ kHz}$)	h_{fe}	25 15	100 -	-
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SWITCHING CHARACTERISTICS

Rise Time	$I_C = 5.0\text{ A}$, $I_{B1} = I_{B2} = 1.0\text{ A}$ (See Figure 2)	t_r	-	5.0	μs
Storage Time		t_s	-	7.0	μs
Fall Time		t_f	-	8.0	μs

*Indicates JEDEC Registered Data.

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



$_{2N}2293$

PNP GERMANIUM POWER SWITCHING TRANSISTORS

... designed for fast switching applications requiring low saturation voltage and excellent collector-emitter sustaining voltage capability.

- Alloy-Diffused Epitaxial Construction
- Low Saturation Voltages –
 $V_{CE(sat)} = 0.5 \text{ Vdc @ } I_C = 5.0 \text{ Adc}$
 $V_{BE(sat)} = 1.0 \text{ Vdc @ } I_C = 5.0 \text{ Adc}$

MAXIMUM RATINGS

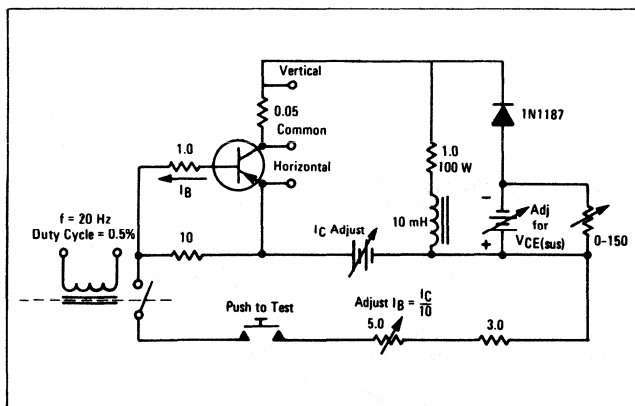
Rating	Symbol	2N291	2N292	2N293	Unit
*Collector-Emitter Voltage	V_{CEO}	30	50	70	Vdc
*Collector-Base Voltage	V_{CB}	40	80	120	Vdc
*Emitter-Base Voltage	V_{EB}	← 1.5 →			Vdc
*Collector Current - Continuous	I_C	← 10 →			Adc
*Base Current - Continuous	I_B	← 3.0 →			Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	← 70 →	← 0.83 →		Watts $W/^\circ\text{C}$
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +110 →			$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.2	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 – SUSTAINING VOLTAGE TEST CIRCUIT

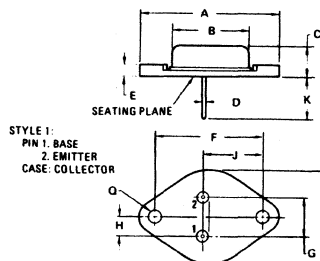


10 AMPERE

POWER TRANSISTORS
PNP ADE GERMANIUM

40-120 VOLTS
70 WATTS

DS 85



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	-	35.37	-	1.550
B	-	21.08	-	0.830
C	-	7.62	-	0.300
D	1.22	1.32	0.048	0.052
E	-	3.43	-	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.84	17.15	0.655	0.675
K	8.13	10.67	0.320	0.420
Q	3.84	4.08	0.151	0.161
R	-	26.67	-	1.050

Collector Connected to Case

CASE 11A
(TO-3)

Except Pin Diameter

2N2291, 2N2292, 2N2293 (continued)

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 100\text{ mA}$, $I_B = 0$)	BV_{CEO}	30 50 70	- - -	Vdc
*Collector-Emitter Sustaining Voltage (See Figure 1) *($I_C = 500\text{ mA}$)	$V_{CE(sus)}$	30 50 70	- - -	Vdc
**($I_C = 5.0\text{ A}$)		25 50 70	- - -	
*Collector-Emitter Breakdown Voltage ($I_C = 50\text{ mA}$, $R_{BE} = 100\text{ ohms}$)	BV_{CER}	40 80 120	- - -	Vdc
*Collector Cutoff Current ($V_{CE} = 15\text{ Vdc}$, $I_B = 0$) ($V_{CE} = 25\text{ Vdc}$, $I_B = 0$) ($V_{CE} = 35\text{ Vdc}$, $I_B = 0$)	I_{CEO}	- - -	50 50 50	mA
*Collector Cutoff Current ($V_{CE} = 40\text{ Vdc}$, $V_{BE(off)} = 0.1\text{ Vdc}$, $T_C = 100^\circ\text{C}$) ($V_{CE} = 80\text{ Vdc}$, $V_{BE(off)} = 0.1\text{ Vdc}$, $T_C = 100^\circ\text{C}$) ($V_{CE} = 120\text{ Vdc}$, $V_{BE(off)} = 0.1\text{ Vdc}$, $T_C = 100^\circ\text{C}$)	I_{CEX}	- - -	35 35 35	mA
Collector Cutoff Current *($V_{CB} = -2.0\text{ Vdc}$, $I_E = 0$) *($V_{CB} = 40\text{ Vdc}$, $I_E = 0$) *($V_{CB} = 80\text{ Vdc}$, $I_E = 0$) *($V_{CB} = 120\text{ Vdc}$, $I_E = 0$)	I_{CBO}	- - - -	200 5.0 5.0 5.0	μA mA
Emitter Cutoff Current ($V_{EB} = 1.5\text{ Vdc}$, $I_C = 0$)	I_{EBO}	-	50	mA

ON CHARACTERISTICS

*DC Current Gain ($I_C = 2.0\text{ A}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 5.0\text{ A}$, $V_{CE} = 2.0\text{ Vdc}$)	h_{FE}	40 50	- 120	-
Collector-Emitter Saturation Voltage ($I_C = 5.0\text{ A}$, $I_B = 0.5\text{ A}$)	$V_{CE(sat)}$	-	0.5	Vdc
*Base-Emitter Saturation Voltage ($I_C = 5.0\text{ A}$, $I_B = 0.5\text{ A}$)	$V_{BE(sat)}$	-	1.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

*Small-Signal Current Gain ($I_C = 0.5\text{ A}$, $V_{CE} = 14\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 0.5\text{ A}$, $V_{CE} = 6.0\text{ Vdc}$, $f = 30\text{ kHz}$)	h_{fe}	50 15	200 -	-
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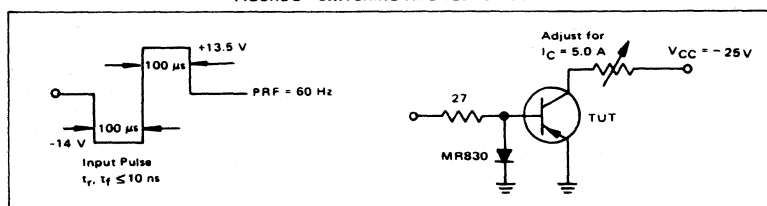
SWITCHING CHARACTERISTICS

Rise Time	$(I_C = 5.0\text{ A}$, $I_{B1} = I_{B2} = 0.5\text{ A}$) (See Figure 2)	t_r	-	7.0	μs
Storage Time		t_s	-	10	μs
Fall Time		t_f	-	8.0	μs

*Indicates JEDEC Registered Data.

**Motorola guarantees this data in addition to the JEDEC Registered Data Shown.

FIGURE 2 - SWITCHING TIME TEST CIRCUIT



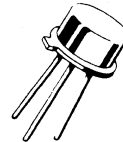
2N2297S (SILICON)

NPN SILICON ANNULAR HIGH-CURRENT AMPLIFIER TRANSISTOR

... designed for use in medium-current amplifier applications.

- Collector-Emitter Sustaining Voltage –
BVCEO(sus) = 35 Vdc (Min) @ IC = 30 mAdc
- Current-Gain – Bandwidth Product –
fT = 100 MHz (Typ) @ IC = 50 mAdc
- DC Current Gain – 10 mAdc to 1.0 Adc

NPN SILICON AMPLIFIER TRANSISTOR



*MAXIMUM RATINGS

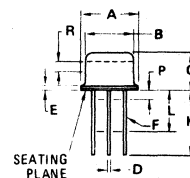
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO	35	Vdc
Collector-Base Voltage	VCB	80	Vdc
Emitter-Base Voltage	VEB	7.0	Vdc
Collector Current – Continuous	IC	1.0	Adc
Total Power Dissipation @ TA = 25°C Derate above 25°C	PD	800 4.56	mW mW/°C
Total Power Dissipation @ TC = 25°C Derate above 25°C	PD	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	TJ, Tstg	-65 to +200	°C

*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	RθJA(1)	219	°C/W
Thermal Resistance, Junction to Case	RθJC	35	°C/W
Lead Temperature, 1/16" from Case for 10 seconds	TL	300	°C

*Indicates JEDEC Registered Data.

(1) RθJA is measured with the device soldered into a typical printed circuit board.



STYLE 1

PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° NOM	—	45° NOM	—
P	—	1.27	—	0.050
Q	90° NOM	—	90° NOM	—
R	2.54	—	0.100	—

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage ⁽¹⁾ ($I_C = 30\text{ mAdc}$, $I_B = 0$)	$BV_{CEO(sus)}$	35	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	80	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	7.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 60\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 60\text{ Vdc}$, $I_E = 0$, $T_A = +150^\circ\text{C}$)	I_{CBO}	— —	— —	10 10	nAdc μAdc
Emitter Cutoff Current ($V_{EB} = 5.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	—	10	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 150\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 1.0\text{ Adc}$, $V_{CE} = 10\text{ Vdc}$)	h_{FE}	30 40 15	60 80 40	— 120 —	—
Collector-Emitter Saturation Voltage ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$) ($I_C = 1.0\text{ Adc}$, $I_B = 100\text{ mAdc}$)	$V_{CE(sat)}$	— —	0.1 0.6	0.2 1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 1.0\text{ Adc}$, $I_B = 100\text{ mAdc}$)	$V_{BE(sat)}$	—	0.8	1.6	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 50\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 20\text{ MHz}$)	f_T	60	100	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)	C_{ob}	—	8.0	12	pF
Input Capacitance ($V_{EB} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)	C_{ib}	—	60	80	pF
Collector-Base Time Constant ($I_C = 10\text{ mAdc}$, $V_{CB} = 10\text{ Vdc}$, $f = 4.0\text{ MHz}$)	$r_b C_c$	—	—	800	ps

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.

NPN SILICON ANNULAR SWITCHING TRANSISTOR

... designed for use in high-speed low-current switching applications requiring TO-46 package configuration.

- Collector-Emitter Breakdown Voltage –
BVCEO = 15 Vdc (Min) @ IC = 10 mAdc
- High-Current-Gain-Bandwidth Product –
fT = 350 MHz (Typ) @ IC = 10 mAdc
- DC Current Gain – 100 μ Adc to 20 mAdc
- Fast Switching Time @ IC = 20 mAdc (Figure 1)
ton = 45 μ s (Typ)
toff = 40 μ s (Typ)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*Collector-Emitter Voltage	VCEO	15	Vdc
*Collector-Emitter Voltage	VCEs	30	Vdc
*Collector-Base Voltage	VCB	30	Vdc
*Emitter-Base Voltage	VEB	5.0	Vdc
Collector Current – Continuous	IC	200	mAdc
*Total Power Dissipation @ TA = 25°C Derate above 25°C	PD	300 1.7	mW mW/°C
Total Power Dissipation @ TC = 25°C Derate above 25°C	PD	1.0 5.71	Watt mW/°C
*Operating and Storage Junction Temperature Range	TJ, Tstg	-65 to +200	°C

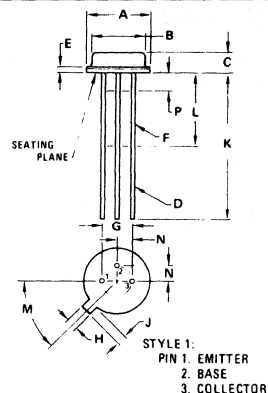
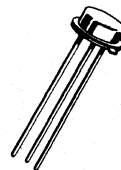
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Thermal Resistance, Junction to Ambient	R θ JA ⁽¹⁾	583	°C/W
Thermal Resistance, Junction to Case	R θ JC	175	°C/W
*Lead Temperature 1/16" + 1/32" from Case for 15 seconds	TL	300	°C

*Indicates JEDEC Registered Data

(1) R θ JA is measured with the device soldered into a typical printed circuit board.

NPN SILICON SWITCHING TRANSISTOR



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	1.65	2.16	0.065	0.085
D	0.406	0.533	0.016	0.021
E	—	1.02	—	0.040
F	0.305	0.483	0.012	0.019
G	2.54 BSC	—	0.100 BSC	—
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC	—	45° BSC	—
N	1.27 BSC	—	0.050 BSC	—
P	—	1.27	—	0.050

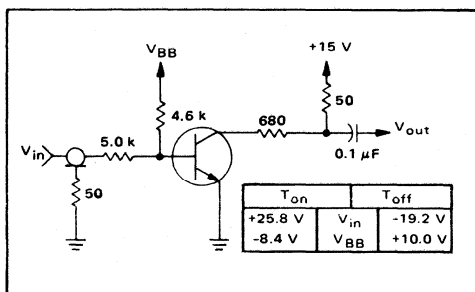
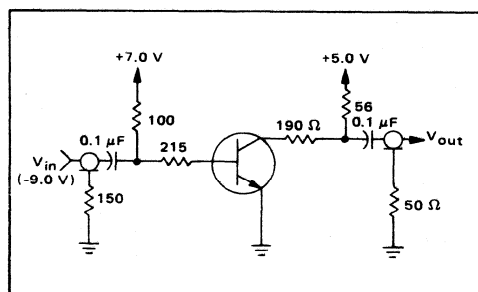
All JEDEC dimensions and notes apply

CASE 26-03
TO-46

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 10\text{ mA}$, $I_B = 0$)	BV_{CEO}	15	—	—	Vdc
*Collector-Base Breakdown Voltage ($I_C = 1.0\text{ }\mu\text{A}$, $I_E = 0$)	BV_{CBO}	30	—	—	Vdc
*Emitter-Base Breakdown Voltage ($I_E = 1.0\text{ }\mu\text{A}$, $I_C = 0$)	BV_{EBO}	5.0	—	—	Vdc
*Collector Cutoff Current ($V_{CB} = 20\text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	—	50	nAdc
*Emitter Cutoff Current ($V_{BE} = 3.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	—	50	nAdc
*Collector Cutoff Current ($V_{CE} = 25\text{ Vdc}$, $V_{EB} = 1.5\text{ Vdc}$, $R_{BE} = 720\text{ k Ohms}$)	I_{CEX}	—	—	5.0	μAdc
*ON CHARACTERISTICS					
DC Current Gain (1) ($I_C = 100\text{ }\mu\text{A}$, $V_{CE} = 300\text{ mVdc}$) ($I_C = 1.0\text{ mA}$, $V_{CE} = 300\text{ mVdc}$) ($I_C = 10\text{ mA}$, $V_{CE} = 400\text{ mVdc}$) ($I_C = 20\text{ mA}$, $V_{CE} = 400\text{ mVdc}$)	h_{FE}	15 20 30 40	25 30 45 50	— — — —	—
Collector-Emitter Saturation Voltage ($I_C = 20\text{ mA}$, $I_B = 1.0\text{ mA}$)	$V_{CE(sat)}$	—	200	350	mVdc
Base-Emitter Saturation Voltage ($I_C = 20\text{ mA}$, $I_B = 1.0\text{ mA}$)	$V_{BE(sat)}$	—	780	900	mVdc
*DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	300	350	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{ob}	—	3.0	5.0	pF
*SWITCHING CHARACTERISTICS					
Turn-On Time (Figure 1) ($V_{CC} = 15\text{ Vdc}$, $V_{BE(off)} = 4.0\text{ V}$, $I_C = 20\text{ mA}$, $I_{B1} = 2.0\text{ mA}$)	t_{on}	—	45	60	ns
Storage Time (Figure 2) ($V_{CC} = 5.0\text{ Vdc}$, $I_C = 20\text{ mA}$, $I_{B1} = I_{B2} = 20\text{ mA}$)	t_s	—	14	20	ns
Turn-Off Time (Figure 1) ($V_{CC} = 15\text{ Vdc}$, $I_C = 20\text{ mA}$, $I_{B1} = I_{B2} = 2.0\text{ mA}$)	t_{off}	—	40	50	ns

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.**FIGURE 1 – SWITCHING TIME TEST CIRCUIT****FIGURE 2 – STORAGE TIME TEST CIRCUIT****NOTES:**

1. Bypass and decoupling capacitors omitted for clarity.
2. V_{in} ($Z = 50\text{ }\Omega$) $t_r \leq 1\text{ ns}$; $t_p = 96\text{ ns}$; Duty Cycle $\leq 2\%$.
3. V_{out} (Fig. 1) to $50\text{ }\Omega$ probe; V_{out} (Fig. 2) to 100 k oscilloscope input.

2N2322 (SILICON)

thru

2N2326



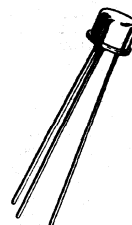
SILICON CONTROLLED RECTIFIERS

... all-diffused PNPN devices designed for gating operation in mA/ μ A signal or detection circuits.

- Low-Level Gate Characteristics –
 $I_{GT} = 200 \mu\text{A}$ (Max) @ 25°C
- Low Holding Current – $I_H = 2.0 \text{ mA}$ (Max) @ 25°C
- Anode Common to Case
- Glass-to-Metal Bond for Maximum Hermetic Seal

THYRISTORS PNPN

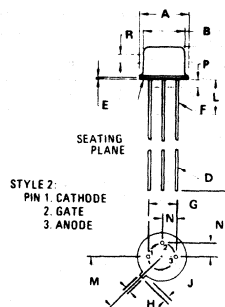
1.6 AMPERE RMS
25 thru 200 VOLTS



*MAXIMUM RATINGS ($T_C = 25^\circ\text{C}$ unless otherwise noted, $R_{GK} = 1000 \text{ ohms}$)

Rating	Symbol	Value	Unit
Repetitive Peak Reverse Blocking Voltage (Notes 2 and 3)	V_{RRM}	25 50 100 150 200	Volts
Non-Repetitive Peak Reverse Blocking Voltage ($t \leq 5.0 \text{ ms}$, Notes 2 and 3)	V_{RSM}	40 75 150 225 300	Volts
RMS On-State Current (All Conduction Angles)	$I_T(RMS)$	1.6	Amp
Average On-State Current $T_C = 85^\circ\text{C}$ $T_A = 30^\circ\text{C}$	$I_T(AV)$	1.0 0.45	Amp
Peak Non-Repetitive Surge Current (One Cycle, 60 Hz, $T_C = 80^\circ\text{C}$) Preceded and followed by rated current and voltage	I_{TSM}	15	Amp
Peak Gate Power	P_{GM}	0.1	Watt
Average Gate Power	$P_{G(AV)}$	0.01	Watt
Peak Gate Current	I_{GM}	0.1	Amp
Peak Gate Voltage	V_{GM}	6.0	Volts
Operating Junction Temperature Range	T_J	-65 to +125	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +150	$^\circ\text{C}$
Lead Solder Temperature ($> 1/16''$ from case, 10 s max)	—	+230	$^\circ\text{C}$

*Indicates JEDEC Registered Data



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	0.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	5.08	BSC	0.200	BSC
H	0.711	0.864	0.028	0.034
J	0.734	1.14	0.029	0.045
K	38.10	—	1.500	—
L	6.35	—	0.250	—
M	—	45° BSC	—	45° BSC
N	—	2.54 BSC	—	0.100 BSC
P	—	1.27	—	0.050
R	2.54	—	0.100	—
S	—	0.179	—	0.007

All JEDEC dimensions and notes apply.
CASE 31-03
TO-5

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted, $R_{GK} = 1000\text{ ohms}$)

Characteristic	Symbol	Min	Max	Unit
*Peak Forward Blocking Voltage (Note 2)	V_{DRM}			Volts
2N2322		25	—	
2N2323		50	—	
2N2324		100	—	
2N2325		150	—	
2N2326		200	—	
*Peak Reverse Blocking Current (Rated V_{RRM} , $T_J = 125^\circ\text{C}$)	I_{RRM}	—	100	μA
*Peak Forward Blocking Current (Rated V_{DRM} , $T_J = 125^\circ\text{C}$)	I_{DRM}	—	100	μA
Peak On-State Voltage ($I_{TM} = 1.0\text{ A Peak}$) ($I_{TM} = 3.14\text{ A Peak}$, $T_C = 85^\circ\text{C}$)*	V_{TM}	—	1.5 2.0	Volts
Gate Trigger Current (Note 1) ($V_{AK} = 6.0\text{ Vdc}$, $R_L = 100\text{ ohms}$) ($V_{AK} = 6.0\text{ Vdc}$, $R_L = 100\text{ ohms}$, $T_C = -65^\circ\text{C}$)	I_{GT}	—	200 350*	μA
Gate Trigger Voltage ($V_{AK} = 6.0\text{ Vdc}$, $R_L = 100\text{ ohms}$) ($V_{AK} = 6.0\text{ Vdc}$, $R_L = 100\text{ ohms}$, $T_C = -65^\circ\text{C}$)* ($V_{AK} = \text{Rated } V_{DRM}$, $R_L = 100\text{ ohms}$, $T_J = 125^\circ\text{C}$)*	V_{GT}	— 0.1	0.8 1.0 —	Volts
Holding Current ($V_{AK} = 6.0\text{ Vdc}$) ($V_{AK} = 6.0\text{ Vdc}$, $T_C = -65^\circ\text{C}$)* ($V_{AK} = 6.0\text{ Vdc}$, $T_C = 125^\circ\text{C}$)*	I_H	— — 0.15	2.0 3.0 —	mA

*Indicates JEDEC Registered Data.

Notes: 1. R_{GK} current is not included in measurement.

2. Thyristor devices shall not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

3. Thyristor devices shall not have a positive bias applied to the gate concurrently with a negative potential applied to the anode.

CURRENT DERATING

FIGURE 1 — CASE TEMPERATURE

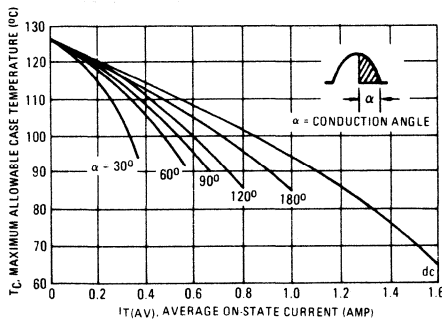
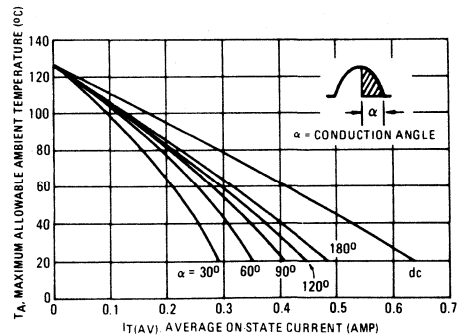
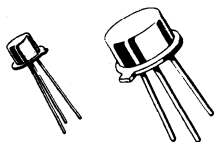


FIGURE 2 — AMBIENT TEMPERATURE



2N2330S (SILICON)

2N2331S



NPN silicon annular transistors for low-level DC/AC chopper applications.

CASE 22

(TO-18)

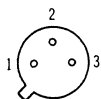
2N2331

Collector connected to case

CASE 79

(TO-39)

2N2330



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*** MAXIMUM RATINGS**

Rating	Symbol	2N2330 (TO-5)	2N2331 (TO-18)	Unit
Collector-Emitter Voltage	V_{CEO}	20	20	Vdc
Collector-Base Voltage	V_{CB}	30	30	Vdc
Emitter-Base Voltage	V_{EB}	5.0	5.0	Vdc
Collector Current	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25^{\circ}\text{C}$ Derate above 25°C	P_D	0.8	0.5	Watt
		5.33	3.33	mW/ $^{\circ}\text{C}$
Total Device Dissipation @ $T_C = 25^{\circ}\text{C}$ Derate above 25°C	P_D	3.0	1.8	Watts
		20	12	mW/ $^{\circ}\text{C}$
Operating Junction Temperature Range	T_J	-65 to +175		$^{\circ}\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200		$^{\circ}\text{C}$

* Indicates JEDEC Registered Data

*** ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 1 \text{ mAdc}$, $I_B = 0$)	BV_{CEO}	20	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \text{ } \mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	30	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \text{ } \mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current ($V_{CB} = 4.5 \text{ Vdc}$, $I_E = 0$)	I_{CBO}	-	1.0	nAdc
Emitter Cutoff Current ($V_{BE} = 4.5 \text{ Vdc}$)	I_{EBO}	-	5.0	nAdc
Offset Current ($V_{BC} = 2 \text{ Vdc}$, $V_{CE} = 0$, $T_A = 25^\circ\text{C}$) ($V_{BC} = 2 \text{ Vdc}$, $V_{CE} = 0$, $T_A = 85^\circ\text{C}$)	$I_{(off)}$	- -	1 10	nAdc

ON CHARACTERISTICS

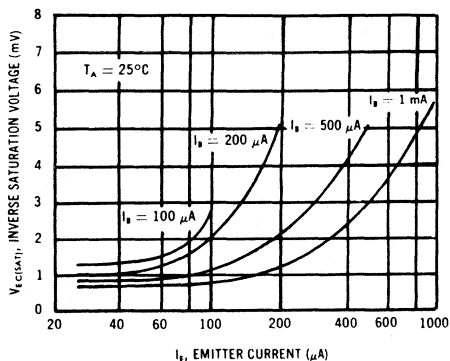
DC Current Gain ($I_C = 10 \text{ mAdc}$, $V_{CE} = 1 \text{ Vdc}$)	h_{FE}	50	-	-
Offset Voltage ($I_B = 200 \text{ } \mu\text{Adc}$, $I_E = 0$)	$V_{(off)}$	-	0.75	mVdc
Inverse Saturation Voltage ($I_B = 200 \text{ } \mu\text{Adc}$, $I_E = 50 \text{ } \mu\text{Adc}$)	$V_{EC(sat)}$	-	3.0	mVdc

DYNAMIC CHARACTERISTICS

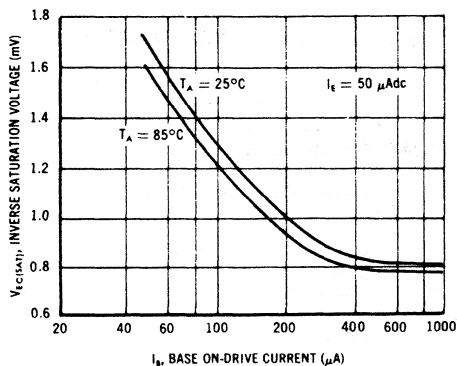
Current-Gain - Bandwidth Product ($I_C = 1 \text{ mAdc}$, $V_{CE} = 1 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	100	-	MHz
Output Capacitance ($V_{CB} = 2 \text{ Vdc}$, $I_E = 0$)	C_{ob}	-	10	pF
Input Capacitance ($V_{BE} = 2 \text{ Vdc}$, $I_C = 0$)	C_{ib}	-	20	pF

* Indicates JEDEC Registered Data

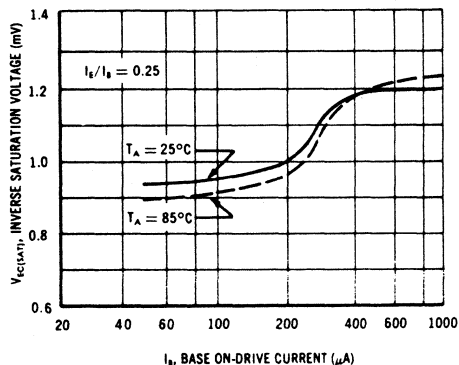
INVERSE SATURATION VOLTAGE
versus
EMITTER CURRENT



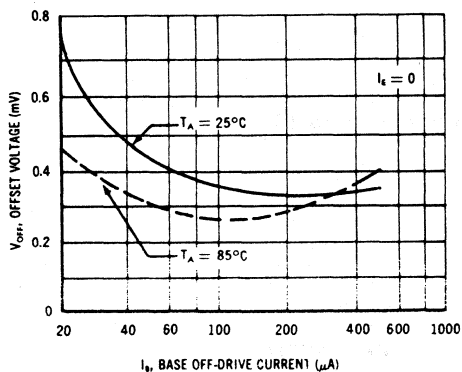
INVERSE SATURATION VOLTAGE
versus
BASE CURRENT



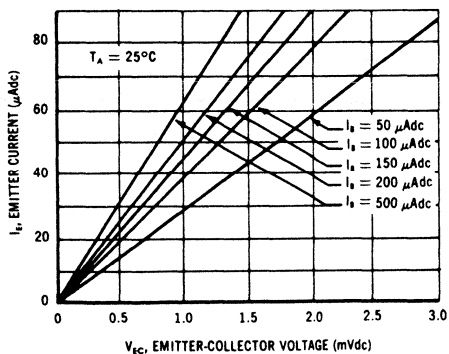
INVERSE SATURATION VOLTAGE
versus
BASE CURRENT



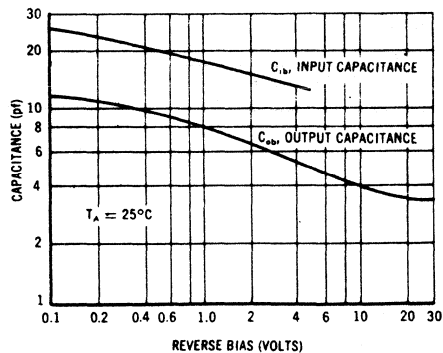
OFFSET VOLTAGE
versus
BASE CURRENT



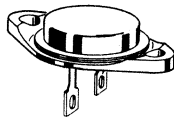
INVERSE
SATURATION
CHARACTERISTICS



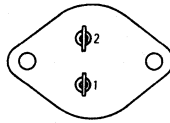
OUTPUT CAPACITANCE versus COLLECTOR-BASE VOLTAGE
and
INPUT CAPACITANCE versus EMITTER-BASE VOLTAGE



2N2357 thru 2N2359 (Germanium)



CASE 161



STYLE 1:
PIN 1: BASE
2: EMITTER
CASE: COLLECTOR

Collector Connected to Case

PNP Germanium power transistors designed for very high-current switching applications requiring low saturation voltages, fast switching times and good safe operating area.

MAXIMUM RATINGS

Rating	Symbol	2N2357	2N2358	2N2359	Unit
Collector-Emitter Voltage	V_{CEO}	30	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	100	120	Vdc
Emitter-Base Voltage	V_{EB}	← 2.5 →			Vdc
Collector Current - Continuous	I_C	← 50 →			A dc
Base Current - Continuous	I_B	← 10 →			A dc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	← 170 2.0 →			Watts W/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +110 →			$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.5	$^\circ\text{C/W}$

FIGURE 1 – SUSTAINING VOLTAGE TEST CIRCUIT

$R_1 = 1.0 \text{ Ohm}, 20 \text{ Watts}$
 $R_2 = 10 \text{ Ohms}, 2.0 \text{ Watts}$
 $R_3 = 0.1 \text{ Ohm}, 1.0\%$
 $R_4 \leq 0.04 \text{ Ohm}$

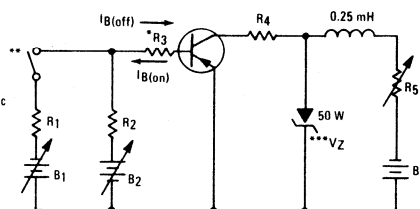
$R_5: I_C \text{ Adjust @ } V_{CE} = V_Z$
 $B_1: \text{ Adjust for } I_{B(\text{on})} = \frac{I_C}{10}$
 $B_2 = 2.0 \text{ Vdc, Adjust for } I_{B(\text{off})} = 0.2 \text{ A dc}$
 $B_3 = 12 \text{ Vdc}$

*Not required if current probe is used to read I_B

**PRF $\approx 60 \text{ Hz}$

***Zener selected to establish Sustaining Voltage.

NOTE: Series impedance and inductance must be kept to a minimum.



2N2357 thru 2N2359 (continued)

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 100\text{ mA}$, $I_B = 0$)	BV_{CEO}	30 60 80	- - -	- - -	Vdc
Collector-Emitter Sustaining Voltage (See Figure 1) ($I_C = 50\text{ A}$)	$V_{CE(sus)}$	35 40 45	- - -	- - -	Vdc
Collector -Emitter Cutoff Current ($V_{CE} = 60\text{ Vdc}$, $V_{BE} = 0$)	I_{CES}	-	-	50	mA
($V_{CE} = 100\text{ Vdc}$, $V_{BE} = 0$)		-	-	50	
($V_{CE} = 120\text{ Vdc}$, $V_{BE} = 0$)		-	-	50	
Collector Cutoff Current ($V_{CB} = 2.0\text{ Vdc}$, $I_E = 0$)	I_{CBO}	-	-	200	μA
Collector-Emitter Cutoff Current ($V_{CE} = 40\text{ Vdc}$, $V_{BE(off)} = 0.2\text{ Vdc}$)	I_{CEX}	-	-	5.0	mA
($V_{CE} = 80\text{ Vdc}$, $V_{BE(off)} = 0.2\text{ Vdc}$)		-	-	5.0	
($V_{CE} = 100\text{ Vdc}$, $V_{BE(off)} = 0.2\text{ Vdc}$)		-	-	5.0	
($V_{CE} = 40\text{ Vdc}$, $V_{BE(off)} = 0.2\text{ Vdc}$, $T_C = 100^\circ\text{C}$)		-	-	35	
($V_{CE} = 80\text{ Vdc}$, $V_{BE(off)} = 0.2\text{ Vdc}$, $T_C = 100^\circ\text{C}$)		-	-	35	
($V_{CE} = 100\text{ Vdc}$, $V_{BE(off)} = 0.2\text{ Vdc}$, $T_C = 100^\circ\text{C}$)		-	-	35	
Emitter Cutoff Current ($V_{EB} = 2.5\text{ Vdc}$, $I_C = 0$)	I_{EBO}	-	-	50	mA

ON CHARACTERISTICS

DC Current Gain ($I_C = 20\text{ A}$, $V_{CE} = 1.5\text{ Vdc}$)	h_{FE}	30	-	90	-
($I_C = 50\text{ A}$, $V_{CE} = 1.5\text{ Vdc}$)		15	-	-	
Collector-Emitter Saturation Voltage ($I_C = 50\text{ A}$, $I_B = 5.0\text{ A}$)	$V_{CE(sat)}$	-	-	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 50\text{ A}$, $I_B = 5.0\text{ A}$)	$V_{BE(sat)}$	-	-	0.9	Vdc

SMALL-SIGNAL CHARACTERISTICS

Small-Signal Current Gain ($I_C = 0.5\text{ A}$, $V_{CE} = 6.0\text{ Vdc}$, $f = 30\text{ kHz}$)	h_{fe}	20	-	-	-
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SWITCHING CHARACTERISTICS

Rise Time	$V_{CC} = -28\text{ Vdc}$, $I_C = 50\text{ A}$, $I_{B1} = 5.0\text{ A}$, $I_{B2} = 3.0\text{ A}$ (See Figure 3)	t_r	-	12	μs
Storage Time		t_s	-	5.0	μs
Fall Time		t_f	-	6.0	μs

FIGURE 2 – SWITCHING TIMES

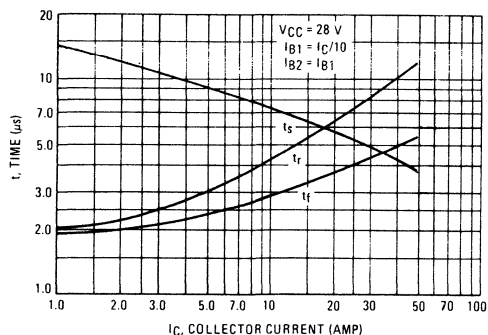
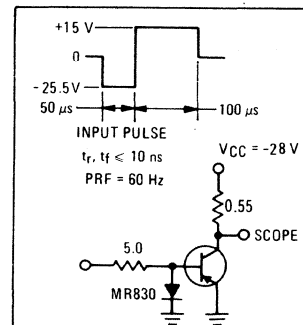
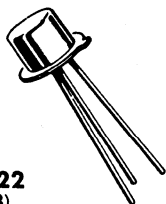


FIGURE 3 – SWITCHING TIME TEST CIRCUIT



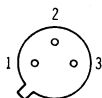
2N2368 (SILICON)



NPN silicon annular transistor designed for high-speed, low-level, saturated-switching application.

CASE 22 (TO-18)

Collector connected to case



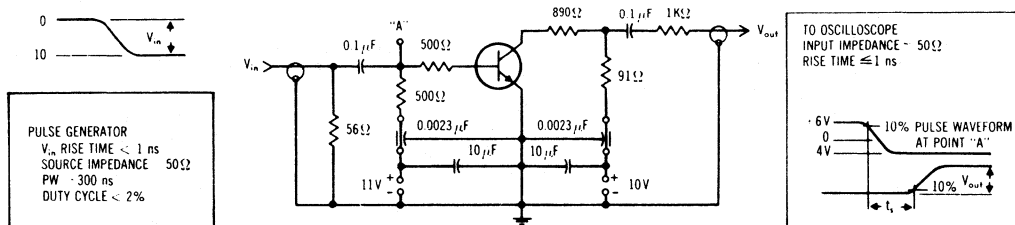
STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Total Device Dissipation@ $T_A = 25^{\circ}\text{C}$ Derate above 25°C	P_D	0.36 2.06	Watt mW/ $^{\circ}\text{C}$
Total Device Dissipation@ $T_C = 25^{\circ}\text{C}$ Derate above 25°C	P_D	1.2 6.85	Watt mW/ $^{\circ}\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^{\circ}\text{C}$

* Indicates JEDEC Registered Data

FIGURE 1 — STORAGE TIME TEST CIRCUIT



*ELECTRICAL CHARACTERISTICS (T_A = 25 °C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ⁽¹⁾ (I _C = 10 mA _{dc} , I _B = 0)	BV _{CEO}	15	—	V _{dc}
Collector-Emitter Breakdown Voltage (I _C = 10 μA _{dc} , V _{BE} = 0)	BV _{CES}	40	—	V _{dc}
Collector-Base Breakdown Voltage (I _C = 10 μA _{dc} , I _E = 0)	BV _{CBO}	40	—	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 10 μA _{dc} , I _C = 0)	BV _{EBO}	4.5	—	V _{dc}
Collector Cutoff Current (V _{CB} = 20 V _{dc} , I _E = 0) (V _{CB} = 20 V _{dc} , I _E = 0, T _A = 150°C)	I _{CBO}	— —	0.4 30	μA _{dc}

ON CHARACTERISTICS

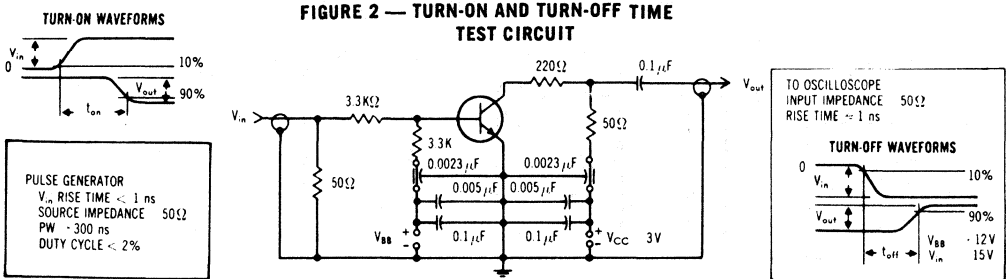
DC Current Gain ⁽¹⁾ (I _C = 10 mA _{dc} , V _{CE} = 1.0 V _{dc}) (I _C = 10 mA _{dc} , V _{CE} = 1.0 V _{dc} , T _A = -55°C) (I _C = 100 mA _{dc} , V _{CE} = 2.0 V _{dc})	h _{FE}	20 10 10	60 — —	—
Collector-Emitter Saturation Voltage (I _C = 10 mA _{dc} , I _B = 1.0 mA _{dc})	V _{CE(sat)}	—	0.25	V _{dc}
Base-Emitter Saturation Voltage (I _C = 10 mA _{dc} , I _B = 1.0 mA _{dc})	V _{BE(sat)}	0.7	0.85	V _{dc}

DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product (I _C = 10 mA _{dc} , V _{CE} = 10 V _{dc} , f = 100 MHz)	f _T	400	—	MHz
Output Capacitance (V _{CB} = 5.0 V _{dc} , I _E = 0, f = 140 kHz)	C _{ob}	—	4.0	pF
Storage Time (Figure 1) (I _C = I _{B1} = 10 mA _{dc} , I _{B2} = -10 mA _{dc})	t _s	—	10	ns
Turn-On Time (Figure 2) (I _C = 10 mA _{dc} , I _{B1} = 3.0 mA _{dc} , I _{B2} = -1.5 mA _{dc})	t _{on}	—	12	ns
Turn-Off Time (Figure 2) (I _C = 10 mA _{dc} , I _{B1} = 3.0 mA _{dc} , I _{B2} = -1.5 mA _{dc})	t _{off}	—	15	ns

⁽¹⁾ Pulse Test: Pulse Width = 300 μs; Duty Cycle ≤ 2%

*Indicates JEDEC Registered Data



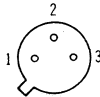
2N2369 (SILICON) 2N3227



CASE 22 (TO-18)

Collector connected to case

*MAXIMUM RATINGS



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

NPN silicon annular transistors for low-current, high-speed switching applications.

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	40	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Emitter Voltage 2N2369 2N3227	V_{CEO}	15 20	Vdc
Emitter-Base Voltage 2N2369 2N3227	V_{EB}	4.5 6.0	Vdc
Collector Current (10 μ sec pulse)	$I_C(\text{Peak})$	500	mA
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor Above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ 25°C Case Temperature Derating Factor Above 25°C	P_D	1.2 6.85	Watts mW/°C
Junction Temperature, Operating	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 — t_{on} CIRCUIT — 10 mA

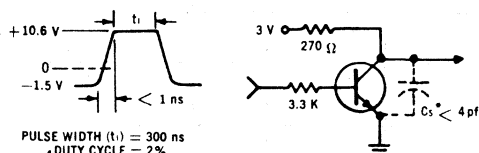


FIGURE 2 — t_{on} CIRCUIT — 100 mA

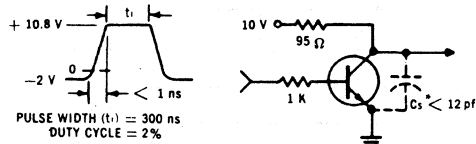


FIGURE 3 — t_{off} CIRCUIT — 10 mA

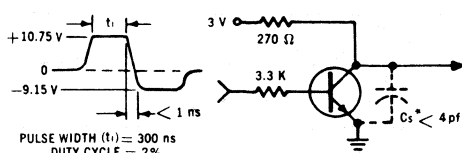
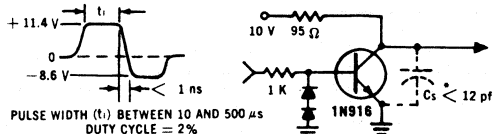


FIGURE 4 — t_{off} CIRCUIT — 100 mA



* Total shunt capacitance of test jig and connectors.

***ELECTRICAL CHARACTERISTICS**

Characteristic		Fig. No.	Symbol	Min	Max	Unit
Collector Cutoff Current ($V_{CB} = 20 \text{ Vdc}$)	2N2369		I_{CBO}	—	0.4	$\mu \text{ Adc}$
	2N3227			—	0.2	
	($V_{CB} = 20 \text{ Vdc}, T_A = 150^\circ\text{C}$)			—	30	
	2N3227			—	50	
Collector Cutoff Current ($V_{CE} = 20 \text{ Vdc}, V_{EB(off)} = 3 \text{ Vdc}$)	2N3227		I_{CEX}	—	0.2	$\mu \text{ Adc}$
Base Cutoff Current ($V_{CE} = 20 \text{ Vdc}, V_{EB(off)} = 3 \text{ Vdc}$)	2N3227		I_{BL}	—	0.5	$\mu \text{ Adc}$
Collector-Base Breakdown Voltage ($I_C = 10 \mu \text{ Adc}, I_B = 0$)			BV_{CBO}	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu \text{ Adc}, I_C = 0$)	2N2369 2N3227		BV_{EBO}	4.5 6.0	—	Vdc
Collector-Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 10 \text{ mAdc}$)	2N2369 2N3227		BV_{CEO}	15 20	—	Vdc
Collector-Emitter Voltage ($I_C = 10 \mu \text{ Adc}, I_B = 0$)			BV_{CES}	40	—	Vdc
Collector-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 10 \text{ mAdc}, I_B = 1 \text{ mAdc}$) ($I_C = 100 \text{ mAdc}, I_B = 10 \text{ mAdc}$)	Both Types 2N3227	11,13	$V_{CE(sat)}$	— —	0.25 0.45	Vdc
Base-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 10 \text{ mAdc}, I_B = 1 \text{ mAdc}$) ($I_C = 100 \text{ mAdc}, I_B = 10 \text{ mAdc}$)	Both Types 2N3227	13	$V_{BE(sat)}$	0.70 0.8	0.85 1.4	Vdc
DC Current Gain ⁽¹⁾ ($I_C = 10 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$)	2N2369 2N3227	12	h_{FE}	40 100	120 300	—
($I_C = 10 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}, T_A = -55^\circ\text{C}$)	2N2369 2N3227	12		20 40	— —	
($I_C = 100 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$)	2N3227	12		30	—	
($I_C = 100 \text{ mAdc}, V_{CE} = 2 \text{ Vdc}$)	2N2369			20	—	
Small Signal Current Gain ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 100 \text{ MHz}$)			h_{fe}	5.0	—	—
Output Capacitance ($V_{CB} = 5 \text{ Vdc}, I_E = 0, f = 140 \text{ kHz}$)		5	C_{ob}	—	4.0	pF
Input Capacitance ($V_{BE} = 1 \text{ Vdc}, I_C = 0, f = 140 \text{ kHz}$)	2N3227		C_{ib}		4.0	pF
Storage Time ($I_C = I_{B1} = I_{B2} = 10 \text{ mA}$)		10	t_s	—	13	ns
Turn-On Time ($I_C = 10 \text{ mA}, I_{B1} = 3 \text{ mA}, V_{CC} = 3 \text{ V}, V_{EB(off)} = 1.5 \text{ Vdc}$)		1,6	t_{on}	—	12	ns
Turn-Off Time ($I_C = 10 \text{ mA}, I_{B1} = 3 \text{ mA}, I_{B2} = 1.5 \text{ mA}, V_{CC} = 3 \text{ V}$)		3,6	t_{off}	—	18	ns
Total Control Charge ($I_C = 10 \text{ mA}, I_B = 1 \text{ mA}, V_{CC} = 3 \text{ V}$)	2N3227	7,8	Q_T	—	50	pC
Delay Time	$V_{CC}=10 \text{ V}, V_{EB(off)} = 2 \text{ Vdc},$ $I_C = 100 \text{ mA}, I_{B1} = 10 \text{ mA}$	2,6	t_d	—	5.0	ns
Rise Time			t_r	—	18	ns
Storage Time	$V_{CC} = 10 \text{ V}$ $I_C = 100 \text{ mA}, I_{B1} = I_{B2} = 10 \text{ mA}$	4,6	t_s	—	13	ns
Fall Time			t_f	—	15	ns

⁽¹⁾ Pulse Test: Pulse Width = 300 μs , Duty Cycle = 2%

* Indicates JEDEC Registered Data

FIGURE 5 — JUNCTION CAPACITANCE VARIATIONS

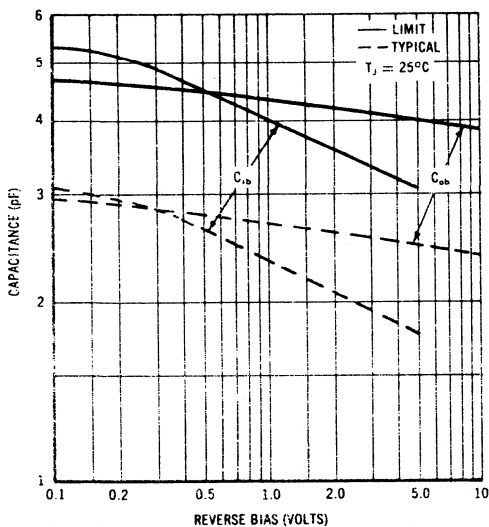


FIGURE 6 — TYPICAL SWITCHING TIMES

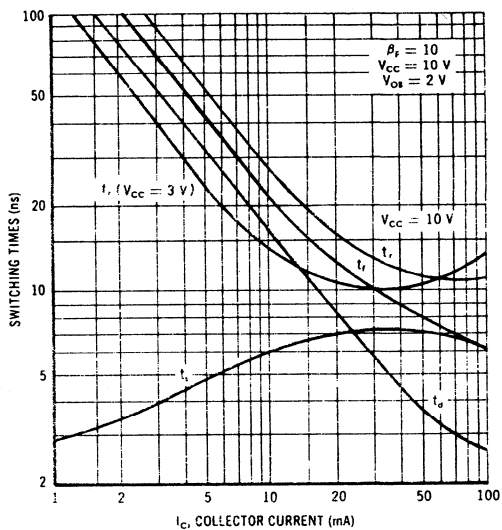


FIGURE 7 — MAXIMUM CHARGE DATA

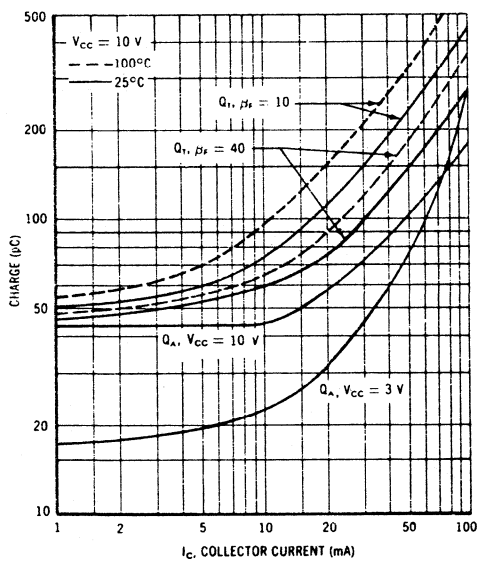


FIGURE 8 — Q_T TEST CIRCUIT

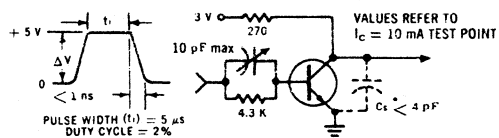


FIGURE 9 — TURN-OFF WAVE FORM

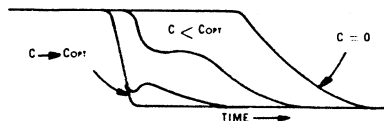
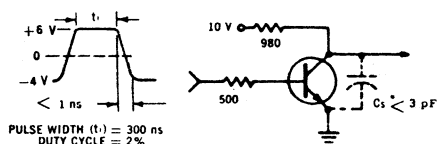


FIGURE 10 — STORAGE TIME EQUIVALENT TEST CIRCUIT



* Total shunt capacitance of test jig and connectors.

FIGURE 11 — MAXIMUM COLLECTOR SATURATION VOLTAGE CHARACTERISTICS

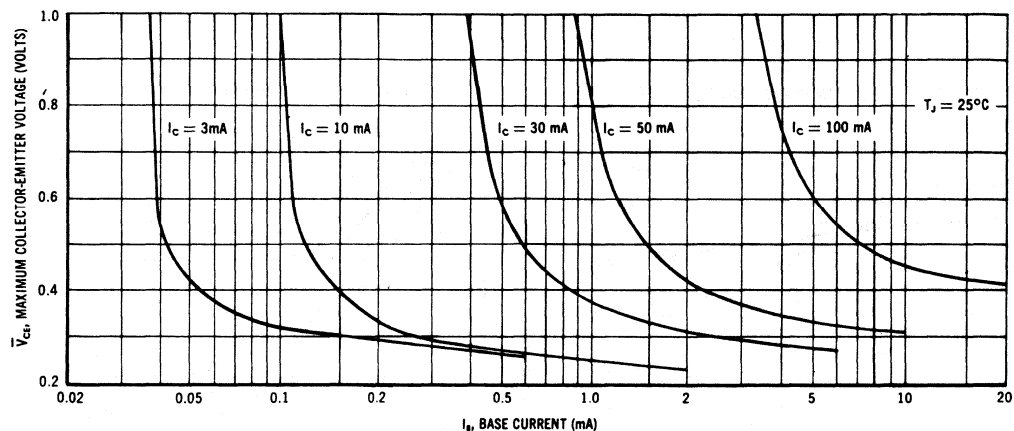


FIGURE 12 — MINIMUM CURRENT GAIN CHARACTERISTICS

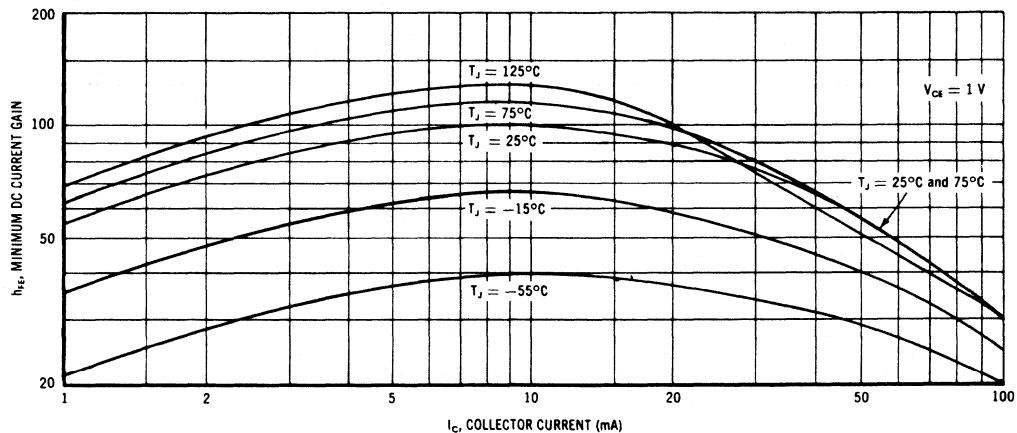


FIGURE 13 — SATURATION VOLTAGE LIMITS

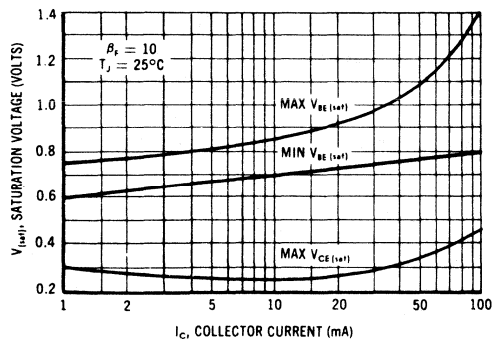
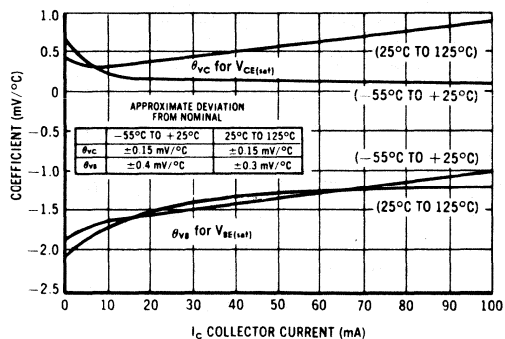
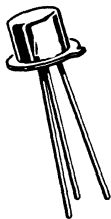


FIGURE 14 — TYPICAL TEMPERATURE COEFFICIENTS

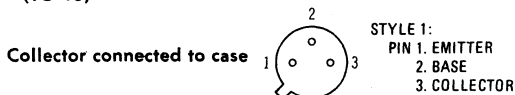


2N2369A (SILICON) **2N2369A** JAN,JTX,JTXV AVAILABLE



CASE 22
(TO-18)

NPN silicon epitaxial transistor for high-speed range of .10 – 100 mAdc switching applications. Specifications provided at -55°C to +125°C for critical dc characteristics.



***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Collector Current – Continuous	I_C	200	mAdc
Peak (10 μ s Pulse)		500	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$	P_D	0.36	Watt
Derate above 25°C		2.06	mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$	P_D	1.2	Watts
Derate above 25°C		6.85	mW/ $^\circ\text{C}$
Operating Junction Temperature Range	T_J	+200	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

* Indicates JEDEC Registered Data

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 – t_{on} CIRCUIT – 10 mA

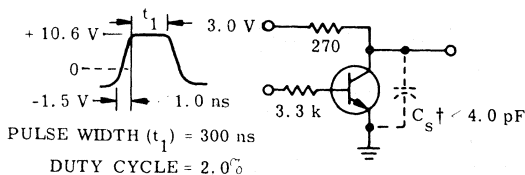
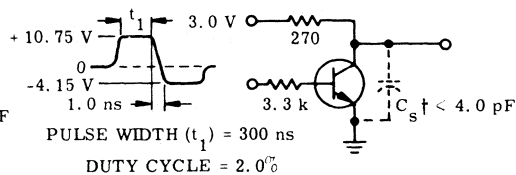


FIGURE 2 – t_{off} CIRCUIT – 10 mA



† Total shunt capacitance of test jig and connectors.

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10\text{ mAdc}$, $I_B = 0$)	-	BV_{CEO}	15	-	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $I_B = 0$)	-	BV_{CES}	40	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $I_E = 0$)	-	BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{Adc}$, $I_C = 0$)	-	BV_{EBO}	4.5	-	Vdc
Collector Cutoff Current ($V_{CE} = 20\text{ Vdc}$, $V_{BE} = 0$)	-	I_{CES}	-	0.4	μAdc
Collector Cutoff Current ($V_{CB} = 20\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	-	I_{CBO}	-	30	μAdc
Base Current ($V_{CE} = 20\text{ Vdc}$, $V_{BE} = 0$)	-	I_B	-	0.4	μAdc

ON CHARACTERISTICS

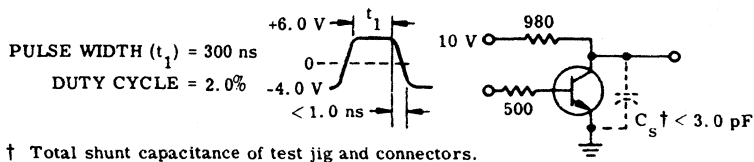
DC Current Gain(1) ($I_C = 10\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 0.35\text{ Vdc}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 0.35\text{ Vdc}$, $T_A = -55^\circ\text{C}$) ($I_C = 30\text{ mAdc}$, $V_{CE} = 0.4\text{ Vdc}$) ($I_C = 100\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$)	-	h_{FE}	- 40 20 30 20	120 - - - -	-
Collector-Emitter Saturation Voltage(1) ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$) ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$, $T_A = +125^\circ\text{C}$) ($I_C = 30\text{ mAdc}$, $I_B = 3.0\text{ mAdc}$) ($I_C = 100\text{ mAdc}$, $I_B = 10\text{ mAdc}$)	-	$V_{CE(sat)}$	- - - -	0.20 0.30 0.25 0.50	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$) ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$, $T_A = +125^\circ\text{C}$) ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$, $T_A = -55^\circ\text{C}$) ($I_C = 30\text{ mAdc}$, $I_B = 3.0\text{ mAdc}$) ($I_C = 100\text{ mAdc}$, $I_B = 10\text{ mAdc}$)	-	$V_{BE(sat)}$	0.70 0.59 - - -	0.85 - 1.02 1.15 1.60	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	-	f_T	500	-	MHz
Output Capacitance ($V_{CB} = 5.0\text{ Vdc}$, $I_E = 0$, $f = 140\text{ kHz}$)	-	C_{ob}	-	4.0	pF
Turn-On Time ($V_{CC} = 3.0\text{ V}$, $V_{BE(off)} = 1.5\text{ V}$, $I_C = 10\text{ mAdc}$, $I_{B1} = 3.0\text{ mAdc}$, $I_{B2} = 1.5\text{ mAdc}$)	1	t_{on}	-	12	ns
Turn-Off Time ($V_{CC} = 3.0\text{ V}$, $I_C = 10\text{ mAdc}$, $I_{B1} = 3.0\text{ mAdc}$, $I_{B2} = 1.5\text{ mAdc}$)	2	t_{off}	-	18	ns
Storage Time ($I_C = 10\text{ mAdc}$, $I_{B1} = I_{B2} = 10\text{ mAdc}$)	3	t_s	-	13	ns

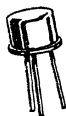
 (1) Pulse Test: PW = 300 μs , Duty Cycle = 2.0%

* Indicates JEDEC Registered Data

FIGURE 3 — STORAGE TIME EQUIVALENT TEST CIRCUIT


2N2381 (Ge Mesa)

2N2382



PNP germanium mesa transistors for high-speed, high-current switching applications.

CASE 79-02
(TO-39)

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

Collector connected to case

* MAXIMUM RATINGS

Rating	Symbol	2N2381	2N2382	Unit
Collector-Emitter Voltage	V_{CEO}	15	20	Vdc
Collector-Base Voltage	V_{CB}	30	45	Vdc
Emitter-Base Voltage	V_{EB}	4.0	4.0	Vdc
Collector Current-Continuous	I_C	500		mA dc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 4.0		mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	750 10		mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100		$^\circ\text{C}$

*Indicates JEDEC Registered Data

2N2381, 2N2382 (Continued)* ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 10 \text{ mAdc}$, $I_E = 0$) 2N2381 2N2382		BV_{CEO}	15 20	- -	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}$, $I_E = 0$) 2N2381 2N2382		BV_{CBO}	30 45	- -	Vdc
Latch-Up Voltage 2N2381 2N2382	2	LV_{CEX}	20 25	- -	Vdc
Collector Cutoff Current ($V_{CE} = 30 \text{ Vdc}$, $V_{BE} = 0$) ($V_{CE} = 45 \text{ Vdc}$, $V_{BE} = 0$) 2N2381 2N2382		I_{CES}	- -	100 100	μAdc
Collector Cutoff Current ($V_{CB} = 5 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 5 \text{ Vdc}$, $I_E = 0$, $T_A = 85^\circ\text{C}$) ($V_{CB} = 20 \text{ Vdc}$, $I_E = 0$) 2N2381 2N2382		I_{CBO}	- - - -	7.0 100 25 15	μAdc
Emitter Cutoff Current ($V_{BE} = 0.5 \text{ Vdc}$, $I_C = 0$) ($V_{BE} = 4 \text{ Vdc}$, $I_C = 0$)		I_{EBO}	- -	0.005 1.0	mAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 200 \text{ mAdc}$, $V_{CE} = 0.5 \text{ Vdc}$) ($I_C = 400 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$)		h_{FE}	40 25	- -	-
Collector-Emitter Saturation Voltage ($I_C = 200 \text{ mAdc}$, $I_B = 20 \text{ mAdc}$) ($I_C = 400 \text{ mAdc}$, $I_B = 40 \text{ mAdc}$)		$V_{CE(sat)}$	- -	0.4 0.7	Vdc
Base-Emitter Saturation Voltage ($I_C = 200 \text{ mAdc}$, $I_B = 20 \text{ mAdc}$) ($I_C = 400 \text{ mAdc}$, $I_B = 40 \text{ mAdc}$)		$V_{BE(sat)}$	0.45 -	0.7 0.9	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain – Bandwidth Product ($I_C = 20 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 100 \text{ MHz}$)		f_T	300	-	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 4 \text{ MHz}$)		C_{ob}	-	6.0	pF
Input Capacitance ($V_{BE} = 1 \text{ Vdc}$, $I_C = 0$, $f = 4 \text{ MHz}$)		C_{ib}	-	15	pF
Delay Time	1	t_d	-	7.0	ns
Rise Time	1	t_r	-	15	ns
Storage Time	1	t_s	-	30	ns
Fall Time	1	t_f	-	15	ns
Active Region Time Constant	1	τ_A	-	3.0	ns

*Indicates JEDEC Registered Data

FIGURE 1 — SWITCHING TIME EQUATIONS & TEST CIRCUIT

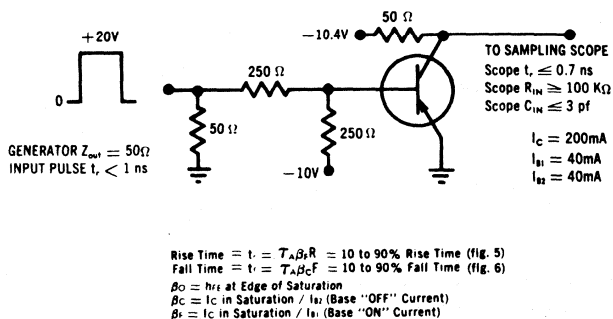
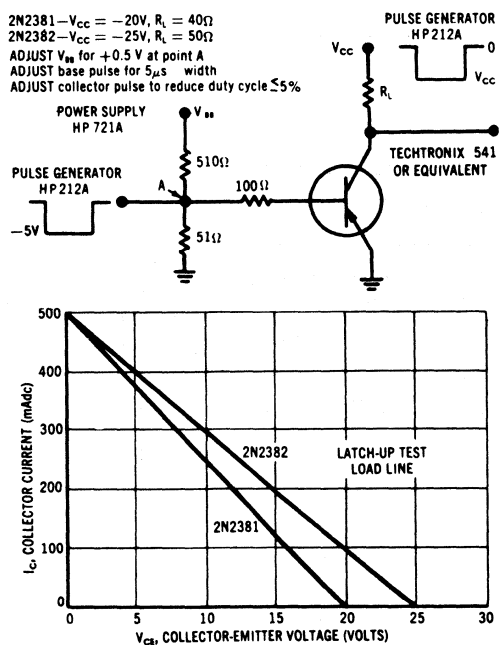


FIGURE 2 — COLLECTOR LATCH-UP VOLTAGE AND TEST CIRCUIT



2N2405S

For Specifications, See 2N1893S Data

2N2453 (SILICON)

2N2453A

MULTIPLE SILICON ANNULAR TRANSISTORS

... designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Excellent Temperature Tracking — Dual Devices — 2N2453A
 $\Delta|V_{BE1} - V_{BE2}| = 10 \mu\text{Vdc (Max)} @ -55 \text{ to } +25^\circ\text{C}$
- Low Collector-Emitter Saturation Voltage —
 $V_{CE(sat)} = 1.0 \text{ Vdc (Typ)} @ I_C = 5.0 \text{ mAdc}$
- DC Current Gain Specified — $10 \mu\text{Adc}$ to 1.0 mAdc
- High Current-Gain-Bandwidth Product —
 $f_T = 60 \text{ MHz} @ I_C = 5.0 \text{ mAdc}$

*MAXIMUM RATINGS

Rating	Symbol	2N2453	2N2453A	Unit
Collector-Emitter Voltage	V_{CE0}	30	50	V _{ac}
Collector-Base Voltage	V_{CB}	60	80	V _{dc}
Emitter-Base Voltage	V_{EB}	7.0		V _{ac}
Collector Current — Continuous	I_C	50		mA _{dc}
		One Die	Both Die	
Total Power Dissipation @ $T_A = 25^{\circ}\text{C}$ Derate above 25°C	P_D	200	300	mW
		1.14	1.71	mW/ $^{\circ}\text{C}$
Total Power Dissipation @ $T_C = 25^{\circ}\text{C}$ Derate above 25°C	P_D	800	1200	mW
		3.43	6.86	mW/ $^{\circ}\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^{\circ}\text{C}$

*ELECTRICAL CHARACTERISTICS (each side) ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage ⁽¹⁾ ($I_C = 10 \text{ mAdc}, I_E = 0$)	$V_{CE0(sust)}$	30	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	BVC_{BO}	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1 \mu\text{Adc}, I_C = 0$)	BVE_{BO}	7.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 50 \text{ Vdc}, I_E = 0$) ($V_{CB} = 50 \text{ Vdc}, I_E = 0, T_A = 150^\circ\text{C}$)	I_{CBO}	—	0.005 10	μAdc
Emitter Cutoff Current ($V_{BE} = 5.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	0.002	μAdc

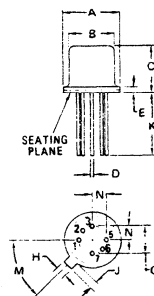
(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

*Indicates JEDEC Registered Data.

NPN SILICON MULTIPLE TRANSISTORS



STYLE 1:
 PIN 1. COLLECTOR 5. EMITTER
 2. BASE 6. BASE
 3. EMITTER 7. COLLECTOR
 4. OMITTED 8. OMITTED



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70		0.500	
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

2N2453, 2N2453A (continued)

* ELECTRICAL CHARACTERISTICS (each side) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
DC Current Gain ($I_C = 10\ \mu\text{A}$, $V_{CE} = 5.0\ \text{Vdc}$) ($I_C = 10\ \mu\text{A}$, $V_{CE} = 5.0\ \text{Vdc}$, $T_A = -55^\circ\text{C}$) ($I_C = 1.0\ \text{mA}$, $V_{CE} = 5.0\ \text{Vdc}$) ($I_C = 1.0\ \text{mA}$, $V_{CE} = 5.0\ \text{Vdc}$, $T_A = -55^\circ\text{C}$)	h_{FE}	80 40 150 75	- - 600 -	-
Collector-Emitter Saturation Voltage ($I_C = 5.0\ \text{mA}$, $I_B = 0.5\ \text{mA}$)	$V_{CE(sat)}$	-	1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 5.0\ \text{mA}$, $I_B = 0.5\ \text{mA}$)	$V_{BE(sat)}$	-	0.9	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 5.0\ \text{mA}$, $V_{CE} = 10\ \text{Vdc}$, $f = 30\ \text{MHz}$)	f_T	60	-	MHz
Output Capacitance ($V_{CB} = 10\ \text{Vdc}$, $I_E = 0$, $f = 140\ \text{kHz}$)	C_{ob}	-	8.0	pF
Input Capacitance ($V_{BE} = 0.5\ \text{Vdc}$, $I_C = 0$, $f = 140\ \text{kHz}$)	C_{ib}	-	10	pF
Input Impedance ($I_C = 1.0\ \text{mA}$, $V_{CE} = 5.0\ \text{Vdc}$, $f = 1.0\ \text{kHz}$)	h_{ie}	5.0	-	k ohms
Voltage Feedback Ratio ($I_C = 1.0\ \text{mA}$, $V_{CE} = 5.0\ \text{Vdc}$, $f = 1.0\ \text{kHz}$)	h_{re}	-	6.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0\ \text{mA}$, $V_{CE} = 5.0\ \text{Vdc}$, $f = 1.0\ \text{kHz}$)	h_{fe}	150	600	-
Output Admittance ($I_C = 1.0\ \text{mA}$, $V_{CE} = 5.0\ \text{Vdc}$, $f = 1.0\ \text{kHz}$)	h_{oe}	5.0	30	μmhos
Input Impedance ($I_C = 1.0\ \text{mA}$, $V_{CB} = 5.0\ \text{Vdc}$, $f = 1.0\ \text{kHz}$)	h_{ib}	20	30	Ohms
Voltage Feedback Ratio ($I_C = 1.0\ \text{mA}$, $V_{CB} = 5.0\ \text{Vdc}$, $f = 1.0\ \text{kHz}$)	h_{rb}	-	5.0	$\times 10^{-4}$
Output Admittance ($I_C = 1.0\ \text{mA}$, $V_{CB} = 5.0\ \text{Vdc}$, $f = 1.0\ \text{kHz}$)	h_{ob}	-	0.2	μmho
Noise Figure ($I_C = 10\ \mu\text{A}$, $V_{CE} = 5.0\ \text{Vdc}$, $R_S = 10\ \text{k ohms}$, $f = 1.0\ \text{kHz}$)	NF	-	7.0	dB

MATCHING CHARACTERISTICS

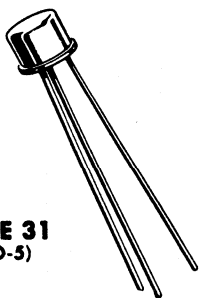
DC Current Gain Ratio (2) ($I_C = 100\ \mu\text{A}$, $V_{CE} = 5.0\ \text{Vdc}$) ($I_C = 1.0\ \text{mA}$, $V_{CE} = 5.0\ \text{Vdc}$) ($I_C = 1.0\ \text{mA}$, $V_{CE} = 5.0\ \text{Vdc}$, $T_A = -55^\circ\text{C}$ to -125°C)	h_{FE1}/h_{FE2}	0.90 0.90 0.85	1.0 1.0 1.0	-
Base-Emitter Voltage Differential ($I_C = 10\ \mu\text{A}$, $V_{CE} = 5.0\ \text{Vdc}$) ($I_C = 1.0\ \text{mA}$, $V_{CE} = 5.0\ \text{Vdc}$)	$ V_{BE1} - V_{BE2} $	- -	3.0 5.0	mVdc
Base-Emitter Voltage Differential Change Due to Temperature ($I_C = 10\ \mu\text{A}$, $V_{CE} = 5.0\ \text{Vdc}$, $T_A = -55^\circ\text{C}$ to -125°C) 2N2453 2N2453A	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	- -	10 5.0	$\mu\text{V}/^\circ\text{C}$

* Indicates JEDEC Registered Data

(2) Lowest h_{FE} reading is taken as h_{FE1} for this ratio.

2N2476 (SILICON)

2N2477



CASE 31
(TO-5)

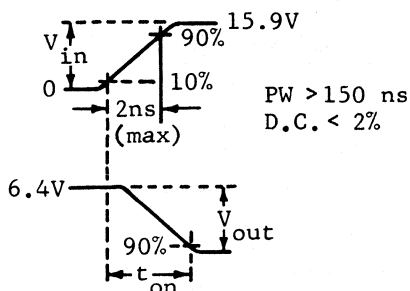
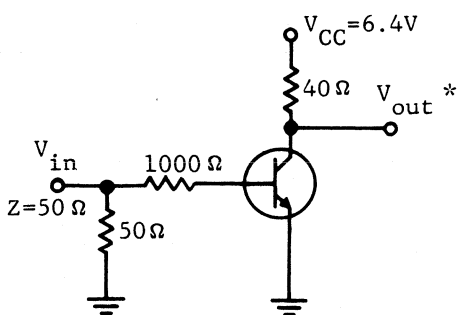
Collector connected to case

NPN silicon annular transistors designed for high-speed, low-power saturated switching applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.6 3.4	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	2.0 11.4	Watts mW/ $^\circ\text{C}$
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

FIGURE 1 — TURN-ON TIME TEST CIRCUIT



*Input and output waveforms monitored by means of an oscilloscope or other indicating device having a rise time $< 0.5 \text{ ns}$; input capacitance of probe $< 2.5 \text{ pF}$ with shunt resistance $\geq 1 \text{ megohm}$.

2N2476, 2N2477 (continued)

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 50\text{ mAdc}$, $I_B = 0$)	BV_{CEO}	20	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	60	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current ($V_{CB} = 30\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 30\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	-	0.2 200	μAdc
Emitter Cutoff Current ($V_{BE} = 5.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	-	100	μAdc

ON CHARACTERISTICS

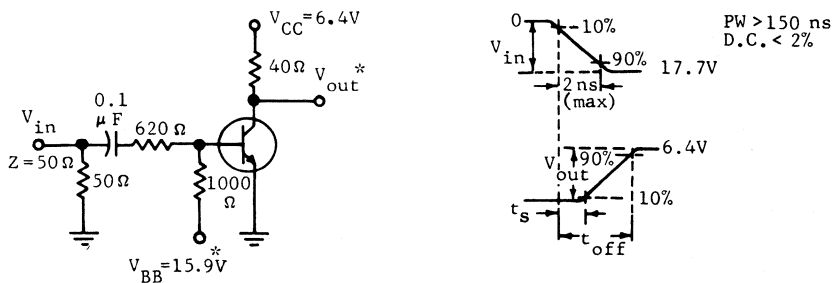
DC Current Gain ($I_C = 150\text{ mAdc}$, $V_{CE} = 0.4\text{ Vdc}$)	2N2476 2N2477	h_{FE}	20 40	-	-
Collector-Emitter Saturation Voltage ($I_C = 150\text{ mAdc}$, $I_B = 7.5\text{ mAdc}$) ($I_C = 150\text{ mAdc}$, $I_B = 3.75\text{ mAdc}$) ($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$)	2N2476 2N2477 2N2476 2N2477	$V_{CE(sat)}$	- - -	0.4 0.4 0.75 0.65	Vdc
Base-Emitter Saturation Voltage ($I_C = 150\text{ mAdc}$, $I_B = 7.5\text{ mAdc}$) ($I_C = 150\text{ mAdc}$, $I_B = 3.75\text{ mAdc}$)	2N2476 2N2477	$V_{BE(sat)}$	- -	1.0 0.95	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 50\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	250	-	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 140\text{ kHz}$)	C_{ob}	-	10	pF
Turn-On Time (Figure 1) ($V_{CC} = 6.4\text{ Vdc}$, $I_C = 150\text{ mAdc}$, $I_{B1} = 15\text{ mAdc}$)	t_{on}	-	25	ns
Turn-Off Time (Figure 2) ($V_{CC} = 6.4\text{ Vdc}$, $I_C = 150\text{ mAdc}$, $I_{B1} = I_{B2} = 15\text{ mAdc}$)	t_{off}	-	45	ns
Storage Time (Figure 2) ($I_C = 150\text{ mAdc}$, $I_{B1} = I_{B2} = 15\text{ mAdc}$)	t_s	-	25	ns

⁽¹⁾ Pulse Test: pulse width $\leq 400\text{ }\mu\text{s}$, duty cycle $\leq 3\%$.

FIGURE 2 — TURN-OFF TIME TEST CIRCUIT



*Input and output waveforms monitored by means of an oscilloscope or other indicating device having a rise time $< 0.5\text{ ns}$; input capacitance of probe $< 2.5\text{ pF}$ with shunt resistance $\geq 1\text{ megohm}$.

2N2480, A

For Specifications, See 2N2060 Data.

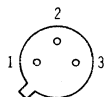
2N2481 (SILICON)

2N2481 JAN, JTX AVAILABLE



CASE 22
(TO-18)

Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

NPN silicon annular transistor for high-speed switching applications.

* MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	40	Vdc
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation @ 25°C Ambient Temperature (Derate 2.06 mW/°C above 25°C)	P_D	0.36	Watt
Total Device Dissipation @ 25°C Case Temperature (Derate 6.9 mW/°C above 25°C)	P_D	1.2	Watts
Junction Temperature	T_J	200	°C
Storage Temperature	T_{stg}	-65 to + 200	°C

* Indicates JEDEC Registered Data

2N2481 (Continued)

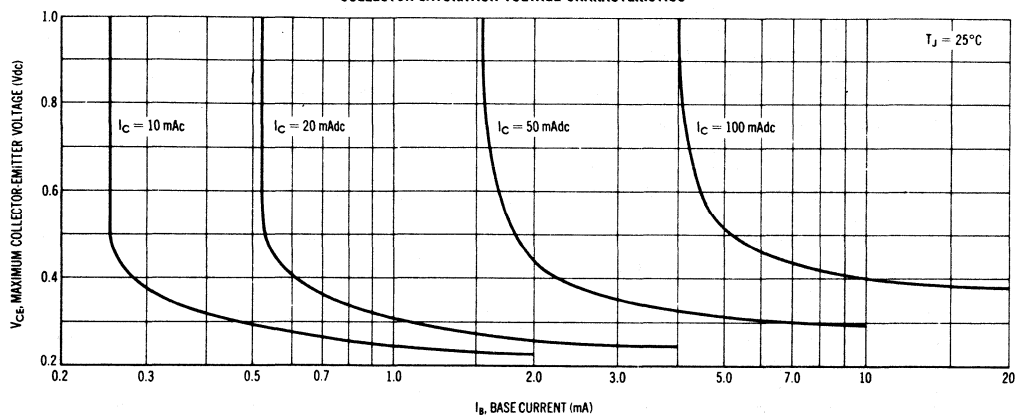
*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	40	---	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	5.0	---	Vdc
Collector-Emitter Breakdown Voltage* ($I_C = 30 \text{ mAdc}$, $I_B = 0$)	BV_{CEO}	15	---	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 1.0 \mu\text{Adc}$, $V_{BE} = 0$)	BV_{CES}	30	---	Vdc
Collector Leakage Current ($V_{CE} = 20 \text{ Vdc}$, $V_{BE} = 3 \text{ Vdc}$) ($V_{CE} = 20 \text{ Vdc}$, $V_{BE} = 3 \text{ Vdc}$, $T_A = 150^\circ\text{C}$)	I_{CEX}	---	0.050 15	μAdc
Base Leakage Current ($V_{CE} = 20 \text{ Vdc}$, $V_{BE} = 3 \text{ Vdc}$)	I_{BL}	---	50	nAdc
Emitter Cutoff Current ($V_{EB} = 4.0 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	---	100	nAdc
DC Forward Current Transfer Ratio ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$)* ($I_C = 10 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$, $T_A = -55^\circ\text{C}$) ⁽¹⁾ ($I_C = 150 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$) ⁽¹⁾	h_{FE}	25 40 20 20	--- 120 --- ---	---
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 1.0 \text{ mAdc}$) ($I_C = 100 \text{ mAdc}$, $I_B = 10 \text{ mAdc}$) ⁽¹⁾	$V_{CE}(\text{sat})$	---	0.25 0.40	Vdc
Base-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 1.0 \text{ mAdc}$) ($I_C = 100 \text{ mAdc}$, $I_B = 10 \text{ mAdc}$) ⁽¹⁾	$V_{BE}(\text{sat})$	0.7 ---	0.82 1.25	Vdc
Output Capacitance ($V_{CB} = 5 \text{ V}$, $I_C = 0$, $f = 1 \text{ MHz}$)	C_{ob}	---	5.0	pF
Input Capacitance ($V_{EB} = 0.5 \text{ V}$, $f = 1 \text{ MHz}$)	C_{ib}	---	7.0	pF
Small-Signal Forward Current Transfer Ratio ($V_{CE} = 10 \text{ V}$, $I_C = 10 \text{ mA}$, $f = 100 \text{ MHz}$)	h_{fe}	3.0	---	---
Small-Signal, Short-Circuit, Input Impedance (Real part) ($I_C = 10 \text{ mA}$, $V_{CE} = 10 \text{ V}$, $f = 250 \text{ MHz}$)	$\text{Re}(h_{ie})$	---	60	ohms
Turn-On Time ($I_C = 100 \text{ mA}$, $I_{B1} = 10 \text{ mA}$, $V_{BE}(\text{off}) = 2 \text{ V}$) ($I_C = 10 \text{ mA}$, $I_{B1} = 1.0 \text{ mA}$, $V_{BE}(\text{off}) = 2 \text{ V}$)	t_{on}	---	40 75	ns
Turn-Off Time ($I_C = 100 \text{ mA}$, $I_{B1} = 10 \text{ mA}$, $I_{B2} = 5 \text{ mA}$) ($I_C = 10 \text{ mA}$, $I_{B1} = 1.0 \text{ mA}$, $I_{B2} = 0.5 \text{ mA}$)	t_{off}	---	55 45	ns
Storage Time ($I_C = 10 \text{ mA}$, $I_{B1} = 10 \text{ mA}$, $I_{B2} = 10 \text{ mA}$)	t_s	---	20	ns

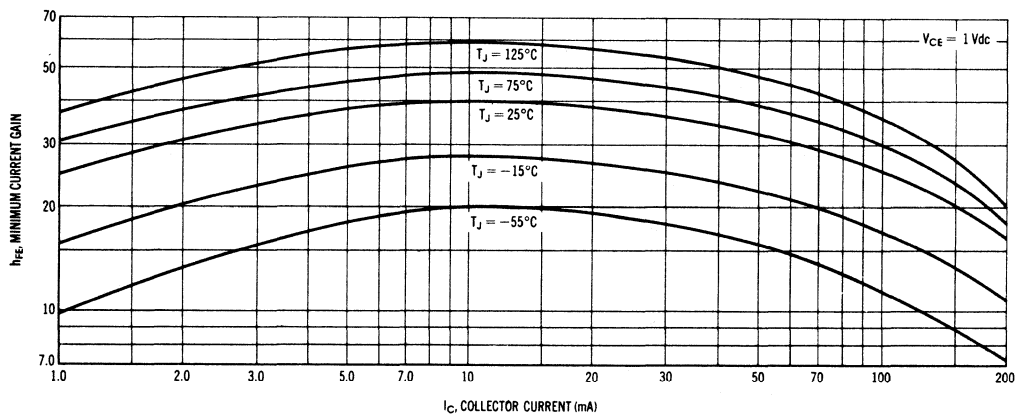
⁽¹⁾ Pulse width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2\%$

* Indicates JEDEC Registered Data

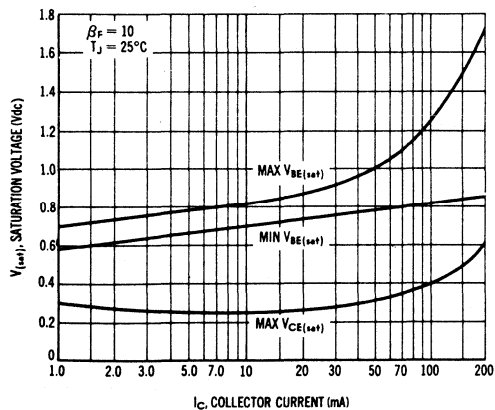
COLLECTOR SATURATION VOLTAGE CHARACTERISTICS



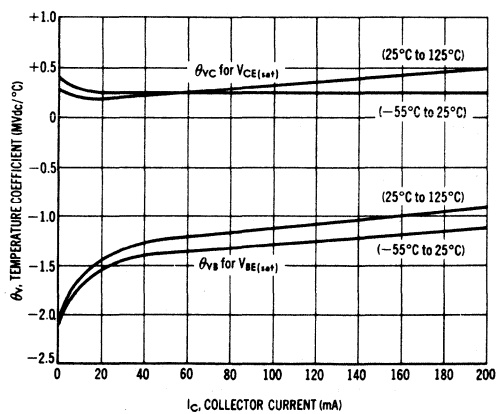
MINIMUM CURRENT GAIN CHARACTERISTICS



LIMITS OF SATURATION VOLTAGES

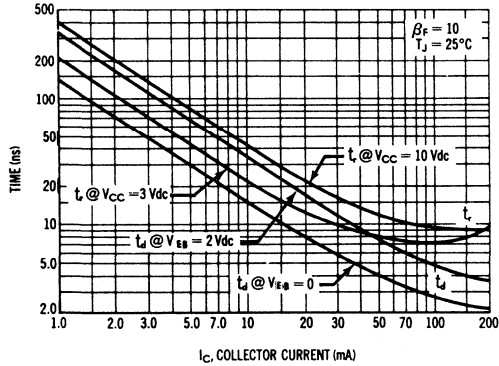


TYPICAL TEMPERATURE COEFFICIENTS

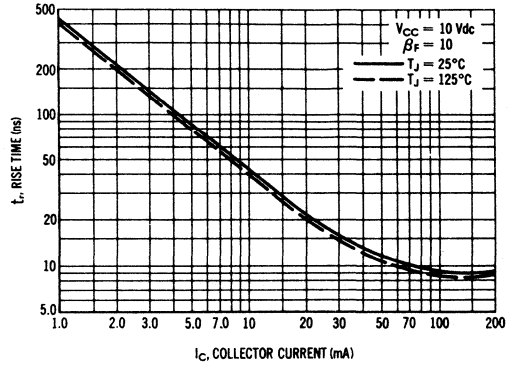


TYPICAL SWITCHING CHARACTERISTICS

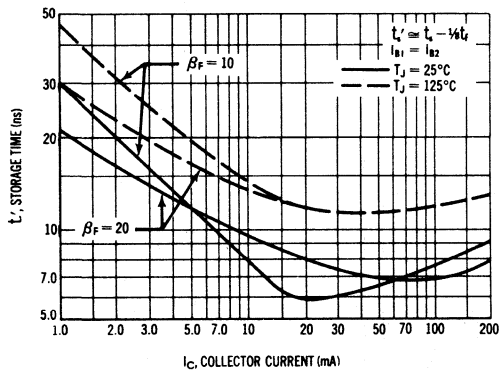
TURN-ON TIME VARIATIONS WITH VOLTAGE



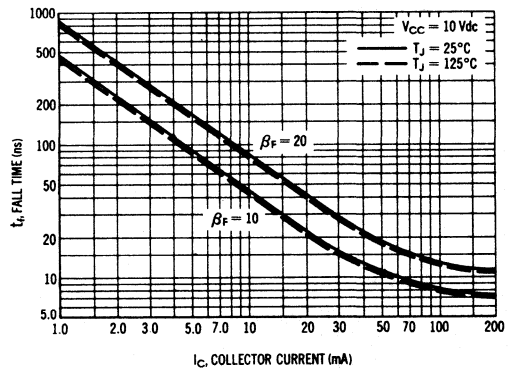
RISE TIME BEHAVIOR



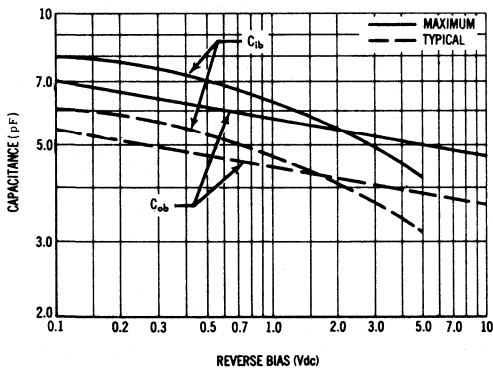
STORAGE TIME BEHAVIOR



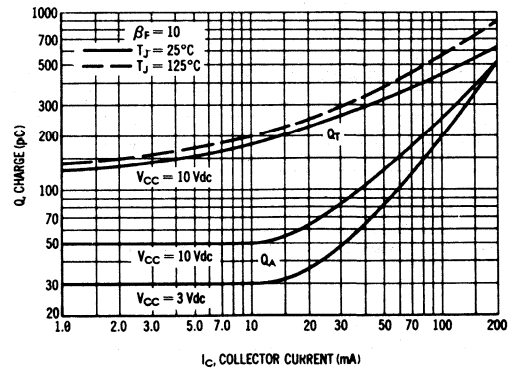
FALL TIME BEHAVIOR



JUNCTION CAPACITANCE VARIATIONS



MAXIMUM CHARGE DATA



2N2483(SILICON)

2N2484

NPN SILICON ANNULAR HIGH-GAIN TRANSISTORS

... designed for use in high-gain audio amplifier applications.

- Collector-Emitter Breakdown Voltage –
 $V_{CEO} = 60 \text{ Vdc (Min) @ } I_C = 10 \text{ mAdc}$
- DC Current Gain – $1.0 \mu\text{Adc to } 10 \text{ mAdc} - 2N2484$
- Current-Gain – Bandwidth Product –
 $f_T = 100 \text{ MHz (Typ) @ } I_C = 500 \mu\text{Adc}$
- Low Noise Figure –
 $NF = 8.0 \text{ dB (Typ) @ } I_C = 10 \mu\text{Adc, } f = 100 \text{ Hz}$

***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current – Continuous	I_C	50	mAdc
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	360 2.06	mW mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.2 6.85	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

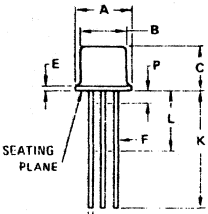
***THERMAL CHARACTERISTICS**

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}^{(1)}$	485	$^\circ\text{C/W}$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	146	$^\circ\text{C/W}$
Lead Temperature 1/16" from Case for 10 Seconds	T_L	300	$^\circ\text{C}$

*Indicates JEDEC Registered Data

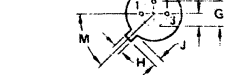
(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

**NPN SILICON
HIGH GAIN AMPLIFIER
TRANSISTORS**



STYLE 1:

- PIN 1. EMITTER
- 2. BASE
- 3. COLLECTOR



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	—	0.762	—	0.030
F	0.406	0.483	0.016	0.019
G	—	2.54 BSC	—	0.100 BSC
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	—	45° BSC	—	45° BSC
N	—	1.27 BSC	—	0.050 BSC
P	—	1.27	—	0.050

All JEDEC notes and dimensions apply.

CASE 22-03
TO 18

2N2483, 2N2484 (continued)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 10\text{ mA}$, $I_B = 0$)	BV_{CEO}	60	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{A}$, $I_E = 0$)	BV_{CBO}	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{A}$, $I_C = 0$)	BV_{EBO}	6.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 45\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 45\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	— —	10 10	nAdc μAdc
Emitter Cutoff Current ($V_{BE} = 5.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	—	10	nAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 1.0\text{ }\mu\text{A}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 10\text{ }\mu\text{A}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 10\text{ }\mu\text{A}$, $V_{CE} = 5.0\text{ Vdc}$, $T_A = 55^\circ\text{C}$) ($I_C = 100\text{ }\mu\text{A}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 500\text{ }\mu\text{A}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 1.0\text{ mA}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 10\text{ mA}$, $V_{CE} = 5.0\text{ Vdc}$) (1)	2N2484 2N2483 2N2484 2N2483 2N2484 2N2483 2N2484 2N2483 2N2484 2N2483 2N2484	h_{FE}	30 40 100 10 20 75 175 100 200 175 250 — —	190 95 250 20 40 100 275 150 300 200 350 300 400	— 120 500 — — — — — — — 500 800	—
Collector-Emitter Saturation Voltage ($I_C = 1.0\text{ mA}$, $I_B = 0.1\text{ mA}$)		$V_{CE(sat)}$	—	0.25	0.35	Vdc
Base-Emitter On Voltage ($I_C = 0.1\text{ mA}$, $V_{CE} = 5.0\text{ Vdc}$)		$V_{BE(on)}$	0.5	0.65	0.7	Vdc

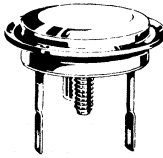
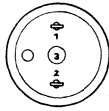
DYNAMIC CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 0.05\text{ mA}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 5.0\text{ MHz}$) ($I_C = 0.5\text{ mA}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 30\text{ MHz}$)	2N2483 2N2484	f_T	12 15 60	50 50 100	— — —	MHz
Output Capacitance ($V_{CB} = 5.0\text{ Vdc}$, $I_E = 0$, $f = 140\text{ kHz}$)		C_{ob}	—	3.0	6.0	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 140\text{ kHz}$)		C_{ib}	—	4.0	6.0	pF
Input Impedance ($I_C = 1.0\text{ mA}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N2483 2N2484	h_{ie}	1.5 3.5	— —	13 24	k Ω
Voltage Feedback Ratio ($I_C = 1.0\text{ mA}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)		h_{re}	—	—	800	$\times 10^{-6}$
Small-Signal Current Gain ($I_C = 1.0\text{ mA}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N2483 2N2484	h_{fe}	80 150	— —	450 900	—
Output Admittance ($I_C = 1.0\text{ mA}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N2483 2N2484	h_{oe}	— —	— —	30 40	μmhos
Noise Figure ($I_C = 10\text{ }\mu\text{A}$, $V_{CE} = 5.0\text{ Vdc}$, $R_S = 10\text{ k}\Omega$, $f = 100\text{ Hz}$, $BW = 20\text{ Hz}$) ($I_C = 10\text{ }\mu\text{A}$, $V_{CE} = 5.0\text{ Vdc}$, $R_S = 10\text{ k}\Omega$, $f = 1.0\text{ kHz}$, $BW = 200\text{ Hz}$) ($I_C = 10\text{ }\mu\text{A}$, $V_{CE} = 5.0\text{ Vdc}$, $R_S = 10\text{ k}\Omega$, $f = 10\text{ kHz}$, $BW = 2.0\text{ kHz}$) ($I_C = 10\text{ }\mu\text{A}$, $V_{CE} = 5.0\text{ Vdc}$, $R_S = 10\text{ k}\Omega$, $f = 10\text{ Hz}$ to 15.7 kHz , $BW = 15.7\text{ kHz}$)	2N2483 2N2484 2N2483 2N2484 2N2483 2N2484 2N2483 2N2484	NF	— — — — — — — —	8.0 8.0 — — — — — —	15 10 4.0 3.0 3.0 2.0 4.0 3.0	dB

*Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.

2N2490 thru 2N2493 (GERMANIUM)



STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

CASE 5 (TO-36)

PNP germanium power transistors for general purpose power and switching applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	2N2490	2N2491	2N2492	2N2493	Unit
Collector-Base Voltage	V_{CB}	70	60	80	100	Volts
Collector-Emitter Voltage	V_{CES}	60	50	70	85	Volts
Emitter-Base Voltage	V_{EB}	40	30	60	80	Volts
Collector Current	I_C	15				Amp
Power Dissipation at $T_C = 25^\circ\text{C}$	P_D	170				Watts
Junction Temperature Range	T_J	-65 to +110				$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Cutoff Current ($V_{CB} = -2 \text{ Vdc}$)	I_{CBO}	—	0.2	mAdc
Emitter-Base Cutoff Current ($V_{EB} = -40 \text{ Vdc}$) ($V_{EB} = -30 \text{ Vdc}$) ($V_{EB} = -60 \text{ Vdc}$) ($V_{EB} = -80 \text{ Vdc}$)	I_{EBO}	— — — —	3.0 3.0 2.0 3.0	mAdc
Collector Cutoff Current ($V_{CE} = -70 \text{ Vdc}$, $V_{BE} = 1.5 \text{ Vdc}$) ($V_{CE} = -60 \text{ Vdc}$, $V_{BE} = 1.5 \text{ Vdc}$) ($V_{CE} = -80 \text{ Vdc}$, $V_{BE} = 1.5 \text{ Vdc}$) ($V_{CE} = -100 \text{ Vdc}$, $V_{BE} = 1.5 \text{ Vdc}$) ($V_{CE} = -35 \text{ Vdc}$, $V_{BE} = 1.5 \text{ Vdc}$, $T_C = +100^\circ\text{C}$) ($V_{CE} = -40 \text{ Vdc}$, $V_{BE} = 1.5 \text{ Vdc}$, $T_C = +100^\circ\text{C}$) ($V_{CE} = -50 \text{ Vdc}$, $V_{BE} = 1.5 \text{ Vdc}$, $T_C = +100^\circ\text{C}$)	I_{CEX}	— — — — — — —	3.0 3.0 2.0 3.0 35 35 35	mAdc
Collector-Emitter Breakdown Voltage ($I_C = 1 \text{ A}$, $I_B = 0$)	V_{CEO}	50 40 65 75	— — — —	Volts
Base-Emitter Voltage ($I_C = 5 \text{ Adc}$, $V_{CE} = -2 \text{ Vdc}$) ($I_C = 12 \text{ Adc}$, $V_{CE} = -2 \text{ Vdc}$)	V_{BE}	— — —	0.9 0.8 1.5	Vdc
Collector-Emitter Saturation Voltage ($I_C = 12 \text{ Adc}$, $I_B = 2 \text{ Adc}$)	$V_{CE(sat)}$	— —	0.7 0.5	Vdc
DC Current Gain ($I_C = 1 \text{ Adc}$, $V_{CE} = -2 \text{ Vdc}$) ($I_C = 5 \text{ Adc}$, $V_{CE} = -2 \text{ Vdc}$) ($I_C = 5 \text{ Adc}$, $V_{CE} = -2 \text{ Vdc}$, $T_A = -65^\circ\text{C}$) ($I_C = 12 \text{ Adc}$, $V_{CE} = -2 \text{ Vdc}$)	h_{FE}	45 65 50 20 35 25 15 25 20 8 12 10	— — — 40 70 50 — — — — —	—
Common Emitter Cutoff Frequency ($I_C = 5 \text{ A}$, $V_{CE} = -6 \text{ V}$)	$f_{\alpha e}$	5.0	—	kHz
Turn-On Time ($I_C = 5 \text{ A}$, $I_{B1} = I_{B2} = 0.5 \text{ A}$)	t_{on}	—	25	μs
Turn-Off Time ($I_C = 5 \text{ A}$, $I_{B1} = I_{B2} = 0.5 \text{ A}$)	t_{off}	—	15	μs

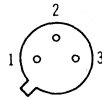
2N2501 (SILICON)



NPN silicon annular transistor for high-speed switching applications.

CASE 22 (TO-18)

Collector connected to case



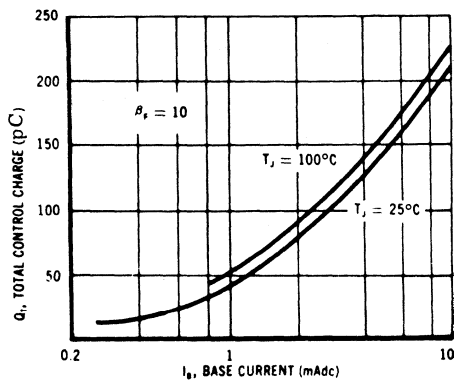
STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

* MAXIMUM RATINGS

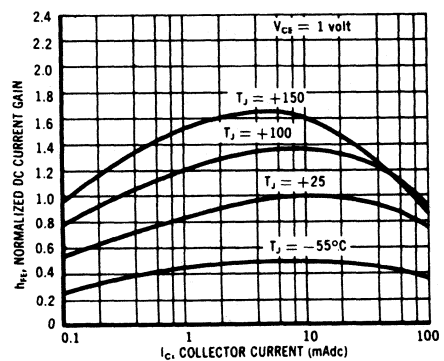
Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	40	Vdc
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Total Device Dissipation @ 25°C Ambient Temperature (Derate 2.06 mW/°C above 25°C)	P_D	0.36	Watts
Junction Temperature	T_J	+200	°C
Storage Temperature	T_{stg}	-65 to +200	°C
Total Device Dissipation @ 25°C Case Temperature (Derate 6.9 mW/°C above 25°C)	P_D	1.2	Watts

* Indicates JEDEC Registered Data

TOTAL CONTROL CHARGE



NORMALIZED CURRENT GAIN CHARACTERISTICS

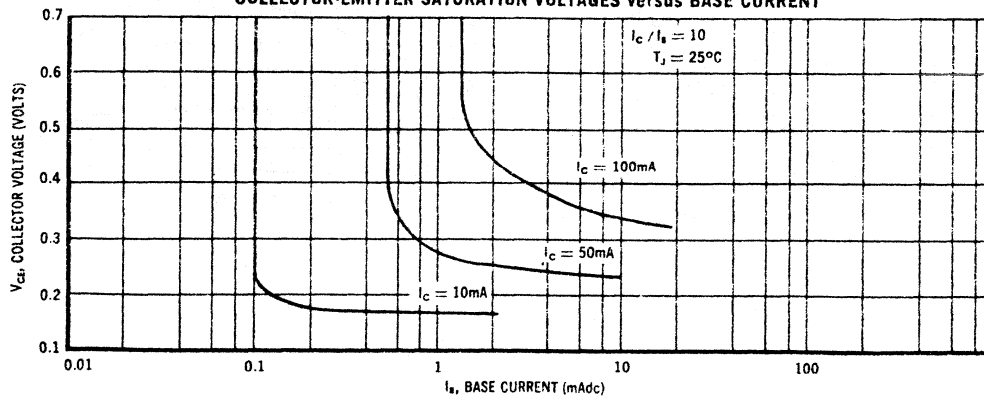


*** ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

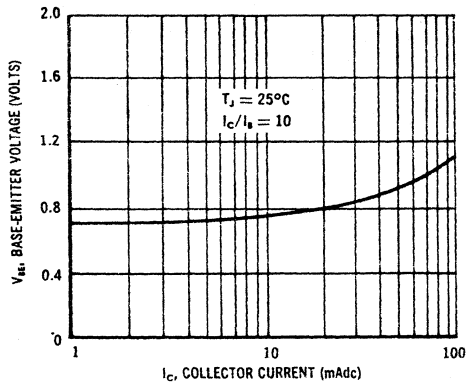
Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage ($I_C = 10\ \mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	40	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 30\ \text{mAdc}$, $I_B = 0$, Pulsed)	BV_{CEO}	20	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	6.0	—	Vdc
Collector Leakage Current ($V_{CE} = 20\ \text{Vdc}$, $V_{BE} = 3\ \text{Vdc}$)	I_{CEX}	—	25	nAdc
Base Leakage Current ($V_{CE} = 20\ \text{Vdc}$, $V_{BE} = 3\ \text{Vdc}$) ($V_{CE} = 20\ \text{Vdc}$, $V_{BE} = 3\ \text{Vdc}$, $T_A = 150^\circ\text{C}$)	I_{BL}	— —	0.025 50	μAdc μAdc
DC Forward Current Transfer Ratio(1) ($I_C = 100\ \mu\text{Adc}$, $V_{CE} = 1\ \text{Vdc}$) ($I_C = 1\ \text{mAdc}$, $V_{CE} = 1\ \text{Vdc}$) ($I_C = 10\ \text{mAdc}$, $V_{CE} = 1\ \text{Vdc}$) ($I_C = 10\ \text{mAdc}$, $V_{CE} = 1\ \text{Vdc}$, $T_A = -55^\circ\text{C}$) ($I_C = 50\ \text{mAdc}$, $V_{CE} = 1\ \text{Vdc}$) ($I_C = 100\ \text{mAdc}$, $V_{CE} = 1\ \text{Vdc}$) ($I_C = 500\ \text{mAdc}$, $V_{CE} = 5\ \text{Vdc}$)	h_{FE}	20 30 50 20 40 30 10	— — 150 — — — —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 10\ \text{mAdc}$, $I_B = 1\ \text{mAdc}$) ($I_C = 50\ \text{mAdc}$, $I_B = 5\ \text{mAdc}$) ($I_C = 100\ \text{mAdc}$, $I_B = 10\ \text{mAdc}$)	$V_{CE(sat)}$	— — —	0.2 0.3 0.4	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 10\ \text{mAdc}$, $I_B = 1\ \text{mAdc}$) ($I_C = 50\ \text{mAdc}$, $I_B = 5\ \text{mAdc}$) ($I_C = 100\ \text{mAdc}$, $I_B = 10\ \text{mAdc}$)	$V_{BE(sat)}$	— — —	0.85 1.0 1.2	Vdc
Output Capacitance ($V_{CB} = 10\ \text{Vdc}$, $I_E = 0$, $f = 100\ \text{kHz}$)	C_{ob}	—	4.0	pF
Input Capacitance ($V_{EB} = 0.5\ \text{Vdc}$, $I_C = 0$, $f = 100\ \text{kHz}$)	C_{ib}	—	7.0	pF
Small Signal Forward Current Transfer Ratio ($V_{CE} = 20\ \text{Vdc}$, $I_C = 10\ \text{mAdc}$, $f = 100\ \text{MHz}$)	h_{fe}	3.5	—	—
Current-Gain-Bandwidth Product ($V_{CE} = 20\ \text{Vdc}$, $I_C = 10\ \text{mAdc}$, $f = 100\ \text{MHz}$)	f_T	350	—	MHz
Charge Storage Time Constant ($I_C = I_{B1} = I_{B2} = 10\ \text{mAdc}$)	τ_S	—	15	ns
Total Control Charge ($I_C = 10\ \text{mAdc}$, $I_B = 1\ \text{mAdc}$)	Q_T	—	60	pC
Active Region Time Constant ($I_C = 10\ \text{mAdc}$)	τ_A	—	2.5	ns

* Indicates JEDEC Registered

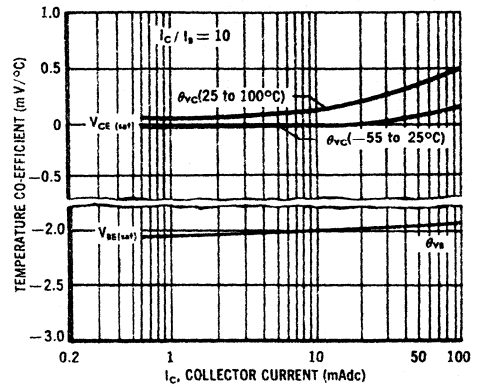
(1) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

COLLECTOR-EMITTER SATURATION VOLTAGES versus BASE CURRENT


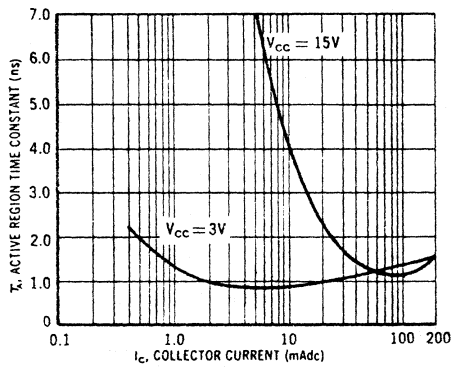
BASE-EMITTER VOLTAGE
versus COLLECTOR CURRENT



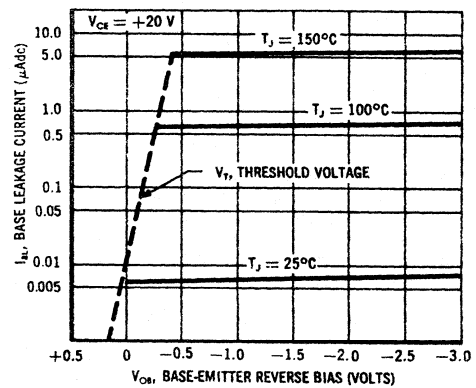
TEMPERATURE COEFFICIENTS



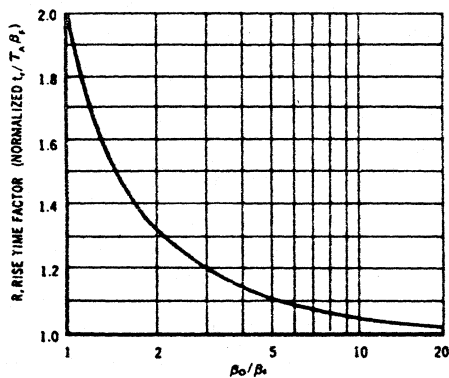
ACTIVE REGION TIME CONSTANT



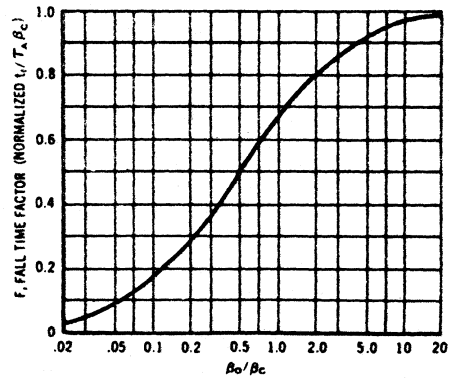
COMMON EMITTER DC
LEAKAGE CHARACTERISTICS



RISE TIME FACTOR



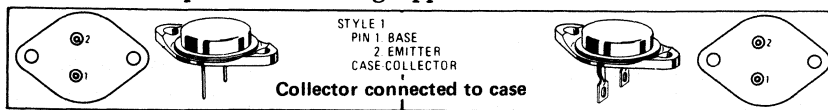
FALL TIME FACTOR



2N2526 (GERMANIUM) PNIP germanium power transistors for high-voltage power switching applications.

2N2527

2N2528



CASE 11A

For units with solder lugs attached, specify devices MP2526 etc. (Case 4-04)

CASE 4-04

MAXIMUM RATINGS

Rating	Symbol	2N2526	2N2527	2N2528	Unit
Collector-Emitter Voltage	V_{CE}	80	120	160	Vdc
Collector-Base	V_{CB}	80	120	160	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current - Continuous	I_C	10			Adc
Base Current	I_B	5.0			Adc
Emitter Reverse Current (Surge 60 Hz Recurrent)	I_E	1.5			Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$	P_D	85			Watts
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110			$^\circ\text{C}$

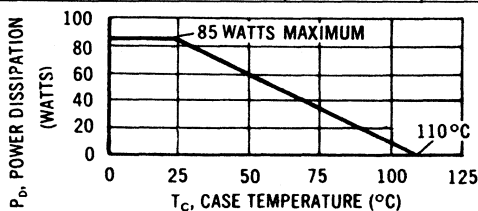
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.0	$^\circ\text{C/W}$

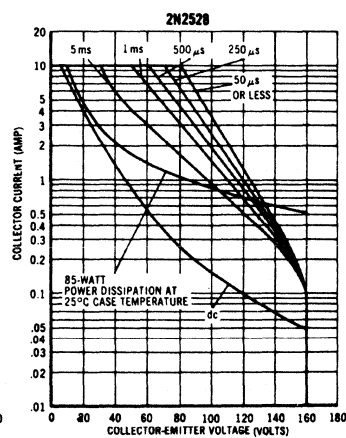
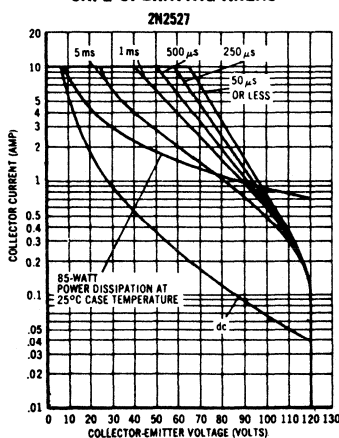
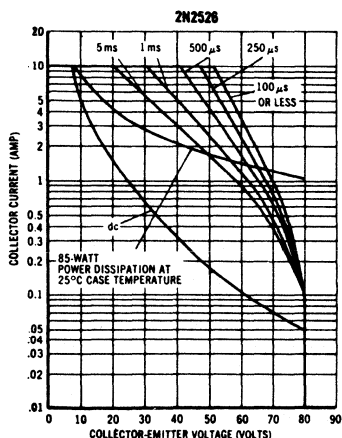
POWER-TEMPERATURE DERATING CURVE

The maximum continuous power is related to maximum junction temperature by the thermal resistance factor. This curve has a value of 85 watts at a case temperature of 25°C and is 0 watts at 110°C with a linear relation between the two temperatures such that:

$$\text{Allowable } P_D = \frac{110^\circ - T_C}{1.0} \text{ Watts}$$



SAFE OPERATING AREAS



The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short.

(Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J , the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N2526 thru 2N2528 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I _C = 100 mA _{dc} , I _B = 0)	BV _{CEO(sus)} *	80 120 160	- - -	- - -	Volts
Emitter-Base Breakdown Voltage (I _E = 50 mA _{dc} , I _C = 0)	BV _{EBO}	5.0	-	-	V _{dc}
Collector Cutoff Current* (V _{CE} = 80 V _{dc} , V _{BE(off)} = 0.2 V _{dc} , T _C = 100°C) (V _{CE} = 120 V _{dc} , V _{BE(off)} = 0.2 V _{dc} , T _C = 100°C) (V _{CE} = 160 V _{dc} , V _{BE(off)} = 0.2 V _{dc} , T _C = 100°C)	I _{CEX} *	- - -	- - -	35 35 35	mA _{dc}
Collector-Emitter Cutoff Current (V _{CE} = 80 V _{dc} , R _{BE} = 100 ohms) (V _{CE} = 120 V _{dc} , R _{BE} = 100 ohms) (V _{CE} = 160 V _{dc} , R _{BE} = 100 ohms)	I _{CER}	- - -	- - -	25 25 25	mA _{dc}
Collector Cutoff Current (V _{CB} = 80 V _{dc} , I _E = 0) (V _{CB} = 120 V _{dc} , I _E = 0) (V _{CB} = 160 V _{dc} , I _E = 0) (V _{CB} = 2.0 V _{dc} , I _E = 0)	I _{CBO}	- - - -	- - - -	3.0 3.0 3.0 150	mA _{dc} μA _{dc}

ON CHARACTERISTICS

DC Current Gain (I _C = 3.0 A _{dc} , V _{CE} = 2.0 V _{dc})	h _{FE}	20	-	50	-
DC Transconductance (I _C = 3.0 A _{dc} , V _{CE} = 2.0 V _{dc})	g _{FE}	4.0	6.0	-	mhos
Collector-Emitter Saturation Voltage (I _C = 10 A _{dc} , I _B = 1.0 A _{dc})	V _{CE(sat)}	-	0.5	0.8	V _{dc}
Base-Emitter Saturation Voltage (I _C = 10 A _{dc} , I _B = 1.0 A _{dc})	V _{BE(sat)}	-	0.8	1.2	V _{dc}

DYNAMIC CHARACTERISTICS

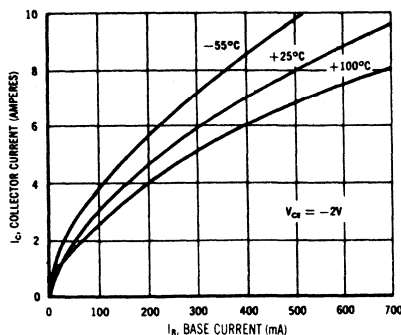
Small-Signal Current Gain (I _C = 0.5 A _{dc} , V _{CE} = 12 V _{dc} , f = 30 kHz)	h _{fe}	10	15	-	-
Rise Time	t _r	-	5.5	-	μs
Storage Time	t _s	-	1.2	-	μs
Fall Time	t _f	-	2.0	-	μs

*To avoid excessive heating of collector junction, perform this test with a sweep method.

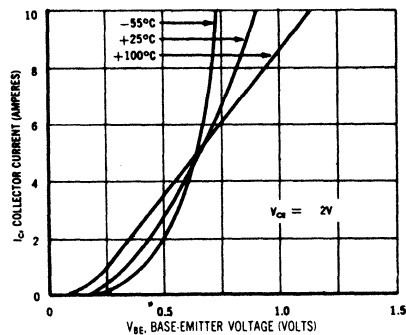
TYPICAL INPUT CHARACTERISTICS

COLLECTOR CURRENT versus BASE CURRENT

ALL TYPES



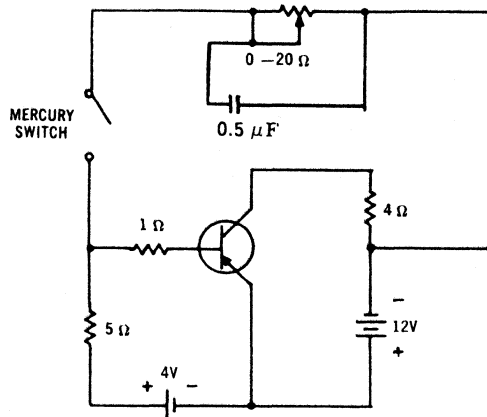
COLLECTOR CURRENT versus DRIVE VOLTAGE



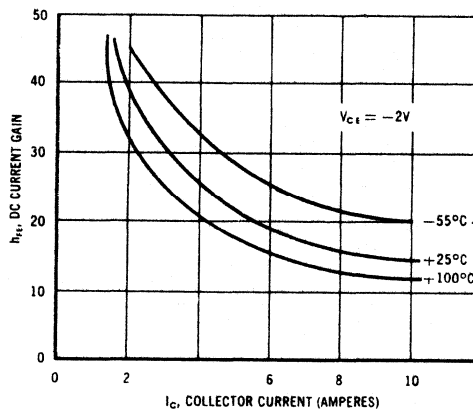
2N2526 thru 2N2528 (continued)

SWITCHING TEST CIRCUIT

PULSE CONDITIONS : $I_C = 3 \text{ A dc}$, $I_B = 300 \text{ mA dc}$



DC CURRENT GAIN versus COLLECTOR CURRENT



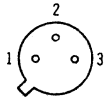
2N2539, 2N2540 (SILICON)



NPN silicon annular transistors for high-speed switching.

CASE 22 (TO-18)

2N2539
2N2540



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

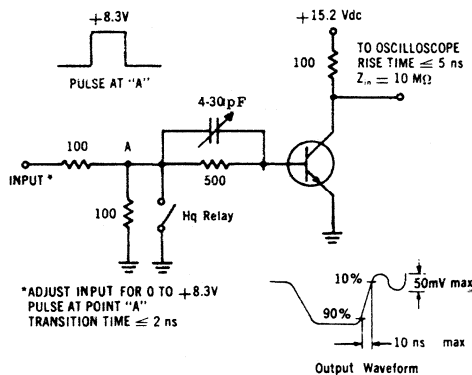
Collector connected to case

*MAXIMUM RATINGS

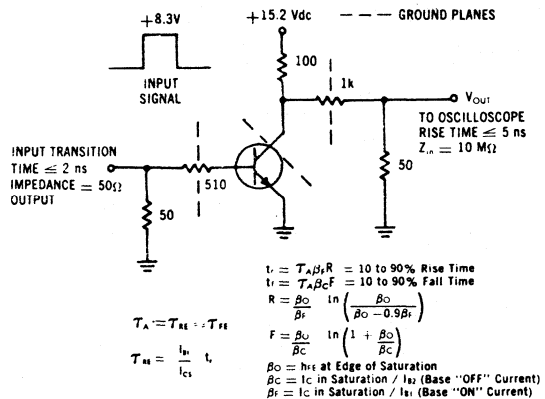
Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	60	Vdc
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Emitter Voltage	V_{CER}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation 25°C Case Temperature Derate above 25°C	P_D	1.8 10.3	Watts mW/°C
Total Device Dissipation 25°C Ambient Temperature Derate above 25°C	P_D	0.5 2.86	Watts mW/°C
Junction Temperature	T_J	-65 to +200	°C
Storage Temperature	T_{stg}	-65 to +200	°C

* Indicates JEDEC Registered Data

TOTAL CONTROL CHARGE TEST CIRCUIT



ACTIVE REGION TIME CONSTANT TEST CIRCUIT



***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current ($V_{CB} = 40\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 40\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	0.250 200	μAdc
Emitter Cutoff Current ($V_{EB} = 3\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	0.05	μAdc
Collector Cutoff Current ($V_{BE} = 0.2\text{ Vdc}$, $V_{CE} = 20\text{ Vdc}$)	I_{CEX}	—	0.250	μAdc
Base Cutoff Current ($V_{BE} = 0.2\text{ Vdc}$, $V_{CE} = 20\text{ Vdc}$) ($V_{BE} = 0.2\text{ Vdc}$, $V_{CE} = 20\text{ Vdc}$, $T_A = 150^\circ\text{C}$)	I_{BL}	— —	0.250 200	μAdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	60	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100\text{ mAdc}$, pulsed, $I_B = 0$)	BV_{CEO}	30	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100\text{ mAdc}$, pulsed, $R_{BE} \leq 10\text{ }\Omega$)	BV_{CER}	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	5.0	—	Vdc
Collector Saturation Voltage * ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$) ($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$)	$V_{CE(sat)}$	— —	0.45 1.6	Vdc
Base-Emitter Saturation Voltage ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$) ⁽¹⁾ ($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$)	$V_{BE(sat)}$	— —	1.3 2.6	Vdc
DC Forward Current Transfer Ratio ($I_C = 1\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 150\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ⁽¹⁾ ($I_C = 500\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ⁽¹⁾	h_{FE}	20 35 30 50 50 100 20 30	— — — — 150 300 — —	—
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)	C_{ob}	—	8.0	pF
Input Capacitance ($V_{EB} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)	C_{ib}	—	25	pF
Small Signal Forward Current Transfer Ratio ($V_{CE} = 20\text{ Vdc}$, $I_C = 20\text{ mAdc}$, $f = 100\text{ MHz}$)	h_{fe}	2.5	—	—

⁽¹⁾ Pulse Test: Pulse width $\leq 300\text{ }\mu\text{s}$, duty cycle $\leq 2\%$

* Indicates JEDEC Registered Data

SWITCHING CHARACTERISTICS

Characteristic	Symbol	Max.	Unit
Total Control Charge	Q_T	750	pC
Storage Time ($I_C = I_{B1} = I_{B2} = 20\text{ mAdc}$, $V_{CC} = 5\text{ V}$)	τ_S	20	ns
Active Region Time Constant	τ_A	2.0	ns
Turn-on Time ($I_{B1} = I_{B2} = 15\text{ mAdc}$, $I_C = 150\text{ mAdc}$, $V_{CC} = 7\text{ Vdc}$, $R_L = 40\text{ }\Omega$)	t_{on}	40	ns
Turn-off Time ($I_{B1} = I_{B2} = 15\text{ mAdc}$, $I_C = 150\text{ mAdc}$, $V_{CC} = 7\text{ Vdc}$, $R_L = 40\text{ }\Omega$)	t_{off}	40	ns

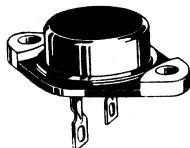
2N2552 thru 2N2559

For Specifications, See 2N1038 Data.

2N2560 thru 2N2567

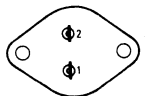
For Specifications, See 2N1042 Data.

2N2573 thru 2N2579 (SILICON)



Industrial-type, silicon controlled rectifiers in a "diamond" package for applications requiring a high surge-current rating or low thermal resistance.

CASE 61 **CASE 54**
(TO-41) (TO-3 Modified)



STYLE 1:
PIN 1: GATE
2: CATHODE
CASE: ANODE

For units with pins (TO-3 Modified) specify devices MCR649AP-1(2N2573) thru MCR649AP-7(2N2579).

MAXIMUM RATINGS ($T_J = 125^\circ\text{C}$ unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage* 2N2573 2N2574 2N2575 2N2576 2N2577 2N2578 2N2579	$V_{RSM(rep)}^*$	25 50 100 200 300 400 500	Volts
Forward Current RMS (all conduction angles)	$I_{T(RMS)}$	25	Amp
Circuit Fusing Considerations ($T_J = -65^\circ$ to $+125^\circ\text{C}$, $t \leq 8.3$ ms)	I^2t	275	A^2s
Peak Surge Current (One Cycle, 60 Hz, $T_J = -65$ to $+125^\circ\text{C}$)	I_{TSM}	260	Amp
Peak Gate Power - Forward	P_{GM}	5.0	Watts
Average Gate Power - Forward	$P_{G(AV)}$	0.5	Watt
Peak Gate Current - Forward	I_{GM}	2.0	Amp
Peak Gate Voltage - Forward Reverse	V_{GFM} V_{GRM}	10 5.0	Volts
Operating Junction Temperature Range	T_J	-65 to +125	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +150	$^\circ\text{C}$

* V_{RSM} for all types can be applied on a continuous dc basis without incurring damage.

V_{RSM} Ratings apply for zero or negative gate voltage.

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

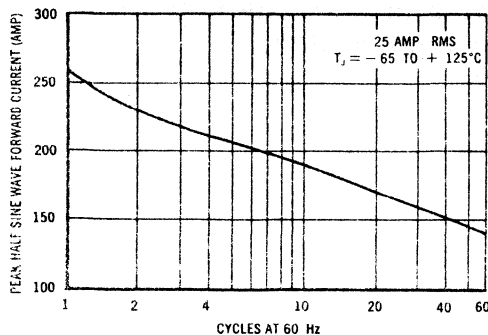
Characteristic	Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage* ($T_J = 125^\circ\text{C}$)	V_{DRM}^*	25 50 100 200 300 400 500	— — — — — — —	— — — — — — —	Volts
Peak Forward Blocking Current (Rated V_{DRM} with gate open, $T_J = 125^\circ\text{C}$)	I_{DRM}	—	0.6	5.0	mA
Peak Reverse Blocking Current (Rated V_{RSM} , $T_J = 125^\circ\text{C}$)	I_{RRM}	—	0.6	5.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, $R_L = 100\ \Omega$)	I_{GT}	—	20	40	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, $R_L = 100\ \Omega$) ($V_{\text{DRM}} = \text{Rated } R_L = 100\ \Omega$, $T_J = 125^\circ\text{C}$)	V_{GT} V_{GNT}	— 0.3	1.0 —	3.5 3.5	Volts
Forward On Voltage ($I_T = 20\ \text{Adc}$)	V_T	—	1.1	1.4	Volts
Holding Current (Anode Voltage = 7 Vdc, Gate Open)	I_H	—	20	—	mA
Turn-On Time ($t_d + t_r$) ($I_{\text{GT}} = 50\ \text{mA}$, $I_T = 10\ \text{A}$)	t_{gt}	—	1.0	—	μs
Turn-Off Time ($I_T = 10\ \text{A}$, $I_R = 10\ \text{A}$, $dv/dt = 20\ \text{V}/\mu\text{s}$, $T_J = 125^\circ\text{C}$) ($V_{\text{DRM}} = \text{rated voltage}$)	t_q	—	30	—	μs
Forward Voltage Application Rate (Gate Open, $T_J = 125^\circ\text{C}$)	dv/dt	—	30	—	$\text{V}/\mu\text{s}$
Thermal Resistance (Junction to Case)	θ_{JC}	—	1.0	1.5	$^\circ\text{C}/\text{W}$

* V_{DRM} for all types can be applied on a continuous dc basis without incurring damage.

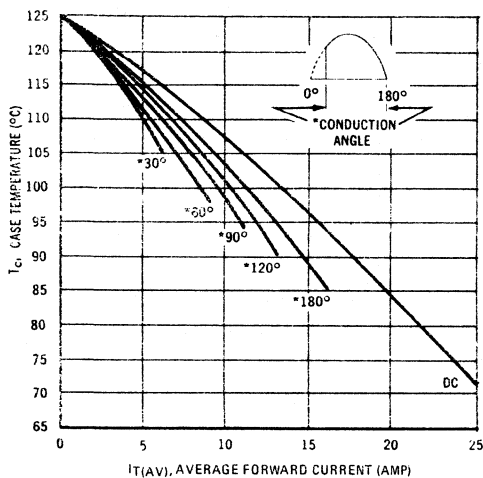
V_{DRM} ratings apply for zero or negative gate voltage.

2N2573 thru 2N2579 (continued)

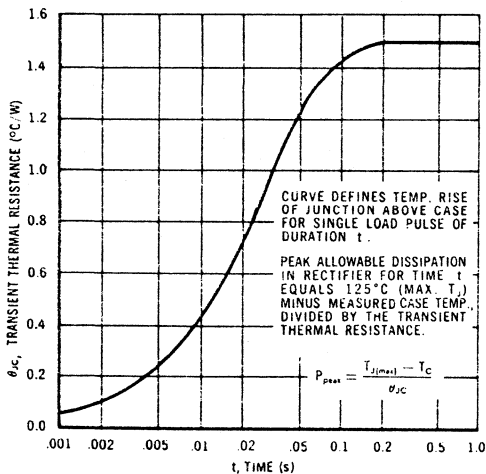
MAXIMUM ALLOWABLE NON-RECURRENT SURGE CURRENT



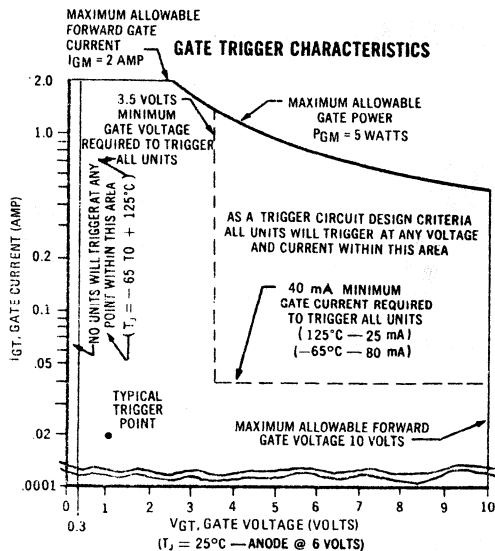
MAXIMUM ALLOWABLE CASE TEMPERATURE



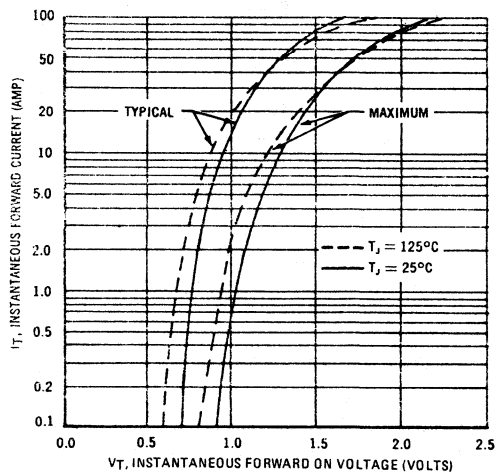
MAXIMUM TRANSIENT THERMAL RESISTANCE JUNCTION TO CASE



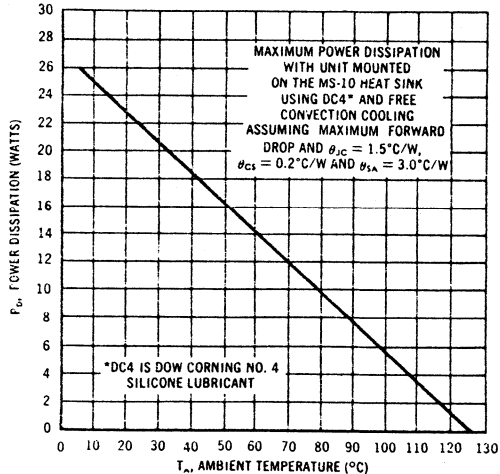
GATE TRIGGER CHARACTERISTICS



LOW CURRENT LEVEL



POWER DERATING CURVE



2N2635 (Ge Mesa)



CASE 22-03 STYLE 1:
(TO-18) PIN 1. EMITTER
2. BASE
3. COLLECTOR

Collector connected to case

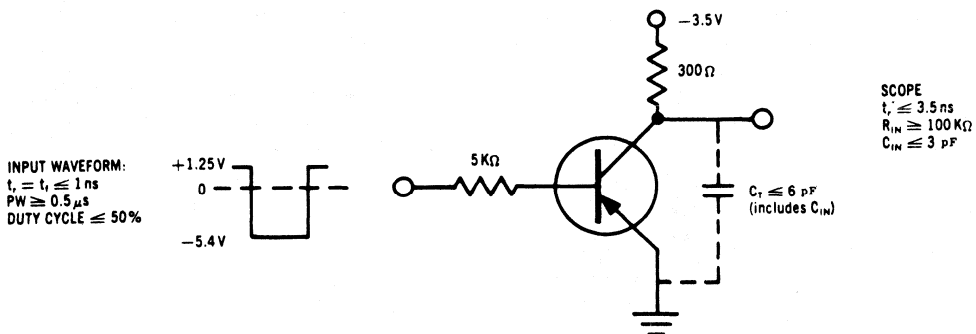
PNP germanium mesa transistor for high-speed switching applications.

* **MAXIMUM RATINGS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	30	Vdc
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Emitter-Base Voltage	V_{EB}	2.5	Vdc
Collector Current - Continuous	I_C	100	mAdc
Junction Temperature	T_J	+100	$^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +100	$^\circ\text{C}$
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	150 2.0	mW mW/ $^\circ\text{C}$

*Indicates JEDEC Registered Data

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



*** ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage ($I_C = 100\ \mu\text{A}$, $I_E = 0$)	BV_{CBO}	30	---	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 2\ \text{mA}$, $I_B = 0$)	BV_{CEO}	15	---	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu\text{A}$, $I_C = 0$)	BV_{EBO}	2.5	---	Vdc
Collector-Base Cutoff Current ($V_{CB} = 25\text{V}$, $I_E = 0$) ($V_{CB} = 25\text{V}$, $I_E = 0$, $T_A = +55^\circ\text{C}$)	I_{CBO}	---	5.0 20	μA
Emitter-Base Cutoff Current ($V_{EB} = 1\text{V}$, $I_C = 0$)	I_{EBO}	---	20	μA
Static Forward Current Transfer Ratio ($I_C = 10\ \text{mA}$, $V_{CE} = 0.5\text{V}$) ($I_C = 50\ \text{mA}$, $V_{CE} = 1\text{V}$) ($I_C = 50\ \text{mA}$, $V_{CE} = 1\text{V}$, $T_A = -55^\circ\text{C}$) ($I_C = 100\ \text{mA}$, $V_{CE} = 1\text{V}$)	h_{FE}	30 45 25 30	--- 300 --- ---	---
Base-Emitter Voltage ($I_C = 10\ \text{mA}$, $I_B = 0.5\ \text{mA}$) ($I_C = 50\ \text{mA}$, $I_B = 2.5\ \text{mA}$) ($I_C = 50\ \text{mA}$, $I_B = 2.5\ \text{mA}$, $T_A = -55^\circ\text{C}$) ($I_C = 100\ \text{mA}$, $I_B = 10\ \text{mA}$)	V_{BE}	--- --- --- ---	0.45 0.70 0.85 0.90	Vdc
Collector-Emitter Saturation Voltage ($I_C = 10\ \text{mA}$, $I_B = 0.5\ \text{mA}$) ($I_C = 50\ \text{mA}$, $I_B = 2.5\ \text{mA}$) ($I_C = 50\ \text{mA}$, $I_B = 2.5\ \text{mA}$, $T_A = +55^\circ\text{C}$) ($I_C = 100\ \text{mA}$, $I_B = 10\ \text{mA}$)	$V_{CE}(\text{sat})$	--- --- --- ---	0.20 0.40 0.45 0.75	Vdc
Small-Signal Forward Current Transfer Ratio ($I_C = 30\ \text{mA}$, $V_{CE} = 2\text{V}$, $f = 100\ \text{MHz}$)	$ h_{fe} $	1.5	---	---
Collector Output Capacitance ($V_{CB} = 5\ \text{V}$, $I_E = 0$, $f = 1\ \text{MHz}$)	C_{ob}	---	5.0	pF
Input Capacitance ($V_{BE} = 1\text{V}$, $I_C = 0$, $f = 1\ \text{MHz}$)	C_{ib}	---	4.0	pF
Delay Time (Figure 1)	t_d	---	20	ns
Rise Time (Figure 1)	t_r	---	30	ns
Storage Time (Figure 1)	t_s	---	185	ns
Fall Time (Figure 1)	t_f	---	65	ns

*Indicates JEDEC Registered Data

2N2639 thru 2N2644 (SILICON)

MULTIPLE SILICON ANNULAR TRANSISTORS

... designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Low Collector-Emitter Saturation Voltage —
 $V_{CE(sat)} = 1.0 \text{ Vdc (Max) @ } I_C = 10 \text{ mAdc}$
- DC Current Gain Specified — $10 \mu\text{Adc}$ to 1.0 mAdc
- High Current-Gain-Bandwidth Product —
 $f_T = 40 \text{ MHz (Max) @ } I_C = 1.0 \text{ mAdc}$
- 2N2639JAN,JTX,JTXV and 2N2642JAN,JTX,JTXV Available

NPN SILICON MULTIPLE TRANSISTORS

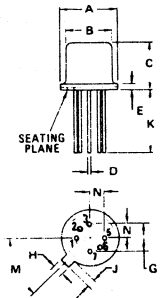


*MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	45		Vdc
Collector-Base Voltage	V_{CB}	45		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	30		mAdc
		One Die	Both Die	
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300	600	mW
		1.72	3.43	mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	600	1200	mW
		3.43	6.87	mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

*Indicates JEDEC Registered Data.

STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	—	0.500	—
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

2N2639 thru 2N2644 (continued)

*ELECTRICAL CHARACTERISTICS (each side) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage ⁽¹⁾ ($I_C = 10\text{ mAdc}$, $I_B = 0$)	$BV_{CEO(sus)}$	45	—	Vdc
Collector-Emitter Cutoff Current ($V_{CE} = 5\text{ Vdc}$, $I_B = 0$)	I_{CEO}	—	0.010	μAdc
Collector Cutoff Current ($V_{CB} = 45\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 45\text{ Vdc}$, $I_E = 0$, $T_A = +150^\circ\text{C}$)	I_{CBO}	— —	0.010 10	μAdc
Emitter-Base Cutoff Current ($V_{EB} = 5\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	0.010	μAdc

ON CHARACTERISTICS ⁽¹⁾

DC Current Gain ($I_C = 10\text{ }\mu\text{Adc}$, $V_{CE} = 5\text{ Vdc}$)	2N2639, 2N2640, 2N2641 2N2642, 2N2643, 2N2644	h_{FE}	50 100	300 300	—
($I_C = 10\text{ }\mu\text{Adc}$, $V_{CE} = 5\text{ Vdc}$, $T_A = -55^\circ\text{C}$)	2N2639, 2N2640, 2N2641 2N2642, 2N2643, 2N2644		10 20	— —	
($I_C = 100\text{ }\mu\text{Adc}$, $V_{CE} = 5\text{ Vdc}$)	2N2639, 2N2640, 2N2641 2N2642, 2N2643, 2N2644		55 110	— —	
($I_C = 1\text{ mAdc}$, $V_{CE} = 5\text{ Vdc}$)	2N2639, 2N2640, 2N2641 2N2642, 2N2643, 2N2644		65 130	— —	
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 0.5\text{ mAdc}$)		$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 0.5\text{ mAdc}$)		$V_{BE(sat)}$	0.6	1.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 1\text{ mAdc}$, $V_{CE} = 5\text{ Vdc}$, $f = 20\text{ MHz}$)		f_T	40	—	MHz
Output Capacitance ($V_{CB} = 5\text{ Vdc}$, $I_E = 0$, $f = 1\text{ MHz}$)		C_{ob}	—	8.0	pF
Input Impedance ($I_C = 1\text{ mAdc}$, $V_{CB} = 5\text{ Vdc}$, $f = 1\text{ kHz}$)		h_{ib}	25	32	k ohms
Reverse Voltage Transfer Ratio ($I_C = 1\text{ mAdc}$, $V_{CB} = 5\text{ Vdc}$, $f = 1\text{ kHz}$)		h_{rb}	—	600	$\times 10^{-6}$
Small-Signal Current Gain ($I_C = 1\text{ mAdc}$, $V_{CB} = 5\text{ Vdc}$, $f = 1\text{ kHz}$)	2N2639, 2N2640, 2N2641 2N2642, 2N2643, 2N2644	h_{fe}	65 130	600 600	—
Output Admittance ($I_C = 1\text{ mAdc}$, $V_{CB} = 5\text{ Vdc}$, $f = 1\text{ kHz}$)		h_{ob}	—	1.0	μmhos
Noise Figure ($I_C = 10\text{ }\mu\text{Adc}$, $V_{CB} = 5\text{ Vdc}$, $R_S = 10\text{ k ohms}$, Bandwidth = 10 Hz to 15 kHz)		NF	—	4.0	dB

MATCHING CHARACTERISTICS

DC Current Gain Ratio ⁽²⁾ ($I_C = 10\text{ }\mu\text{Adc}$, $V_{CE} = 5\text{ Vdc}$)	2N2639, 2N2642 2N2640, 2N2643	h_{FE1}/h_{FE2}	0.9 0.8	1.0 1.0	—
Base-Emitter Voltage Differential ($I_C = 10\text{ }\mu\text{Adc}$, $V_{CE} = 5\text{ Vdc}$)	2N2639, 2N2642 2N2640, 2N2643	$ V_{BE1} - V_{BE2} $	—	5.0 10	mVdc
Base-Emitter Voltage Differential Change Due to Temperature ($I_C = 10\text{ }\mu\text{Adc}$, $V_{CE} = 5\text{ Vdc}$, $T_A = -55\text{ to }+125^\circ\text{C}$)	2N2639, 2N2642 2N2640, 2N2643	$\frac{\Delta V_{BE1} - V_{BE2} }{\Delta T_A}$	— —	10 20	$\mu\text{V}/^\circ\text{C}$

* Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width = 300 μs ; Duty Cycle $\leq 2\%$

(2) The lowest h_{FE} reading is taken as h_{FE1} for this test.

2N2646 (SILICON)

2N2647

SILICON ANNULAR PN UNIUNCTION TRANSISTORS

... designed for use in pulse and timing circuits, sensing circuits and thyristor trigger circuits. These devices feature:

- Low Peak Point Current – $2.0 \mu\text{A}$ (Max)
- Low Emitter Reverse Current – 200 nA (Max)
- Passivated Surface for Reliability and Uniformity

PN UNIUNCTION TRANSISTORS

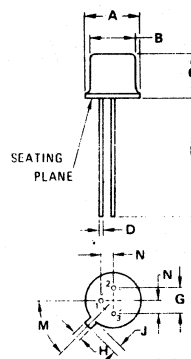


*MAXIMUM RATINGS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Rating	Symbol	Value	Unit
Power Dissipation (1)	P_D	300	mW
RMS Emitter Current	$I_E(\text{RMS})$	50	mA
Peak Pulse Emitter Current (2)	I_E	2.0	Amp
Emitter Reverse Voltage	V_{B2E}	30	Volts
Interbase Voltage	V_{B2B1}	35	Volts
Operating Junction Temperature Range	T_J	-65 to +125	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +150	$^\circ\text{C}$

* Indicates JEDEC Registered Data.

- (1) Derate $3.0 \text{ mW}/^\circ\text{C}$ increase in ambient temperature. The total power dissipation (available power to Emitter and Base-Two) must be limited by the external circuitry
- (2) Capacitor discharge – $10 \mu\text{F}$ or less, 30 volts or less.



STYLE 1:
PIN 1. EMITTER
2. BASE 1
3. BASE 2

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.48	0.016	0.019
G	2.54 TYP		0.100 TYP	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	—	0.500	—
M	45° TYP		45° TYP	
N	1.27 TYP		0.050 TYP	

CASE 22A

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Intrinsic Standoff Ratio ($V_{B2B1} = 10\text{ V}$) (Note 1)	η	0.56 0.68	— —	0.75 0.82	—
Interbase Resistance ($V_{B2B1} = 3.0\text{ V}$, $I_E = 0$)	r_{BB}	4.7	7.0	9.1	k ohms
Interbase Resistance Temperature Coefficient ($V_{B2B1} = 3.0\text{ V}$, $I_E = 0$, $T_A = -55^\circ\text{C}$ to $+125^\circ\text{C}$)	$\alpha_{r_{BB}}$	0.1	—	0.9	%/ $^\circ\text{C}$
Emitter Saturation Voltage ($V_{B2B1} = 10\text{ V}$, $I_E = 50\text{ mA}$) (Note 2)	$V_{EB1(\text{sat})}$	—	3.5	—	Volts
Modulated Interbase Current ($V_{B2B1} = 10\text{ V}$, $I_E = 50\text{ mA}$)	$I_{B2(\text{mod})}$	—	15	—	mA
Emitter Reverse Current ($V_{B2E} = 30\text{ V}$, $I_{B1} = 0$)	I_{EB20}	— —	0.005 0.005	12 0.2	μA
Peak Point Emitter Current ($V_{B2B1} = 25\text{ V}$)	I_P	— —	1.0 1.0	5.0 2.0	μA
Valley Point Current ($V_{B2B1} = 20\text{ V}$, $R_{B2} = 100\text{ ohms}$) (Note 2)	I_V	4.0 8.0	6.0 10	— 18	mA
Base-One Peak Pulse Voltage (Note 3, Figure 3)	V_{OB1}	3.0 6.0	5.0 7.0	— —	Volts

*Indicates JEDEC Registered Data.

Notes:

- (1) Intrinsic standoff ratio, η , is defined by equation:

$$\eta = \frac{V_P - V_F}{V_{B2B1}}$$

Where V_P = Peak Point Emitter Voltage

V_{B2B1} = Interbase Voltage

V_F = Emitter to Base-One Junction Diode Drop
($\approx 0.5\text{ V}$ @ $10\text{ }\mu\text{A}$)

- (2) Use pulse techniques: $PW \approx 300\text{ }\mu\text{s}$, duty cycle $\leq 2\%$ to avoid internal heating due to interbase modulation which may result in erroneous readings.

- (3) Base-One Peak Pulse Voltage is measured in circuit of Figure 3. This specification is used to ensure minimum pulse amplitude for applications in SCR firing circuits and other types of pulse circuits.

FIGURE 1
UNIUNCTION TRANSISTOR SYMBOL
AND NOMENCLATURE

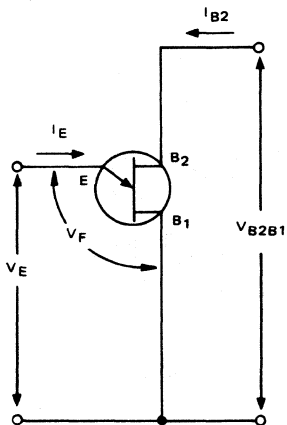


FIGURE 2
STATIC EMITTER CHARACTERISTIC
CURVES
(Exaggerated to Show Details)

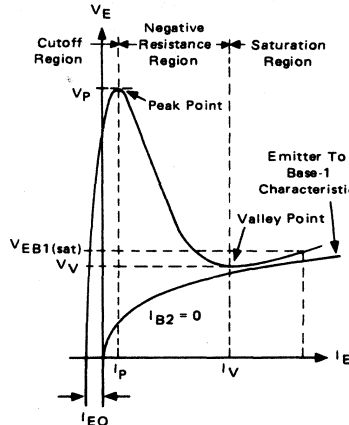
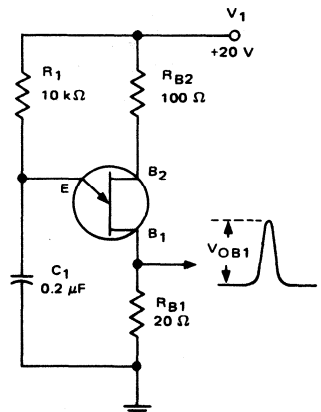


FIGURE 3 — V_{OB1} TEST CIRCUIT
(Typical Relaxation Oscillator)



2N2652 (SILICON)

2N2652A

MULTIPLE SILICON ANNULAR TRANSISTORS

... designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Excellent Temperature Tracking — Dual Devices
 $\Delta|V_{BE1} - V_{BE2}| = 10 \mu\text{Vdc (Max) @ } -55 \text{ to } +25^\circ\text{C}$
- Low Collector-Emitter Saturation Voltage —
 $V_{CE(\text{sat})} = 1.2 \text{ Vdc (Max) @ } I_C = 50 \text{ mAdc}$
- DC Current Gain Specified — 100 μAdc to 1.0 mAdc
- High Current-Gain-Bandwidth Product —
 $f_T = 60 \text{ MHz @ } I_C = 50 \text{ mAdc}$

NPN SILICON MULTIPLE TRANSISTORS



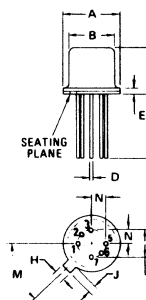
*MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	60		Vdc
Collector-Base Voltage	V_{CB}	100		Vdc
Emitter-Base Voltage	V_{EB}	7.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		One Die	Both Die	
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.3 1.72	0.6 3.43	Watt mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 5.7	2.0 11.4	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

*Indicates JEDEC Registered Data.

STYLE 1:

- PIN 1. COLLECTOR 5. EMITTER
 2. BASE 6. BASE
 3. EMITTER 7. COLLECTOR
 4. OMITTED 8. OMITTED



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.306	0.336
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	—	0.500	—
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

2N2652, 2N2652A (continued)

*ELECTRICAL CHARACTERISTICS (each side) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) ($I_C = 20\text{ mA dc}$, $I_B = 0$)	BV_{CEO}	60	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\text{ }\mu\text{A dc}$, $I_E = 0$)	BV_{CBO}	100	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\text{ }\mu\text{A dc}$, $I_C = 0$)	BV_{EBO}	7.0	-	Vdc
Collector Cutoff Current ($V_{CB} = 50\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 50\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	- - -	0.010 0.002 15	$\mu\text{A dc}$
Emitter Cutoff Current ($V_{BE} = 5.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	- -	0.010 0.002	$\mu\text{A dc}$

ON CHARACTERISTICS

DC Current Gain ($I_C = 100\text{ }\mu\text{A dc}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 1.0\text{ mA dc}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 1.0\text{ mA dc}$, $V_{CE} = 5.0\text{ Vdc}$, $T_A = -55^\circ\text{C}$)	h_{FE}	35 50 15	- 200 -	-
Collector-Emitter Saturation Voltage ($I_C = 50\text{ mA dc}$, $I_B = 5.0\text{ mA dc}$)	$V_{CE(sat)}$	-	1.2	Vdc
Base-Emitter Saturation Voltage ($I_C = 50\text{ mA dc}$, $I_B = 5.0\text{ mA dc}$)	$V_{BE(sat)}$	-	0.9	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 50\text{ mA dc}$, $V_{CE} = 10\text{ Vdc}$, $f = 20\text{ MHz}$)	f_T	60	-	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{ob}	-	15	pF
Input Capacitance ($V_{BE} = 0$, 0.5 Vdc , $I_C = 0$, $f = 1.0\text{ MHz}$)	C_{ib}	-	85	pF
Input Impedance ($I_C = 1.0\text{ mA dc}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ie}	1.0	10.5	k ohms
Input Impedance ($I_C = 1.0\text{ mA dc}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ib}	20	35	ohms
Small-Signal Current Gain ($I_C = 1.0\text{ mA dc}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	50	300	-
Output Admittance ($I_C = 1.0\text{ mA dc}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{oe}	-	50	μmhos
Noise Figure ($I_C = 0.3\text{ mA dc}$, $V_{CE} = 10\text{ Vdc}$, $R_S = 510\text{ ohms}$, B. W. = 1.0 Hz , $f = 1.0\text{ kHz}$)	NF	-	8.0	dB

MATCHING CHARACTERISTICS

DC Current Gain Ratio (2) ($I_C = 100\text{ }\mu\text{A dc}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 1.0\text{ mA dc}$, $V_{CE} = 5.0\text{ Vdc}$)	h_{FE1}/h_{FE2}	0.85 0.9 0.85 0.9	1.0 1.0 1.0 1.0	-
Base-Emitter Voltage Differential ($I_C = 100\text{ }\mu\text{A dc}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 1.0\text{ mA dc}$, $V_{CE} = 5.0\text{ Vdc}$)	$ V_{BE1} - V_{BE2} $	- -	3.0 3.0	mVdc
Base-Emitter Voltage Differential Gradient ($I_C = 100\text{ }\mu\text{A dc}$, $V_{CE} = 5.0\text{ Vdc}$, $T_A = -55\text{ to }+125^\circ\text{C}$)	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	-	10	$\mu\text{V}/^\circ\text{C}$

* Indicates JEDEC Registered Data

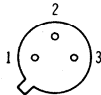
(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.

(2) The lowest of the two h_{FE} readings is taken as h_{FE1} for the purpose of measurement.

2N2710 (SILICON)



CASE 22
(TO-18)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

NPN silicon transistor primarily designed for high-speed, low-power saturated switching applications for industrial service.

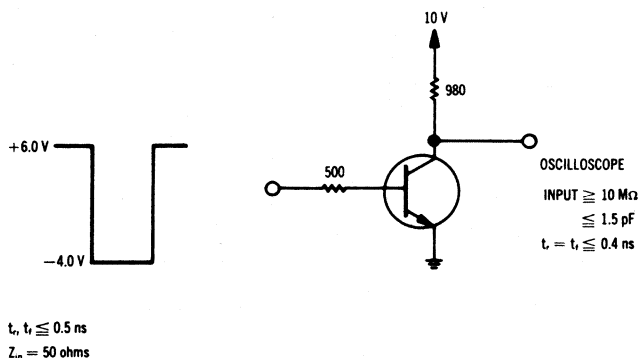
Collector connected to case

* MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current-Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.36 2.1	W mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.2 6.85	W mW/ $^\circ\text{C}$
Operating Junction Temperature Range	T_J	+200	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

* Indicates JEDEC Registered Data

FIGURE 1 — STORAGE TIME TEST CIRCUIT



2N2710 (continued)

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I _C = 10 mA _{dc} , I _B = 0)	V _{CE}	20	-	V _{dc}
Collector-Emitter Breakdown Voltage (I _C = 10 μA _{dc} , V _{BE} = 0)	V _{CES}	30	-	V _{dc}
Collector-Base Breakdown Voltage (I _C = 10 μA _{dc} , I _E = 0)	V _{CBO}	40	-	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 10 μA _{dc} , I _C = 0)	V _{EBO}	5.0	-	V _{dc}
Collector-Cutoff Current (V _{CB} = 20 V _{dc} , I _E = 0) (V _{CB} = 20 V _{DC} , I _E = 0, T _A = +150°C)	I _{CBO}	-	0.03 30	μA _{dc}
Emitter Cutoff Current (V _{BE} = 3.0 V _{dc} , I _C = 0)	I _{EBO}	-	1.0	μA _{dc}

ON CHARACTERISTICS

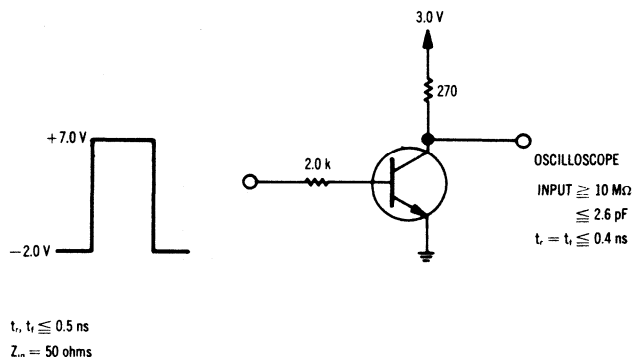
DC Current Gain (I _C = 10 mA _{dc} , V _{CE} = 1.0 V _{dc}) (I _C = 50 mA _{dc} , V _{CE} = 1.0 V _{dc})	h _{FE}	40 40	- -	-
Collector-Emitter Saturation Voltage (I _C = 10 mA _{dc} , I _B = 1.0 mA _{dc}) (I _C = 50 mA _{dc} , I _B = 5.0 mA _{dc})	V _{CE(sat)}	- -	0.25 0.4	V _{dc}
Base-Emitter Saturation Voltage (I _C = 10 mA _{dc} , I _B = 1.0 mA _{dc}) (I _C = 50 mA _{dc} , I _B = 5.0 mA _{dc})	V _{BE(sat)}	- -	0.9 1.3	V _{dc}

DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product (I _C = 10 mA _{dc} , V _{CE} = 20 V _{dc} , f = 100 MHz)	f _T	500	-	MHz
Output Capacitance (V _{CB} = 10 V _{dc} , I _E = 0, f = 4.0 MHz)	C _{ob}	-	4.0	pF
Turn-On Time (Figure 2) (V _{CC} = 3.0 V _{dc} , V _{BE(off)} = 2.0 V _{dc} , I _C = 10 mA _{dc} , I _{B1} = 3.0 mA _{dc})	t _{on}	-	20	ns
Turn-Off Time (Figure 2) (V _{CC} = 3.0 V _{dc} , I _C = 10 mA _{dc} , I _{B1} = 3.0 mA _{dc} , I _{B2} = 1.0 mA _{dc})	t _{off}	-	35	ns
Charge-Storage Time (Figure 1) (V _{CC} = 10 V _{dc} , I _C = I _{B1} = I _{B2} = 10 mA _{dc})	t _s	-	15	ns

*Indicates JEDEC Registered Data

FIGURE 2 — TURN ON AND TURN OFF TIME TEST CIRCUIT



2N2720 (SILICON)

2N2721

MULTIPLE SILICON ANNULAR TRANSISTORS

... designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Excellent Temperature Tracking – Dual Devices – 2N2721
 $\Delta|V_{BE1} - V_{BE2}| = 1.6 \text{ mVdc (Max) @ } -55 \text{ to } +25^{\circ}\text{C}$
 $= 2.0 \text{ mVdc (Max) @ } +25 \text{ to } +125^{\circ}\text{C}$
- Low Collector-Emitter Saturation Voltage –
 $V_{CE(sat)} = 1.0 \text{ Vdc (Max) @ } I_C = 10 \text{ mAdc}$
- DC Current Gain Specified – $100 \mu\text{Adc to } 10 \text{ mAdc}$
- High Current-Gain – Bandwidth Product –
 $f_T = 80 \text{ MHz @ } I_C = 10 \text{ mAdc}$

NPN SILICON MULTIPLE TRANSISTORS

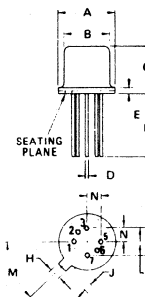


*MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	60		Vdc
Collector-Base Voltage	V_{CB}	80		Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current – Continuous	I_C	40		mAdc
		One Die	Both Die	
Total Power Dissipation @ $T_A = 25^{\circ}\text{C}$ Derate above 25°C	P_D	0.3 1.71	0.6 3.4	Watt mW/ $^{\circ}\text{C}$
Total Power Dissipation @ $T_C = 25^{\circ}\text{C}$ Derate above 25°C	P_D	0.6 3.4	1.2 6.8	Watt mW/ $^{\circ}\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^{\circ}\text{C}$

*Indicates JEDEC Registered Data.

STYLE 1
 PIN 1. COLLECTOR 5. EMITTER
 2. BASE 6. BASE
 3. EMITTER 7. COLLECTOR
 4. OMITTED 8. OMITTED



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC 0.200 BSC			
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	—	0.500	—
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

2N2720, 2N2721 (continued)

*ELECTRICAL CHARACTERISTICS (each side) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (1) ($I_C = 10\text{ mAdc}$, $I_B = 0$)	BV_{CEO}	60	-	Vdc
Collector Cutoff Current ($V_{CE} = 5.0\text{ Vdc}$, $I_B = 0$)	I_{CEO}	-	10	nAdc
Collector Cutoff Current ($V_{CB} = 80\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 80\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	- -	0.01 10	μAdc
Emitter Cutoff Current ($V_{EB} = 5.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	-	10	nAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 100\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$)	h_{FE}	30 35 42	120 - -	-
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$)	$V_{CE(sat)}$	-	1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$)	$V_{BE(sat)}$	0.65	0.85	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 20\text{ MHz}$)	f_T	80	-	MHz
Output Capacitance ($V_{CB} = 5.0\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{ob}	-	6.0	pF
Input Impedance ($I_E = 1.0\text{ mAdc}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ib}	25	32	ohms
Voltage Feedback Ratio ($I_E = 1.0\text{ mAdc}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{rb}	-	500	$\times 10^{-6}$
Small-Signal Current Gain ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	30	200	-
Output Admittance ($I_E = 1.0\text{ mAdc}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ob}	-	1.0	μmhos

MATCHING CHARACTERISTICS

DC Current Gain Ratio (2) ($I_C = 100\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$)	2N2720 2N2721	h_{FE1}/h_{FE2}	0.9 0.8	1.0 1.0	-
Base-Emitter Voltage Differential ($I_C = 100\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$)	2N2720 2N2721	$ V_{BE1} - V_{BE2} $	- -	5.0 10	mVdc
Base-Emitter Voltage Differential Change Due to Temperature ($I_C = 100\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$, $T_A = -55\text{ to }+25^\circ\text{C}$) ($I_C = 100\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$, $T_A = +25\text{ to }+125^\circ\text{C}$)	2N2720 2N2721 2N2720 2N2721	$\Delta(V_{BE1} - V_{BE2})$	- - - -	0.8 1.6 1.0 2.0	mV

* Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width = 300 μs , Duty Cycle = 2%

(2) The lower of the two h_{FE} readings is taken as h_{FE1} for the purpose of measurement.

2N2722 (SILICON)

MULTIPLE SILICON ANNULAR TRANSISTORS

... designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Excellent Temperature Tracking – Dual Devices –
 $\Delta|V_{BE1} - V_{BE2}| = 0.8 \text{ mVdc (Max) @ } -55 \text{ to } +25^{\circ}\text{C}$
 $= 1.0 \text{ mVdc (Max) @ } +25 \text{ to } +125^{\circ}\text{C}$
- Low Collector-Emitter Saturation Voltage –
 $V_{CE(sat)} = 1.0 \text{ Vdc (Max) @ } I_C = 10 \text{ mAdc}$
- DC Current Gain Specified – $1.0 \mu\text{Adc to } 0.1 \text{ mAdc}$
- High Current-Gain – Bandwidth Product –
 $f_T = 100 \text{ MHz @ } I_C = 10 \text{ mAdc}$

*MAXIMUM RATINGS

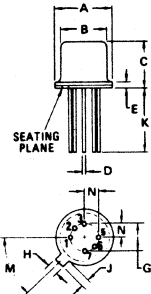
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	45		Vdc
Collector-Base Voltage	V_{CB}	45		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	40		mAdc
		One Die	Both Die	
Total Power Dissipation @ $T_A = 25^{\circ}\text{C}$ Derate above 25°C	P_D	0.3 1.7	0.6 3.4	Watt mW/ $^{\circ}\text{C}$
Total Power Dissipation @ $T_C = 25^{\circ}\text{C}$ Derate above 25°C	P_D	0.6 3.4	1.2 6.8	Watts mW/ $^{\circ}\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^{\circ}\text{C}$

*Indicates JEDEC Registered Data.

NPN SILICON
MULTIPLE TRANSISTORS



STYLE 1:
PIN 1: COLLECTOR 5. EMITTER
2. BASE 6. BASE
3. EMITTER 7. COLLECTOR
4. OMITTED 8. OMITTED



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	—	0.500	—
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

***ELECTRICAL CHARACTERISTICS** (each side) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (1) ($I_C = 10\text{ mAdc}$, $I_B = 0$)	BV_{CEO}	45	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	45	-	Vdc
Collector Cutoff Current ($V_{CE} = 5.0\text{ Vdc}$, $I_B = 0$)	I_{CEO}	-	2.0	nAdc
Collector Cutoff Current ($V_{CB} = 30\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 30\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	-	0.001 1.0	μAdc
Emitter Cutoff Current ($V_{EB} = 5.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	-	1.0	nAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 1.0\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 10\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 0.1\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$)	h_{FE}	50 100 125	250 - -	-
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 0.5\text{ mAdc}$)	$V_{CE(sat)}$	-	1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 0.5\text{ mAdc}$)	$V_{BE(sat)}$	0.65	0.85	Vdc

SMALL SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 20\text{ MHz}$)	f_T	100	-	MHz
Output Capacitance ($V_{CB} = 5.0\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{ob}	-	6.0	pF
Input Impedance ($I_E = 1.0\text{ mAdc}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ib}	25	32	ohms
Voltage Feedback Ratio ($I_E = 1.0\text{ mAdc}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{rb}	-	600	$\times 10^{-6}$
Small-Signal Current Gain ($I_E = 0.1\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	100	700	-
Output Admittance ($I_E = 1.0\text{ mAdc}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ob}	-	1.0	μmhos
Noise Figure ($I_C = 10\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$, $R_S = 10\text{ k ohms}$, $f = 10\text{ Hz}$ to 15.7 kHz)	NF	-	4.0	dB

MATCHING CHARACTERISTICS

DC Current Gain Ratio (2) ($I_C = 1.0\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$)	h_{FE1}/h_{FE2}	0.9	1.0	-
Base-Emitter Voltage Differential ($I_C = 10\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$)	$ V_{BE1} - V_{BE2} $	-	5.0	mVdc
Base-Emitter Voltage Differential Change Due to Temperature ($I_C = 10\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$, $T_A = -55$ to $+25^\circ\text{C}$) ($I_C = 10\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$, $T_A = +25$ to $+125^\circ\text{C}$)	$\Delta(V_{BE1} - V_{BE2})$	-	0.8 1.0	mVdc

* Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width = $300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.

(2) The lower of the two h_{FE} readings is taken as h_{FE1} for the purpose of measurement.

2N2723 (SILICON)

NPN SILICON ANNULAR DARLINGTON TRANSISTORS

... containing two NPN silicon annular transistors in a darlington connection, and designed for applications requiring:

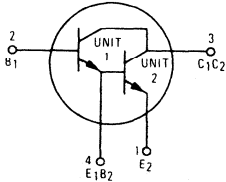
- High DC Current Gain —
 $h_{FE} = 2,000$ (Min) @ $I_C = 10$ mA dc
- Low Noise —
NF = 10 dB @ $I_C = 50$ μ Adc
- Low Leakage —
 $I_{CB10} = 0.01$ μ Adc(Max) @ $V_{CB1} = 60$ Vdc
 $I_{E2B10} = 10$ nAdc(Max) @ $V_{B1E2} = 10$ Vdc

*MAXIMUM RATINGS (Numerical subscripts refer to unit number.)

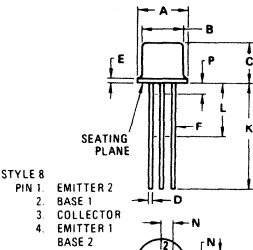
Rating	Symbol	Value	Unit
Collector-Emitter Voltage (Base 1 and Base 2 open)	V_{CE20}	60	Vdc
Collector-Base Voltage	V_{CB1}	80	Vdc
Emitter-Base Voltage	V_{E2B1}	12	Vdc
Collector Current — Continuous	I_C	40	Adc
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.5 2.9	Watt mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.8 10.5	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

*Indicates JEDEC Registered Data.

NPN SILICON DARLINGTON TRANSISTORS



The input unit is identified as Unit 1 regardless of terminal numbering.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	—	0.76	—	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC	—	0.100 BSC	—
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC	—	45° BSC	—
N	1.27 BSC	—	0.050 BSC	—
P	—	1.27	—	0.050

ALL JEDEC dimensions and notes apply

CASE 20-03
TO-72

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (1) ($I_C = 10\text{ mAdc}$, $I_{B1} = 0$)	BV_{CE2O}	60	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $I_{E2} = 0$)	BV_{CB1O}	80	-	Vdc
Emitter-Base Breakdown Voltage ($I_{E2} = 10\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{E2B1O}	12	-	Vdc
Collector Cutoff Current ($V_{CB1} = 60\text{ Vdc}$, $I_E = 0$) ($V_{CB1} = 60\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CB1O}	- -	0.01 10	μAdc
Emitter Cutoff Current ($V_{B1E2} = 10\text{ Vdc}$, $I_C = 0$)	I_{E2B1O}	-	10	nAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 10\text{ mAdc}$, $V_{CE2} = 5.0\text{ Vdc}$, $I_{B2} = 0$)	h_{FE}	2000	10,000	-
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_{B1} = 1.0\text{ mAdc}$)	$V_{CE2(sat)}$	-	1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_{B1} = 1.0\text{ mAdc}$)	$V_{BE2(sat)}$	-	1.7	Vdc

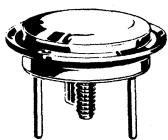
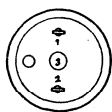
SMALL-SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product (Each Unit) ($I_C = 10\text{ mAdc}$, V_{CE1} or $V_{CE2} = 10\text{ Vdc}$, $f = 20\text{ MHz}$)	$ h_{fe} $	5.0	-	-
Output Capacitance ($V_{CB1} = 10\text{ Vdc}$, $I_{E2} = 0$, $f = 140\text{ kHz}$)	C_{ob1}	-	10	pF
Small-Signal Current Gain ($I_C = 10\text{ mAdc}$, $V_{CE2} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) 2N2723	h_{fe}	1500	15,000	-
Noise Figure (Input Stage Only) ($I_C = 50\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$, $R_S = 3.0\text{ k ohms}$, $f = 1.0\text{ kHz}$, $BW = 100\text{ kHz}$)	NF	-	10	dB

* Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width $\leq 12\text{ ms}$, Duty Cycle $\leq 2.0\%$.

2N2728 (GERMANIUM)



CASE 7
(TO-68)

STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

Collector connected to case

PNP germanium high-current power transistors especially designed for switching and power converter circuit operating from low-voltage power sources such as solar cells, thermo-electric generators, sea cells, fuel cells, and 1.5-volt batteries.

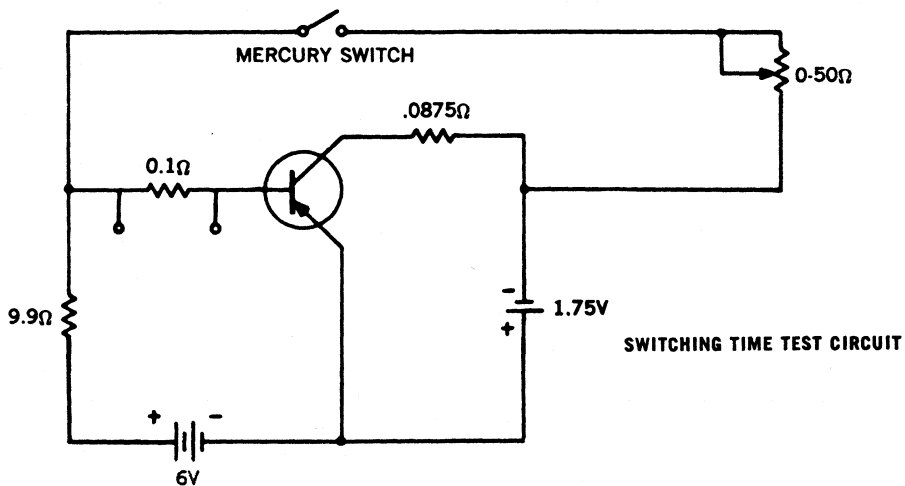
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	15	Vdc
Collector-Emitter Voltage	V_{CEO}	5.0	Vdc
Emitter-Base Voltage	V_{EB}	15	Vdc
Collector Current (continuous)	I_C	50	Adc
Base Current (continuous)	I_B	10	Adc
Total Device Dissipation @ 25°C Case Temperature	P_D	170	Watts
Operating Temperature	T_J	+110	°C
Storage Temperature	T_{stg}	-65 to +110	°C
Thermal Resistance (Junction to Case)	θ_{JC}	0.5	°C/W

2N2728 (continued)**ELECTRICAL CHARACTERISTICS**

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current $V_{CE} = 15 \text{ V}, V_{BE} = 1 \text{ V}$ $V_{CE} = 10 \text{ V}, V_{BE} = 1 \text{ V}, T_C = 100^\circ\text{C}$	I_{CEX}	-	-	10 35	mAdc
Emitter-Base Cutoff Current $V_{EB} = 15 \text{ V}$	I_{EBO}	-	-	10	mAdc
Emitter Floating Potential $V_{CB} = 15 \text{ V}, I_E = 0$	V_{EBF}	-	-	0.5	Vdc
Collector-Emitter Breakdown Voltage* $I_C = 500 \text{ mA}, I_B = 0$	BV_{CEO}	5.0	10	-	V
DC Current Transfer Ratio $I_C = 20 \text{ A}, V_{CE} = 2 \text{ V}$	h_{FE}	40	-	130	-
Collector-Emitter Saturation Voltage $I_C = 50 \text{ A}, I_B = 5 \text{ A}$	$V_{CE(sat)}$	-	0.075	0.1	Vdc
Base-Emitter Voltage $I_C = 50 \text{ A}, I_B = 5 \text{ A}$	$V_{BE(sat)}$	-	0.85	1.0	Vdc
Common Emitter Cutoff Frequency $I_C = 20 \text{ A}, V_{CE} = 2 \text{ V}$	$f_{\alpha e}$	3.0	4.5	-	kHz
Rise Time $I_C = 20 \text{ A}, V_{CC} = 1.75 \text{ V}, I_{B(on)} = 2 \text{ A}$	t_r	-	18	25	μs
Storage Time $V_{BE} = 6 \text{ V}, R_{be} = 10 \Omega$	t_s	-	15	20	μs
Fall Time $V_{BE} = 6 \text{ V}, R_{be} = 10 \Omega$	t_f	-	10	15	μs

* To avoid excessive heating of the collector junction, perform these tests with an oscilloscope.



NPN SILICON ANNULAR DARLINGTON TRANSISTOR

... containing two NPN silicon annular transistors in a darlington connection, and designed for applications requiring:

- High DC Current Gain –
 $h_{FE} = 2,000$ (Min) @ $I_C = 100$ mAdc
- Guaranteed DC Current Gain from 1.0 mA to 100 mAdc
- Low Leakage –
 $I_{CB10} = 0.05$ μ Adc (Max) @ $V_{CB1} = 30$ Vdc
 $I_{E2B10} = 20$ nAdc (Max) @ $V_{E2B1} = 5.0$ Vdc

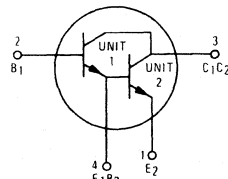
*MAXIMUM RATINGS (Numerical subscripts refer to unit number.)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage (Base 1 and Base 2 open)	V_{CE2}	40	Vdc
Collector-Base Voltage	V_{CB1}	60	Vdc
Emitter-Base Voltage (Pin 4 to Pin 2)	V_{E2B1}	15 7.5	Vdc
**Collector Current – Continuous	I_C	200	mAdc
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.5 3.33	Watt mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.8 10	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

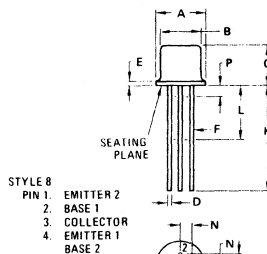
*Indicates JEDEC Registered Data.

**Motorola guarantees this data in addition to JEDEC Registered Data.

NPN SILICON DARLINGTON TRANSISTOR



The input unit is identified as Unit 1 regardless of terminal numbering



STYLE 8
PIN 1. EMITTER 2
2. BASE 1
3. COLLECTOR
4. EMITTER 1
BASE 2

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	-	0.76	-	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC	-	0.100 BSC	-
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	-	0.500	-
L	6.35	-	0.250	-
M	45° BSC	-	45° BSC	-
N	1.27 BSC	-	0.050 BSC	-
P	-	1.27	-	0.050

ALL JEDEC dimensions and notes apply

CASE 20-03
TO 72

2N2785 (continued)

* ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (1) ($I_C = 20\text{ mAdc}$, $I_{B1} = 0$)	BV_{CE20}	40	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\text{ }\mu\text{Adc}$, $I_{E2} = 0$)	BV_{CB10}	60	-	Vdc
Emitter-Base Breakdown Voltage ($I_{E2} = 100\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{E2B10}	15	-	Vdc
Collector Cutoff Current ($V_{CE} = 20\text{ Vdc}$, $I_B = 0$)	I_{CEO}	-	500	nAdc
Collector Cutoff Current ($V_{CB1} = 30\text{ Vdc}$, $I_E = 0$) ($V_{CB1} = 30\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CB10}	- -	0.05 10	μAdc
Emitter Cutoff Current ($V_{E2B1} = 5.0\text{ Vdc}$, $I_C = 0$)	I_{E2B10}	-	20	nAdc

ON CHARACTERISTICS

DC Current Gain (1) ($I_C = 1.0\text{ mAdc}$, $V_{CE2} = 4.0\text{ Vdc}$) ($I_C = 10\text{ mAdc}$, $V_{CE2} = 5.0\text{ Vdc}$) ($I_C = 100\text{ mAdc}$, $V_{CE2} = 5.0\text{ Vdc}$)	h_{FE}	600 1200 2000	- - 20,000	-
Collector-Emitter Saturation Voltage ($I_C = 15\text{ mAdc}$, $I_{B1} = 3.0\text{ mAdc}$)	$V_{CE2(sat)}$	-	1.0	Vdc

SMALL SIGNAL CHARACTERISTICS

Current-Gain— High Frequency ($I_C = 1.0\text{ mAdc}$, $V_{CE2} = 5.0\text{ Vdc}$, $f = 10\text{ MHz}$)	$ h_{fe} $	1.0	-	-
Output Capacitance ($V_{CB1} = 10\text{ Vdc}$, $I_{E2} = 0$, $f = 1.0\text{ MHz}$)	C_{ob1}	-	30	pF
Input Impedance ($I_C = 1.0\text{ mAdc}$, $V_{CB1} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ib}	30	80	Ohm
Voltage Feedback Ratio ($I_C = 1.0\text{ mAdc}$, $V_{CE2} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{rb}	-	10	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0\text{ mAdc}$, $V_{CE2} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	600	-	-
Output Admittance ($I_C = 1.0\text{ mAdc}$, $V_{CB1} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ob}	-	0.5	μmhos

* Indicates JEDEC Registered Data

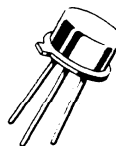
(1) Pulse Test: Pulse Width $\sim 300\text{ }\mu\text{s}$, Duty Cycle $\sim 2.0\%$.

NPN SILICON ANNULAR TRANSISTOR

... designed for use in general-purpose amplifiers and switching applications.

- Collector-Emitter Breakdown Voltage –
BVCEO = 35 Vdc (Min) @ IC = 10 mAdc
- Current-Gain – Bandwidth Product –
fT = 300 MHz (Typ) @ IC = 20 mAdc
- DC Current Gain – 100 μAdc to 500 mAdc
- Fast Switching Time (Figure 1 and 2) – @ IC ≈ 16 mAdc
ton = 40 ns (Typ)
toff = 60 ns (Typ)

NPN SILICON AMPLIFIER TRANSISTOR



*MAXIMUM RATINGS

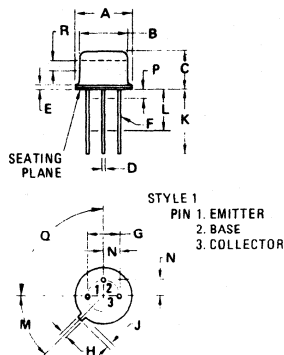
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO	35	Vdc
Collector-Emitter Voltage	VCER	50	Vdc
Collector-Base Voltage	VCB	75	Vdc
Emitter-Base Voltage	VEB	5.0	Vdc
Collector Current – Continuous	IC	800	mAdc
Total Power Dissipation @ TA = 25°C	PD	800	mW
Derate above 25°C		5.33	mW/°C
Total Power Dissipation @ TC = 25°C	PD	3.0	Watt
Derate above 25°C		20	mW/°C
Operating Junction Temperature Range	TJ	-65 to +175	°C
Storage Temperature Range	Tstg	-65 to +200	°C

* THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	RθJA (1)	187	°C/W
Thermal Resistance, Junction to Case	RθJC	50	°C/W

*Indicates JEDEC Registered Data.

(1) RθJA is measured with the device soldered into a typical printed circuit board.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM	–	45° NOM	–
P	–	1.27	–	0.050
Q	90° NOM	–	90° NOM	–
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 10\text{ mA}$, $I_B = 0$)	BV_{CEO}	35	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100\text{ mA}$, $R_{BE} = 10\text{ Ohms}$)	BV_{CER}	50	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{A}$, $I_E = 0$)	BV_{CBO}	75	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{A}$, $I_C = 0$)	BV_{EBO}	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 50\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 50\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	— —	0.01 10	μA
Collector Cutoff Current ($V_{CE} = 35\text{ Vdc}$, $V_{EB} = 0.5\text{ Vdc}$)	I_{CEV}	—	—	10	μA
Emitter Cutoff Current ($V_{BE} = 3.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	—	0.01	μA
Base Cutoff Current ($V_{CE} = 35\text{ Vdc}$, $V_{EB} = 0.5\text{ Vdc}$)	I_{BEV}	—	—	10	μA

ON CHARACTERISTICS⁽¹⁾

DC Current Gain ($I_C = 100\text{ }\mu\text{A}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 1.0\text{ mA}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 150\text{ mA}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 150\text{ mA}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 500\text{ mA}$, $V_{CE} = 10\text{ Vdc}$)	h_{FE}	35 50 75 100 50 30	75 90 100 150 90 60	— — — 300 — —	—
Collector-Emitter Saturation Voltage ($I_C = 150\text{ mA}$, $I_B = 15\text{ mA}$) ($I_C = 500\text{ mA}$, $I_B = 50\text{ mA}$)	$V_{CE(sat)}$	— —	0.3 0.8	0.4 1.6	Vdc
Base-Emitter Saturation Voltage ($I_C = 150\text{ mA}$, $I_B = 15\text{ mA}$) ($I_C = 500\text{ mA}$, $I_B = 50\text{ mA}$)	$V_{BE(sat)}$	— —	0.9 1.4	1.3 2.6	Vdc

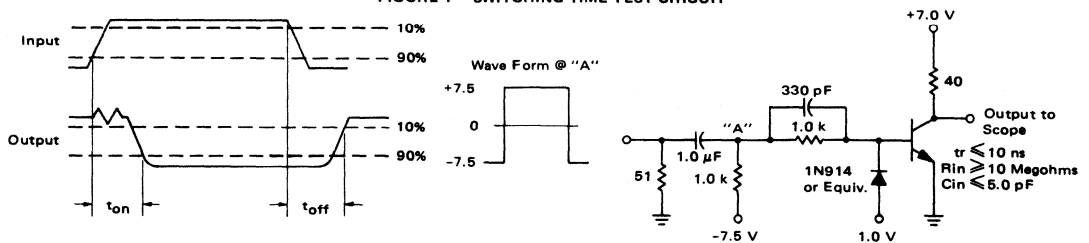
DYNAMIC CHARACTERISTICS

Current-Gain – Bandwidth Product ($I_C = 20\text{ mA}$, $V_{CE} = 20\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	250	300	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)	C_{ob}	—	4.0	8.0	pF
Input Impedance ($I_C = 1.0\text{ mA}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 20\text{ mA}$, $V_{CE} = 20\text{ Vdc}$, $f = 300\text{ MHz}$)	h_{ib} $Re(h_{ie})$	25 20	— —	35 60	Ohms
Voltage Feedback Ratio ($I_C = 1.0\text{ mA}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{rb}	0.9	—	2.5	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0\text{ mA}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 20\text{ mA}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$) ($I_C = 20\text{ mA}$, $V_{CE} = 20\text{ Vdc}$, $f = 100\text{ MHz}$)	h_{fe}	80 150 2.5	— — —	250 400 7.0	—
Output Admittance ($I_C = 1.0\text{ mA}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ob}	—	—	0.2	μmhos

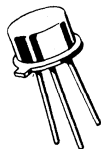
SWITCHING CHARACTERISTICS

Turn-On Time (Figure 1)	t_{on}	—	40	50	ns
Turn-Off Time (Figure 1)	t_{off}	—	60	70	ns

*Indicates JEDEC Registered Data.

(1) Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.**FIGURE 1 – SWITCHING TIME TEST CIRCUIT**

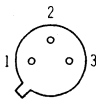
2N2800S (SILICON)
2N2801S



PNP silicon annular transistors for medium-speed switching applications.

CASE 79
(TO-39)

2N2800
2N2801



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

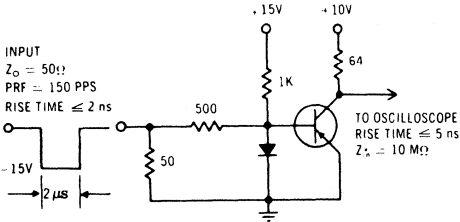
Collector connected to case

*MAXIMUM RATINGS

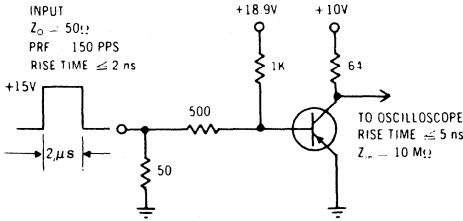
Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	50	Vdc
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	800	mA
Total Device Dissipation @ 25°C Ambient Temperature 2N2800, 2N2801 — TO-5 Derating Factor Above 25°C	P_D	0.8 4.57	Watt mW/°C
Total Device Dissipation @ 25°C Case Temperature 2N2800, 2N2801 — TO-5 Derating Factor Above 25°C	P_D	3.0 17.3	Watts mW/°C
Junction Temperature, Operating	T_J	+200	°C
Storage Temperature	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data

DELAY AND RISE TIME TEST CIRCUIT



STORAGE AND FALL TIME TEST CIRCUIT



***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage ($I_C = 10\ \mu\text{A}$, $I_E = 0$)	BV_{CBO}	50	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu\text{A}$, $I_C = 0$)	BV_{EBO}	5.0	-	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100\ \text{mA}$, $I_B = 0$)	BV_{CEO}	35	-	Vdc
Collector Cutoff Current ($V_{CE} = 25\ \text{Vdc}$, $V_{BE} = 0.5\ \text{Vdc}$)	I_{CEX}	-	100	nA
Base Cutoff Current ($V_{CE} = 25\ \text{Vdc}$, $V_{BE} = 0.5\ \text{Vdc}$)	I_{BL}	-	100	nA
DC Forward Current Transfer Ratio ($I_C = 0.1\ \text{mA}$, $V_{CE} = 10\ \text{Vdc}$) 2N2800 2N2801 ($I_C = 150\ \text{mA}$, $V_{CE} = 10\ \text{Vdc}$) ⁽¹⁾ 2N2800 2N2801 ($I_C = 150\ \text{mA}$, $V_{CE} = 1\ \text{Vdc}$) ⁽¹⁾ 2N2800 2N2801 ($I_C = 500\ \text{mA}$, $V_{CE} = 10\ \text{Vdc}$) ⁽¹⁾ 2N2800 2N2801	h_{FE}	20 30 30 75 15 30 25 40	- - 90 225 - - - -	-
Collector Saturation Voltage ($I_C = 150\ \text{mA}$, $I_B = 15\ \text{mA}$) ($I_C = 500\ \text{mA}$, $I_B = 50\ \text{mA}$)	$V_{CE(sat)}$	- -	0.4 1.2	Vdc
Base-Emitter Saturation Voltage ($I_C = 150\ \text{mA}$, $I_B = 15\ \text{mA}$) ($I_C = 500\ \text{mA}$, $I_B = 50\ \text{mA}$)	$V_{BE(sat)}$	- -	1.3 1.8	Vdc
Output Capacitance ($V_{CB} = 10\ \text{Vdc}$, $f = 100\ \text{kHz}$)	C_{ob}	-	25	pF
Current-Gain — Bandwidth Product ($I_C = 50\ \text{mA}$, $V_{CE} = 10\ \text{Vdc}$, $f = 100\ \text{MHz}$)	f_T	120	-	MHz

***SWITCHING CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Typical	Maximum	Unit
Delay Time	t_d	9	25	ns
Rise Time	t_r	25	45	ns
Storage Time	t_s	100	225	ns
Fall Time	t_f	30	45	ns

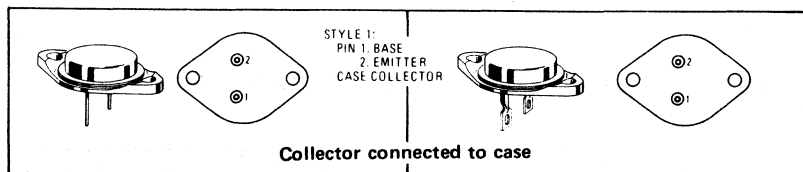
⁽¹⁾ Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, duty cycle $\leq 2\%$

*Indicates JEDEC Registered Data

2N2832 (GERMANIUM) PNP germanium transistors for switching and amplifier applications.

2N2833

2N2834



CASE 11A

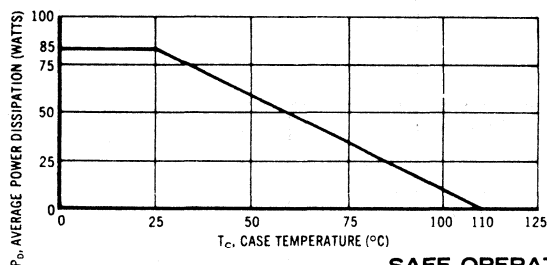
For units with solder lugs attached, specify device MP2832 etc. (Case 4-04)

CASE 4-04

MAXIMUM RATINGS

Rating	Symbol	2N2832	2N2833	2N2834	Unit
Collector-Emitter Voltage	V_{CEO}	50	75	100	Vdc
Collector-Base Voltage	V_{CB}	80	120	140	Vdc
Emitter-Base Voltage	V_{EB}	2.0			Vdc
Collector Current - Continuous	I_C	20			Adc
Base Current	I_B	5.0			Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$	P_D	85			Watts
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110			

FIGURE 1 — POWER DERATING CURVE



THESE TRANSISTORS ARE ALSO SUBJECT TO SAFE AREA CURVES AS INDICATED BY FIGURES 2, 3, 4. BOTH LIMITS ARE APPLICABLE AND MUST BE OBSERVED

SAFE OPERATING AREAS

FIGURE 2 — 2N2832

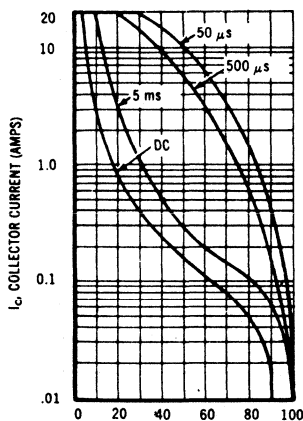


FIGURE 3 — 2N2833

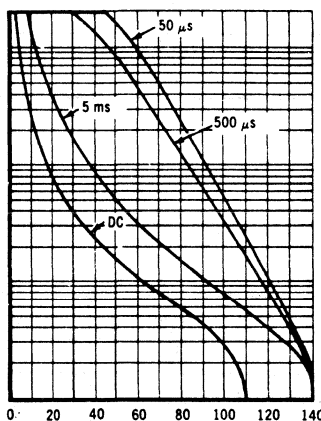
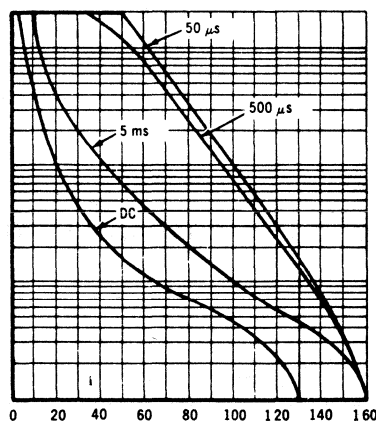


FIGURE 4 — 2N2834



The Safe Operating Area Curves indicate the $I_C - V_{CE}$ limits below which the devices will not go into secondary breakdown. As secondary breakdown is independent of temperature and duty cycle, these curves can be used as long as the average power derating curve (Figure 1) is also taken into consideration to insure operation below the maximum junction temperature.

2N2832 thru 2N2834 (Continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ⁽¹⁾ (I _C = 100 mA dc, I _B = 0)	BV _{CEO(sus)}	50 75 100	- - -	- - -	Volts
Emitter-Base Breakdown Voltage (I _E = 50 mA dc, I _C = 0)	BV _{EBO}	2.0	-	-	Vdc
Floating Potential* (V _{CB} = 80 Vdc, I _E = 0) (V _{CB} = 120 Vdc, I _E = 0) (V _{CB} = 140 Vdc, I _E = 0)	V _{EBF} *	- - -	- - -	0.5 0.5 0.5	Volts
Collector Cutoff Current* (V _{CE} = 100 Vdc, V _{BE} = 0) (V _{CE} = 140 Vdc, V _{BE} = 0) (V _{CE} = 160 Vdc, V _{BE} = 0)	I _{CES} *	- - -	- - -	20 20 20	mA dc
Collector Cutoff Current** (V _{CE} = 50 Vdc, V _{BE(off)} = 0.2 Vdc, T _C = +85°C) (V _{CE} = 75 Vdc, V _{BE(off)} = 0.2 Vdc, T _C = +85°C) (V _{CE} = 100 Vdc, V _{BE(off)} = 0.2 Vdc, T _C = +85°C)	I _{CEX} **	- - -	- - -	40 40 40	mA dc
Collector Cutoff Current* (V _{CB} = 2.0 Vdc, I _E = 0) (V _{CB} = 80 Vdc, I _E = 0) (V _{CB} = 120 Vdc, I _E = 0) (V _{CB} = 140 Vdc, I _E = 0)	I _{CBO} *	- - - -	- - - -	0.3 10 10 10	mA dc

ON CHARACTERISTICS

DC Current Gain (I _C = 1.0 A dc, V _{CE} = 2.0 Vdc) (I _C = 10 A dc, V _{CE} = 2.0 Vdc)	h _{FE}	50 25	75 -	- 100	-
Collector-Emitter Saturation Voltage (I _C = 1.0 A dc, I _B = 100 mA dc) (I _C = 10 A dc, I _B = 1.0 A dc) (I _C = 20 A dc, I _B = 2.0 A dc)	V _{CE(sat)}	- - -	- - -	0.15 0.30 0.5	Vdc
Base-Emitter Saturation Voltage (I _C = 1.0 A dc, I _B = 100 mA dc) (I _C = 10 A dc, I _B = 1.0 A dc) (I _C = 20 A dc, I _B = 2.0 A dc)	V _{BE(sat)}	- - -	- - -	0.6 0.75 1.0	Vdc

DYNAMIC CHARACTERISTICS

Small Signal Current Gain (I _C = 1.0 A dc, V _{CE} = 10 Vdc, f = 5.0 MHz)	h _{fe}	2.0	3.5	-	-
Rise Time	t _r	-	2.0	4.0	μs
Storage Time	t _s	-	3.0	6.0	μs
Fall Time	t _f	-	1.0	2.5	μs

*SWEEP TEST: 1.2 Sine Wave, 60 Hz min.

⁽¹⁾PULSE TEST: Pulse Width = 1.0 ms, 2.0% Duty Cycle.

FIG 5 — BASE-EMITTER SATURATION VOLTAGE VARIATIONS

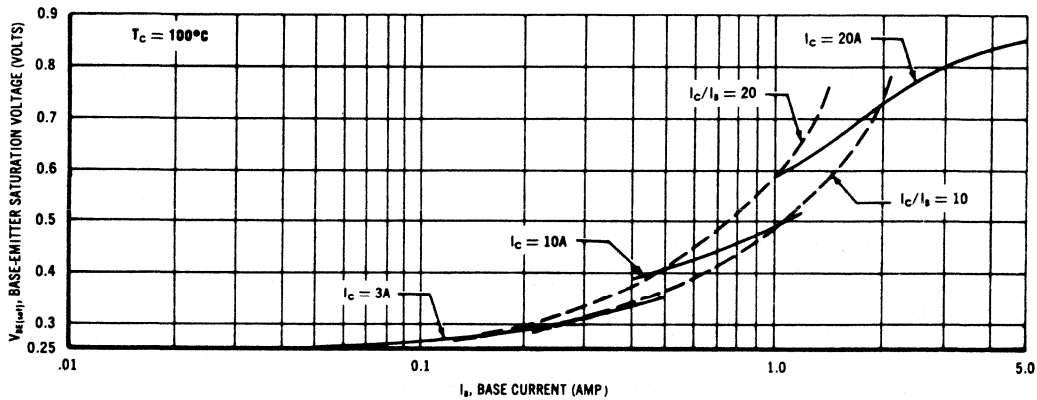
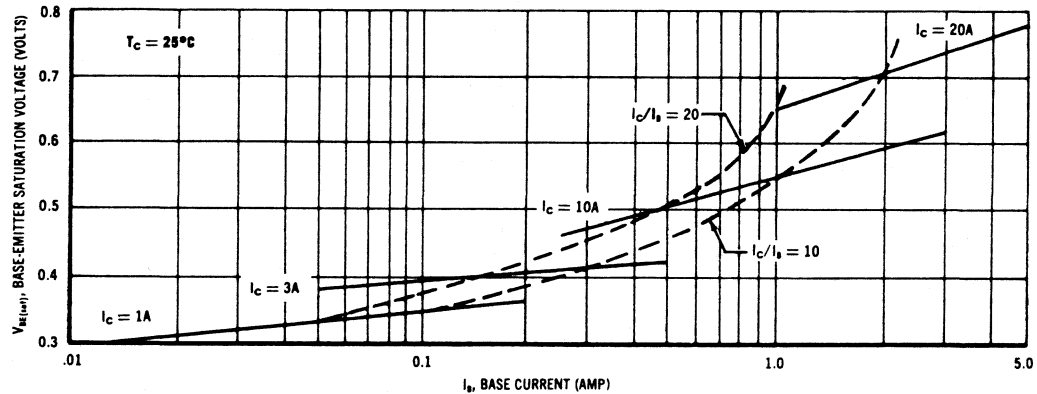
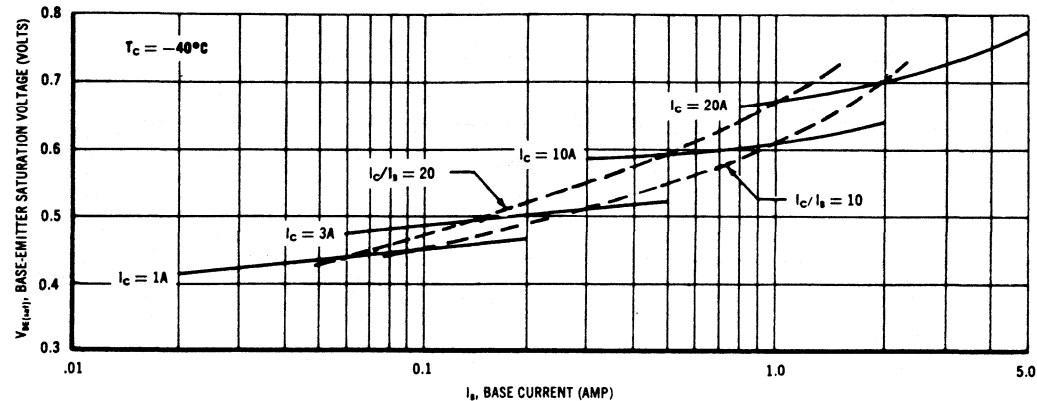


FIG 6 — COLLECTOR-EMITTER SATURATION VOLTAGE VARIATIONS

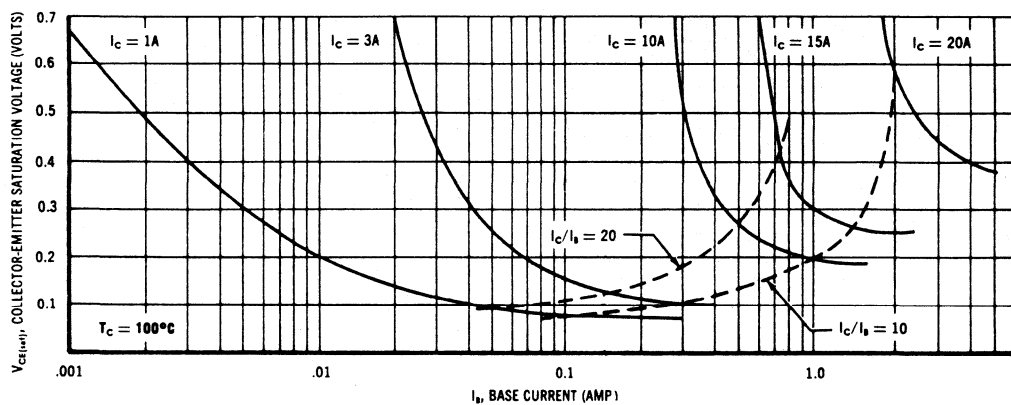
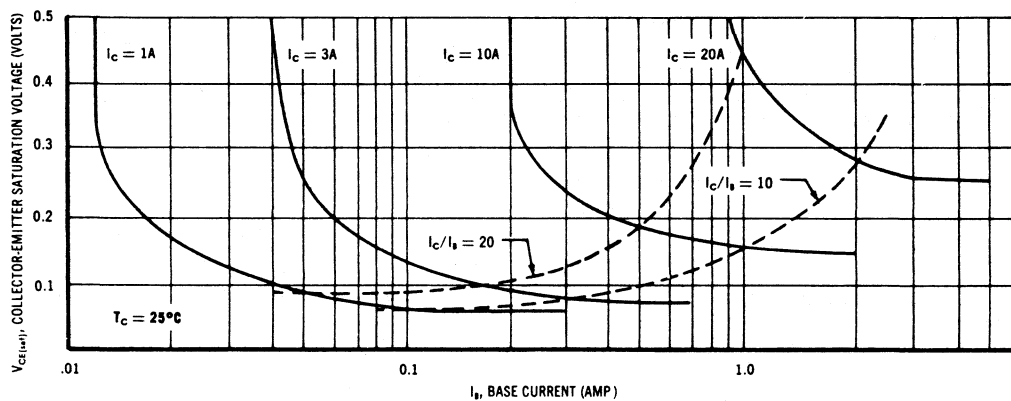
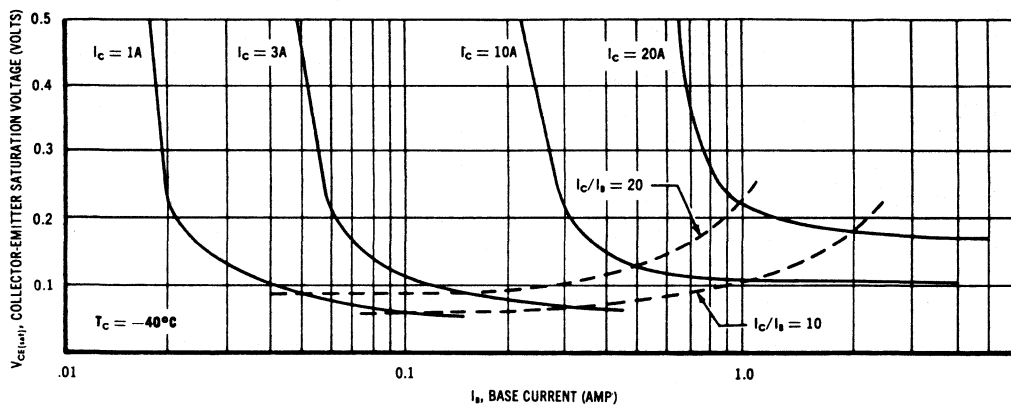


FIGURE 7 — CURRENT VARIATIONS

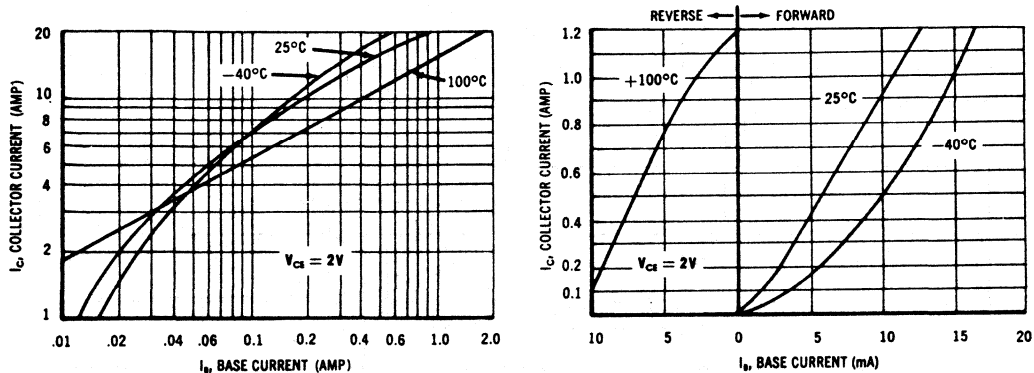


FIGURE 8 — COLLECTOR CURRENT-VOLTAGE VARIATION

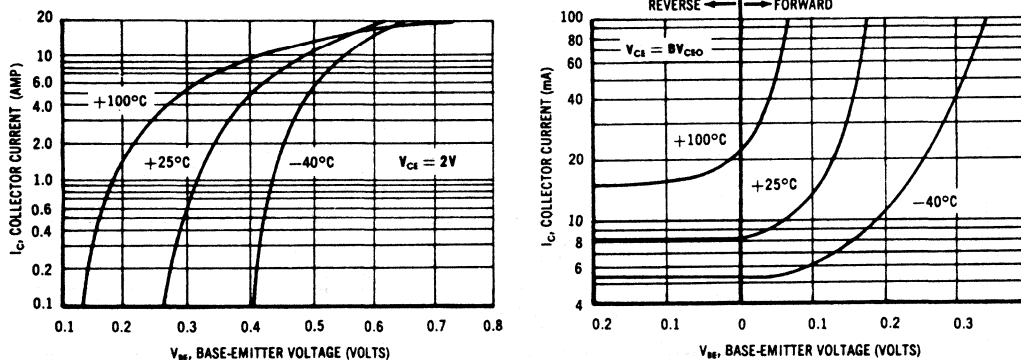


FIG 9 — BASE CURRENT-VOLTAGE VARIATIONS

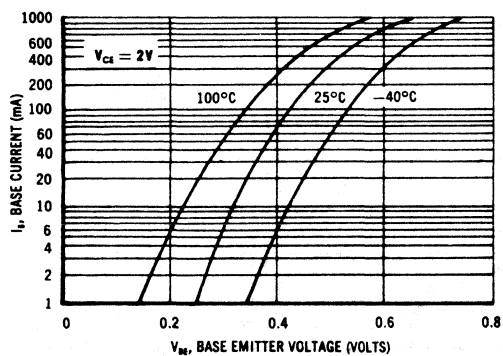


FIGURE 10 CURRENT-GAIN VARIATIONS

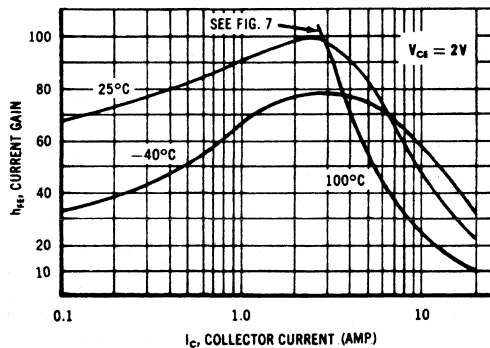


FIG 11 — RISE and FALL TIME vs COLLECTOR CURRENT

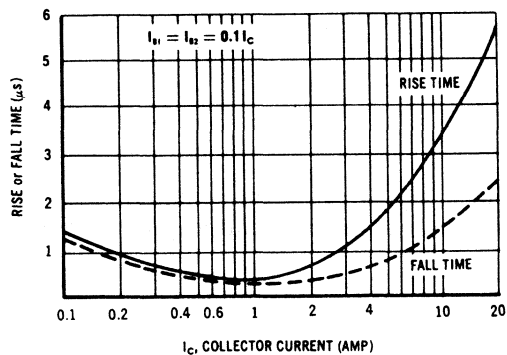


FIG 12 — STORAGE TIME vs COLLECTOR CURRENT

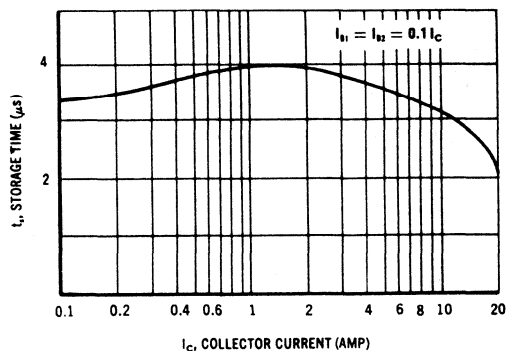
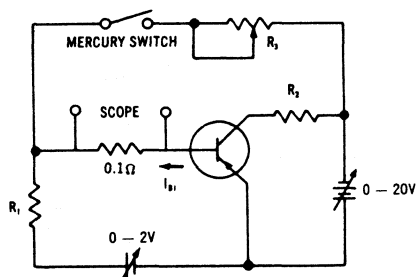


FIG 13 — SWITCHING TIME TEST CIRCUIT



Characteristic	Sym	Max	Unit
Rise Time	t_r	4	μs
Storage Time	t_s	6	μs
Fall Time	t_f	2.5	μs

ADJUST R_1 , R_2 , R_3 , for $I_{b1} = I_{b2} = 0.1 I_C$

PULSE CONDITIONS; $I_C = 5$ AMP, $I_{b1} = 0.5$ AMP

Switching times shown are for constant current drive conditions. Faster times can be realized by the use of a lower source impedance or a speed-up capacitor. See Chapter 5 of the Motorola Switching Handbook for a more detailed explanation.

FIG 14 — CURRENT GAIN — BANDWIDTH PRODUCT vs COLLECTOR CURRENT

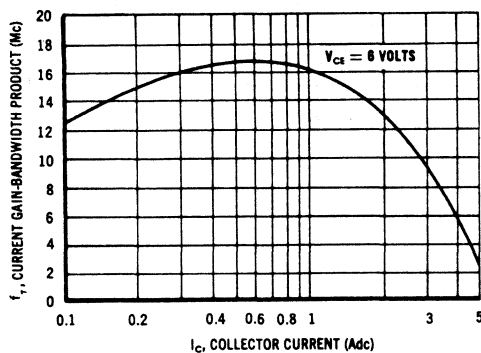
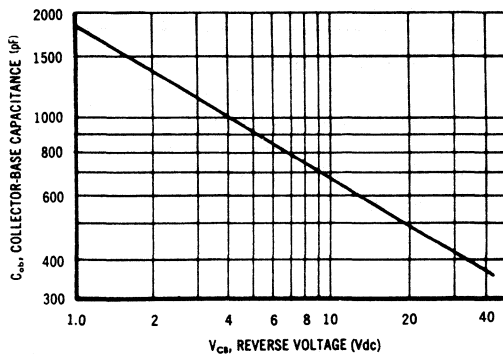
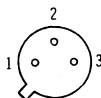


FIG 15 — OUTPUT CAPACITANCE vs REVERSE VOLTAGE



2N2845, 2N2847 (SILICON)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 22
(TO-18)
2N2845
2N2847

NPN silicon annular transistors designed for high-speed, medium-power saturated switching applications.

*MAXIMUM RATINGS

Rating	Symbol	2N2845	2N2847	Unit
Collector-Emitter Voltage(1)	V_{CEO}	30	20	Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Total Device Dissipation @ $T_A = 25^{\circ}\text{C}$ Derate above 25°C	P_D	360 2.1		mW mW/ $^{\circ}\text{C}$
Total Device Dissipation @ $T_C = 25^{\circ}\text{C}$ Derate above 25°C	P_D	1.2 6.9		Watts mW/ $^{\circ}\text{C}$
Operating Junction Temperature Range	T_J	-65 to 200		$^{\circ}\text{C}$
Storage Temperature Range	T_{stg}	-65 to 200		$^{\circ}\text{C}$

(1) Applicable from 1 mA to 30 mA (Pulsed)

*Indicates JEDEC Registered Data

2N2845, 2N2847(continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I _C = 30 mAdc, I _B = 0) (I _C = 30 mAdc, I _B = 0)	BV _{CEO(sus)}	30 20	— —	Vdc
Collector-Base Breakdown Voltage (I _C = 0.1 mAdc, I _E = 0)	BV _{CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage (I _E = 0.1 mAdc, I _C = 0)	BV _{EB0}	5.0	—	Vdc
Collector-Cutoff Current (V _{CE} = 30 Vdc, V _{BE} = 0)	I _{CES}	—	0.2	μA dc
Collector Cutoff Current (V _{CB} = 30 Vdc, I _E = 0, T _A = 150°C)	I _{CBO}	—	200	μA dc
Base Leakage Current (V _{CE} = 30 Vdc, V _{BE} = 0)	I _{BL}	—	0.2	μA dc

ON CHARACTERISTICS (1)

DC Current Gain (I _C = 150 mAdc, V _{CE} = 10 Vdc) (I _C = 500 mAdc, V _{CE} = 10 Vdc) (I _C = 500 mAdc, V _{CE} = 1 Vdc)	h _{FE}	30 40 20 30 10	120 140 — — —	—
Collector-Emitter Saturation Voltage (I _C = 150 mAdc, I _B = 15 mAdc) (I _C = 500 mAdc, I _B = 50 mAdc)	V _{CE(sat)}	— — —	0.4 1.0 0.75	Vdc
Base-Emitter Saturation Voltage (I _C = 150 mAdc, I _B = 15 mAdc) (I _C = 500 mAdc, I _B = 50 mAdc)	V _{BE(sat)}	— —	1.2 1.6	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product (I _C = 50 mAdc, V _{CE} = 10 Vdc, f = 100 MHz)	f _T	250	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 140 kHz)	C _{ob}	—	8.0	pF
Turn-On Time (Figure 1) (V _{CC} = 10 Vdc, I _C = 150 mAdc, I _{B1} = 15 mAdc) (V _{CC} = 6 Vdc, I _C = 150 mAdc, I _{B1} = 15 mAdc)	t _{on}	— —	40 25	ns
Turn-Off Time (Figure 2) (V _{CC} = 10 Vdc, I _C = 150 mAdc, I _{B1} = I _{B2} = 15 mAdc) (V _{CC} = 6 Vdc, I _C = 150 mAdc, I _{B1} = I _{B2} = 15 mAdc)	t _{off}	— —	40 40	ns

(1) Pulse Test: Pulse Width = 300 μs; Duty Cycle = ≤ 2%

* Indicates JEDEC Registered Data

FIGURE 1 — TURN-ON TIME TEST CIRCUIT

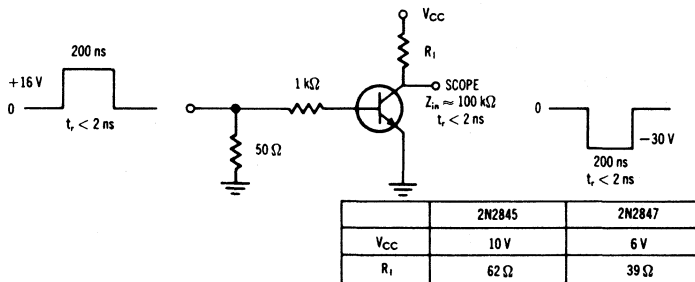
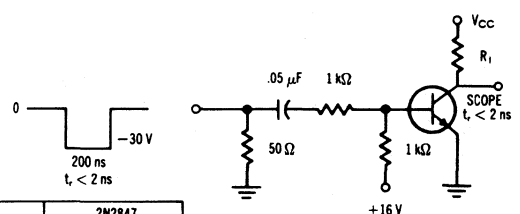


FIGURE 2 — TURN-OFF TIME TEST CIRCUIT



The RF Line

NPN SILICON RF SMALL-SIGNAL TRANSISTORS

... designed primarily for use in high-gain, low-noise amplifier, oscillator, and mixer applications. Can also be used in UHF converter applications.

- High Current-Gain-Bandwidth Product —
 $f_T = 1.6 \text{ GHz (Typ) @ } I_C = 8.0 \text{ mAdc}$
- Low Noise Figure —
 $NF = 3.9 \text{ dB (Max) @ } f = 450 \text{ MHz — 2N3839}$
- Low Collector-Base Time Constant —
 $r_b C_C = 15 \text{ ps (Max) @ } I_E = 2.0 \text{ mAdc}$
- Characterized with Scattering Parameters
- Ideal for Micro-Power Applications

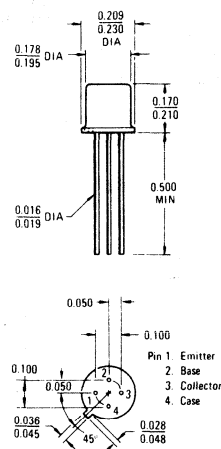
NPN SILICON RF SMALL-SIGNAL TRANSISTORS



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CE0}	15	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	2.5	Vdc
Collector Current — Continuous	I_C	40	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	200 1.14	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	300 1.72	mW mW/ $^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

*Indicates JEDEC Registered Data.



CASE 20 (10)
TO-72 PACKAGE

Active Elements Isolated from Case

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage** ($I_C = 3.0 \text{ mAdc}$, $I_B = 0$)	BV_{CEO}	15	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 1.0 \text{ } \mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	30	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \text{ } \mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	2.5	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 15 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 15 \text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	— —	0.01 1.0	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 3.0 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$)	h_{FE}	30	—	150	—
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DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product ① ($I_C = 5.0 \text{ mAdc}$, $V_{CE} = 6.0 \text{ Vdc}$, $f = 100 \text{ MHz}$)	2N2857 2N3839	f_T	1000 1000	— —	1900 2000	MHz
Collector-Base Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 0.1$ to 1.0 MHz)		C_{cb}	—	0.7	1.0	pF
Small-Signal Current Gain ($I_C = 2.0 \text{ mAdc}$, $V_{CE} = 6.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)		h_{fe}	50	—	220	—
Collector-Base Time Constant ($I_E = 2.0 \text{ mAdc}$, $V_{CB} = 6.0 \text{ Vdc}$, $f = 31.9 \text{ MHz}$)	2N2857 2N3839	$r_b C_c$	4.0 1.0	— —	15 15	ps
Noise Figure (Figure 1) ($I_E = 0.1 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$, $R_S = 50 \text{ ohms}$, $f = 450 \text{ MHz}$) ② ($I_C = 1.5 \text{ mAdc}$, $V_{CE} = 6.0 \text{ Vdc}$, $R_S = 50 \text{ ohms}$, $f = 450 \text{ MHz}$)	Both Types 2N2857 2N3839	NF	— — —	5.8 4.1 —	— 4.5 3.9	dB

FUNCTIONAL TEST

Common-Emitter Amplifier Power Gain (Figure 1) ($I_E = 0.1 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$, $f = 450 \text{ MHz}$) ② ($I_C = 1.5 \text{ mAdc}$, $V_{CE} = 6.0 \text{ Vdc}$, $f = 450 \text{ MHz}$)	G_{pe}	— 12.5	11 —	— 19	dB
Power Output (Figure 2) ($I_E = 12 \text{ mAdc}$, $V_{CB} = 10 \text{ Vdc}$, $f = 500 \text{ MHz}$)	P_{out}	30	—	—	mW

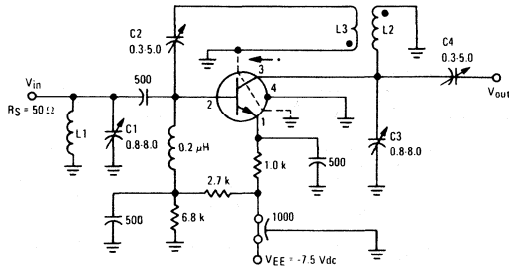
*Indicates JEDEC Registered Data.

**Motorola guarantees this data in addition to JEDEC Registered Data.

① f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

② Micro-Power Specifications.

FIGURE 1 – TEST CIRCUIT FOR NOISE FIGURE AND POWER GAIN



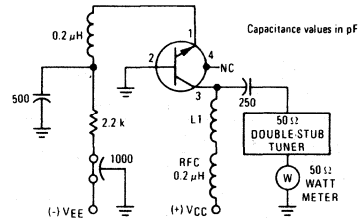
Capacitance values in pF

- L1, L2 - Silver plated brass rod, 1 1/2" long and 1/4" dia. Install at least 1/2" from nearest vertical chassis surface.
L3 - 1/2 turn #16 AWG wire, located 1/4" from and parallel to L2.
* External interlead shield to isolate collector lead from emitter and base leads.

Neutralization Procedure:

- (A) Connect 450 MHz signal generator (with $R_S = 50$ ohms) to input terminals of amplifier.
(B) Connect 50-ohm RF voltmeter across output terminals of amplifier.

FIGURE 2 – TEST CIRCUIT FOR OSCILLATOR POWER OUTPUT



L1 - 3 turns #16 AWG wire, 3/8" O.D. 1-1/4" long.

- (C) Apply VEE, and with signal generator adjusted for 5 mV output from amplifier, tune C1, C3, and C4 for maximum output.
(D) Interchange connections to signal generator and RF voltmeter.
(E) With sufficient signal applied to output terminals of amplifier, adjust C2 for minimum indication at input.
(F) Repeat steps (A), (B), and (C) to determine if retuning is necessary.

FIGURE 3 – NOISE FIGURE versus FREQUENCY

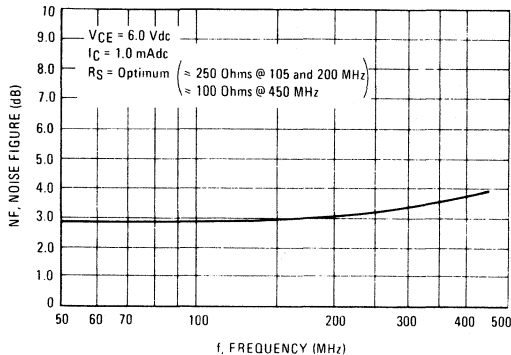


FIGURE 4 – NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT

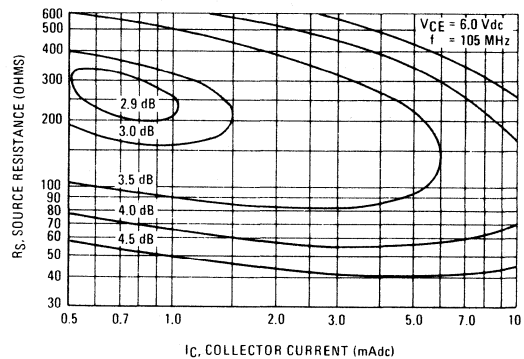


FIGURE 5 – NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT

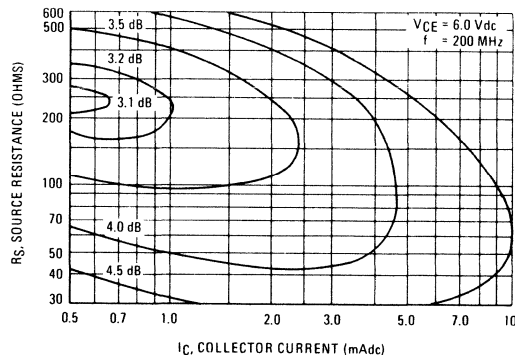


FIGURE 6 – CURRENT-GAIN-BANDWIDTH PRODUCT

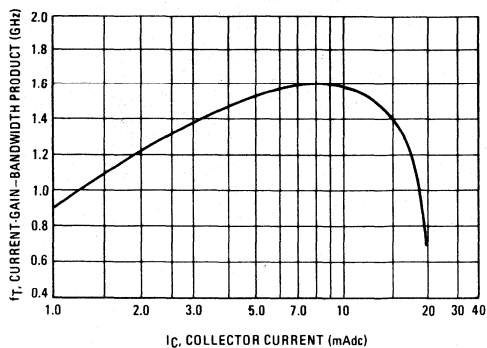


FIGURE 7 – NOISE FIGURE AND POWER GAIN
versus COLLECTOR CURRENT

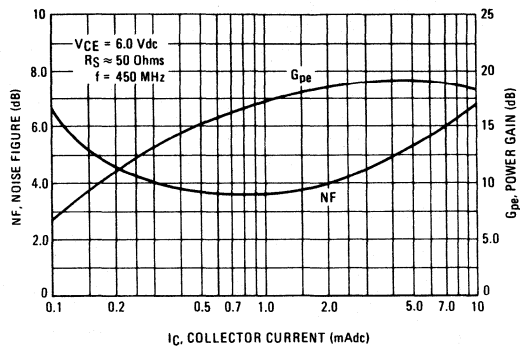


FIGURE 8 – INPUT ADMITTANCE
versus FREQUENCY

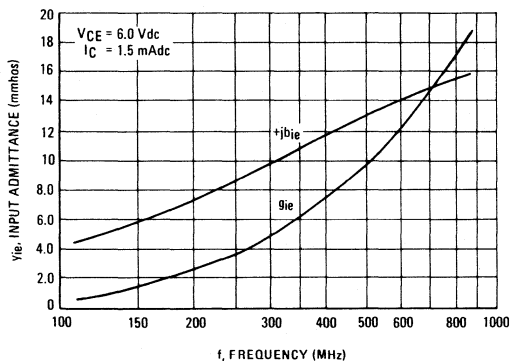


FIGURE 9 – OUTPUT ADMITTANCE
versus FREQUENCY

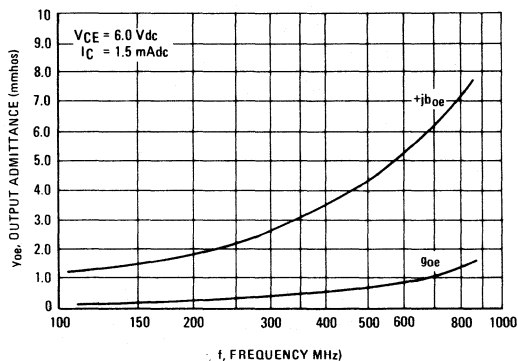


FIGURE 10 – FORWARD TRANSFER
ADMITTANCE versus FREQUENCY

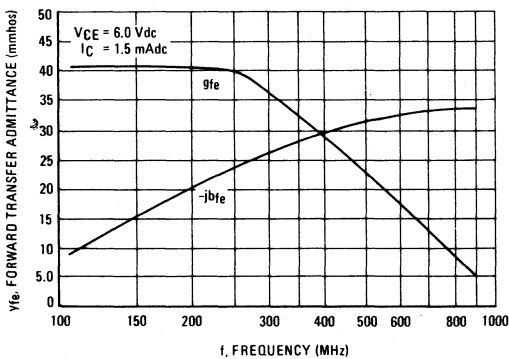


FIGURE 11 – REVERSE TRANSFER
ADMITTANCE versus FREQUENCY

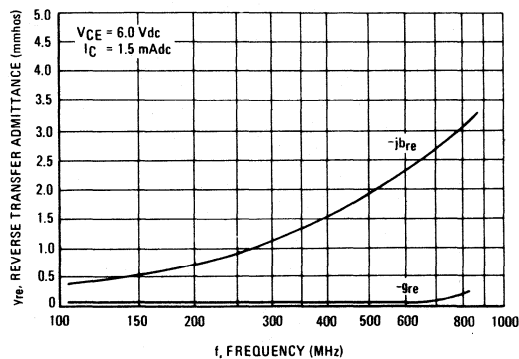


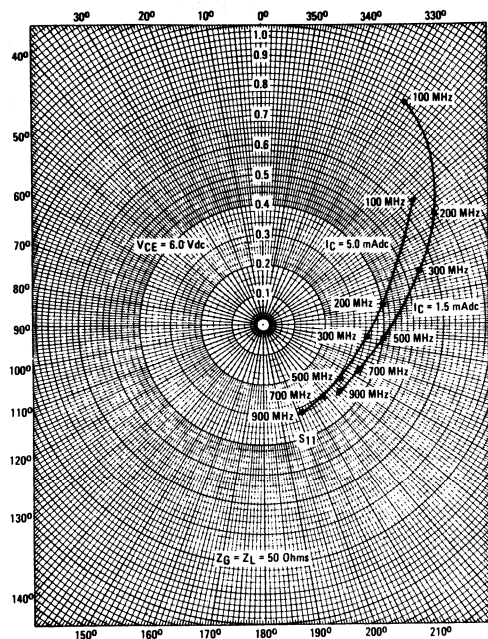
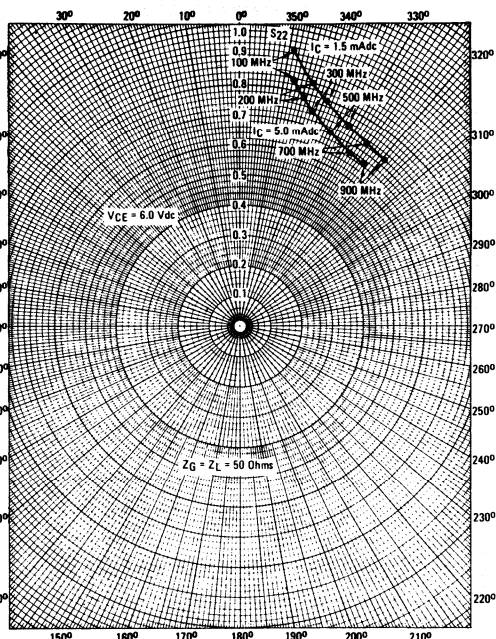
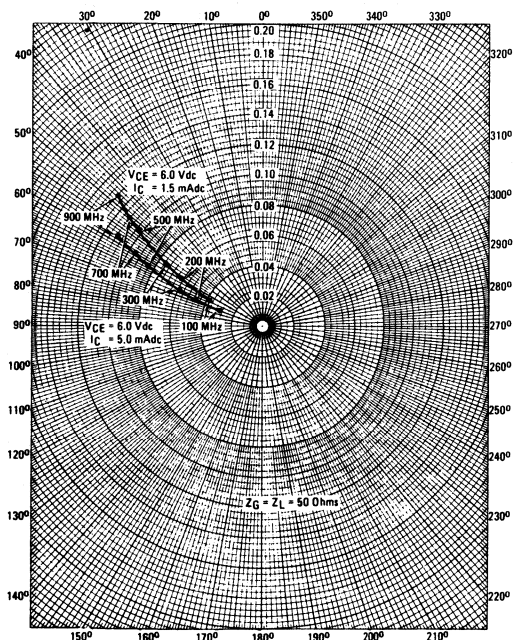
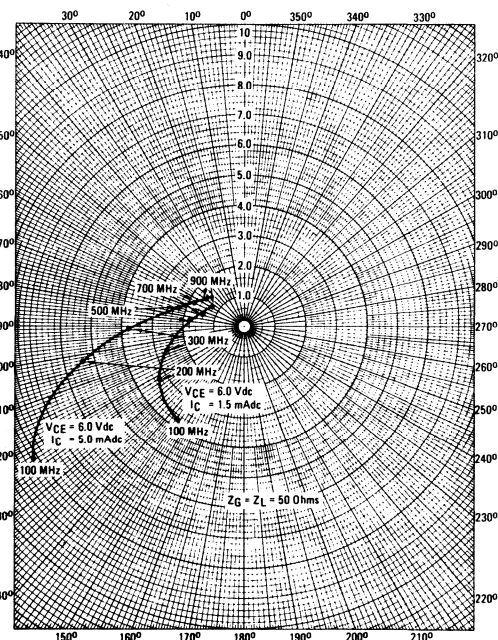
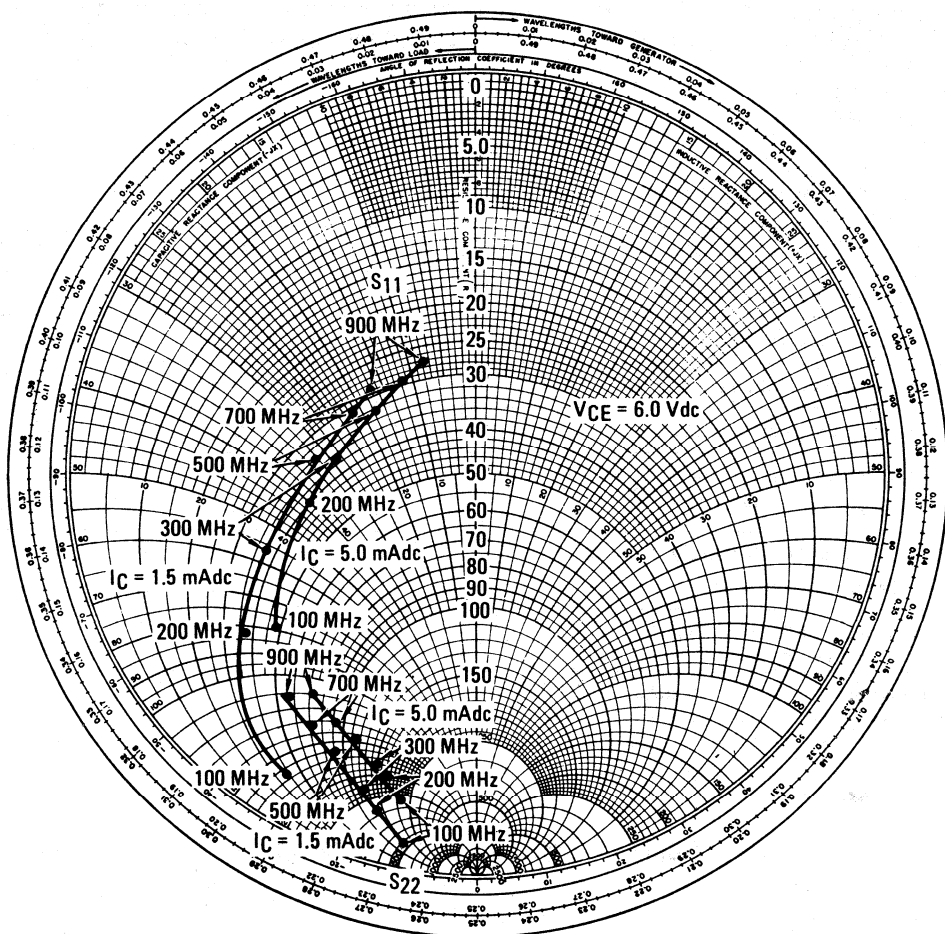
FIGURE 12 — S_{11} , INPUT REFLECTION COEFFICIENTFIGURE 13 — S_{22} , OUTPUT REFLECTION COEFFICIENTFIGURE 14 — S_{12} , REVERSE TRANSMISSION COEFFICIENTFIGURE 15 — S_{21} , FORWARD TRANSMISSION COEFFICIENT

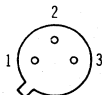
FIGURE 16 – S_{11} , INPUT REFLECTION COEFFICIENT AND S_{22} , OUTPUT REFLECTION COEFFICIENT



2N2894 (SILICON)



CASE 22
(TO-18)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

PNP silicon annular transistor designed for low-level, high-speed switching applications.

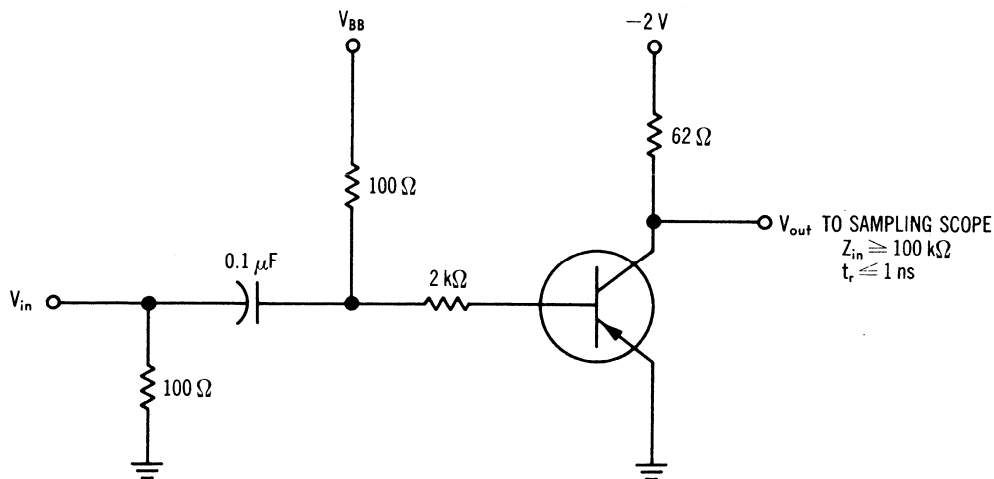
*MAXIMUM RATINGS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage (1)	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	12	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current-Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	360 2.06	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1200 6.85	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

(1) Applicable from 0.01 to 10 mAdc.

* Indicates JEDEC Registered Data

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



*** ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) ($I_C = 10 \text{ mA}$, $I_B = 0$)	$BV_{CEO(sus)}$	12	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10 \mu\text{A}$, $V_{BE} = 0$)	BV_{CES}	12	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{A}$, $I_E = 0$)	BV_{CBO}	12	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{A}$, $I_C = 0$)	BV_{EBO}	4.0	—	Vdc
Collector-Cutoff Current ($V_{CE} = 6 \text{ Vdc}$, $V_{BE} = 0$)	I_{CES}	—	80	nAdc
Collector-Cutoff Current ($V_{CB} = 6 \text{ Vdc}$, $I_E = 0$, $T_A = 125^\circ\text{C}$)	I_{CBO}	—	10	μAdc
Base Current ($V_{CE} = 6 \text{ Vdc}$, $V_{BE} = 0$)	I_B	—	80	nAdc
ON CHARACTERISTICS				
DC Current Gain (1) ($I_C = 10 \text{ mA}$, $V_{CE} = 0.3 \text{ Vdc}$) ($I_C = 30 \text{ mA}$, $V_{CE} = 0.5 \text{ Vdc}$) ($I_C = 30 \text{ mA}$, $V_{CE} = 0.5 \text{ Vdc}$, $T_A = -55^\circ\text{C}$) ($I_C = 100 \text{ mA}$, $V_{CE} = 1.0 \text{ Vdc}$)	h_{FE}	30 40 17 25	— 150 — —	—
Collector-Emitter Saturation Voltage (1) ($I_C = 10 \text{ mA}$, $I_B = 1 \text{ mA}$) ($I_C = 30 \text{ mA}$, $I_B = 3 \text{ mA}$) ($I_C = 100 \text{ mA}$, $I_B = 10 \text{ mA}$)	$V_{CE(sat)}$	— — —	0.15 0.2 0.5	Vdc
Base-Emitter Saturation Voltage (1) ($I_C = 10 \text{ mA}$, $I_B = 1 \text{ mA}$) ($I_C = 30 \text{ mA}$, $I_B = 3 \text{ mA}$) ($I_C = 100 \text{ mA}$, $I_B = 10 \text{ mA}$)	$V_{BE(sat)}$	0.78 0.85 —	0.98 1.2 1.7	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product ($I_C = 30 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	400	—	MHz
Output Capacitance ($V_{CB} = 5 \text{ Vdc}$, $I_E = 0$, $f = 140 \text{ kHz}$)	C_{ob}	—	6.0	pF
Input Capacitance ($V_{BE} = -0.5 \text{ Vdc}$, $I_C = 0$, $f = 140 \text{ kHz}$)	C_{ib}	—	6.0	pF
Turn-On Time, Figure 1 ($V_{CC} = 2 \text{ Vdc}$, $V_{BE(off)} = 3 \text{ Vdc}$, $I_C = 30 \text{ mA}$, $I_{B1} = 1.5 \text{ mA}$)	t_{on}	—	60	ns
Turn-Off Time, Figure 1 ($V_{CC} = 2 \text{ Vdc}$, $I_C = 30 \text{ mA}$, $I_{B1} = I_{B2} = 1.5 \text{ mA}$)	t_{off}	—	90	ns

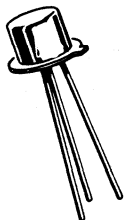
(1) Pulse Test: Pulse Width = 300 μs ; Duty Cycle = 1%

*Indicates JEDEC Registered Data

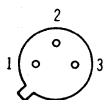
2N2895 (SILICON)

2N2896

2N2897



CASE 22
(TO-18)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

NPN silicon annular transistors designed for small-signal amplifier and general purpose switching applications.

***MAXIMUM RATINGS**

Rating	Symbol	2N2895	2N2896	2N2897	Unit
Collector-Emitter Voltage	V_{CEO}	65	90	45	Vdc
Collector-Emitter Voltage	V_{CER}	80	140	60	Vdc
Collector-Base Voltage	V_{CB}	120	140	60	Vdc
Emitter-Base Voltage	V_{EB}	← 7.0 →			Vdc
Collector Current	I_C	← 1.0 →			Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	← 0.5 →			Watt
		← 2.86 →			mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	← 1.8 →			Watts
		← 10.3 →			mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →			$^\circ\text{C}$

*Indicates JEDEC Registered Data

2N2895, 2N2896, 2N2897 (Continued)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage ⁽¹⁾ ($I_C = 100 \text{ mAdc}$, $I_B = 0$)	$BV_{CEO(sus)}$	65 90 45	- - -	Vdc
Collector-Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 100 \text{ mAdc}$, $R_{BE} = 10 \text{ ohms}$)	BV_{CER}	80 140 60	- - -	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1 \text{ mAdc}$, $I_E = 0$)	BV_{CBO}	120 140 60	- - -	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1 \text{ mAdc}$, $I_C = 0$)	BV_{EBO}	7.0	-	Vdc
Collector Cutoff Current ($V_{CB} = 60 \text{ Vdc}$, $I_E = 0$)	I_{CBO}	- - - - - -	0.002 0.01 0.05 2.0 50 0.01	μA
($V_{CB} = 60 \text{ Vdc}$, $I_E = 0$, $T_A = +150^\circ\text{C}$)				
($V_{CB} = 90 \text{ Vdc}$, $I_E = 0$)				
($V_{CB} = 90 \text{ Vdc}$, $I_E = 0$, $T_A = +150^\circ\text{C}$)			10	
Emitter Cutoff Current ($V_{BE} = 5.0 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	- - -	0.002 0.01 0.05	μA

ON CHARACTERISTICS

DC Current Gain ($I_C = 10 \mu\text{A}$, $V_{CE} = 10 \text{ Vdc}$)	2N2895	h_{FE}	10	-	-
($I_C = 100 \mu\text{A}$, $V_{CE} = 10 \text{ Vdc}$)	2N2895		20	-	
($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$)	2N2896, 2N2897		35	-	
($I_C = 10 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$)	2N2895		35	-	
($I_C = 10 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $T_A = -55^\circ\text{C}$)	2N2895, 2N2896		20	-	
($I_C = 150 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$) ⁽¹⁾	2N2895		40 60 50 25	120 200 200 -	
($I_C = 500 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$) ⁽¹⁾	2N2895				
Collector-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 150 \text{ mAdc}$, $I_B = 15 \text{ mAdc}$)	2N2895, 2N2896 2N2897	$V_{CE(sat)}$	- -	0.6 1.0	Vdc
Base-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 150 \text{ mAdc}$, $I_B = 15 \text{ mAdc}$)	2N2895, 2N2896 2N2897	$V_{BE(sat)}$	- -	1.2 1.3	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 50 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 20 \text{ MHz}$)	2N2895, 2N2896 2N2897	f_T	120 100	- -	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)		C_{ob}	-	15	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 100 \text{ kHz}$)		C_{ib}	-	80	pF
Small-Signal Current Gain ($I_C = 5.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	2N2895 2N2896, 2N2897	h_{fe}	50 50	200 275	-
Noise Figure ($I_C = 0.3 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $R_S = 500 \text{ ohms}$, $f = 1.0 \text{ kHz}$, BW = 15 kHz)	2N2895	NF	-	8.0	dB

⁽¹⁾ Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 1.8\%$.

*Indicates JEDEC Registered Data

2N2903 (SILICON)
2N2903A

MULTIPLE SILICON ANNULAR TRANSISTORS

... designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Excellent Temperature Tracking – Dual Devices – 2N2903
 $\Delta|V_{BE1} - V_{BE2}| = 20 \text{ mVdc (Max) @ } -55 \text{ to } +25^{\circ}\text{C}$
 $= 1.0 \text{ mVdc (Max) @ } +25 \text{ to } +125^{\circ}\text{C}$
- Low Collector-Emitter Saturation Voltage –
 $V_{CE(sat)} = 1.0 \text{ Vdc (Max) @ } I_C = 5.0 \text{ mAdc}$
- DC Current Gain Specified – $10 \mu\text{Adc to } 1.0 \text{ mAdc}$
- High Current-Gain-Bandwidth Product –
 $f_T = 60 \text{ MHz @ } I_C = 5.0 \text{ mAdc}$

NPN SILICON
MULTIPLE TRANSISTORS



*MAXIMUM RATINGS

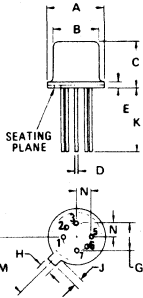
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	7.0		Vdc
Collector Current – Continuous	I_C	50		mAdc
		One Die	Both Die	
Total Power Dissipation @ $T_A = 25^{\circ}\text{C}$ Derate above 25°C	P_D	200 1.14	300 1.71	mW mW/ $^{\circ}\text{C}$
Total Power Dissipation @ $T_C = 25^{\circ}\text{C}$ Derate above 25°C	P_D	0.6 3.43	1.2 6.86	Watts mW/ $^{\circ}\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^{\circ}\text{C}$

*ELECTRICAL CHARACTERISTICS (each side) ($T_A = 25^{\circ}\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage ⁽¹⁾ ($I_C = 10 \text{ mAdc}, I_E = 0$)	$V_{CEO(sus)}$	30	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	BV_{CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1 \mu\text{Adc}, I_C = 0$)	BV_{EBO}	7.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 50 \text{ Vdc}, I_E = 0$) ($V_{CB} = 50 \text{ Vdc}, I_E = 0, T_A = 150^{\circ}\text{C}$)	I_{CBO}	— —	0.01 15	μAdc
Emitter Cutoff Current ($V_{BE} = 5.0 \text{ Vdc}, I_C = 0$)	I_{EBO}	—	0.01	μAdc

⁽¹⁾ Pulse Test: I_{se} Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.
* Indicates JEDEC Registered Data

STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	—	0.500	—
M	45 $^{\circ}$ BSC		45 $^{\circ}$ BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

2N2903, 2N2903A (continued)

*ELECTRICAL CHARACTERISTICS (each side) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
DC Current Gain ($I_C = 10\ \mu\text{A}$ dc, $V_{CE} = 5.0\ \text{V}$ dc) ($I_C = 10\ \mu\text{A}$ dc, $V_{CE} = 5.0\ \text{V}$ dc, $T_A = -55^\circ\text{C}$) ($I_C = 1.0\ \text{mA}$ dc, $V_{CE} = 5.0\ \text{V}$ dc) ($I_C = 1.0\ \text{mA}$ dc, $V_{CE} = 5.0\ \text{V}$ dc, $T_A = -55^\circ\text{C}$)	h_{FE}	60 25 125 60	- - 625 -	-
Collector-Emitter Saturation Voltage ($I_C = 5.0\ \text{mA}$ dc, $I_B = 0.5\ \text{mA}$ dc)	$V_{CE(sat)}$	-	1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 5.0\ \text{mA}$ dc, $I_B = 0.5\ \text{mA}$ dc)	$V_{BE(sat)}$	-	0.9	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 5.0\ \text{mA}$ dc, $V_{CE} = 10\ \text{V}$ dc, $f = 30\ \text{MHz}$)	f_T	60	-	MHz
Output Capacitance ($V_{CB} = 10\ \text{V}$ dc, $I_E = 0$, $f = 140\ \text{kHz}$)	C_{ob}	-	8.0	pF
Input Capacitance ($V_{BE} = 0.5\ \text{V}$ dc, $I_C = 0$, $f = 140\ \text{kHz}$)	C_{ib}	-	10	pF
Input Impedance ($I_C = 1.0\ \text{mA}$ dc, $V_{CE} = 5.0\ \text{V}$ dc, $f = 1.0\ \text{kHz}$)	h_{ie}	1.0	-	k ohm
Voltage Feedback Ratio ($I_C = 1.0\ \text{mA}$ dc, $V_{CE} = 5.0\ \text{V}$ dc, $f = 1.0\ \text{kHz}$)	h_{re}	-	6.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0\ \text{mA}$ dc, $V_{CE} = 5.0\ \text{V}$ dc, $f = 1.0\ \text{kHz}$)	h_{fe}	150	600	-
Output Admittance ($I_C = 1.0\ \text{mA}$ dc, $V_{CE} = 5.0\ \text{V}$ dc, $f = 1.0\ \text{kHz}$)	h_{oe}	5.0	30	μmhos
Input Impedance ($I_C = 1.0\ \text{mA}$ dc, $V_{CB} = 5.0\ \text{V}$ dc, $f = 1.0\ \text{kHz}$)	h_{ib}	20	30	ohms
Voltage Feedback Ratio ($I_C = 1.0\ \text{mA}$ dc, $V_{CB} = 5.0\ \text{V}$ dc, $f = 1.0\ \text{kHz}$)	h_{rb}	-	5.0	$\times 10^{-4}$
Output Admittance ($I_C = 1.0\ \text{mA}$ dc, $V_{CB} = 5.0\ \text{V}$ dc, $f = 1.0\ \text{kHz}$)	h_{ob}	-	0.2	μmho
Noise Figure ($I_C = 10\ \mu\text{A}$ dc, $V_{CE} = 5.0\ \text{V}$ dc, $R_S = 10\ \text{k ohms}$, $f = 1.0\ \text{kHz}$)	NF	-	7.0	dB

MATCHING CHARACTERISTICS

DC Current Gain Ratio (2) ($I_C = 1.0\ \text{mA}$ dc, $V_{CE} = 5.0\ \text{V}$ dc)	2N2903 2N2903A	h_{FE1}/h_{FE2}	0.8 0.9	1.0 1.0	-
Base-Emitter Voltage Differential ($I_C = 10\ \mu\text{A}$ dc, $V_{CE} = 5.0\ \text{V}$ dc)	2N2903 2N2903A	$ V_{BE1} - V_{BE2} $	- -	10 5.0	mVdc
Base-Emitter Voltage Differential Gradient ($I_C = 10\ \mu\text{A}$ dc, $V_{CE} = 5.0\ \text{V}$ dc, $T_A = -55^\circ\text{C}$ to $+125^\circ\text{C}$)	2N2903 2N2903A	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	- -	20 10	$\mu\text{V}/^\circ\text{C}$

* Indicates JEDEC Registered Data

(2) Lowest h_{FE} reading is taken as h_{FE1} for this ratio.

2N2904S, AS, 2N2905S, AS 2N2906, A 2N2907, A(SILICON) 2N3485, A, 2N3486, A

PNP SILICON ANNULAR HERMETIC TRANSISTORS

... designed for high-speed switching circuits, DC to VHF amplifier applications and complementary circuitry.

- High DC Current Gain Specified – 0.1 to 500 mAdc
- High Current-Gain–Bandwidth Product –
 $f_T = 200 \text{ MHz (Min) @ } I_C = 50 \text{ mAdc}$
- Low Collector-Emitter Saturation Voltage –
 $V_{CE(sat)} = 0.4 \text{ Vdc (Max) @ } I_C = 150 \text{ mAdc}$
- 2N2904, A thru 2N2907, A Complement to NPN 2N2218, A,
2N2219, A, 2N2221, A, 2N2222, A
- JAN, JTX, JTXV Available, Except 2N2904S, AS, 2N3485 and 2N3486

PNP SILICON SWITCHING AND AMPLIFIER TRANSISTORS

SELECTOR GUIDE

Device Type	Characteristic				Package
	BV _{CEO} I _C = 10 mAdc Volts	I _C = 1.0 mAdc Min	h _{FE} I _C = 150 mAdc Min	I _C = 500 mAdc Min	
2N2904 2N2905	40	25 50	40 100	20 30	TO-39
2N2906 2N2907	↓	25 50	40 100	20 30	TO-18
2N3485 2N3486	↓	25 50	40 100	20 30	TO-46
2N2904A 2N2905A	60	40 100	40 100	40 50	TO-39
2N2906A 2N2907A	↓	40 100	40 100	40 50	TO-18
2N3485A 2N3486A	↓	40 100	40 100	40 50	TO-46

*MAXIMUM RATINGS

Rating	Symbol	Non-A Suffix		A-Suffix	Unit
Collector-Emitter Voltage	V _{CEO}	40		60	Vdc
Collector-Base Voltage	V _{CB}	60			Vdc
Emitter-Base Voltage	V _{EB}	5.0			Vdc
Collector Current – Continuous	I _C	600			mAdc
		2N2904, A 2N2905, A	2N2906, A 2N2907, A	2N3485, A 2N3486, A	
Total Device Dissipation @ T _A = 25°C	P _D	600	400	400	mW
Derate above 25°C		3.43	2.28	2.28	mW/°C
Total Device Dissipation @ T _C = 25°C	P _D	3.0	1.8	2.0	Watts
Derate above 25°C		17.2	10.3	11.43	mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200			°C

*Indicates JEDEC Registered Data

CASE 79-02
TO-39
2N2904S, AS
2N2905S, AS



CASE 22-03
(TO-18)
2N2906, A
2N2907, A



CASE 26-03
(TO-46)

2N3485, A
2N3486, A



*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) ($I_C = 10 \text{ mAdc}$, $I_B = 0$)	BV_{CEO}	40 60	— —	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 30 \text{ Vdc}$, $V_{BE} = 0.5 \text{ Vdc}$)	I_{CEX}	—	—	50	nAdc
Collector Cutoff Current ($V_{CB} = 50 \text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	—	0.020 0.010	μAdc
($V_{CB} = 50 \text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)		—	—	20 10	
Base Cutoff Current ($V_{CE} = 30 \text{ Vdc}$, $V_{BE} = 0.5 \text{ Vdc}$)	I_B	—	—	50	nAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 0.1 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$)	2N2904, 2N2906, 2N3485 2N2905, 2N2907, 2N3486 2N2904A, 2N2906A, 2N3485A 2N2905A, 2N2907A, 2N3486A	h_{FE}	20 35 40 75	— — — —	— — — —	—
($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$)	2N2904, 2N2906, 2N3485 2N2905, 2N2907, 2N3486 2N2904A, 2N2906A, 2N3485A 2N2905A, 2N2907A, 2N3486A		25 50 40 100	— — — —	— — — —	
($I_C = 10 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$)	2N2904, 2N2906, 2N3485 2N2905, 2N2907, 2N3486 2N2904A, 2N2906A, 2N3485A 2N2905A, 2N2907A, 2N3486A		35 75 40 100	— — — —	— — — —	
($I_C = 150 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$)(1)	2N2904, A, 2N2906, A, 2N3485, A 2N2905, A, 2N2907, A, 2N3486, A		40 100	— —	120 300	
($I_C = 500 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$)(1)	2N2904, 2N2906, 2N3485 2N2905, 2N2907, 2N3486 2N2904A, 2N2906A, 2N3485A 2N2905A, 2N2907A, 2N3486A		20 30 40 50	— — — —	— — — —	
Collector-Emitter Saturation Voltage(1) ($I_C = 150 \text{ mAdc}$, $I_B = 15 \text{ mAdc}$) ($I_C = 500 \text{ mAdc}$, $I_B = 50 \text{ mAdc}$)		$V_{CE(sat)}$	— —	— —	0.4 1.6	Vdc
Base-Emitter Saturation Voltage ($I_C = 150 \text{ mAdc}$, $I_B = 15 \text{ mAdc}$)(1) ($I_C = 500 \text{ mAdc}$, $I_B = 50 \text{ mAdc}$)		$V_{BE(sat)}$	— —	— —	1.3 2.6	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product(2) ($I_C = 50 \text{ mAdc}$, $V_{CE} = 20 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	200	—	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)	C_{ob}	—	—	8.0	pF
Input Capacitance ($V_{BE} = 2.0 \text{ Vdc}$, $I_C = 0$, $f = 100 \text{ kHz}$)	C_{ib}	—	—	30	pF

SWITCHING CHARACTERISTICS

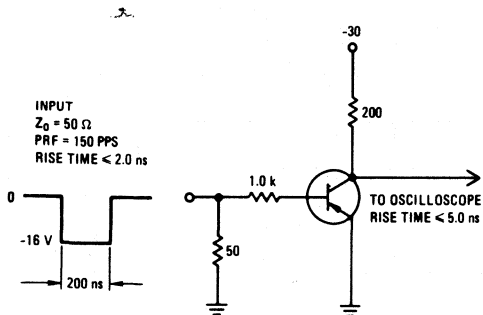
Turn-On Time	$(V_{CC} = 30 \text{ Vdc}$, $I_C = 150 \text{ mAdc}$, $I_{B1} = 15 \text{ mAdc}$) (Figure 15a)	t_{on}	—	26	45	ns
Delay Time		t_d	—	6.0	10	ns
Rise Time		t_r	—	20	40	ns
Turn-Off Time	$(V_{CC} = 6.0 \text{ Vdc}$, $I_C = 150 \text{ mAdc}$, $I_{B1} = I_{B2} = 15 \text{ mAdc}$) (Figure 15b)	t_{off}	—	70	180	ns
Storage Time		t_s	—	50	80	ns
Fall Time		t_f	—	20	150	ns

*Indicates JEDEC Registered Data.

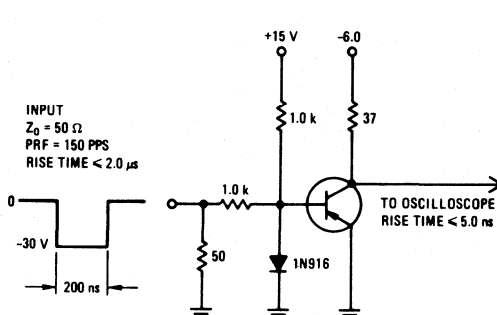
(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

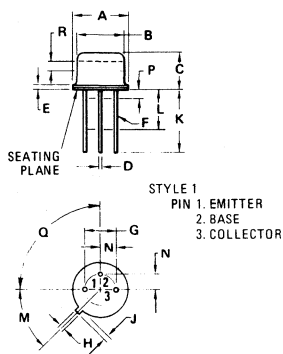
**FIGURE 15a — DELAY AND RISE
TIME TEST CIRCUIT**



**FIGURE 15b — STORAGE AND FALL
TIME TEST CIRCUIT**



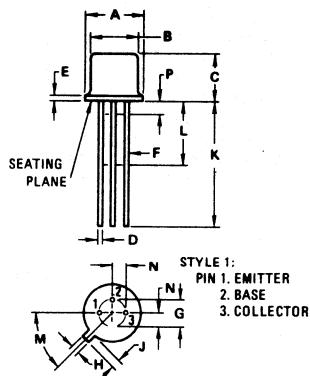
OUTLINE DIMENSIONS



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° NOM	—	45° NOM	—
P	—	1.27	—	0.050
Q	90° NOM	—	90° NOM	—
R	2.54	—	0.100	—

All JEDEC dimensions and notes apply.

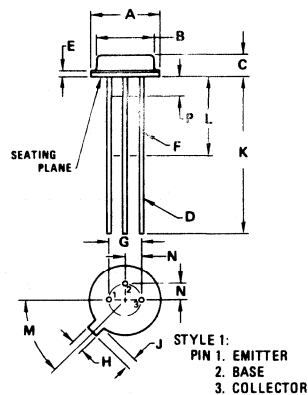
CASE 79-02
TO-39



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	—	0.762	—	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC	—	0.100 BSC	—
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC	—	45° BSC	—
N	1.27 BSC	—	0.050 BSC	—
P	—	1.27	—	0.050

All JEDEC notes and dimensions apply.

CASE 22
TO-18

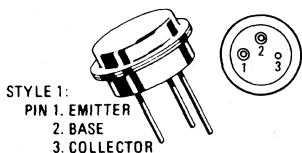


DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	1.65	2.16	0.065	0.085
D	0.406	0.533	0.016	0.021
E	—	1.02	—	0.040
F	0.305	0.483	0.012	0.019
G	2.54 BSC	—	0.100 BSC	—
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC	—	45° BSC	—
N	1.27 BSC	—	0.050 BSC	—
P	—	1.27	—	0.050

All JEDEC dimensions and notes apply.

CASE 26
TO-46

2N2912 (GERMANIUM)



STYLE 1:

PIN 1. EMITTER
2. BASE
3. COLLECTOR

PNP high-speed, high-frequency power transistor especially designed for switching and power converter circuits operating from low-voltage power sources such as solar cells, thermo-electric generators, sea cells, fuel cells and 1.5 volt batteries.

CASE 8

Collector connected to case

MAXIMUM RATINGS

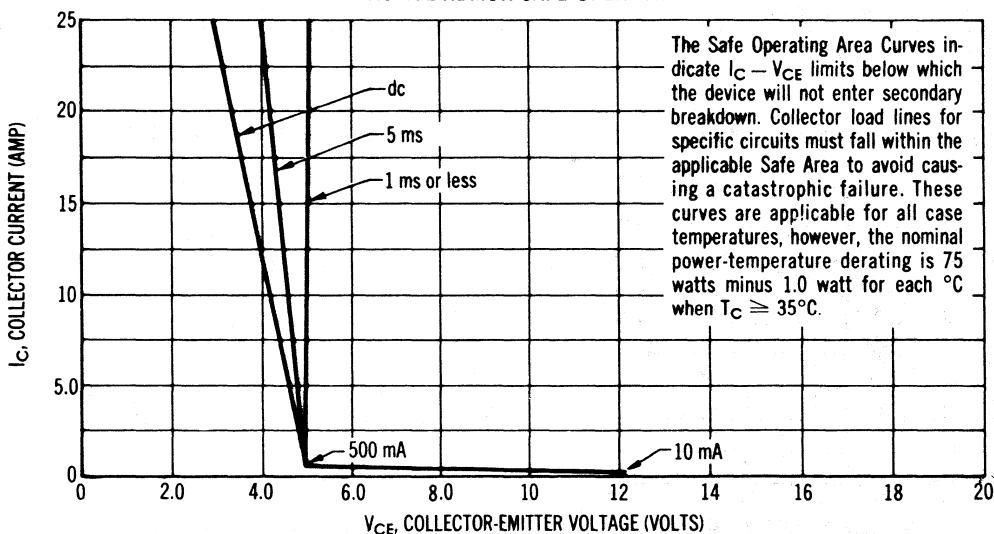
Rating	Symbol	Rating	Unit
Collector-Emitter Voltage	V_{CEO}	5.0	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	1.5	Vdc
Collector Current-Continuous	I_C	25	Adc
Base Current-Continuous	I_B	3.0	Adc
Total Device Dissipation @ $T_C = 35^\circ\text{C}$ Derate above 35°C	P_D	75 1.0	Watts W/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110	$^\circ\text{C}$

Lead temperature 1/16" from case for 10 seconds = 240°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.0	$^\circ\text{C/W}$
Thermal Resistance, Case to Ambient	θ_{CA}	30	$^\circ\text{C/W}$

FIGURE 1 — ACTIVE-REGION SAFE OPERATING AREA



2N2912 (continued)

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* ($I_C = 500\text{ mA dc}$, $I_B = 0$)		BV_{CEO}^*	5.0	—	Vdc
Collector-Emitter Sustaining Voltage* ($I_C = 500\text{ mA dc}$, $I_B = 0$)		$BV_{CEO(sus)}^*$	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 15\text{ Vdc}$, $V_{BE} = 0$)		I_{CES}	—	10	mA dc
Collector Cutoff Current ($V_{CE} = 15\text{ Vdc}$, $R_{BE} = 5.0\text{ ohms}$)		I_{CER}	—	10	mA dc
Collector Cutoff Current ($V_{CE} = 15\text{ Vdc}$, $V_{BE(off)} = 0.2\text{ Vdc}$) ($V_{CE} = 5.0\text{ Vdc}$, $V_{EB(off)} = 0.2\text{ Vdc}$, $T_C = 85^\circ\text{C}$)		I_{CEX}	—	10 15	mA dc
Collector Cutoff Current ($V_{CB} = 15\text{ Vdc}$, $I_E = 0$)		I_{CBO}	—	10	mA dc
Emitter Cutoff Current ($V_{BE} = 1.5\text{ Vdc}$, $I_C = 0$)		I_{EBO}	—	50	mA dc

ON CHARACTERISTICS

DC Current Gain ($I_C = 10\text{ A dc}$, $V_{CE} = 2.0\text{ Vdc}$) ($I_C = 5.0\text{ A dc}$, $V_{CE} = 2.0\text{ Vdc}$)	2	h_{FE}	150 200	— 800	—
Collector-Emitter Saturation Voltage ($I_C = 5.0\text{ A dc}$, $I_B = 0.5\text{ A dc}$) ($I_C = 25\text{ A dc}$, $I_B = 2.5\text{ A dc}$)	2	$V_{CE(sat)}$	— —	0.12 0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 5.0\text{ A dc}$, $I_B = 0.5\text{ A dc}$) ($I_C = 25\text{ A dc}$, $I_B = 2.5\text{ A dc}$)		$V_{BE(sat)}$	— —	0.5 1.2	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 5.0\text{ A dc}$, $V_{CE} = 2.0\text{ Vdc}$, $f = 1.0\text{ MHz}$)		f_T	10	—	MHz
Rise Time ($V_{CC} = 10\text{ Vdc}$, $I_C = 5.0\text{ A dc}$)	3	t_r	—	2.0	μs
Storage Time ($V_{CC} = 10\text{ Vdc}$, $I_C = 5.0\text{ A dc}$)	3	t_s	—	10	μs
Fall Time ($V_{CC} = 10\text{ Vdc}$, $I_C = 5.0\text{ A dc}$)	3	t_f	—	2.0	μs

*Sweep Test: 1/2 Cycle sine wave, 60 Hz

FIGURE 2 — TYPICAL COLLECTOR CHARACTERISTICS

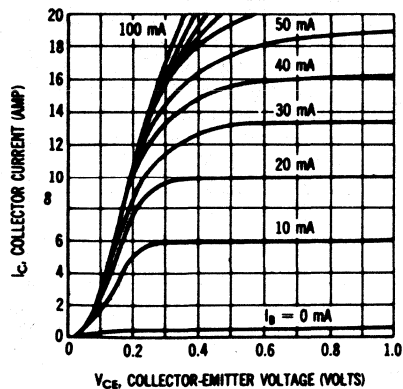
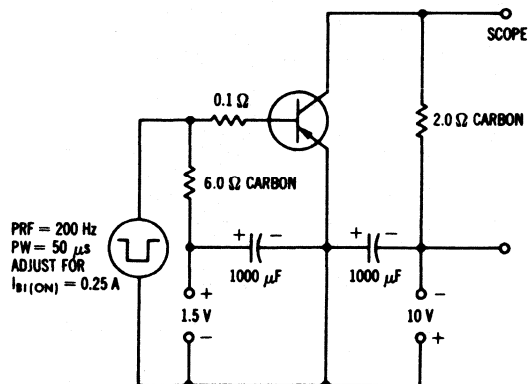


FIGURE 3 — SWITCHING-TIME TEST CIRCUIT



2N2913 thru 2N2920 (SILICON)

2N2919 JAN, JTX, JTXV Available

2N2920 JAN, JTX, JTXV Available

MULTIPLE SILICON ANNULAR TRANSISTORS

... designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Excellent Temperature Tracking – Dual Devices
– 2N2917, 2N2918
 $\Delta|V_{BE1} - V_{BE2}| = 1.6 \text{ mVdc (Max) @ } -55 \text{ to } +25^{\circ}\text{C}$
 $= 2.0 \text{ mVdc (Max) @ } +25 \text{ to } +125^{\circ}\text{C}$
- Low Collector-Emitter Saturation Voltage –
 $V_{CE(sat)} = 0.35 \text{ Vdc (Max) @ } I_C = 1.0 \text{ mAdc}$
- DC Current Gain Specified – $10 \mu\text{Adc to } 1.0 \text{ mAdc}$
- High Current-Gain – Bandwidth Product –
 $f_T = 60 \text{ MHz @ } I_C = 500 \mu\text{Adc}$

NPN SILICON MULTIPLE TRANSISTORS

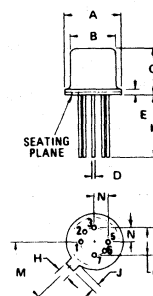


* MAXIMUM RATINGS

Rating	Symbol	2N2913 thru 2N2918	2N2919 2N2920	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	Vdc
Collector-Base Voltage	V_{CB}	45	60	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current – Continuous	I_C	30		mAdc
		One Die	Both Die	
Total Power Dissipation @ $T_A = 25^{\circ}\text{C}$ Derate above 25°C	P_D	300	600	mW
		1.7	3.4	mW/ $^{\circ}\text{C}$
Total Power Dissipation @ $T_C = 25^{\circ}\text{C}$ Derate above 25°C	P_D	750	1500	mW
		4.3	8.6	mW/ $^{\circ}\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^{\circ}\text{C}$

*Indicates JEDEC Registered Data

STYLE 1:
PIN 1. COLLECTOR 5. EMITTER
2. BASE 6. BASE
3. EMITTER 7. COLLECTOR
4. OMITTED 8. OMITTED



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70		0.500	
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

2N2913 thru 2N2920 (continued)

ELECTRICAL CHARACTERISTICS (each side) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage ($I_C = 10\text{ mAdc}$, $I_B = 0$)	$V_{CE(sus)}$	45 60		-	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $I_E = 0$)	V_{CBO}	45 60		-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{Adc}$, $I_C = 0$)	V_{EBO}	6.0		-	Vdc
Collector Cutoff Current ($V_{CE} = 5.0\text{ Vdc}$, $I_B = 0$)	I_{CEO}	-	-	0.002	μAdc
Collector Cutoff Current ($V_{CB} = 45\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 45\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	- - -	- - -	0.010 0.002 10	μAdc
Emitter Cutoff Current ($V_{EB} = 5.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	-	-	0.002	μAdc

ON CHARACTERISTICS

DC Current Gain (1) ($I_C = 10\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 10\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$, $T_A = -55^\circ\text{C}$) ($I_C = 100\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$)	2N2913, 15, 17, 19, 2N2914, 16, 18, 20 2N2913, 15, 17, 19, 2N2914, 16, 18, 20 2N2913, 15, 17, 19, 2N2914, 16, 18, 20 2N2913, 15, 17, 19, 2N2914, 16, 18, 20	h_{FE}	60 150 15 30 100 225 150 300	- - - - - - - -	240 600 - - - - - -	-
Collector-Emitter Saturation Voltage ($I_C = 1.0\text{ mAdc}$, $I_B = 0.1\text{ mAdc}$)		$V_{CE(sat)}$	-	-	0.35	Vdc
Base-Emitter On Voltage ($I_C = 100\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$)		$V_{BE(on)}$	-	-	0.7	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 500\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 20\text{ MHz}$)		f_T	60	-	-	MHz
Output Capacitance ($V_{CB} = 5.0\text{ Vdc}$, $I_E = 0$, $f = 140\text{ kHz}$)		C_{ob}	-	4.0	6.0	pF
Input Impedance ($I_C = 1.0\text{ mAdc}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)		h_{ib}	25	28	32	ohms
Output Admittance ($I_C = 1.0\text{ mAdc}$, $V_{CB} = 5.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)		h_{ob}	-	-	1.0	μmhos
Noise Figure ($I_C = 10\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$, $R_S = 10\text{ k ohms}$, $f = 1.0\text{ kHz}$, $BW = 200\text{ Hz}$) ($I_C = 10\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$, $R_S = 10\text{ k ohms}$, $f = 10\text{ Hz to }15.7\text{ kHz}$, $BW = 10\text{ kHz}$)	2N2914, 16, 18, 20, 2N2913, 15, 17, 19 2N2914, 16, 18, 20, 2N2913, 15, 17, 19	NF	- - -	2.0 3.0 2.0 3.0	3.0 4.0 3.0 4.0	dB
DC Current Gain Ratio (2) ($I_C = 100\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$)	2N2917, 18, 2N2915, 16, 19, 20	h_{FE1}/h_{FE2}	0.8 0.9	- -	1.0 1.0	-
Base-Emitter Voltage Differential ($I_C = 10\text{ }\mu\text{Adc}$ to 1.0 mAdc , $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 100\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$)	2N2917, 18, 2N2915, 16, 19, 20 2N2917, 18, 2N2915, 16, 19, 20	$ V_{BE1} - V_{BE2} $	- - -	- - -	10 5.0 5.0 3.0	mVdc
Base-Emitter Voltage Differential Change Due to Temperature ($I_C = 100\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$, $T_A = -55^\circ\text{C}$ to $+25^\circ\text{C}$) ($I_C = 100\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$, $T_A = +25^\circ\text{C}$ to $+125^\circ\text{C}$)	2N2917, 18, 2N2915, 16, 19, 20 2N2917, 18, 2N2915, 16, 19, 20	$\Delta(V_{BE1} - V_{BE2})$	- - -	- - -	1.6 0.8 2.0 1.0	mVdc

* Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$. Duty Cycle $\leq 2.0\%$.

(2) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

2N2944(SILICON)

thru

2N2946

PNP SILICON ANNULAR TRANSISTORS

... designed for low-level, high-speed chopper applications.

- Low Offset Voltage — $V_{EC(ofs)} = 0.18 \text{ mVdc (Typ)}$
@ $I_B = 200 \mu\text{Adc}$
- High Emitter-Base Voltage — $V_{EB} = 40 \text{ Vdc (2N2946)}$
- Low Dynamic "On" Series Resistance
 $r_{ec(on)} = 4.0 \text{ Ohms (Typ) @ } I_B = 1.0 \text{ mAdc (2N2944)}$

PNP SILICON CHOPPER TRANSISTORS



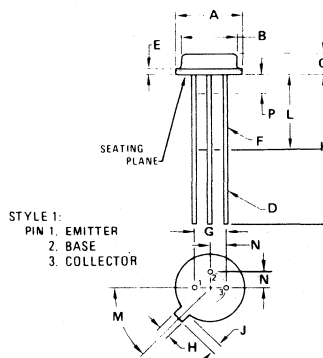
MAXIMUM RATINGS

Rating	Symbol	2N2944	2N2945	2N2946	Unit
*Emitter-Collector Voltage	V_{CEO}	10	20	35	Vdc
*Collector-Base Voltage	V_{CB}	15	25	40	Vdc
*Emitter-Base Voltage	V_{EB}	15	25	40	Vdc
*Collector Current	I_C	100			mAdc
*Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	400			mW
		2.3			mW/ $^\circ\text{C}$
*Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	2.0			Watts
		11.43			mW/ $^\circ\text{C}$
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	435	$^\circ\text{C/W}$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	87.5	$^\circ\text{C/W}$

*Indicates JEDEC Registered Data.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	1.65	2.16	0.065	0.085
D	0.406	0.533	0.016	0.021
E	—	1.02	—	0.040
F	0.305	0.483	0.012	0.019
G	2.54 BSC	—	0.100 BSC	—
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC	—	45° BSC	—
N	1.27 BSC	—	0.050 BSC	—
P	—	1.27	—	0.050

All JEDEC dimensions and notes apply

CASE 26-03
TO-46

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
*OFF CHARACTERISTICS					
Collector Cutoff Current ($V_{CB} = 15\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 25\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 40\text{ Vdc}$, $I_E = 0$)	I_{CBO}	— — —	— — —	0.1 0.2 0.5	nAdc
Emitter Cutoff Current ($V_{EB} = 15\text{ Vdc}$, $I_C = 0$) ($V_{EB} = 25\text{ Vdc}$, $I_C = 0$) ($V_{EB} = 40\text{ Vdc}$, $I_C = 0$)	I_{EBO}	— — —	— — —	0.1 0.2 0.5	nAdc
ON CHARACTERISTICS					
*DC Current Gain ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 0.5\text{ Vdc}$)	h_{FE}	80 40 30	180 160 130	— — —	—
DC Current Gain (inverted connection) ($I_E = 200\text{ }\mu\text{Adc}$, $V_{EC} = 0.5\text{ Vdc}$)	$h_{FE}(\text{inv})$	6.0 4.0 3.0	20 17 15	— — —	—
Emitter-Collector Offset Voltage ($I_B = 200\text{ }\mu\text{Adc}$, $I_E = 0$) ($I_B = 1.0\text{ mAdc}$, $I_E = 0$)* ($I_B = 2.0\text{ mAdc}$, $I_E = 0$)	$V_{EC}(\text{ofs})$	— — — — — — —	0.18 0.23 0.27 0.4 0.5 0.6 0.8	0.3 0.5 0.8 0.6 1.0 2.0 1.0	mVdc
				1.6 2.5	
*DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 6.0\text{ Vdc}$, $f = 1.0\text{ MHz}$)	f_T	10 5.0 3.0	15 13 12	— — —	MHz
Output Capacitance ($V_{CB} = 6.0\text{ Vdc}$, $I_E = 0$, $f = 500\text{ kHz}$)	C_{ob}	—	3.2	10	pF
Input Capacitance ($V_{EB} = 6.0\text{ Vdc}$, $I_C = 0$, $f = 500\text{ kHz}$)	C_{ib}	—	1.9	6.0	pF
Dynamic "On" Series Resistance ($I_B = 1.0\text{ mAdc}$, $I_E = 0$, $I_C = 100\text{ }\mu\text{Arms}$, $f = 1.0\text{ kHz}$)	$r_{ec}(\text{on})$	— — —	4.0 4.5 5.0	20 35 45	Ohms

*Indicates JEDEC Registered Data.

2N2945A (SILICON)

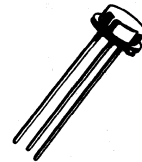
2N2946A

PNP SILICON ANNULAR TRANSISTORS

... designed for low level, high-speed chopper applications.

- Low Offset Voltage — $V_{EC(ofs)} = 0.23 \text{ mVdc (Typ)}$
@ $I_B = 200 \mu\text{Adc (2N2945A)}$
- High Emitter-Base Voltage — $V_{EB} = 40 \text{ Vdc (2N2946A)}$
- Low Dynamic "On" Series Resistance —
 $r_{ec(on)} = 5.0 \text{ Ohms (Typ) @ } I_B = 1.0 \text{ mAdc (2N2945A)}$

PNP SILICON CHOPPER TRANSISTORS



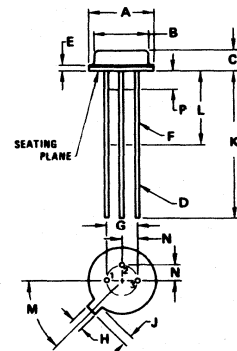
MAXIMUM RATINGS

Rating	Symbol	2N2945A	2N2946A	Unit
*Emitter-Collector Voltage	V_{ECO}	20	35	Vdc
*Collector-Base Voltage	V_{CB}	25	40	Vdc
*Emitter-Base Voltage	V_{EB}	25	40	Vdc
*Collector Current	I_C	100		mAdc
*Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	400 2.3		mW mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	2.0 11.43		Watts mW/ $^\circ\text{C}$
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$
*Lead Temperature 1/16" from Case fo 10 seconds	T_L	240		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	435	$^\circ\text{C/W}$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	87.5	$^\circ\text{C/W}$

*Indicates JEDEC Registered Data.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	1.85	2.16	0.065	0.085
D	0.406	0.533	0.016	0.021
E	—	1.02	—	0.040
F	0.305	0.463	0.012	0.019
G	2.54 BSC	—	0.100 BSC	—
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC	—	45° BSC	—
N	1.27 BSC	—	0.050 BSC	—
P	—	1.27	—	0.050

All JEDEC dimensions and notes apply

CASE 26-03
TO-46

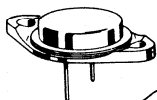
ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Emitter-Collector Breakdown Voltage ($I_E = 10\ \mu\text{A}$, $I_B = 0$)	BV_{ECO}	20 35	— —	— —	Vdc
*Collector Cutoff Current ($V_{CB} = 25\ \text{Vdc}$, $I_E = 0$)	I_{CBO}	—	—	0.2	nAdc
($V_{CB} = 40\ \text{Vdc}$, $I_E = 0$)		—	—	0.5	
($V_{CB} = 25\ \text{Vdc}$, $I_E = 0$, $T_A = 100^\circ\text{C}$)		—	—	20	
($V_{CB} = 40\ \text{Vdc}$, $I_E = 0$, $T_A = 100^\circ\text{C}$)		—	—	25	
*Emitter Cutoff Current ($V_{EB} = 25\ \text{Vdc}$, $I_C = 0$)	I_{EBO}	—	—	0.2	nAdc
($V_{EB} = 40\ \text{Vdc}$, $I_C = 0$)		—	—	0.5	
($V_{EB} = 25\ \text{Vdc}$, $I_C = 0$, $T_A = 100^\circ\text{C}$)		—	—	15	
($V_{EB} = 40\ \text{Vdc}$, $I_C = 0$, $T_A = 100^\circ\text{C}$)		—	—	20	
*ON CHARACTERISTICS					
DC Current Gain ($I_C = 1.0\ \text{mA}$, $V_{CE} = 0.5\ \text{Vdc}$)	h_{FE}	70 50	200 200	— —	—
DC Current Gain (Inverted Connection) ($I_B = 200\ \mu\text{A}$, $V_{EC} = 0.5\ \text{Vdc}$)	$h_{FE(inv)}$	30 20	32 25	— —	—
Emitter-Collector Offset Voltage ($I_B = 200\ \mu\text{A}$, $I_E = 0$)	$V_{EC(ofs)}$	— —	0.23 0.27	0.5 0.8	mVdc
($I_B = 1.0\ \text{mA}$, $I_E = 0$)		—	0.5	1.0	
($I_B = 2.0\ \text{mA}$, $I_E = 0$)		—	0.6	2.0	
		—	0.9	1.6	
		—	1.0	2.5	
*DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product ($I_C = 1.0\ \text{mA}$, $V_{CE} = 6.0\ \text{Vdc}$, $f = 1.0\ \text{MHz}$)	f_T	10 5.0	15 8.0	— —	MHz
Output Capacitance ($V_{CB} = 6.0\ \text{Vdc}$, $I_E = 0$, $f = 0.1\ \text{MHz}$ to $1.0\ \text{MHz}$)	C_{ob}	—	3.2	10	pF
Input Capacitance ($V_{EB} = 6.0\ \text{Vdc}$, $I_C = 0$, $f = 0.1\ \text{MHz}$ to $1.0\ \text{MHz}$)	C_{ib}	—	1.9	6.0	pF
Dynamic "On" Series Resistance ($I_B = 1.0\ \text{mA}$, $I_E = 0$, $I_E = 100\ \mu\text{A}$, $f = 1.0\ \text{kHz}$)	$r_{ec(on)}$	— —	5.0 7.0	6.0 8.0	Ohms

*Indicates JEDEC Registered Data.

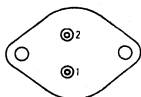
2N2947(SILICON)

2N2948



NPN silicon annular transistors for power amplifier applications to 100 MHz.

CASE 1
(TO-3)



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE - COLLECTOR

Collector connected to case

MAXIMUM RATINGS*

Rating	Symbol	2N2947	2N2948	Unit
Collector-Base Voltage	V_{CB}	60	40	Vdc
Collector-Emitter Voltage	V_{CES}	60	40	Vdc
Emitter - Base Voltage	V_{EB}	3.0	2.0	Vdc
Collector-Current (continuous)	I_C	1.5		Adc
Base-Current (continuous)	I_B	500		mAdc
Power Input (Nominal)	P_{in}	5.0		Watts
Power Output (Nominal)	P_{out}	20.0		Watts
Total Device Dissipation @ 25°C Case Temperature	P_D	25.0		Watts
Derating Factor above 25°C		167		mW/°C
Junction Temperature	T_J	175		°C
Storage Temperature Range	T_{stg}	-65 to + 175		°C

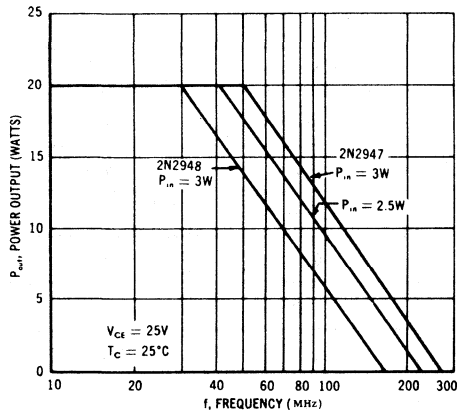
*The maximum ratings as given for dc conditions can be exceeded on a pulse basis. See electrical characteristics.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

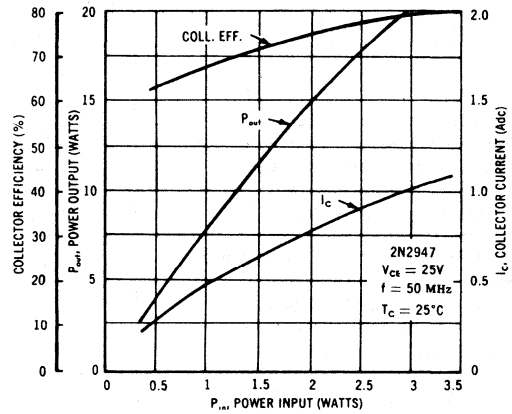
Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Collector-Emitter Sustain Voltage	$V_{CES}^{(1)}$	2N2947: $I_C = 0.250\text{ A}$, $R_{BE} = 0$ 2N2948: $I_C = 0.250\text{ A}$, $R_{BE} = 0$	90 80	120 100	-- --	Volts
Collector-Emitter-Open Base Sustain Voltage	$V_{CEO(sus)}^{(1)}$	2N2947: $I_C = 0.250\text{ A}$, $I_B = 0$ 2N2948: $I_C = 0.250\text{ A}$, $I_B = 0$	40 20	-- --	-- --	Volts
Collector-Emitter Current	I_{CES}	2N2947: $V_{CE} = 60\text{ Vdc}$, $V_{BE} = 0$ $V_{CE} = 50\text{ Vdc}$, $V_{BE} = 0$, $T_C = 175^\circ\text{C}$ 2N2948: $V_{CE} = 40\text{ Vdc}$, $V_{BE} = 0$ $V_{CE} = 30\text{ Vdc}$, $V_{BE} = 0$, $T_C = 175^\circ\text{C}$	-- -- -- --	-- -- -- --	0.5 1.0 0.5 1.0	mAdc
Collector Cutoff Current	I_{CBO}	2N2947: $V_{CB} = 50\text{ Vdc}$, $I_E = 0$ 2N2948: $V_{CB} = 30\text{ Vdc}$, $I_E = 0$	-- --	-- --	1.0 1.0	μAdc
Emitter Cutoff Current	I_{EBO}	2N2947: $V_{EB} = 3\text{ Vdc}$, $I_C = 0$ 2N2948: $V_{EB} = 2\text{ Vdc}$, $I_C = 0$	-- --	-- --	100 100	μAdc
DC Current Gain	h_{FE}	2N2947: $I_C = 400\text{ mAdc}$, $V_{CE} = 2\text{ Vdc}$ 2N2948: $I_C = 400\text{ mAdc}$, $V_{CE} = 2\text{ Vdc}$ Both Types: $I_C = 1\text{ Adc}$, $V_{CE} = 2\text{ Vdc}$	6.0 2.5 2.5	-- -- --	60 100 --	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C = 1.0\text{ Adc}$, $I_B = 500\text{ mAdc}$	--	--	0.5	Vdc
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	$I_C = 1.0\text{ Adc}$, $I_B = 500\text{ mAdc}$	--	--	2.0	Vdc
AC Current Gain	$ h_{fe} $	$V_{CE} = 2.0\text{ Vdc}$, $I_C = 400\text{ mAdc}$, $f = 50\text{ MHz}$	2.0	--	--	
Collector Output Capacitance	C_{ob}	$V_{CB} = 25\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$	--	--	60	pF
Power Input	P_{in}	$P_{out} = 15\text{ W}$, $f = 50\text{ MHz}$, $V_{CE} = 25\text{ Vdc}$	--	2.0	3.0	Watts
Efficiency	η	$I_{C(max)} = 1\text{ A}$ 2N2947	60	80	--	%
Power Input	P_{in}	$P_{out} = 15\text{ W}$, $f = 30\text{ MHz}$, $V_{CE} = 25\text{ Vdc}$	--	2.0	3.0	Watts
Efficiency	η	$I_{C(max)} = 1.0\text{ A}$ 2N2948	60	70	--	%

(1) Pulse Measurement: Pulse Width $\leq 100\text{ }\mu\text{s}$, Duty Cycle = 2.0%.

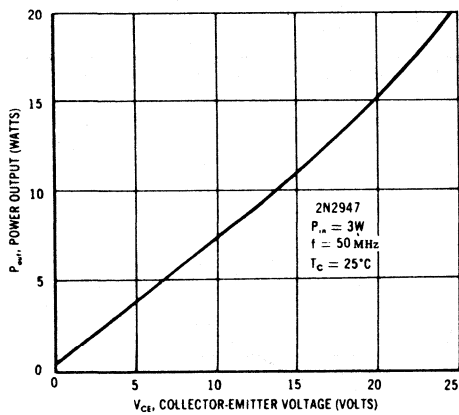
POWER OUTPUT versus FREQUENCY



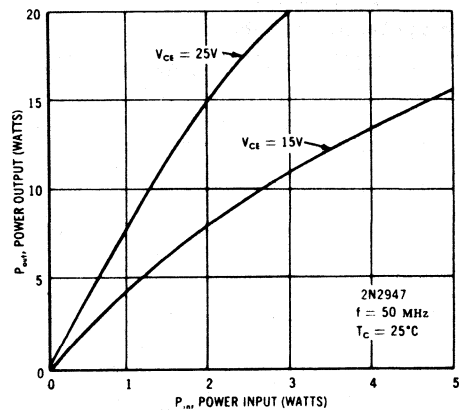
OUTPUT CHARACTERISTICS versus POWER INPUT

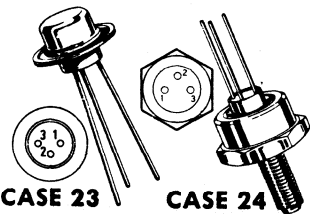


POWER OUTPUT versus COLLECTOR VOLTAGE



POWER OUTPUT versus POWER INPUT



2N2949 (SILICON)**2N2950****CASE 23**
(TO-18)**CASE 24**
(TO-18)

2N2949

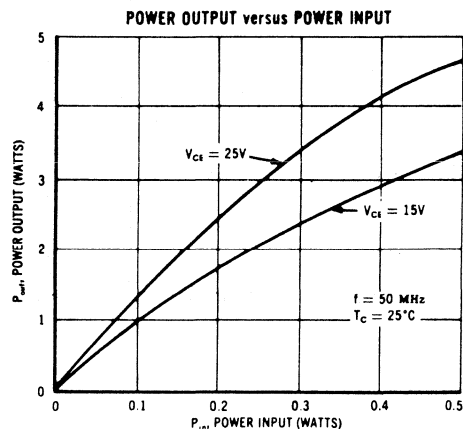
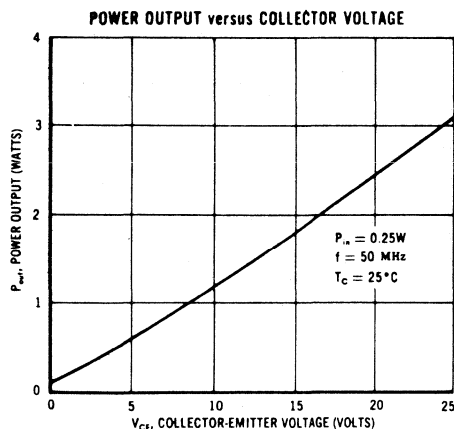
2N2950

NPN silicon annular transistors for power amplifier and driver applications to 100 MHz.

Collector connected to case;
stud isolated from casePIN 1. EMITTER
2. BASE
3. COLLECTOR**MAXIMUM RATINGS***

Rating	Symbol	Value		Unit
Collector-Base Voltage	V _{CB}	60		Vdc
Collector-Emitter Voltage	V _{CES}	60		Vdc
Emitter - Base Voltage	V _{EB}	3.0		Vdc
Collector Current (Continuous)	I _C	0.7		Adc
Base Current (Continuous)	I _B	100		mAdc
RF Input Power (Nom)	P _{in}	1.0		Watt
RF Output Power (Nom)	P _{out}	5.0		Watts
Total Device Dissipation (25°C Case temperature) (Derating Factor above 25°C)	P _D	6.0 40		Watts mW/°C
Total Device Dissipation at 25° Ambient (Derating Factor above 25°C)	P _D	2N2949	2N2950	Watt mW/°C
		0.5	0.7	
		3.33	4.67	
Junction Temperature	T _J	175		°C
Storage Temperature Range	T _{stg}	-65 to +175		°C

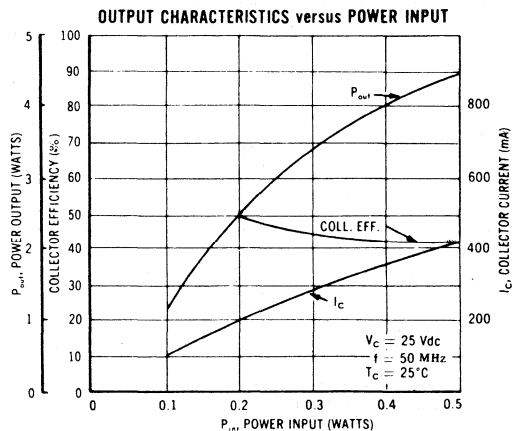
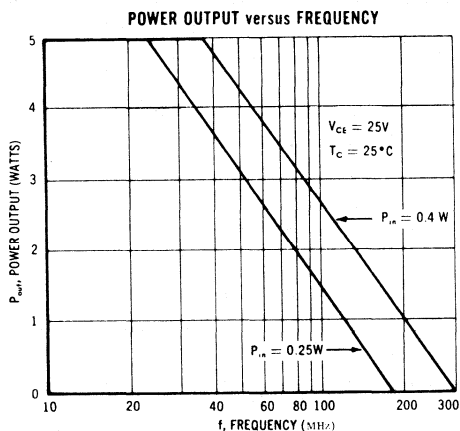
* The maximum ratings as given for dc conditions can be exceeded on a pulse basis. See Electrical Characteristics.



ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

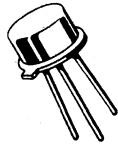
Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Collector-Emitter Sustain Voltage	$V_{CES(sus)}^{(1)}$	$I_C = 0.250\text{ A}$, $R_{BE} = 0$	85	120	--	Volts
Collector Emitter-Open Base Sustain Voltage	$V_{CEO(sus)}^{(1)}$	$I_C = 0.250\text{ A}$, $I_B = 0$	40	--	--	Volts
Collector-Emitter Current	I_{CES}	$V_{CE} = 60\text{ Vdc}$, $V_{BE} = 0$ $V_{CE} = 50\text{ Vdc}$, $V_{BE} = 0$ $T_C = +175^\circ\text{C}$	--	--	100 500	μAdc
Collector - Cutoff Current	I_{CBO}	$V_{CB} = 50\text{ Vdc}$, $I_E = 0$	--	--	0.1	μAdc
Emitter-Cutoff Current	I_{EBO}	$V_{EB} = 3\text{ Vdc}$, $I_C = 0$	--	--	100	μAdc
DC Current Gain	h_{FE}	$V_{CE} = 2.0\text{ Vdc}$ $I_C = 40\text{ mAdc}$ $V_{CE} = 2.0\text{ Vdc}$ $I_C = 400\text{ mAdc}$	5.0 5.0	--	100 --	--
Collector - Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C = 400\text{ mAdc}$, $I_B = 80\text{ mAdc}$	--	--	0.5	Vdc
Emitter-Base Saturation Voltage	$V_{BE(sat)}$	$I_C = 400\text{ mAdc}$, $I_B = 80\text{ mAdc}$	--	--	2.0	Vdc
AC Current Gain	$ h_{fe} $	$V_{CE} = 2.0\text{ Vdc}$ $I_C = 40\text{ mAdc}$, $f = 50\text{ MHz}$	2.0	--	--	--
Collector Output Capacitance	C_{ob}	$V_{CB} = 25\text{ Vdc}$, $I_E = 0$ $f = 100\text{ kHz}$	--	--	20	pF
Power Input	P_{in}	$P_{out} = 3.5\text{ watts}$, $f = 50\text{ MHz}$	--	--	0.35	Watt
Efficiency	η	$V_{CE} = 25\text{ Vdc}$, $I_{C(max)} = 325\text{ mA}$	43	--	--	%

⁽¹⁾ Pulse Width $\leq 100\text{ }\mu\text{s}$, Duty Cycle = 2%



2N2951S (SILICON)

2N2952



CASE 79
(TO-39)

2N2951

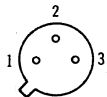


CASE 22
(TO-18)

2N2952

Collector connected to case

NPN silicon annular Star transistors for power amplifier applications to 100 MHz.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS⁽¹⁾

Rating	Symbol	Value		Units
Collector-Base Voltage	V_{CB}	60		Vdc
Collector-Emitter Voltage	V_{CES}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current (continuous)	I_C	250		mAdc
Base Current (continuous)	I_B	50		mAdc
Total Device Dissipation (25°C Case Temperature) (Derate above 25°C)	P_D	2N2951	2N2952	Watts mW/°C
		3.0 20	1.8 12	
Total Device Dissipation (25°C Ambient Temperature) (Derate above 25°C)	P_D	0.8 5.33	0.5 3.33	mW/°C
Junction Temperature	T_J	-65 to 175		°C
Storage Temperature Range	T_{stg}	-65 to 175		°C

(1) The maximum ratings as given for dc conditions can be exceeded on a pulse basis.
See Electrical Characteristics.

* Indicates JEDEC Registered Data

2N2951S, 2N2952 (Continued)
***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Conditions	Min	Max	Unit
Collector-Emitter Current	I_{CES}	$V_{CE} = 60\text{Vdc}, V_{BE} = 0$	--	100	μAdc
		$V_{CE} = 50\text{Vdc}, V_{BE} = 0, T_C = 175^\circ\text{C}$	--	500	μAdc
Collector Cutoff Current	I_{CBO}	$V_{CB} = 50\text{Vdc}, I_E = 0$	--	0.1	μAdc
Emitter Cutoff Current	I_{EBO}	$V_{EB} = 5\text{Vdc}, I_C = 0$	--	100	μAdc
DC Current Gain	h_{FE}	$I_C = 10\text{mAdc}, V_{CE} = 10\text{Vdc}$	20	150	--
		$I_C = 150\text{mAdc}, V_{CE} = 10\text{Vdc}^*$	20	--	--
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C = 150\text{mAdc}, I_B = 15\text{mAdc}$	--	0.5	Vdc
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	$I_C = 150\text{mAdc}, I_B = 15\text{mAdc}$	--	2.0	Vdc
Collector-Emitter Sustain Voltage ⁽¹⁾	$V_{CES(sus)}$	$I_C = 100\text{mA}, R_{BE} = 0$	30	--	Volts
Collector-Emitter Open Base ⁽¹⁾ Sustain Voltage	$V_{CEO(sus)}$	$I_C = 100\text{mA}, I_B = 0$	20	--	Volts
AC Current Gain	$ h_{fe} $	$V_{CE} = 10\text{Vdc}, I_C = 10\text{mAdc}$ $f = 50\text{MHz}$	4.0	--	--
Collector Output Capacitance	C_{ob}	$V_{CB} = 10\text{Vdc}, I_E = 0, f = 100\text{kHz}$	--	8.0	pF
Power Input	P_{in}	Test Circuit Fig. 1 $P_{out} = 600\text{mW}$ $f = 50\text{MHz}$ $V_{CE} = 13.6\text{Vdc}$ $I_{C(max)} = 125\text{mA}$	--	100	mW
Efficiency	η		35	--	%

⁽¹⁾Pulse Width = 100 μs , Duty Cycle = 2%

*Indicates JEDEC Registered Data

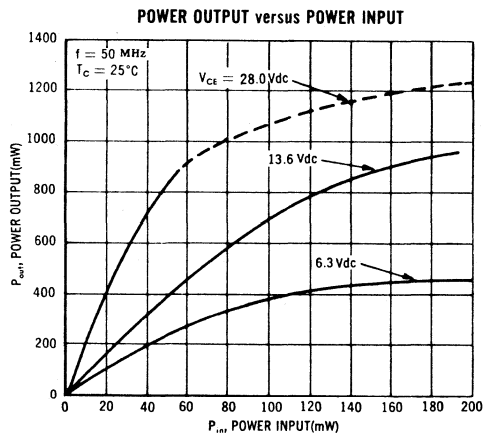
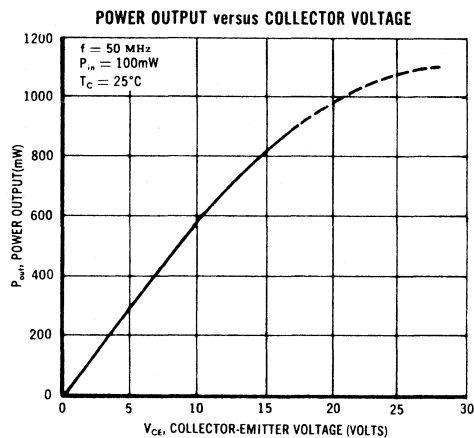
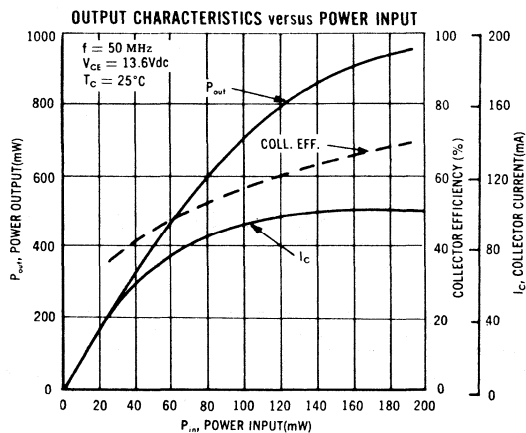
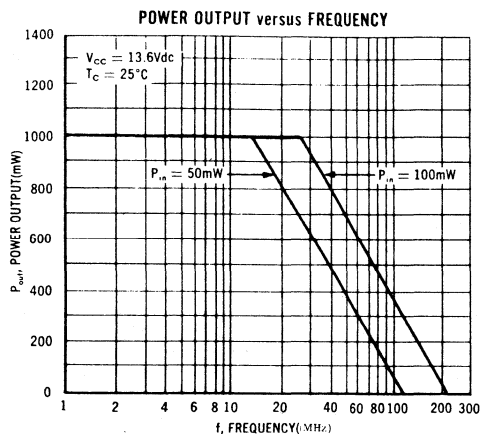
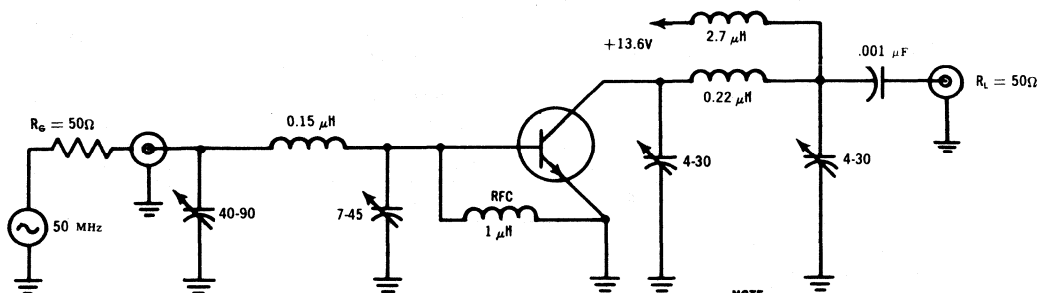


FIGURE 1 — POWER OUTPUT AND POWER GAIN CIRCUIT



NOTE:
GROUND POINT must be kept as close as possible to the transistor emitter lead.
Transistor must be mounted with heat sink.

2N2955 (Ge Mesa)

2N2956



CASE 22-03
(TO-18)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

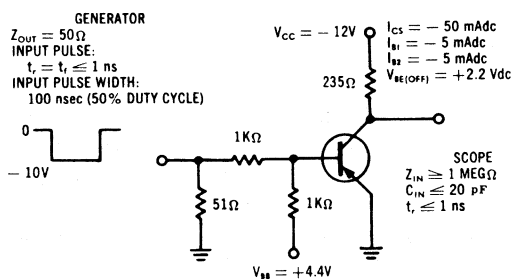
PNP germanium mesa transistors for high-speed switching applications.

* MAXIMUM RATINGS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector-Emitter Voltage	V_{CEO}	25 20 18	Vdc
Collector Current - Continuous	I_C	100	mAdc
Junction Temperature	T_J	100	$^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +100	$^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	300 4.0	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	150 2.0	mW mW/ $^\circ\text{C}$

*Indicates JEDEC Registered Data

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



2N2955, 2N2956 (Continued)

* ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{A}$, $I_E = 0$)	BV_{CBO}	40	---	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{A}$, $I_C = 0$)	BV_{EBO}	3.5	---	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10 \text{ mA}$)	BV_{CEO}	25 20	---	Vdc
Collector-Emitter Reverse Current ($V_{CE} = 25 \text{ Vdc}$, $V_{EB} = 0.5 \text{ Vdc}$)	I_{CEX}	---	10	μA
Base Leakage Current ($V_{CE} = 25 \text{ Vdc}$, $V_{EB} = 0.5 \text{ Vdc}$)	I_{BL}	---	10	μA

On Characteristics

Forward Current Transfer Ratio ($I_C = 10 \text{ mA}$, $V_{CE} = 1 \text{ Vdc}$)	2N2955 2N2956	h_{FE}	20 30	---	---
($I_C = 50 \text{ mA}$, $V_{CE} = 1 \text{ Vdc}$)	2N2955 2N2956		20 40	60 120	
($I_C = 100 \text{ mA}$, $V_{CE} = 1 \text{ Vdc}$)	2N2956		30	---	
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mA}$, $I_B = 1 \text{ mA}$)	2N2955 2N2956	$V_{CE(sat)}$	---	0.20 0.18	Vdc
($I_C = 50 \text{ mA}$, $I_B = 5 \text{ mA}$)	2N2955 2N2956		---	0.30 0.25	
($I_C = 100 \text{ mA}$, $I_B = 10 \text{ mA}$)	2N2956		---	0.34	
Base-Emitter Voltage ($I_C = 10 \text{ mA}$, $I_B = 1 \text{ mA}$)	2N2955 2N2956	V_{BE}	---	0.50 0.47	Vdc
($I_C = 50 \text{ mA}$, $I_B = 5 \text{ mA}$)	2N2955 2N2956		---	0.65 0.60	
($I_C = 100 \text{ mA}$, $I_B = 10 \text{ mA}$)	2N2956		---	0.70	

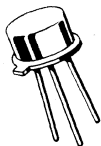
Transient Characteristics

Output Capacitance ($V_{CB} = 5 \text{ Vdc}$, $I_E = 0$, $f = 1 \text{ MHz}$)		C_{ob}	---	4.0	pF
Small Signal Forward Current Transfer Ratio ($V_{CE} = 5 \text{ Vdc}$, $I_C = 10 \text{ mA}$, $f = 100 \text{ MHz}$)	2N2955 2N2956	h_{fe}	2.0 2.5	---	---
Delay Time ($V_{CC} = 12 \text{ Vdc}$, $I_{CS} = 50 \text{ mA}$, $I_{B1} = 5 \text{ mA}$, $V_{BE}(\text{Off}) = 2.2 \text{ Vdc}$)		t_d	---	15	ns
Rise Time (same conditions as t_d)	2N2955 2N2956	t_r	---	40 30	ns
Storage Time ($V_{CC} = 12 \text{ Vdc}$, $I_{CS} = 50 \text{ mA}$, $I_{B1} = 5 \text{ mA}$, $I_{B2} = 5 \text{ mA}$)	2N2955 2N2956	t_s	---	40 55	ns
Fall Time (same conditions as t_g)	2N2955 2N2956	t_f	---	40 35	ns

*Indicates JEDEC Registered Data

2N2959S(SILICON)

2N3116

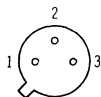


CASE 79
(TO-39)



CASE 22
(TO-18)

NPN silicon annular transistors for high-speed switching and amplifier applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

2N2959

2N3116

Collector connected to case

*MAXIMUM RATINGS

Rating	Symbol	2N2959	2N3116	Unit
Collector-Base Voltage	V_{CB}	60	60	Vdc
Collector-Emitter Voltage	V_{CEO}	20	20	Vdc
Emitter-Base Voltage	V_{EB}	5.0	5.0	Vdc
Collector-Current	I_C	600	600	mAdc
Total Device Dissipation 25°C Case Temperature Derate above 25°C	P_D	3.0 20	1.8 12	Watts mW/°C
Total Device Dissipation 25°C Ambient Temperature Derate above 25°C	P_D	0.6 4.00	0.4 2.67	Watts mW/°C
Junction Temperature Range	T_J	-65 to +175		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

* Indicates JEDEC Registered Data

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

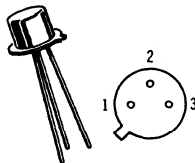
Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current ($V_{CB} = 50\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 50\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	---	0.025 15	μAdc
Collector Cutoff Current ($V_{CE} = 30\text{ Vdc}$, $V_{BE} = 0.5\text{ Vdc}$)	I_{CEX}	---	.050	μAdc
Base Cutoff Current ($V_{CE} = 30\text{ Vdc}$, $V_{BE} = 0.5\text{ Vdc}$)	I_{BL}	---	.050	μAdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	60	---	Vdc
Collector-Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 10\text{ mAdc}$, pulsed, $I_B = 0$)	BV_{CEO}	20	---	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	5.0	---	Vdc
Collector Saturation Voltage ⁽¹⁾ ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$)	$V_{CE}(\text{sat})$	---	0.5	Vdc
Base-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$)	$V_{BE}(\text{sat})$	---	1.3	Vdc
DC Forward Current Transfer Ratio ($I_C = 150\text{ mAdc}$, 2N2958, 2N3115 $V_{CE} = 10\text{ Vdc}$) 2N2959, 2N3116	h_{FE}	40 100	120 300	---
Common-Base Open Circuit Output Capacitance ($V_{CB} = 10\text{ V}$, $I_E = 0$, $f = 100\text{ kHz}$)	C_{ob}	---	8.0	pF
Delay Time ($V_{CC} = 30\text{ V}$, $I_{CS} = 150\text{ mA}$, $I_{B1} = 15\text{ mA}$)	t_d	---	20	ns
Rise Time ($V_{CC} = 30\text{ V}$, $I_{CS} = 150\text{ mA}$, $I_{B1} = 15\text{ mA}$)	t_r	---	75	ns
Storage Time ($V_{CC} = 6\text{ V}$, $I_{CS} = 150\text{ mA}$, $I_{B1} = 15\text{ mA}$, $I_{B2} = 15\text{ mA}$)	t_s	---	300	ns
Fall Time ($V_{CC} = 6\text{ V}$, $I_{CS} = 150\text{ mA}$, $I_{B1} = 15\text{ mA}$, $I_{B2} = 15\text{ mA}$)	t_f	---	200	ns
Current Gain-Bandwidth Product ($I_C = 20\text{ mA}$, $V_{CE} = 20\text{ V}$, $f = 100\text{ MHz}$)	f_T	250	---	MHz

⁽¹⁾ PULSE TEST: Pulse width $\leq 300\text{ }\mu\text{s}$, duty cycle $\leq 2\%$

*Indicates JEDEC Registered Data

2N3009 (SILICON)**2N3013****2N3013JAN AVAILABLE****2N3014**

NPN silicon epitaxial switching transistors designed for high-speed, medium-power saturated switching applications



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*** MAXIMUM RATINGS**

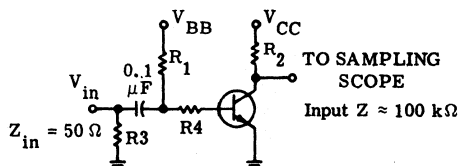
Rating	Symbol	Value	Unit
Collector-Emitter Voltage (1) 2N3009, 2N3013 2N3014	V_{CEO}	15 20	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage 2N3009 2N3013, 2N3014	V_{EB}	4.0 5.0	Vdc
Collector Current — Continuous (10 μ s pulse) Peak	I_C	200 500	mA dc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.36 2.06	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ @ $T_C = 100^\circ\text{C}$ Derate above 25°C	P_D	1.20 0.68 6.85	Watts Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

CASE 27
(TO-52)

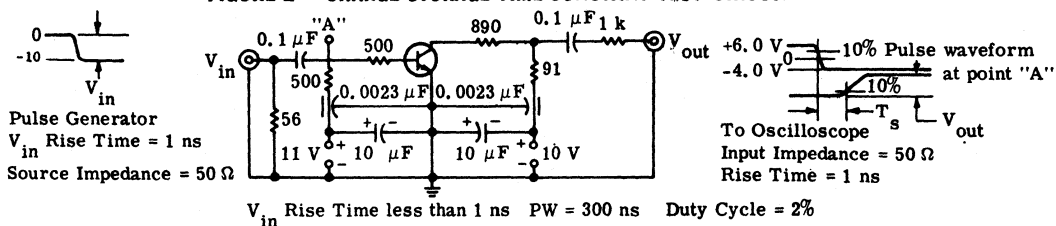
Collector Connected to Case

(1) Applicable from 0.01 mA to 10 mA (Pulsed)

* Indicates JEDEC Registered Data

FIGURE 1 — TURN-ON AND TURN-OFF TIME TEST CIRCUIT

		SWITCHING TEST CIRCUIT VALUES							INPUT PULSE		
Type	Test	V _{in}	V _{BB}	V _{CC}	R ₁	R ₂	R ₃	R ₄	t _r	t _f	Pulse Width
2N3009 2N3013	t _{on} & t _{off}	(volts)			(ohms)				(nanoseconds)		
		11	-5.0	15	300	50	75	170	<1.0	<1.0	>100
2N3014	t _{on}	7.0	GND	2.0	100	62	100	2.0 k	<1.0	-	>200
	t _{off}	-13	7.0	2.0							

FIGURE 2 — CHARGE STORAGE TIME CONSTANT TEST CIRCUIT

2N3009, 2N3013, 2N3014 (continued)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) ($I_C = 10\text{ mAdc}$, $I_B = 0$)	$BV_{CEO(sus)}$	15 20	- -	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100\text{ }\mu\text{Adc}$, $V_{BE} = 0$)	BV_{CES}	40	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	4.0 5.0	- -	Vdc
Collector-Cutoff Current ($V_{CE} = 20\text{ Vdc}$, $V_{BE} = 0$)	I_{CES}	-	0.5	μAdc
($V_{CE} = 20\text{ Vdc}$, $V_{BE} = 0$, $T_A = +85^\circ\text{C}$)		-	15	
($V_{CE} = 20\text{ Vdc}$, $V_{BE} = 0$)		-	0.3	
($V_{CE} = 20\text{ Vdc}$, $V_{BE} = 0$, $T_A = +125^\circ\text{C}$)		-	40	
Base Current ($V_{CE} = 20\text{ Vdc}$, $V_{BE} = 0$)	I_B	-	0.5 0.3	μAdc

ON CHARACTERISTICS (1)

DC Current Gain ($I_C = 30\text{ mAdc}$, $V_{CE} = 0.4\text{ Vdc}$)	All Types	h_{FE}	30	120	
($I_C = 10\text{ mAdc}$, $V_{CE} = 0.4\text{ Vdc}$)	2N3014		25	-	
($I_C = 100\text{ mAdc}$, $V_{CE} = 0.5\text{ Vdc}$)	2N3009, 2N3013		25	-	
($I_C = 100\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$)	2N3014		25	-	
($I_C = 300\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$)	2N3009, 2N3013		15	-	
($I_C = 30\text{ mAdc}$, $V_{CE} = 0.4\text{ Vdc}$, $T_A = -55^\circ\text{C}$)	2N3013, 2N3014		12	-	
Collector-Emitter Saturation Voltage ($I_C = 30\text{ mAdc}$, $I_B = 3.0\text{ mAdc}$)	All Types	$V_{CE(sat)}$	-	0.18	Vdc
($I_C = 100\text{ mAdc}$, $I_B = 10\text{ mAdc}$)	2N3009, 2N3013		-	0.28	
($I_C = 100\text{ mAdc}$, $I_B = 10\text{ mAdc}$)	2N3014		-	0.35	
($I_C = 300\text{ mAdc}$, $I_B = 30\text{ mAdc}$)	2N3009, 2N3013		-	0.50	
($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$)	2N3014		-	0.18	
($I_C = 30\text{ mAdc}$, $I_B = 3.0\text{ mAdc}$, $T_A = +85^\circ\text{C}$)	2N3009		-	0.30	
($I_C = 30\text{ mAdc}$, $I_B = 3.0\text{ mAdc}$, $T_A = +125^\circ\text{C}$)	2N3013, 2N3014		-	0.25	
Base-Emitter Saturation Voltage ($I_C = 30\text{ mAdc}$, $I_B = 3.0\text{ mAdc}$)	All Types	$V_{BE(sat)}$	0.75	0.95	Vdc
($I_C = 100\text{ mAdc}$, $I_B = 10\text{ mAdc}$)	All Types		-	1.20	
($I_C = 300\text{ mAdc}$, $I_B = 30\text{ mAdc}$)	2N3009, 2N3013		-	1.70	
($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$)	2N3014		0.70	0.80	

DYNAMIC CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 30\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	350	-	MHz
Output Capacitance ($V_{CB} = 5.0\text{ Vdc}$, $I_E = 0$, $f = 140\text{ kHz}$)	C_{ob}	-	5.0	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 140\text{ kHz}$)	C_{ib}	-	8.0	pF
Turn-On Time (Figure 1) ($V_{EB(off)} = 5.0\text{ V}$, $V_{CC} = 15\text{ V}$, $I_C = 300\text{ mAdc}$, $I_{B1} \approx 30\text{ mAdc}$)	t_{on}	-	15	ns
($V_{EB(off)} = 0$, $V_{CC} = 2.0\text{ V}$, $I_C = 30\text{ mAdc}$, $I_{B1} \approx 3.0\text{ mAdc}$)		-	16	
Turn-Off Time (Figure 1) ($V_{CC} = 15\text{ V}$, $I_C = 300\text{ mAdc}$, $I_{B1} \approx I_{B2} \approx 30\text{ mAdc}$)	t_{off}	-	25	ns
($V_{CC} = 2.0\text{ V}$, $I_C = 30\text{ mAdc}$, $I_{B1} \approx I_{B2} \approx 3.0\text{ mAdc}$)		-	25	
Charge-Storage Time (Figure 2) ($I_C \approx I_{B1} \approx I_{B2} \approx 10\text{ mAdc}$)	t_s	-	18	ns

(1) Pulse Test: Pulse Width = 300 μs ; Duty Cycle $\leq 2\%$.

*Indicates JEDEC Registered Data

NPN SILICON SWITCHING TRANSISTOR

... designed primarily for high-speed, saturated switching applications.

- High Speed Switching Times @ $I_C = 10 \text{ mA dc}$ —
 $t_{on} \leq 12 \text{ ns (Max)}$
 $t_{off} \leq 12 \text{ ns (Max)}$

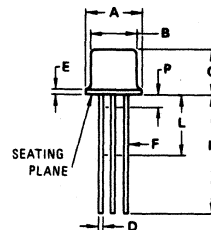
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage (1)	V_{CEO}	6.0	Vdc
Collector-Emitter Voltage	V_{CES}	11	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector-Current — Continuous	I_C	50	mA dc
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.30 1.71	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$
Lead Temperature (Soldering, 60 second time limit)	T_L	300	$^\circ\text{C}$

*Indicates JEDEC Registered Data.

(1) applicable from 0.01 mA dc to 10 mA dc (Pulsed).

NPN SILICON SWITCHING TRANSISTOR



PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	—	0.762	—	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	—	1.27	—	0.050

All JEDEC notes and dimensions apply.

CASE 22-03
(TO-18)

FIGURE 1 — TURN-ON AND TURN-OFF TIME TEST CIRCUIT

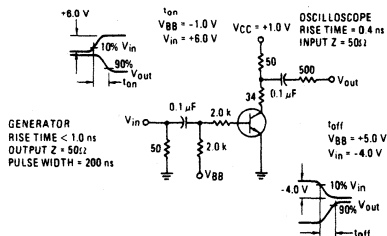
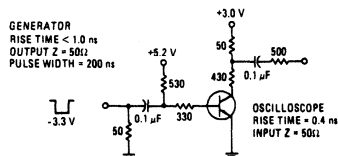


FIGURE 2 — CHARGE-STORAGE TIME TEST CIRCUIT



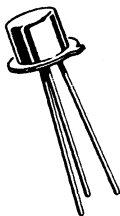
***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) ($I_C = 10\text{ mAdc}$, $I_B = 0$)	$V_{CE(sus)}$	6.0	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $V_{BE} = 0$)	BV_{CES}	11	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	15	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	4.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 11\text{ Vdc}$, $V_{BE} = 0$) ($V_{CE} = 5.0\text{ Vdc}$, $V_{BE} = 0$) ($V_{CE} = 5.0\text{ Vdc}$, $V_{BE} = 0$, $T_A = +85^\circ\text{C}$)	I_{CES}	— — —	10 0.1 5.0	μAdc
Base Cutoff Current ($V_{CE} = 11\text{ Vdc}$, $V_{EB(off)} = 0$)	I_{BL}	—	10	μAdc
ON CHARACTERISTICS (1)				
DC Current Gain ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 0.4\text{ Vdc}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 0.4\text{ Vdc}$) ($I_C = 30\text{ mAdc}$, $V_{CE} = 0.4\text{ Vdc}$)	h_{FE}	15 25 15	— 125 —	—
Collector-Emitter Saturation Voltage ($I_C = 1.0\text{ mAdc}$, $I_B = 0.1\text{ mAdc}$) ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$) ($I_C = 30\text{ mAdc}$, $I_B = 3.0\text{ mAdc}$) ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$, $T_A = 85^\circ\text{C}$)	$V_{CE(sat)}$	— — — —	0.25 0.25 0.38 0.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 1.0\text{ mAdc}$, $I_B = 0.1\text{ mAdc}$) ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$) ($I_C = 30\text{ mAdc}$, $I_B = 3.0\text{ mAdc}$)	$V_{BE(sat)}$	0.68 0.75 —	0.85 0.95 1.3	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product ($I_C = 10\text{ mAdc}$, $V_{CE} = 4.0\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	600	—	MHz
Output Capacitance ($V_{CB} = 5.0\text{ Vdc}$, $I_E = 0$, $f = 140\text{ kHz}$)	C_{ob}	—	3.0	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 140\text{ kHz}$)	C_{ib}	—	2.0	pF
SWITCHING TIMES				
Turn-On Time (Figure 1) ($V_{CC} = 1.0\text{ Vdc}$, $V_{BE(off)} = 1.0\text{ Vdc}$, $I_C = 10\text{ mAdc}$, $I_{B1} \approx 2.0\text{ mAdc}$)	t_{on}	—	12	ns
Turn-Off Time (Figure 1) ($V_{CC} = 1.0\text{ Vdc}$, $I_C = 10\text{ mAdc}$, $I_{B1} \approx I_{B2} \approx 1.0\text{ mAdc}$)	t_{off}	—	12	ns
Charge Storage Time (Figure 2) ($I_C = I_{B1} \approx I_{B2} = 5.0\text{ mAdc}$)	t_s	—	6.0	ns

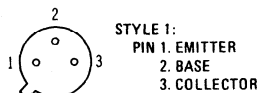
*Indicates JEDEC Registered Data.

(1) pulse Test: Pulse Length = $300\text{ }\mu\text{s}$; Duty Cycle $\leq 2.0\%$

2N3011 (SILICON)



NPN silicon low-power transistor primarily designed for high-speed, saturated switching applications.



CASE 22 (TO-18)

Collector connected to case

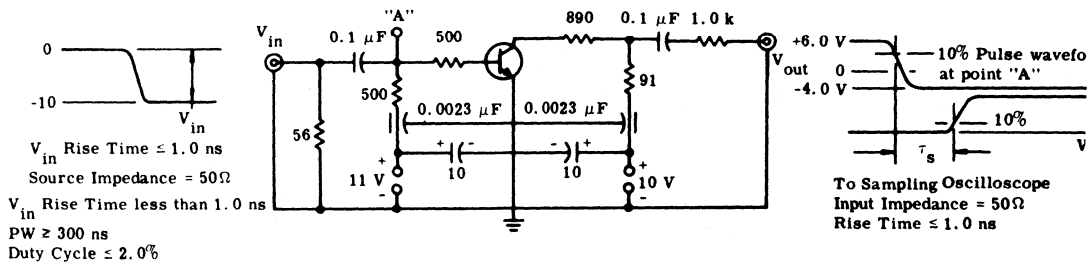
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage(1)	V_{CEO}	12	Vdc
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector-Current-Continuous	I_C	200	mAdc
Peak (10 μ s Pulse)		500	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$	P_D	0.36	Watt
Derate above 25°C		2.06	mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$	P_D	1.20	Watt
$T_C = 100^\circ\text{C}$		0.68	
Derate above 25°C		6.85	mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

(1) Applicable from 0.01 mA to 10 mA (Pulsed)

* Indicates JEDEC Registered Data

FIGURE 1 — CHARGE-STORAGE TIME TEST CIRCUIT



ZN3011 (continued)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage ⁽¹⁾ ($I_C = 10\text{ mAdc}$, $I_B = 0$)	$BV_{CEO(sus)}$	12	-	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $V_{BE} = 0$)	BV_{CES}	30	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	30	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current ($V_{CE} = 20\text{ Vdc}$, $V_{BE} = 0$) ($V_{CE} = 20\text{ Vdc}$, $V_{BE} = 0$, $T_A = +85^\circ\text{C}$)	I_{CES}	-	0.4 10	μAdc
Base Cutoff Current ($V_{CE} = 20\text{ Vdc}$, $V_{BE} = 0$)	I_{BL}	-	0.4	μAdc

ON CHARACTERISTICS ⁽¹⁾

DC Current Gain ($I_C = 10\text{ mAdc}$, $V_{CE} = 0.35\text{ Vdc}$) ($I_C = 30\text{ mAdc}$, $V_{CE} = 0.4\text{ Vdc}$) ($I_C = 100\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$)	h_{FE}	30 25 12	120 - -	-
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$) ($I_C = 30\text{ mAdc}$, $I_B = 3.0\text{ mAdc}$) ($I_C = 100\text{ mAdc}$, $I_B = 10\text{ mAdc}$) ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$, $T_A = +85^\circ\text{C}$)	$V_{CE(sat)}$	- - - -	0.20 0.25 0.50 0.30	Vdc
Base-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$) ($I_C = 30\text{ mAdc}$, $I_B = 3.0\text{ mAdc}$) ($I_C = 100\text{ mAdc}$, $I_B = 10\text{ mAdc}$)	$V_{BE(sat)}$	0.72 - -	0.87 1.15 1.60	Vdc

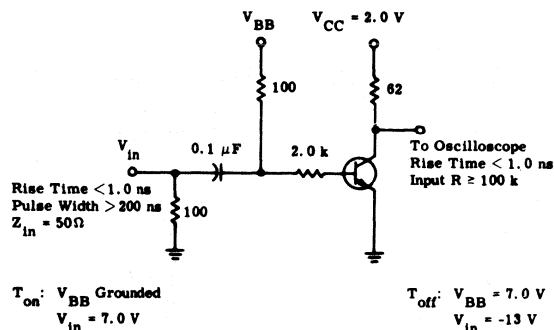
DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 20\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	400	-	MHz
Output Capacitance ($V_{CB} = 5.0\text{ Vdc}$, $I_E = 0$, $f = 140\text{ kHz}$)	C_{ob}	-	4.0	pF
Turn-On Time (Figure 2) ($V_{CC} = 2.0\text{ Vdc}$, $V_{EB(off)} = 0$, $I_C \approx 30\text{ mAdc}$, $I_{B1} \approx 3.0\text{ mAdc}$)	t_{on}	-	15	ns
Turn-Off Time (Figure 2) ($V_{CC} = 2.0\text{ Vdc}$, $I_C = 30\text{ mAdc}$, $I_{B1} \approx -I_{B2} \approx 3.0\text{ mAdc}$)	t_{off}	-	20	ns
Charge Storage Time (Figure 1) ($I_C = I_{B1} \approx -I_{B2} \approx 10\text{ mAdc}$)	t_s	-	13	ns

(1) Pulse Test: Pulse Length = 300 μs , Duty Cycle $\leq 2.0\%$.

* Indicates JEDEC Registered Data

FIGURE 2 – TURN-ON AND TURN-OFF TIME TEST CIRCUIT



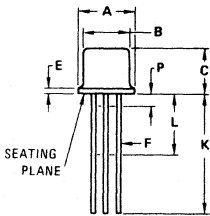
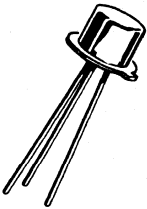
2N3012 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

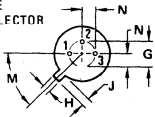
... designed for use in medium-speed saturated switching applications.

- Collector-Emitter Sustaining Voltage –
 $V_{CE(sus)} = 12 \text{ Vdc @ } I_C = 10 \text{ mAdc}$
- Low Collector-Emitter Saturation Voltage –
 $V_{CE(sat)} = 0.15 \text{ Vdc @ } I_C = 10 \text{ mAdc}$

PNP SILICON
SWITCHING
TRANSISTOR



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	—	0.762	—	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	—	1.27	—	0.050

All JEDEC notes and dimensions apply.

CASE 22-03
(TO-18)

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	12	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.36 2.06	Watts mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.2 6.85	Watts W/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

*Indicates JEDEC Registered Data.

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) ($I_C = 10\text{ mA}$, $I_B = 0$) (Emitter-Base Termination — Open Base)	$V_{CE(sus)}$	12	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10\text{ }\mu\text{A}$, $V_{BE} = 0$)	BV_{CES}	12	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{A}$, $I_E = 0$)	BV_{CBO}	12	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\text{ }\mu\text{A}$, $I_C = 0$)	BV_{EBO}	4.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 6.0\text{ Vdc}$, $V_{BE} = 0$) ($V_{CE} = 6.0\text{ Vdc}$, $V_{BE} = 0$, $T_A = +85^\circ\text{C}$)	I_{CES}	—	80 5.0	nAdc μAdc
Base Current ($V_{CE} = 6.0\text{ Vdc}$, $V_{BE} = 0$)	I_B	—	30	nAdc

ON CHARACTERISTICS

DC Current Gain(1) ($I_C = 10\text{ mA}$, $V_{CE} = 0.3\text{ Vdc}$) ($I_C = 30\text{ mA}$, $V_{CE} = 0.5\text{ Vdc}$) ($I_C = 100\text{ mA}$, $V_{CE} = 1.0\text{ Vdc}$)	h_{FE}	25 30 20	— 120 —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 10\text{ mA}$, $I_B = 1.0\text{ mA}$) ($I_C = 30\text{ mA}$, $I_B = 3.0\text{ mA}$) ($I_C = 30\text{ mA}$, $I_B = 3.0\text{ mA}$, $T_A = +85^\circ\text{C}$) ($I_C = 100\text{ mA}$, $I_B = 10\text{ mA}$)	$V_{CE(sat)}$	— — — —	0.15 0.2 0.4 0.5	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 10\text{ mA}$, $I_B = 1.0\text{ mA}$) ($I_C = 30\text{ mA}$, $I_B = 3.0\text{ mA}$) ($I_C = 100\text{ mA}$, $I_B = 10\text{ mA}$)	$V_{BE(sat)}$	0.78 0.85 —	0.98 1.2 1.7	Vdc

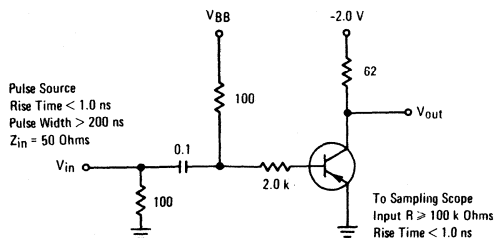
SMALL-SIGNAL CHARACTERISTICS

Output Capacitance ($V_{CB} = 5.0\text{ Vdc}$, $I_E = 0$, $f = 140\text{ kHz}$)	C_{ob}	—	6.0	pF
Input Capacitance ($V_{EB} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 140\text{ kHz}$)	C_{ib}	—	6.0	pF
Small-Signal Current Gain ($I_C = 30\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	h_{fe}	4.0	—	—

SWITCHING CHARACTERISTICS (See Figure 1)

Turn-On Time ($V_{CC} = 2.0\text{ Vdc}$, $I_C \approx 30\text{ mA}$, $I_{B1} \approx 1.5\text{ mA}$)	t_{on}	—	60	ns
Turn-Off Time ($V_{CC} = 2.0\text{ Vdc}$, $I_C \approx 30\text{ mA}$, $I_{B1} = I_{B2} \approx 1.5\text{ mA}$)	t_{off}	—	75	ns

* Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width = 300 μs , Duty Cycle = 1.0%.**FIGURE 1 — TURN-ON AND TURN-OFF TIME TEST CIRCUIT****Notes:**

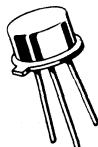
- (1) Collector Current $\approx 30\text{ mA}$
- (2) Turn On and Turn Off Base Currents $\approx 1.5\text{ mA}$
- (3) t_{on} $V_{BB} = +3.0\text{ V}$ $V_{in} = -7.0\text{ V}$
 t_{off} $V_{BB} = -4.0\text{ V}$ $V_{in} = +6.0\text{ V}$

2N3013

2N3014

For Specifications, See 2N3009 Data.

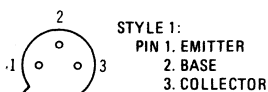
2N3019S (SILICON) **2N3020S**



NPN silicon annular transistors designed for high-current, high-frequency amplifier applications.

CASE 79 **(TO-39)**

Collector connected to case



***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Base Voltage	V_{CB}	140	Vdc
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Collector Current	I_C	1.0	Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.8 4.6	W mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	5.0 28.6	W mW/ $^\circ\text{C}$
Operating Junction Temperature Range	T_J	-65 to +200	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

*Indicates JEDEC Registered Data

2N3019S, 2N3020S (continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 30 \text{ mA}$, $I_B = 0$)	BV_{CEO}	80	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \text{ } \mu\text{A}$, $I_E = 0$)	BV_{CBO}	140	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \text{ } \mu\text{A}$, $I_C = 0$)	BV_{EBO}	7.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 90 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 90 \text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	0.010 10	μA
Emitter Cutoff Current ($V_{BE} = 5 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	0.010	μA

ON CHARACTERISTICS

DC Current Gain ⁽¹⁾ ($I_C = 0.1 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$) ($I_C = 10 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$) ($I_C = 150 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$) ($I_C = 150 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$, $T_C = -55^\circ\text{C}$) ($I_C = 500 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$) ($I_C = 1 \text{ A}$, $V_{CE} = 10 \text{ Vdc}$)	2N3019 2N3020 2N3019 2N3020 2N3019 2N3020 2N3019 2N3020 Both Types	h_{FE}	50 30 90 40 100 40 40 50 30 15	— 100 — 120 300 120 — — 100 —	—
Collector-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 150 \text{ mA}$, $I_B = 15 \text{ mA}$) ($I_C = 500 \text{ mA}$, $I_B = 50 \text{ mA}$)		$V_{CE(sat)}$	— —	0.2 0.5	Vdc
Base-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 150 \text{ mA}$, $I_B = 15 \text{ mA}$)		$V_{BE(sat)}$	—	1.1	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 50 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$, $f = 20 \text{ MHz}$)	2N3019 2N3020	f_T	100 80	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 1 \text{ MHz}$)		C_{ob}	—	12	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 1 \text{ MHz}$)		C_{ib}	—	60	pF
Small-Signal Current Gain ($I_C = 1 \text{ mA}$, $V_{CE} = 5 \text{ Vdc}$, $f = 1 \text{ kHz}$)	2N3019 2N3020	h_{fe}	80 30	400 200	—
Collector-Base Time Constant ($I_C = 10 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$, $f = 4 \text{ MHz}$)		$r_{b'c}$	—	400	ps
Noise Figure ($I_C = 100 \text{ } \mu\text{A}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1 \text{ kHz}$, $R_S = 1 \text{ kohm}$) 2N3019		NF	—	4.0	dB

(1) Pulse Test: Pulse Width $\leq 300 \text{ } \mu\text{s}$, duty cycle $\leq 1\%$

*Indicates JEDEC Registered Data

2N3021 (SILICON)

thru

2N3026

HIGH-SPEED SILICON PNP POWER TRANSISTORS

... designed for high-speed switching and high-frequency amplifier applications.

- Collector-Emitter Sustaining Voltage –
 $V_{CE(sus)} = 30 \text{ Vdc (Min)} - 2N3021, 2N3024$
 $= 45 \text{ Vdc (Min)} - 2N3022, 2N3025$
 $= 60 \text{ Vdc (Min)} - 2N3023, 2N3026$
- Low Collector-Emitter Saturation Voltage – @ $I_C = 3.0 \text{ Adc}$
 $V_{CE(sat)} = 1.5 \text{ Vdc (Max)} - 2N3021, 2N3022, 2N3023$
 $= 1.0 \text{ Vdc (Max)} - 2N3024, 2N3025, 2N3026$
- DC Current Gain – @ $I_C = 1.0 \text{ Adc}$
 $h_{FE} = 20-60 - 2N3021, 2N3022, 2N3023$
 $= 50-180 - 2N3024, 2N3025, 2N3026$
- Current-Gain-Bandwidth Product –
 $f_T = 100 \text{ MHz (Typ)} @ I_C = 0.5 \text{ Adc}$
- Recommended for High-Current Core Switching and Class C Power Amplifier Applications

*MAXIMUM RATINGS

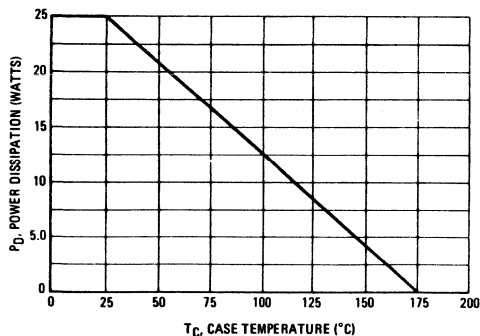
Rating	Symbol	2N3021 2N3024	2N3022 2N3025	2N3023 2N3026	Unit
Collector-Emitter Voltage	V_{CEO}	30	45	60	Vdc
Collector-Base Voltage	V_{CB}	30	45	60	Vdc
Emitter-Base Voltage	V_{EB}	4.0			Vdc
Collector Current – Continuous	I_C	3.0			Adc
Peak		10			
Base Current	I_B	0.5			Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$	P_D	25			Watts
Derate above 25°C		0.167			W/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175			$^\circ\text{C}$

THERMAL CHARACTERISTICS

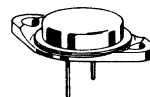
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	6.0	$^\circ\text{C/W}$

*Indicates JEDEC Registered Data.

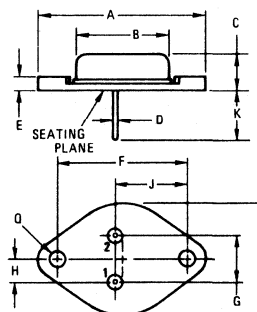
FIGURE 1 – POWER DERATING



**3 AMPERE
POWER TRANSISTORS
PNP SILICON**
30, 45, 60 VOLTS
25 WATTS



STYLE 1:
PIN 1: BASE
2: EMITTER
CASE: COLLECTOR



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	—	39.37	—	1.550
B	—	21.08	—	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	—	3.43	—	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
L	3.84	4.09	0.151	0.161
M	—	26.67	—	1.050

Collector connected to case.
CASE 11

* ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) ($I_C = 100\text{ mAdc}$, $I_B = 0$) 2N3021, 2N3024 ($I_C = 50\text{ mAdc}$, $I_B = 0$) 2N3022, 2N3025 ($I_C = 20\text{ mAdc}$, $I_B = 0$) 2N3023, 2N3026	$V_{CE(sus)}$	30 45 60	— — —	Vdc
Collector Cutoff Current ($V_{CE} = 25\text{ Vdc}$, $V_{BE(off)} = 2.0\text{ Vdc}$) 2N3021, 2N3024 ($V_{CE} = 40\text{ Vdc}$, $V_{BE(off)} = 2.0\text{ Vdc}$) 2N3022, 2N3025 ($V_{CE} = 54\text{ Vdc}$, $V_{BE(off)} = 2.0\text{ Vdc}$) 2N3023, 2N3026 ($V_{CE} = 15\text{ Vdc}$, $V_{BE(off)} = 2.0\text{ Vdc}$, $T_C = 150^\circ\text{C}$) 2N3021, 2N3024 ($V_{CE} = 25\text{ Vdc}$, $V_{BE(off)} = 2.0\text{ Vdc}$, $T_C = 150^\circ\text{C}$) 2N3022, 2N3025 ($V_{CE} = 35\text{ Vdc}$, $V_{BE(off)} = 2.0\text{ Vdc}$, $T_C = 150^\circ\text{C}$) 2N3023, 2N3026	I_{CEX}	— — — — — —	0.2 0.2 0.2 2.0 2.0 2.0	mAcd
Emitter Cutoff Current ($V_{BE} = 4.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	1.0	mAcd
ON CHARACTERISTICS (1)				
DC Current Gain ($I_C = 1.0\text{ Adc}$, $V_{CE} = 2.0\text{ Vdc}$) 2N3021, 2N3022 2N3023 2N3024, 2N3025, 2N3026	h_{FE}	20 50	60 180	
Collector-Emitter Saturation Voltage ($I_C = 3.0\text{ Adc}$, $I_B = 0.3\text{ Adc}$) 2N3021, 2N3022, 2N3023 2N3024, 2N3025, 2N3026	$V_{CE(sat)}$	— —	1.5 1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 3.0\text{ Adc}$, $I_B = 0.3\text{ Adc}$)	$V_{BE(sat)}$	—	1.5	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (2) ($I_C = 0.5\text{ Adc}$, $V_{CE} = 15\text{ Vdc}$, $f_{test} = 30\text{ MHz}$)	f_T	60	—	MHz
SWITCHING CHARACTERISTICS				
Turn On Time ($V_{CC} = 12\text{ Vdc}$, $V_{BE(off)} = 0$, $I_C = 1.0\text{ Adc}$, $I_B = 100\text{ mAcd}$)	t_{on}	—	100	ns
Storage Time ($V_{CC} = 12\text{ Vdc}$, $I_C = 1.0\text{ Adc}$, $I_{B1} = I_{B2} = 100\text{ mAcd}$)	t_s	—	325	ns
Fall Time ($V_{CC} = 12\text{ Vdc}$, $I_C = 1.0\text{ Adc}$, $I_{B1} = I_{B2} = 100\text{ mAcd}$)	t_f	—	75	ns

*Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 1.0\%$.(2) $f_T = |h_{fe}| \cdot f_{test}$.

FIGURE 2 — SWITCHING TIME TEST CIRCUIT

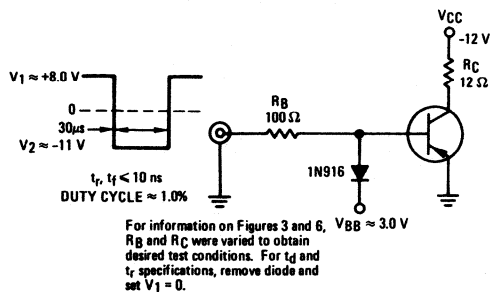


FIGURE 3 — TURN-ON TIME

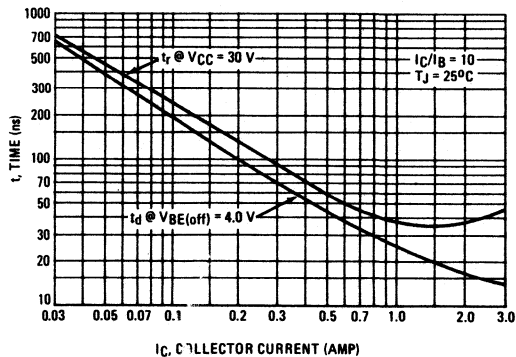


FIGURE 4 – THERMAL RESPONSE

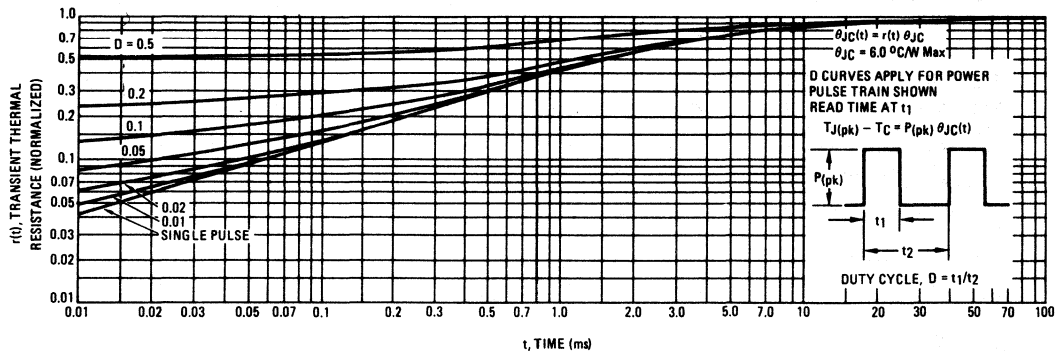
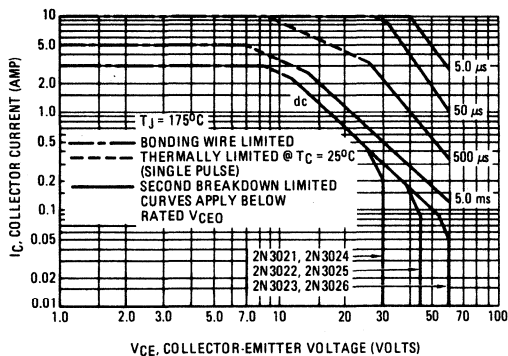


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 175^{\circ}\text{C}$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 175^{\circ}\text{C}$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

FIGURE 6 – TURN-OFF TIME

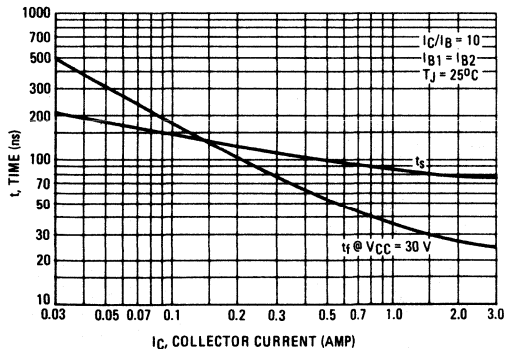


FIGURE 7 – CAPACITANCE

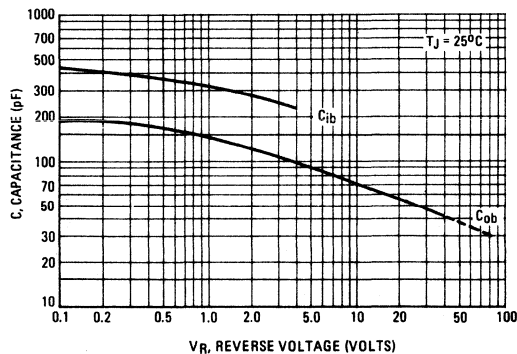


FIGURE 8 – DC CURRENT GAIN

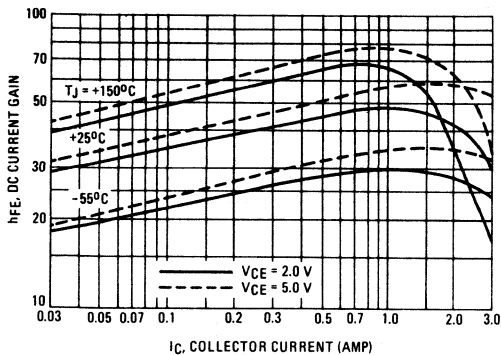


FIGURE 9 – COLLECTOR SATURATION REGION

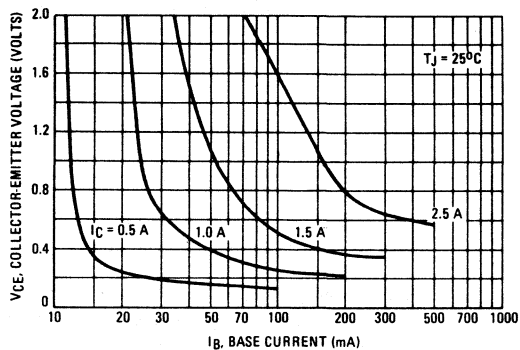


FIGURE 10 – "ON" VOLTAGES

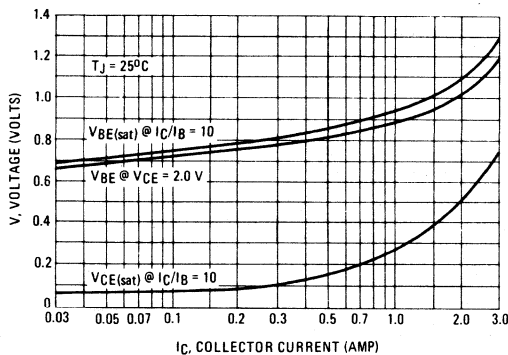


FIGURE 11 – TEMPERATURE COEFFICIENTS

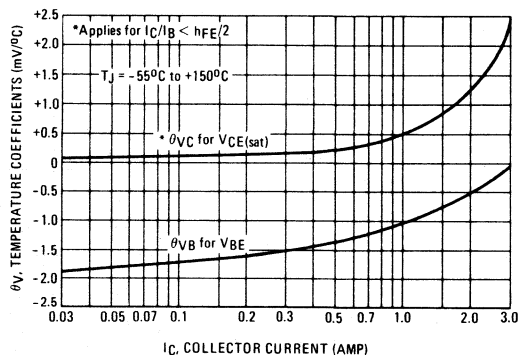


FIGURE 12 – COLLECTOR CUT-OFF REGION

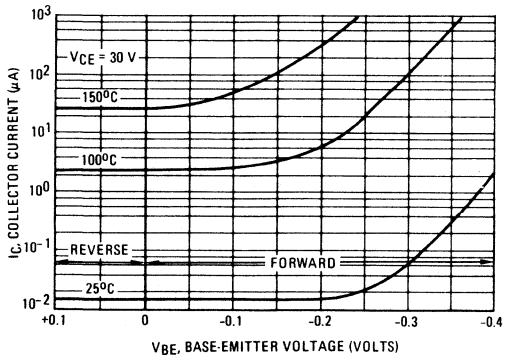
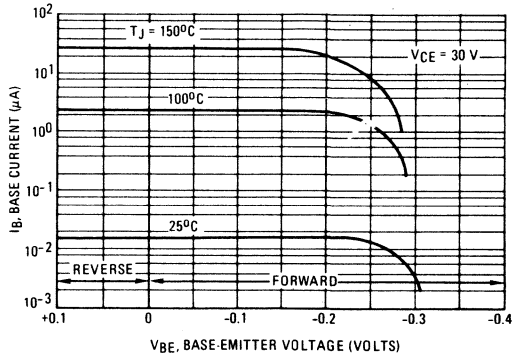


FIGURE 13 – BASE CUT-OFF REGION

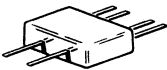


MULTIPLE SILICON ANNULAR TRANSISTORS

... designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Excellent Temperature Tracking – Dual Devices –
2N3044, 2N3047
 $\Delta|V_{BE1} - V_{BE2}| = 10 \mu V_{dc}$ (Max) @ -55 to +25°C
- Low Collector-Emitter Saturation Voltage –
 $V_{CE(sat)} = 1.0 V_{dc}$ (Max) @ $I_C = 10 \text{ mAdc}$
- DC Current Gain Specified – $10 \mu\text{Adc}$ to 1.0 mAdc
- High Current-Gain–Bandwidth Product –
 $f_T = 30 \text{ MHz}$ @ $I_C = 1.0 \text{ mAdc}$

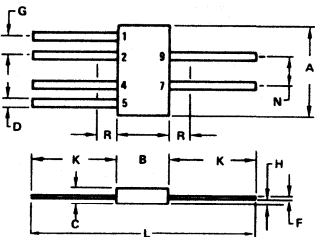
NPN SILICON
MULTIPLE TRANSISTORS



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CB}	45	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	30	mAdc
		One Die	Both Die
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	250 1.67	350 2.33 mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	0.7 4.67	1.4 9.33 Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

*Indicates JEDEC Registered Data.



STYLE 1:
PIN 1: BASE
2: EMITTER
4: EMITTER
5: BASE
7: COLLECTOR
9: COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	— 0.89		— 0.035	
K	3.81		0.150	
N	2.54 BSC		0.100 BSC	
R	— 1.27		— 0.050	

CASE 610A-03

2N3043 thru 2N3048 (continued)

* ELECTRICAL CHARACTERISTICS (each side) ($T_A = 25^{\circ}\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) ($I_C = 10 \text{ mAdc}$, $I_B = 0$)	$BV_{CEO(sus)}$	45	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 45 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 45 \text{ Vdc}$, $I_E = 0$, $T_A = +150^{\circ}\text{C}$)	I_{CBO}	— —	0.010 10	μAdc
Emitter-Base Cutoff Current ($V_{EB} = 4 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	0.010	μAdc

ON CHARACTERISTICS

DC Current Gain (1) ($I_C = 10 \mu\text{Adc}$, $V_{CE} = 5 \text{ Vdc}$) ($I_C = 1 \text{ mAdc}$, $V_{CE} = 5 \text{ Vdc}$)	2N3043, 2N3044, 2N3045 2N3046, 2N3047, 2N3048 2N3043, 2N3044, 2N3045 2N3046, 2N3047, 2N3048	h_{FE}	100 50 130 65	300 200 — —	—
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 0.5 \text{ mAdc}$)		$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter On Voltage ($I_C = 10 \text{ mAdc}$, $V_{CE} = 5 \text{ Vdc}$)		$V_{BE(on)}$	0.6	0.8	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 1 \text{ mAdc}$, $V_{CE} = 5 \text{ Vdc}$, $f = 20 \text{ MHz}$)		f_T	30	—	MHz
Output Capacitance ($V_{CB} = 5 \text{ Vdc}$, $I_E = 0$, $f = 1 \text{ MHz}$)		C_{ob}	—	8.0	pF
Input Impedance ($I_C = 1 \text{ mAdc}$, $V_{CE} = 5 \text{ Vdc}$, $f = 1 \text{ kHz}$)	2N3043, 2N3044, 2N3045 2N3046, 2N3047, 2N3048	h_{ie}	3.2k 1.6k	19k 13k	Ohms
Small-Signal Current Gain ($I_C = 1 \text{ mAdc}$, $V_{CE} = 5 \text{ Vdc}$, $f = 1 \text{ kHz}$)	2N3043, 2N3044, 2N3045 2N3046, 2N3047, 2N3048	h_{fe}	130 65	600 400	—
Output Admittance ($I_C = 1 \text{ mAdc}$, $V_{CE} = 5 \text{ Vdc}$, $f = 1 \text{ kHz}$)	2N3043, 2N3044, 2N3045 2N3046, 2N3047, 2N3048	h_{oe}	— —	100 70	μmhos
Noise Figure ($I_C = 10 \mu\text{Adc}$, $V_{CE} = 5 \text{ Vdc}$, $R_G = 10\text{k ohms}$, Bandwidth = 10 Hz to 15.7 kHz)		NF	—	5.0	dB

MATCHING CHARACTERISTICS

DC Current Gain Ratio (2) ($I_C = 10 \mu\text{Adc}$, $V_{CE} = 5 \text{ Vdc}$)	2N3043, 2N3046 2N3044, 2N3047	h_{FE1}/h_{FE2}	0.9 0.8	1.0 1.0	—
Base-Emitter Voltage Differential ($I_C = 10 \mu\text{Adc}$, $V_{CE} = 5 \text{ Vdc}$)	2N3043, 2N3046 2N3044, 2N3047	$ V_{BE1} - V_{BE2} $	— —	5.0 10	mVdc
Base-Emitter Voltage Differential Temperature Gradient ($I_C = 10 \mu\text{Adc}$, $V_{CE} = 5 \text{ Vdc}$, $T_A = -55$ to $+125^{\circ}\text{C}$)	2N3043, 2N3046 2N3044, 2N3047	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	— —	10 20	$\mu\text{V}/^{\circ}\text{C}$

* Indicates JEDEC Registered Data

(1)Pulse Test: Pulse Width $\leq 300 \mu\text{s}$; Duty Cycle $\leq 2\%$

(2)The lowest h_{FE} reading is taken as h_{FE1} for this test.

2N3053S (SILICON)

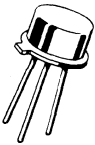
2N3053AS

NPN SILICON TRANSISTORS

... designed for general-purpose, medium-current amplifier applications.

- Collector-Emitter Breakdown Voltage – 2N3053A
 $V_{CEO} = 60 \text{ Vdc (Min) @ } I_C = 100 \mu\text{Adc}$
- Low Collector-Emitter Saturation Voltage – 2N3053A
 $V_{CE(sat)} = 0.3 \text{ Vdc (Max) @ } I_C = 150 \text{ mAdc}$

NPN SILICON TRANSISTORS



*MAXIMUM RATINGS

Rating	Symbol	2N3053	2N3053A	Unit
Collector-Emitter Voltage (1)	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	700		mAdc
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	5.0	28.6	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$
Lead Temperature 1/16", $\pm 1/32$ " From Case for 10 s	T_L	+235		$^\circ\text{C}$

*THERMAL CHARACTERISTICS

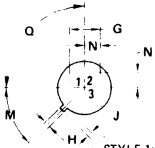
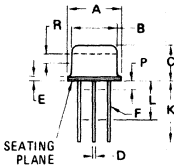
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	$^\circ\text{C/W}$

*Indicates JEDEC Registered Data.

(1) Applicable 0 to 100 mA (Pulsed);

Pulse Width $\leq 300 \mu\text{sec.}$, Duty Cycle $\leq 2.0\%$

0 to 700 mA; Pulse Width $\leq 10 \mu\text{sec.}$, Duty Cycle $\leq 2.0\%$



STYLE 1:
PIN 1: EMITTER
2: BASE
CASE: COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.10	—	0.500	—
L	6.35	—	0.250	—
M	45° NOM	45° NOM	—	—
P	—	1.27	—	0.050
Q	90° NOM	90° NOM	—	—
R	2.54	—	0.100	—

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

2N3053S, 2N3053AS (continued)

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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*OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (2) (I _C = 100 mA _{dc} , I _B = 0) (I _C = 100 μA _{dc} , I _B = 0)	2N3053 2N3053A	BV _{CEO}	40 60	— —	V _{dc}
Collector-Emitter Breakdown Voltage (2) (I _C = 100 mA _{dc} , R _{BE} = 10 Ohms)	2N3053 2N3053A	BV _{CER}	50 70	— —	V _{dc}
Collector-Base Breakdown Voltage (I _C = 100 μA _{dc} , I _E = 0)	2N3053 2N3053A	BV _{CBO}	60 80	— —	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 100 μA _{dc} , I _C = 0)		BV _{EBO}	5.0	—	V _{dc}
Emitter Cutoff Current (V _{BE} = 4.0 V _{dc} , I _C = 0)	2N3053	I _{EB0}	—	0.25	μA _{dc}
Base Cutoff Current (V _{CE} = 60 V _{dc} , V _{BE(off)} = 1.5 V _{dc})	2N3053A	I _{BEV}		0.25	μA _{dc}
Collector Cutoff Current (V _{CE} = 30 V _{dc} , V _{BE(off)} = 5.0 V _{dc}) (V _{CE} = 60 V _{dc} , V _{EB(off)} = 1.5 V _{dc})	2N3053 2N3057A	I _{CEV}	—	0.25	μA _{dc}

*ON CHARACTERISTICS (1)

DC Current Gain (I _C = 150 mA _{dc} , V _{CE} = 2.5 V _{dc}) (I _C = 150 mA _{dc} , V _{CE} = 10 V _{dc})		h _{FE}	25 50	— 250	—
Collector-Emitter Saturation Voltage (I _C = 150 mA _{dc} , I _B = 15 mA _{dc})	2N3053 2N3053A	V _{CE(sat)}	— —	1.4 0.3	V _{dc}
Base-Emitter Saturation Voltage (I _C = 150 mA _{dc} , I _B = 15 mA _{dc})	2N3053 2N3053A	V _{BE(sat)}	— 0.6	1.7 1.0	V _{dc}
Base-Emitter On Voltage (I _C = 150 mA _{dc} , V _{CE} = 2.5 V _{dc})	2N3053 2N3053A	V _{BE(on)}	— —	1.7 1.0	V _{dc}

DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product (I _C = 50 mA _{dc} , V _{CE} = 10 V _{dc} , f = 20 MHz)		f _T	100	—	MHz
Output Capacitance (V _{CB} = 10 V _{dc} , I _E = 0, f = 140 kHz)		C _{ob}	—	15	pF
Input Capacitance (V _{BE} = 0.5 V _{dc} , I _C = 0, f = 140 kHz)		C _{ib}	—	80	pF

*Indicates JEDEC Registered Data.

(2) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N3054A (SILICON)

MEDIUM-POWER NPN SILICON TRANSISTOR

... designed for general purpose switching and amplifier applications.

- Aluminum TO-66 Package for Better Power Handling Capability – 75 Watts @ $T_C = 25^\circ\text{C}$
- Excellent Safe Operating Area
- DC Current Gain Specified to 3.0 Amperes
- Complement to PNP Type 2N6049

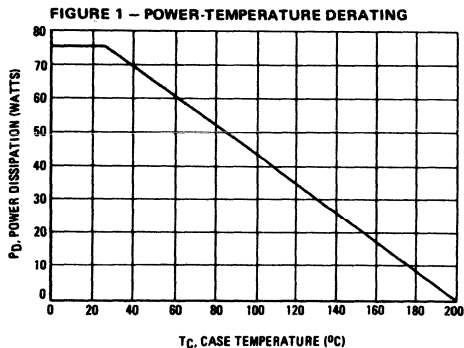
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	55	Vdc
Collector-Emitter Voltage ($R_{BE} = 100 \Omega$)	V_{GER}	60	Vdc
Collector-Base Voltage	V_{CB}	90	Vdc
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Collector Current – Continuous	I_C	4.0	Adc
Peak		10	
Base Current	I_B	2.0	Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$	P_D	75	Watts
Derate above 25°C		0.43	W/ $^\circ\text{C}$
Operating and Storage Junction, Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

*Indicates JEDEC Registered Data

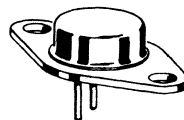
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.33	$^\circ\text{C}/\text{W}$

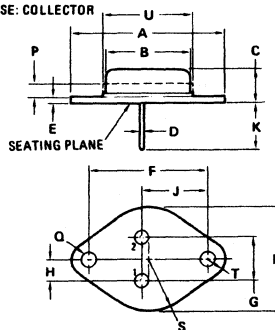


4 AMPERE POWER TRANSISTOR NPN SILICON

**55 VOLTS
75 WATTS**



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
B	11.94	12.70	0.470	0.500
C	8.35	8.64	0.290	0.340
D	0.71	0.86	0.028	0.034
E	1.27	1.91	0.050	0.075
F	24.33	24.43	0.958	0.962
G	4.83	5.33	0.190	0.210
H	2.41	2.67	0.095	0.105
J	14.48	14.99	0.570	0.590
K	9.14	—	0.360	—
P	—	1.27	—	0.050
Q	3.61	3.86	0.142	0.152
S	—	8.89	—	0.350
T	—	3.68	—	0.145
U	—	15.75	—	0.620

All JEDEC Dimensions and Notes Apply.

CASE 80-02
TO-66

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
*OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) ($I_C = 100 \text{ mAdc}$, $I_B = 0$)	$V_{CEO(sus)}$	55	—	Vdc
Collector-Emitter Sustaining Voltage (1) ($I_C = 100 \text{ mAdc}$, $R_{BE} = 100 \Omega$)	$V_{CER(sus)}$	60	—	Vdc
Collector Cutoff Current ($V_{CE} = 30 \text{ Vdc}$, $I_B = 0$)	I_{CEO}	—	500	μAdc
Collector Cutoff Current ($V_{CE} = 90 \text{ Vdc}$, $V_{BE(off)} = 1.5 \text{ Vdc}$) ($V_{CE} = 90 \text{ Vdc}$, $V_{BE(off)} = 1.5 \text{ Vdc}$, $T_C = 150^\circ\text{C}$)	I_{CEX}	—	1.0 6.0	mAdc
Emitter Cutoff Current ($V_{BE} = 7.0 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	1.0	mAdc

***ON CHARACTERISTICS (1)**

DC Current Gain ($I_C = 0.5 \text{ Adc}$, $V_{CE} = 4.0 \text{ Vdc}$) ($I_C = 3.0 \text{ Adc}$, $V_{CE} = 4.0 \text{ Vdc}$)	h_{FE}	25 5.0	100 —	—
Collector-Emitter Saturation Voltage ($I_C = 500 \text{ mAdc}$, $I_B = 50 \text{ mAdc}$) ($I_C = 3.0 \text{ Adc}$, $I_B = 1.0 \text{ Adc}$)	$V_{CE(sat)}$	—	1.0 6.0	Vdc
Base-Emitter On Voltage ($I_C = 500 \text{ mAdc}$, $V_{CE} = 4.0 \text{ Vdc}$)	$V_{BE(on)}$	—	1.7	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 200 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$)	f_T	3.0	—	MHz
*Small-Signal Current Gain ($I_C = 100 \text{ mAdc}$, $V_{CE} = 4.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{fe}	25	180	—
*Common-Emitter Cutoff Frequency ($I_C = 100 \text{ mAdc}$, $V_{CE} = 4.0 \text{ Vdc}$)	f_{hfe}	30	—	kHz

*Indicates JEDEC Registered Data

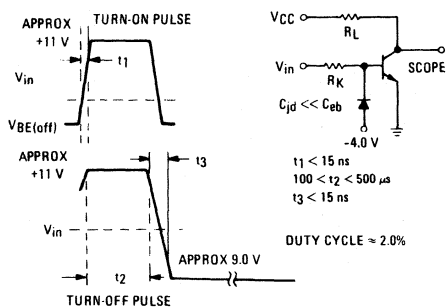
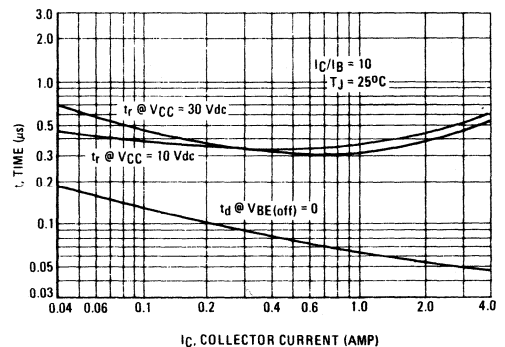
(1) Pulse test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$ **FIGURE 2 – SWITCHING TIME EQUIVALENT TEST CIRCUIT****FIGURE 3 – TURN-ON TIME**

FIGURE 4 – THERMAL RESPONSE

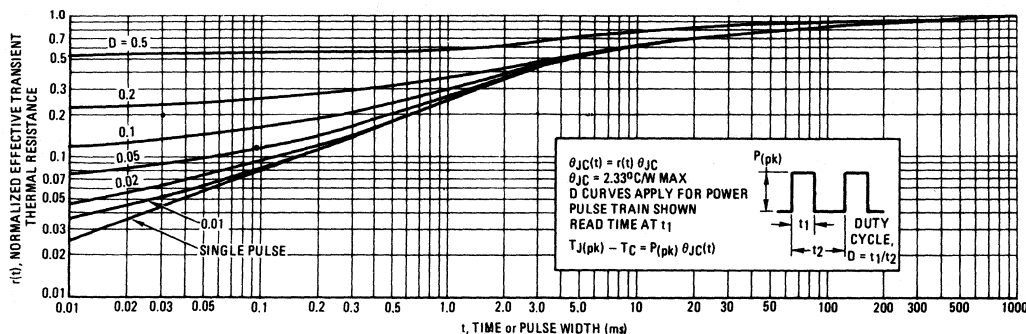
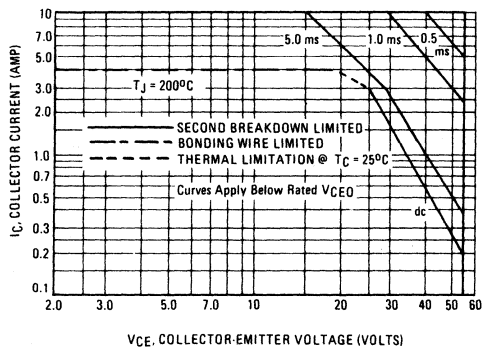


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_J(pk) = 200^\circ\text{C}$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_J(pk) < 200^\circ\text{C}$. $T_J(pk)$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

FIGURE 6 – TURN-OFF TIME

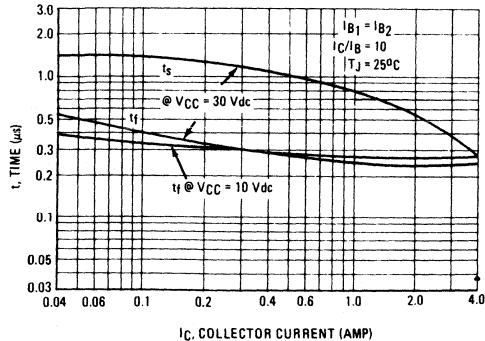


FIGURE 7 – CAPACITANCE

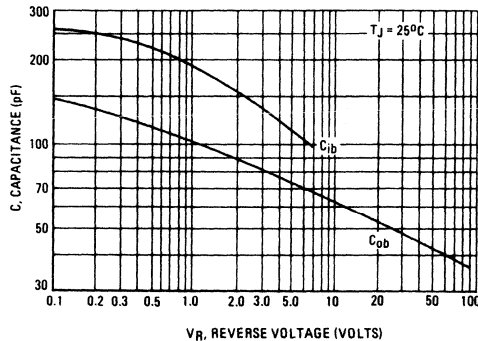


FIGURE 8 – DC CURRENT GAIN

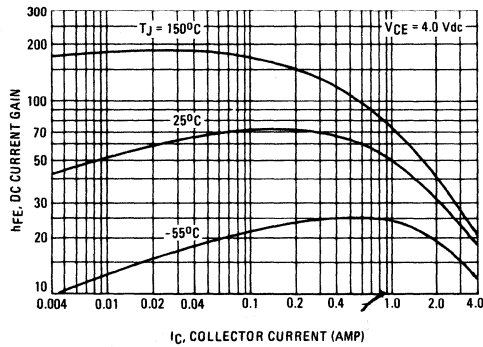


FIGURE 9 – COLLECTOR SATURATION REGION

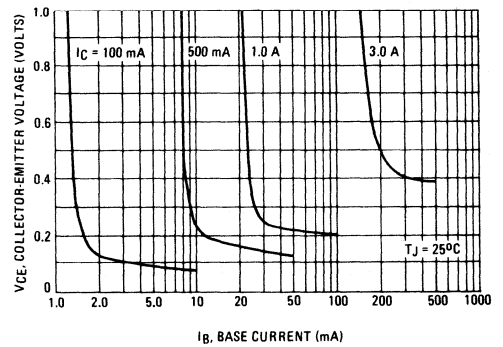


FIGURE 10 – TEMPERATURE COEFFICIENTS

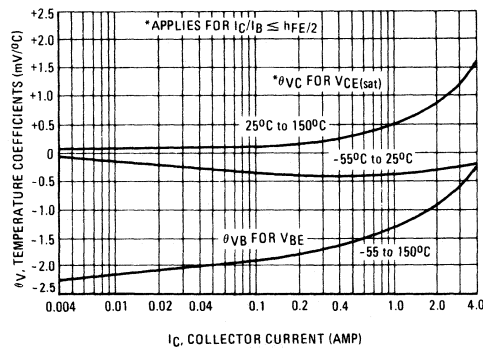


FIGURE 11 – "ON" VOLTAGES

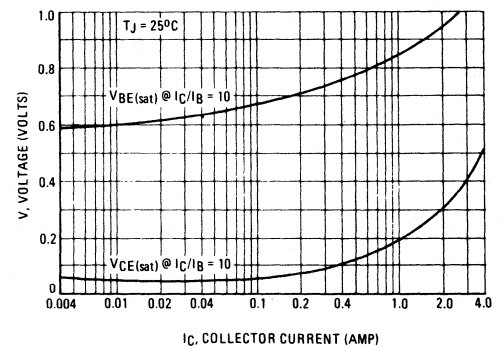


FIGURE 12 – COLLECTOR CUT-OFF REGION

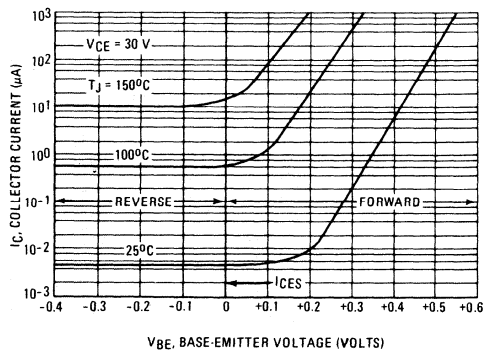
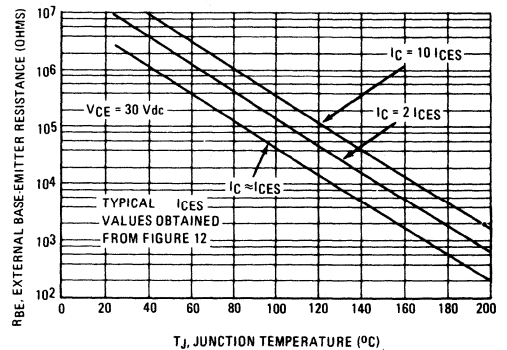


FIGURE 13 – EFFECTS OF BASE-EMITTER RESISTANCE



2N3055 (SILICON)

HIGH POWER NPN SILICON POWER TRANSISTOR

... EPIBASE transistors for ultimate circuit performance based on the designers requirements.

EPIBASE designed for power amplifier and switching regulator applications. The best choice where high frequency response, low switching losses and good safe operating area are required.

- Current-Gain – Bandwidth Product – $f_T = 2.5 \text{ MHz (Min) @ } I_C = 1.0 \text{ Adc}$
- Safe Operating Area – Full Power Rating to 40 V

*MAXIMUM RATINGS

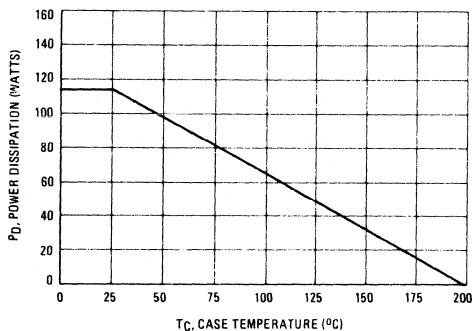
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Emitter Voltage Uni-Base	$V_{CEX}^{\dagger}$	90	Vdc
Collector-Emitter Voltage ($R_{BE} = 100 \Omega$)	V_{CER}	70	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Collector Current – Continuous	I_C	15	Adc
Base Current	I_B	7.0	Adc
Total Device Dissipation $T_C = 25^{\circ}\text{C}$ Derate above 25°C	P_D	115 0.657	Watts W/ $^{\circ}\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^{\circ}\text{C}$

*Devices selected from either process meet or exceed JEDEC Registration.
 † Not a Registered Rating.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.52	$^{\circ}\text{C/W}$

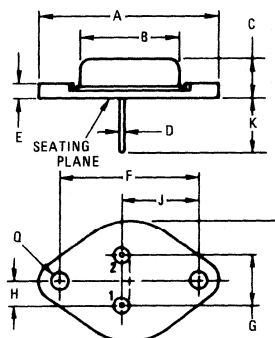
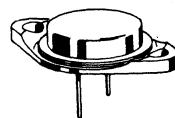
FIGURE 1 – POWER DERATING



15 AMPERE

POWER TRANSISTOR
NPN SILICON

60 VOLTS
115 WATTS



STYLE 1:

PIN 1. BASE

2. EMITTER

CASE: COLLECTOR

NOTE:

1. DIM "Q" IS DIA.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	—	39.37	—	1.550
B	—	21.08	—	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	—	3.43	—	0.135
F	28.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	—	26.67	—	1.050

CASE 11

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
* Collector-Emitter Sustaining Voltage ($I_C = 0.2 \text{ Adc}$, $I_B = 0$)	$V_{CE(sus)}$	60	—	Vdc
* Collector-Emitter Sustaining Voltage ($I_C = 0.2 \text{ Adc}$, $R_{BE} = 100 \Omega$)	$V_{CER(sus)}$	70	—	Vdc
* Collector Cutoff Current ($V_{CE} = 30 \text{ Vdc}$, $I_B = 0$)	I_{CEO}	—	0.7	mAdc
Collector Cutoff Current ($V_{CE} = 100 \text{ Vdc}$, $V_{EB(off)} = 1.5 \text{ Vdc}$) ($V_{CE} = 100 \text{ Vdc}$, $V_{EB(off)} = 1.5 \text{ Vdc}$, $T_C = 150^\circ\text{C}$)	I_{CEX}	— —	1.0 5.0	mAdc
* Emitter Cutoff Current ($V_{BE} = 7.0 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	5.0	mAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 4.0 \text{ Adc}$, $V_{CE} = 4.0 \text{ Vdc}$) ($I_C = 10 \text{ Adc}$, $V_{CE} = 4.0 \text{ Vdc}$)	h_{FE}	20 5.0	70 —	—
Collector-Emitter Saturation Voltage * ($I_C = 4.0 \text{ Adc}$, $I_B = 0.4 \text{ Adc}$) ($I_C = 10 \text{ Adc}$, $I_B = 3.3 \text{ Adc}$)	$V_{CE(sat)}$	— —	1.1 3.0	Vdc
Base-Emitter On Voltage ($I_C = 4.0 \text{ Adc}$, $V_{CE} = 4.0 \text{ Vdc}$)	$V_{BE(on)}$	—	1.5	Vdc
Second Breakdown Collector Current With Base Forward-Biased ($t = 1.0 \text{ s}$) ($V_{CE} = 40 \text{ Vdc}$)	$I_{S/b}$	2.87	—	Adc
DYNAMIC CHARACTERISTICS				
Current-Gain – Bandwidth Product ($I_C = 1.0 \text{ Adc}$, $V_{CE} = 4.0 \text{ Vdc}$, $f_{test} = 1.0 \text{ MHz}$)	f_T	2.5	—	MHz
* Small-Signal Current Gain ($I_C = 1.0 \text{ Adc}$, $V_{CE} = 4.0 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{fe}	15	120	—

*Indicates JEDEC Registered Data.

FIGURE 2 – SWITCHING TIMES TEST CIRCUIT

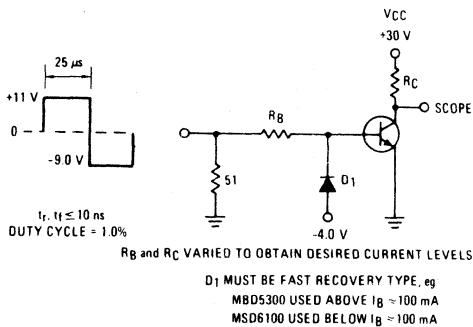


FIGURE 3 – TURN-ON TIME

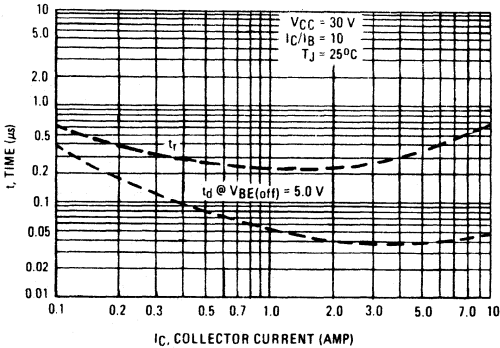
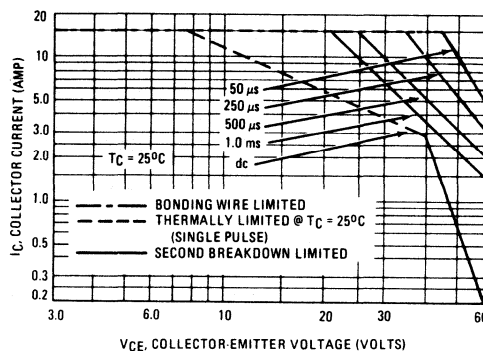


FIGURE 4 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

Second breakdown pulse limits are valid for duty cycles to 10%. At high case temperatures, thermal limitations may reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

FIGURE 5 – COLLECTOR CUT-OFF REGION

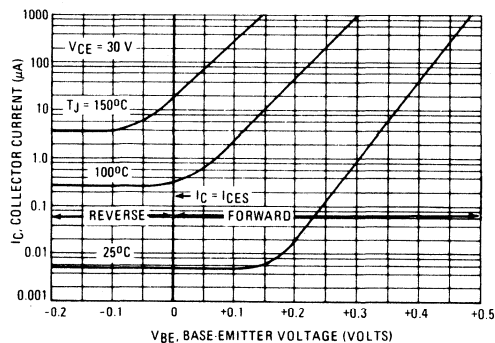


FIGURE 6 – TURN-OFF TIME

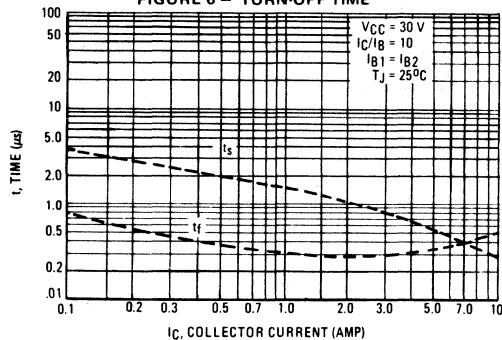


FIGURE 7 – CAPACITANCE

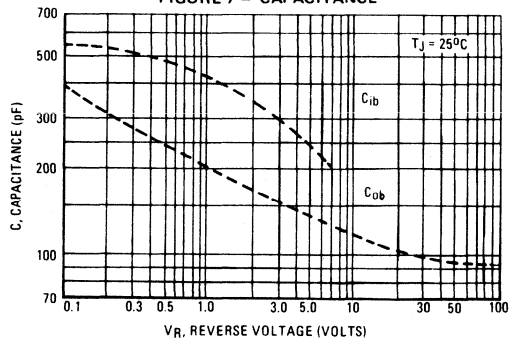


FIGURE 8 – DC CURRENT GAIN

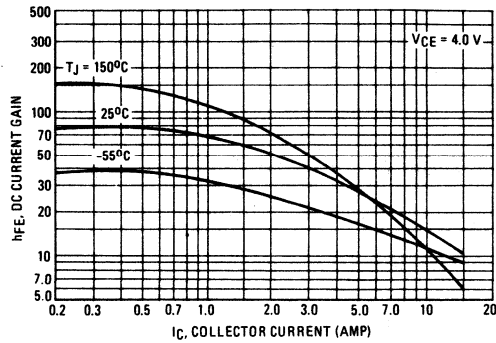


FIGURE 9 – COLLECTOR SATURATION REGION

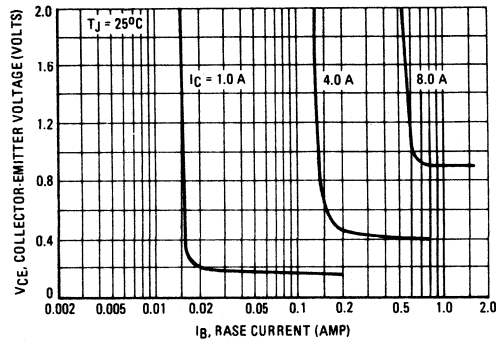
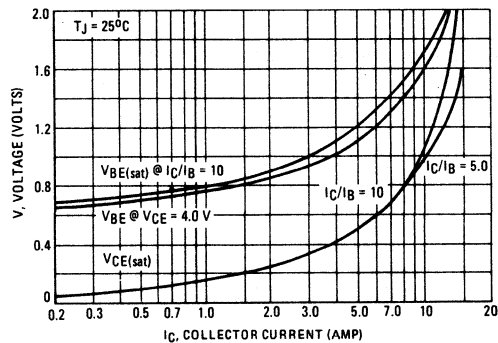


FIGURE 10 – "ON" VOLTAGES



2N3072 (SILICON)

2N3073

PNP SILICON ANNULAR TRANSISTORS

... designed for medium-speed, industrial switching applications.

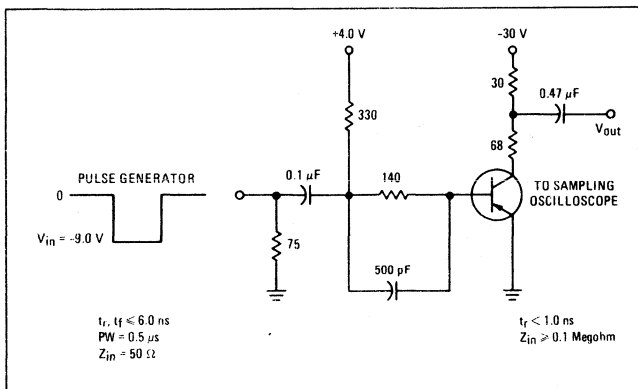
- Choice of Package and Power Ratings
- Low Collector-Emitter Saturation Voltage –
 $V_{CE(sat)} = 0.25 \text{ Vdc (Max) @ } I_C = 50 \text{ mAdc}$
- High Small-Signal Current Gain –
 $h_{fe} = 180 \text{ (Max) @ } I_C = 10 \text{ mAdc}$

*MAXIMUM RATINGS

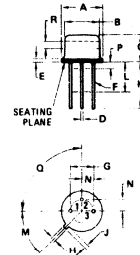
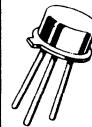
Rating	Symbol	2N3072	2N3073	Unit
Collector-Emitter Voltage	V_{CEO}	60		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current – Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	800 4.56	360 2.06	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	3.0 17.1	1.2 6.85	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

*Indicates JEDEC Registered Data.

FIGURE 1 – TURN-ON AND TURN-OFF SWITCHING TIMES TEST CIRCUIT



PNP SILICON TRANSISTORS



STYLE 1

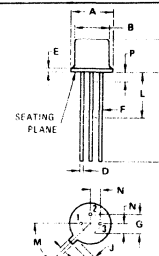
- Pin 1. Emitter
2. Base
3. Collector

DIM	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.375
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.532	0.016	0.021
E	0.228	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.111	0.864	0.004	0.034
J	0.737	1.02	0.029	0.040
K	12.70		0.500	
L	6.35		0.250	
M	45° NOM		45° NOM	
P		1.27		0.050
Q	50° NOM		50° NOM	
R	2.54		0.100	

All JEDEC dimensions and notes apply.

CASE 79-02
(TO 39)

2N3072



STYLE 1

- Pin 1. Emitter
2. Base
3. Collector

DIM	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.532	0.016	0.021
E		0.762		0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.211	1.22	0.008	0.048
K	12.70		0.500	
L	6.35		0.250	
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P		1.27		0.050

All JEDEC notes and dimensions apply.

CASE 22-03
(TO 18)

2N3073

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
----------------	--------	-----	-----	------

OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage(1) ($I_C = 30\text{ mA}$, $I_B = 0$)	BV_{CEO}	60	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\text{ }\mu\text{A}$, $I_E = 0$)	BV_{CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\text{ }\mu\text{A}$, $I_C = 0$)	BV_{EBO}	4.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 30\text{ Vdc}$, $V_{BE} = 0$) ($V_{CE} = 30\text{ Vdc}$, $V_{BE} = 0$, $T_A = 125^\circ\text{C}$)	I_{CES}	—	10 10	nAdc μAdc
Emitter Cutoff Current ($V_{EB} = 4.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	100	μAdc
Base Current ($V_{CE} = 30\text{ Vdc}$, $V_{BE} = 0$)	I_B	—	10	nAdc

ON CHARACTERISTICS

DC Current Gain(1) ($I_C = 50\text{ mA}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 50\text{ mA}$, $V_{CE} = 1.0\text{ Vdc}$, $T_A = -55^\circ\text{C}$) ($I_C = 300\text{ mA}$, $V_{CE} = 2.0\text{ Vdc}$)	h_{FE}	30 12 15	130 — —	—
Collector-Emitter Saturation Voltage ($I_C = 50\text{ mA}$, $I_B = 2.5\text{ mA}$) ($I_C = 300\text{ mA}$, $I_B = 30\text{ mA}$)	$V_{CE(sat)}$	— —	0.25 1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 50\text{ mA}$, $I_B = 2.5\text{ mA}$) ($I_C = 300\text{ mA}$, $I_B = 30\text{ mA}$)	$V_{BE(sat)}$	— —	1.2 2.0	Vdc
Base-Emitter On Voltage ($I_C = 50\text{ mA}$, $V_{CE} = 1.0\text{ Vdc}$)	$V_{BE(on)}$	—	1.2	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product(2) ($I_C = 50\text{ mA}$, $V_{CE} = 20\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	130	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 140\text{ kHz}$)	C_{ob}	—	10	pF
Input Impedance ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ie}	—	1.5	k ohms
Voltage Feedback Ratio ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{re}	—	26	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	25	180	—
Output Admittance ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{oe}	—	1200	μmhos

SWITCHING CHARACTERISTICS (Figure 1)

Turn-On Time ($I_C \approx 300\text{ mA}$, $I_{B1} \approx 30\text{ mA}$)	t_{on}	—	40	ns
Turn-Off Time ($I_C \approx 300\text{ mA}$, $I_{B1} \approx I_{B2} \approx 30\text{ mA}$)	t_{off}	—	100	ns

*Indicates JEDEC Registered Data.

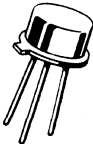
(1) Pulse Test: Pulse Width = 300 μs , Duty Cycle = 1.0%.(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

NPN SILICON ANNULAR HIGH-CURRENT
AMPLIFIER TRANSISTOR

... designed for use in medium-current amplifier applications.

- Collector-Emitter Breakdown Voltage –
BV_{CEO} = 40 Vdc (Min) @ I_C = 30 mAdc
- DC Current Gain – 100 μAdc to 500 mAdc
- Low Noise Figure –
NF = 5.0 dB (Typ) @ I_C = 30 μAdc

NPN SILICON
AMPLIFIER TRANSISTOR



*MAXIMUM RATINGS

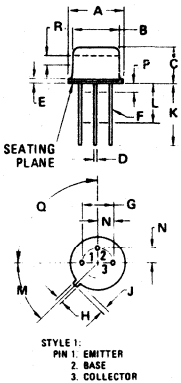
Rating	Symbol	Value	Unit
Collector-Emitter Voltage (1)	V _{CEO}	40	Vdc
Collector-Base Voltage	V _{CB}	80	Vdc
Emitter-Base Voltage	V _{EB}	7.0	Vdc
Collector Current – Continuous	I _C	1000	mAdc
Total Power Dissipation @ T _A = 25°C Derate above 25°C	P _D	800 4.57	mW mW/°C
Total Power Dissipation @ T _C = 25°C Derate above 25°C	P _D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200	°C

*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	R _{θJA} (2)	220	°C/W
Thermal Resistance, Junction to Case	R _{θJC}	35	°C/W
Lead Temperature, 1/16" ± 1/32" from Case for 60 Seconds	T _L	300	°C

*Indicates JEDEC Registered Data

- (1) Applicable for I_C = 1.0 to 50 mA
(2) R_{θJA} is measured with the device soldered into a typical printed circuit board.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° NOM	—	45° NOM	—
P	—	1.27	—	0.050
Q	90° NOM	—	90° NOM	—
R	2.54	—	0.100	—

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

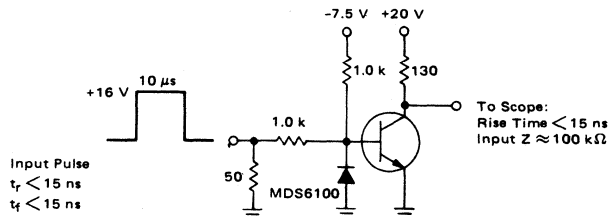
***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 30\text{ mAdc}$, $I_B = 0$)	BV_{CEO}	40	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	80	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	7.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 60\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	—	—	10	μAdc
Collector Cutoff Current ($V_{CE} = 60\text{ Vdc}$, $V_{BE} = 0$)	I_{CES}	—	—	10	nAdc
Emitter Cutoff Current ($V_{EB} = 5.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	—	10	nAdc
Base Current ($V_{CE} = 60\text{ Vdc}$, $V_{BE} = 0$)	I_B	—	—	10	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain ($I_C = 100\text{ }\mu\text{Adc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 150\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 500\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 150\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $T_A = -55^\circ\text{C}$)	h_{FE}	20 40 25 15	60 80 70 30	— 120 — —	—
Collector-Emitter Saturation Voltage ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$) ($I_C = 1.0\text{ Adc}$, $I_B = 100\text{ mAdc}$)	$V_{CE(sat)}$	— —	0.2 0.8	0.25 1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$) ($I_C = 1.0\text{ Adc}$, $I_B = 100\text{ mAdc}$)	$V_{BE(sat)}$	— —	0.8 1.2	1.1 2.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product ($I_C = 50\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 20\text{ MHz}$)	f_T	60	100	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 140\text{ kHz}$)	C_{ob}	—	15	25	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 140\text{ kHz}$)	C_{ib}	—	60	80	pF
Noise Figure ($I_C = 30\text{ }\mu\text{Adc}$, $V_{CE} = 10\text{ Vdc}$, $R_S = 1.0\text{ k}\Omega$, $f = 1.0\text{ kHz}$, $BW = 200\text{ Hz}$)	NF	—	5.0	7.0	dB
SWITCHING CHARACTERISTICS					
Turn-On Time ($V_{CC} = 20\text{ Vdc}$, $I_C = 150\text{ mAdc}$, $I_{B1} = 7.5\text{ mAdc}$) (Figure 1)	t_{on}	—	150	200	ns
Turn-Off Time ($V_{CC} = 20\text{ Vdc}$, $I_C = 150\text{ mAdc}$, $I_{B1} = I_{B2} = 7.5\text{ mAdc}$) (Figure 1)	t_{off}	—	490	600	ns

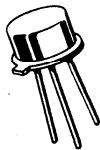
*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT

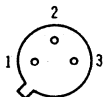


2N3114S (SILICON)



NPN silicon annular transistor designed for high-voltage, low-power video amplifier applications.

CASE 79
(TO-39)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

Collector connected to case

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	150	Vdc
Collector-Emitter Voltage ⁽¹⁾	V_{CEO}	150	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derating Factor Above 25°C	P_D	0.8 4.57	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derating Factor Above 25°C	P_D	5.0 28.6	Watts mW/ $^\circ\text{C}$
Operating Junction Temperature	T_J	200	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

(1) Between 0 and 30 mA.

*Indicates JEDEC Registered Data

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage ($I_C = 100\ \mu\text{A}$, $I_E = 0$)	BV_{CBO}	150	—	Vdc
Collector-Emitter Breakdown Voltage(1) ($I_C = 30\ \text{mA}$, $I_B = 0$)	BV_{CEO}	150	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu\text{A}$, $I_C = 0$)	BV_{EBO}	5.0	—	Vdc
Collector Saturation Voltage(1) ($I_C = 50\ \text{mA}$, $I_B = 5\ \text{mA}$)	$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 50\ \text{mA}$, $I_B = 5\ \text{mA}$)	$V_{BE(sat)}$	—	0.9	Vdc
DC Current Gain(1) ($I_C = 0.1\ \text{mA}$, $V_{CE} = 10\ \text{Vdc}$) ($I_C = 30\ \text{mA}$, $V_{CE} = 10\ \text{Vdc}$) ($I_C = 30\ \text{mA}$, $V_{CE} = 10\ \text{Vdc}$, $T_A = -55^\circ\text{C}$)	h_{FE}	15 30 12	— 120 —	—
Collector Cutoff Current ($V_{CB} = 100\ \text{Vdc}$, $I_E = 0$) ($V_{CB} = 100\ \text{Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	0.010 10	μA
Emitter Cutoff Current ($V_{EB} = 4\ \text{Vdc}$, $I_C = 0$)	I_{EBO}	—	0.10	μA
Small Signal Current Gain ($V_{CE} = 10\ \text{Vdc}$, $I_C = 30\ \text{mA}$, $f = 20\ \text{MHz}$)	$ h_{fe} $	2.0	—	—
Output Capacitance ($V_{CB} = 20\ \text{Vdc}$, $I_E = 0$, $f = 140\ \text{kHz}$)	C_{ob}	—	9.0	pF
Input Capacitance ($V_{EB} = 0.5\ \text{Vdc}$, $I_C = 0$, $f = 140\ \text{kHz}$)	C_{ib}	—	80	pF
Small Signal Current Gain ($I_C = 1.0\ \text{mA}$, $V_{CE} = 5\ \text{V}$, $f = 1\ \text{kHz}$)	h_{fe}	25	—	—
Real Part of Input Impedance ($I_C = 10\ \text{mA}$, $V_{CE} = 10\ \text{V}$, $f = 100\ \text{MHz}$)	$\text{Re}(h_{ie})$	—	30	ohms

* Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, duty cycle $\leq 1\%$

2N3116 (SILICON)

For Specifications, See 2N2959S Data

2N3120 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

... designed for general-purpose, medium-speed switching applications.

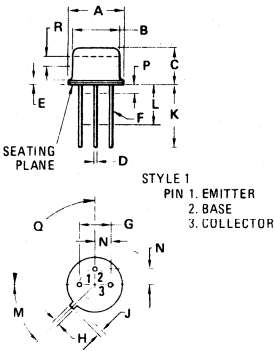
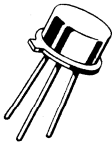
- Choice of Package and Power Ratings
- Low Collector-Emitter Saturation Voltage –
 $V_{CE(sat)} = 0.25 \text{ Vdc (Max) @ } I_C = 50 \text{ mAdc}$
- DC Current Gain Specified From 50 mAdc to 300 mAdc

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CB}	45	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	800 4.56	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	3.0 17.1	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

*Indicates JEDEC Registered Data

PNP SILICON
TRANSISTOR



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45°	NOM	45°	NOM
P	—	1.27	—	0.050
Q	90°	NOM	90°	NOM
R	2.54	—	0.100	—

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 30\text{ mA}$, $I_B = 0$)	BV_{CEO}	45	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\text{ }\mu\text{A}$, $I_E = 0$)	BV_{CBO}	45	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\text{ }\mu\text{A}$, $I_C = 0$)	BV_{EBO}	4.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 30\text{ Vdc}$, $V_{BE} = 0$) ($V_{CE} = 30\text{ Vdc}$, $V_{BE} = 0$, $T_A = 125^\circ\text{C}$)	I_{CES}	— —	10 10	nAdc μAdc
Emitter Cutoff Current ($V_{EB} = 4.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	100	μAdc
Base Current ($V_{CE} = 30\text{ Vdc}$, $V_{BE} = 0$)	I_B	—	10	nAdc

ON CHARACTERISTICS

DC Current Gain(1) ($I_C = 50\text{ mA}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 50\text{ mA}$, $V_{CE} = 1.0\text{ Vdc}$, $T_A = -55^\circ\text{C}$) ($I_C = 300\text{ mA}$, $V_{CE} = 2.0\text{ Vdc}$)	h_{FE}	30 12 15	130 — —	—
Collector-Emitter Saturation Voltage ($I_C = 50\text{ mA}$, $I_B = 2.5\text{ mA}$) ($I_C = 300\text{ mA}$, $I_B = 30\text{ mA}$) ($I_C = 500\text{ mA}$, $I_B = 50\text{ mA}$)	$V_{CE(sat)}$	— — —	0.25 0.5 1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 50\text{ mA}$, $I_B = 2.5\text{ mA}$) ($I_C = 500\text{ mA}$, $I_B = 50\text{ mA}$)	$V_{BE(sat)}$	— —	1.2 2.0	Vdc
Base-Emitter On Voltage ($I_C = 50\text{ mA}$, $V_{CE} = 1.0\text{ Vdc}$)	$V_{BE(on)}$	—	1.2	Vdc

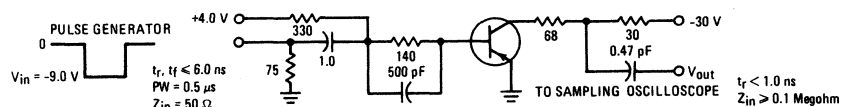
SMALL-SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product(2) ($I_C = 50\text{ mA}$, $V_{CE} = 20\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	130	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 140\text{ kHz}$)	C_{ob}	—	10	pF
Input Impedance ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ie}	—	1.5	k ohms
Voltage Feedback Ratio ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{re}	—	26	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	25	180	—
Output Admittance ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{oe}	—	1200	μmhos

SWITCHING CHARACTERISTICS (Figure 1)

Turn-On Time ($I_C \approx 300\text{ mA}$, $I_{B1} \approx 30\text{ mA}$)	t_{on}	—	40	ns
Turn-Off Time ($I_C \approx 300\text{ mA}$, $I_{B1} = I_{B2} \approx 30\text{ mA}$)	t_{off}	—	100	ns

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width = $300\text{ }\mu\text{s}$, Duty Cycle = 1.0%.(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.**FIGURE 1 – SWITCHING TIMES TEST CIRCUIT**



PNP germanium mesa transistor designed for VHF/UHF amplifier applications.

**CASE 20-03
(TO-72)**

STYLE 10
PIN 1. EMITTER
2. BASE
3. COLLECTOR
4. CASE

Active Elements Isolated From Case

* MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Emitter Voltage	V_{CES}	25	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	0.75	Vdc
Collector Current - Continuous	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	100 1.33	mW mW/ $^\circ\text{C}$
Operating & Storage Junction Temperature	T_J, T_{stg}	-65 to +100	$^\circ\text{C}$

*Indicates JEDEC Registered Data

*TABLE I - GROUP A INSPECTION ($T_A = 25^{\circ}\text{C}$ unless otherwise noted)

Examination or Test	Symbol	Limits		Unit
		Min	Max	
SUBGROUP 1				
Visual and Mechanical Examination	—	—	—	—
SUBGROUP 2				
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	25	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 2 \text{ mAdc}$, $I_B = 0$)	BV_{CEO}	20	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100 \mu\text{Adc}$, $V_{BE} = 0$)	BV_{CES}	25	—	Vdc
Collector-Base Cutoff Current ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	3.0	μAdc
Emitter-Base Cutoff Current ($V_{BE} = 0.75 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	100	μAdc
DC Current Gain ($I_C = 3 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$)	h_{FE}	20	100	—
Base-Emitter Saturation Voltage ($I_C = 5 \text{ mAdc}$, $I_B = 1 \text{ mAdc}$)	$V_{BE(sat)}$	—	0.6	Vdc
Collector-Emitter Saturation Voltage ($I_C = 5 \text{ mAdc}$, $I_B = 1 \text{ mAdc}$)	$V_{CE(sat)}$	—	0.3	Vdc
SUBGROUP 3				
Small-Signal Current Gain ($I_C = 3 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1 \text{ kHz}$)	h_{fe}	20	125	—
Current-Gain — Bandwidth Product ($I_C = 2 \text{ mAdc}$, $V_{CE} = 6 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	400	—	MHz
Collector - Base Capacitance (1) ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f \geq 0.1 \leq 1.0 \text{ MHz}$)	$C_{cb} (1)$	—	1.2	pF
SUBGROUP 4				
Collector-Base Cutoff Current ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $T_A = 85^{\circ}\text{C}$)	I_{CBO}	—	50	μAdc
DC Current Gain ($I_C = 3 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $T_A = -55^{+0}_{-3}^{\circ}\text{C}$)	h_{FE}	7.0	—	—
SUBGROUP 5				
Power Gain (Figure 1) ($I_C = 3 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $R_S = 50 \text{ ohms}$, $f = 200 \text{ MHz}$)	G_{pe}	17	25	dB
Noise Figure (Figure 1) ($I_C = 3 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $R_S = 50 \text{ ohms}$, $f = 200 \text{ MHz}$)	NF	—	5.0	dB

*Indicates JEDEC Registered Data

(1) Measured in a guarded circuit, such that the can capacitance is not included.

* TABLE II - GROUP C INSPECTION ($T_A = 25^{\circ}\text{C}$ unless otherwise noted)

Examination or Test	Symbol	Limits		Unit
		Min	Max	
SUBGROUP 1				
Collector-Base Time Constant (Figure 2) ($I_C = 3 \text{ mAdc}$, $V_{CB} = 10 \text{ Vdc}$, $f = 31.8 \text{ MHz}$)	$r_b' C_c$	—	12	ps
Salt Atmosphere (Corrosion)	—	—	—	—
<u>End-Point Tests:</u>				
Collector-Base Cutoff Current ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$)	I_{CBO}	-	3.0	μAdc
DC Current Gain ($I_C = 3 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$)	h_{FE}	20	100	—
SUBGROUP 2				
Output Conductance ($I_C = 2 \text{ mAdc}$, $V_{CE} = 6 \text{ Vdc}$, $f = 30 \text{ MHz}$)	$\text{Re}(h_{oe})$	1.0	3.5	mmhos
Input Conductance ($I_C = 2 \text{ mAdc}$, $V_{CE} = 6 \text{ Vdc}$, $f = 30 \text{ MHz}$)	$\text{Re}(y_{ie})$	1.25	5.0	mmhos

Group C tests shall be performed on the initial lot and every six months thereafter.

FIGURE 1 — TEST CIRCUIT FOR POWER GAIN AND NOISE FIGURE

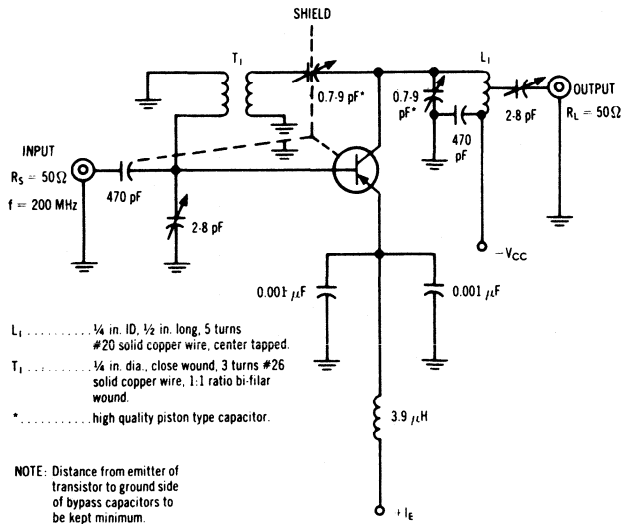
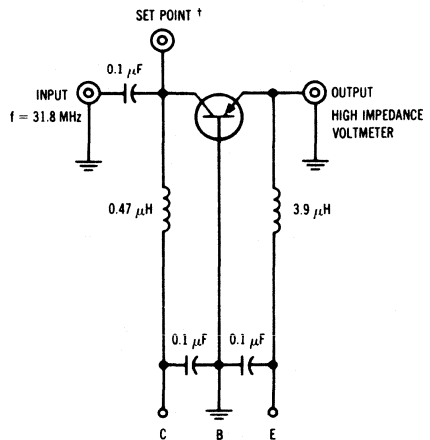
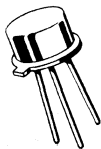


FIGURE 2 — TEST CIRCUIT FOR COLLECTOR-BASE TIME CONSTANT



† NOTE: $E_{in} = 0.5 \text{ V}$ measured at set point.
 $r_b' C_c = E_{out} (\text{in mV}) \times 10$

2N3133S, 2N3135 (SILICON)



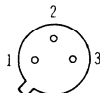
PNP silicon annular Star transistors for high-speed switching and DC to UHF amplifier applications.

CASE 79
(TO-39)

2N3133

CASE 22
(TO-18)

2N3135



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

Collector connected to case

*MAXIMUM RATINGS

Rating	Symbol	2N3133	2N3135	Unit
Collector-Base Voltage	V_{CB}	50	50	Vdc
Collector-Emitter Voltage	V_{CEO}	35	35	Vdc
Emitter-Base Voltage	V_{EB}	4.0	4.0	Vdc
Collector Current	I_C	600	600	mA
Total Device Dissipation @ 25°C Case Temperature Derate Above 25°C	P_D	3 17.3	1.8 10.3	Watts mW/°C
Total Device Dissipation @ 25°C Ambient Temperature Derate Above 25°C	P_D	0.6 3.43	0.4 2.28	Watts mW/°C
Junction Temperature	T_J	-65 to +200		°C
Storage Temperature	T_{stg}	-65 to +200		°C

*SWITCHING CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Typ	Max	Unit
Turn-On Time ($V_{CC} = 30\text{ V}$, $I_{CS} = 150\text{ mA}$, $I_{B1} = 15\text{ mA}$)	t_{on}	26	75	ns
Turn-Off Time ($V_{CC} = 6\text{ V}$, $I_{CS} = 150\text{ mA}$, $I_{B1} = I_{B2} = 15\text{ mA}$)	t_{off}	70	150	ns

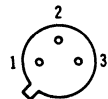
*Indicates JEDEC Registered Data

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current ($V_{CB} = 30 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 30 \text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	---	0.05 30	μAdc
Collector Cutoff Current ($V_{CE} = 30 \text{ V}$, $V_{BE} = 0.5 \text{ V}$)	I_{CEX}	---	0.1	μAdc
Base Cutoff Current ($V_{CE} = 30 \text{ V}$, $V_{BE} = 0.5 \text{ V}$)	I_{BL}	---	0.1	μAdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	50	---	Vdc
Collector-Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 10 \text{ mAdc}$, $I_B = 0$)	BV_{CEO}	35	---	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	4.0	---	Vdc
Collector Saturation Voltage ⁽¹⁾ ($I_C = 150 \text{ mAdc}$, $I_B = 15 \text{ mAdc}$)	$V_{CE}(\text{sat})$	---	0.6	Vdc
Base-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 150 \text{ mAdc}$, $I_B = 15 \text{ mAdc}$)	$V_{BE}(\text{sat})$	---	1.5	Vdc
DC Forward Current Transfer Ratio ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$) ($I_C = 150 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$) ⁽¹⁾	h_{FE}	25 40	--- 120	---
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)	C_{ob}	---	10	pF
Input Capacitance ($V_{BE} = 2 \text{ Vdc}$, $I_C = 0$, $f = 100 \text{ kHz}$)	C_{ib}	---	40	pF
Current-Gain — Bandwidth Product ($I_C = 50 \text{ mAdc}$, $V_{CE} = 20 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	200	---	MHz

⁽¹⁾ Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, duty cycle $\leq 2\%$

*Indicates JEDEC Registered Data

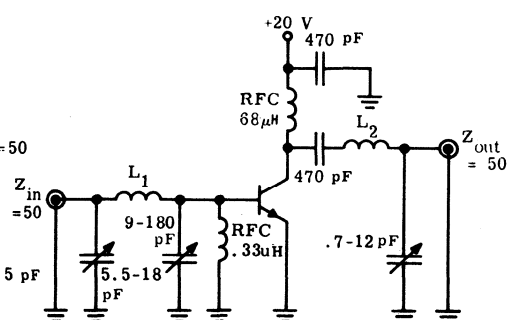
MM1803

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

NPN silicon annular transistors for large signal, VHF and UHF applications.

Rating	Symbol	2N3137	MM1803	Units
Collector-Base Voltage	V_{CB}	40	50	Vdc
Collector-Emitter Voltage	V_{CEO}	20	25	Vdc
Emitter-Base Voltage	V_{EB}	4.0	5.0	Vdc
Collector Current (Continuous)	I_C	150	150	mA dc
Power Dissipation @25° C Case Temperature @25° C Ambient Temperature	P_D	2.0 0.8		Watts
Operating Junction Temperature Storage Temperature Range	T_J , T_{stg}	-65 to +200		°C
Thermal Resistance Junction to Case	θ_{JC}	87.5		°C/ Watt
Thermal Resistance Junction to Ambient	θ_{JA}	153		°C/ Watt

250 MHz POWER GAIN TEST CIRCUIT (MM1803)



$L_1 = 3/4$ turn No. 14 tinned wire $3/8''$ ID
 $L_2 = 4$ turns No. 18 tinned wire $1/4''$ ID $7/16''$ long

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

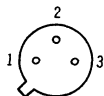
Characteristic		Symbol	Min	Typical	Max	Unit
Collector-Base Breakdown Voltage $I_C = 0.1\text{mA}$, $I_E = 0$	2N3137 MM1803	V_{CBO}	40 50			Vdc
Collector-Emitter Open Base Sus. Voltage $I_C = 15\text{mA}$, $I_B = 0$	2N3137 MM1803	$V_{CEO(sus)}$	20 25			Vdc
Collector Cutoff Current $V_{CB} = 20\text{Vdc}$, $I_E = 0$, $T_C = +150^\circ\text{C}$		I_{CBO}			50	μA
Collector Cutoff Current $V_{CB} = 20\text{Vdc}$, $I_E = 0$		I_{CBO}			.05	μA
Emitter-Base Breakdown Voltage $I_E = 100\mu\text{A}$, $I_C = 0$	2N3137 MM1803	V_{EBO}	4.0 5.0			Vdc
DC Current Gain $V_{CE} = 5\text{Vdc}$, $I_C = 50\text{mA}$	2N3137 MM1803	h_{FE}	20 40		120 160	
Collector-Emitter Saturation Voltage $I_C = 50\text{mA}$, $I_E = 5\text{mA}$		$V_{CE(sat)}$			0.3	Vdc
Small Signal Current Gain $V_{CE} = 10\text{Vdc}$, $I_C = 50\text{mA}$, $f = 100\text{ MHz}$		$ h_{fe} $	5.0			
Common-base Output Capacitance $V_{CB} = 10\text{Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$		C_{ob}			3.5	pF
Power Output		P_{out}	400	600		mWatts
Power Gain $P_{in} = 100\text{mw}$, $f = 250\text{ MHz}$	2N3137	G_e	6.0	7.7		dB
Efficiency $V_{CE} = 20\text{Vdc}$		η	40	65		%
Power Output		P_{out}	560	700		mWatts
Power Gain $P_{in} = 100\text{mw}$, $f = 250\text{ MHz}$	MM1803	G_e	7.5	8.5		db
Efficiency $V_{CE} = 20\text{V}$		η	45	60		%

*Pulse Width $\approx 300\ \mu\text{s}$, Duty cycle = 1%

2N3210 (SILICON)



CASE 22
(TO-18)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

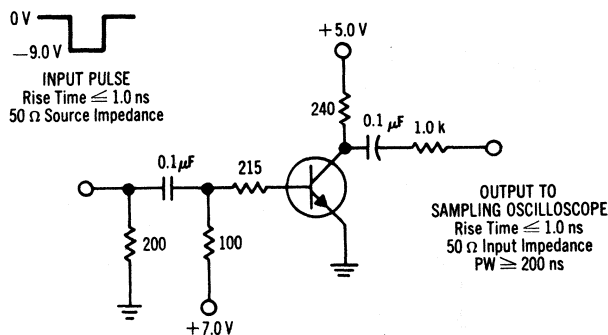
NPN silicon high frequency switching transistor is designed for high speed, saturated switching applications for industrial service.

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage Applicable from 0 to 500 mAdc	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.36 2.06	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.2 6.9	Watts mW/ $^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

*Indicates JEDEC Registered Data

FIGURE 1 — STORAGE TIME TEST CIRCUIT



2N3210 (continued)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage ⁽¹⁾ ($I_C = 30 \text{ mA}$, $I_B = 0$)	$BV_{CEO(sus)}$	15	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 2.0 \text{ }\mu\text{A}$, $I_E = 0$)	BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \text{ }\mu\text{A}$, $I_C = 0$)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current ($V_{CE} = 20 \text{ Vdc}$, $V_{EB(off)} = 3.0 \text{ Vdc}$)	I_{CEX}	-	25	nA
Collector Cutoff Current ($V_{CB} = 20 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 20 \text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	-	0.010 15	μA
Emitter Cutoff Current ($V_{EB} = 2.0 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	-	100	nA
Base Cutoff Current ($V_{CE} = 20 \text{ Vdc}$, $V_{EB(off)} = 3.0 \text{ Vdc}$)	I_{BL}	-	0.025	μA

ON CHARACTERISTICS

DC Current Gain ⁽¹⁾ ($I_C = 10 \text{ mA}$, $V_{CE} = 1.0 \text{ Vdc}$)	h_{FE}	30	120	-
Collector-Emitter Saturation Voltage ($I_C = 20 \text{ mA}$, $I_B = 2.0 \text{ mA}$, $T_A = +125^\circ\text{C}$) ($I_C = 200 \text{ mA}$, $I_B = 20 \text{ mA}$)	$V_{CE(sat)}$	- -	0.25 0.75	Vdc
Base-Emitter Saturation Voltage ($I_C = 10 \text{ mA}$, $I_B = 1.0 \text{ mA}$) ($I_C = 200 \text{ mA}$, $I_B = 20 \text{ mA}$)	$V_{BE(sat)}$	0.7 -	0.8 1.5	Vdc

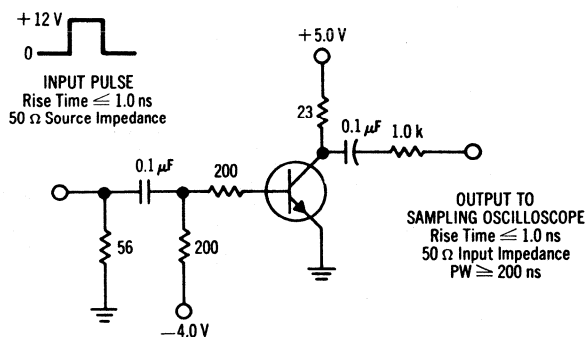
DYNAMIC CHARACTERISTICS

Current-Gain - Bandwidth Product ($I_C = 20 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	300	-	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)	C_{ob}	-	6.0	pF
Turn-On Time ($V_{BE(off)} \approx 0.2 \text{ Vdc}$, $I_C = 200 \text{ mA}$, $I_{B1} = 40 \text{ mA}$) (Figure 2)	t_{on}	-	40	ns
Turn-Off Time ($I_C = 200 \text{ mA}$, $I_{B1} = 40 \text{ mA}$, $I_{B2} = 20 \text{ mA}$) (Figure 2)	t_{off}	-	40	ns
Storage Time ($I_C \approx I_{B1} \approx I_{B2} \approx 20 \text{ mA}$) (Figure 1)	t_s	-	20	ns

* Indicates JEDEC Registered Data

⁽¹⁾ Pulse Test: Pulse Width $\leq 300 \text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.

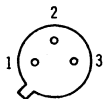
FIGURE 2 — TURN-ON AND TURN-OFF TEST CIRCUIT



2N3211 (SILICON)



CASE 22
(TO-18)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

NPN silicon high frequency switching transistor designed for high speed, saturated switching applications for industrial service.

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$	P_D	0.36	Watt
Derate above 25°C		2.06	mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$	P_D	1.2	Watts
Derate above 25°C		6.9	mW/ $^\circ\text{C}$
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 30 \text{ mAdc}, I_B = 0$)	BV_{CEO}	15	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \text{ } \mu\text{Adc}, I_E = 0$)	BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \text{ } \mu\text{Adc}, I_C = 0$)	BV_{EBO}	6.0	-	Vdc
Collector Cutoff Current ($V_{CE} = 20 \text{ Vdc}, V_{EB(off)} = 3.0 \text{ Vdc}$)	I_{CEX}	-	25	nAdc
Base Cutoff Current ($V_{CE} = 20 \text{ Vdc}, V_{EB(off)} = 3.0 \text{ Vdc}$) ($V_{CE} = 20 \text{ Vdc}, V_{EB(off)} = 3.0 \text{ Vdc}, T_A = 85^\circ\text{C}$)	I_{BL}	-	0.025 10	μAdc

ON CHARACTERISTICS

DC Current Gain ⁽¹⁾ ($I_C = 100 \text{ } \mu\text{Adc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 1.0 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}, T_A = -55^\circ\text{C}$) ($I_C = 50 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 100 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 500 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	20 50 50 20 40 30 10	- - 150 - - - -	-
Collector-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$) ($I_C = 50 \text{ mAdc}, I_B = 5.0 \text{ mAdc}$) ($I_C = 100 \text{ mAdc}, I_B = 10 \text{ mAdc}$)	$V_{CE(sat)}$	- - -	0.2 0.3 0.4	Vdc
Base-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 10 \text{ mAdc}, I_B = 1.0 \text{ mAdc}$) ($I_C = 50 \text{ mAdc}, I_B = 5.0 \text{ mAdc}$) ($I_C = 100 \text{ mAdc}, I_B = 10 \text{ mAdc}$)	$V_{BE(sat)}$	- - -	0.85 1.0 1.2	Vdc

⁽¹⁾ Pulse Test: Pulse Width $\leq 300 \text{ } \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

* Indicates JEDEC Registered Data

2N3211 (continued)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
DYNAMIC CHARACTERISTICS				
Current-Gain - Bandwidth Product ($I_C = 10\text{ mA dc}$, $V_{CE} = 20\text{ V dc}$, $f = 100\text{ MHz}$)	f_T	350	-	MHz
Output Capacitance ($V_{CB} = 10\text{ V dc}$, $I_E = 0$, $f = 100\text{ kHz}$)	C_{ob}	-	4.0	pF
Input Capacitance ($V_{BE} = 0.5\text{ V dc}$, $I_C = 0$, $f = 100\text{ kHz}$)	C_{ib}	-	7.0	pF
Charge-Storage Time Constant ($I_C \approx I_{B1} \approx I_{B2} = 10\text{ mA dc}$) (Figure 1)	τ_s	-	15	ns
Total Control Charge ($I_C = 10\text{ mA dc}$, $I_B = 1.0\text{ mA dc}$) (Figure 2)	Q_T	-	60	pC
Active Region Time Constant ($I_C = 10\text{ mA dc}$, $I_B = 1.0\text{ mA dc}$) (Figure 3)	τ_A	-	2.5	ns

* Indicates JEDEC Registered Data

FIGURE 1 — CHARGE STORAGE TIME CONSTANT TEST CIRCUIT

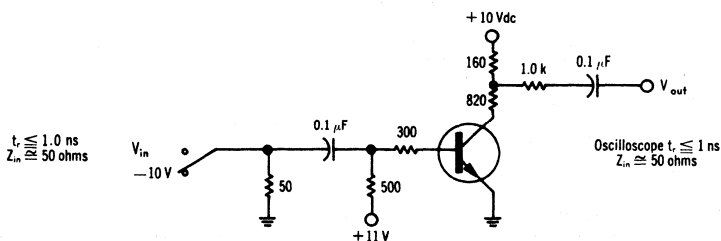


FIGURE 2 — TOTAL CONTROL CHARGE TEST CIRCUIT

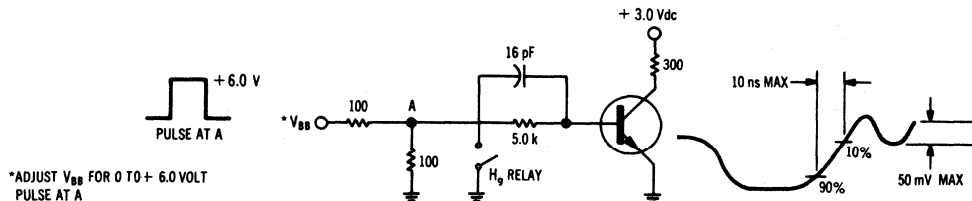
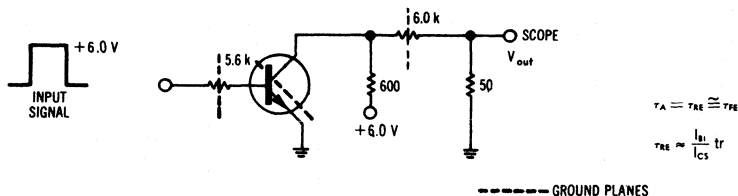


FIGURE 3 — ACTIVE REGION TIME CONSTANT TEST CIRCUIT

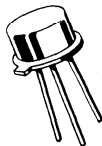


NOTES FOR FIGURES 2, 3

INPUT PULSE — TRANSITION TIME TO +6.0 Vdc $\leq 2.0\text{ ns}$
INPUT PULSE — OPTIONAL GENERATOR OUTPUT IMPEDANCE: ADJUST FOR +6.0 Vdc
SCOPE INPUT CAPACITANCE = 3.0 pF MAX
SCOPE INPUT IMPEDANCE = 10 MEGOHMS
SCOPE RISE TIME $\leq 0.7\text{ ns}$

2N3244S(SILICON)

2N3245S



CASE 79
(TO-39)

Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

PNP silicon annular transistors for medium-current, high-speed switching and driver applications.

***MAXIMUM RATINGS**

Rating	Symbol	2N 3244	2N 3245	Unit
Collector-Base Voltage	V_{CB}	40	50	Vdc
Collector-Emitter Voltage	V_{CEO}	40	50	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	1.0		Adc
Total Device Dissipation @ 25° C Ambient Temperature Derating Factor Above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ 25° C Case Temperature Derating Factor Above 25°C	P_D	5.0 28.6		Watts mW/°C
Junction Temperature, Operating	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
Thermal Resistance, Junction to Ambient Thermal Resistance, Junction to Case	θ_{JA} θ_{JC}	0.175 35		°C/mW °C/W

*Indicates JEDEC Registered Data

2N3244S, 2N3245S (continued)

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
Collector Cutoff Current ($V_{CB} = 30 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 30 \text{ Vdc}$, $I_E = 0$, $T_A = 100^\circ\text{C}$)			I_{CBO}	— —	.050 10	μAdc
Collector Cutoff Current ($V_{CE} = 30 \text{ Vdc}$, $V_{BE(off)} = 3 \text{ Vdc}$)			I_{CEX}	—	50	nAdc
Emitter-Base Leakage Current ($V_{EB} = 3 \text{ Vdc}$, $I_C = 0$)			I_{EBO}	—	30	nAdc
Base Cutoff Current ($V_{CE} = 30 \text{ Vdc}$, $V_{BE(off)} = 3 \text{ Vdc}$)			I_{BL}	—	80	nAdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}$, $I_E = 0$)		2N3244 2N3245	BV_{CBO}	40 50	— —	Vdc
Collector-Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 10 \text{ mAdc}$, $I_B = 0$)		2N3244 2N3245	BV_{CEO}	40 50	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}$, $I_C = 0$)			BV_{EBO}	5.0	—	Vdc
Collector Saturation Voltage ⁽¹⁾ ($I_C = 150 \text{ mAdc}$, $I_B = 15 \text{ mAdc}$) ($I_C = 500 \text{ mAdc}$, $I_B = 50 \text{ mAdc}$) ($I_C = 1 \text{ Adc}$, $I_B = 100 \text{ mAdc}$)		2,3	$V_{CE(sat)}$	— — — — — —	0.3 0.35 0.5 0.6 1.0 1.2	Vdc
Base-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 150 \text{ mAdc}$, $I_B = 15 \text{ mAdc}$) ($I_C = 500 \text{ mAdc}$, $I_B = 50 \text{ mAdc}$) ($I_C = 1 \text{ Adc}$, $I_B = 100 \text{ mAdc}$)		3	$V_{BE(sat)}$	— 0.75 —	1.1 1.5 2.0	Vdc
DC Forward Current Transfer Ratio ⁽¹⁾ ($I_C = 150 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 500 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 1 \text{ Adc}$, $V_{CE} = 5 \text{ Vdc}$)		1	h_{FE}	60 35 50 30 25 20	— — 150 90 — —	—
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)		5	C_{ob}	—	25	pF
Input Capacitance ($V_{OB} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 100 \text{ kHz}$)		5	C_{ib}	—	100	pF
Current-Gain - Bandwidth Product ($I_C = 50 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 100 \text{ MHz}$)		2N3244 2N3245	f_T	175 150	— —	MHz
Delay Time	$(I_C = 500 \text{ mA}$, $I_{B1} = 50 \text{ mA}$ $V_{OB} = 2 \text{ V}$, $V_{CC} = 30 \text{ V})$	6,8	t_d	—	15	ns
Rise Time			t_r	— —	35 40	ns
Storage Time	$(I_C = 500 \text{ mA}$, $V_{CC} = 30 \text{ V}$ $I_{B1} = I_{B2} = 50 \text{ mA})$	6,9	t_s	—	140 120	ns
Fall Time			t_f	—	45	ns
Total Control Charge ($I_C = 500 \text{ mA}$, $I_B = 50 \text{ mA}$, $V_{CC} = 30 \text{ V}$)		7,10	Q_T	— —	14 12	nC

⁽¹⁾ Pulse Test: $PW \leq 300 \mu\text{s}$, Duty Cycle $\leq 2\%$

*Indicates JEDEC Registered Data

FIGURE 1 — MINIMUM CURRENT GAIN CHARACTERISTICS

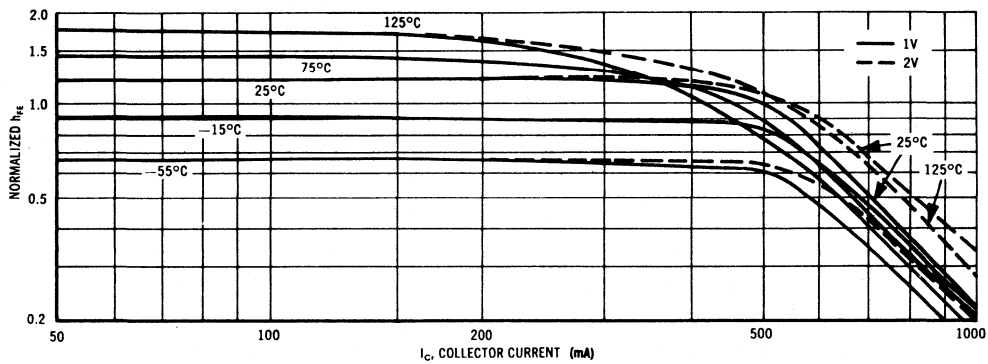


FIGURE 2 — COLLECTOR-EMITTER SATURATION VOLTAGE CHARACTERISTICS

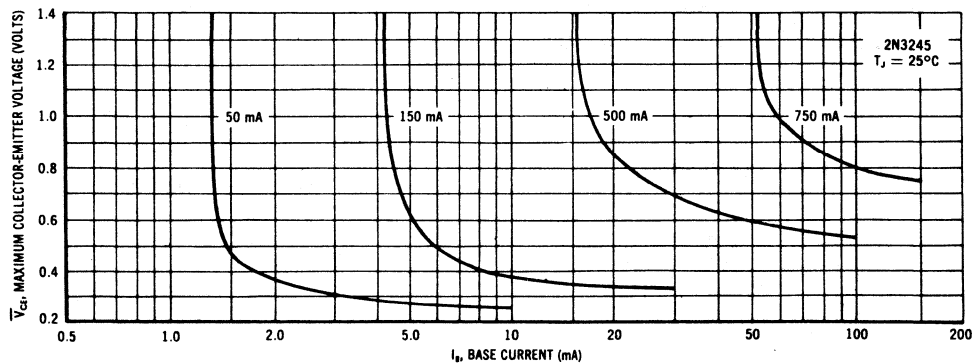
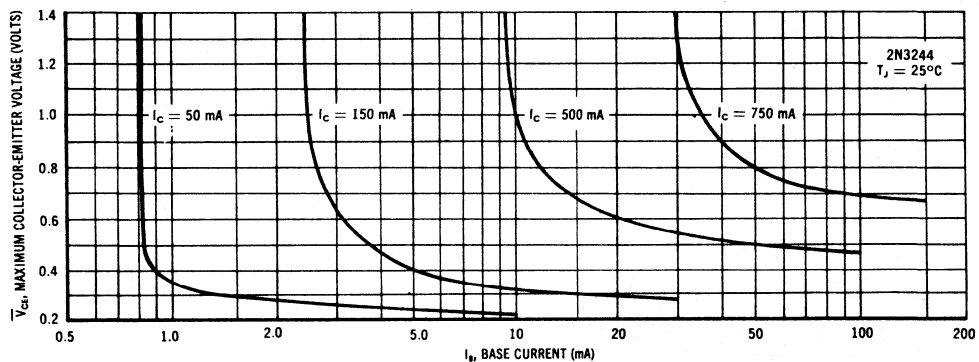


FIGURE 3 — MAXIMUM SATURATION VOLTAGES

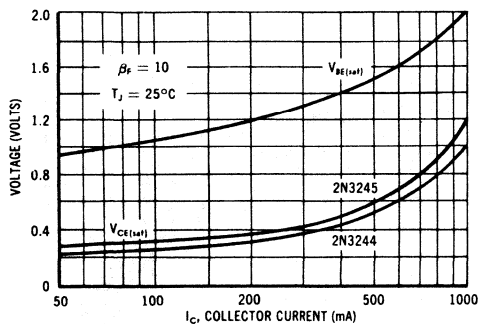


FIGURE 4 — TYPICAL TEMPERATURE COEFFICIENTS

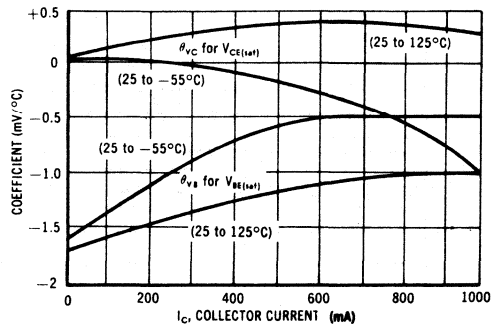


FIGURE 5 — JUNCTION CAPACITANCE

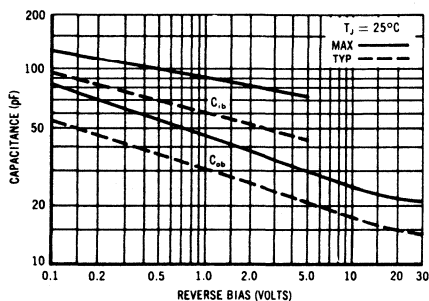


FIGURE 6 — TYPICAL SWITCHING TIMES

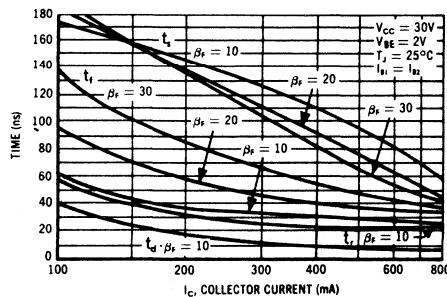


FIGURE 7 — CHARGE DATA

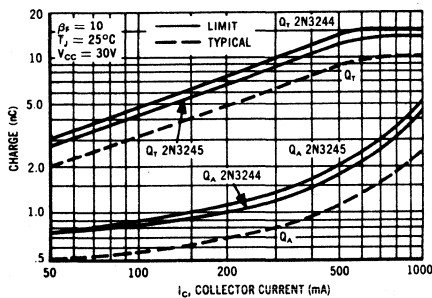


FIGURE 8 — TURN-ON EQUIVALENT TEST CIRCUIT

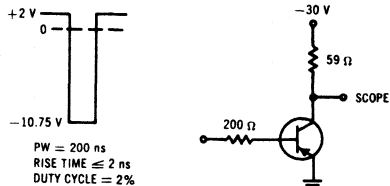


FIGURE 9 — TURN-OFF EQUIVALENT TEST CIRCUIT

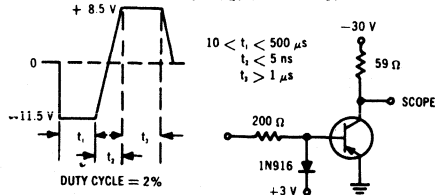


FIGURE 10 — Q_T TEST CIRCUIT

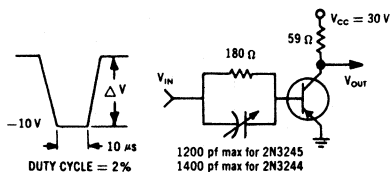
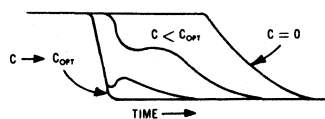
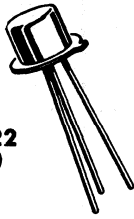


FIGURE 11 — TURN-OFF WAVEFORM

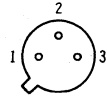


2N3248 (SILICON)

2N3249



CASE 22
(TO-18)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

PNP silicon annular transistors for low-level, high-speed switching applications.

Collector connected to case

***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	15	Vdc
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation @ 25°C Ambient Temperature Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ 25°C Case Temperature Derate above 25°C	P_D	1.2 6.9	Watts mW/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

* Indicates JEDEC Registered Data

FIGURE 1 - t_{on} CIRCUIT

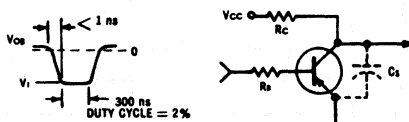
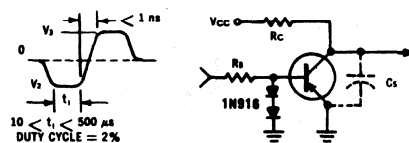


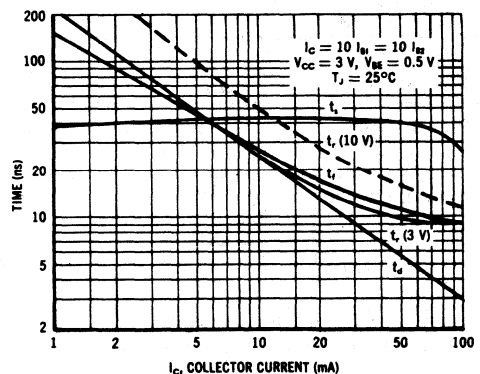
FIGURE 2 - t_{off} CIRCUIT



I_C mA	V_{CC} volts	R_B ohms	R_C ohms	$C_{S(max)}$ pF	V_{CE} volts	V_1 volts	V_2 volts	V_3 volts
10	3	10 K	285	4	+0.5	-10.6	-10.9	+9.1
100	10	1 K	95	12	+0.5	-10.7	-11.3	+8.7

*Total shunt capacitance of test jig and connectors.

FIGURE 3 - TYPICAL SWITCHING TIMES



2N3248, 2N3249 (Continued)

* ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Fig.No.	Symbol	Min	Max	Unit
Collector-Cutoff Current ($V_{CE} = 10\text{ Vdc}$, $V_{BE(off)} = 1\text{ Vdc}$, ($V_{CE} = 10\text{ Vdc}$, $V_{BE(off)} = 1\text{ Vdc}$, $T_A = 100^\circ\text{C}$)		I_{CEX}	— —	0.05 5.0	μAdc
Base Cutoff Current ($V_{CE} = 10\text{ Vdc}$, $V_{BE(off)} = 1\text{ Vdc}$)		I_{BL}	—	50	nAdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $I_E = 0$)		BV_{CBO}	15	—	Vdc
Collector-Emitter Breakdown Voltage ⁽¹⁾ : ($I_C = 10\text{ mAdc}$, $I_B = 0$)		BV_{CEO}	12	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{Adc}$, $I_C = 0$)		BV_{EBO}	5.0	—	Vdc
Collector Saturation Voltage ⁽¹⁾ : ($I_C = 10\text{ mAdc}$, $I_B = 1\text{ mAdc}$) ($I_C = 50\text{ mAdc}$, $I_B = 5\text{ mAdc}$) ($I_C = 100\text{ mAdc}$, $I_B = 10\text{ mAdc}$)	7,8 2N3248 2N3249	$V_{CE(sat)}$	— — — —	0.125 0.25 0.4 0.45	Vdc
Base-Emitter Saturation Voltage ⁽¹⁾ : ($I_C = 10\text{ mAdc}$, $I_B = 1\text{ mAdc}$) ($I_C = 50\text{ mAdc}$, $I_B = 5\text{ mAdc}$) ($I_C = 100\text{ mAdc}$, $I_B = 10\text{ mAdc}$)	8	$V_{BE(sat)}$	0.6 — 0.7	0.9 1.1 1.3	Vdc
DC Current Gain ⁽¹⁾ : ($I_C = 0.1\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$) ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$) ($I_C = 50\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$) ($I_C = 100\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$)	4 2N3248 2N3249 2N3248 2N3249 2N3248 2N3249 2N3248 2N3249 2N3248 2N3249	h_{FE}	50 100 50 100 50 100 35 75 25 35	— — — — 150 300 — — — —	—
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)	6	C_{ob}	—	8.0	pF
Input Capacitance ($V_{BE} = 1\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)	6	C_{ib}	—	8.0	pF
Current-Gain — Bandwidth Product ($I_C = 20\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	2N3248 2N3249	f_T	250 300	— —	MHz
Total Control Charge ($I_C = 10\text{ mA}$, $I_B = 0.25\text{ mA}$, $V_{CC} = 3\text{ V}$)	5,10	Q_T	—	150	pC
Delay Time	1,3	t_d	—	5.0	ns
Rise Time		t_r	—	15	ns
Storage Time	2,3	t_s	—	60	ns
Fall Time		t_f	—	20	ns
Turn-On Time	1,3	t_{on}	—	90	ns
Turn-Off Time	2,3	t_{off}	—	100	ns

* Indicates JEDEC Registered Data

⁽¹⁾ Pulse Test: PW = 300 μs , Duty Cycle $\leq 2\%$

FIGURE 4 — MINIMUM CURRENT GAIN CHARACTERISTICS

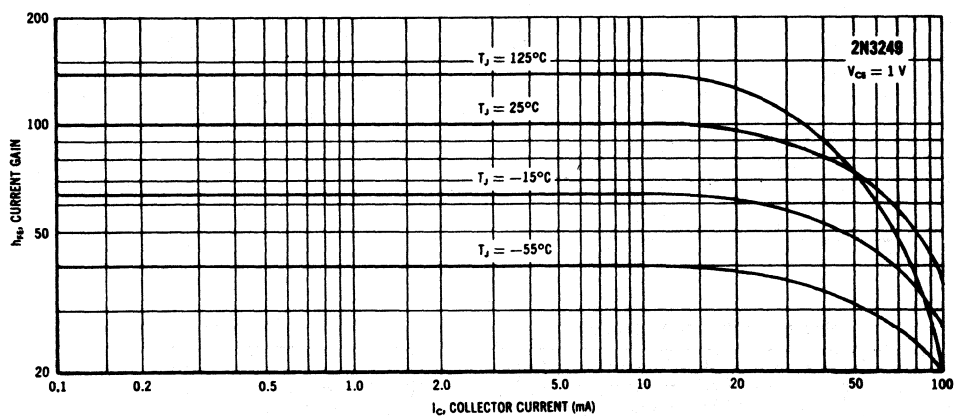
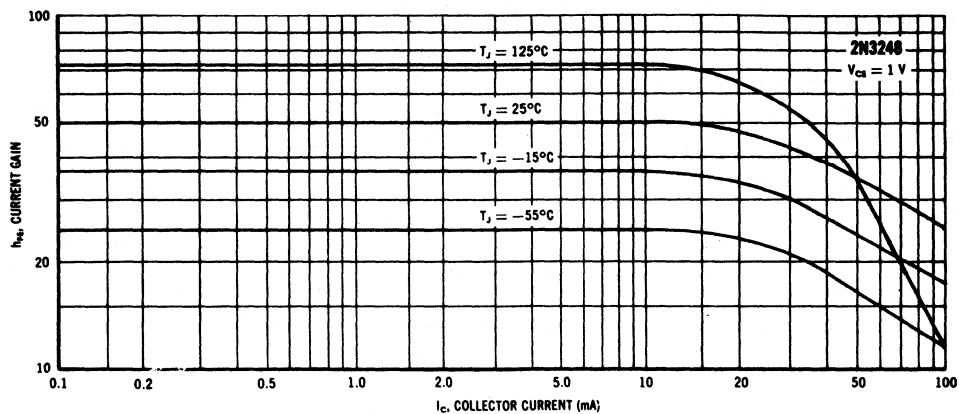


FIGURE 6 — JUNCTION CAPACITANCE

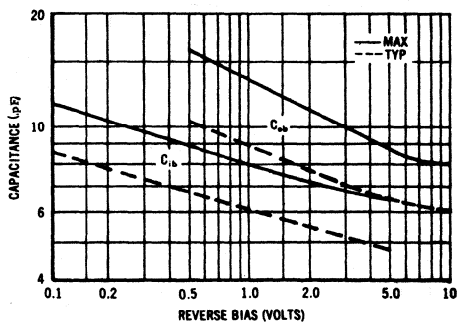


FIGURE 7 COLLECTOR SATURATION VOLTAGE CHARACTERISTICS

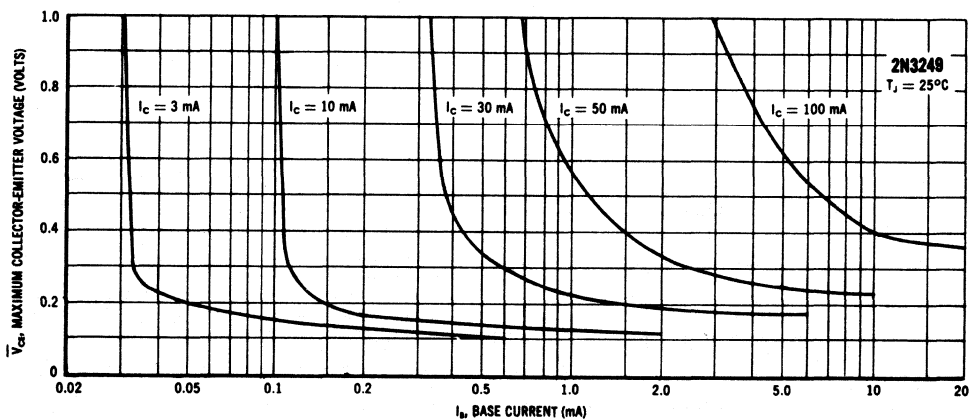
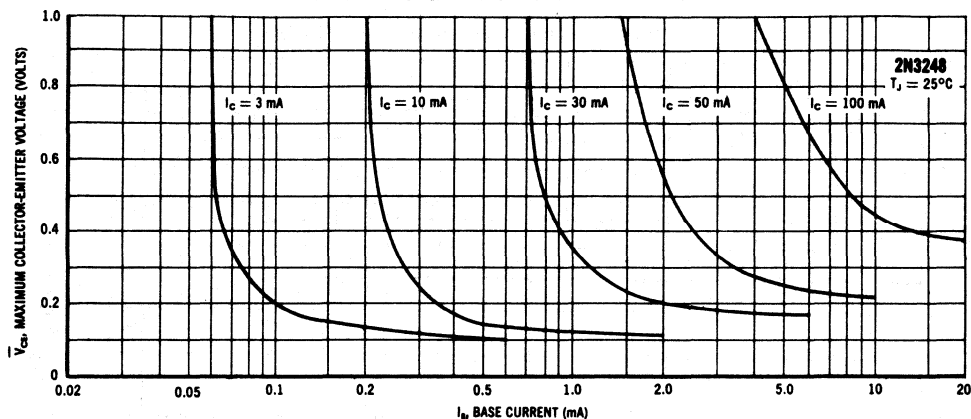


FIGURE 8 — SATURATION VOLTAGE LIMITS

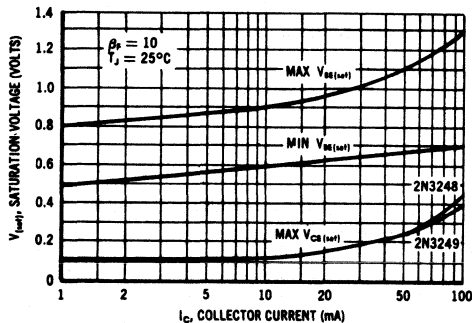


FIGURE 9 — TYPICAL TEMPERATURE COEFFICIENTS

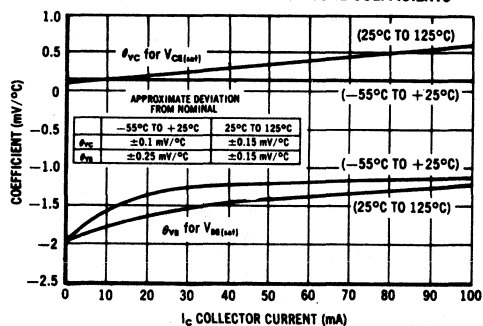


FIGURE 10 — Q_T TEST CIRCUIT

VALUES REFER TO I_c = 10 mA TEST POINT

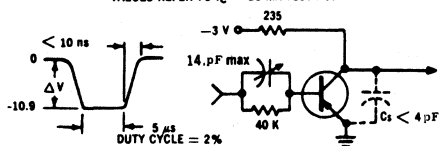
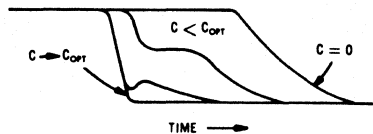


FIGURE 11 — TURN-OFF WAVE FORM

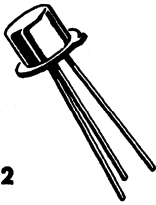


2N3250, A (SILICON)

2N3251, A

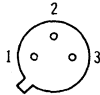
2N3250A JAN, JTX, JTXV AVAILABLE

2N3251A JAN, JTX AVAILABLE



PNP silicon annular transistors for high-speed switching and amplifier applications.

CASE 22
(TO-18)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

Collector connected to case

*** MAXIMUM RATINGS**

Rating	Symbol	2N3250 2N3251	2N3250A 2N3251A	Unit
Collector-Base Voltage	V_{CB}	50	60	Vdc
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	200		mAdc
Total Device Dissipation @ 25°C Case Temperature Derating Factor Above 25°C	P_D	1.2 6.9		Watts mW/°C
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor Above 25°C	P_D	0.36 2.06		Watts mW/°C
Junction Operating Temperature	T_J	200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
Thermal Resistance, Junction to Ambient Thermal Resistance, Junction to Case	θ_{JA} θ_{JC}	0.49 0.15		°C/mW °C/mW

*Indicates JEDEC Registered Data

2N3250, A, 2N3251, A (Continued)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current ($V_{CE} = 40 \text{ Vdc}$, $V_{BE(\text{off})} = 3 \text{ Vdc}$)	I_{CEX}	--	30	nAde
Base Cutoff Current ($V_{CE} = 40 \text{ Vdc}$, $V_{BE(\text{off})} = 3 \text{ Vdc}$)	I_{BL}	--	50	nAde
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Ade}$)	BV_{CBO}	50 60	--	Vdc
Collector-Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 10 \text{ mAde}$)	BV_{CEO}	40 60	--	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Ade}$)	BV_{EBO}	5.0	--	Vdc
Collector Saturation Voltage ⁽¹⁾ ($I_C = 10 \text{ mAde}$, $I_B = 1 \text{ mAde}$)	$V_{CE(\text{sat})}$	--	0.25	Vdc
		--	0.5	
Base-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 10 \text{ mAde}$, $I_B = 1 \text{ mAde}$)	$V_{BE(\text{sat})}$	0.6	0.9	Vdc
		--	1.2	
DC Forward Current Transfer Ratio ⁽¹⁾ ($I_C = 0.1 \text{ mAde}$, $V_{CE} = 1 \text{ Vdc}$)	h_{FE}	40 80	--	--
		45	--	
($I_C = 1 \text{ mAde}$, $V_{CE} = 1 \text{ Vdc}$)		90	--	
($I_C = 10 \text{ mAde}$, $V_{CE} = 1 \text{ Vdc}$)		50 100	150 300	
($I_C = 50 \text{ mAde}$, $V_{CE} = 1 \text{ Vdc}$)		15 30	--	
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)	C_{ob}	--	6.0	pF
Input Capacitance ($V_{CB} = 1 \text{ Vdc}$, $I_C = 0$, $f = 100 \text{ kHz}$)	C_{ib}	--	8.0	pF
Current-Gain - Bandwidth Product ($I_C = 10 \text{ mAde}$, $V_{CE} = 20 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	250 300	--	MHz

SMALL SIGNAL CHARACTERISTICS

Characteristic	Symbol	Min	Max	Unit
Small Signal Current Gain ($I_C = 1.0 \text{ mA}$, $V_{CE} = 10 \text{ V}$, $f = 1 \text{ kHz}$)	h_{fe}	50 100	200 400	--
Voltage Feedback Ratio ($I_C = 1.0 \text{ mA}$, $V_{CE} = 10 \text{ V}$, $f = 1 \text{ kHz}$)	h_{re}	-- --	10 20	$\times 10^{-4}$
Input Impedance ($I_C = 1.0 \text{ mA}$, $V_{CE} = 10 \text{ V}$, $f = 1 \text{ kHz}$)	h_{ie}	1.0 2.0	6.0 12	kohms
Output Admittance ($I_C = 1.0 \text{ mA}$, $V_{CE} = 10 \text{ V}$, $f = 1 \text{ kHz}$)	h_{oe}	4.0 10	40 60	$\mu\text{ mhos}$
Collector-Base Time Constant ($I_C = 10 \text{ mA}$, $V_{CE} = 20 \text{ V}$)	r'_{bcC}	--	250	ps
Noise Figure ($I_C = 100 \mu\text{A}$, $V_{CE} = 5 \text{ V}$, $R_s = 1 \text{ k}\Omega$, $f = 100 \text{ Hz}$)	NF	--	6.0	dB

* Indicates JEDEC Registered Data

⁽¹⁾ Pulse Test: $PW = 300 \mu\text{s}$, Duty Cycle = 2%

SWITCHING CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic			Symbol	Max	Unit
Delay Time	(V _{CC} = 3 Vdc, V _{BE} = 0.5 Vdc I _C = 10 mA, I _{B1} = 1 mA)		t _d	35	ns
Rise Time			t _r	35	ns
Storage Time	(I _{B1} = I _{B2} = 1 mA, V _{CC} = 3V)	2N3250, 2N3250A	t _s	175	ns
		2N3251, 2N3251A		200	
Fall Time			t _f	50	ns

SWITCHING TIME CHARACTERISTICS

FIGURE 1 — DELAY AND RISE TIME

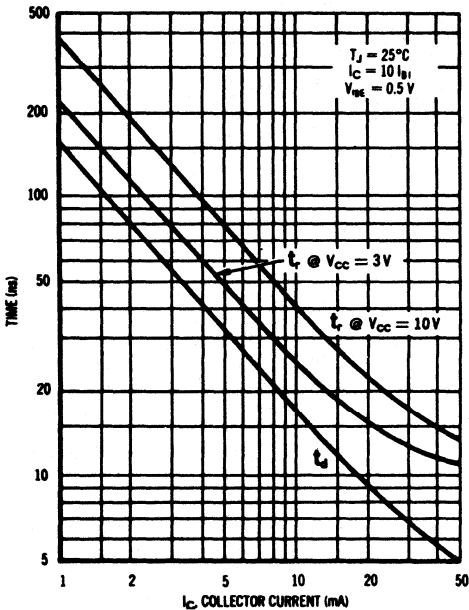
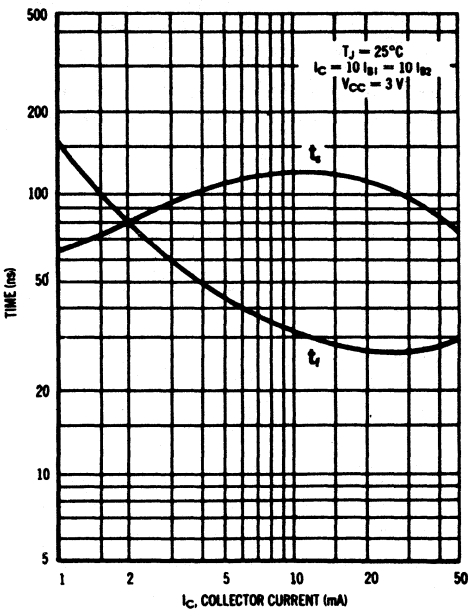


FIGURE 2 — STORAGE AND FALL TIME



AUDIO SMALL SIGNAL CHARACTERISTICS
NOISE FIGURE VARIATIONS
 $(V_{CE} = 6V, T_A = 25^\circ C)$

FIGURE 3 — FREQUENCY

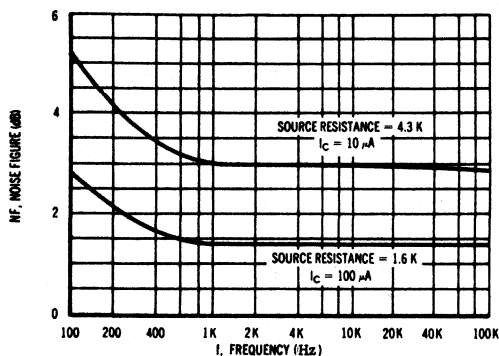
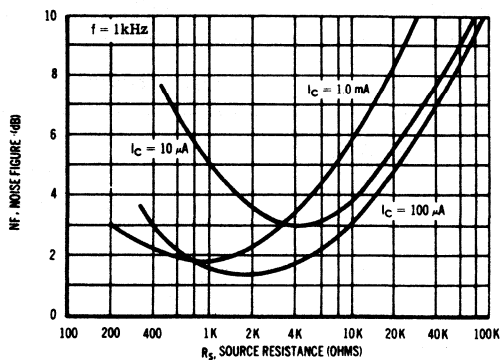


FIGURE 4 — SOURCE RESISTANCE



h PARAMETERS

$V_{CE} = 10V, f = 1kHz, T_A = 25^\circ C$

FIGURE 5 — CURRENT GAIN

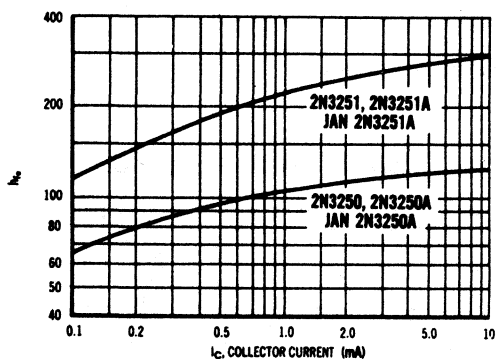


FIGURE 6 — OUTPUT ADMITTANCE

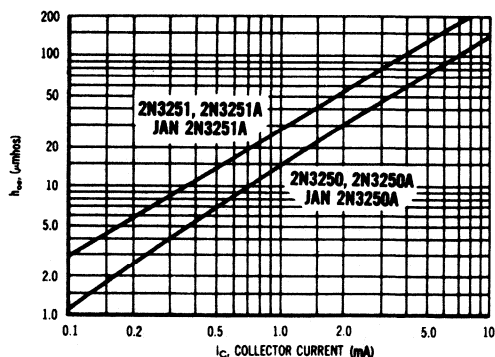


FIGURE 7 — VOLTAGE FEEDBACK RATIO

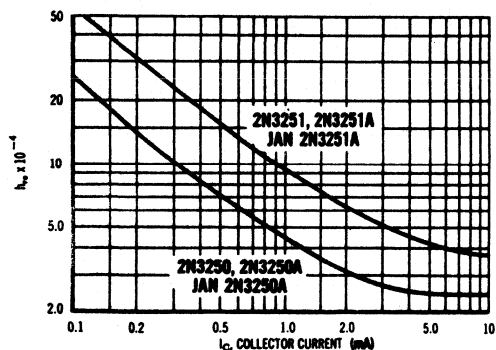


FIGURE 8 — INPUT IMPEDANCE

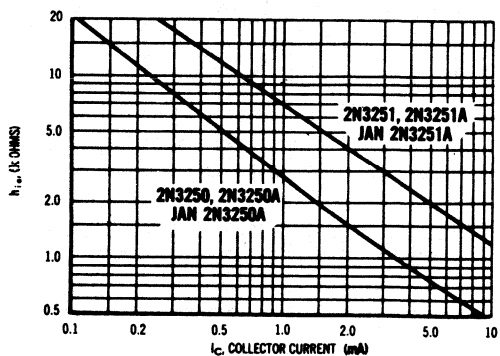


FIGURE 9 — NORMALIZED CURRENT GAIN CHARACTERISTICS

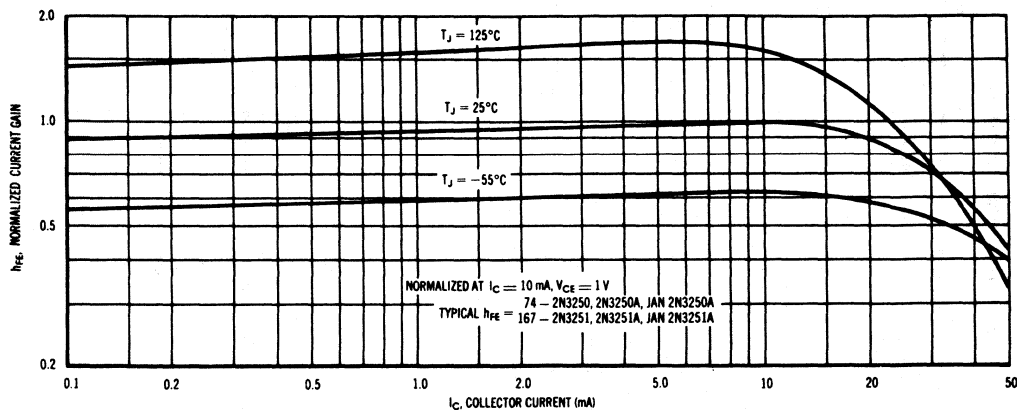
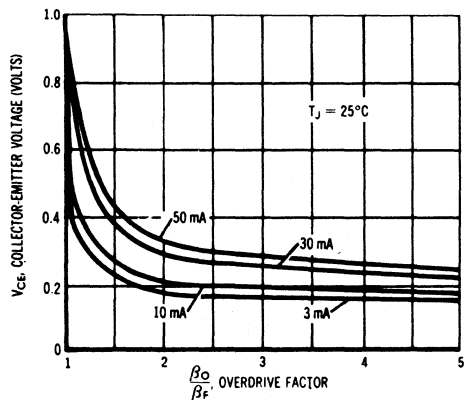


FIGURE 10 — COLLECTOR SATURATION REGION



This graph shows the effect of base current on collector current. β_O is the current gain of the transistor at 1 volt, and β_F (forced gain) is the ratio of I_C/I_{BF} in a circuit. EXAMPLE: For type 2N3251, estimate a base current (I_{BF}) to insure saturation at a temperature of 25°C and a collector current of 10 mA.

Observe that at $I_C = 10$ mA an overdrive factor of at least 2.5 is required to drive the transistor well into the saturation region. From Figure 9, it is seen that h_{FE} @ 1 volt is typically 167 (guaranteed limits from the Table of Characteristics can be used for "worst-case" design) ...

$$\frac{\beta_O}{\beta_F} = \frac{h_{FE} @ 1 \text{ Volt}}{I_C / I_{BF}} \quad 2.5 = \frac{167}{10 \text{ mA} / I_{BF}} \quad I_{BF} \approx 6.68 \text{ mA typ}$$

FIGURE 11 — SATURATION VOLTAGES

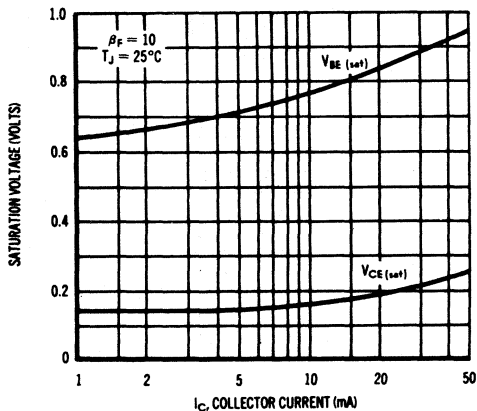


FIGURE 12 — TEMPERATURE COEFFICIENTS

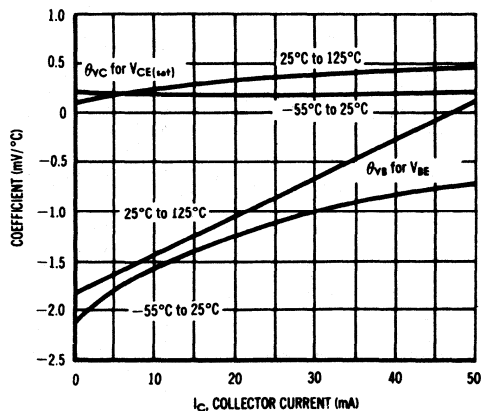


FIGURE 13 — f_T AND $r_b'C_C$ versus I_C

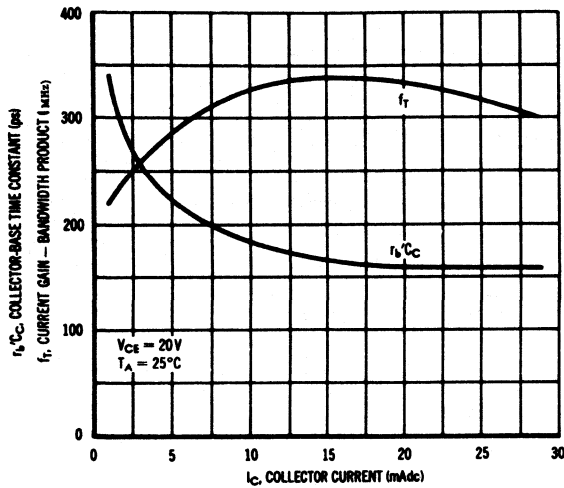


FIGURE 14 — 30 MC EQUIVALENT CIRCUIT

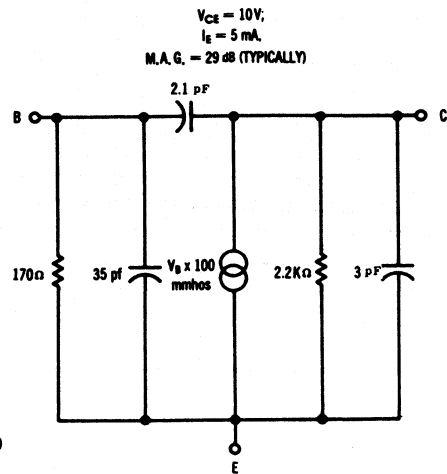


FIGURE 15 — JUNCTION CAPACITANCE

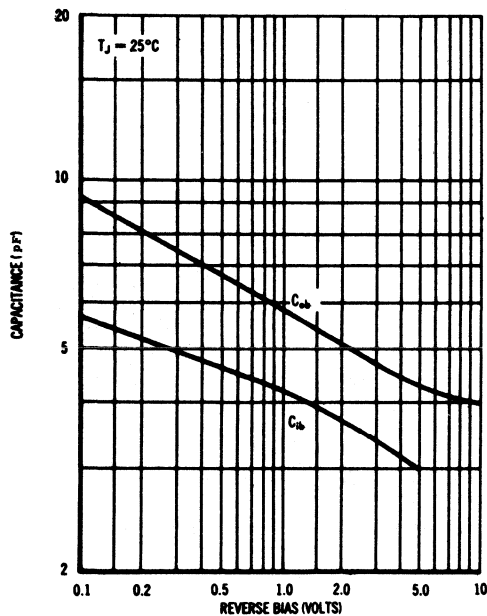
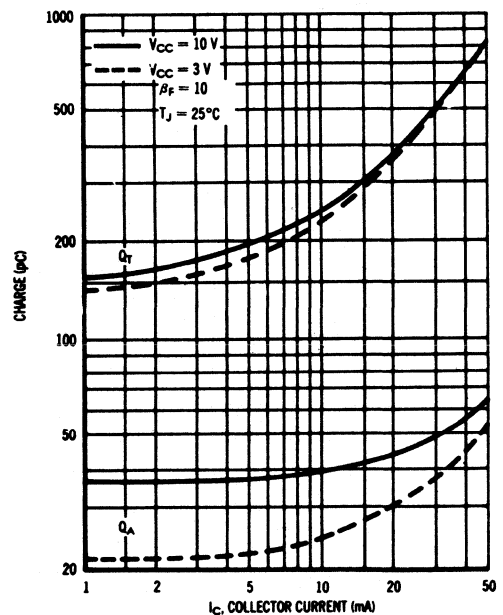


FIGURE 16 — CHARGE DATA

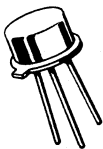


2N3252S, 2N3253S (SILICON)

2N3253 JAN AVAILABLE

2N3444S

2N3444 JAN AVAILABLE



CASE 79

(TO-39)

Collector connected to case



STYLE 1:

PIN 1. EMITTER

2. BASE

3. COLLECTOR

NPN silicon annular transistors for high-current saturated switching and core driver applications.

*MAXIMUM RATINGS

Rating	Symbol	2N3252	2N3253	2N3444	Unit
Collector-Base Voltage	V_{CB}	60	75	80	Vdc
Collector-Emitter Voltage	V_{CEO}	30	40	50	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Total Device Dissipation 25°C Case Temperature Derate above 25°C	P_D	5.0 28.6			Watts mW/°C
Total Device Dissipation 25°C Ambient Temperature Derate above 25°C	P_D	1.0 5.71			Watt mW/°C
Junction Operating Temperature Range	T_J	-65 to +200			°C
Storage Temperature Range	T_{stg}	-65 to +200			°C
Thermal Resistance:	θ_{JC}	35			°C/W
	θ_{JA}	0.175			°C/mW

SWITCHING CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)		C_{ob}	—	12	pF
Input Capacitance ($V_{EB} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 100 \text{ kHz}$)		C_{ib}	—	80	pF
Current Gain-Bandwidth Product ($I_C = 50 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 100 \text{ MHz}$)		f_T	200 175	— —	MHz
Total Control Charge ($I_C = 500 \text{ mAdc}$, $I_{B1} = 50 \text{ mAdc}$, $V_{CC} = 30 \text{ V}$)		Q_T	—	5.0	nC
Delay Time	$I_C = 500 \text{ mAdc}$, $I_{B1} = 50 \text{ mAdc}$ $V_{CC} = 30 \text{ V}$, $V_{BE} = 2 \text{ V}$	t_d	—	15	ns
Rise Time		t_r	— —	30 35	ns
Storage Time	$I_C = 500 \text{ mAdc}$, $I_{B1} = I_{B2} = 50 \text{ mAdc}$ $V_{CC} = 30 \text{ V}$	t_s	—	40	ns
Fall Time		t_f	—	30	ns

* Indicates JEDEC Registered Data

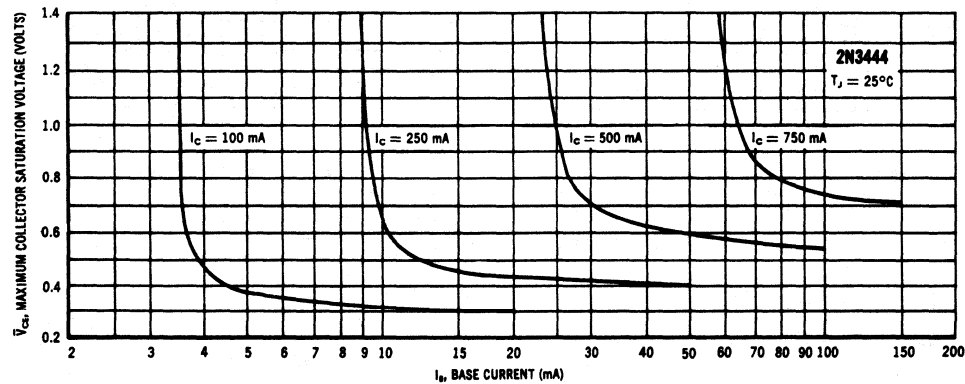
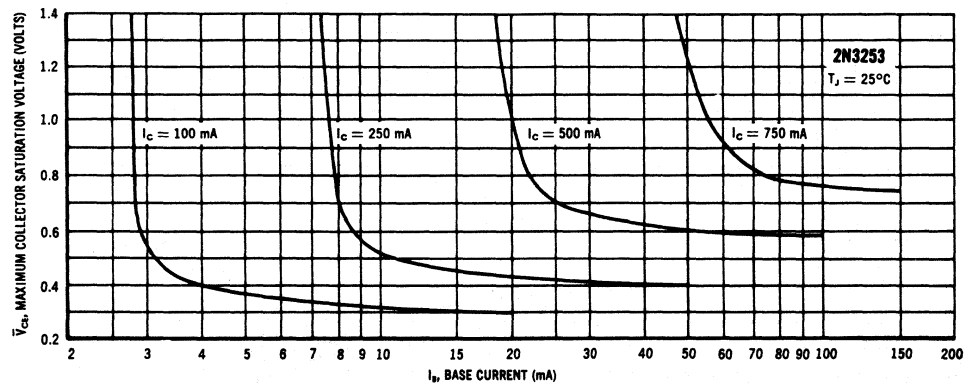
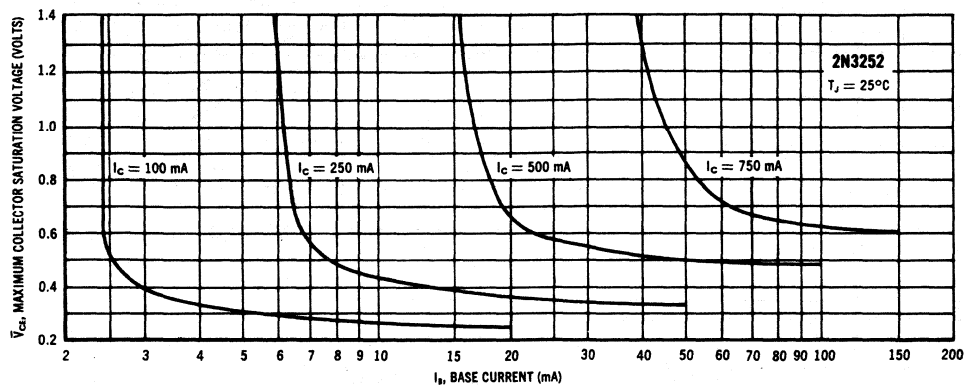
*** ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current ($V_{CB} = 40\text{ Vdc}$, $I_E = 0$) 2N3252 ($V_{CB} = 40\text{ Vdc}$, $I_E = 0$, $T_A = 100^\circ\text{C}$) 2N3252 ($V_{CB} = 60\text{ Vdc}$, $I_E = 0$) 2N3253, 2N3444 ($V_{CB} = 60\text{ Vdc}$, $I_E = 0$, $T_A = 100^\circ\text{C}$) 2N3253, 2N3444	I_{CBO}	—	0.50 75.0 0.50 75.0	μAdc
Emitter Cutoff Current ($V_{BE} = 4\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	0.05	μAdc
Collector Cutoff Current ($V_{CE} = 40\text{ Vdc}$, $V_{EB(\text{off})} = 4\text{ Vdc}$) 2N3252 ($V_{CE} = 60\text{ Vdc}$, $V_{EB(\text{off})} = 4\text{ Vdc}$) 2N3253, 2N3444	I_{CEX}	— —	0.5 0.5	μAdc
Base Cutoff Current ($V_{CE} = 40\text{ Vdc}$, $V_{EB(\text{off})} = 4\text{ Vdc}$) 2N3252 ($V_{CE} = 60\text{ Vdc}$, $V_{EB(\text{off})} = 4\text{ Vdc}$) 2N3253, 2N3444	I_{BL}	— —	0.50 0.50	μAdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $I_E = 0$) 2N3252 2N3253 2N3444	BV_{CBO}	60 75 80	— — —	Vdc
Collector-Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 10\text{ mAdc}$, pulsed, $I_B = 0$) 2N3252 2N3253 2N3444	BV_{CEO}	30 40 50	— — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	5.0	—	Vdc
Collector Saturation Voltage ⁽¹⁾ ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$) 2N3252 2N3253, 2N3444 ($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$) 2N3252 2N3253, 2N3444 ($I_C = 1.0\text{ Adc}$, $I_B = 100\text{ mAdc}$) 2N3252 2N3253, 2N3444	$V_{CE(\text{sat})}$	— — — — — —	0.3 0.35 0.5 0.60 1.0 1.2	Vdc
Base-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$) ($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$) ($I_C = 1.0\text{ Adc}$, $I_B = 100\text{ mAdc}$)	$V_{BE(\text{sat})}$	— 0.7 —	1.0 1.3 1.8	Vdc
DC Forward Current Transfer Ratio ⁽¹⁾ ($I_C = 150\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$) 2N3252 2N3253 2N3444 ($I_C = 500\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$) 2N3252 2N3253 2N3444 ($I_C = 1\text{ Adc}$, $V_{CE} = 5\text{ Vdc}$) 2N3252 2N3253 2N3444	h_{FE}	30 25 20 30 25 20 25 20 15	— — — 90 75 60 — — —	—

⁽¹⁾ Pulse Test: Pulse width = 300 μs , duty cycle = 2%

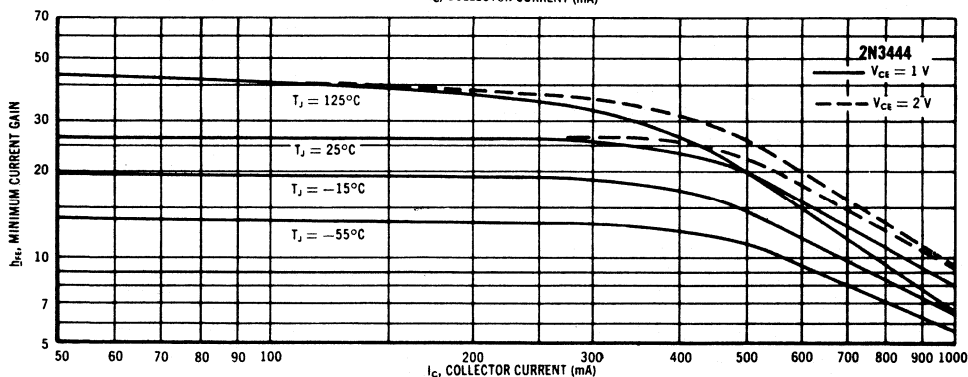
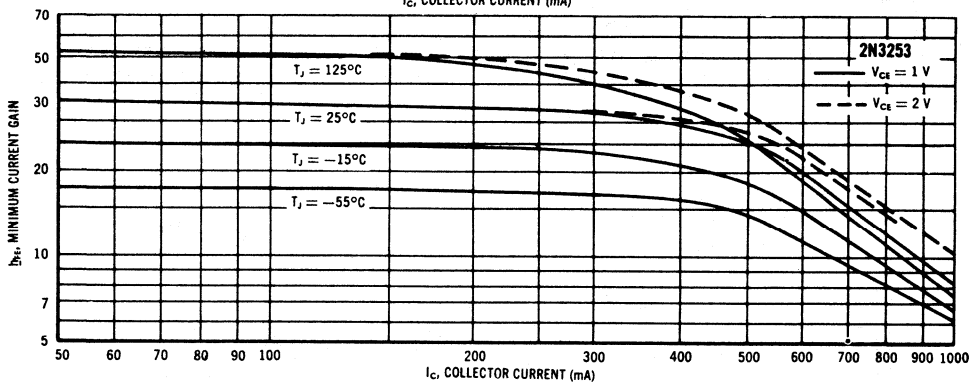
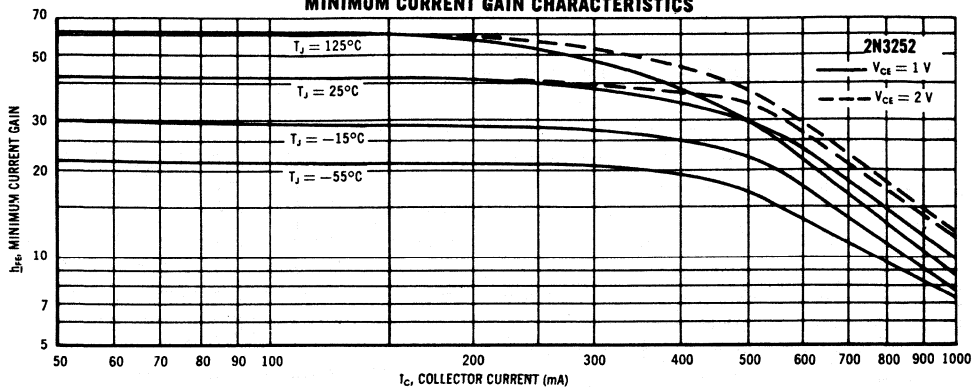
* Indicates JEDEC Registered Data

COLLECTOR SATURATION VOLTAGE CHARACTERISTICS

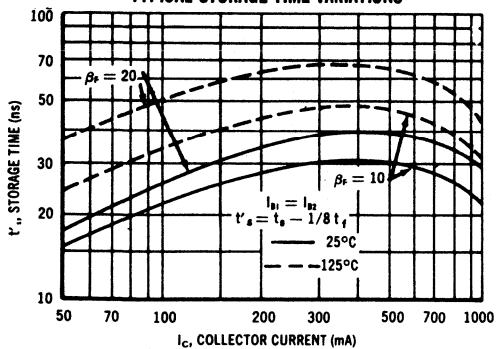


2N3252S, 2N3253S, 2N3444S (continued)

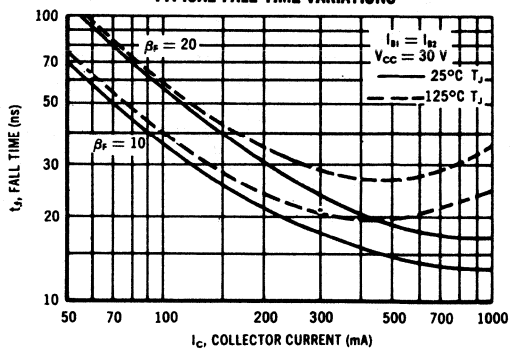
MINIMUM CURRENT GAIN CHARACTERISTICS



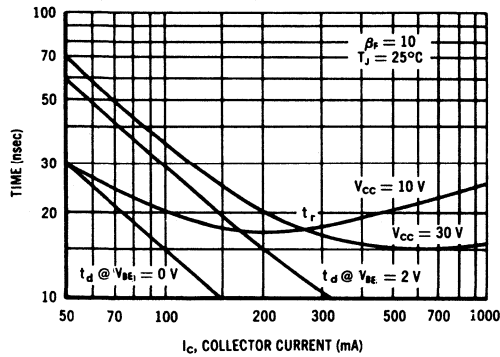
TYPICAL STORAGE TIME VARIATIONS



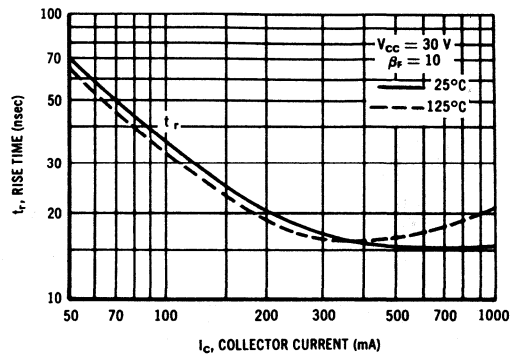
TYPICAL FALL TIME VARIATIONS



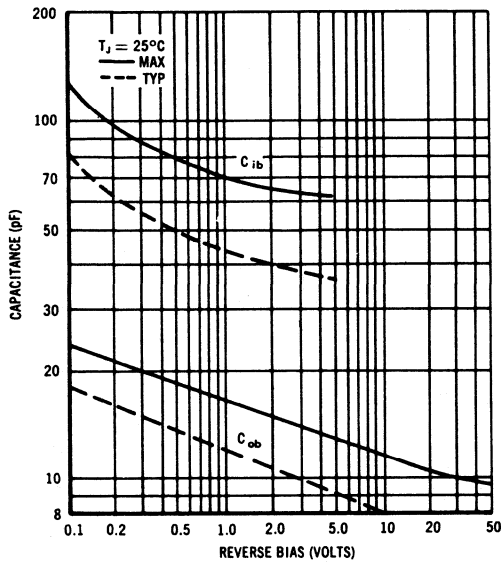
TYPICAL TURN-ON TIME VARIATIONS WITH VOLTAGE



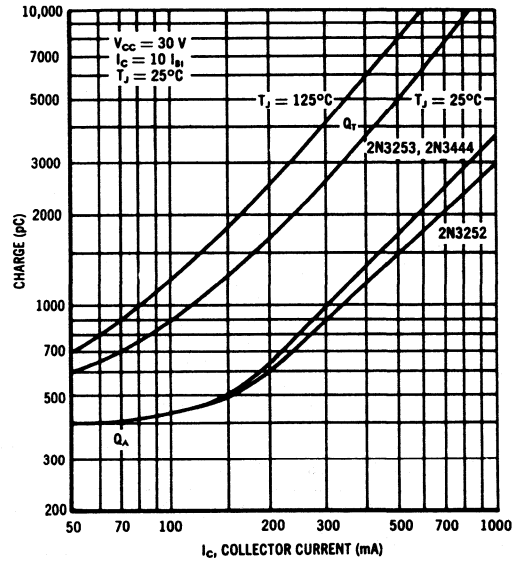
TYPICAL RISE TIME VARIATIONS WITH TEMPERATURE



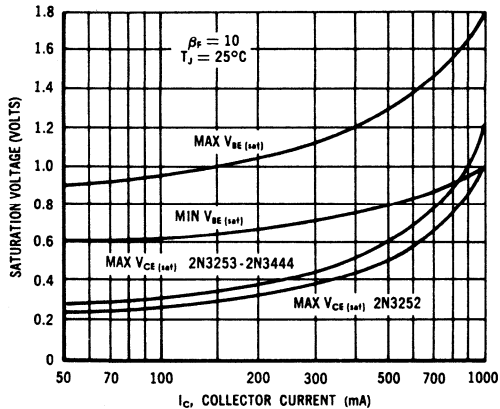
JUNCTION CAPACITANCE VARIATIONS



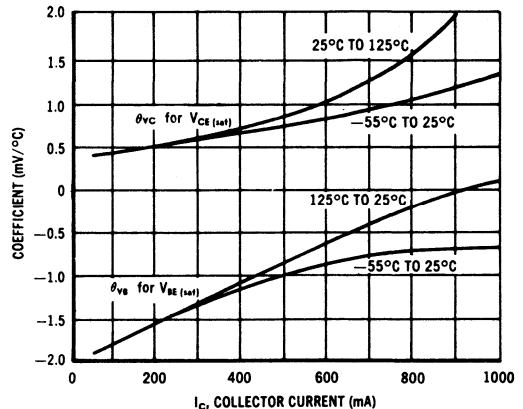
MAXIMUM CHARGE DATA



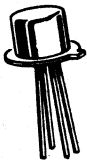
LIMITS OF SATURATION VOLTAGES



TYPICAL TEMPERATURE COEFFICIENTS



2N3283 thru 2N3285 (Ge Mesa)



**CASE 20-03
(TO-72)**



STYLE 10
PIN 1. EMITTER
2. BASE
3. COLLECTOR
4. CASE

PNP germanium mesa transistors for IF and RF amplifier, oscillator and general purpose high-gain, low-noise amplifier applications.

* MAXIMUM RATINGS

Rating	Symbol	2N3283 2N3284	2N3285	Unit
Collector-Emitter Voltage	V_{CES}	25	20	Vdc
Collector-Base Voltage	V_{CB}	25	20	Vdc
Emitter-Base Voltage	V_{EB}	0.5		Vdc
Collector Current - Continuous	I_C	50		mA dc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	100 1.33		mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100		$^\circ\text{C}$

*Indicates JEDEC Registered Data

2N3283 thru 2N3285 (continued)

* ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
----------------	--------	-----	-----	------

OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu\text{A}$, $V_{BE} = 0$) 2N3283, 2N3284 2N3285	BV_{CES}	25 20	- -	Vdc
Collector Cutoff Current ($V_{CB} = 10\ \text{Vdc}$, $I_E = 0$)	I_{CBO}	-	10	μA
Emitter Cutoff Current ($V_{BE} = 0.5\ \text{Vdc}$, $I_C = 0$)	I_{EBO}	-	100	μA

ON CHARACTERISTICS

DC Current Gain ($I_C = 3.0\ \text{mA}$, $V_{CE} = 10\ \text{Vdc}$) 2N3283, 2N3284 2N3285	h_{FE}	10 5.0	- -	-
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DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 3.0\ \text{mA}$, $V_{CE} = 10\ \text{Vdc}$, $f = 100\ \text{MHz}$)	f_T	250	800	MHz
Maximum Frequency of Oscillation ($I_C = 3.0\ \text{mA}$, $V_{CE} = 10\ \text{Vdc}$)	f_{max}	-	-	MHz
Output Capacitance (1) ($V_{CB} = 10\ \text{Vdc}$, $I_E = 0$, $f = 100\ \text{kHz}$)	C_{ob}	-	1.5	pF
Small-Signal Current Gain ($I_C = 3.0\ \text{mA}$, $V_{CE} = 10\ \text{Vdc}$, $f = 1.0\ \text{kHz}$) 2N3283, 2N3284 2N3285	h_{fe}	10 5.0	200 200	-
Collector-Base Time Constant ($I_E = 3.0\ \text{mA}$, $V_{CB} = 10\ \text{Vdc}$, $f = 31.8\ \text{MHz}$)	$r_b' C_c$	-	25	ps
Noise Figure ($I_C = 3.0\ \text{mA}$, $V_{CE} = 10\ \text{Vdc}$, $f = 200\ \text{MHz}$) 2N3283 2N3284	NF	- -	5.0 6.0	dB

FUNCTIONAL TESTS

Common-Emitter Amplifier Power Gain ($V_{CE} = 10\ \text{Vdc}$, $I_C = 3.0\ \text{mA}$, $f = 200\ \text{MHz}$) 2N3283, 2N3284	G_{pe}	16	23	dB
Power Output ($V_{EE} = 12\ \text{Vdc}$, $f = 247\ \text{MHz}$) 2N3285	P_{out}	2.0	-	mW

*Indicates JEDEC Registered Data

(1) C_{ob} is measured in a guarded circuit such that the can capacitance is not included.

FIGURE 1 — 200 MHz POWER GAIN AND NOISE FIGURE TEST CIRCUIT

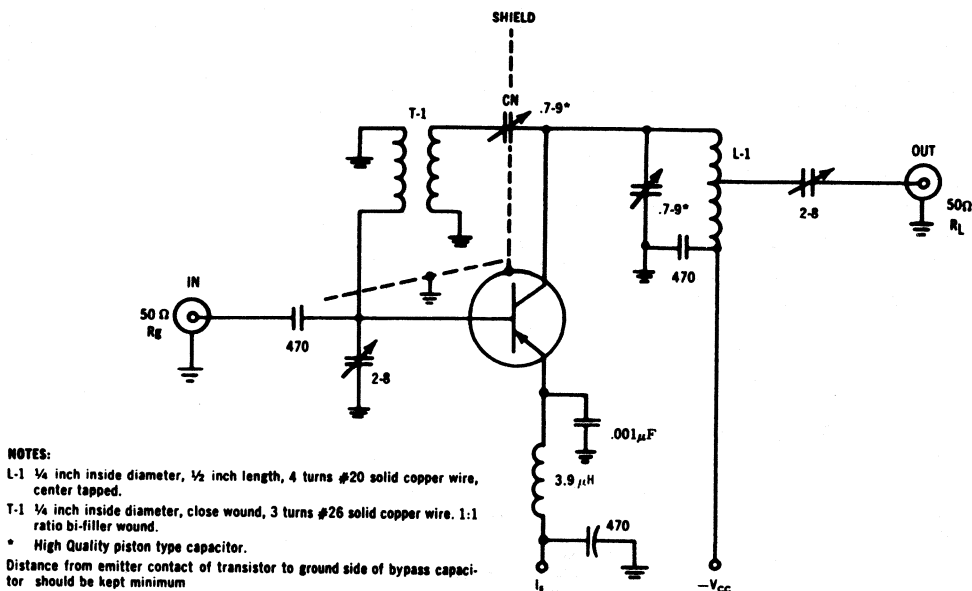
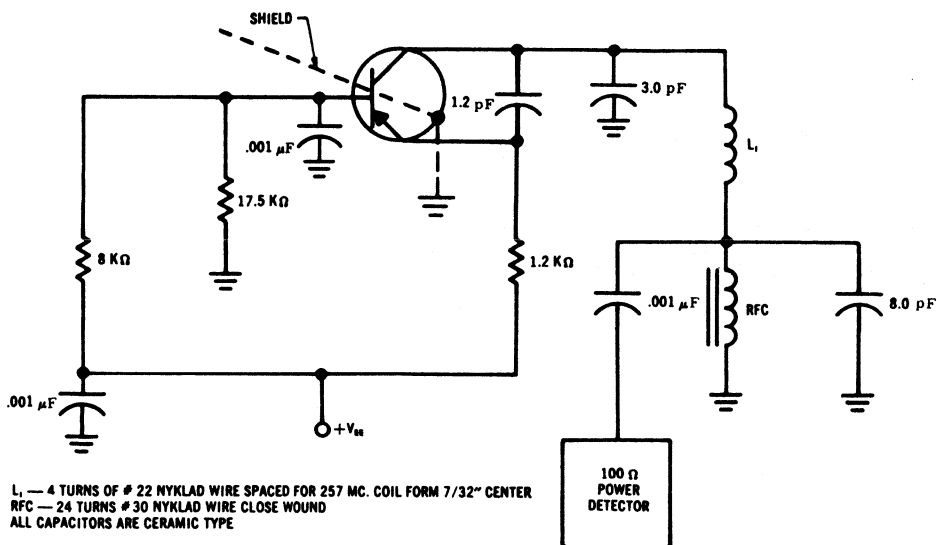
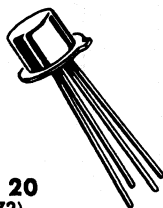


FIGURE 2 — 257 MHz OSCILLATOR POWER OUTPUT TEST CIRCUIT

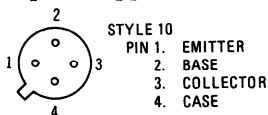


2N3287 (SILICON)



CASE 20
(TO-72)

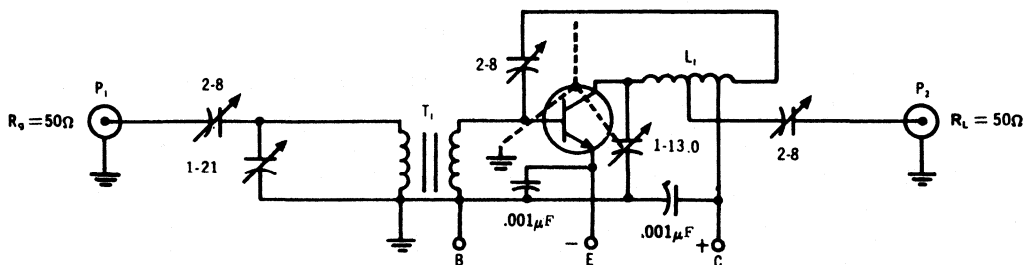
NPN silicon annular transistor for high-gain, low-noise amplifier, oscillator, mixer and frequency multiplier applications.



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector - Base Voltage	V_{CB}	40	Volts
Collector - Emitter Voltage	V_{CES}	40	Volts
Collector - Emitter Voltage	V_{CEO}	20	Volts
Emitter - Base Voltage	V_{EB}	3.0	Volts
Collector Current	I_C	50	mA
Power Dissipation at 25°C Case Above 25°C derate 1.71 mW/°C	P_D	300	mW
Power Dissipation at 25°C amb. Above 25°C derate 1.14 mW/°C	P_D	200	mW
Junction Temperature	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

200 MHz TEST CIRCUIT: POWER GAIN, NOISE FIGURE, & AGC



L_1 -6 turns of #16 tinned wire; $\frac{3}{8}$ " ID; Air wound; winding length $\frac{3}{4}$ ";
 V_{CC} feeds tap 4 $\frac{3}{4}$ turns from collector end; output tap 3 $\frac{1}{2}$ turns from collector end.

T_1 -3 turns primary and secondary Bifilar wound (close wound) on $\frac{1}{4}$ " ceramic form (cambion type) with brass slug. #22 enameled wire.

P_1 -General Radio 874 G6 Pad (6dB)

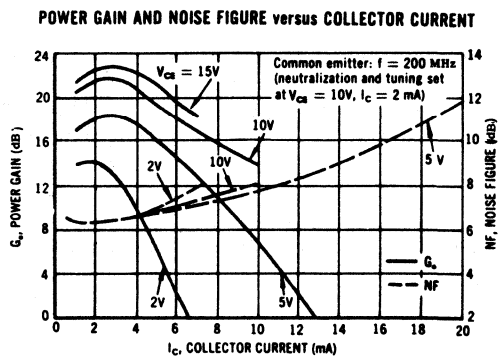
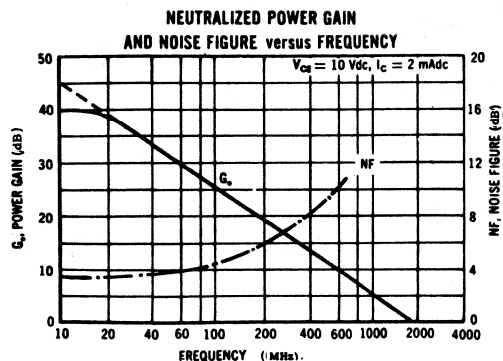
P_2 -General Radio 874 G6 Pad (6dB)

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage	BV_{CBO}	$I_C = 10 \mu\text{Adc}$, $I_E = 0$	40	—	—	Vdc
Collector-Emitter Breakdown Voltage	BV_{CES}	$I_C = 10 \mu\text{Adc}$, $V_{BE} = 0$	40	—	—	Vdc
Collector-Emitter Breakdown Voltage	BV_{CEO}	$I_C = 2.0 \text{ mAdc}$, $I_B = 0$	20	—	—	Vdc
Emitter-Base Breakdown Voltage	BV_{EBO}	$I_E = 10 \mu\text{Adc}$, $I_C = 0$	3.0	—	—	Vdc
Collector Cutoff Current	I_{CBO}	$V_{CB} = 15 \text{ Vdc}$ $V_{CB} = 15 \text{ Vdc}$, $T_A = 150^\circ\text{C}$	—	—	.010 3.0	μAdc
DC Forward Current Transfer Ratio	h_{FE}	$V_{CE} = 10 \text{ Vdc}$, $I_C = 2 \text{ mAdc}$	15	—	100	—
Collector-Emitter Saturation Voltage	$V_{CE}(\text{sat})$	$I_C = 5 \text{ mAdc}$, $I_B = 0.5 \text{ mAdc}$	—	—	0.3	Vdc
Base-Emitter Saturation Voltage	$V_{BE}(\text{sat})$	$I_C = 5 \text{ mAdc}$, $I_B = 0.5 \text{ mAdc}$	—	—	0.9	Vdc
AC Current Gain	h_{fe}	$V_{CE} = 10 \text{ Vdc}$, $I_C = 2 \text{ mAdc}$, $f = 1 \text{ kHz}$	15	—	150	—
Output Capacitance	C_{ob}	$V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 0.1 \text{ MHz}$ (Note 1)	—	0.9	1.1	pF
Collector-Base Time Constant	$r_b' C_c$	$V_{CB} = 10 \text{ Vdc}$, $I_C = 2 \text{ mAdc}$, $f = 31.8 \text{ MHz}$	3.0	8.0	15	ps
Current Gain - Bandwidth Product	f_T	$V_{CE} = 10 \text{ Vdc}$, $I_C = 2 \text{ mAdc}$	350	600	1200	MHz
Maximum Frequency of Oscillation	f_{max}	$V_{CE} = 10 \text{ Vdc}$, $I_C = 2 \text{ mAdc}$	—	2000	—	MHz
Power Gain	G_e	$V_{CE} = 10 \text{ Vdc}$, $I_C = 2 \text{ mAdc}$, $f = 200 \text{ MHz}$	17	—	24	dB
Noise Figure	NF	$V_{CE} = 10 \text{ Vdc}$, $I_C = 2 \text{ mAdc}$, $f = 200 \text{ MHz}$	—	4.9	6.0	dB
Power Gain (AGC)	G_e	$V_{CE} = 5.0 \text{ Vdc}$, $I_C = 20 \text{ mAdc}$, $f = 200 \text{ MHz}$ (Note 2)	—	—	0	dB

Note 1. C_{ob} is measured in guarded circuit such that the can capacitance is not included.

Note 2. AGC is obtained by increasing I_C . The circuit remains adjusted for $V_{CE} = 10 \text{ Vdc}$, $I_C = 2 \text{ mAdc}$ operation.



2N3291 (SILICON)

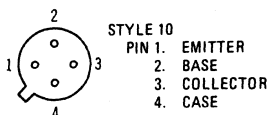
2N3292

2N3294

NPN silicon annular transistor for TV and FM mixer, RF and IF amplifier and general-purpose, low-noise, high-gain amplifier applications.

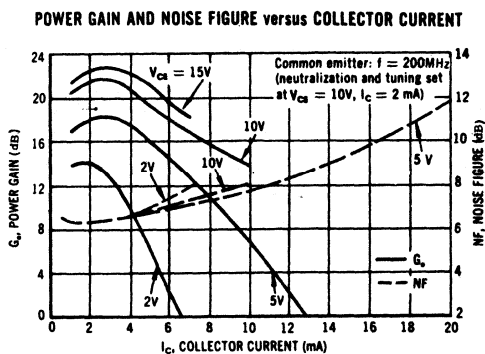
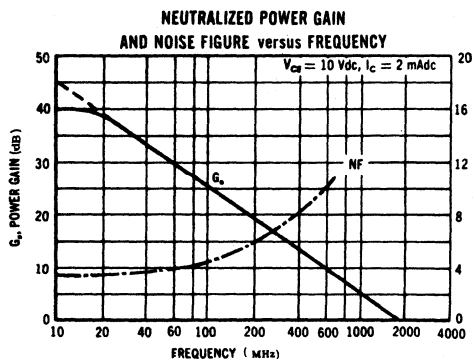


CASE 20
(TO-72)



MAXIMUM RATINGS

Rating	Symbol	2N3291 2N3292	2N3294	Unit
Collector - Base Voltage	V_{CB}	25	20	Volts
Collector - Emitter Voltage	V_{CES}	25	20	Volts
Emitter - Base Voltage	V_{EB}	3.0	3.0	Volts
Collector Current	I_C	50	50	mA
Power Dissipation at 25°C Case Above 25°C derate 1.71 mW/°C	P_D	300	300	mW
Power Dissipation at 25°C Amb. Above 25°C derate 1.14 mW/°C	P_D	200	200	mW
Junction Temperature	T_J	+200	+200	°C
Storage Temperature Range	T_{stg}	← -65 to +200 →		°C



2N3291, 2N3292, 2N3294 (Continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage	V_{CES}	$I_C = 25 \mu\text{Adc}$, $V_{BE} = 0$ 2N3291, 2N3292 2N3294	25 20	35 30	— —	Vdc
Collector Cutoff Current	I_{CBO}	$V_{CB} = 10 \text{ Vdc}$, $I_E = 0$	—	.01	0.1	μAdc
Emitter Cutoff Current	I_{EBO}	$V_{EB} = 0.5 \text{ Vdc}$, $I_C = 0$	—	—	100	μAdc
DC Forward Current Transfer Ratio	h_{FE}	$V_{CE} = 10 \text{ Vdc}$, $I_C = 2 \text{ mAdc}$	10	—	—	—
AC Current Gain	h_{fe}	$V_{CE} = 10 \text{ Vdc}$, $I_C = 2 \text{ mAdc}$, $f = 1 \text{ kHz}$	10	—	200	—
Output Capacitance	C_{ob}	$V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$, Note 1	—	1.0	2.0	pF
AC Current Gain	$ h_{fe} $	$V_{CE} = 10 \text{ Vdc}$, $I_C = 2 \text{ mAdc}$ $f = 100 \text{ MHz}$	2.5	6.0	12	—
Collector-Base Time Constant	$r_b' C_c$	$V_{CB} = 10 \text{ Vdc}$, $I_C = 2 \text{ mAdc}$ $f = 31.8 \text{ MHz}$	—	15	30	ps
Maximum Frequency of Oscillation	f_{max}	$V_{CE} = 10 \text{ Vdc}$, $I_C = 2 \text{ mA}$	—	2000	—	MHz

2N3291

Power Gain	G_e	$V_{CE} = 10 \text{ Vdc}$, $I_C = 2 \text{ mAdc}$, $f = 200 \text{ MHz}$	16	20	24	dB
Noise Figure	NF		—	6.0	8.0	dB
Power Gain (AGC)	G_e	Note 2 $V_{CE} = 5 \text{ Vdc}$, $I_C = 20 \text{ mAdc}$ $f = 200 \text{ MHz}$	—	—	0	dB

2N3292

Power Gain	G_e	$V_{CE} = 10 \text{ Vdc}$, $I_C = 2 \text{ mAdc}$ $f = 200 \text{ MHz}$	16	20	24	dB
Noise Figure	NF		—	7.0	9.0	dB
Power Gain (AGC)	G_e	Note 2 $V_{CE} = 5 \text{ Vdc}$, $I_C = 20 \text{ mAdc}$ $f = 200 \text{ MHz}$	—	0	—	dB

2N3294

Power Gain	G_e	$V_{CE} = 10 \text{ Vdc}$, $I_C = 2 \text{ mAdc}$ $f = 200 \text{ MHz}$	14	—	—	dB
Noise Figure	NF		—	7.0	—	dB

Note 1. C_{ob} is measured in guarded circuit such that the can capacitance is not included.

Note 2. AGC is obtained by increasing I_C . The circuit remains adjusted for $V_{CE} = 10 \text{ Vdc}$,
 $I_C = 2 \text{ mAdc}$ operation.

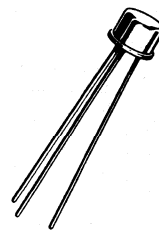
The RF Line

NPN SILICON RF HIGH FREQUENCY TRANSISTOR

... designed for amplifier applications from 2 MHz to 100 MHz.

- Amplifier Characteristics –
30 MHz IMD: = 30 dB down @ $P_{out} = 0.3$ Watts PEP
- High Power Gain
 $G_e = 14$ dB Min @ 30 MHz with $P_{out} = 0.3$ Watts PEP

HIGH FREQUENCY TRANSISTOR NPN SILICON

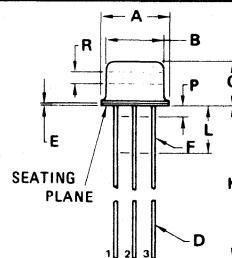


*MAXIMUM RATING (Note 1)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CBO}	60	Vdc
Collector-Emitter Voltage	V_{CES}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current – Continuous	I_C	250	mA dc
Base Current – Continuous	I_B	50	mA dc
Total Power Dissipation @ $T_C = 25^\circ\text{C}$	P_D	2.0	Watts
Derate above 25°C		13.3	mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_A = 25^\circ\text{C}$	P_D	0.8	Watts
Derate above 25°C		5.33	mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to 175	$^\circ\text{C}$

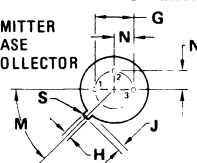
*Indicates JEDEC Registered Data

Note 1: The maximum ratings as given for DC Conditions can be exceeded on a pulse basis. See Electrical Characteristics.



STYLE 1:

- PIN 1. EMITTER
- BASE
- COLLECTOR



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	6.10	6.80	0.240	0.260
D	0.41	0.48	0.016	0.019
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	38.10	—	1.500	—
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 031-01

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

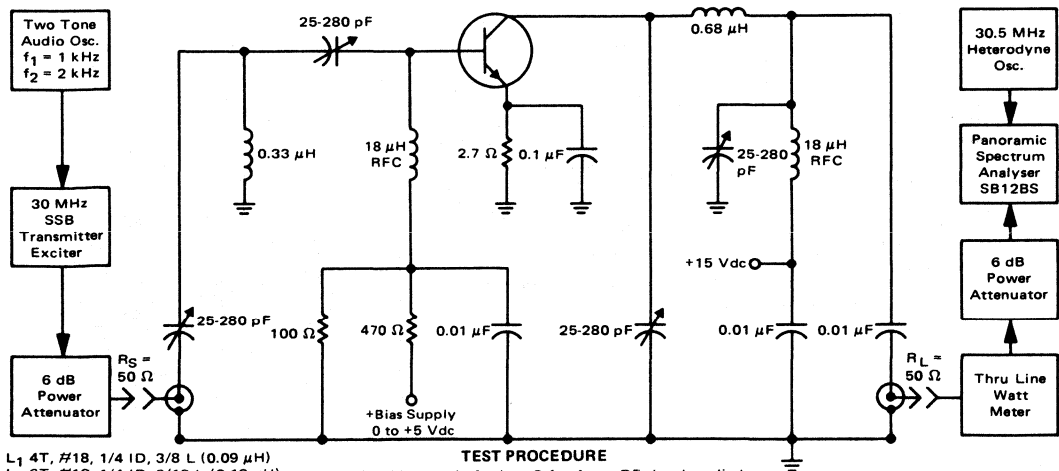
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) ($I_C = 100\text{ mA}$, $I_B = 0$)	$V_{CEO(sus)}$	20	—	—	Vdc
Collector-Emitter Sustaining Voltage (1) ($I_C = 100\text{ mA}$, $R_{BE} = 0$)	$V_{CES(sus)}$	30	—	—	Vdc
Collector-Emitter Current ($V_{CE} = 60\text{ Vdc}$, $V_{BE} = 0$) ($V_{CE} = 50\text{ Vdc}$, $V_{BE} = 0$, $T_C = 175^\circ\text{C}$)	I_{CES}	—	—	100 500	μAdc
Collector Cutoff Current ($V_{CB} = 50\text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	—	0.1	μAdc
Emitter Cutoff Current ($V_{EB} = 5.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	—	100	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 150\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) (1)	h_{FE}	20 20	— —	60 —	—
Collector-Emitter Saturation Voltage ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$)	$V_{CE(sat)}$	—	—	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$)	$V_{BE(sat)}$	—	—	2.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product ($V_{CE} = 10\text{ Vdc}$, $I_C = 10\text{ mAdc}$, $f = 50\text{ MHz}$)	f_T	200	—	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)	C_{ob}	—	—	8.0	pF
FUNCTIONAL TEST (Figure 1)					
Power Input (PEP) (2)	P_{in}	—	—	12	mW
Power Gain	G_e	14	17	—	dB
Intermodulation Distortion	IMD	30	32	—	dB
Efficiency	η	25	30	—	%

*Indicates JEDEC Registered Data.

(1) Pulse Width = $100\text{ }\mu\text{s}$, Duty Cycle = 2.0%.

(2) PEP — Peak Envelope Power

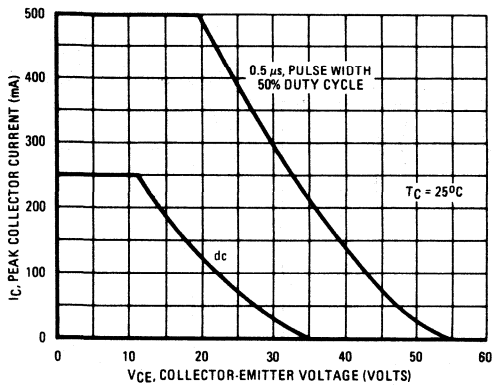
FIGURE 1 — 30 MHz TWO TONE LINEAR AMPLIFIER TEST CIRCUIT



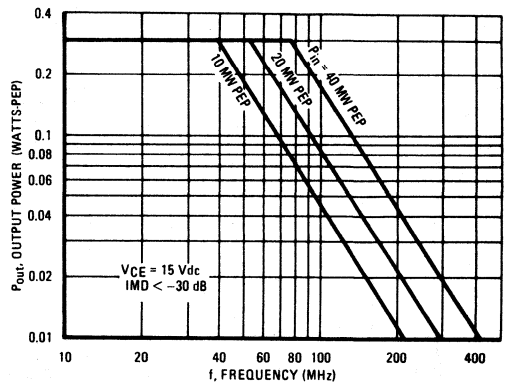
TEST PROCEDURE

1. Adjust bias supply for $I_C = 3.4\text{ mA}$, no RF signal applied.
2. Apply RF signal and tune until $P_{out} = 0.3\text{ watts PEP}$.
3. Read IMD, I_C , and P_{in} .

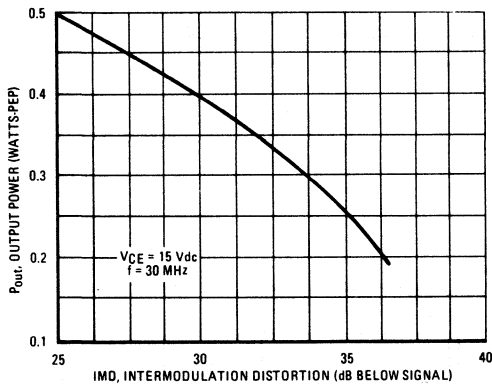
SAFE OPERATING AREA



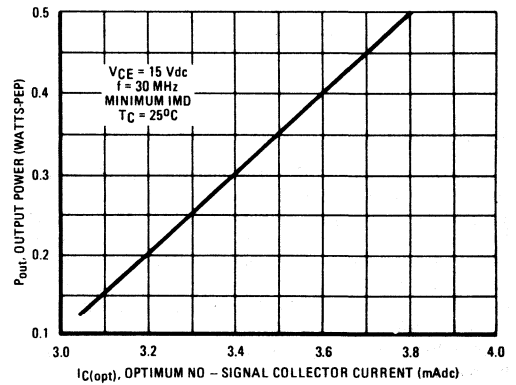
OUTPUT POWER versus FREQUENCY



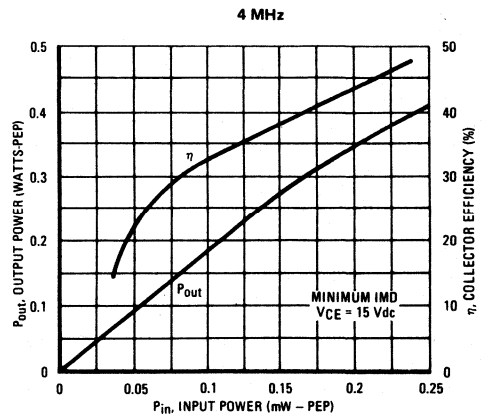
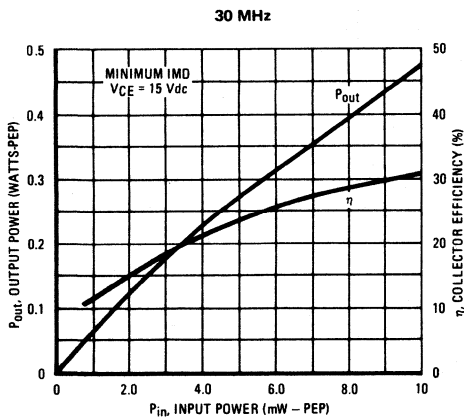
MAXIMUM OUTPUT POWER FOR GIVEN INTERMODULATION DISTORTION LEVEL



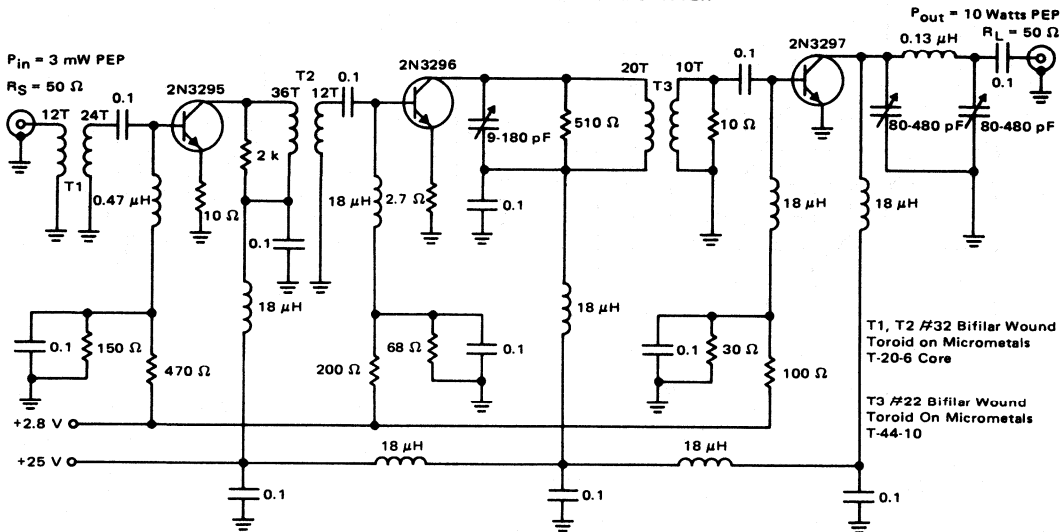
OUTPUT POWER versus OPTIMUM BIAS



OUTPUT CHARACTERISTICS versus INPUT POWER



30 MHz SINGLE – SIDE BAND TRANSMITTER



APPLICATION NOTE

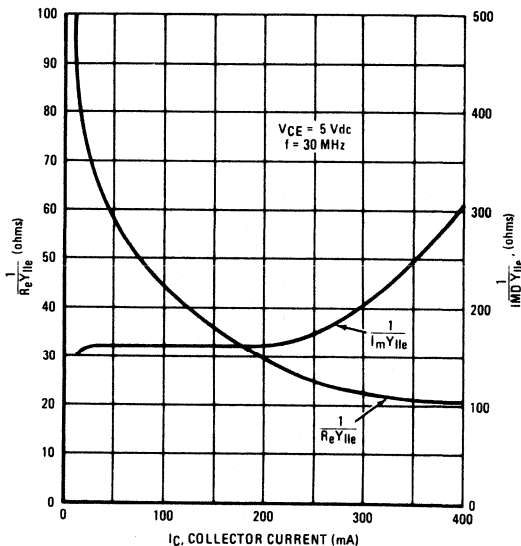
The schematic for a 30 MHz single sideband transmitter shown in Figure 1 illustrates circuitry which can be used to provide linear power amplification with Motorola RF Line transistors. This particular circuit provides peak envelope power output of 10 watts with an overall power gain of 35 dB. All odd order distortion products (Intermodulation Distortion — IMD) are more than 30 dB down from the reference level as measured in a two tone test with 1 kHz separation using a panoramic SB-12BS spectrum analyzer.

This performance is readily obtained without feedback loops. Current feedback for stability is obtained in stage one and stage two by the use of unbypassed emitter resistors.

Although the power output for this system is 10 watts of peak envelope power, you are not limited by the transistors. Four (2N3297) in parallel are capable of delivering in excess of 40 Watts PEP.

In the design of a linear amplifier stage there are two important factors which must be considered. These are optimum driving source impedance and slight forward bias. Optimum R_S is determined by observing the linearity of transistor collector characteristics when the device is driven from a variable generator source impedance. Forward bias is applied from a low-voltage bias supply and resistive divider. Values of resistance in the bias divider are critical. Resistive values too low decrease efficiency and present thermal runaway possibility; values too high degrade IMD performance. Optimum bias for the 2N3297 with no signal applied is approximately 5 mA to 10 mA. Note that improved IMD performance is possible as the device supply voltage is increased up to 30 volts.

$R_{eY_{11e}}$ AND $IMD Y_{11e}$ versus COLLECTOR CURRENT



The RF Line

NPN SILICON RF HIGH FREQUENCY TRANSISTOR

... designed for amplifier applications from 2 MHz to 100 MHz.

- Amplifier Characteristics
30 MHz IMD: 30 dB down @ P_{out} = 3.0 Watts PEP
- High Power Gain
G_e = 16 dB (Min) @ 30 MHz with P_{out} = 3.0 Watts PEP
- High Pulse Breakdown Voltage
BV_{CES} = 85 Volts (Min)
- Isolated Stud Package

HIGH FREQUENCY TRANSISTOR
NPN SILICON

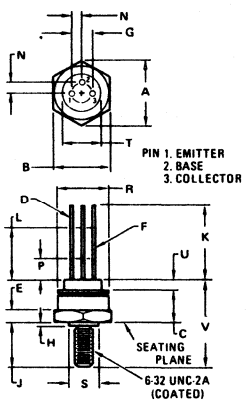


*MAXIMUM RATINGS (Note 1.)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V _{CBO}	60	Vdc
Collector-Emitter Voltage	V _{CES}	60	Vdc
Emitter-Base Voltage	V _{EBO}	3.0	Vdc
Collector Current — Continuous	I _C	700	mA _{dc}
Base Current — Continuous	I _B	100	mA _{dc}
RF Input Power	P _{in}	1.0	Watt (PEP)
RF Output Power	P _{out}	5.0	Watts (PEP)
Total Power Dissipation @ T _C = 25°C	P _D	6.0	Watts
Derate above 25°C		40	mW/°C
Total Power Dissipation @ T _A = 25°C	P _D	0.7	Watts
Derate above 25°C		4.67	mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	175	°C

*Indicates JEDEC Registered Data

Note 1: The maximum ratings as given for DC Conditions can be exceeded on a pulse basis. See Electrical Characteristics.



DIM	MIN	MAX	MIN	MAX
A	10.48	11.00	0.413	0.433
B	9.19	9.53	0.362	0.375
C	5.33	5.72	0.210	0.225
D	0.406	0.533	0.016	0.021
E	1.65	1.78	0.065	0.070
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.508	0.889	0.020	0.035
J	6.73	7.42	0.265	0.292
K	12.70	—	0.500	—
L	5.35	—	0.210	—
M	1.27 BSC		0.050 BSC	
P	—	1.27	—	0.050
R	8.89	9.14	0.350	0.360
S	4.45	4.83	0.175	0.190
T	4.11	4.25	0.162	0.168
U	1.14	1.52	0.045	0.060

All JEDEC dimensions and notes apply

CASE 24
TO-102

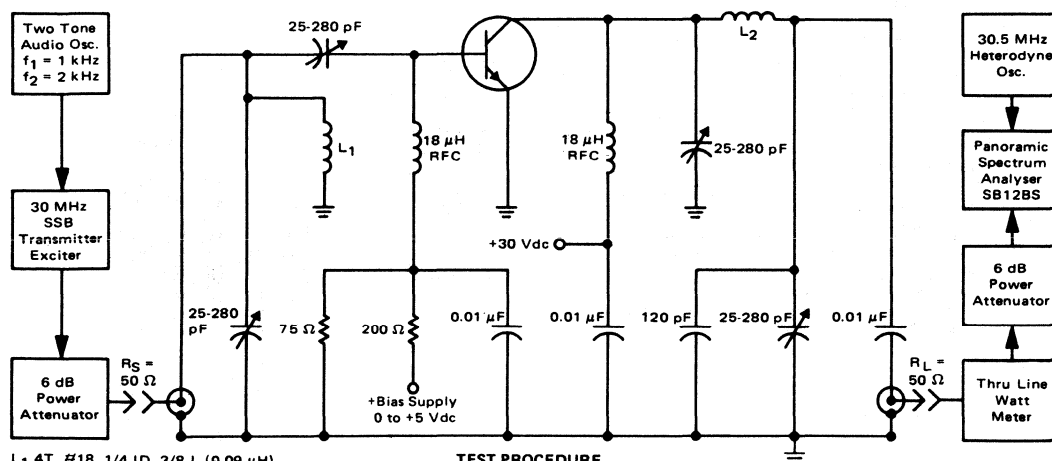
***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) ($I_C = 200\text{ mA}$, $I_B = 0$)	$V_{CE(sus)}$	40	—	—	Vdc
Collector-Emitter Sustaining Voltage (1) ($I_C = 200\text{ mA}$, $R_{BE} = 0$)	$V_{CES(sus)}$	85	120	—	Vdc
Collector-Emitter Current ($V_{CE} = 60\text{ Vdc}$, $V_{BE} = 0$) ($V_{CE} = 50\text{ Vdc}$, $V_{BE} = 0$, $T_C = 175^\circ\text{C}$)	I_{CES}	—	—	100 500	μAdc
Collector Cutoff Current ($V_{CB} = 50\text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	—	0.1	μAdc
Emitter Cutoff Current ($V_{EB} = 3.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	—	100	μAdc
ON CHARACTERISTICS					
DC Current Gain ($V_{CE} = 2.0\text{ Vdc}$, $I_C = 40\text{ mA}$) ($V_{CE} = 2.0\text{ Vdc}$, $I_C = 400\text{ mA}$)	h_{FE}	5.0 5.0	— —	50 —	—
Collector-Emitter Saturation Voltage ($I_C = 400\text{ mA}$, $I_B = 80\text{ mA}$)	$V_{CE(sat)}$	—	—	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 400\text{ mA}$, $I_B = 80\text{ mA}$)	$V_{BE(sat)}$	—	—	2.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product ($V_{CE} = 2.0\text{ Vdc}$, $I_C = 40\text{ mA}$, $f = 50\text{ MHz}$)	f_T	100	—	—	MHz
Output Capacitance ($V_{CB} = 25\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)	C_{ob}	—	—	20	pF
FUNCTIONAL TEST (Figure 1)					
Power Input (PEP) (2)	P_{in}	—	—	75	mW
Power Gain ($P_{out} = 3.0\text{ Watts (PEP)}$ (1.5 W rms), $V_{CE} = 30\text{ Volts}$, $f = 30\text{ MHz}$, $I_{C(max)} = 125\text{ mA}$)	G_p	16	19	—	dB
Intermodulation Distortion	IMD	30	35	—	dB
Efficiency	η	40	48	—	%

*Indicates JEDEC Registered Data.

(1) Pulse Width = 100 μs , Duty Cycle = 2.0%.

(2) PEP — Peak Envelope Power

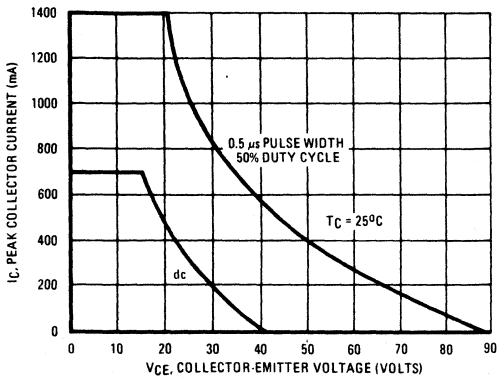
FIGURE 1 — 30 MHz TWO TONE LINEAR AMPLIFIER TEST CIRCUIT

L_1 4T, #18, 1/4 ID, 3/8 L (0.09 μH)
 L_2 6T, #18, 1/4 ID, 9/16 L (0.13 μH)

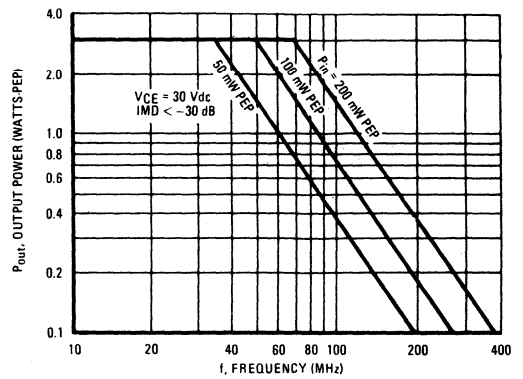
TEST PROCEDURE

1. Adjust bias supply for $I_C = 3.4\text{ mA}$, no RF signal applied.
2. Apply RF signal and tune until $P_{out} = 0.3\text{ watts PEP}$.
3. Read IMD, I_C , and P_{in} .

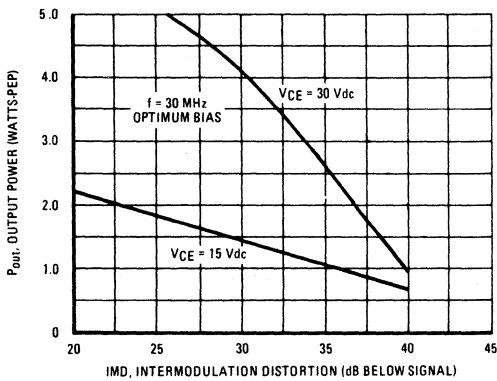
SAFE OPERATING AREA



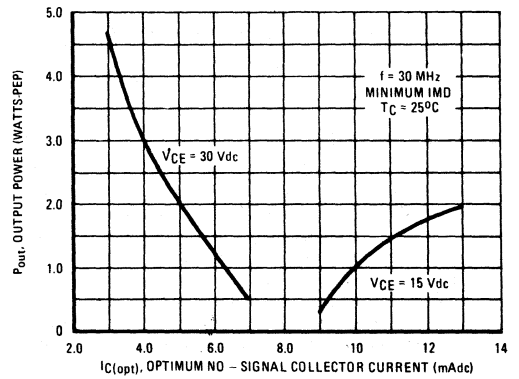
OUTPUT POWER versus FREQUENCY



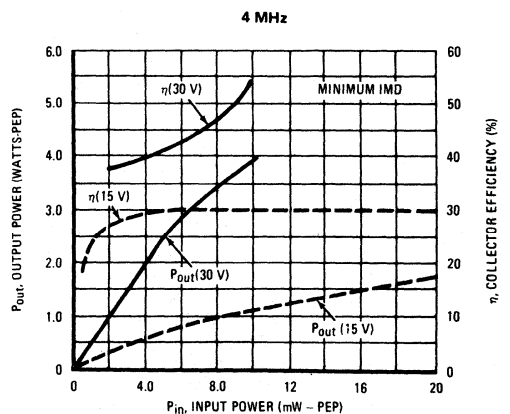
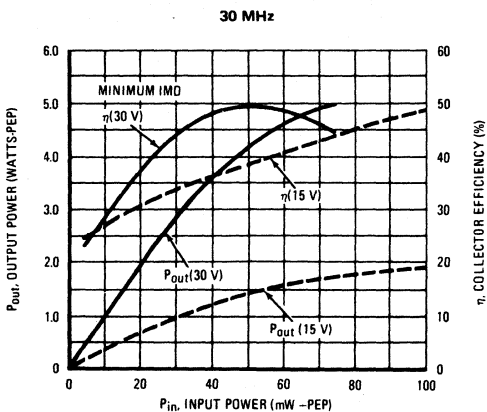
MAXIMUM OUTPUT POWER FOR GIVEN INTERMODULATION DISTORTION LEVEL



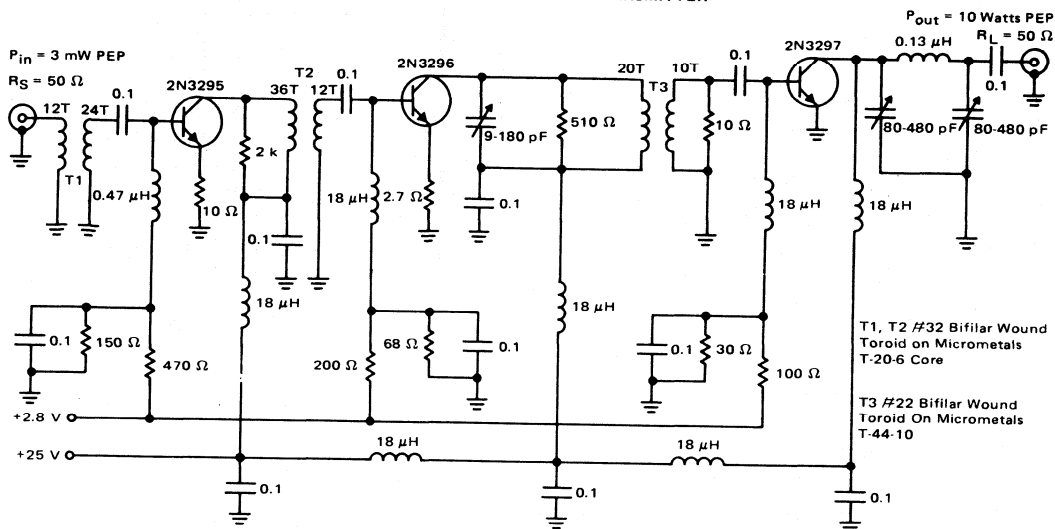
OUTPUT POWER versus OPTIMUM BIAS



OUTPUT CHARACTERISTICS versus INPUT POWER



30 MHz SINGLE - SIDE BAND TRANSMITTER



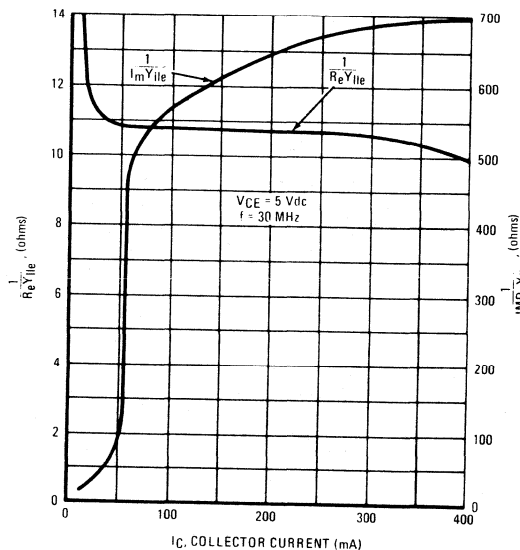
APPLICATION NOTE

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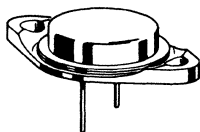
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ReY_{11e} AND IMD Y_{11e} versus COLLECTOR CURRENT

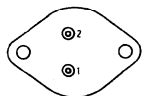
2N3297(SILICON)



NPN silicon annular transistor for linear amplifier applications for 2 to 100 MHz.

CASE 1 (TO-3)

Collector connected to case



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

MAXIMUM RATINGS *

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	60	Vdc
Collector-Emitter Voltage	V_{CES}	60	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current (Continuous)	I_C	1.5	Adc
Base-Current (Continuous)	I_B	500	mAdc
Power Input (PEP)	P_{in}	5.0	Watts (PEP)
Power Output (PEP)	P_{out}	20.0	Watts (PEP)
Total Device Dissipation @ 25°C Case Temperature	P_D	25.0	Watts
Derating Factor above 25°C		167	mW/°C
Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

* The maximum ratings as given for dc conditions can be exceeded on a pulse basis. See electrical characteristics

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Conditions	Min	Typ	Max	Unit
Collector-Emitter Sustain Voltage	$V_{CES(sus)}^{(1)}$	$I_C = 0.250\text{A}$, $R_{BE} = 0$	80	100	--	Volts
Collector Emitter-Open Base Sustain Voltage	$V_{CEO(sus)}^{(1)}$	$I_C = 0.250\text{A}$, $I_B = 0$	40	--	--	Volts

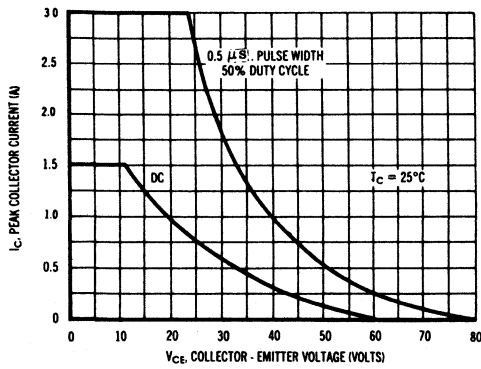
Collector-Emitter Current	I_{CES}	$V_{CE} = 60\text{Vdc}$, $V_{BE} = 0$	--	--	0.5	mAdc
		$V_{CE} = 50\text{Vdc}$, $V_{BE} = 0$, $T_C = +175^\circ\text{C}$	--	--	1.0	
Collector-Cutoff Current	I_{CBO}	$V_{CB} = 50\text{Vdc}$, $I_E = 0$	--	--	1.0	μAdc
Emitter-Cutoff Current	I_{EBO}	$V_{EB} = 3\text{Vdc}$, $I_C = 0$	--	--	100	μAdc
DC Current Gain	h_{FE}	$I_C = 400\text{mAdc}$, $V_{CE} = 2\text{Vdc}$	6.0	--	60	--
		$I_C = 1\text{Adc}$, $V_{CE} = 2\text{Vdc}$	2.5	--	--	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C = 1\text{Adc}$, $I_B = 500\text{mAdc}$	--	--	0.5	Vdc
Emitter-Base Saturation Voltage	$V_{BE(sat)}$	$I_C = 1\text{Adc}$, $I_B = 500\text{mAdc}$	--	--	2.0	Vdc

AC Current Gain	$ h_{fe} $	$V_{CE} = 2\text{Vdc}$, $I_C = 400\text{mAdc}$, $f = 50\text{MHz}$	2.0	--	--	--
Collector Output Capacitance	C_{ob}	$V_{CB} = 25\text{Vdc}$, $I_E = 0$, $f = 100\text{kHz}$	--	--	60	pF

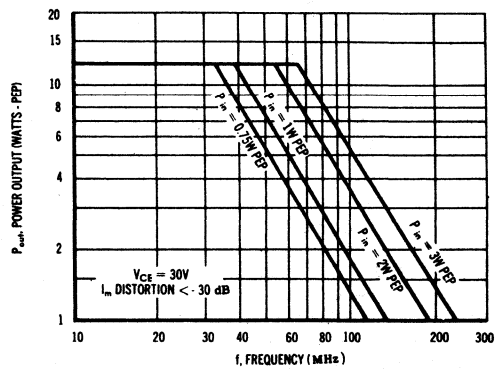
Power Input (PEP) Note 2	P_{in}	$P_{out} = 12\text{ Watts PEP (6.0W rms)}$ $V_{CE} = 30\text{ Volts}$, $f = 30\text{ MHz}$ $I_{C(max)} = 0.50\text{ Amp}$	--	--	1.2	Watts PEP
Power Gain	G_e		10	13	--	dB
Intermodulation Distortion Ratio	I_m		30	33	--	dB
Efficiency	η		40	45	--	%

⁽¹⁾ Pulse Test: Pulse Width = $100\mu\text{s}$, Duty Cycle = 2 %
Note 2. PEP. Peak Envelope Power

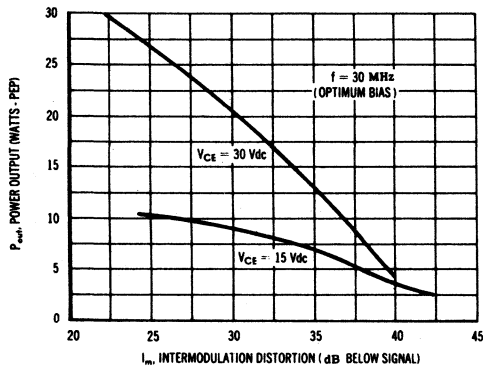
SAFE OPERATING AREA



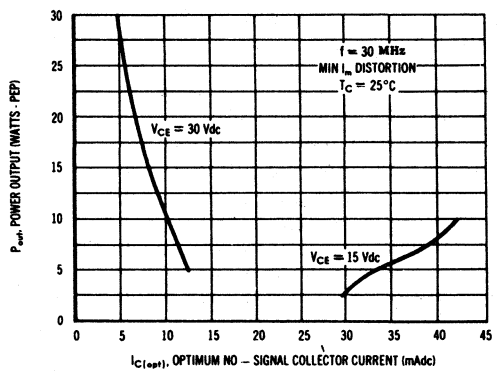
POWER OUTPUT versus FREQUENCY



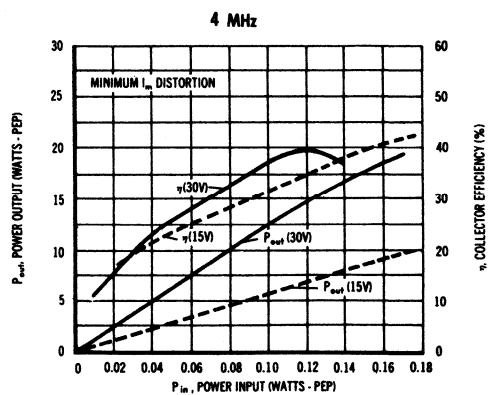
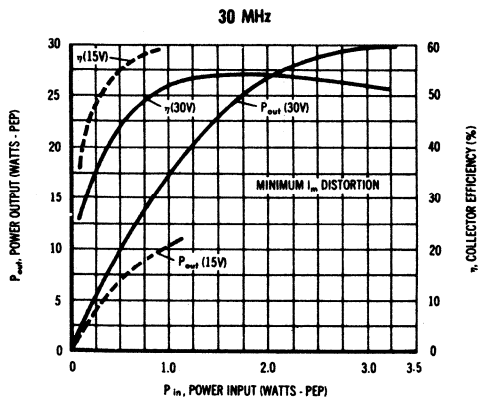
MAXIMUM POWER OUTPUT FOR GIVEN I_m DISTORTION LEVEL



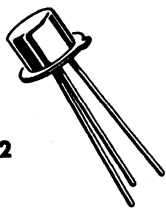
POWER OUTPUT versus OPTIMUM BIAS



OUTPUT CHARACTERISTICS versus POWER INPUT



2N3298 (SILICON)

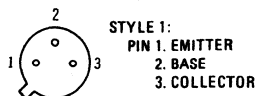


CASE 22 (TO-18)

Collector connected to case

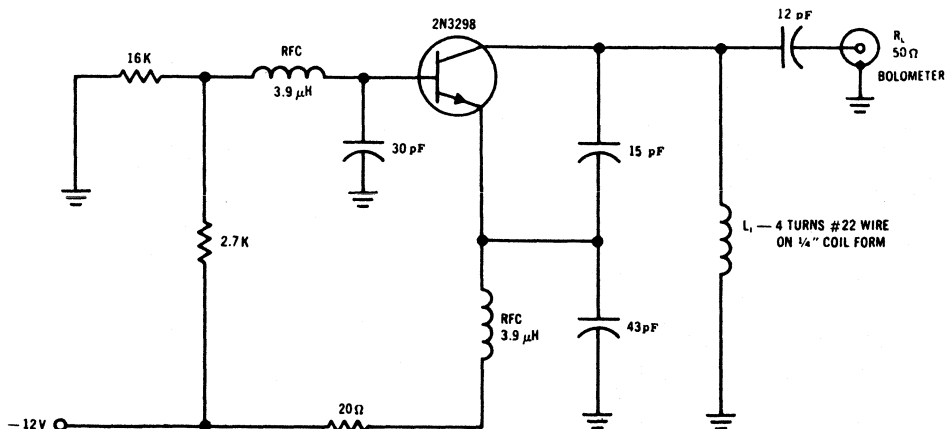
MAXIMUM RATINGS

NPN silicon annular transistor for power oscillator applications to 150 MHz.



Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	25	Vdc
Collector-Emitter Voltage	V_{CES}	25	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current	I_C	100	mA
Total Device Dissipation (25°C Case Temperature) Derate Above 25°C	P_D	1.0 6.67	Watt mW/°C
Total Device Dissipation (25°C Ambient Temperature) Derate Above 25°C 2mW/°C	P_D	0.3 2.0	Watt mW/°C
Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

80 MHz OSCILLATOR POWER OUTPUT TEST CIRCUIT

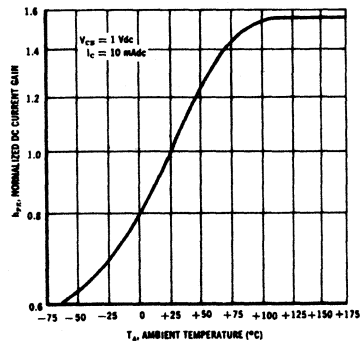


ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

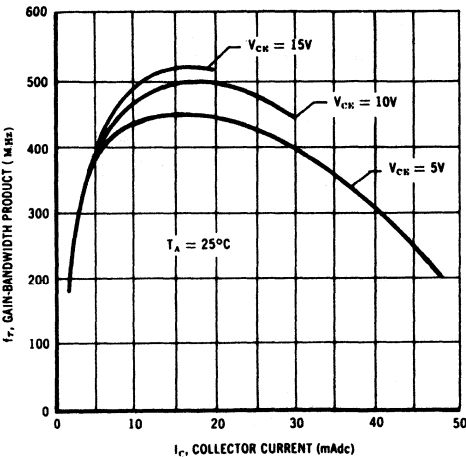
Characteristic	Symbol	Conditions	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage	BV _{CES}	I _C = 25 μAdc, V _{BE} = 0	25	35	-	Vdc
Collector-Emitter Open Base Sustaining Voltage	BV _{CEO(sus)} ⁽¹⁾	I _C = 10mA, I _B = 0	15	24	-	Vdc
Collector Cutoff Current	I _{CBO}	V _{CB} = 10 Vdc, I _E = 0 V _{CB} = 10 Vdc, I _E = 0, T _A = 150°C	-	0.01 10	0.5 50	μAdc
Emitter Cutoff Current	I _{EBO}	V _{EB} = 3 Vdc, I _C = 0	-	-	10	μAdc
DC Current Gain	h _{FE}	V _{CE} = 1 Vdc, I _C = 10 mAdc	60	90	120	-
AC Current Gain	h _{fe}	V _{CE} = 10 Vdc, I _C = 10mAdc, f = 100 MHz	2.0	-	-	-
Collector Output Capacitance	C _{ob}	V _{CB} = 10 Vdc, I _E = 0, f = 100 kHz	-	5.0	6.0	pF
Power Output	P _{out}	f = 80 MHz V _{CC} = 12 Vdc I _{C(max)} = 20 mA	60	-	100	mW
Efficiency	η		25	40	-	%

(1) Pulse Width = 300 μs, Duty Cycle = 2%

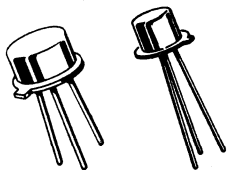
NORMALIZED DC CURRENT GAIN
versus AMBIENT TEMPERATURE



f_T versus COLLECTOR CURRENT



2N3299S, 2N3300S, 2N3301, 2N3302 (SILICON)



NPN silicon annular transistors for high-speed switching circuits and DC to UHF amplifier applications.

CASE 79
(TO-39)
2N3299
2N3300

CASE 22
(TO-18)
2N3301
2N3302



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

Collector connected to case

*MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage (Applicable 0 to 10 mA _{dc})	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	500		mA _{dc}
Operating Junction Temperature Range	T_J	-65 to +200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	2N3299 2N3300	2N3301 2N3302	Watt mW/°C
		0.8 4.56	0.36 2.06	
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	3.0 17.2	1.8 10.3	Watts mW/°C

*Indicates JEDEC Registered Data

FIGURE 1 — SATURATED TURN-ON SWITCHING TIME TEST CIRCUIT

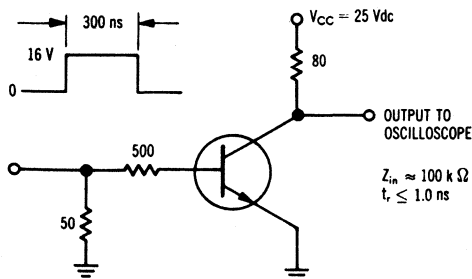
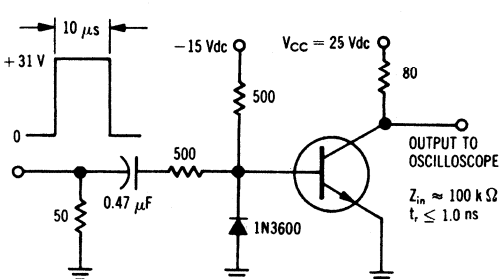


FIGURE 2 — SATURATED TURN-OFF SWITCHING TIME TEST CIRCUIT



2N3299S, 2N3300S, 2N3301, 2N3302 (continued)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 10\text{ mAdc}$, $I_B = 0$)	BV_{CEO}	30	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	60	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current ($V_{CE} = 50\text{ Vdc}$, $V_{BE} = 0$) ($V_{CE} = 50\text{ Vdc}$, $V_{BE} = 0$, $T_A = 150^\circ\text{C}$)	I_{CES}	-	0.01 10	μAdc
Emitter Cutoff Current ($V_{BE} = 3.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	-	10	nAdc
Base Current ($V_{CE} = 50\text{ Vdc}$, $V_{BE} = 0$)	I_B	-	10	nAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 0.1\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ⁽¹⁾ ($I_C = 150\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$) ⁽¹⁾ ($I_C = 150\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ⁽¹⁾ ($I_C = 500\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ⁽¹⁾	2N3299, 2N3301 2N3300, 2N3302 2N3299, 2N3301 2N3300, 2N3302 2N3299, 2N3301 2N3300, 2N3302 2N3299, 2N3301 2N3300, 2N3302 2N3299, 2N3301 2N3300, 2N3302	h_{FE}	20 35 25 50 35 75 20 50 40 100 20 50	- - - - - - - - 120 300 - -	-
Collector-Emitter Saturation Voltage ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$) ($I_C = 300\text{ mAdc}$, $I_B = 30\text{ mAdc}$) ($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$)		$V_{CE(sat)}$	- - -	0.22 0.45 0.6	Vdc
Base-Emitter Saturation Voltage ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$) ($I_C = 300\text{ mAdc}$, $I_B = 30\text{ mAdc}$) ($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$)		$V_{BE(sat)}$	- - -	1.1 1.3 1.5	Vdc
Base-Emitter On Voltage ($I_C = 150\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$)		$V_{BE(on)}$	-	1.1	Vdc

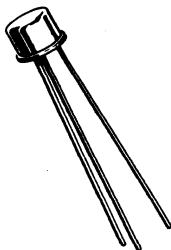
DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 50\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	250	-	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 140\text{ kHz}$)	C_{ob}	-	8.0	pF
Input Capacitance ($V_{BE} = 2.0\text{ Vdc}$, $I_C = 0$, $f = 140\text{ kHz}$)	C_{ib}	-	20	pF
Turn-On Time (Figure 1) ($V_{CC} = 25\text{ Vdc}$, $I_C \approx 300\text{ mAdc}$, $I_{B1} \approx 30\text{ mAdc}$)	t_{on}	-	60	ns
Turn-Off Time (Figure 2) ($V_{CC} = 25\text{ Vdc}$, $I_C \approx 300\text{ mAdc}$, $I_{B1} = I_{B2} \approx 30\text{ mAdc}$)	t_{off}	-	150	ns

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$; Duty Cycle $\leq 2\%$.

* Indicates JEDEC Registered Data

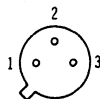
2N3303 (SILICON)



NPN silicon annular transistor designed for high-speed, high-current switching and driving applications.

CASE 31A

Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current-Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.6 3.43	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	3.0 17.2	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

* ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Voltage(1) ($I_C = 30 \text{ mAdc}, I_B = 0$)	BV_{CEO}	12	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.5 \text{ mAdc}, I_E = 0$)	BV_{CBO}	25	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1 \text{ mAdc}, I_C = 0$)	BV_{EBO}	4.0	-	Vdc
Collector Cutoff Current ($V_{CE} = 15 \text{ Vdc}, V_{BE} = 0$)	I_{CES}	-	100	μAdc
Base Current ($V_{CE} = 15 \text{ Vdc}, V_{BE} = 0$)	I_B	-	100	μAdc

(1) Pulse Test: Pulse Width = 300 μs , Duty Cycle $\leq 2\%$

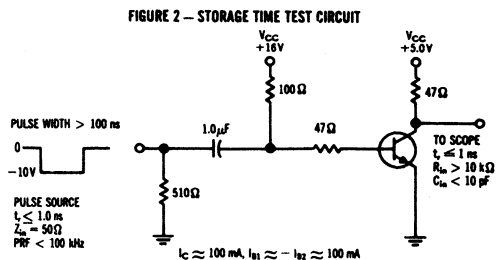
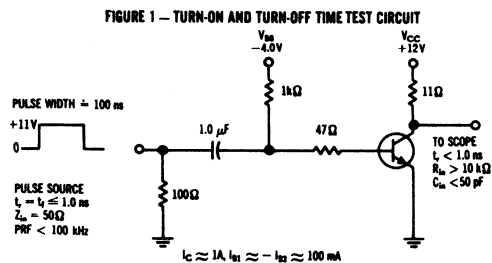
* Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
DC Current Gain ($I_C = 10 \text{ mA}$, $V_{CE} = 0.5 \text{ Vdc}$) ($I_C = 100 \text{ mA}$, $V_{CE} = 0.5 \text{ Vdc}$) ⁽¹⁾ ($I_C = 300 \text{ mA}$, $V_{CE} = 0.5 \text{ Vdc}$) ⁽¹⁾ ($I_C = 300 \text{ mA}$, $V_{CE} = 0.5 \text{ Vdc}$, $T_A = -55^\circ\text{C}$) ⁽¹⁾	h_{FE}	20 30 30 10	- - 120 -	
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mA}$, $I_B = 1 \text{ mA}$) ($I_C = 100 \text{ mA}$, $I_B = 10 \text{ mA}$) ⁽¹⁾ ($I_C = 300 \text{ mA}$, $I_B = 30 \text{ mA}$) ⁽¹⁾ ($I_C = 300 \text{ mA}$, $I_B = 30 \text{ mA}$, $T_A = 125^\circ\text{C}$) ⁽¹⁾ ($I_C = 1 \text{ A}$, $I_B = 100 \text{ mA}$) ⁽¹⁾	$V_{CE(sat)}$	- - - - -	0.25 0.23 0.33 0.50 0.70	Vdc
Base-Emitter Saturation Voltage ($I_C = 10 \text{ mA}$, $I_B = 1 \text{ mA}$) ($I_C = 100 \text{ mA}$, $I_B = 10 \text{ mA}$) ⁽¹⁾ ($I_C = 300 \text{ mA}$, $I_B = 30 \text{ mA}$) ⁽¹⁾ ($I_C = 1 \text{ A}$, $I_B = 100 \text{ mA}$) ⁽¹⁾	$V_{BE(sat)}$	- - - -	0.78 1.10 1.30 2.1	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain - Bandwidth Product ($I_C = 100 \text{ mA}$, $V_{CE} = 5 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	450	-	MHz
Output Capacitance ($V_{CB} = 5 \text{ Vdc}$, $I_E = 0$, $f = 140 \text{ kHz}$)	C_{ob}	-	15	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 140 \text{ kHz}$)	C_{ib}	-	25	pF
Turn-On Time (Figure 1) ($V_{EB(off)} \approx 4 \text{ Vdc}$, $I_C \approx 1 \text{ A}$, $I_{B1} \approx 100 \text{ mA}$)	t_{on}	-	15	ns
Turn-Off Time (Figure 1) ($I_C \approx 1 \text{ A}$, $I_{B1} \approx I_{B2} \approx 100 \text{ mA}$)	t_{off}	-	25	ns
Storage Time (Figure 2) ($I_C \approx 100 \text{ mA}$, $I_{B1} \approx I_{B2} \approx 100 \text{ mA}$)	t_s	-	15	ns

(1) Pulse Test: Pulse Width = 300 μs , Duty Cycle $\leq 2\%$

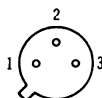
* Indicates JEDEC Registered Data



2N3304 (SILICON)



PNP silicon annular transistor designed for low-level, high-speed switching applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 22
(TO-18)

Collector connected to case

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	6.0	Vdc
Collector-Base Voltage	V_{CB}	6.0	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Total Device Dissipation @ $T_A = 25^{\circ}\text{C}$ Derate above 25°C	P_D	300 1.72	mW mW/ $^{\circ}\text{C}$
Total Device Dissipation @ $T_C = 100^{\circ}\text{C}$ Derate above 100°C	P_D	500 5.0	mW mW/ $^{\circ}\text{C}$
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^{\circ}\text{C}$

* Indicates JEDEC Registered Data

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (†) ($I_C = 10 \text{ mA}$, $I_B = 0$)	$BV_{CEO(sus)}$	6.0	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100 \mu\text{A}$, $V_{BE} = 0$)	BV_{CES}	6.0	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{A}$, $I_E = 0$)	BV_{CBO}	6.0	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{A}$, $I_C = 0$)	BV_{EBO}	4.0	—	Vdc
Collector-Cutoff Current ($V_{CE} = 3 \text{ Vdc}$, $V_{BE} = 0$) ($V_{CE} = 3 \text{ Vdc}$, $V_{BE} = 0$, $T_A = +125^\circ\text{C}$)	I_{CES}	—	0.01 10	μA
Base Current ($V_{CE} = 3 \text{ Vdc}$, $V_{BE} = 0$)	I_B	—	10	nA

ON CHARACTERISTICS

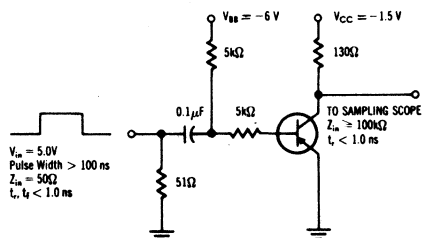
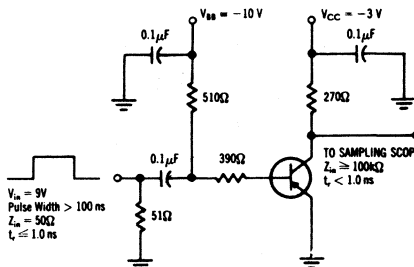
DC Current Gain (†) ($I_C = 1 \text{ mA}$, $V_{CE} = 0.5 \text{ Vdc}$) ($I_C = 10 \text{ mA}$, $V_{CE} = 0.3 \text{ Vdc}$, $T_A = -55^\circ\text{C}$) ($I_C = 10 \text{ mA}$, $V_{CE} = 0.3 \text{ Vdc}$) ($I_C = 50 \text{ mA}$, $V_{CE} = 1.0 \text{ Vdc}$)	h_{FE}	15 12 30 20	— — 120 —	—
Collector-Emitter Saturation Voltage ($I_C = 1 \text{ mA}$, $I_B = 0.1 \text{ mA}$) ($I_C = 10 \text{ mA}$, $I_B = 1 \text{ mA}$, $T_A = +125^\circ\text{C}$) ($I_C = 10 \text{ mA}$, $I_B = 1 \text{ mA}$) ($I_C = 50 \text{ mA}$, $I_B = 5 \text{ mA}$)	$V_{CE(sat)}$	— — — —	0.15 0.23 0.16 0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 1 \text{ mA}$, $I_B = 0.1 \text{ mA}$) ($I_C = 10 \text{ mA}$, $I_B = 1 \text{ mA}$) ($I_C = 50 \text{ mA}$, $I_B = 5 \text{ mA}$)	$V_{BE(sat)}$	0.7 0.8 —	0.8 1.0 1.5	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 10 \text{ mA}$, $V_{CE} = 5 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	500	—	MHz
Output Capacitance ($V_{CB} = 5 \text{ Vdc}$, $I_E = 0$, $f = 140 \text{ kHz}$)	C_{ob}	—	3.5	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 140 \text{ kHz}$)	C_{ib}	—	3.5	pF
Turn-On Time (Figure 1) ($V_{CC} = 1.5 \text{ Vdc}$, $V_{BB} = 6 \text{ Vdc}$, $I_C = 10 \text{ mA}$, $I_{B1} = I_{B2} = 0.5 \text{ mA}$)	t_{on}	—	60	ns
Turn-Off Time (Figure 1) ($V_{CC} = 1.5 \text{ Vdc}$, $I_C = 10 \text{ mA}$, $I_{B1} = I_{B2} = 0.5 \text{ mA}$)	t_{off}	—	60	ns
Charge-Storage Time (Figure 2) ($I_C = 10 \text{ mA}$, $V_{CC} = 3 \text{ Vdc}$, $I_{B1} = I_{B2} = 10 \text{ mA}$)	t_s	—	30	ns

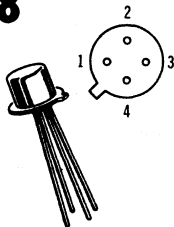
(†) Pulse Test: Pulse Width = 300 μs ; Duty Cycle = 2%

* Indicates JEDEC Registered Data

FIGURE 1 — TURN-ON & TURN-OFF TIME TEST CIRCUIT

FIGURE 2 — CHARGE-STORAGE TIME TEST CIRCUIT


2N3307 (SILICON)

2N3308



STYLE 10
PIN 1. EMITTER
2. BASE
3. COLLECTOR
4. CASE

CASE 20
(TO-72)

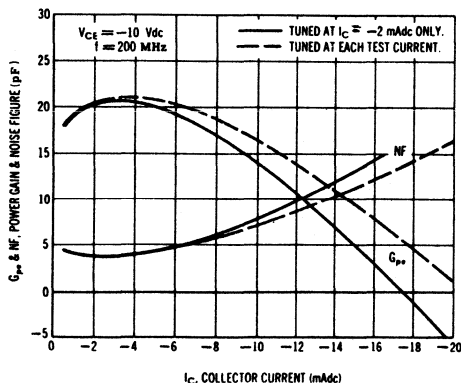
PNP silicon annular transistors for high-gain, low-noise amplifier, oscillator, mixer and frequency multiplier applications.

*MAXIMUM RATINGS

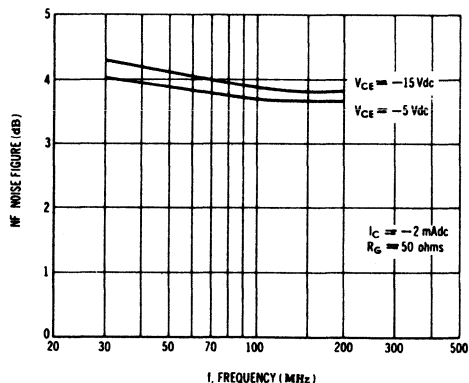
Rating	Symbol	Value		Unit
		2N3307	2N3308	
Collector-Base Voltage	V_{CB}	40	30	Vdc
Collector-Emitter Voltage	V_{CES}	40	30	Vdc
Collector-Emitter Voltage	V_{CEO}	35	25	Vdc
Emitter-Base Voltage	V_{EB}	3.0		Vdc
Collector Current	I_C	50		mAdc
Power Dissipation at $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	300 1.71		mW mW/ $^\circ\text{C}$
Power Dissipation at $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	200 1.14		mW mW/ $^\circ\text{C}$
Junction Temperature	T_J	200		$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200		$^\circ\text{C}$

*Indicates JEDEC Registered Data

COMMON EMITTER AVERAGE SMALL POWER GAIN
& NOISE FIGURE versus COLLECTOR CURRENT



NOISE FIGURE versus FREQUENCY



2N3307, 2N3308 (Continued)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

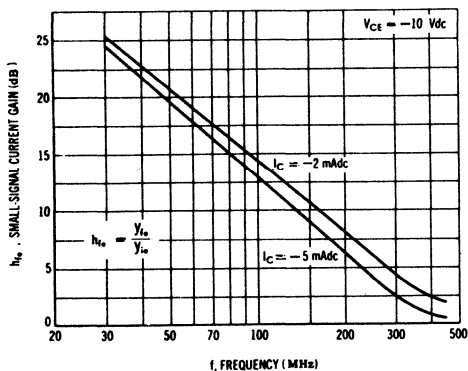
Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage	BV_{CBO}	$I_C = 10 \mu\text{A}$, $I_E = 0$	2N3307 2N3308	40 30	— —	Vdc
Collector-Emitter Breakdown Voltage	BV_{CES}	$I_C = 10 \mu\text{A}$, $V_{BE} = 0$	2N3307 2N3308	40 30	— —	Vdc
Collector-Emitter Breakdown Voltage	BV_{CEO}	$I_C = 2.0 \text{ mA}$, $I_B = 0$	2N3307 2N3308	35 25	— —	Vdc
Emitter-Base Breakdown Voltage	BV_{EBO}	$I_E = 10 \mu\text{A}$, $I_C = 0$	Both Types	3.0	—	Vdc
Collector Cutoff Current	I_{CBO}	$V_{CB} = 15 \text{ Vdc}$ $V_{CB} = 15 \text{ Vdc}$, $T = 150^\circ\text{C}$	Both Types 2N3307	— 0.001 0.5	0.010 3.0	μA
DC Current Gain	h_{FE}	$V_{CE} = 10 \text{ Vdc}$, $I_C = 2 \text{ mA}$	2N3307 2N3308	40 25	250 250	—
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C = 3 \text{ mA}$, $I_B = 0.6 \text{ mA}$	Both Types	—	0.4	Vdc
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	$I_C = 3 \text{ mA}$, $I_B = 0.6 \text{ mA}$	Both Types	—	1.0	Vdc
AC Current Gain	h_{fe}	$V_{CE} = 10 \text{ Vdc}$, $I_C = 2 \text{ mA}$, $f = 1 \text{ kHz}$	2N3307 2N3308	40 25	250 250	—
Output Capacitance (1)	C_{ob}	$V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 0.1 \text{ MHz}$	2N3307 2N3308	— 1.0 1.2	1.3 1.6	pF
Collector-Base Time Constant	τ_{bc}	$V_{CB} = 10 \text{ Vdc}$, $I_C = 2 \text{ mA}$, $f = 31.8 \text{ MHz}$	2N3307 2N3308	2.0 2.0	15 20	ps
Current Gain-Bandwidth Product	f_T	$V_{CE} = 10 \text{ Vdc}$, $I_C = 2 \text{ mA}$, $f = 100 \text{ MHz}$	Both Types	300	1200	MHz
Maximum Frequency of Oscillation	f_{max}	$V_{CE} = 10 \text{ Vdc}$, $I_C = 2 \text{ mA}$	Both Types	—	2000	MHz
Power Gain	G_e	$V_{CE} = 10 \text{ Vdc}$, $I_C = 2 \text{ mA}$, $f = 200 \text{ MHz}$	Both Types	17	24	dB
Noise Figure	NF	$V_{CE} = 10 \text{ Vdc}$, $I_C = 2 \text{ mA}$, $f = 200 \text{ MHz}$	2N3307 2N3308	— 4.0 5.0	4.5 6.0	dB
Power Gain (AGC) (2)	G_e	$V_{CE} = 5.0 \text{ Vdc}$, $I_C = 20 \text{ mA}$, $f = 200 \text{ MHz}$	2N3307 2N3308	— — 0	0 —	dB

(1) C_{ob} is measured in guarded circuit such that the can capacitance is not included.

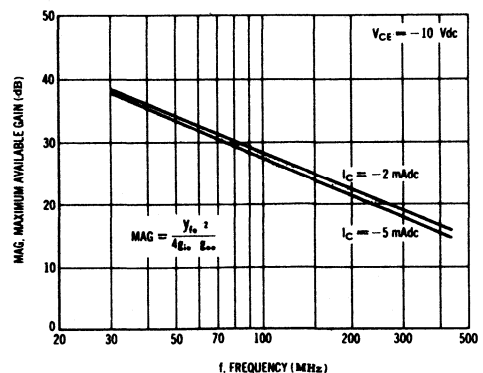
(2) AGC is obtained by increasing I_C . The circuit remains adjusted for $V_{CE} = -10 \text{ Vdc}$, $I_C = -2 \text{ mA}$ operation.

* Indicates JEDEC Registered Data

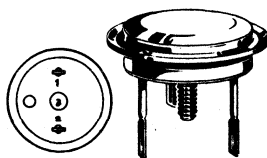
SMALL SIGNAL CURRENT GAIN versus FREQUENCY



MAXIMUM AVAILABLE GAIN versus FREQUENCY



2N3311 thru 2N3316 (GERMANIUM)



CASE 5
(TO-36)

STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

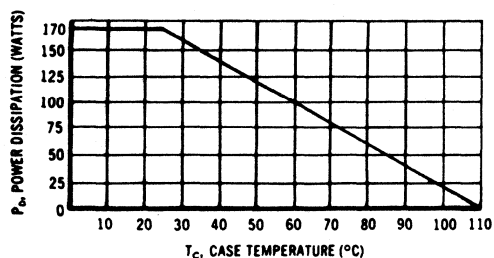
Collector connected to case

PNP germanium power transistors for high-power applications.

MAXIMUM RATINGS

Rating	Symbol	2N3311 2N3314	2N3312 2N3315	2N3313 2N3316	Unit
Collector-Base Voltage	V_{CB}	30	45	60	Volts
Collector-Emitter Voltage	V_{CES}	30	45	60	Volts
Collector-Emitter Voltage	V_{CEO}	20	30	40	Volts
Emitter-Base Voltage	V_{EB}	20	25	30	Volts
Collector Current (Continuous)	I_C	5.0			Amp
Power Dissipation at $T_C = 25^\circ\text{C}$	P_D	170			Watts
Junction Temperature Range	T_J	-65 to +110			$^\circ\text{C}$
Thermal Resistance	θ_{JC}	0.5			$^\circ\text{C/W}$

POWER-TEMPERATURE DERATING CURVE



The maximum continuous power is related to maximum junction temperature by the thermal resistance factor. This curve has a value of 170 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that:

$$\text{allowable } P_D = \frac{110^\circ - T_c}{0.5}$$

2N3311 thru 2N3316 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25 °C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage* (I _C = 500 mA _{dc} , I _B = 0)	2N3311, 2N3314 2N3312, 2N3315 2N3313, 2N3316	BV _{CEO} *	20 30 40	- - -	V _{dc}
Collector-Emitter Breakdown Voltage* (I _C = 300 mA _{dc} , V _{BE} = 0)	2N3311, 2N3314 2N3312, 2N3315 2N3313, 2N3316	BV _{CES} *	30 45 60	- - -	V _{dc}
Collector Cutoff Current (V _{CE} = 10 V _{dc} , I _B = 0)	2N3311, 2N3314	I _{CEO}	-	200	mA _{dc}
(V _{CE} = 15 V _{dc} , I _B = 0)	2N3312, 2N3315		-	200	
(V _{CE} = 20 V _{dc} , I _B = 0)	2N3313, 2N3316		-	200	
Collector Cutoff Current (V _{CE} = 25 V _{dc} , V _{BE} = 1.0 V _{dc} , T _C = 100 °C)	2N3311, 2N3314	I _{CEX}	-	35	mA _{dc}
(V _{CE} = 40 V _{dc} , V _{BE} = 1.0 V _{dc} , T _C = 100 °C)	2N3312, 2N3315		-	35	
(V _{CE} = 55 V _{dc} , V _{BE} = 1.0 V _{dc} , T _C = 100 °C)	2N3313, 2N3316		-	35	
Collector-Base Cutoff Current (V _{CB} = V _{CB max}) (V _{CB} = 2.0 V _{dc} , I _E = 0)		I _{CBO}	-	5.0 0.3	mA _{dc}
Emitter-Base Cutoff Current (V _{BE} = V _{BE max} , I _C = 0)		I _{EBO}	-	4.0	mA _{dc}

ON CHARACTERISTICS

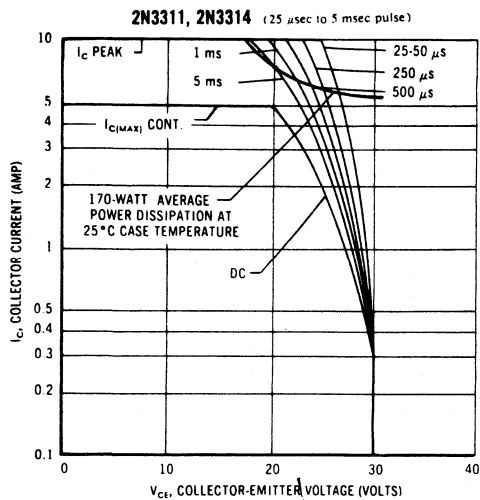
DC Current Gain (I _C = 500 mA _{dc} , V _{CB} = 2.0 V _{dc})	2N3311 thru 2N3313 2N3314 thru 2N3316	h _{FE}	- - 60 100	150 250 120 200	-
(I _C = 3.0 A _{dc} , V _{CB} = 2.0 V _{dc})	2N3311 thru 2N3313 2N3314 thru 2N3316				
Collector-Emitter Saturation Voltage (I _C = 3.0 A _{dc} , I _B = 300 mA _{dc})		V _{CE(sat)}	-	0.1	V _{dc}
Base-Emitter Voltage (I _C = 3.0 A _{dc} , V _{CE} = 2.0 V _{dc})	2N3311 thru 2N3313 2N3314 thru 2N3316	V _{BE(on)}	- -	0.6 0.5	V _{dc}

DYNAMIC CHARACTERISTICS

Common Emitter Cutoff Frequency (I _C = 3.0 A _{dc} , V _{CE} = 2.0 V _{dc})		f _{oe}	1.0	-	kHz
Small Signal Current Gain (I _C = 3.0 A _{dc} , V _{CE} = 2.0 V _{dc} , f = 0.5 kHz)	2N3311 thru 2N3313 2N3314 thru 2N3316	h _{fe}	30 40	90 120	-

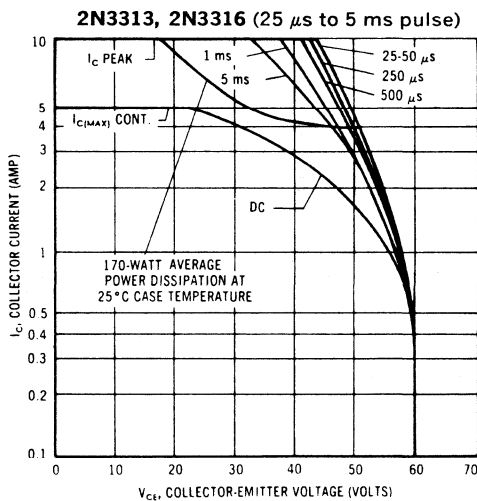
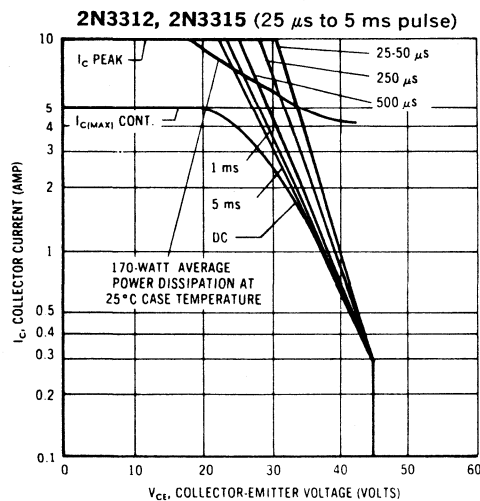
*To avoid excessive heating of the collector junction, perform these tests with an oscilloscope.

2N3311 thru 2N3316 (continued)

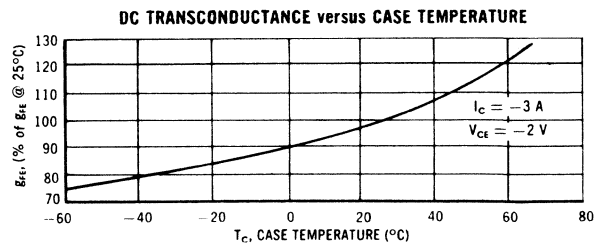
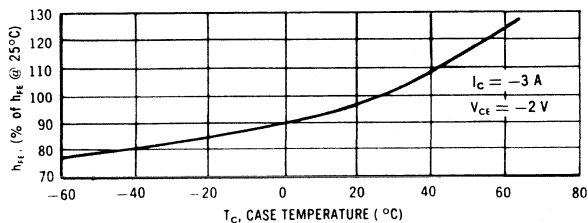
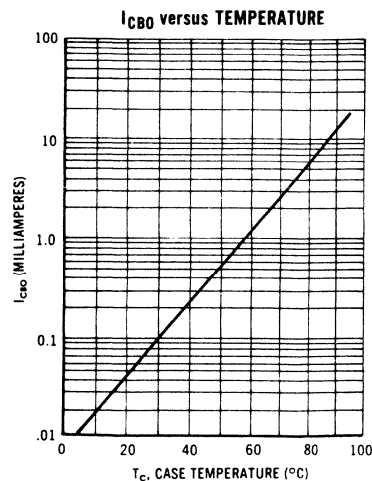


SAFE OPERATING AREA

The Safe Operating Area Curves indicate the I_C - V_{CE} limits below which the devices will not go into secondary breakdown. As the safe operating areas shown are independent of temperature and duty cycle, these curves can be used as long as the average power derating curve is also taken into consideration to insure operation below the maximum junction temperature.



TEMPERATURE CHARACTERISTICS



2N3323 (Ge Mesa)

2N3324

2N3325



CASE 22-03
(TO-18)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

PNP germanium transistors for RF, IF, mixer and oscillator and RF, IF and converter applications.

Collector connected to case

*** MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	35	Vdc
Collector-Emitter Voltage	V_{CES}	35	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current - Continuous	I_C	100	mA
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	300 4.0	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	150 2.0	mW mW/ $^\circ\text{C}$
Junction Temperature	T_J	+100	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +100	$^\circ\text{C}$

*Indicates JEDEC Registered Data

*** ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Conditions	Min	Max	Unit
Collector-Emitter Breakdown Voltage	BV_{CER}	$I_C = 100 \mu\text{A dc}$, $R_{\text{BE}} = 10\text{K}$	35	--	Vdc
Collector-Emitter Current	I_{CES}	$V_{\text{CE}} = 35 \text{ Vdc}$, $V_{\text{BE}} = 0$	--	100	$\mu\text{A dc}$
Collector Cutoff Current	I_{CBO}	$V_{\text{CB}} = 10 \text{ Vdc}$, $I_E = 0$	--	10	$\mu\text{A dc}$
Emitter Cutoff Current	I_{EBO}	$V_{\text{EB}} = 2 \text{ Vdc}$, $I_C = 0$	--	100	$\mu\text{A dc}$
DC Current Gain	h_{FE}	$V_{\text{CE}} = 10 \text{ Vdc}$, $I_C = 3 \text{ mA dc}$	30	200	--
AC Current Gain	h_{fe}	$V_{\text{CE}} = 10 \text{ Vdc}$, $I_C = 3 \text{ mA dc}$ $f = 1 \text{ kHz}$	30	225	--
Current-Gain — Bandwidth Product	f_T	$V_{\text{CE}} = 10 \text{ Vdc}$, $I_C = 3 \text{ mA dc}$ $f = 100 \text{ MHz}$	200	600	MHz
Collector-Base Time Constant	$r_b' C_C$	$V_{\text{CE}} = 10 \text{ Vdc}$, $I_C = 3 \text{ mA dc}$ $f = 31.8 \text{ MHz}$	--	100	ps
Output Capacitance	C_{ob}	$V_{\text{CB}} = 10 \text{ Vdc}$, $I_E = 0$ $f = 100 \text{ kHz}$	--	3.0	pF

2N3323

Power Gain	G_e	Test Circuit Figure 1 $V_{\text{CE}} = 10 \text{ Vdc}$, $I_C = 3 \text{ mA dc}$ $f = 100 \text{ MHz}$	11	15	dB
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2N3324

Power Gain	G_e	Test Circuit Figure 2 $V_{\text{CE}} = 10 \text{ Vdc}$, $I_C = 3 \text{ mA dc}$ $f = 10 \text{ MHz}$	24	31	dB
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*Indicates JEDEC Registered Data

FIGURE 1: 100 MHz POWER GAIN TEST CIRCUIT 2N3323

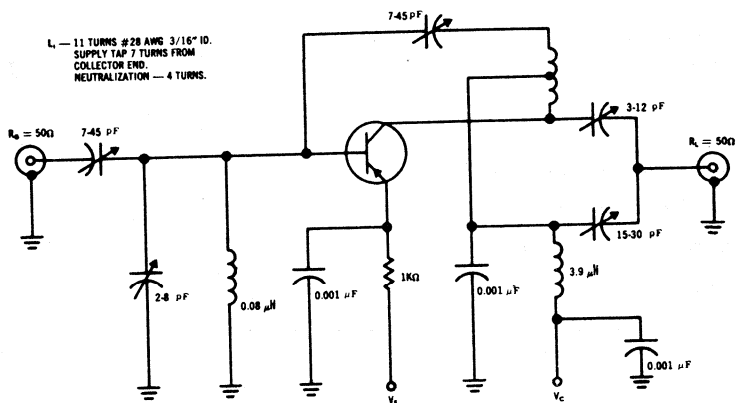
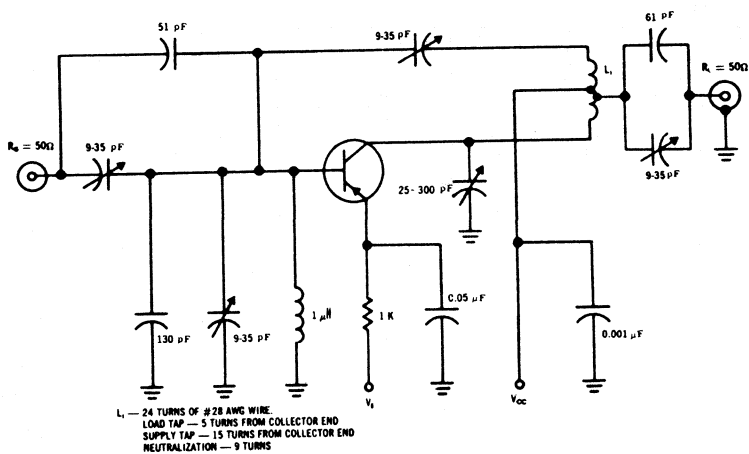


FIGURE 2: 10 MHz POWER GAIN TEST CIRCUIT — 2N3324



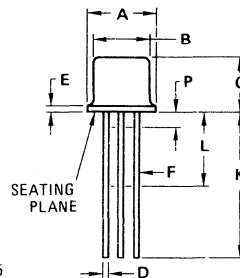
SILICON P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR

Depletion Mode (Type A) Junction Field-Effect Transistor designed primarily for low-power audio-amplifier applications.

- High AC Input Resistance –
Typically > 30 Megohms @ $f = 1.0$ kHz
- Drain and Source Interchangeable
- Active Elements Isolated from Case

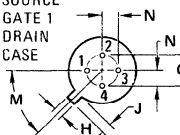
P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR

(Type A)



STYLE 5

- PIN 1. SOURCE
2. GATE 1
3. DRAIN
4. CASE



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	20	Vdc
Reverse Gate-Source Voltage	V_{GSR}	20	Vdc
*Gate Current	I_G	10	mAdc
*Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 2.0	mW mW/ $^\circ\text{C}$
*Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

*Indicates JEDEC Registered Data.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	—	0.76	—	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	—	1.27	—	0.050

ALL JEDEC dimensions and notes apply

CASE 20-03
TO-72

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^{\circ}\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Gate-Source Breakdown Voltage ($I_C = 10\ \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	20	—	Vdc
Gate Reverse Current ($V_{GS} = 10\ \text{Vdc}$, $V_{DS} = 0$) ($V_{GS} = 10\ \text{Vdc}$, $V_{DS} = 0$, $T_A = 150^{\circ}\text{C}$)	I_{GSS}	— —	10 10	nAdc μAdc
Zero-Gate Voltage Drain Current (Note 1) ($V_{DS} = -10\ \text{Vdc}$, $V_{GS} = 0$)	I_{DSS}	2.0	6.0	mAdc

ON CHARACTERISTICS

Gate-Source Voltage ($V_{DG} = -15\ \text{Vdc}$, $I_D = 10\ \mu\text{Adc}$)	V_{GS}	—	6.0	Vdc
Drain-Source Resistance ($I_D = 100\ \mu\text{Adc}$, $V_{GS} = 0$)	r_{DS}	—	800	Ohms

SMALL-SIGNAL CHARACTERISTICS

Forward Transadmittance (Note 1) ($V_{DS} = -10\ \text{Vdc}$, $I_D = 2.0\ \text{mAdc}$, $f = 1.0\ \text{kHz}$) ($V_{DS} = -10\ \text{Vdc}$, $I_D = 2.0\ \text{mAdc}$, $f = 10\ \text{MHz}$)	$ y_{fs} $	1500 1350	3000 —	μmhos
Output Admittance ($V_{DS} = -10\ \text{Vdc}$, $I_D = 2.0\ \text{mAdc}$, $f = 1.0\ \text{kHz}$)	$ y_{os} $	—	40	μmhos
Reverse Transfer Conductance ($V_{DS} = -10\ \text{Vdc}$, $I_D = 2.0\ \text{mAdc}$, $f = 1.0\ \text{kHz}$)	$ y_{rs} $	—	0.1	μmhos
Input Conductance ($V_{DS} = -10\ \text{Vdc}$, $I_D = 2.0\ \text{mAdc}$, $f = 1.0\ \text{kHz}$)	$ y_{is} $	—	0.2	μmhos
Input Capacitance ($V_{DS} = -10\ \text{Vdc}$, $V_{GS} = 1.0\ \text{Vdc}$, $f = 1.0\ \text{MHz}$)	C_{iss}	—	20	pF
Common-Source Noise Figure ($V_{DS} = -5.0\ \text{Vdc}$, $I_D = 1.0\ \text{mAdc}$, $R_G = 1.0\ \text{Megohm}$, $f = 1.0\ \text{kHz}$)	NF	—	3.0	dB

*Indicates JEDEC Registered Data.

Note 1: Pulse Test: Pulse Width $\leq 630\ \text{ms}$, Duty Cycle $\leq 10\%$.

2N3365 (SILICON)

2N3366

2N3367

SILICON LOW NOISE N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode Junction Field-Effect Transistors designed for audio amplifiers in low-power or battery operated applications.

- Low Zero-Gate Voltage Drain Current @ $V_{DS} = 30 \text{ Vdc}$ –
 $I_{DSS} = 800 \mu\text{Adc}$ to 4.0 mAdc – 2N3365
 $200 \mu\text{Adc}$ to 1.0 mAdc – 2N3366
 $50 \mu\text{Adc}$ to $250 \mu\text{Adc}$ – 2N3367
- Low Gate Source Voltage @ $V_{DS} = 20 \text{ Vdc}$ and $I_D = 1.0 \mu\text{Adc}$ –
 $V_{GS} = 4.0 \text{ Vdc}$ (Typ) and 11.5 Vdc (Max) – 2N3365
 3.0 Vdc (Typ) and 6.5 Vdc (Max) – 2N3366
 1.0 Vdc (Typ) and 2.2 Vdc (Max) – 2N3367
- Low Noise Voltage –
 $e_n = 75 \text{ nV}/\sqrt{\text{Hz}}$ (Max) @ $f = 1.0 \text{ kHz}$
- Drain and Source Interchangeable

LOW NOISE N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

$$e_n = 75 \text{ nV}/\sqrt{\text{Hz}}$$



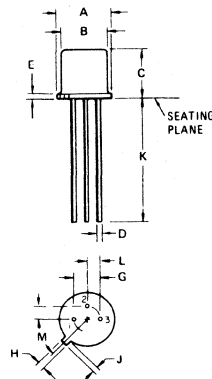
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	40	Vdc
Reverse Gate-Source Voltage	$V_{GS(R)}$	40	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 2.4	mW mW/ $^\circ\text{C}$
Operating Case Temperature	T_C	150	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +175	$^\circ\text{C}$

*Indicates JEDEC Registered Data.

MECHANICAL CHARACTERISTICS:

Maximum Lead Temperature for Soldering:
 300°C , not less than $1/16''$ from case for 10 s.



PIN 1 DRAIN
2 SOURCE
3 GATE

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.209	0.230	5.310	5.840
B	0.178	0.195	4.520	4.950
C	0.170	0.210	4.320	5.330
D	0.016	0.019	0.406	0.483
E	—	0.030	—	0.762
G	0.100	NOM	2.540	NOM
H	0.036	0.046	0.914	1.170
J	0.028	0.048	0.711	1.220
K	0.500	—	12.700	—
L	0.050	NOM	1.270	NOM
M	45°	NOM	45°	NOM

All JEDEC dimensions and notes apply

CASE 22
TO-18

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
*OFF CHARACTERISTICS				
Gate-Drain Breakdown Voltage ($I_D = 1.0 \mu\text{Adc}$, $I_S = 0$)	$V_{(BR)GDO}$	40	—	Vdc
Gate-Source Cutoff Voltage ($V_{DS} = 20 \text{ Vdc}$, $I_D = 5.0 \text{ nAdc}$)	$V_{GS(off)}$	—	12 7.0 2.5	Vdc
Gate-Source Voltage ($V_{DS} = 20 \text{ Vdc}$, $I_D = 1.0 \mu\text{Adc}$)	V_{GS}	—	11.5 6.5 2.2	Vdc
Gate Reverse Current ($V_{GS} = 30 \text{ Vdc}$, $V_{DS} = 0$) ($V_{GS} = 30 \text{ Vdc}$, $V_{DS} = 0$, $T_A = 100^\circ\text{C}$)	I_{GSS}	—	5.0 1.0	nAdc μAdc

*ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current (1) ($V_{DS} = 30 \text{ Vdc}$, $V_{GS} = 0$)	I_{DSS}	0.8 0.2 0.05	4.0 1.0 0.25	mAdc

SMALL-SIGNAL CHARACTERISTICS

*Forward Transadmittance (1) ($V_{DS} = 30 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)	$ y_{fs} $	400 250 100	2000 1000 1000	μmhos
*Output Admittance ($V_{DS} = 30 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	$ y_{os} $	— — —	50 20 10	μmhos
*Input Capacitance ($V_{DS} = 8.0 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{iss}	—	15	pF
*Output Capacitance ($V_{DS} = 30 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{oss}	—	2.5	pF
Equivalent Short-Circuit Input Noise Voltage ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$, $BW = 1.0 \text{ Hz}$)	e_n	—	75	$\text{nV}/\sqrt{\text{Hz}}$

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width = 360 ms, Duty Cycle = 2.0%.

TYPICAL SMALL-SIGNAL CHARACTERISTICS

FIGURE 1 – FORWARD TRANSFER ADMITTANCE

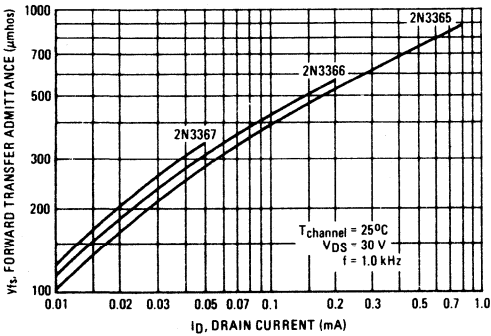
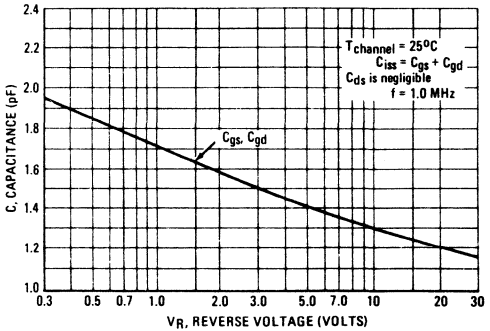
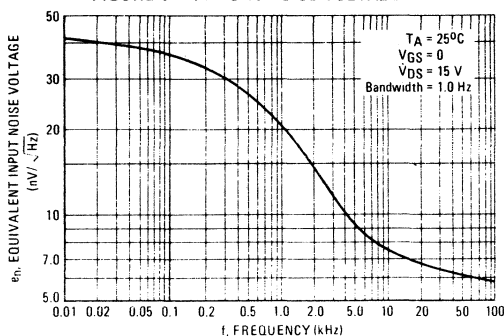


FIGURE 2 – CAPACITANCE



NOISE DATA

FIGURE 3 — TYPICAL NOISE VOLTAGE



In a junction field-effect transistor, the current flow is due to carrier drift, therefore total noise at the input may be expressed as:

$$V_T = [e^2 n + 4 K T R_S]^{1/2}$$

where V_T = total noise voltage at the FET input (volts/ $\sqrt{\text{Hz}}$)
 e_n = noise voltage of the FET referred to the input (Figure 3).
 K = Boltzman's constant (1.38×10^{-23} j/°K)
 T = temperature of the source resistance (°K)
 R_S = source resistance (ohms)

Example:

Find the total noise at the input of a 2N3365 FET with a source impedance of 10 kilohms at a frequency of 1.0 kHz and at a temperature of 25°C.

Read $e_n = 20.5$ nV/ $\sqrt{\text{Hz}}$ from Figure 3. (Note that this is for a one cycle bandwidth).

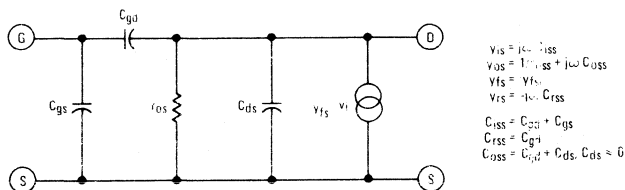
$$V_T = [(20.5 \times 10^{-9})^2 + (4)(1.38 \times 10^{-23})(300)(1 \times 10^4)]^{1/2} \\ = 24.2 \text{ nV}/\sqrt{\text{Hz}}$$

Noise over a frequency band can be handled in one of two ways depending upon whether FET noise is constant or variable over the bandwidth of interest:

1. For constant FET noise, multiply V_T by the square root of bandwidth, i.e., $V'_T = V_T \bullet \Delta f^{1/2}$
2. For variable FET noise, plot V'_T (where $\Delta f = 1.0$ Hz) versus frequency over the bandwidth and integrate the result.

Total noise voltage at the output of the FET stage can be found by multiplying V_T by the voltage gain of the stage.

FIGURE 4 — LOW FREQUENCY CIRCUIT MODEL



TYPICAL LIMIT TRANSFER CHARACTERISTICS
(Temperatures Noted are T_{channel})

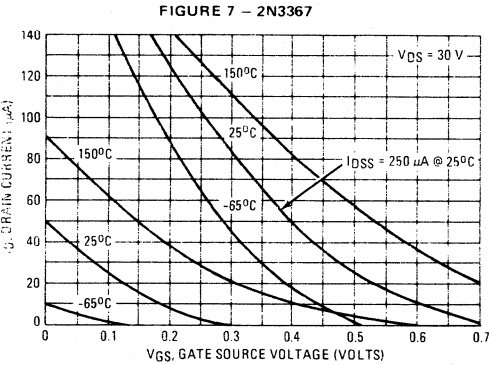
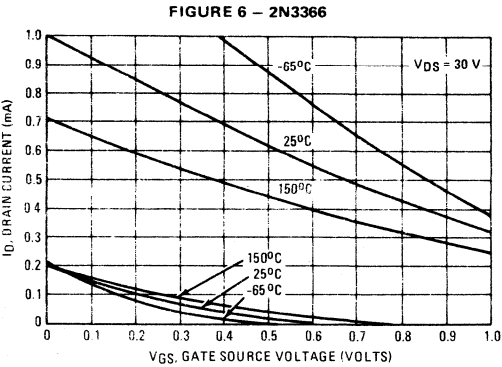
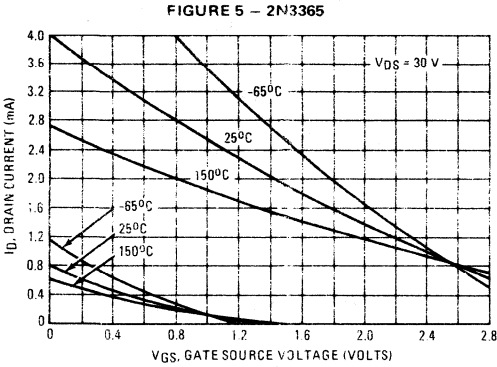
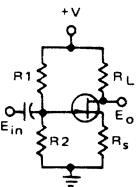
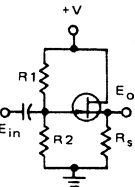
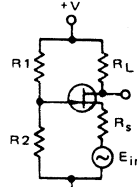
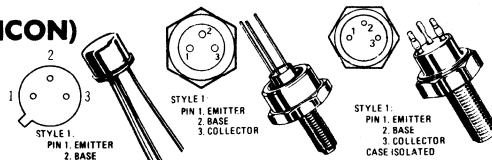


FIGURE 8 – AMPLIFIER EQUATIONS

Circuit Characteristic	Common Source	Source Follower	Common Gate
			
Voltage Gain	$A_v \approx \frac{-R_L}{\frac{1}{g_m} + R_s}$	$A_v \approx \frac{R_s}{\frac{1}{g_m} + R_s}$	$A_v \approx \frac{R_L}{\frac{1}{g_m} + R_s}$
Input Impedance	$Z_{in} \approx R1 \parallel R2$	$Z_{in} \approx R1 \parallel R2$	$Z_{in} \approx R_s + \frac{1}{g_m}$
Output Impedance	$Z_o \approx R_L$	$Z_o \approx R_s \parallel \frac{1}{g_m}$	$Z_o \approx R_L$

2N3375 (SILICON)**2N3553****2N3632****2N3961**

CASE 79
(TO-39)

2N3553

CASE 24
(TO-102)

2N3961

CASE 36
(TO-60)
2N3375
2N3632

* Collector Connected
to Case

** Collector electrically connected
to case; stud electrically
isolated from case

*** Stud electrically
isolated from case

NPN silicon RF Power transistors, optimized for large-signal power amplifier and driver applications to 400MHz, provide wide choice of power levels and guaranteed safe operating areas.

MAXIMUM RATINGS

Rating	Symbol	2N3375	2N3553	2N3632	2N3961	Unit
Collector-Emitter Voltage	V_{CEO}	40				Vdc
Collector-Base Voltage	V_{CB}	65				Vdc
Emitter-Base Voltage	V_{EB}	4.0				Vdc
Collector Current	I_C	1.5	1.0	3.0	1.0	Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$	P_D	11.6	7.0	23	10	Watts
Derate above 25°C		66.4	40	131	57.2	mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200				$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage* ($I_C = 200 \text{ mAdc}$, $I_B = 0$)	$BV_{CEO(sus)}^*$	40	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.25 \text{ mAdc}$, $I_C = 0$)	BV_{EBO}	4.0	-	Vdc
($I_E = 0.1 \text{ mAdc}$, $I_C = 0$)		4.0	-	
($I_E = 1.0 \text{ mAdc}$, $I_C = 0$)		4.0	-	
Collector Cutoff Current ($V_{CE} = 30 \text{ Vdc}$, $I_B = 0$)	I_{CEO}	-	0.1	mAdc
		-	0.25	
Collector Cutoff Current ($V_{CE} = 30 \text{ Vdc}$, $V_{BE(off)} = 1.5 \text{ Vdc}$, $T_C = 200^\circ\text{C}$)	I_{CEX}	-	5.0	mAdc
		-	10	
($V_{CE} = 65 \text{ Vdc}$, $V_{BE(off)} = 1.5 \text{ Vdc}$)		-	1.0	
		-	5.0	
Collector Cutoff Current ($V_{CB} = 28 \text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	-	5.0	mAdc
($V_{CB} = 65 \text{ Vdc}$, $I_E = 0$)		-	0.5	
		-	1.0	
Emitter Cutoff Current ($V_{BE} = 4.0 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	-	0.1	mAdc
		-	0.25	

* Pulsed thru 25 mH inductor (See Figures 5 and 6).

2N3375, 2N3553, 2N3632, 2N3961 (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Typ	Max	Unit
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ON CHARACTERISTICS

DC Current Gain ($I_C = 250 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$) ($I_C = 1.0 \text{ Adc}$, $V_{CE} = 5.0 \text{ Vdc}$)	2N3375, 2N3553, 2N3632 2N3632	h_{FE}	10 5.0	- -	- -
Collector-Emitter Saturation Voltage ($I_C = 250 \text{ mAdc}$, $I_B = 50 \text{ mAdc}$) ($I_C = 500 \text{ mAdc}$, $I_B = 100 \text{ mAdc}$)	2N3553 2N3375, 2N3632	$V_{CE(sat)}$	- -	- -	1.0 1.0 Vdc
Base-Emitter Saturation Voltage ($I_C = 1.0 \text{ Adc}$, $I_B = 5.0 \text{ Adc}$)	2N3632	$V_{BE(sat)}$	-	-	1.5 Vdc

DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 100 \text{ mAdc}$, $V_{CE} = 28 \text{ Vdc}$, $f = 100 \text{ MHz}$) ($I_C = 125 \text{ mAdc}$, $V_{CE} = 28 \text{ Vdc}$, $f = 100 \text{ MHz}$) ($I_C = 150 \text{ mAdc}$, $V_{CE} = 28 \text{ Vdc}$, $f = 100 \text{ MHz}$)	2N3553 2N3961 2N3375 2N3632	f_T	- 350 -	500 500 400	- - -	MHz
Output Capacitance ($V_{CB} = 28 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$) ($V_{CB} = 30 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)	2N3961 2N3375, 2N3553 2N3632	C_{ob}	- - -	8.0 8.0 16	10 10 20	pF

FUNCTIONAL TESTS

2N3375

Power Input	Test Circuit Figure 7 ($V_{CE} = 28 \text{ Vdc}$, $P_{out} = 7.5 \text{ Watts}$, $f = 100 \text{ MHz}$)	P_{in}	-	-	1.0	Watt
Common-Emitter Amplifier Power Gain		G_{pe}	8.75	-	-	dB
Collector Efficiency		η	65	-	-	%
Power Input	Test Circuit Figure 8 ($V_{CE} = 28 \text{ Vdc}$, $P_{out} = 3.0 \text{ Watts}$, $f = 400 \text{ MHz}$)	P_{in}	-	-	1.0	Watt
Common-Emitter Amplifier Power Gain		G_{pe}	4.77	-	-	dB
Collector Efficiency		η	40	-	-	%

2N3553

Power Input	Test Circuit Figure 9 ($V_{CE} = 28 \text{ Vdc}$, $P_{out} = 2.5 \text{ Watts}$, $f = 175 \text{ MHz}$)	P_{in}	-	-	0.25	Watt
Common-Emitter Amplifier Power Gain		G_{pe}	10	-	-	dB
Collector Efficiency		η	50	-	-	%

2N3632

Power Input	Test Circuit Figure 10 ($V_{CE} = 28 \text{ Vdc}$, $P_{out} = 13.5 \text{ Watts}$, $f = 175 \text{ MHz}$)	P_{in}	-	-	3.5	Watts
Common-Emitter Amplifier Power Gain		G_{pe}	5.86	-	-	dB
Collector Efficiency		η	70	-	-	%

2N3961

Power Input	Test Circuit Figure 11 ($V_{CE} = 12.5 \text{ Vdc}$, $P_{out} = 2.0 \text{ Watts}$, $R_S = 50 \text{ ohms}$, $R_L = 50 \text{ ohms}$, $f = 135 \text{ MHz}$)	P_{in}	-	-	0.5	Watt
Common-Emitter Amplifier Power Gain		G_{pe}	6.0	-	-	dB
Collector Efficiency		η	60	-	-	%
Power Input	Test Circuit Figure 12 ($V_{CE} = 28 \text{ Vdc}$, $P_{out} = 4.0 \text{ Watts}$, $R_S = 50 \text{ ohms}$, $R_L = 50 \text{ ohms}$, $f = 175 \text{ MHz}$)	P_{in}	-	-	0.5	Watt
Common-Emitter Amplifier Power Gain		G_{pe}	9.0	-	-	dB
Collector Efficiency		η	60	-	-	%

POWER OUTPUT versus FREQUENCY
COMMON EMITTER — $V_{CE} = 28 \text{ Vdc}$, $T_C = 25^\circ\text{C}$

FIGURE 1 — 2N3375

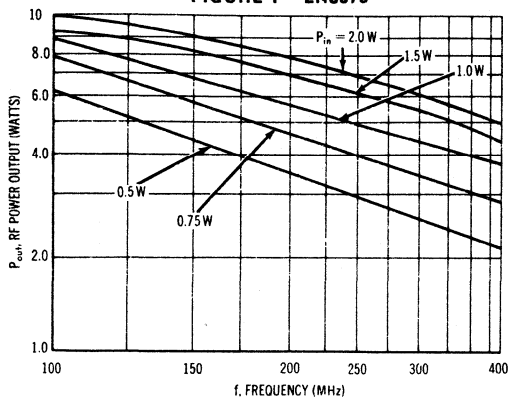


FIGURE 2 — 2N3553

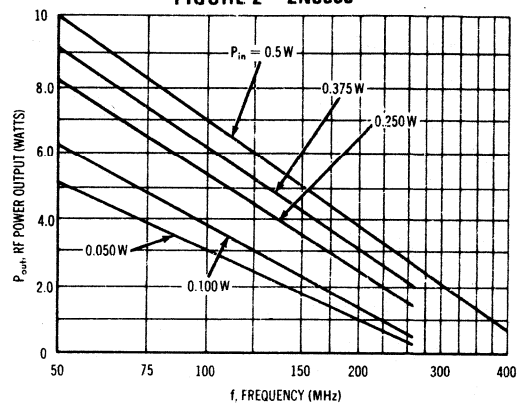


FIGURE 3 — 2N3632

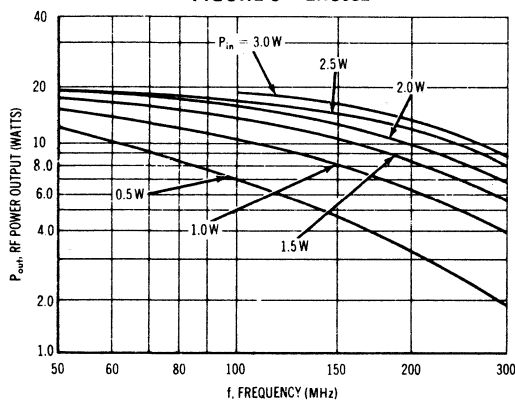
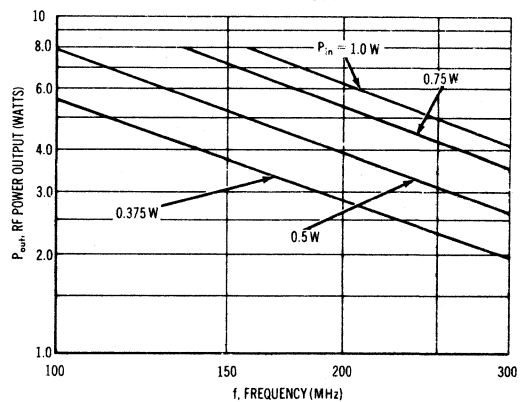


FIGURE 4 — 2N3961



$BV_{CEO(sus)}$ PULSE TEST CIRCUITS

FIGURE 5 — 2N3375, 2N3553, 2N3632

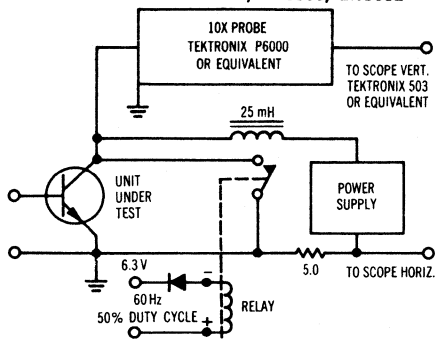
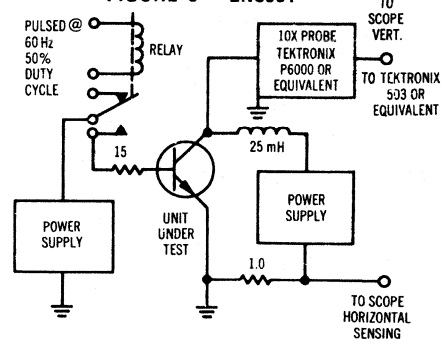
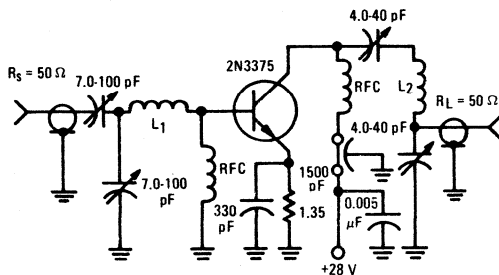


FIGURE 6 — 2N3961



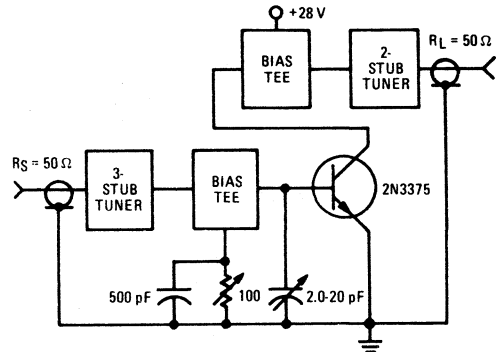
TEST CIRCUITS
2N3375

FIGURE 7 – 100 MHz



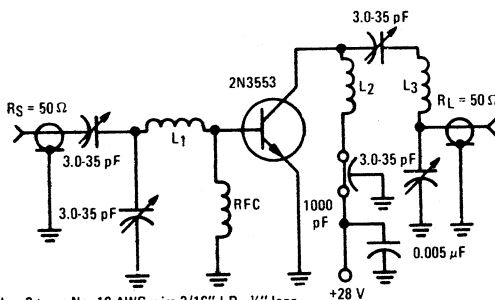
L₁: 3 turns No. 16 AWG wire 3/16" I.D., 5/16" long
L₂: 5 turns No. 16 AWG wire 5/16" I.D., 7/16" long

FIGURE 8 – 400 MHz



2N3553

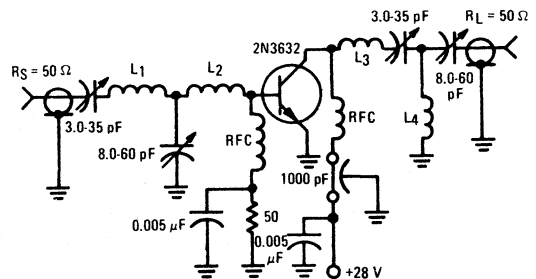
FIGURE 9 – 175 MHz



L₁: 2 turns No. 16 AWG wire 3/16" I.D., 1/4" long
L₂: 2 turns No. 16 AWG wire 3/16" I.D., 1/4" long
L₃: 3 turns No. 16 AWG wire 3/8" I.D., 3/8" long

2N3632

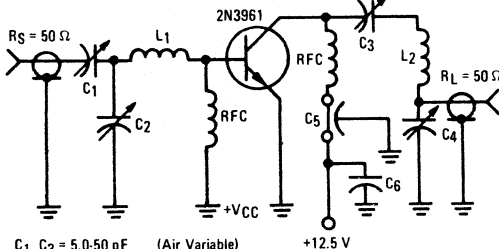
FIGURE 10 – 175 MHz



L₁, L₃: 4 turns No. 18 AWG wire 1/4" I.D., 3/16" long
L₂: 1 turn No. 16 AWG wire 1/4" I.D., 3/16" long
L₄: 2 1/2 turns No. 16 AWG wire 1/4" I.D., 1/4" long

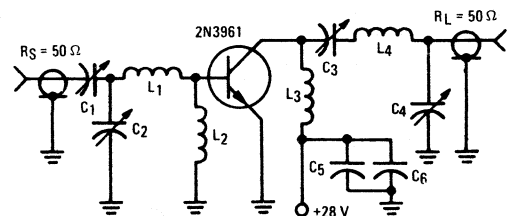
2N3961

FIGURE 11 – 135 MHz



C₁, C₃ = 5.0-50 pF (Air Variable)
C₂ = 7.0-100 pF (Air Variable)
C₄ = 1.0-30 pF (Air Variable)
C₅ = 1000 pF (Disc Ceramic)
C₆ = 0.02 uF (Disc Ceramic)
L₁ = 3 turns No. 16 AWG wire, 5/16" I.D., 5/16" long
L₂ = 5 turns No. 16 AWG wire, 7/16" I.D., 5/8" long

FIGURE 12 – 175 MHz



C₁1.0-12 pF (Air Variable)
C₂1.0-30 pF (Air Variable)
C₃5.0-50 pF (Air Variable)
C₄7.0-75 pF (Air Variable)
C₅470 pF (Disc Ceramic)
C₆0.001 uF (Disc Ceramic)
L₁, L₃, L₄ 2 turns No. 18 AWG enameled wire
1/4" I.D., air wound 3/16" long
L₂ RFC, Q_U < 1

MULTIPLE SILICON ANNULAR TRANSISTORS

... designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

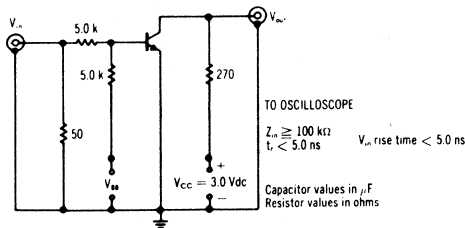
- Low Collector-Emitter Saturation Voltage —
 $V_{CE(sat)} = 0.4 \text{ Vdc (Max) @ } I_C = 10 \text{ mAdc}$
- DC Current Gain Specified — $0.5 \text{ mAdc to } 10 \text{ mAdc}$
- High Current-Gain-Bandwidth Product —
 $f_T = 300 \text{ MHz @ } I_C = 20 \text{ mAdc}$

*MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V _{CEO}	15		V _{dc}
Collector-Emitter Voltage (R _{BE} ≤ 10 Ohms)	V _{CER}	20		V _{dc}
Collector-Base Voltage	V _{CB}	40		V _{dc}
Emitter-Base Voltage	V _{EB}	5.0		V _{dc}
		One Die	Both Die	
Total Power Dissipation @ T _A = 25°C Derate above 25°C	P _D	0.3 1.72	0.4 2.28	Watt mW/°C
Total Power Dissipation @ T _C = 25°C Derate above 25°C	P _D	0.75 4.3	1.5 8.55	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

*Indicates JEDEC Registered Data

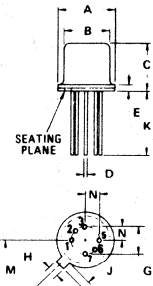
FIGURE 1 — SWITCHING TIME TEST CIRCUIT



NPN SILICON
MULTIPLE TRANSISTORS



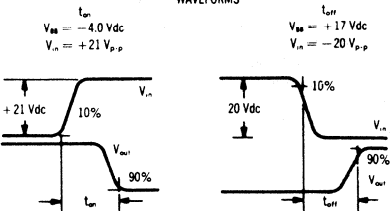
STYLE 1:
PIN 1. COLLECTOR 5. EMITTER
2. BASE 6. BASE
3. EMITTER 7. COLLECTOR
4. OMITTED 8. OMITTED



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70		0.500	
M	.45° BSC		.45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

INPUT AND OUTPUT PULSE
WAVEFORMS



2N3425 (continued)

*ELECTRICAL CHARACTERISTICS (each side) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage ⁽¹⁾ ($I_C = 10\text{ mAdc}$, $I_B = 0$)	$V_{CE(sus)}$	15	-	Vdc
Collector-Emitter Sustaining Voltage ⁽¹⁾ ($I_C = 30\text{ mAdc}$, $R_{BE} \leq 10\text{ ohms}$)	$V_{CE(sus)}$	20	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ uAdc}$, $I_E = 0$)	BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ uAdc}$, $I_C = 0$)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current ($V_{CE} = 20\text{ Vdc}$, $V_{EB(off)} = 0.25\text{ Vdc}$, $T_A = 125^\circ\text{C}$)	I_{CEX}	-	15	μAdc
Collector Cutoff Current ($V_{CB} = 20\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 20\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	-	0.025 15	μAdc
Emitter Cutoff Current ($V_{EB} = 4.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	-	0.2	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 0.5\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$, $T_A = -55^\circ\text{C}$)	h_{FE}	12 30 12	- 120 -	-
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$) ($I_C = 7.0\text{ mAdc}$, $I_B = 0.7\text{ mAdc}$, $T_A = -55^\circ\text{C}$ to -125°C)	$V_{CE(sat)}$	- -	0.4 0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$) ($I_C = 7.0\text{ mAdc}$, $I_B = 0.7\text{ mAdc}$, $T_A = -55^\circ\text{C}$)	$V_{BE(sat)}$	0.7 -	0.85 0.9	Vdc

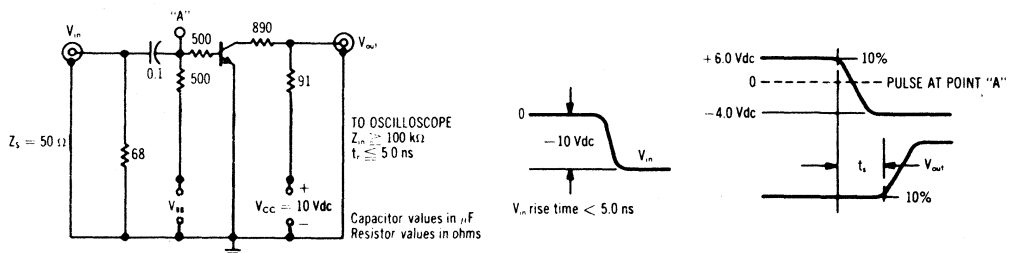
DYNAMIC CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 20\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	300	-	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 140\text{ kHz}$)	C_{ob}	-	6.0	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 140\text{ kHz}$)	C_{ib}	-	9.0	pF
Small-Signal Current Gain ($I_C = 10\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	20	-	-
Real Part of Input Impedance ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 300\text{ MHz}$)	$\text{Re}(h_{ie})$	-	50	Ohms
Turn-On Time (Figure 1) ($V_{CC} = 3.0\text{ Vdc}$, $V_{EB(off)} = 2.0\text{ Vdc}$, $I_C \approx 10\text{ mAdc}$, $I_{B1} \approx 3.0\text{ mAdc}$)	t_{on}	-	50	ns
Turn-Off Time (Figure 1) ($V_{CC} = 3.0\text{ Vdc}$, $I_C \approx 10\text{ mAdc}$, $I_{B1} \approx 3.0\text{ mAdc}$, $I_{B2} \approx 1.0\text{ mAdc}$)	t_{off}	-	90	ns
Storage Time (Figure 2) ($I_C \approx 10\text{ mAdc}$, $I_{B1} \approx 10\text{ mAdc}$, $I_{B2} \approx 10\text{ mAdc}$)	t_s	-	40	ns

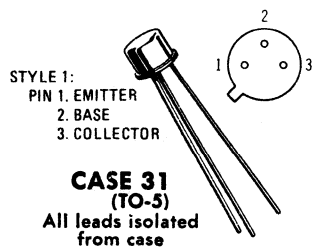
* Indicates JEDEC Registered Data

(1) Pulse Test: Pulse width $\leq 300\text{ us}$, duty cycle $\leq 1\%$

FIGURE 2 — STORAGE TIME TEST CIRCUIT



2N3427 , 2N3428 (GERMANIUM)



PNP germanium transistors for audio amplifier and medium-speed switching applications.

MAXIMUM RATINGS

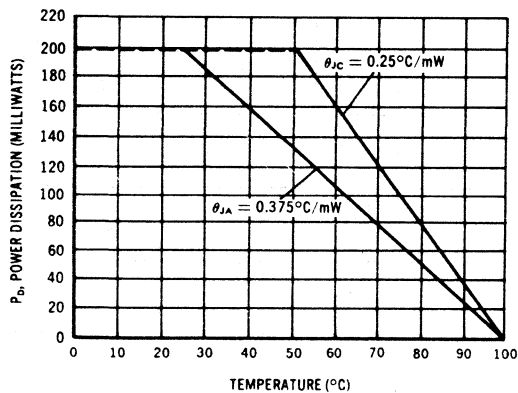
Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	45	Vdc
Collector-Emitter Voltage	V_{CER}	30	Vdc
Emitter-Base Voltage	V_{EB}	30	Vdc
Collector Current (Continuous)	I_C	500*	mAdc
Base Current (Continuous)	I_B	50*	mAdc
Storage and Operating Temperature Range	T_{stg}, T_J	-65 to +100	°C
Collector Dissipation, Ambient Derate Above 25 °C	P_D	200 2.67	mW mW/°C

*Limited by power dissipation

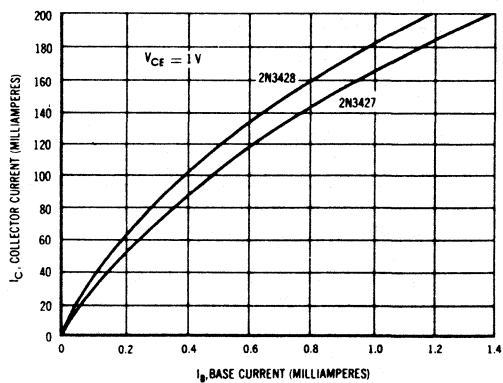
ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current ($V_{CB} = 1.5 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $T_A = +71^\circ\text{C}$) ($V_{CB} = 30 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 45 \text{ Vdc}$, $I_E = 0$)	I_{CBO}	— — — —	3.0 — — —	5.0 100 10 50	μAdc
Emitter-Base Cutoff Current ($V_{EB} = 30 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	3.0	10	μAdc
Collector-Emitter Leakage Current ($V_{CE} = 30 \text{ Vdc}$, $R_{BE} = 10\text{K ohms}$)	I_{CER}	—	—	600	μAdc
Collector-Emitter Punch-Thru Voltage ($V_{fl} = 1.0 \text{ Vdc}$, VTVM impedance $\geq 1 \text{ megohm}$)	V_{pt}	30	—	—	Vdc
Output Capacitance ($V_{CB} = 6 \text{ Vdc}$, $I_E = 0$, $f = 1 \text{ MHz}$)	C_{ob}	—	10	20	pF
Noise Figure ($V_{CE} = 4.5 \text{ Vdc}$, $I_E = 0.5 \text{ mAdc}$, $R_s = 1 \text{ K ohms}$, $f = 1 \text{ kHz}$, $\Delta f = 1 \text{ Hz}$)	NF	—	5.0	10	dB
Small-Signal Current-Gain Cutoff Frequency ($V_{CB} = 6 \text{ Vdc}$, $I_E = 1 \text{ mAdc}$) 2N3427 2N3428	$f_{\alpha b}$	4.0 5.0	6.0 8.0	— —	MHz
Input Impedance ($V_{CB} = 6 \text{ Vdc}$, $I_E = 1 \text{ mAdc}$, $f = 1 \text{ kHz}$)	h_{ib}	25	—	35	Ohms
Output Admittance ($V_{CB} = 6 \text{ Vdc}$, $I_E = 1 \text{ mAdc}$, $f = 1 \text{ kHz}$)	h_{ob}	0.05	—	0.50	μmho
Small-Signal Current Gain ($V_{CE} = 6 \text{ Vdc}$, $I_E = 1 \text{ mAdc}$, $f = 1 \text{ kHz}$) 2N3427 2N3428	h_{fe}	200 350	325 475	500 800	—
Small-Signal Current Gain ($V_{CE} = 6 \text{ Vdc}$, $I_E = 1 \text{ mAdc}$, $f = 2 \text{ MHz}$) 2N3427 2N3428	$ h_{fe} $	2.0 2.5	— —	7.0 8.0	—
DC Current Gain ($I_C = 20 \text{ mAdc}$, $V_{CE} = 1 \text{ Vdc}$) 2N3427 2N3428 ($I_C = 100 \text{ mAdc}$, $V_{CE} = 1 \text{ Vdc}$) 2N3427 2N3428 ($I_C = 200 \text{ mAdc}$, $V_{CE} = 1 \text{ Vdc}$) 2N3427 2N3428	h_{FE}	150 250 100 150 75 125	275 375 210 260 — —	— — 350 400 — —	—
Base-Emitter Input Voltage ($V_{CE} = 1 \text{ Vdc}$, $I_C = 100 \text{ mAdc}$)	V_{BE}	—	—	0.5	Vdc
Collector-Emitter Saturation Voltage ($I_C = 100 \text{ mAdc}$, $I_B = 2 \text{ mAdc}$) 2N3427 2N3428 ($I_C = 200 \text{ mAdc}$, $I_B = 4 \text{ mAdc}$) 2N3427 2N3428	$V_{CE}^{(sat)}$	— — — —	0.155 0.150 0.220 0.200	0.200 0.190 0.300 0.280	Vdc

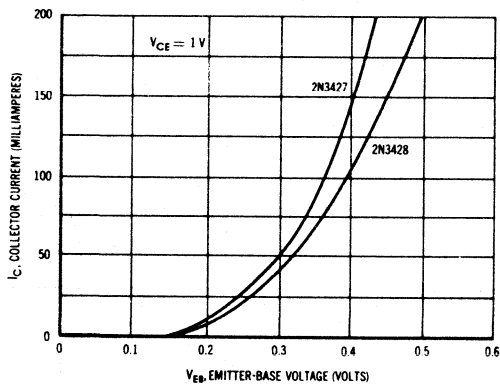
POWER-TEMPERATURE DERATING CURVE



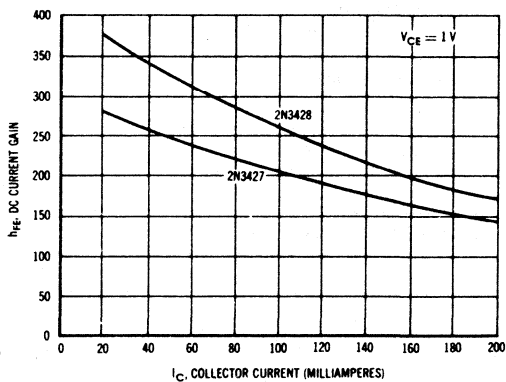
COLLECTOR CURRENT versus BASE CURRENT



OUTPUT CURRENT versus BASE DRIVE VOLTAGE



DC CURRENT GAIN versus COLLECTOR CURRENT



2N3439, 2N3440 NPN (SILICON)

MJ5415, MJ5416 PNP

1 AMPERE
POWER TRANSISTORS
COMPLEMENTARY SILICON

200-350 VOLTS
5 and 10 WATTS

COMPLEMENTARY SILICON HIGH VOLTAGE
POWER TRANSISTORS

... designed for use in consumer and industrial line-operated applications. These devices are particularly suited for audio, video and differential amplifiers as well as high-voltage, low-current inverters, switching and series pass regulators.

- High DC Current Gain –
 $h_{FE} = 40-160 @ I_C = 20 \text{ mAdc} - 2N3439, 2N3440$
 $= 30-150 @ I_C = 50 \text{ mAdc} - MJ5415$
 $= 30-120 @ I_C = 50 \text{ mAdc} - MJ5416$
- Current-Gain – Bandwidth Product –
 $f_T = 15 \text{ MHz (Min) } @ I_C = 10 \text{ mAdc}$
- Low Output Capacitance @ $f = 1.0 \text{ MHz} -$
 $C_{ob} = 10 \text{ pF (Max)} - 2N3439, 2N3440$
 $= 25 \text{ pF (Max)} - MJ5415, MJ5416$

*MAXIMUM RATINGS

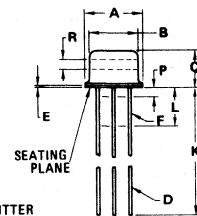
Rating	Symbol	PNP		NPN		Unit
		MJ5415	MJ5416	2N3439	2N3440	
Collector-Emitter Voltage	V_{CEO}	200	300	350	250	Vdc
Collector-Base Voltage	V_{CB}	200	350	450	300	Vdc
Emitter-Base Voltage	V_{EB}	4.0	7.0	7.0	7.0	Vdc
Collector Current – Continuous	I_C	1.0				Adc
Base Current	I_B	0.5				Adc
Total Device Dissipation @ $T_A = 50^\circ\text{C}$ Derate above 50°C	P_D	1.0 6.7	—	—	—	Watts mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	—	—	1.0 5.7	—	Watts mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	10 57	—	5.0 28.6	—	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200				$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	MJ5415, MJ5416	2N3439, 2N3440	Unit
Thermal Resistance, Junction to Case	θ_{JC}	17.5	35	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	θ_{JA}	150	175	$^\circ\text{C/W}$

* Indicates JEDEC Registered Data.

2N3439
2N3440



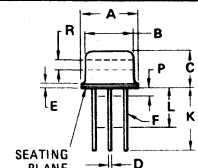
STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	5.08	BSC	0.200	BSC
H	0.711	0.864	0.028	0.034
J	0.734	1.14	0.029	0.045
K	38.10	—	1.500	—
L	6.35	—	0.250	—
M	45°	BSC	45°	BSC
N	2.54	BSC	0.100	BSC
P	—	1.27	—	0.050
R	2.54	—	0.100	—
S	—	0.179	—	0.007

All JEDEC dimensions and notes apply.
CASE 31-03
TO-5

MJ5415
MJ5416



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45°	NOM	45°	NOM
P	—	1.27	—	0.050
Q	90°	NOM	90°	NOM
R	2.54	—	0.100	—

All JEDEC dimensions and notes apply.
CASE 79-02
TO-39

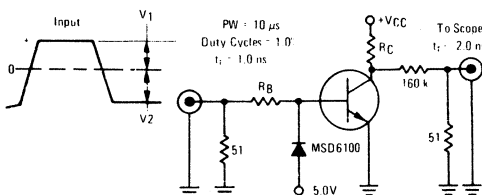
ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
*Collector-Emitter Sustaining Voltage (1) ($I_C = 10\text{ mA dc}$, $I_B = 0$) ($I_C = 50\text{ mA dc}$, $I_B = 0$)	MJ5415 MJ5416 2N3439 2N3440	$V_{CE(sus)}$	200 300 350 250	— — — —	Vdc
Collector Cutoff Current ($V_{CE} = 300\text{ Vdc}$, $I_B = 0$) ($V_{CE} = 200\text{ Vdc}$, $I_B = 0$) ($V_{CE} = 150\text{ Vdc}$, $I_B = 0$)	2N3439 2N3440 MJ5415, MJ5416	I_{CEO}	— — —	20 50 50	$\mu\text{A dc}$
Collector Cutoff Current ($V_{CE} = 450\text{ Vdc}$, $V_{BE(off)} = 1.5\text{ Vdc}$) ($V_{CE} = 300\text{ Vdc}$, $V_{BE(off)} = 1.5\text{ Vdc}$)	2N3439 2N3440	I_{CEX}	— —	500 500	$\mu\text{A dc}$
*Collector Cutoff Current ($V_{CB} = 175\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 280\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 360\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 250\text{ Vdc}$, $I_E = 0$)	MJ5415 MJ5416 2N3439 2N3440	I_{CBO}	— — — —	50 50 20 20	$\mu\text{A dc}$
*Emitter Cutoff Current ($V_{EB} = 4.0\text{ Vdc}$, $I_C = 0$) ($V_{EB} = 6.0\text{ Vdc}$, $I_C = 0$)	MJ5415 MJ5416, 2N3439, 2N3440	I_{EBO}	— —	20 20	$\mu\text{A dc}$
ON CHARACTERISTICS (1)					
DC Current Gain ($I_C = 2.0\text{ mA dc}$, $V_{CE} = 10\text{ Vdc}$) * ($I_C = 20\text{ mA dc}$, $V_{CE} = 10\text{ Vdc}$) * ($I_C = 50\text{ mA dc}$, $V_{CE} = 10\text{ Vdc}$)	2N3439 2N3439, 2N3440 MJ5415 MJ5416	h_{FE}	30 40 30 30	— 160 150 120	—
Collector-Emitter Saturation Voltage * ($I_C = 50\text{ mA dc}$, $I_B = 4.0\text{ mA dc}$) ($I_C = 50\text{ mA dc}$, $I_B = 5.0\text{ mA dc}$)	2N3439, 2N3440 MJ5415, MJ5416	$V_{CE(sat)}$	— —	0.5 2.5	Vdc
*Base-Emitter Saturation Voltage ($I_C = 50\text{ mA dc}$, $I_B = 4.0\text{ mA dc}$)	2N3439, 2N3440	$V_{BE(sat)}$	—	1.3	Vdc
Base-Emitter On Voltage ($I_C = 50\text{ mA dc}$, $V_{CE} = 10\text{ Vdc}$)	MJ5415, MJ5416	$V_{BE(on)}$	—	1.5	Vdc
DYNAMIC CHARACTERISTICS					
*Current-Gain — Bandwidth Product ($I_C = 10\text{ mA dc}$, $V_{CE} = 10\text{ Vdc}$, $f = 5.0\text{ MHz}$)		f_T	15	—	MHz
*Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	MJ5415, MJ5416 2N3439, 2N3440	C_{ob}	— —	25 10	pF
*Input Capacitance ($V_{EB} = 5.0\text{ Vdc}$, $I_C = 0$, $f = 1.0\text{ MHz}$)		C_{ib}	—	75	pF
*Small-Signal Current Gain ($I_C = 5.0\text{ mA dc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)		h_{fe}	25	—	—
*Real Part of Common Emitter Small-Signal Short-Circuit Input Impedance ($V_{CE} = 10\text{ Vdc}$, $I_C = 5.0\text{ mA dc}$, $f = 1.0\text{ MHz}$)		$\text{Re}(h_{ie})$	—	300	Ohms

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT



NOTE: V_{CC} and R_C adjusted for $V_{CE(off)} = 150\text{ V}$ and I_C as desired, R_B chosen for desired I_{B1} , $V_1 \approx 10\text{ V}$, $V_2 \approx 8.0\text{ V}$

For t_d and t_r , D1 is disconnected and $V_2 = 2.0\text{ V}$

For PNP test circuit, reverse all polarities.

PNP
MJ5415, MJ5416

NPN
2N3449, 2N3440

FIGURE 2 – TURN-ON TIME

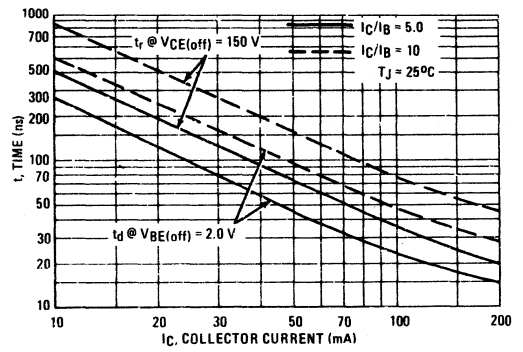
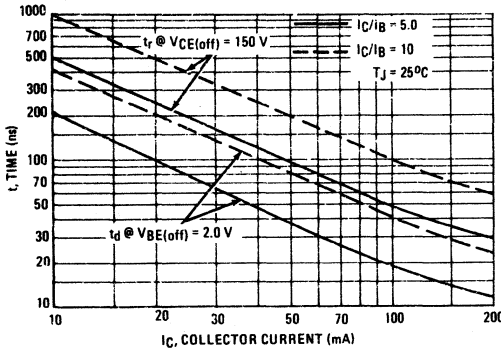


FIGURE 3 – TURN-OFF TIME

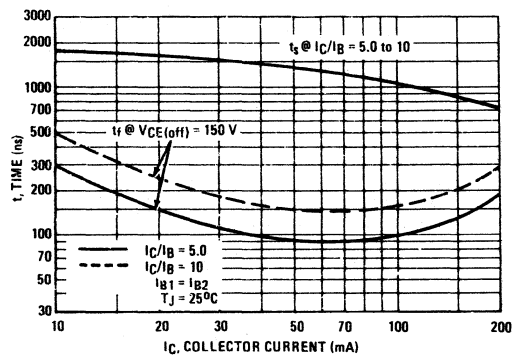
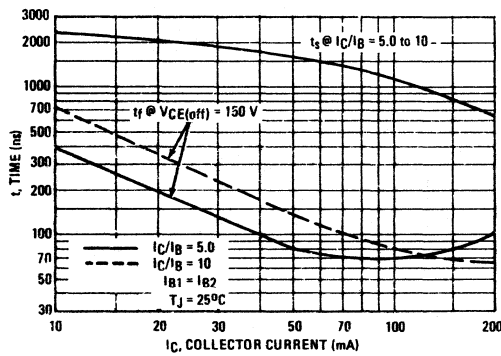


FIGURE 4 – CURRENT-GAIN – BANDWIDTH PRODUCT

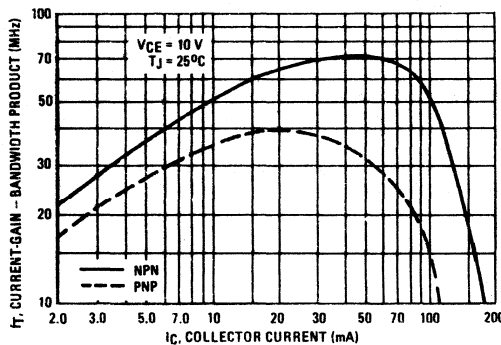


FIGURE 5 – CAPACITANCE

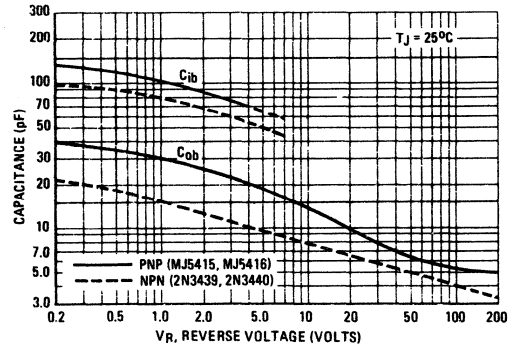


FIGURE 6 – THERMAL RESPONSE

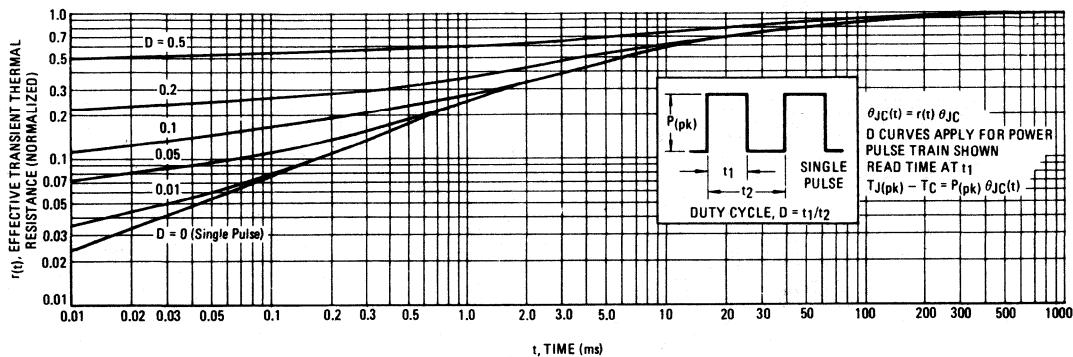
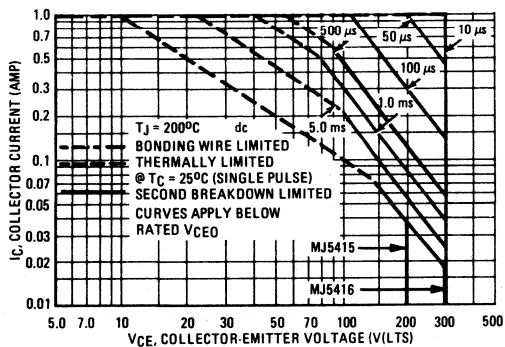


FIGURE 7 – ACTIVE-REGION SAFE OPERATING AREA

PNP – MJ5415, MJ5416



NPN – 2N3439, 2N3440

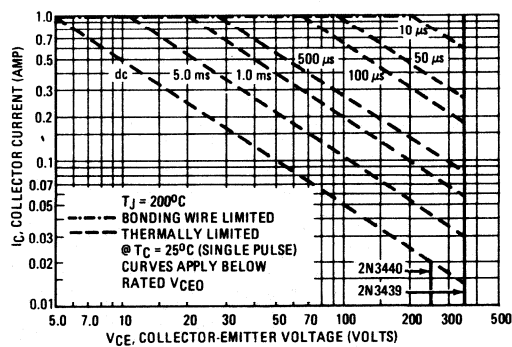
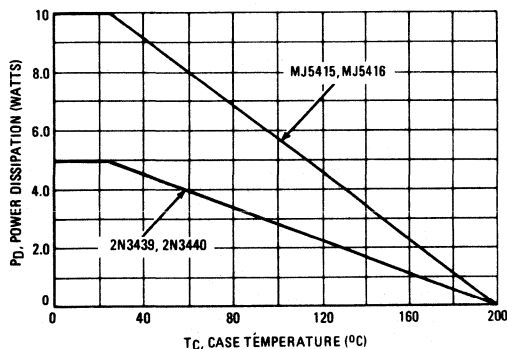


FIGURE 8 – POWER DERATING



There are two limitations on the power handling ability of a transistor, average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 7 is based on $T_{J(pk)} = 200^\circ C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200^\circ C$. $T_{J(pk)}$ may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

PNP
MJ5415, MJ5416

NPN
2N3439 2N3440

FIGURE 9 - DC CURRENT GAIN

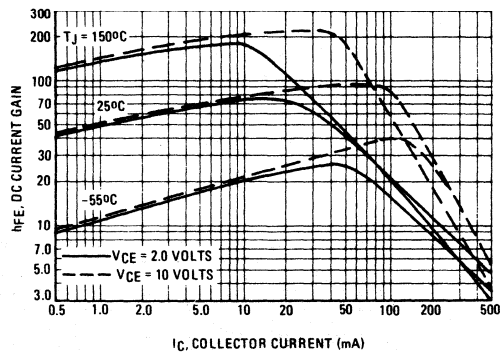
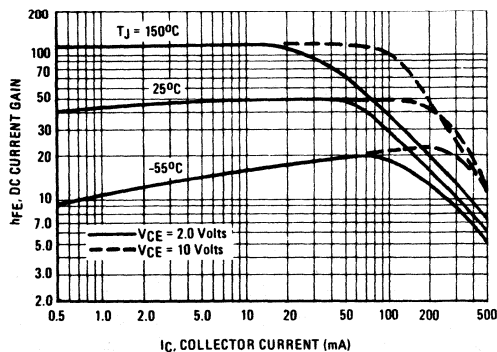


FIGURE 10 - COLLECTOR SATURATION REGION

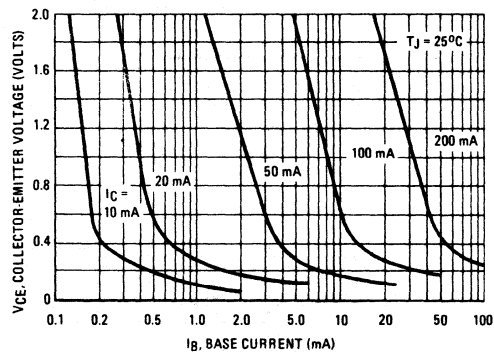
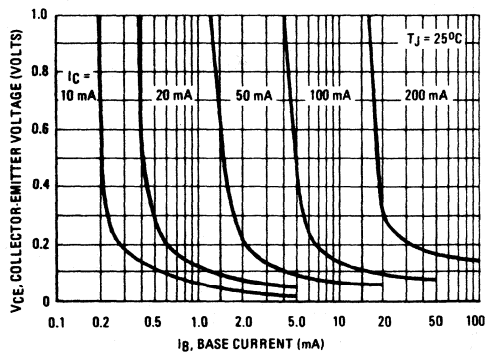


FIGURE 11 - "ON" VOLTAGES

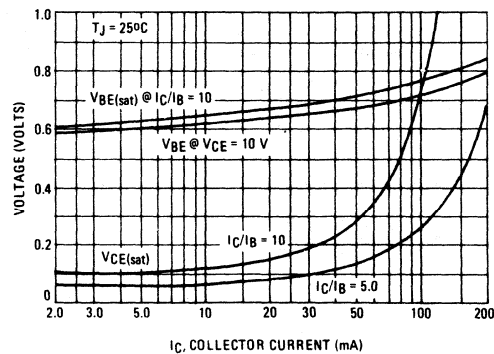
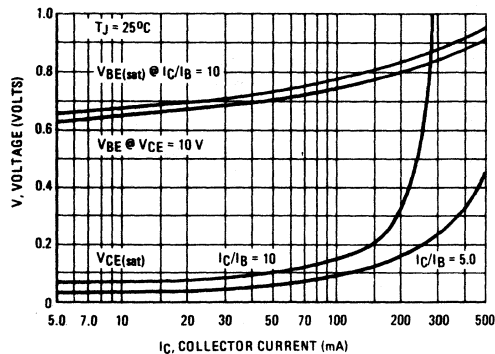


FIGURE 12 – TEMPERATURE COEFFICIENTS

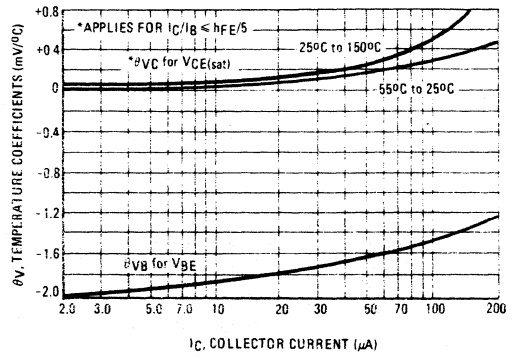
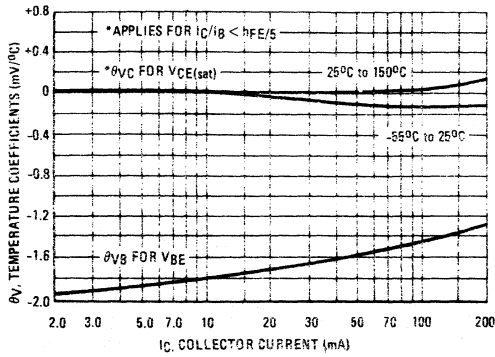


FIGURE 13 – COLLECTOR CUTOFF REGION

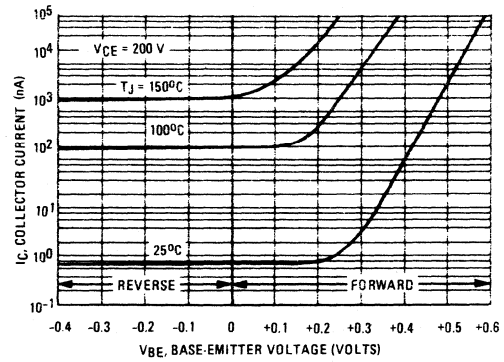
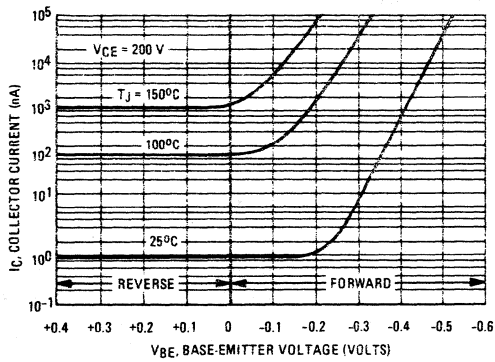
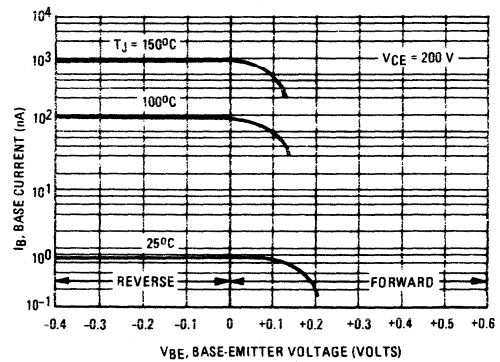
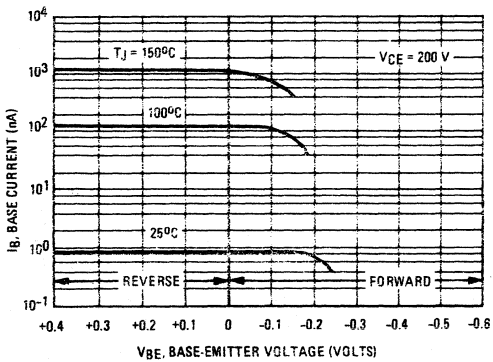


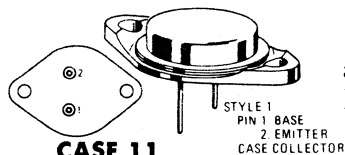
FIGURE 14 – BASE CUTOFF REGION



2N3444S

For Specifications, See 2N3252S Data.

2N3445 thru 2N3448 (SILICON)



CASE 11

Collector connected to case

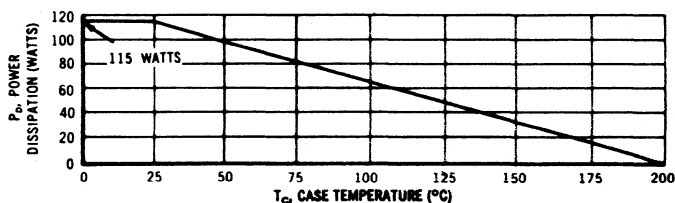
NPN silicon power transistors for switching and amplifier applications requiring fast response, wide band and good Beta linearity.

MAXIMUM RATINGS

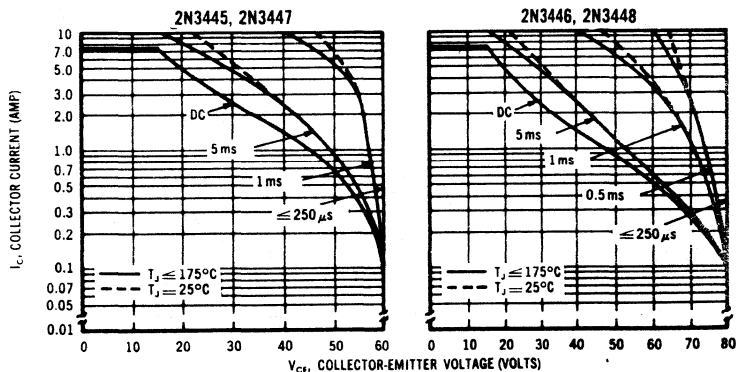
Rating	Symbol	2N3445 2N3447	2N3446 2N3448	Unit
Collector-Base Voltage	V_{CB}	80	100	Volts
Collector-Emitter Voltage	V_{CEO}	60	80	Volts
Emitter-Base Voltage	V_{EB}	6.0	10	Volts
Collector Current	I_C	7.5		Amp
Base Current	I_B	4.0		Amp
Power Dissipation	P_D	115		Watts
Junction Operating Temperature Range	T_J	-65 to +200		°C

POWER-TEMPERATURE DERATING CURVE

These transistors are also subject to safe area curves. Both limits are applicable and must be observed.



SAFE OPERATING AREAS



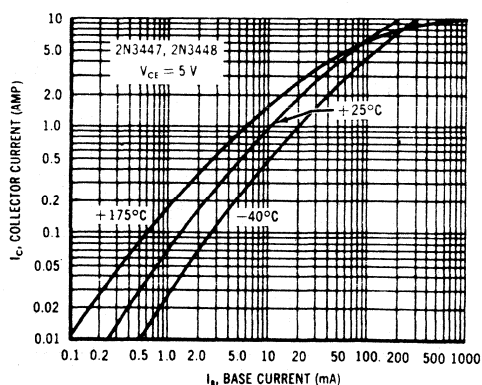
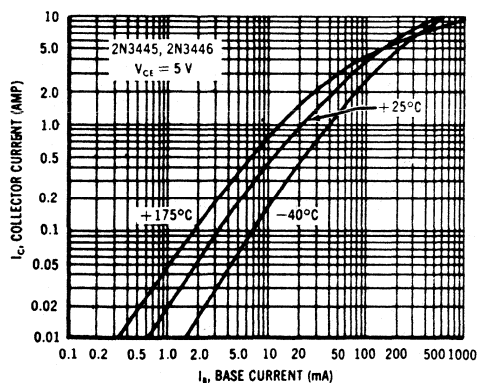
The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J , the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N3445 thru 2N3448 (continued)

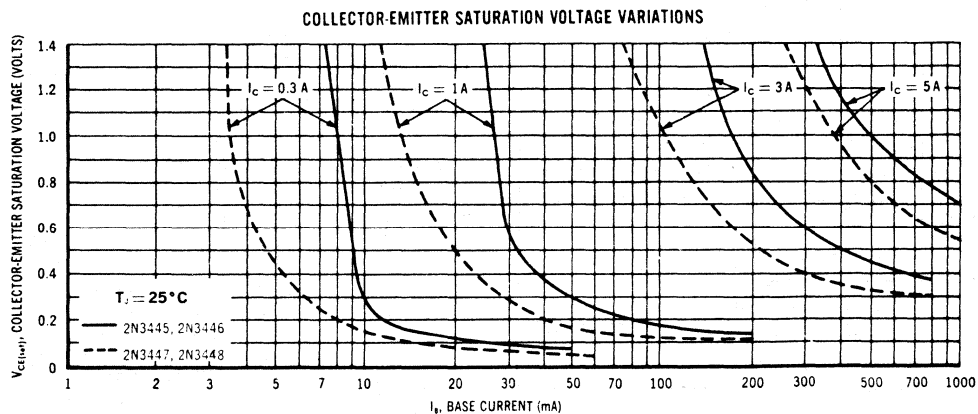
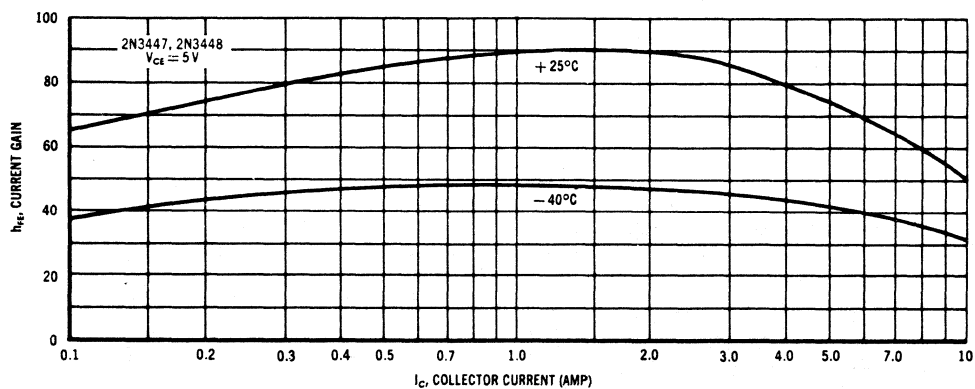
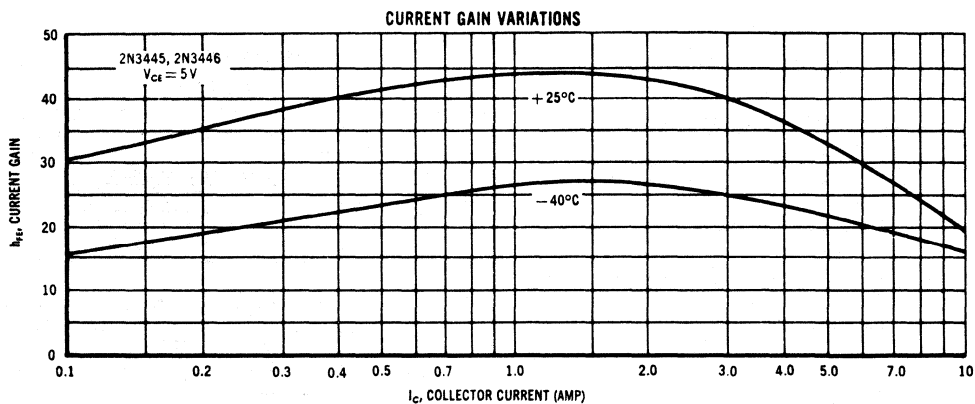
ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Emitter-Base Cutoff Current ($V_{EB} = 6 \text{ Vdc}$) ($V_{EB} = 10 \text{ Vdc}$)	I_{EBO}	— —	— —	0.25 0.25	mA_{dc}
Collector-Emitter Cutoff Current ($V_{CE} = 60 \text{ Vdc}$, $V_{BE} = -1 \text{ Vdc}$) ($V_{CE} = 60 \text{ Vdc}$, $V_{BE} = -1 \text{ Vdc}$, $T_C = 150^\circ\text{C}$) ($V_{CE} = 80 \text{ Vdc}$, $V_{BE} = -1 \text{ Vdc}$) ($V_{CE} = 80 \text{ Vdc}$, $V_{BE} = -1 \text{ Vdc}$, $T_C = 150^\circ\text{C}$)	I_{CEX}	— — — —	— — — —	0.1 1.0 0.1 1.0	mA_{dc}
Collector-Emitter Cutoff Current ($V_{CE} = 40 \text{ Vdc}$, $I_B = 0$) ($V_{CE} = 60 \text{ Vdc}$, $I_B = 0$)	I_{CEO}	— —	— —	1.0 1.0	mA_{dc}
Collector-Base Breakdown Voltage ($I_C = 1 \text{ mA}_{dc}$, $I_B = 0$)	BV_{CBO}	80 100	— —	— —	Vdc
Collector-Emitter Sustaining Voltage ($I_C = 100 \text{ mA}_{dc}$, $I_B = 0$)	$V_{CEO(sus)}$	60 80	— —	— —	Vdc
DC Current Gain ($I_C = 0.5 \text{ Adc}$, $V_{CE} = 5 \text{ Vdc}$) ($I_C = 3 \text{ Adc}$, $V_{CE} = 5 \text{ Vdc}$) ($I_C = 5 \text{ Adc}$, $V_{CE} = 5 \text{ Vdc}$)	h_{FE}	20 40 20 40	45 85 40 75	— — 60 120	—
Collector-Emitter Saturation Voltage ($I_C = 3 \text{ Adc}$, $I_B = 0.3 \text{ Adc}$) ($I_C = 5 \text{ Adc}$, $I_B = 0.5 \text{ Adc}$)	$V_{CE(sat)}$	— —	0.6 0.8	1.5 1.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 3 \text{ Adc}$, $I_B = 0.3 \text{ Adc}$) ($I_C = 5 \text{ Adc}$, $I_B = 0.5 \text{ Adc}$)	$V_{BE(sat)}$	— —	1.0 1.0	1.5 1.5	Vdc
Base-Emitter Voltage ($I_C = 3 \text{ Adc}$, $V_{CE} = 5 \text{ Vdc}$) ($I_C = 5 \text{ Adc}$, $V_{CE} = 5 \text{ Vdc}$)	V_{BE}	— —	1.0 1.0	1.5 1.4	Vdc
Small Signal Current Gain ($V_{CE} = 10 \text{ Vdc}$, $I_C = 0.5 \text{ Adc}$, $f = 1 \text{ kHz}$) ($V_{CE} = 10 \text{ Vdc}$, $I_C = 0.5 \text{ Adc}$, $f = 10 \text{ MHz}$)	h_{fe}	20 40 1.0	— — 1.6	100 200 —	—
Common Base Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $f = 0.1 \text{ MHz}$)	C_{ob}	—	260	400	pF
Switching Times ($V_{CC} = 25 \text{ Vdc}$, $R_L = 5 \text{ ohms}$, $I_C = 5 \text{ A}$, $I_{B1} = I_{B2} = 0.5 \text{ A}$) Delay Time plus Rise Time Storage Time Fall Time	$t_d + t_r$ t_s t_f	— — —	0.15 0.9 0.15	0.35 2.0 0.35	μs

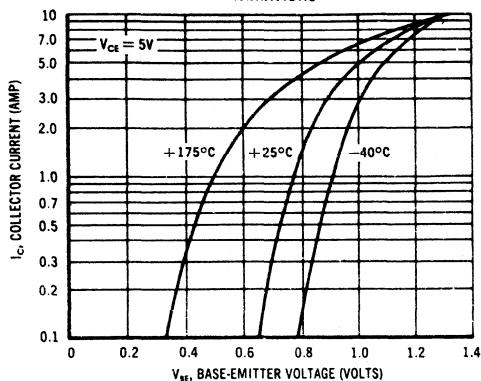
COLLECTOR CURRENT versus BASE CURRENT



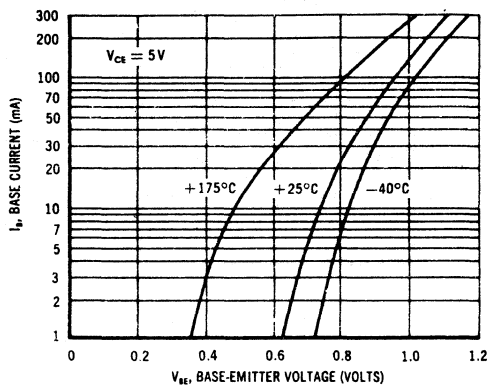
2N3445 thru 2N3448 (continued)



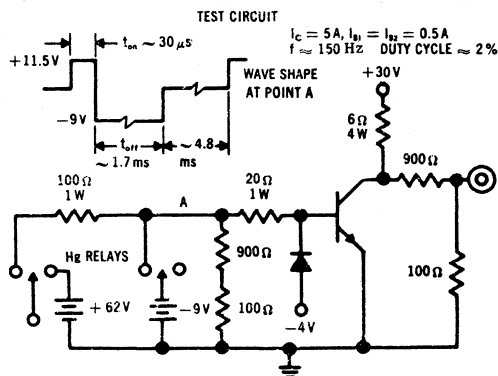
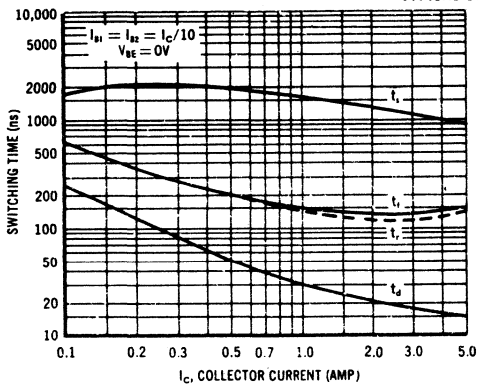
COLLECTOR CURRENT-VOLTAGE
VARIATIONS



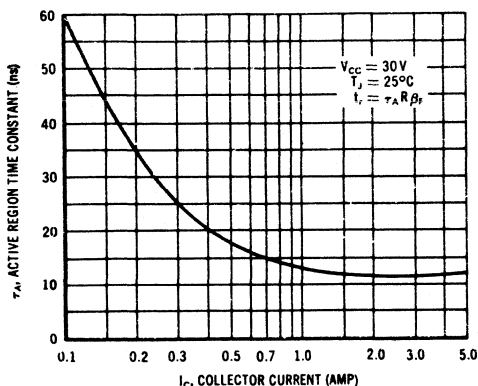
BASE CURRENT-VOLTAGE
VARIATIONS



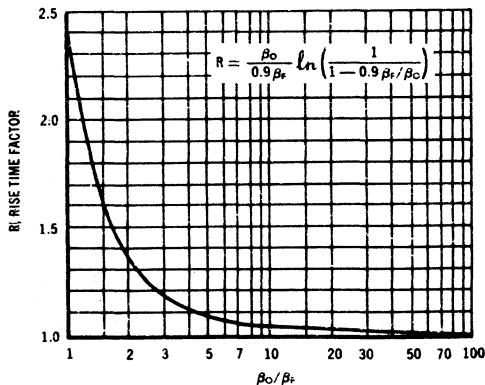
TYPICAL SWITCHING TIMES



ACTIVE REGION TIME CONSTANT



RISE TIME FACTOR

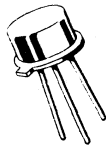


2N3467S, 2N3468S (SILICON)

2N3467S JAN,JTX AVAILABLE

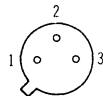
2N3468S JAN,JTX AVAILABLE

CASE 79
(TO-39)



Collector
connected to case

PNP silicon annular transistors for high-speed switching and driver applications.



STYLE 1:
PIN 1, EMITTER
2, BASE
3, COLLECTOR

MAXIMUM RATINGS

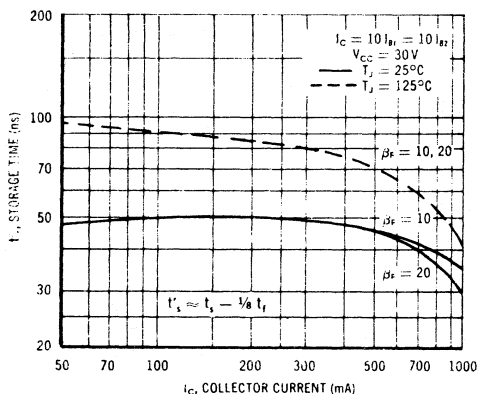
Rating	Symbol	2N3467	2N3468	Unit
Collector-Base Voltage	V_{CB}	40	50	Vdc
Collector-Emitter Voltage	V_{CEO}	40	50	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	1.0		Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derating Factor Above 25°C	P_D	1.0 5.71		Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derating Factor Above 25°C	P_D	5.0 28.6		Watts mW/ $^\circ\text{C}$
Junction Temperature, Operating	T_J	+200		$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200		$^\circ\text{C}$

*Indicates JEDEC Registered Data

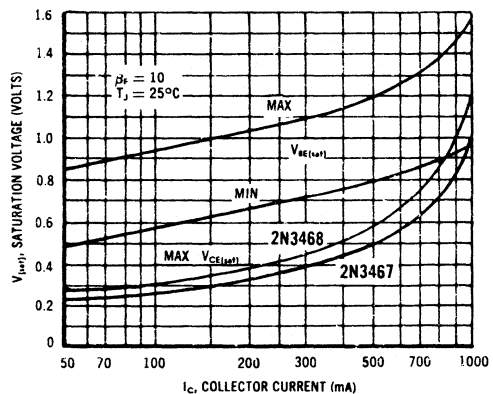
HERMAL RESISTANCE θ_{JA} (air) = $0.175^\circ\text{C}/\text{mW}$

θ_{JC} (case) = $35^\circ\text{C}/\text{W}$

STORAGE TIME VARIATION WITH TEMPERATURE



LIMITS OF SATURATION VOLTAGE



***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current ($V_{CB} = 30 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 30 \text{ Vdc}$, $I_E = 0$, $T_A = 100^\circ\text{C}$)	I_{CBO}	— —	0.10 15	μAdc
Collector Cutoff Current ($V_{CE} = 30 \text{ Vdc}$, $V_{BE(off)} = 3 \text{ Vdc}$)	I_{CEX}	—	100	nAdc
Base Cutoff Current ($V_{CE} = 30 \text{ Vdc}$, $V_{BE(off)} = 3 \text{ Vdc}$)	I_{BL}	—	120	nAdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	40 50	— —	Vdc
Collector-Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 10 \text{ mAdc}$, $I_B = 0$)	BV_{CEO}	40 50	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	5.0	—	Vdc
Collector Saturation Voltage ⁽¹⁾ ($I_C = 150 \text{ mAdc}$, $I_B = 15 \text{ mAdc}$) ($I_C = 500 \text{ mAdc}$, $I_B = 50 \text{ mAdc}$) ($I_C = 1 \text{ Adc}$, $I_B = 100 \text{ mAdc}$)	$V_{CE(sat)}$	— — — — — —	0.3 0.35 0.5 0.6 1.0 1.2	Vdc
Base-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 150 \text{ mAdc}$, $I_B = 15 \text{ mAdc}$) ($I_C = 500 \text{ mAdc}$, $I_B = 50 \text{ mAdc}$) ($I_C = 1 \text{ Adc}$, $I_B = 100 \text{ mAdc}$)	$V_{BE(sat)}$	— 0.8 —	1.0 1.2 1.6	Vdc
DC Forward Current Transfer Ratio ⁽¹⁾ ($I_C = 150 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 500 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 1 \text{ Adc}$, $V_{CE} = 5 \text{ Vdc}$)	h_{FE}	40 25 40 25 40 25	— — 120 75 — —	—
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)	C_{ob}	—	25	pF
Input Capacitance ($V_{EB} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 100 \text{ kHz}$)	C_{ib}	—	100	pF
Current-Gain - Bandwidth Product ($I_C = 50 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	175 150	— —	MHz

⁽¹⁾Pulse Test: $PW \leq 300 \mu\text{s}$, Duty Cycle $\leq 2\%$

* Indicates JEDEC Registered Data

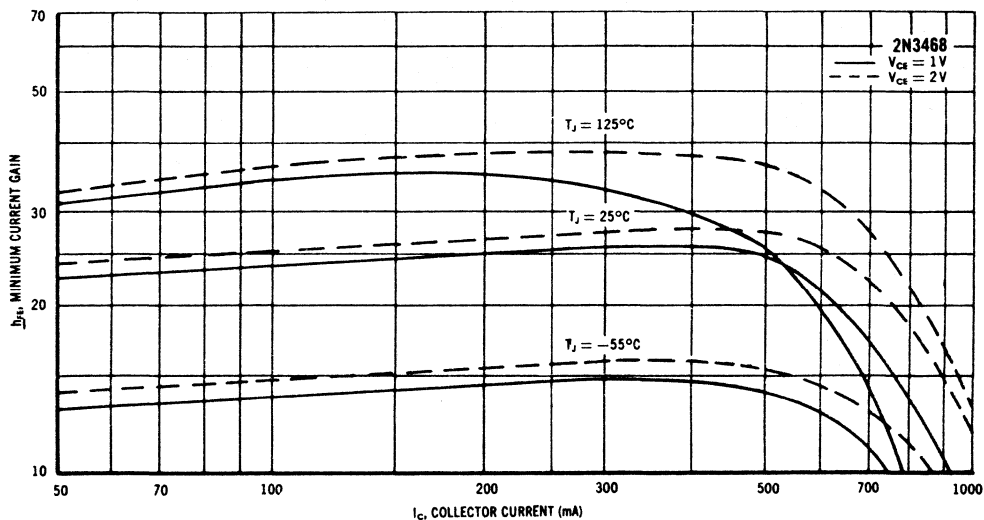
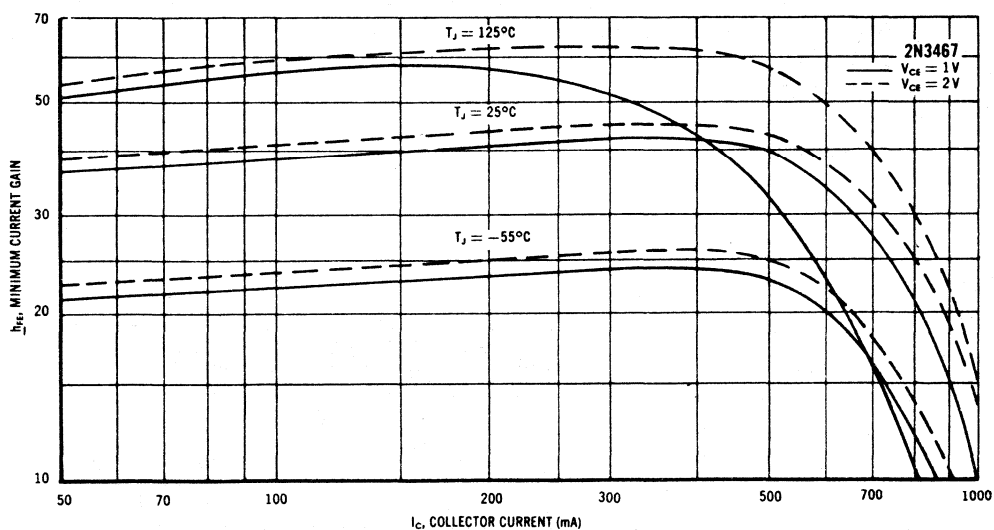
2N3467S, 2N3468S (continued)

* ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Max	Unit
Delay Time	$(I_C = 500 \text{ mA}, I_{B1} = 50 \text{ mA}, V_{BE} = 2 \text{ V}, V_{CC} = 30 \text{ V})$	t_d	—	10	ns
Rise Time		t_r	—	30	ns
Storage Time	$(I_C = 500 \text{ mA}, I_{B1} = I_{B2} = 50 \text{ mA}, V_{CC} = 30 \text{ V})$	t_s	—	60	ns
Fall Time		t_f	—	30	ns
Total Control Charge $(I_C = 500 \text{ mA}, I_B = 50 \text{ mA}, V_{CC} = 30 \text{ V})$		Q_T	—	6.0	nC

* Indicates JEDEC Registered Data

MINIMUM CURRENT GAIN CHARACTERISTICS

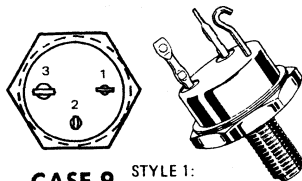


2N3485, A (SILICON)

2N3486, A

For Specifications, See 2N2904S Data

2N3487 thru 2N3492 (SILICON)



CASE 9
(TO-18)

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

NPN silicon power transistors designed for switching and amplifier applications.

MAXIMUM RATINGS

Rating	Symbol	2N3487 2N3490	2N3488 2N3491	2N3489 2N3492	Unit
Collector-Base Voltage	V_{CB}	80	100	120	Vdc
Collector-Emitter Voltage	V_{CEO}	60	80	100	Vdc
Emitter-Base Voltage	V_{EB}	10	10	10	Vdc
Collector Current (Continuous)	I_C	7.5	7.5	7.5	Adc
Base Current (Continuous)	I_B	4.0	4.0	4.0	Adc
Power Dissipation	P_D	117	117	117	Watts
Thermal Resistance, Junction to Case	θ_{JC}	1.5	1.5	1.5	$^{\circ}\text{C}/\text{W}$
Junction Operating Temperature Range	T_J	-65°C to $+200^{\circ}\text{C}$			$^{\circ}\text{C}$

2N3487 thru 2N3492 (continued)
ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Emitter-Base Cutoff Current ($V_{EB} = 10 \text{ Vdc}$)	I_{EBO}	-	0.10	mAdc
Collector-Emitter Cutoff Current ($V_{CE} = 60 \text{ Vdc}$, $V_{BE} = -1 \text{ Vdc}$) ($V_{CE} = 80 \text{ Vdc}$, $V_{BE} = -1 \text{ Vdc}$) ($V_{CE} = 100 \text{ Vdc}$, $V_{BE} = -1 \text{ Vdc}$) ($V_{CE} = 60 \text{ Vdc}$, $V_{BE} = -1 \text{ Vdc}$, $T_C = 150^\circ\text{C}$) ($V_{CE} = 80 \text{ Vdc}$, $V_{BE} = -1 \text{ Vdc}$, $T_C = 150^\circ\text{C}$) ($V_{CE} = 100 \text{ Vdc}$, $V_{BE} = -1 \text{ Vdc}$, $T_C = 150^\circ\text{C}$)	I_{CEX}	- - - - - -	25 25 25 250 250 250	μAdc
Collector-Emitter Cutoff Current ($V_{CE} = 40 \text{ Vdc}$, $I_B = 0$) ($V_{CE} = 60 \text{ Vdc}$, $I_B = 0$) ($V_{CE} = 80 \text{ Vdc}$, $I_B = 0$)	I_{CEO}	- - -	250 250 250	μAdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	80 100 120	- - -	Vdc
Collector-Emitter Sustaining Voltage ($I_C = 100 \text{ mAdc}$, $I_B = 0$)	$V_{CEO(sus)}$	60 80 100	- - -	Vdc
DC Current Gain ($I_C = 0.5 \text{ Adc}$, $V_{CE} = 5 \text{ Vdc}$) ($I_C = 3.0 \text{ Adc}$, $V_{CE} = 5 \text{ Vdc}$) ($I_C = 5.0 \text{ Adc}$, $V_{CE} = 5 \text{ Vdc}$)	h_{FE}	20 40 20 15 40 30	- - 60 45 120 90	-
Collector-Emitter Saturation Voltage ($I_C = 1 \text{ Adc}$, $I_B = 0.1 \text{ Adc}$) ($I_C = 3 \text{ Adc}$, $I_B = 0.3 \text{ Adc}$) ($I_C = 5 \text{ Adc}$, $I_B = 0.5 \text{ Adc}$)	$V_{CE(sat)}$	- - -	0.3 1.2 1.0 1.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 3 \text{ Adc}$, $I_B = 0.3 \text{ Adc}$) ($I_C = 5 \text{ Adc}$, $I_B = 0.5 \text{ Adc}$)	$V_{BE(sat)}$	- -	1.5 1.5	Vdc
Base-Emitter Voltage ($I_C = 3 \text{ Adc}$, $V_{CE} = 5 \text{ Vdc}$) ($I_C = 5 \text{ Adc}$, $V_{CE} = 5 \text{ Vdc}$)	V_{BE}	- -	1.5 1.4	Vdc
Small Signal Current Gain ($V_{CE} = 10 \text{ Vdc}$, $I_C = 0.5 \text{ Adc}$, $f = 1 \text{ kHz}$) ($V_{CE} = 10 \text{ Vdc}$, $I_C = 0.5 \text{ Adc}$, $f = 10 \text{ MHz}$)	h_{fe}	20 40 1.0	100 200 -	-
Common Base Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $f = 0.1 \text{ MHz}$)	C_{ob}	-	550	pF
Switching Times ($V_{CC} \approx 25 \text{ Vdc}$, $R_L = 5 \Omega$, $I_C = 5 \text{ Adc}$, $I_{B1} = -I_{B2} = 0.5 \text{ Adc}$)		-	-	μs
Delay Time plus Rise Time	$t_d + t_r$	-	0.35	μs
Storage Time	t_s	-	2.0	μs
Fall Time	t_f	-	0.35	μs

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE

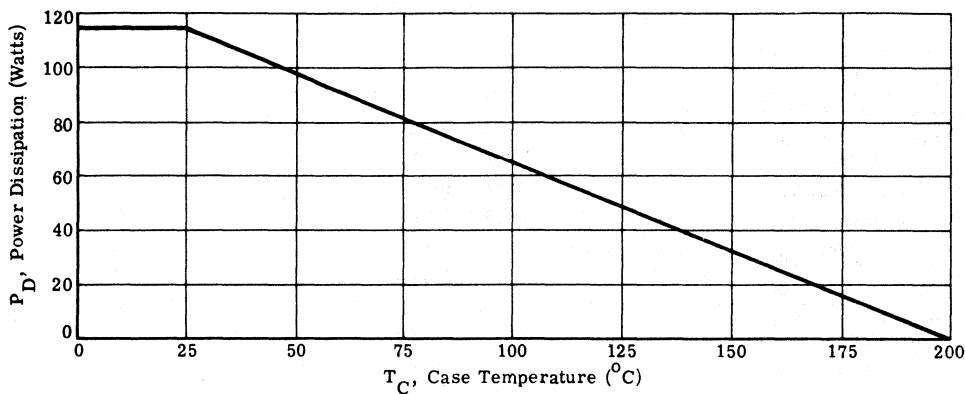
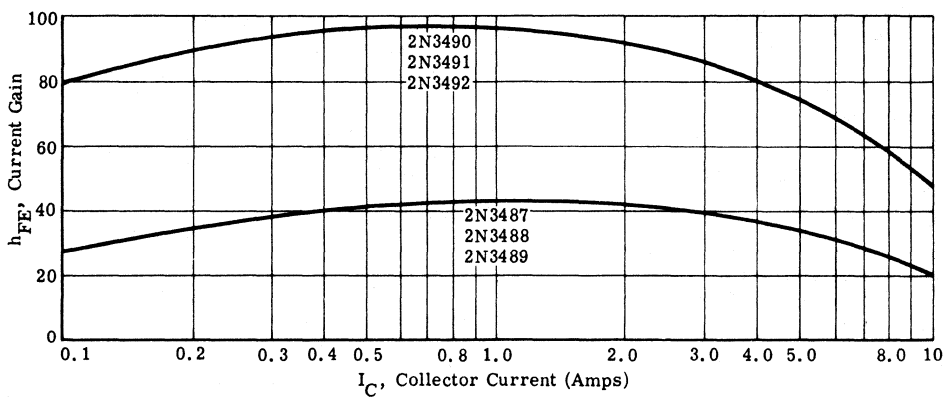


FIGURE 2 — DC CURRENT GAIN versus COLLECTOR CURRENT



ACTIVE - REGION SAFE OPERATING AREAS

FIGURE 3 —
2N3487, 2N3490

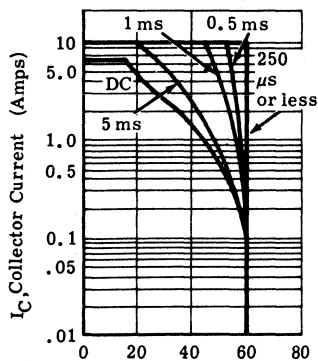


FIGURE 4 —
2N3489, 2N3492

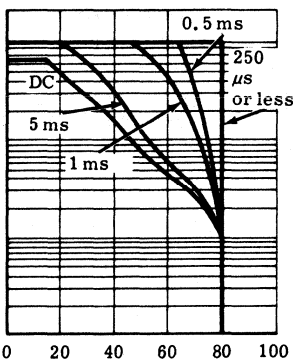
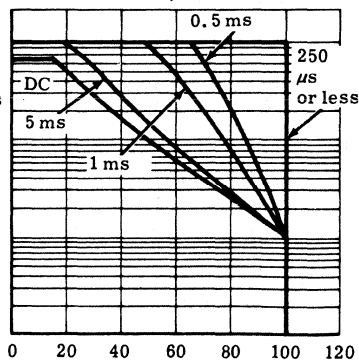


FIGURE 5 —
2N3488, 2N3491



2N3494S, 2N3495S, 2N3496, 2N3497 (SILICON)

PNP SILICON ANNULAR STAR TRANSISTORS

... designed for high-voltage switching circuits and DC to VHF amplifier applications.

- High Collector-Emitter Breakdown Voltage –
BV_{CEO} = 120 Vdc (Min) @ I_C = 10 mAdc (2N3495,97)
- Low Collector-Emitter Saturation Voltage –
V_{CE(sat)} = 0.3 Vdc (Max) @ I_C = 10 mAdc (2N3494,96)
- High Current-Gain-Bandwidth Product –
f_T = 200 MHz (Min) @ I_C = 20 mAdc (2N3494,96)

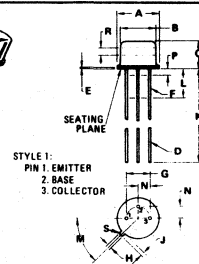
*MAXIMUM RATINGS

Rating	Symbol	2N3494 2N3496	2N3495 2N3497	Unit
Collector-Emitter Voltage	V _{CEO}	80	120	Vdc
Collector-Base Voltage	V _{CB}	80	120	Vdc
Emitter-Base Voltage	V _{EB}	4.5		Vdc
Collector Current – Continuous	I _C	100		mAdc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	600 3.43	400 2.28	mW mW/°C
Total Device Dissipation @ T _C = 25°C** Derate above 25°C	P _D	2.0 11.4	1.2 6.85	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

* Indicates JEDEC Registered Data.

** Motorola guarantees this data in addition to JEDEC Registered Data.

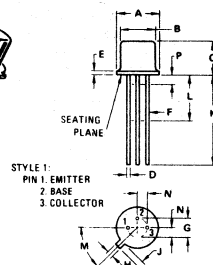
PNP SILICON HIGH-VOLTAGE TRANSISTORS



STYLE 1:
PIN 1: EMITTER
2: BASE
3: COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	6.10	6.90	0.240	0.280
D	0.406	0.533	0.016	0.021
E	0.228	0.318	0.009	0.0125
F	0.406	0.483	0.016	0.019
G	5.09	BSC	0.200	BSC
H	0.711	0.864	0.028	0.034
J	0.734	1.14	0.029	0.045
K	38.10	—	1.500	—
L	6.35	—	0.250	—
M	45°	BSC	45°	BSC
N	2.54	BSC	0.100	BSC
P	—	1.27	—	0.050
R	2.54	—	0.100	—
S	—	0.178	—	0.007

All JEDEC dimensions and notes apply.
CASE 31-03
TO-39



STYLE 1:
PIN 1: EMITTER
2: BASE
3: COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	—	0.762	—	0.030
F	0.406	0.483	0.016	0.019
G	2.54	BSC	0.100	BSC
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45°	BSC	45°	BSC
N	1.27	BSC	0.050	BSC
P	—	1.27	—	0.050

All JEDEC notes and dimensions apply.
CASE 22-03
(TO-18)

2N3494S, 2N3495S, 2N3496, 2N3497 (continued)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 10\text{ mA}$, $I_E = 0$)	BV_{CEO}	80 120	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{A}$, $I_E = 0$)	BV_{CBO}	80 120	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{A}$, $I_C = 0$)	BV_{EBO}	4.5	—	Vdc
Collector Cutoff Current ($V_{CB} = 50\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 90\text{ Vdc}$, $I_E = 0$)	I_{CBO}	— —	100 100	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	25	nAdc

ON CHARACTERISTICS

DC Current Gain ⁽¹⁾ ($I_C = 100\text{ }\mu\text{A}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 1.0\text{ mA}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 50\text{ mA}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 100\text{ mA}$, $V_{CE} = 10\text{ Vdc}$)	All Types All Types All Types All Types 2N3494, 2N3496	h_{FE}	35 40 40 40 35	— — — — —	—
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mA}$, $I_B = 1.0\text{ mA}$)	2N3494, 2N3496 2N3495, 2N3497	$V_{CE(sat)}$	— —	0.3 0.35	Vdc
Base-Emitter Saturation Voltage ($I_C = 10\text{ mA}$, $I_B = 1.0\text{ mA}$)		$V_{BE(sat)}$	0.6	0.9	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain–Bandwidth Product ⁽²⁾ ($I_C = 20\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	2N3494, 2N3496 2N3495, 2N3497	f_T	200 150	— —	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)	2N3494, 2N3496 2N3495, 2N3497	C_{ob}	— —	7.0 6.0	pF
Input Capacitance ($V_{BE} = 2.0\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)		C_{ib}	—	30	pF
Input Impedance ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)		h_{ie}	0.1	1.2	k ohms
Voltage Feedback Ratio ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)		h_{re}	—	2.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)		h_{fe}	40	300	—
Output Admittance ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)		h_{oe}	—	300	μmhos
Real Part of Input Impedance ($I_C = 20\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 300\text{ MHz}$)		$\text{Re}(h_{ie})$	—	30	Ohms

SWITCHING CHARACTERISTICS

Turn-On Time ($V_{CC} = 30\text{ Vdc}$, $I_C = 10\text{ mA}$, $I_{B1} = 10\text{ mA}$) (See Figure 1)	t_{on}	—	300	ns
Turn-Off Time ($V_{CC} = 30\text{ Vdc}$, $I_C = 10\text{ mA}$, $I_{B1} = I_{B2} = 1.0\text{ mA}$) (See Figure 2)	t_{off}	—	1000	ns

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle = 2.0%.

(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 – TURN-ON TIME TEST CIRCUIT

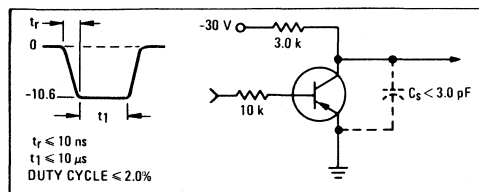
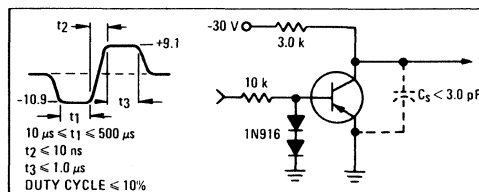


FIGURE 2 – TURN-OFF TIME TEST CIRCUIT



2N3498S thru 2N3501S (SILICON)

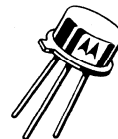
JAN,JTX,JTXV AVAILABLE

NPN SILICON ANNULAR TRANSISTORS

...designed for low-power amplifier and switching applications.

- High Voltage Ratings
 $BV_{CEO} = 150 \text{ Vdc (Min) @ } I_C = 10 \text{ mAdc} - 2N3500 \text{ and } 2N3501$
- Low Saturation Voltage –
 $V_{CE(sat)} = 0.6 \text{ Vdc (Max) @ } I_C = 300 \text{ mAdc} - 2N3498 \text{ and } 2N3499$
- Low Capacitance
 $C_{ob} = 8.0 \text{ pF (Max) @ } V_{CB} = 10 \text{ Vdc} - 2N3500 \text{ and } 2N3501$
- Medium Current Capability with DC Current Gain Specified –
 $0.1 \text{ to } 500 \text{ mAdc} - 2N3498 \text{ and } 2N3499$

NPN SILICON SWITCHING AND AMPLIFIER TRANSISTORS



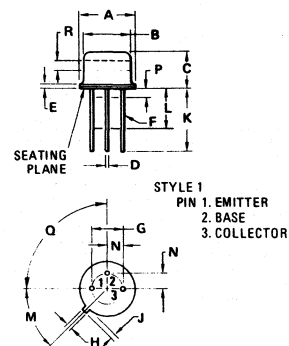
*MAXIMUM RATINGS

Rating	Symbol	2N3498 2N3499	2N3500 2N3501	Unit
Collector-Base Voltage	V_{CBO}	100	150	Vdc
Collector-Emitter Voltage	V_{CEO}	100	150	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current	I_C	500	300	mAdc
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate Above 25°C	P_D	1.0 5.71		Watt mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate Above 25°C	P_D	5.0 28.6		Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	$^\circ\text{C/W}$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	$^\circ\text{C/W}$

*Indicates JEDEC Registered Data.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° NOM	—	45° NOM	—
P	—	1.127	—	0.050
Q	90° NOM	—	90° NOM	—
R	2.54	—	0.100	—

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

2N3498S thru 1N3501S (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
*OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1) (I _C = 10 mA _{dc} , I _B = 0)	2N3498, 2N3499 2N3500, 2N3501	BV _{CEO}	100 150	—	—	V _{dc}
Collector-Base Breakdown Voltage (I _C = 10 mA _{dc} , I _E = 0)	2N3498, 2N3499 2N3500, 2N3501	BV _{CBO}	100 150	—	—	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 10 mA _{dc} , I _C = 0)		BV _{EBO}	6.0	—	—	V _{dc}
Emitter Cutoff Current (V _{BE(off)} = 4.0 V _{dc} , I _C = 0)		I _{EBO}	—	—	25	nA _{dc}
Collector Cutoff Current (V _{CB} = 50 V _{dc} , I _E = 0) (V _{CB} = 50 V _{dc} , I _E = 0, T _A = 150°C) (V _{CB} = 75 V _{dc} , I _E = 0) (V _{CB} = 75 V _{dc} , I _E = 0, T _A = 150°C)	2N3498, 2N3499 2N3500, 2N3501	I _{CBO}	— — — —	— — — —	0.050 50 0.050 50	μA _{dc}

*ON CHARACTERISTICS (1)

DC Current Gain (I _C = 0.1 mA _{dc} , V _{CE} = 10 V _{dc}) (I _C = 1.0 mA _{dc} , V _{CE} = 10 V _{dc}) (I _C = 10 mA _{dc} , V _{CE} = 10 V _{dc}) (I _C = 150 mA _{dc} , V _{CE} = 10 V _{dc}) (I _C = 300 mA _{dc} , V _{CE} = 10 V _{dc}) (I _C = 500 mA _{dc} , V _{CE} = 10 V _{dc})	2N3498, 2N3500 2N3499, 2N3501 2N3498, 2N3500 2N3499, 2N3501 2N3498, 2N3500 2N3499, 2N3501 2N3498, 2N3500 2N3499, 2N3501 2N3500 2N3501 2N3498 2N3499	h _{FE}	20 35 25 50 35 75 40 100 15 20 15 20	— — — — — — — — — — — —	— — — — 120 300 — — — — — —	—
Collector Saturation Voltage (I _C = 10 mA _{dc} , I _B = 1.0 mA _{dc}) (I _C = 50 mA _{dc} , I _B = 5.0 mA _{dc}) (I _C = 150 mA _{dc} , I _B = 15 mA _{dc}) (I _C = 300 mA _{dc} , I _B = 30 mA _{dc})	All Types All Types 2N3500, 2N3501 2N3498, 2N3499	V _{CE(sat)}	— — — —	— — — —	0.2 0.25 0.4 0.6	V _{dc}
Base-Emitter Saturation Voltage (I _C = 10 mA _{dc} , I _B = 1.0 mA _{dc}) (I _C = 50 mA _{dc} , I _B = 5.0 mA _{dc}) (I _C = 150 mA _{dc} , I _B = 15 mA _{dc}) (I _C = 300 mA _{dc} , I _B = 30 mA _{dc})	All Types All Types 2N3500, 2N3501 2N3498, 2N3499	V _{BE(sat)}	— — — —	— — — —	0.8 0.9 1.2 1.4	V _{dc}

*SMALL-SIGNAL CHARACTERISTICS

Current-Gain–Bandwidth Product (2) (V _{CE} = 20 V _{dc} , I _C = 20 mA _{dc} , f = 100 kHz)		f _T	150	—	—	MHz
Output Capacitance (V _{CB} = 10 V _{dc} , I _E = 0, f = 100 kHz)	2N3498, 2N3499 2N3500, 2N3501	C _{ob}	— —	— —	10 8.0	pF
Input Capacitance (V _{BE} = 0.5 V _{dc} , I _C = 0, f = 100 kHz)		C _{ib}	—	—	80	pF
Small-Signal Current Gain (I _C = 10 mA _{dc} , V _{CE} = 10 V _{dc} , f = 1.0 kHz)	2N3498, 2N3500 2N3499, 2N3501	h _{fe}	50 75	— —	300 375	—
Voltage Feedback Ratio (I _C = 10 mA _{dc} , V _{CE} = 10 V _{dc} , f = 1.0 kHz)	2N3498, 2N3500 2N3499, 2N3501	h _{re}	— —	— —	2.5 4.0	×10 ⁻⁴
Input Impedance (I _C = 10 mA _{dc} , V _{CE} = 10 V _{dc} , f = 1.0 kHz)	2N3498, 2N3500 2N3499, 2N3501	h _{ie}	0.2 0.25	— —	1.0 1.25	k ohms
Output Admittance (I _C = 10 mA _{dc} , V _{CE} = 10 V _{dc} , f = 1.0 kHz)	2N3498, 2N3500 2N3499, 2N3501	h _{oe}	— —	— —	100 200	μmhos

SWITCHING CHARACTERISTICS

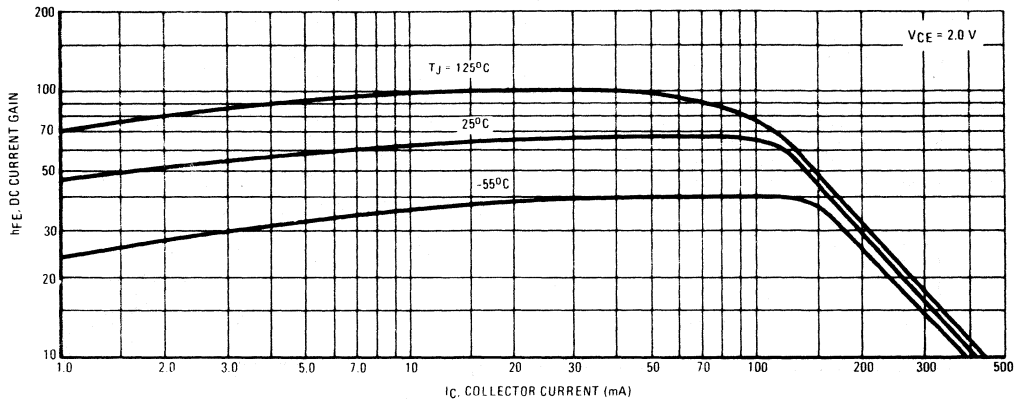
Delay Time (I _C = 150 mA _{dc} , I _{B1} = 15 mA _{dc} , V _{CC} = 100 V _{dc} , V _{BE(off)} = 2.0 V _{dc})	t _d	—	20	—	ns
Rise Time (I _C = 150 mA _{dc} , I _{B1} = 15 mA _{dc} , V _{CC} = 100 V _{dc} , V _{BE(off)} = 2.0 V _{dc})	t _r	—	35	—	ns
Storage Time (I _C = 150 mA _{dc} , I _{B1} = I _{B2} = 15 mA _{dc} , V _{CC} = 100 V _{dc})	t _s	—	800	—	ns
Fall Time (I _C = 150 mA _{dc} , I _{B1} = I _{B2} = 15 mA _{dc} , V _{CC} = 100 V _{dc})	t _f	—	80	—	ns

* Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2) f_T = |h_{fe}| • f_{test}.

FIGURE 1 – CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE
2N3498



2N3499

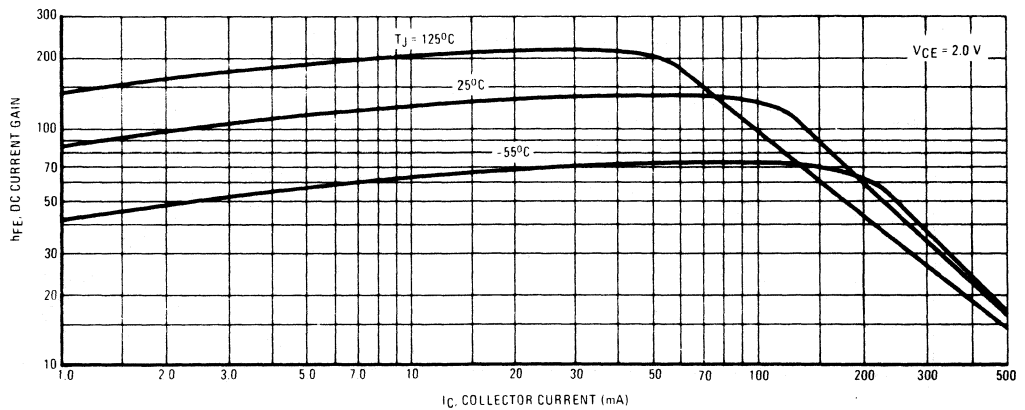


FIGURE 2 – CURRENT GAIN CHARACTERISTICS versus COLLECTOR-EMITTER VOLTAGE

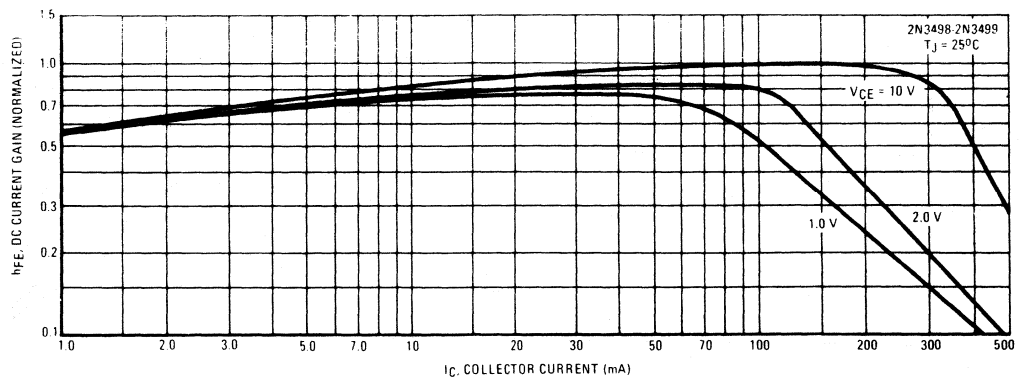


FIGURE 3 – CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE
2N3500

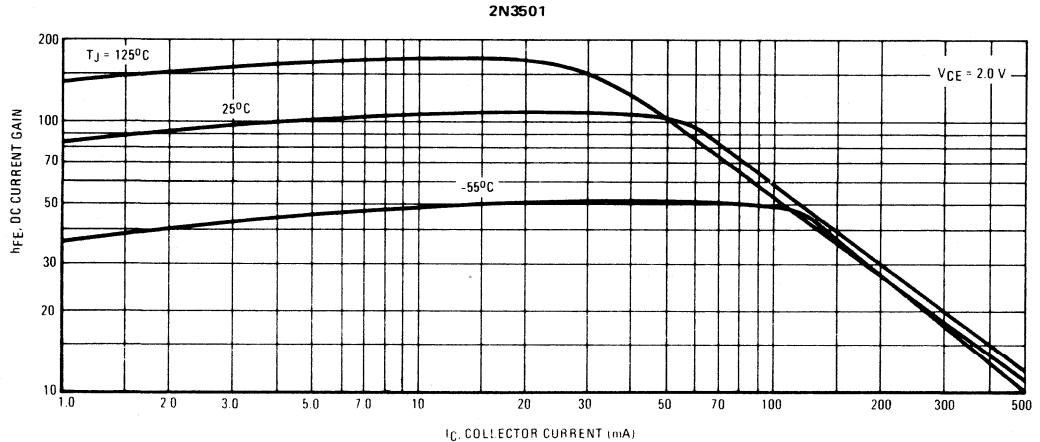
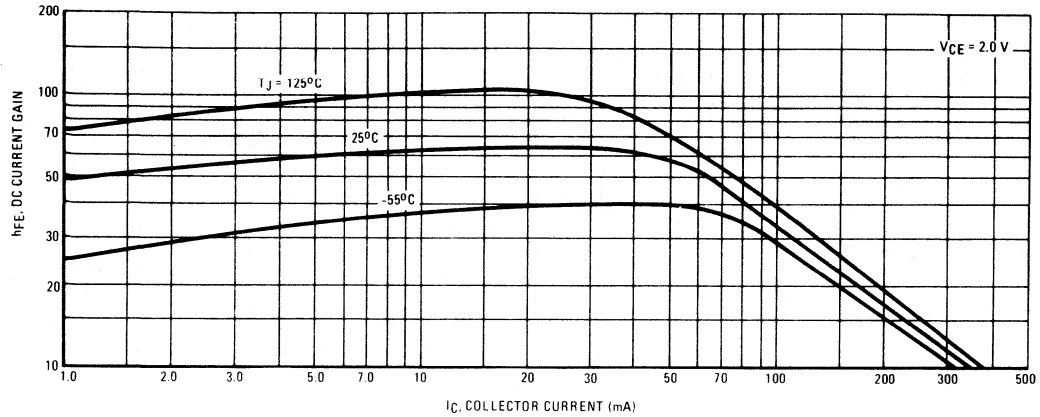


FIGURE 4 – CURRENT GAIN CHARACTERISTICS versus COLLECTOR-EMITTER VOLTAGE

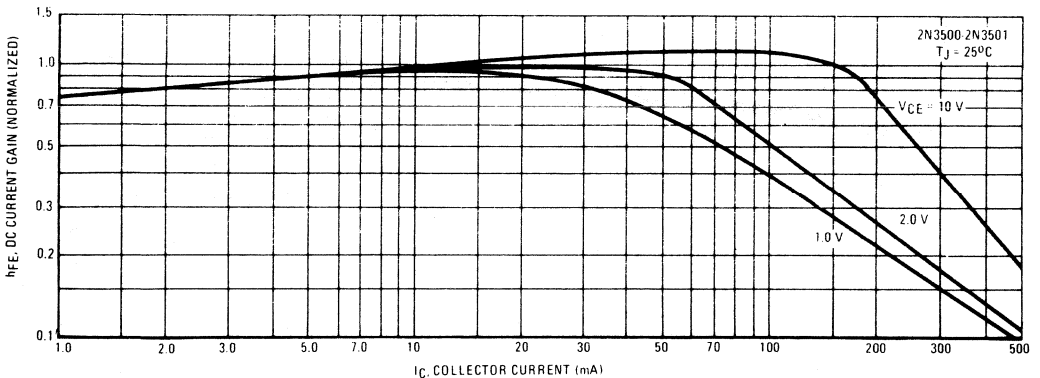


FIGURE 5 – "ON" VOLTAGES

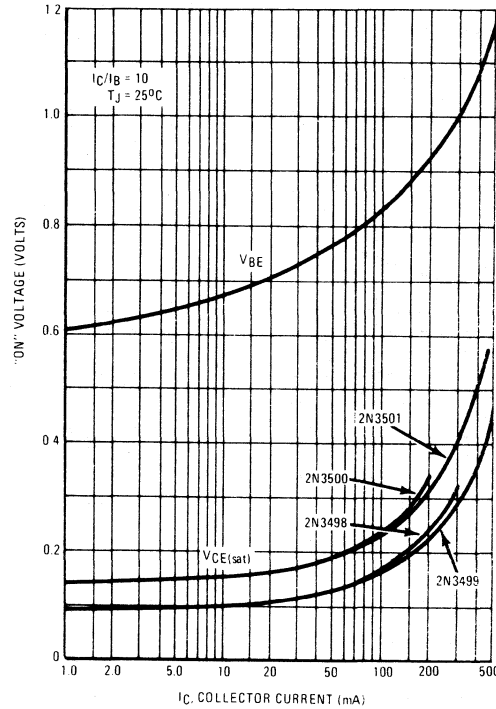


FIGURE 6 – TEMPERATURE COEFFICIENTS

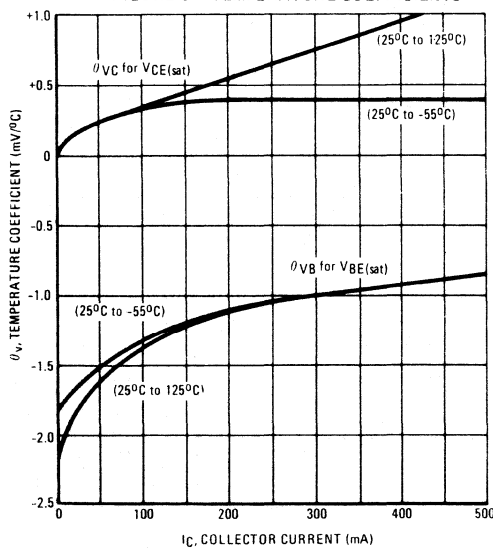
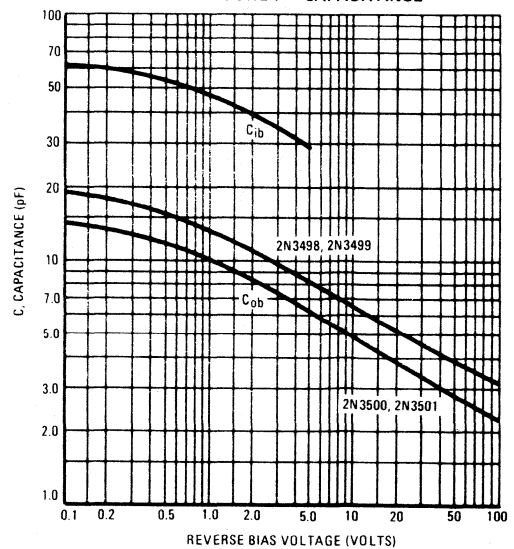


FIGURE 7 – CAPACITANCE



AUDIO SMALL-SIGNAL h PARAMETER CHARACTERISTICS

($V_{CE} = 10$ Vdc, $T_A = 25^\circ\text{C}$, $f = 1.0$ kHz)

FIGURE 8 – CURRENT GAIN

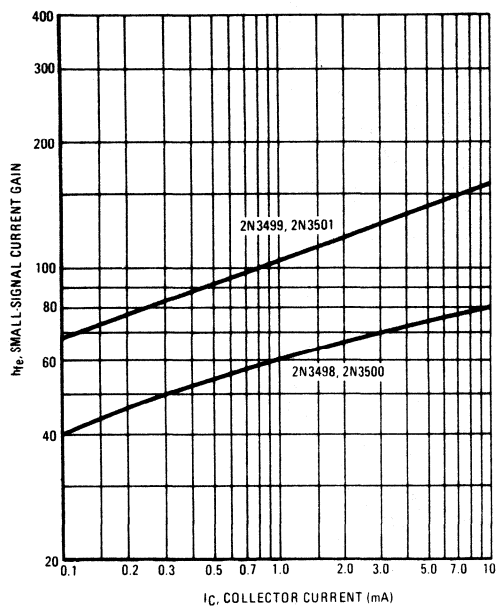


FIGURE 9 – OUTPUT IMPEDANCE

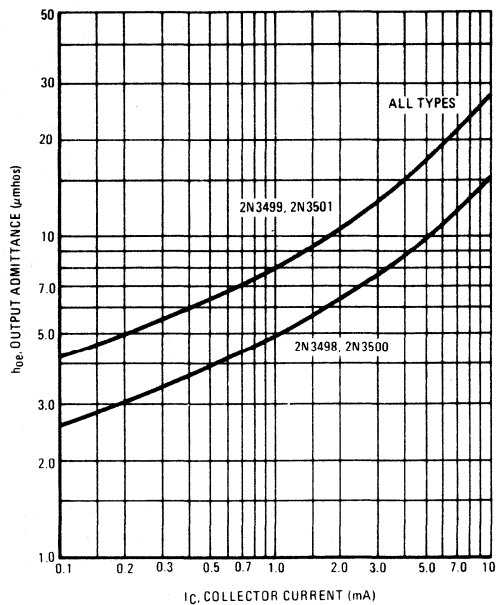


FIGURE 10 – INPUT IMPEDANCE

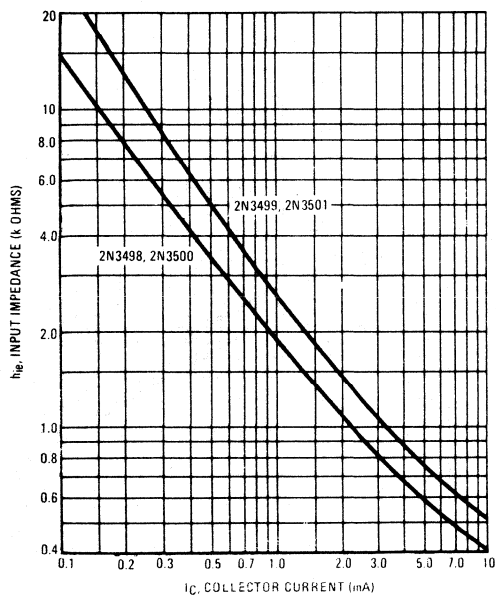
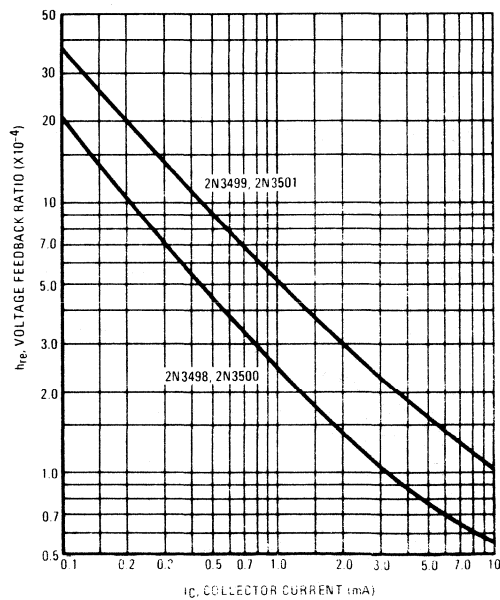


FIGURE 11 – VOLTAGE FEEDBACK RATIO



2N3506S, 2N3507S (SILICON)

JAN, JTX, JTXV AVAILABLE

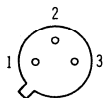


NPN silicon annular transistors for high-current, high-speed, saturated switching and core driver applications.

CASE 79
(TO-39)

Collector connected to case

***MAXIMUM RATINGS**



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

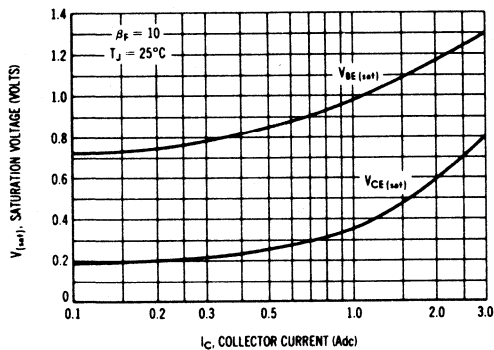
Rating	Symbol	2N3506	2N3507	Unit
Collector-Base Voltage	V_{CB}	60	80	Vdc
Collector-Emitter Voltage	V_{CEO}	40	50	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	3.0		Adc
Total Device Dissipation @ 25°C Case Temperature Derating Factor Above 25°C	P_D	5.0 28.6		Watts mW/°C
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor Above 25°C	P_D	1.0 5.71		Watts mW/°C
Junction Operating Temperature	T_J	200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

* Indicates JEDEC Registered Data

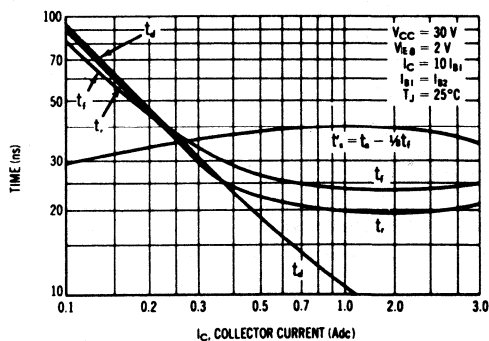
THERMAL RESISTANCE $\theta_{JA} = 0.175^\circ\text{C}/\text{mW}$

$\theta_{JC} = 35^\circ\text{C}/\text{W}$

SATURATION VOLTAGES



SWITCHING TIMES



2N3506S, 2N3507S (continued)

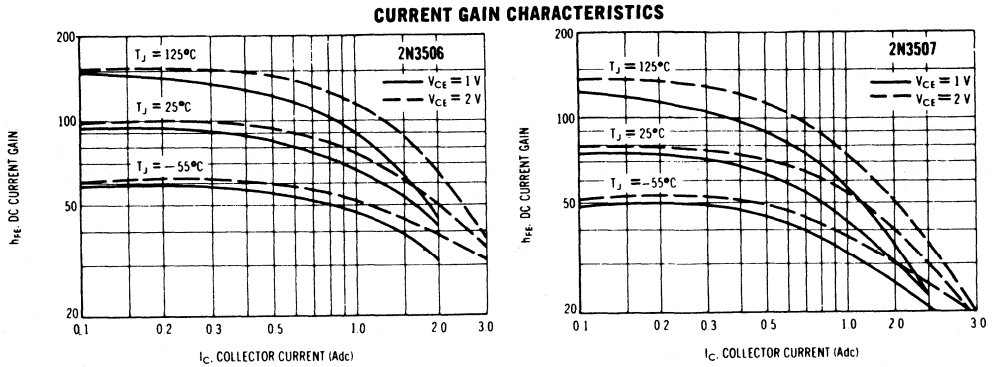
***ELECTRICAL CHARACTERISTICS** ($T_A = 25^{\circ}\text{C}$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current $(V_{CE} = 40 \text{ Vdc}, V_{EB(off)} = 4 \text{ Vdc})$ 2N3506 $(V_{CE} = 40 \text{ Vdc}, V_{EB(off)} = 4 \text{ Vdc}, T_A = 100^\circ\text{C})$ $(V_{CE} = 60 \text{ Vdc}, V_{EB(off)} = 4 \text{ Vdc})$ 2N3507 $(V_{CE} = 60 \text{ Vdc}, V_{EB(off)} = 4 \text{ Vdc}, T_A = 100^\circ\text{C})$		I_{CEX}	--	1.0 150 1.0 150	μAdc
Base Cutoff Current $(V_{CE} = 40 \text{ Vdc}, V_{EB(off)} = 4 \text{ Vdc})$ 2N3506 $(V_{CE} = 60 \text{ Vdc}, V_{EB(off)} = 4 \text{ Vdc})$ 2N3507		I_{BL}	--	1.0 1.0	μAdc
Collector-Base Breakdown Voltage $(I_C = 100 \mu\text{Adc}, I_E = 0)$ 2N3506 2N3507		BV_{CBO}	60 80	-- --	Vdc
Collector-Emitter Breakdown Voltage ⁽¹⁾ $(I_C = 10 \text{ mAdc, pulsed}, I_B = 0)$ 2N3506 2N3507		BV_{CEO}	40 50	-- --	Vdc
Emitter-Base Breakdown Voltage $(I_E = 10 \mu\text{Adc}, I_C = 0)$		BV_{EBO}	5.0	--	Vdc
Collector Saturation Voltage ⁽¹⁾ $(I_C = 500 \text{ mAdc}, I_B = 50 \text{ mAdc})$ $(I_C = 1.5 \text{ Adc}, I_B = 150 \text{ mAdc})$ $(I_C = 2.5 \text{ Adc}, I_B = 250 \text{ mAdc})$		$V_{CE(sat)}$	-- -- --	0.5 1.0 1.5	Vdc
Base-Emitter Saturation Voltage ⁽¹⁾ $(I_C = 500 \text{ mAdc}, I_B = 50 \text{ mAdc})$ $(I_C = 1.5 \text{ Adc}, I_B = 150 \text{ mAdc})$ $(I_C = 2.5 \text{ Adc}, I_B = 250 \text{ mAdc})$		$V_{BE(sat)}$	-- 0.9 --	1.0 1.4 2.0	Vdc
DC Current Gain ⁽¹⁾ $(I_C = 500 \text{ mAdc}, V_{CE} = 1 \text{ Vdc})$ 2N3506 2N3507 $(I_C = 1.5 \text{ Adc}, V_{CE} = 2 \text{ Vdc})$ 2N3506 2N3507 $(I_C = 2.5 \text{ Adc}, V_{CE} = 3 \text{ Vdc})$ 2N3506 2N3507 $(I_C = 3.0 \text{ Adc}, V_{CE} = 5 \text{ Vdc})$ 2N3506 2N3507		h_{FE}	50 35 40 30 30 25 25 20	-- -- 200 150 -- -- -- --	--
Output Capacitance $(V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz})$		C_{ob}	--	40	pF
Input Capacitance $(V_{BE} = 3 \text{ Vdc}, I_C = 0, f = 100 \text{ kHz})$		C_{ib}	--	300	pF
Current Gain-Bandwidth Product $(I_C = 100 \text{ mAdc}, V_{CE} = 5 \text{ Vdc}, f = 20 \text{ MHz})$		f_T	60	--	MHz
Delay Time	$I_C = 1.5 \text{ Adc}, I_{B1} = 150 \text{ mAdc}$ $V_{CC} = 30 \text{ V}, V_{EB} = 0 \text{ V}$ $I_C = 1.5 \text{ Adc}, I_{B1} = I_{B2} = 150 \text{ mAdc}$ $V_{CC} = 30 \text{ V}$	t_d	--	15	ns
Rise Time		t_r	--	30	ns
Storage Time		t_s	--	55	ns
Fall Time		t_f	--	35	ns

* Indicates JEDEC Registered Data

(1) **Pulse Test:** Pulse width = 300 μ s, duty cycle = 2%

2N3506S, 2N3507S (continued)

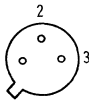


2N3508 (SILICON)

2N3509



CASE 26
(TO-46)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

NPN silicon annular transistor for high-speed, low-current switching applications.

Collector connected to case

***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	40	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current (10 μ s pulse)	$I_C(\text{Peak})$	500	mA
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor Above 25°C	P_D	0.40 2.29	Watt mW/°C
Total Device Dissipation @ 25°C Case Temperature Derating Factor Above 25°C	P_D	2.0 11.43	Watts mW/°C
Junction Temperature, Operating	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Thermal Resistance, Junction to Case	θ_{JC}	0.0875	°C/mW
Thermal Resistance, Junction to Ambient	θ_{JA}	0.438	°C/mW

*Indicates JEDEC Registered Data

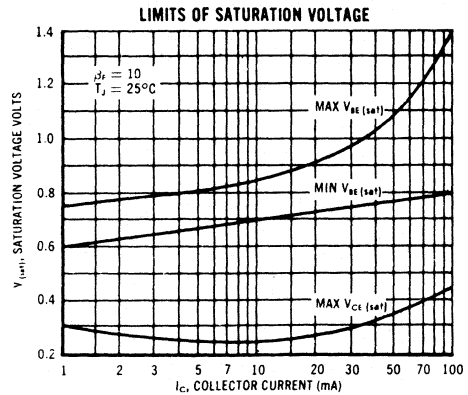
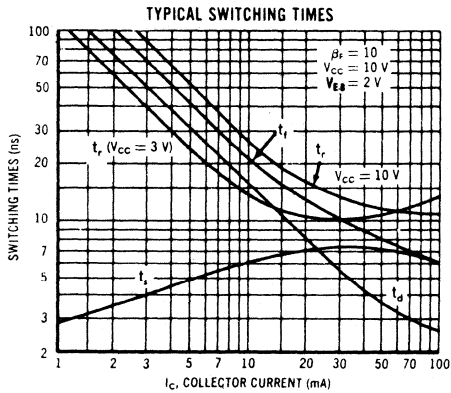
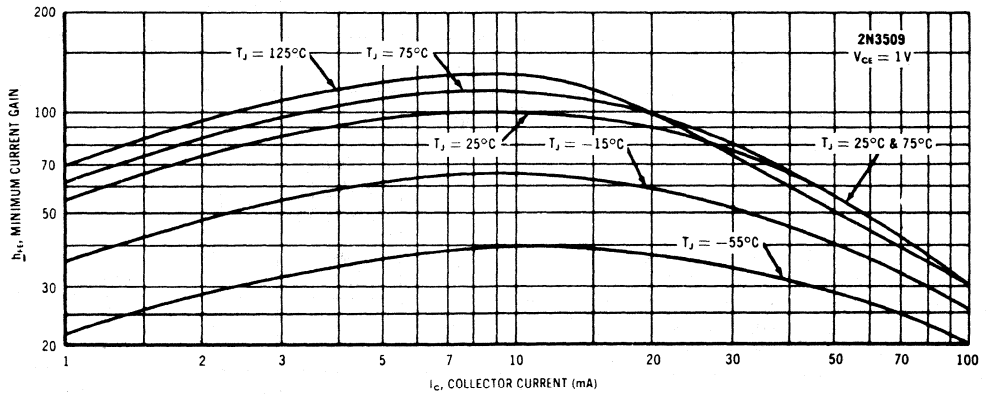
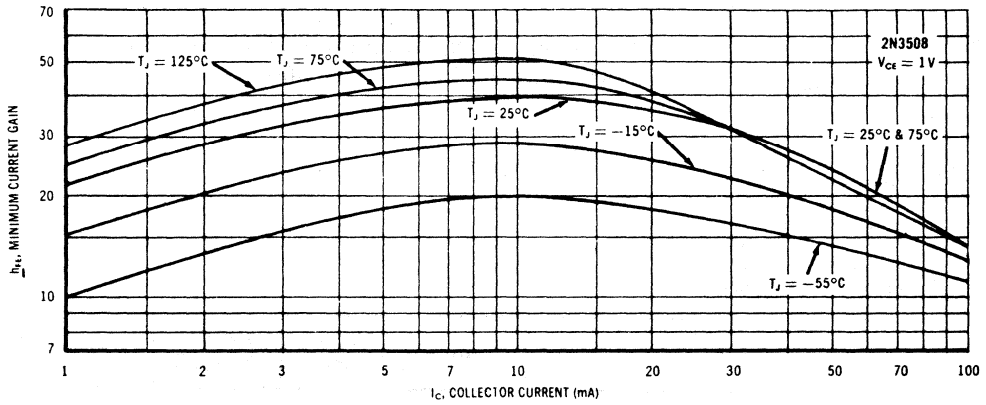
***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current ($V_{CB} = 20\text{ Vdc}$) ($V_{CB} = 20\text{ Vdc}$, $T_A = 150^\circ\text{C}$) Both Types 2N3508 2N3509	I_{CBO}	— — —	0.2 30 50	μAdc
Collector Cutoff Current ($V_{CE} = 20\text{ Vdc}$, $V_{EB(\text{off})} = 3\text{ Vdc}$)	I_{CEX}	—	0.2	μAdc
Base Cutoff Current ($V_{CE} = 20\text{ Vdc}$, $V_{EB(\text{off})} = 3\text{ Vdc}$)	I_{BL}	—	0.5	μAdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $I_B = 0$)	BV_{CBO}	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	6.0	—	Vdc
Collector-Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 10\text{ mAdc}$)	BV_{CEO}	20	—	Vdc
Collector-Emitter Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $I_B = 0$)	BV_{CES}	40	—	Vdc
Collector-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 10\text{ mAdc}$, $I_B = 1\text{ mAdc}$) ($I_C = 100\text{ mAdc}$, $I_B = 10\text{ mAdc}$)	$V_{CE(\text{sat})}$	— —	0.25 0.45	Vdc
Base-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 10\text{ mAdc}$, $I_B = 1\text{ mAdc}$) ($I_C = 100\text{ mAdc}$, $I_B = 10\text{ mAdc}$)	$V_{BE(\text{sat})}$	0.70 0.8	0.85 1.4	Vdc
DC Current Gain ⁽¹⁾ ($I_C = 10\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$, $T_A = -55^\circ\text{C}$) ($I_C = 100\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$) 2N3508 2N3509 2N3508 2N3509 2N3508 2N3509	h_{FE}	40 100 20 40 20 30	120 300 — — — —	—
Small-Signal Current Gain ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	h_{fe}	5.0	—	—
Output Capacitance ($V_{CB} = 5\text{ Vdc}$, $I_E = 0$, $f = 140\text{ kHz}$)	C_{ob}	—	4.0	pF
Input Capacitance ($V_{BE} = 1\text{ Vdc}$, $I_C = 0$, $f = 140\text{ kHz}$)	C_{ib}	—	4.0	pF
Storage Time ($I_C = I_{B1} = I_{B2} = 10\text{ mA}$)	$t_s(\tau_s)$	—	13	ns
Turn-On Time ($I_C = 10\text{ mA}$, $I_{B1} = 3\text{ mA}$, $V_{CC} = 3\text{ V}$, $V_{OB} = 1.5\text{ V}$)	t_{on}	—	12	ns
Turn-Off Time ($I_C = 10\text{ mA}$, $I_{B1} = 3\text{ mA}$, $I_{B2} = 1.5\text{ mA}$, $V_{CC} = 3\text{ V}$)	t_{off}	—	18	ns
Total Control Charge ($I_C = 10\text{ mA}$, $I_B = 1\text{ mA}$, $V_{CC} = 3\text{ V}$)	Q_T	—	50	pC
Delay Time	t_d	—	5.0	ns
Rise Time				
Storage Time	t_s	—	13	ns
Fall Time				

* Indicates JEDEC Registered Data

⁽¹⁾ Pulse Test: $PW = 300\mu\text{s}$, Duty Cycle $\leq 2\%$

MINIMUM CURRENT GAIN CHARACTERISTICS



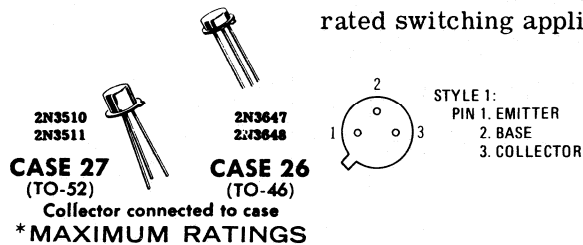
2N3510 (SILICON)

2N3511

2N3647

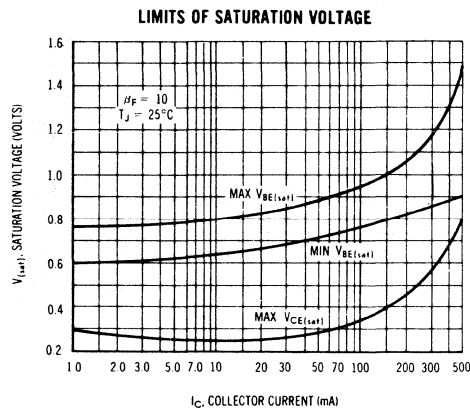
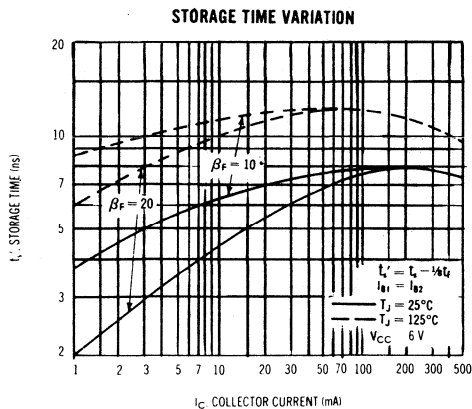
2N3648

NPN silicon annular transistors for high-speed saturated switching applications to 500 mA.



Rating	Symbol	2N3510 2N3647	2N3511 2N3648	Unit
Collector-Base Voltage	V_{CB}	40	40	Vdc
Collector-Emitter Voltage	V_{CEO}	10	15	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derating Factor Above 25°C	P_D	TO-46 2N3647 2N3648	TO-52 2N3510 2N3511	mW $\text{mW}/^\circ\text{C}$
		400 2.28	360 2.06	
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derating Factor Above 25°C	P_D	2.0 11.43	1.2 6.9	Watts $\text{mW}/^\circ\text{C}$
Junction Temperature, Operating	T_J	+200		$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200		$^\circ\text{C}$

* Indicates JEDEC Registered Data



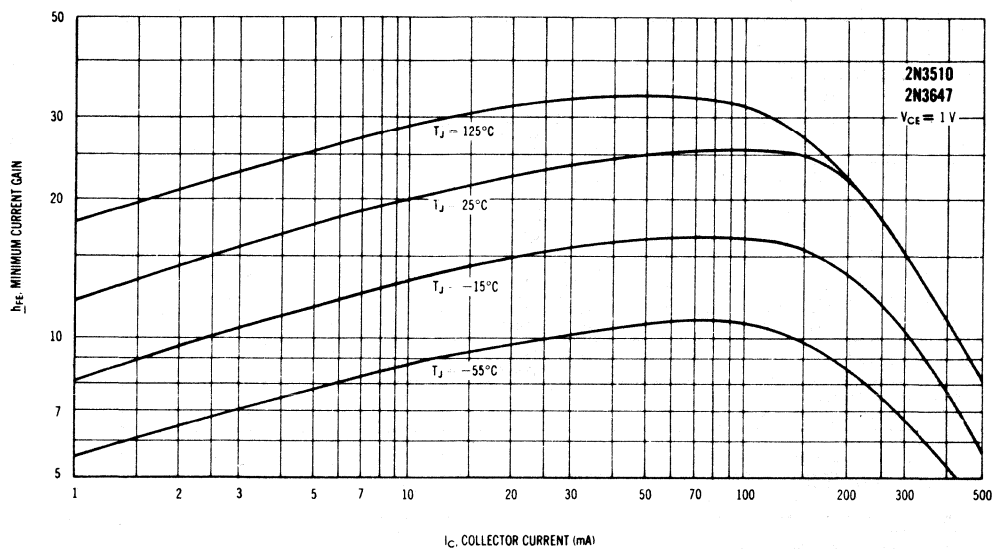
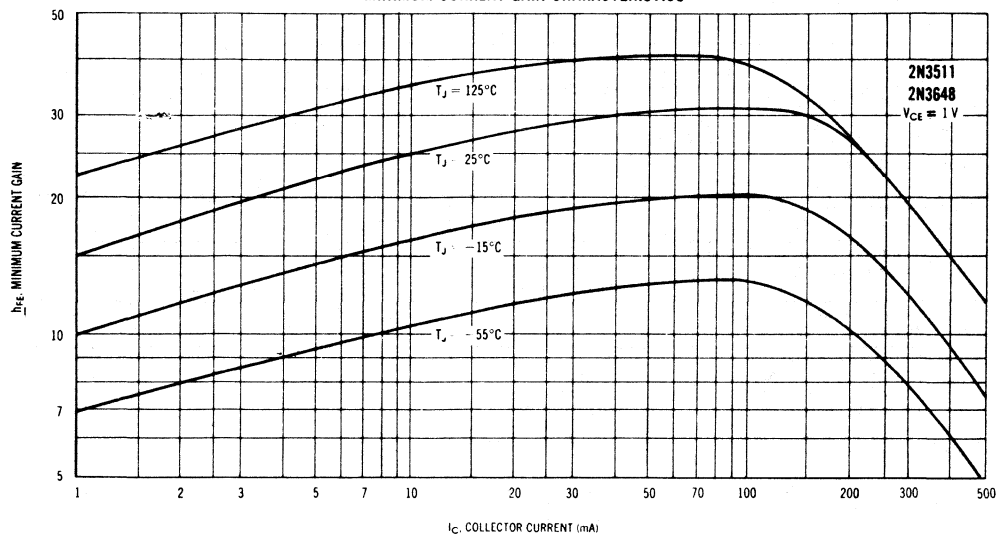
2N3510, 2N3511, 2N3647, 2N3648 (continued)
***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic			Symbol	Min	Max	Unit	
Collector Cutoff Current ($V_{CE} = 10\text{ Vdc}$, $V_{EB(\text{off})} = 1\text{ Vdc}$) ($V_{CE} = 10\text{ Vdc}$, $V_{EB(\text{off})} = 1\text{ Vdc}$, $T_A = 150^{\circ}\text{C}$)			I_{CEX}	— —	.025 50	μAdc	
Base Cutoff Current ($V_{CE} = 10\text{ Vdc}$, $V_{OB} = 1\text{ Vdc}$)			I_{BL}	—	.025	μAdc	
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $I_E = 0$)			BV_{CBO}	40	—	Vdc	
Collector-Emitter Breakdown Voltage(1) ($I_C = 10\text{ mAdc}$, $I_B = 0$) 2N3510, 2N3647 2N3511, 2N3648			BV_{CEO}	10 15	— —	Vdc	
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{Adc}$, $I_C = 0$)			BV_{EBO}	6.0	—	Vdc	
Collector Saturation Voltage(1) ($I_C = 10\text{ mAdc}$, $I_B = 1\text{ mAdc}$) All Types ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$) All Types ($I_C = 300\text{ mAdc}$, $I_B = 30\text{ mAdc}$) 2N3510, 2N3647 ($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$) 2N3511, 2N3648			$V_{CE(\text{sat})}$	— — — —	0.25 0.4 0.6 0.8	Vdc	
Base-Emitter Saturation Voltage(1) ($I_C = 10\text{ mAdc}$, $I_B = 1\text{ mAdc}$) All Types ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$) All Types ($I_C = 300\text{ mAdc}$, $I_B = 30\text{ mAdc}$) 2N3510, 2N3647 ($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$) 2N3511, 2N3648			$V_{BE(\text{sat})}$	— 0.8 — —	0.8 1.0 1.15 1.5	Vdc	
DC Current Gain* ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$) 2N3510, 2N3647 2N3511, 2N3648 ($I_C = 10\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$) 2N3510, 2N3647 2N3511, 2N3648 ($I_C = 150\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$) 2N3510, 2N3647 2N3511, 2N3648 ($I_C = 150\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$, $T_A = -55^{\circ}\text{C}$) 2N3511, 2N3648 ($I_C = 300\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$) 2N3510, 2N3647 ($I_C = 500\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$) 2N3511, 2N3648			h_{FE}	12 15 20 25 25 30 12 15 12	— — — — 150 120 — — —	—	
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)			C_{ob}	—	4.0	pF	
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)			C_{ib}	—	8.0	pF	
Small Signal Current Gain ($I_C = 15\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$) 2N3510, 2N3647 2N3511, 2N3648			h_{fe}	3.5 4.5	— —	—	
Delay Time	$I_C = 150\text{ mA}$, $I_{B1} = 15\text{ mA}$, $V_{EB} = 0.5\text{ V}$, $V_{CC} = 6\text{ V}$	2N3510, 2N3647 2N3511, 2N3648	t_d	— —	10 8.0	ns	
Rise Time		2N3510, 2N3647 2N3511, 2N3648	t_r	— —	12 10	ns	
Turn-On Time		2N3510, 2N3647 2N3511, 2N3648	t_{on}	— —	20 16	ns	
Storage Time		2N3510, 2N3647 2N3511, 2N3648	t_s	— —	16 12	ns	
Fall Time		$I_C = 150\text{ mA}$, $I_{B1} = -I_{B2} = 15\text{ mA}$, $V_{CC} = 6\text{ V}$	2N3510, 2N3647 2N3511, 2N3648	t_f	— —	12 8.0	ns
Turn-Off Time		2N3510, 2N3647 2N3511, 2N3648	t_{off}	— —	25 18	ns	
Total Control Charge ($I_C = 150\text{ mA}$, $I_B = 15\text{ mA}$, $V_{CC} = 6\text{ V}$)			Q_T	—	300	pC	
Small Signal Current Gain ($I_C = 1\text{ mA}$, $V_{CE} = 10\text{ V}$, $f = 1\text{ kHz}$)			h_{fe}	20	150	—	
Voltage Feedback Ratio ($I_C = 1\text{ mA}$, $V_{CE} = 10\text{ V}$, $f = 1\text{ kHz}$)			h_{re}	—	25	$\times 10^{-4}$	
Input Impedance ($I_C = 1\text{ mA}$, $V_{CE} = 10\text{ V}$, $f = 1\text{ kHz}$)			h_{ie}	0.6	4.5	kohms	
Output Admittance ($I_C = 1\text{ mA}$, $V_{CE} = 10\text{ V}$, $f = 1\text{ kHz}$)			h_{oe}	10	100	μmhos	

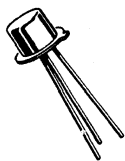
* Indicates JEDEC Registered Data

(1) Pulse Test: $PW \leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2\%$

MINIMUM CURRENT GAIN CHARACTERISTICS



2N3544 (SILICON)

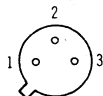


CASE 22 (TO-18)

Collector connected to case

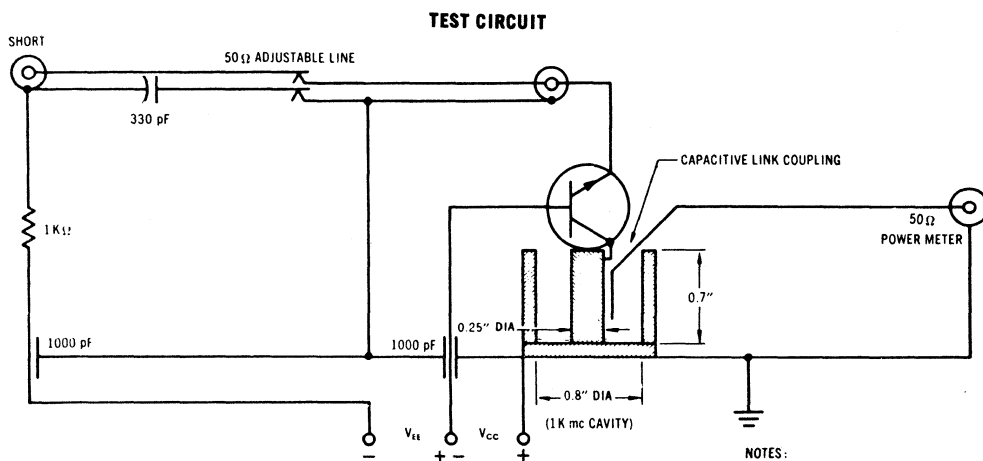
MAXIMUM RATINGS

NPN silicon annular transistor for VHF and UHF oscillator applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	25	Vdc
Collector-Emitter Voltage	V_{CES}	25	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current	I_C	100	mA
Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	400 2.67	mW mW/ $^\circ\text{C}$
Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 2.0	mW mW/ $^\circ\text{C}$
Junction Temperature	T_J	+175	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +175	$^\circ\text{C}$



NOTES:
1. SET $V_{cc} = 12$ Vdc.
2. ADJUST V_{be} FOR $I_C = 12$ mAdc.
3. SET ADJUSTABLE LINE FOR MAXIMUM POWER OUTPUT.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Conditions	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage	BV_{CBO}	$I_C = 10 \mu\text{A dc}, I_E = 0$	25	30	--	Vdc
Collector-Emitter Breakdown Voltage	BV_{CES}	$I_C = 10 \mu\text{A}, V_{BE} = 0$	25	30	--	Vdc
Collector Cutoff Current	I_{CBO}	$V_{CB} = 15 \text{ Vdc}, I_E = 0$	--	0.01	0.1	$\mu\text{A dc}$
Emitter Cutoff Current	I_{EBO}	$V_{EB} = 3 \text{ Vdc}, I_C = 0$	--	0.1	10	$\mu\text{A dc}$
DC Current Gain	h_{FE}	$V_{CE} = 10 \text{ Vdc}, I_C = 10 \text{ mA dc}$	25	50	--	--

AC Current Gain	$ h_{fe} $	$V_{CE} = 10 \text{ Vdc}, I_C = 10 \text{ mA dc}, f = 100 \text{ MHz}$	6.0	9.0	15	--
Collector Output Capacitance	C_{ob}	$V_{CB} = 15 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz}$	--	--	2.5	pF
Collector-Base Time Constant	$r_b' C_c$	$V_{CB} = 10 \text{ Vdc}, I_C = 10 \text{ mA dc}, f = 31.8 \text{ MHz}$	--	--	10	ps

Oscillator Power Output	P_{out}	$f = 1.0 \text{ GHz}, V_C = 12 \text{ Vdc}, I_C = 12 \text{ mA dc}$	10	16	--	mW
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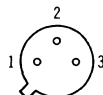
2N3546 (SILICON)

CASE 22 (TO-18)



PNP silicon annular transistor for low-level, high-speed switching applications.

Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	15	Vdc
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.36 2.06	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.2 6.9	Watts mW/ $^\circ\text{C}$
Operating Junction Temperature	T_J	200	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$
Thermal Resistance, Junction to Ambient	θ_{JA}	0.49	$^\circ\text{C}/\text{mW}$
Thermal Resistance, Junction to Case	θ_{JC}	0.15	$^\circ\text{C}/\text{mW}$

* Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current ($V_{CB} = 10\text{ Vdc}$) ($V_{CB} = 10\text{ Vdc}$, $T_A = 150^\circ\text{C}$)		I_{CBO}	--	0.010 10	μAdc
Collector Cutoff Current ($V_{CE} = 10\text{ Vdc}$, $V_{BE(off)} = 3\text{ Vdc}$)		I_{CEX}	--	0.010	μAdc
Base Cutoff Current ($V_{CE} = 10\text{ Vdc}$, $V_{BE(off)} = 3\text{ Vdc}$)		I_{BL}	--	0.10	μAdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $I_E = 0$)		BV_{CBO}	15	--	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{Adc}$, $I_C = 0$)		BV_{EBO}	4.5	--	Vdc
Collector-Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 10\text{ mAdc}$, $I_B = 0$)		BV_{CEO}	12	--	Vdc
Collector Saturation Voltage ⁽¹⁾ ($I_C = 10\text{ mAdc}$, $I_B = 1\text{ mAdc}$) ($I_C = 50\text{ mAdc}$, $I_B = 5\text{ mAdc}$) ($I_C = 100\text{ mAdc}$, $I_B = 10\text{ mAdc}$)		$V_{CE(sat)}$	-- -- --	0.15 0.25 0.50	Vdc
Base-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 10\text{ mAdc}$, $I_B = 1\text{ mAdc}$) ($I_C = 50\text{ mAdc}$, $I_B = 5\text{ mAdc}$) ($I_C = 100\text{ mAdc}$, $I_B = 10\text{ mAdc}$)		$V_{BE(sat)}$	0.7 0.8 --	0.9 1.3 1.6	Vdc
DC Current Gain ⁽¹⁾ ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$, $T_A = -55^\circ\text{C}$) ($I_C = 50\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$) ($I_C = 100\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$)		h_{FE}	20 30 15 25 15	-- 120 -- -- --	--
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1\text{ MHz}$)		C_{ob}	--	6.0	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 1\text{ MHz}$)		C_{ib}	--	5.0	pF
Current-Gain - Bandwidth Product ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)		f_T	700	--	MHz
Total Control Charge ($I_C = 50\text{ mA}$, $I_B = 5\text{ mA}$, $V_{CC} = 3\text{ V}$)		Q_T	--	400	pC
Delay Time	$I_C = 50\text{ mA}$, $I_{B1} = 5\text{ mA}$, $V_{BE} = 2\text{ V}$, $V_{CC} = 3\text{ V}$	t_d	--	10	ns
Rise Time		t_r	--	15	ns
Storage Time		t_s	--	20	ns
Fall Time		t_f	--	15	ns
Turn-On Time	(See Figure 3, 4, 5)	t_{on}	--	40	ns
Turn-Off Time		t_{off}	--	30	ns

* Indicates JEDEC Registered Data

⁽¹⁾ Pulse Test: $PW = 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2\%$

FIGURE 1

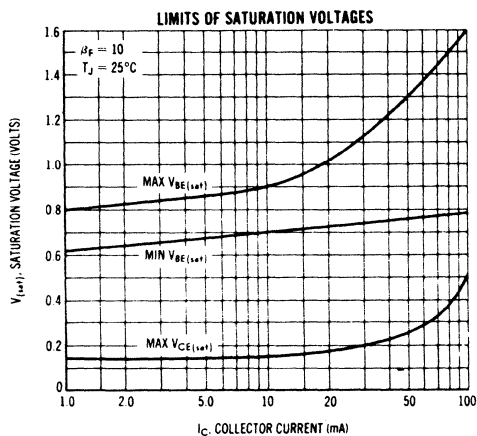


FIGURE 2

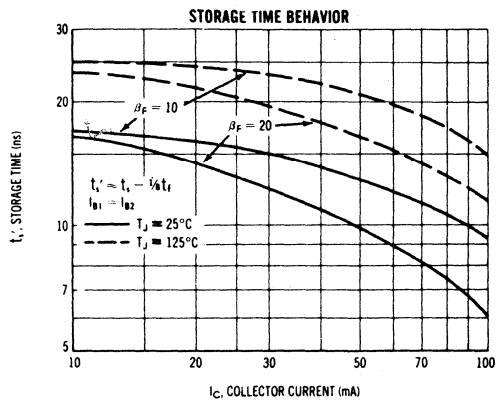
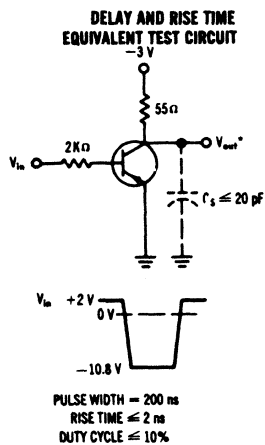


FIGURE 3



*OSCILLOSCOPE RISE TIME ≤ 1 ns

**FIGURE 4
STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT**

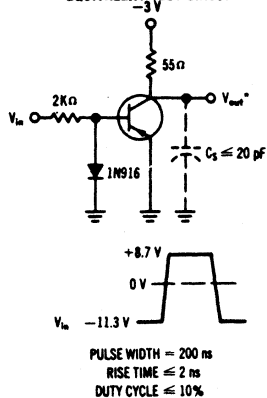


FIGURE 5

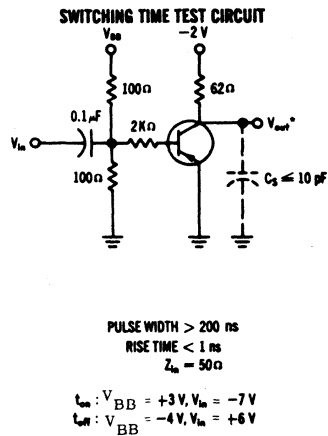
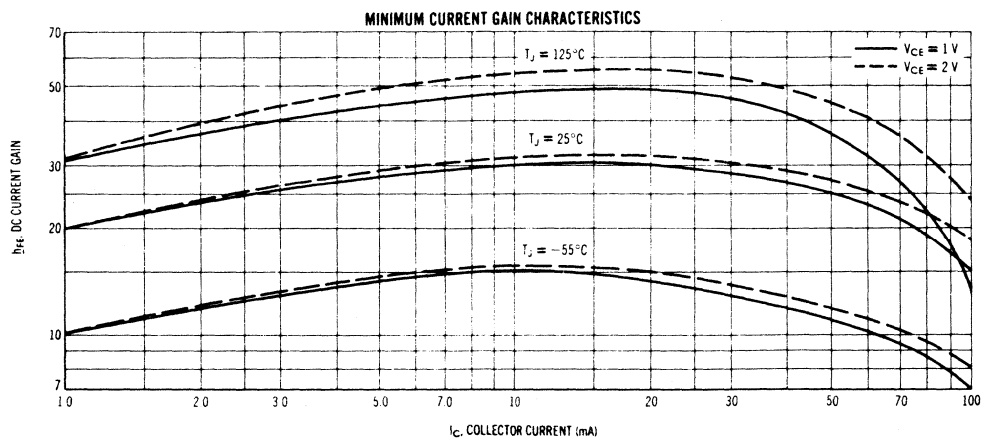


FIGURE 6



2N3553 (SILICON)

For Specifications, See 2N3375 Data.

2N3583 thru 2N3585, 2N4240 NPN (SILICON) MJ3583 thru MJ3585, MJ4240 PNP

COMPLEMENTARY MEDIUM-POWER HIGH VOLTAGE POWER TRANSISTORS

... designed for high-speed switching and linear amplifier applications for high-voltage operational amplifiers, switching regulators, converters, inverters, deflection stages and high fidelity amplifiers.

- Collector-Emitter Sustaining Voltage –
 $V_{CE(sus)} = 175 \text{ to } 300 \text{ Vdc @ } I_C = 200 \text{ mAdc}$
- Second Breakdown Collector Current –
 $I_{S/b} = 350 \text{ mAdc @ } V_{CE} = 100 \text{ Vdc – NPN}$
 $= 150 \text{ mAdc @ } V_{CE} = 100 \text{ Vdc – PNP}$
- Usable DC Current Gain to 2.0 Adc

*MAXIMUM RATINGS

Rating	Symbol	2N3583 MJ3583	2N3584 MJ3584	2N3585 MJ3585	2N4240 MJ4240	Unit
Collector-Emitter Voltage	V_{CEO}	175	250	300	300	Vdc
Collector-Base Voltage	V_{CB}	250	375	500	500	Vdc
Emitter-Base Voltage	V_{EB}	6.0				Vdc
Collector Current -- Continuous -- Peak	I_C	1.0 5.0	2.0 5.0			Adc
Base Current	I_B	1.0				Adc
Total Device Dissipation @ $T_C = 25^{\circ}\text{C}$, Derate above 25°C	P_D	35 0.2				Watts W/ $^{\circ}\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200				$^{\circ}\text{C}$

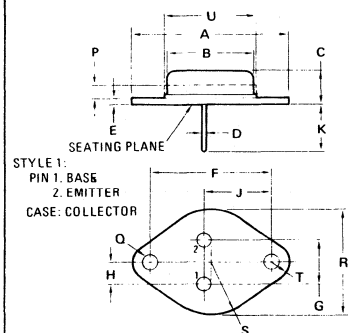
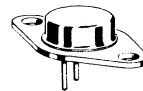
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	5.0	$^\circ\text{C/W}$

* Indicates JEDEC Registered Data for 2N3583 thru 2N3585 and 2N4240.

1.0 AND 2.0 AMPERE POWER TRANSISTORS COMPLEMENTARY SILICON

250-500 VOLTS
35 WATTS



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
B	11.94	12.70	0.470	0.500
C	6.35	8.64	0.250	0.340
D	0.71	0.86	0.028	0.034
E	1.27	1.91	0.050	0.075
F	24.33	24.43	0.958	0.962
G	4.83	5.33	0.190	0.210
H	2.41	2.67	0.095	0.105
J	14.48	14.99	0.570	0.590
K	9.14	—	0.360	—
P	—	1.27	—	0.050
Q	3.61	3.86	0.142	0.152
S	—	8.89	—	0.350
T	—	3.68	—	0.145
U	—	15.75	—	0.620

All JEDEC Dimensions and Notes Apply.

CASE 80-02
TO-66

ELECTRICAL CHARACTERISTICS ($T_C = 25^{\circ}\text{C}$ unless otherwise noted.)

Characteristic	NPN	PNP	Symbol	NPN		PNP		Unit
				Min	Max	Min	Max	
* OFF CHARACTERISTICS								
Collector-Emitter Sustaining Voltage ($I_C = 200 \text{ mAdc}$, $I_B = 0$) NPN ($I_C = 50 \text{ mAdc}$, $I_B = 0$) PNP	2N3583	MJ3583	$V_{CE(sus)}$	175	—	175	—	Vdc
	2N3584	MJ3584		250	—	250	—	
	2N3585	MJ3585		300	—	300	—	
	2N4240	MJ4240		300	—	300	—	
Collector Cutoff Current ($V_{CE} = 150 \text{ Vdc}$, $I_B = 0$)	2N3583	MJ3583	I_{CEO}	—	10	—	10	mAdc
	2N3584	MJ3584		—	5.0	—	5.0	
	2N3585	MJ3585		—	5.0	—	5.0	
	2N4240	MJ4240		—	5.0	—	5.0	
Collector Cutoff Current ($V_{CE} = 225 \text{ Vdc}$, $V_{BE(off)} = 1.5 \text{ Vdc}$) ($V_{CE} = 340 \text{ Vdc}$, $V_{BE(off)} = 1.5 \text{ Vdc}$) ($V_{CE} = 450 \text{ Vdc}$, $V_{BE(off)} = 1.5 \text{ Vdc}$) ($V_{CE} = 225 \text{ Vdc}$, $V_{BE(off)} = 1.5 \text{ Vdc}$, $T_C = 150^{\circ}\text{C}$) ($V_{CE} = 300 \text{ Vdc}$, $V_{BE(off)} = 1.5 \text{ Vdc}$, $T_C = 150^{\circ}\text{C}$)	2N3583	MJ3583	I_{CEX}	—	1.0	—	1.0	mAdc
	2N3584	MJ3584		—	1.0	—	1.0	
	2N3585	MJ3585		—	1.0	—	1.0	
	2N4240	MJ4240		—	2.0	—	2.0	
	2N3583	MJ3583		—	3.0	—	3.0	
	2N3584	MJ3584		—	3.0	—	3.0	
	2N3585	MJ3585		—	3.0	—	3.0	
	2N4240	MJ4240		—	5.0	—	5.0	
Emitter Cutoff Current ($V_{BE} = 6.0 \text{ Vdc}$, $I_C = 0$)	2N3583	MJ3583	I_{EBO}	—	5.0	—	5.0	mAdc
	2N3584	MJ3584		—	0.5	—	0.5	
	2N3585	MJ3585		—	0.5	—	0.5	
	2N4240	MJ4240		—	0.5	—	0.5	

ON CHARACTERISTICS

DC Current Gain ($I_C = 0.1 \text{ Adc}$, $V_{CE} = 10 \text{ Vdc}$)	2N3583*	MJ3583	h_{FE}	40	—	40	—	
	2N3584	MJ3584		40	—	40	—	
	2N3585	MJ3585		40	—	40	—	
	2N4240	MJ4240		40	—	40	—	
* ($I_C = 0.5 \text{ Adc}$, $V_{CE} = 10 \text{ Vdc}$)	2N3583	MJ3583		40	200	40	200	
* ($I_C = 0.75 \text{ Adc}$, $V_{CE} = 2.0 \text{ Vdc}$)	2N4240	MJ4240		10	100	10	100	
($I_C = 0.75 \text{ Adc}$, $V_{CE} = 10 \text{ Vdc}$)	2N4240	MJ4240		30	150	30	150	
* ($I_C = 1.0 \text{ Adc}$, $V_{CE} = 2.0 \text{ Vdc}$)	2N3584	MJ3584		8.0	80	8.0	80	
	2N3585	MJ3585		8.0	80	8.0	80	
	2N3583*	MJ3583		10	—	10	—	
($I_C = 1.0 \text{ Adc}$, $V_{CE} = 10 \text{ Vdc}$)	2N3584	MJ3584		25	100	25	100	
	2N3585	MJ3585		25	100	25	100	
* Collector-Emitter Saturation Voltage ($I_C = 0.75 \text{ Adc}$, $I_B = 75 \text{ mAdc}$) ($I_C = 1.0 \text{ Adc}$, $I_B = 125 \text{ mAdc}$)	2N4240	MJ4240	$V_{CE(sat)}$	—	1.0	—	1.0	Vdc
	2N3583	MJ3583		—	5.0	—	5.0	
	2N3584	MJ3584		—	0.75	—	0.75	
	2N3585	MJ3585		—	0.75	—	0.75	
* Base-Emitter Saturation Voltage ($I_C = 0.75 \text{ Adc}$, $I_B = 75 \text{ mAdc}$) ($I_C = 1.0 \text{ Adc}$, $I_B = 100 \text{ mAdc}$)	2N4240	MJ4240	$V_{BE(sat)}$	—	1.8	—	1.8	Vdc
	2N3584	MJ3584		—	1.4	—	1.4	
	2N3585	MJ3585		—	1.4	—	1.4	
Base-Emitter On Voltage ($I_C = 1.0 \text{ Adc}$, $V_{CE} = 10 \text{ Vdc}$)	2N3583*	MJ3583	$V_{BE(on)}$	—	1.4	—	1.4	Vdc
	2N3584	MJ3584		—	1.4	—	1.4	
	2N3585	MJ3585		—	1.4	—	1.4	
	2N4240	MJ4240		—	1.4	—	1.4	

2N3583 thru 2N3585, 2N4240 NPN, MJ3583 thru MJ3585, MJ4240 PNP(continued)

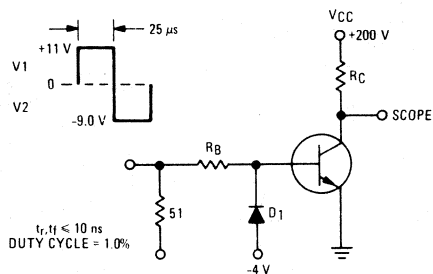
ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	NPN	PNP	Symbol	NPN		PNP		Unit
				Min	Max	Min	Max	
DYNAMIC CHARACTERISTICS								
*Current Gain – Bandwidth Product ⁽¹⁾ ($I_C = 200\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f_{\text{test}} = 5.0\text{ MHz}$)	2N3583 2N3584 2N3585 2N4240	MJ3583 MJ3584 MJ3585 MJ4240	f_T	10 15	— —	10 15	— —	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	All	All	C_{ob}	—	120	—	120	pF
*Small-Signal Current Gain ($I_C = 100\text{ mAdc}$, $V_{CE} = 30\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N3583	MJ3583	h_{fe}	25	350	25	350	—
*SWITCHING CHARACTERISTICS								
Rise Time ($V_{CC} = 200\text{ Vdc}$, $I_C = 1.0\text{ Adc}$, $R_L = 200\text{ Ohms}$, $I_{B1} = 100\text{ mAdc}$) ($V_{CC} = 200\text{ Vdc}$, $I_C = 0.75\text{ Adc}$, $R_L = 267\text{ Ohms}$, $I_{B1} = 75\text{ mAdc}$)	2N3584 2N3585 2N4240	MJ3584 MJ3585 MJ4240	t_r	— —	3.0 0.5	— —	3.0 0.5	μs
Storage Time ($V_{CC} = 200\text{ Vdc}$, $I_C = 1.0\text{ Adc}$, $I_{B1} = I_{B2} = 100\text{ mAdc}$) ($V_{CC} = 200\text{ Vdc}$, $I_C = 0.75\text{ Adc}$, $I_{B1} = I_{B2} = 75\text{ mAdc}$)	2N3584 2N3585 2N4240	MJ3584 MJ3585 MJ4240	t_s	— —	4.0 6.0	— —	4.0 6.0	μs
Fall Time ($V_{CC} = 200\text{ Vdc}$, $I_C = 1.0\text{ Adc}$, $I_{B1} = I_{B2} = 100\text{ mAdc}$) ($V_{CC} = 200\text{ Vdc}$, $I_C = 0.75\text{ Adc}$, $I_{B1} = I_{B2} = 75\text{ mAdc}$)	2N3584 2N3585 2N4240	MJ3584 MJ3585 MJ4240	t_f	— —	3.0 3.0	— —	3.0 3.0	μs
Second Breakdown Collector Current ($V_{CE} = 100\text{ Vdc}$)	All	All	$I_{s/b}$	350	—	150	—	mAdc

* Indicates JEDEC Registered Data for 2N3583 thru 2N3585 and 2N4240.

(1) $f_T = |h_{fe}| \cdot f_{\text{test}}$

FIGURE 1 – SWITCHING TIME TEST CIRCUIT



R_B and R_C VARIED TO OBTAIN DESIRED CURRENT LEVELS

D1 MUST BE FAST RECOVERY TYPE, eg.

MB05300 USED ABOVE $I_B \approx 100\text{ mA}$

MSD6100 USED BELOW $I_B \approx 100\text{ mA}$

FOR t_d and t_r , D1 IS DISCONNECTED AND $V_2 = 0$.

FOR PNP TEST CIRCUIT, REVERSE DIODE AND VOLTAGE POLARITIES.

NPN
2N3583 thru 2N3585, 2N4240

PNP
MJ3583 thru MJ3585, MJ4240

FIGURE 2 – TURN-ON TIME

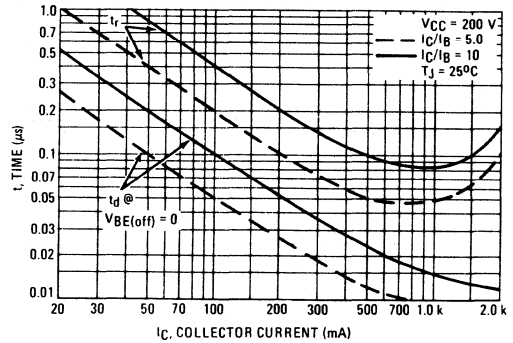
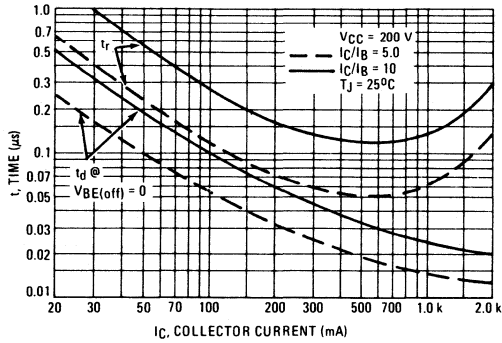


FIGURE 3 – TURN-OFF TIME

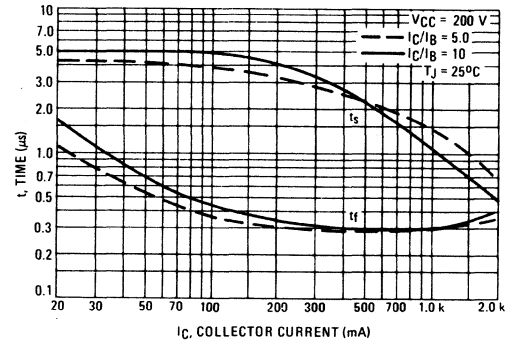
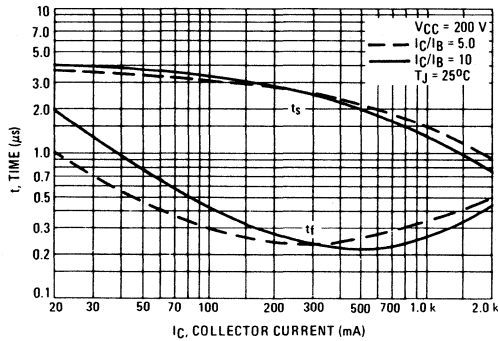


FIGURE 4 – CURRENT-GAIN – BANDWIDTH PRODUCT

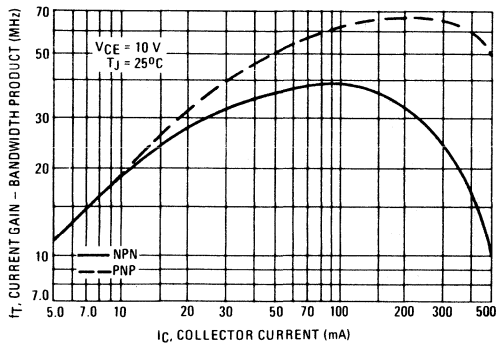


FIGURE 5 – CAPACITANCE

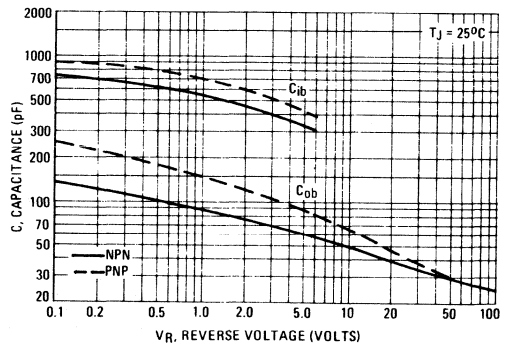
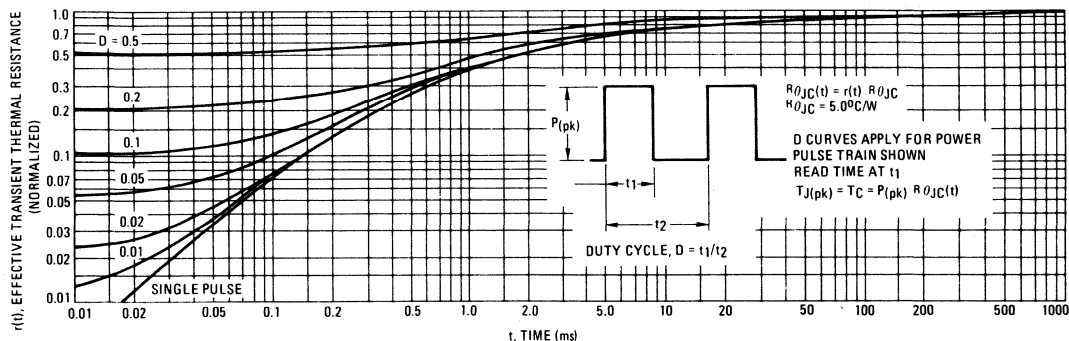


FIGURE 6 – THERMAL RESPONSE



ACTIVE-REGION SAFE OPERATING AREA

FIGURE 7 – 2N3583 thru 2N3585, 2N4240

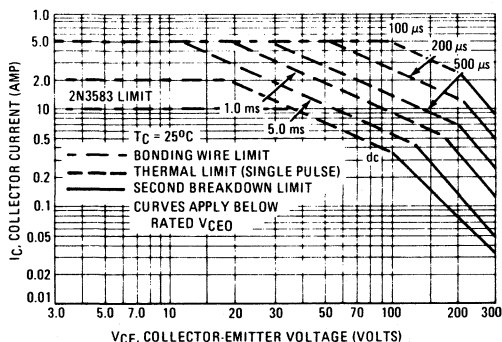


FIGURE 8 – MJ3583 thru MJ3585, MJ4240

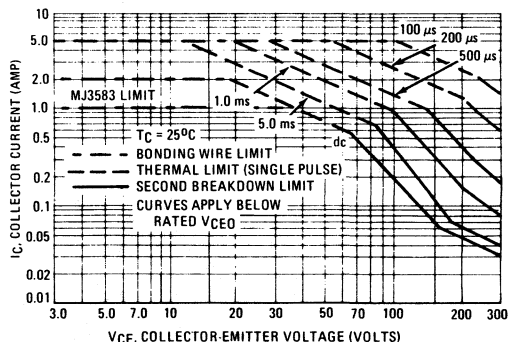
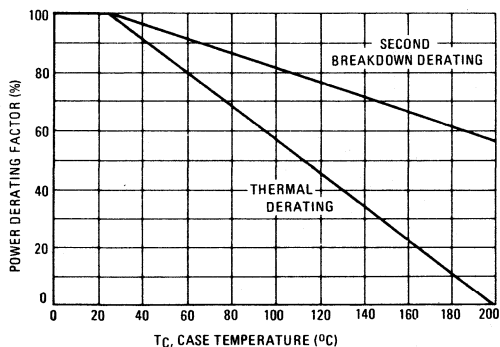


FIGURE 9 – POWER DERATING



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 7 and 8 is based on $T_C = 25^{\circ}\text{C}$; $T_J(pk)$ is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated for temperature according to Figure 9.

$T_J(pk)$ may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figures 7 and 8 may be found at any case temperature by using the appropriate curve on Figure 9.

NPN
2N3583 thru 2N3585, 2N4240

PNP
MJ3583 thru MJ3585, MJ4240

FIGURE 10 — DC CURRENT GAIN

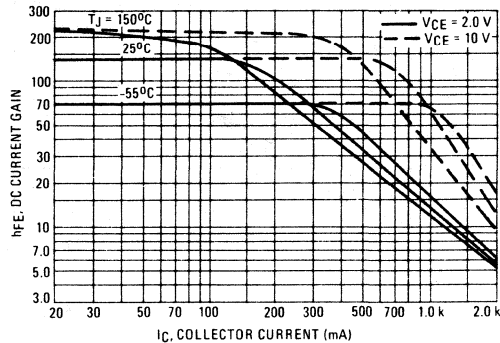
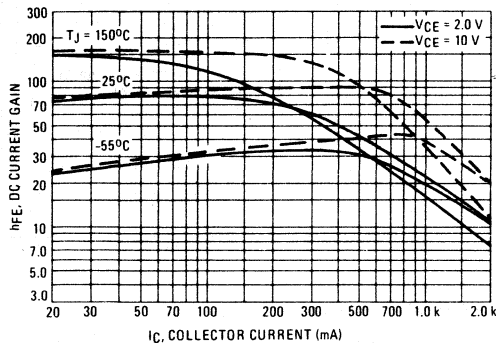


FIGURE 11 — COLLECTOR SATURATION REGION

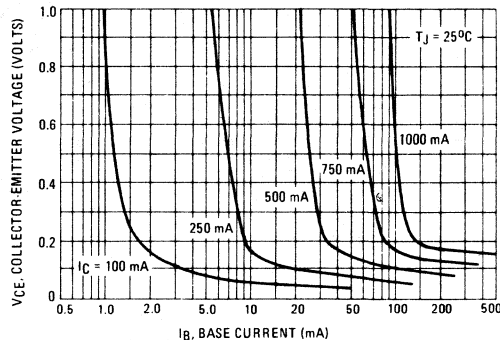
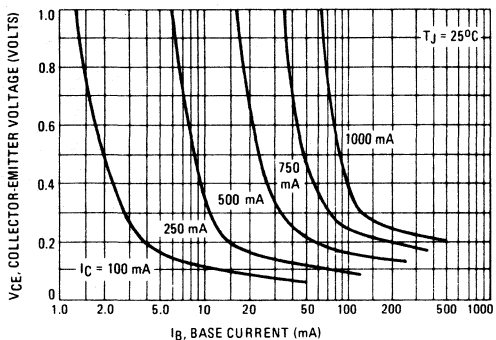
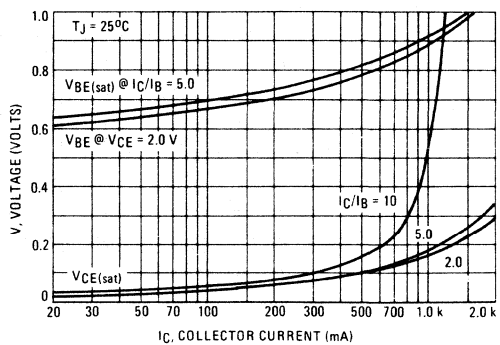
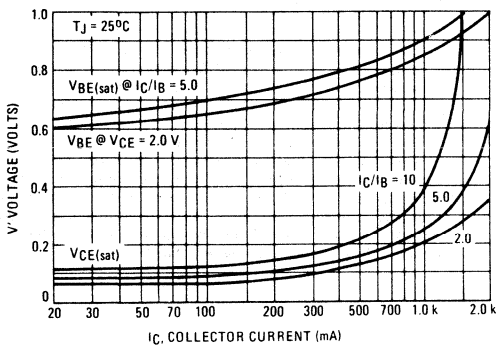


FIGURE 12 — "ON" VOLTAGES



NOTE: DC CURRENT LIMIT FOR 2N3583, MJ3583 is 1.0 Amp.

NPN
2N3583 thru 2N3585, 2N4240

PNP
MJ3583 thru MJ3585, MJ4240

FIGURE 13 – TEMPERATURE COEFFICIENTS

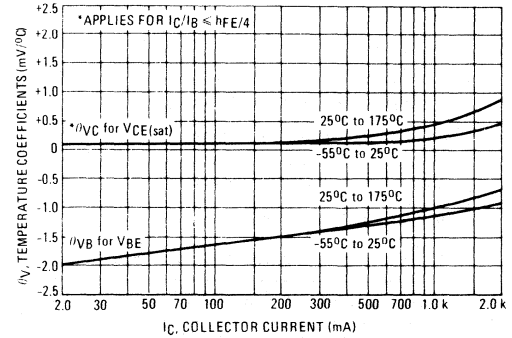
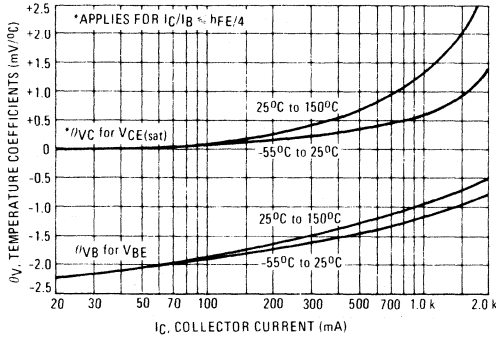


FIGURE 14 – COLLECTOR CUTOFF REGION

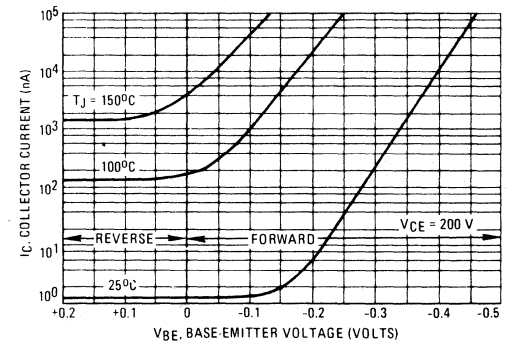
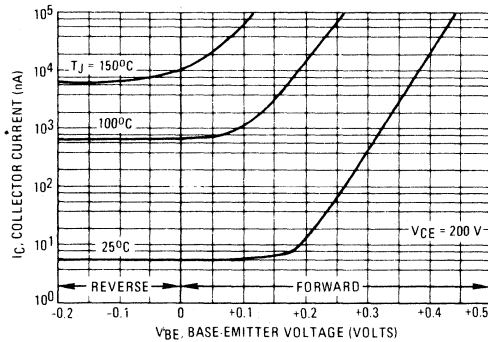
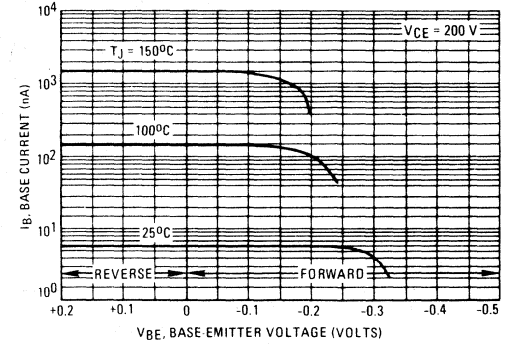
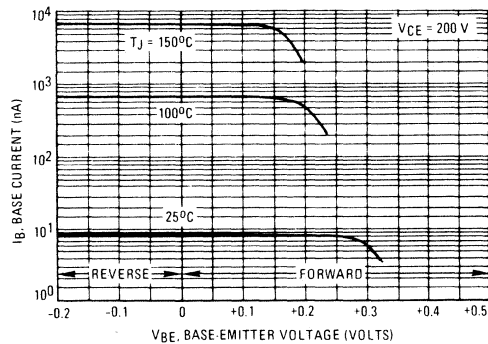
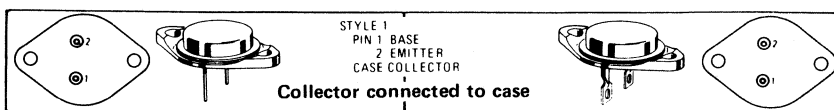


FIGURE 15 – BASE CUTOFF REGION



2N3611 thru 2N3614 (GERMANIUM)

PNP germanium power transistors
for switching and amplifier applications.



CASE 11

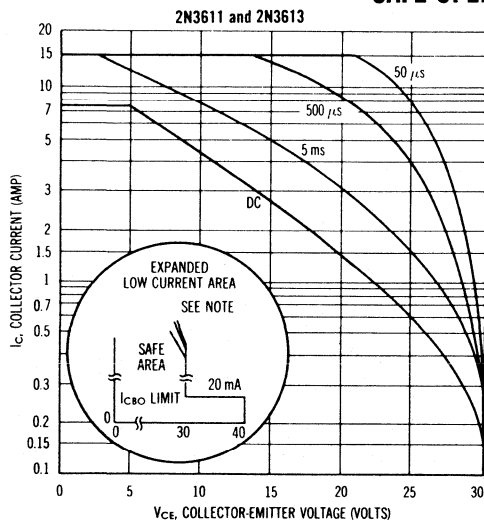
For units with solder lugs attached, specify
devices MP 3611 etc. (Case 4-04)

CASE 4-04

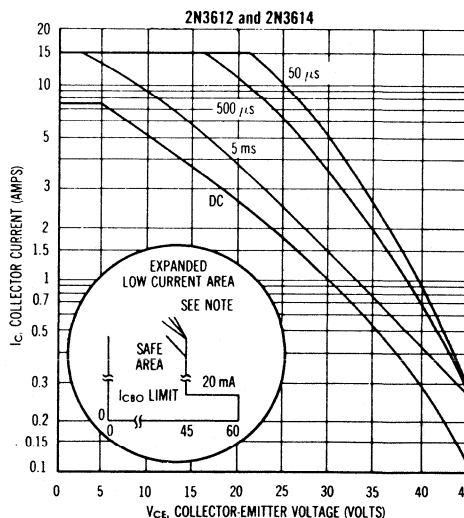
MAXIMUM RATINGS

Rating	Symbol	2N3611 2N3613	2N3612 2N3614	Unit
Collector-Emitter Voltage	V_{CES}	30	45	Vdc
Collector-Emitter Voltage (Open Base)	V_{CEO}	25	35	Vdc
Collector-Base Voltage	V_{CB}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	20	30	Vdc
Collector Current (Continuous)	I_C	7.0		Adc
Peak Collector Current ($PW \leq 5$ msec)	I_C	15		Adc
Base Current (Continuous)	I_B	2.0		Adc
Storage Temperature Range	T_{stg}	-65 to +110		$^{\circ}C$
Operating Case Temperature Range	T_C	-65 to +110		$^{\circ}C$
Total Device Dissipation @ $T_C = 25^{\circ}C$ Derate above $T_C = 25^{\circ}C$	P_D	77 1.0		Watts W/ $^{\circ}C$
Thermal Resistance, Junction to Case	θ_{JC}	1.1		$^{\circ}C/W$
Thermal Resistance, Case to Ambient	θ_{CA}	32.7		$^{\circ}C/W$

SAFE OPERATING AREAS



The Safe Operating Area Curves indicate I_C - V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Case temperature and duty cycle of the excursions make no significant change in these safe areas.) The load line may exceed the BV_{CES} voltage limit only if the collector



current has been reduced to 20 mA or less before or at the BV_{CES} limit; then and only then may the load line be extended to the absolute maximum voltage rating of BV_{CBO} . To insure operation below the maximum T_J , the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N3611 thru 2N3614 (continued)

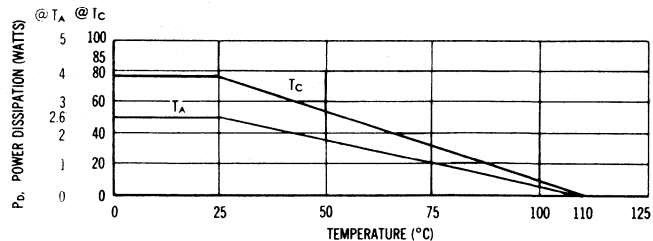
ELECTRICAL CHARACTERISTICS

Characteristics		Symbol	Min	Max	Unit
Collector-Emitter Breakdown Voltage* ($I_C = 250 \text{ mAdc}$)	2N3611, 2N3613 2N3612, 2N3614	BV_{CES}^*	30 45	— —	Vdc
Collector-Emitter Breakdown Voltage* ($I_C = 500 \text{ mAdc}$)	2N3611, 2N3613 2N3612, 2N3614	BV_{CEO}^*	25 35	— —	Vdc
Floating Potential ($V_{CB} = V_{CB \text{ max}}$)		V_{EBF}	—	1.0	Vdc
Collector-Emitter Leakage Current ($V_{CE} = 1/2 V_{CEO \text{ max}}$)		I_{CEO}	—	30	mAdc
Collector-Emitter Leakage Current ($V_{CE} = V_{CE \text{ max}}$, $V_{BE} = 1.0 \text{ Vdc}$, $T_C = +100^\circ\text{C}$)		I_{CEX}	—	10	mAdc
Collector-Base Cutoff Current ($V_{CB} = 2 \text{ Vdc}$)		I_{CBO}	—	.040	mAdc
($V_{CB} = 25 \text{ Vdc}$)	2N3611, 2N3613		—	0.5	
($V_{CB} = 40 \text{ Vdc}$)	2N3612, 2N3614		—	0.5	
($V_{CB} = V_{CB \text{ max}}$)			—	5.0	
Emitter-Base Cutoff Current ($V_{EB} = V_{EB \text{ max}}$)		I_{EBO}	—	500	μA dc
Collector-Emitter Saturation Voltage ($I_C = 3 \text{ A}$ dc, $I_B = 300 \text{ mA}$ dc)		$V_{CE(sat)}$	—	0.25	Vdc
($I_C = 7 \text{ A}$ dc, $I_B = 700 \text{ mA}$ dc)			—	0.35	
Base-Emitter Saturation Voltage ($I_C = 3 \text{ A}$ dc, $I_B = 300 \text{ mA}$ dc)	2N3611, 2N3612 2N3613, 2N3614	$V_{BE(sat)}$	— —	0.7 0.6	Vdc
($I_C = 7 \text{ A}$ dc, $I_B = 700 \text{ mA}$ dc)	2N3611, 2N3612 2N3613, 2N3614		— —	1.1 0.9	
Transconductance ($I_C = 3 \text{ A}$ dc, $V_{CE} = 2 \text{ Vdc}$)	2N3611, 2N3612 2N3613, 2N3614	g_{FE}	3.0 3.5	— —	mhos
Small Signal Current Gain ($I_C = 0.5 \text{ A}$, $V_{CE} = 12 \text{ V}$, $f = 20 \text{ kHz}$)		h_{fe}	15	—	—
($I_C = 0.5 \text{ A}$, $V_{CE} = 2 \text{ V}$, $f = 1 \text{ kHz}$)	2N3611, 2N3612 2N3613, 2N3614		40 60	100 150	
DC Current Gain ($I_C = 3 \text{ A}$ dc, $V_{CE} = 2 \text{ Vdc}$)	2N3611, 2N3612 2N3613, 2N3614	h_{FE}	35 60	70 120	—
($I_C = 7 \text{ A}$ dc, $V_{CE} = 2 \text{ Vdc}$)	2N3611, 2N3612 2N3613, 2N3614		20 30	— —	

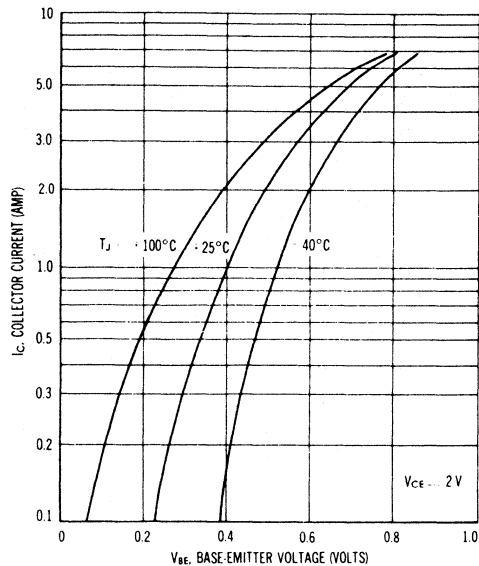
*Sweep Test: 1/2 sine wave, 60 Hz

POWER-TEMPERATURE DERATING CURVE

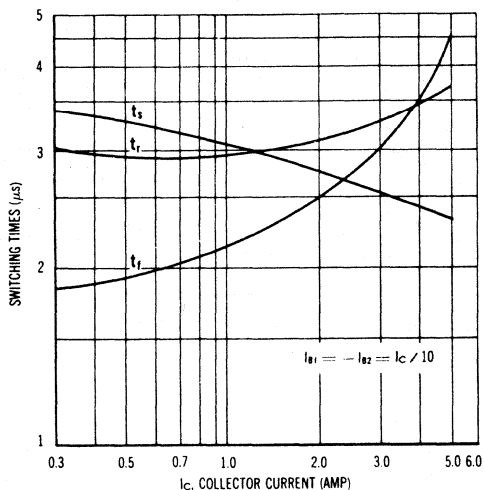
These transistors are also subject to safe area curves. Both limits are applicable and must be observed.



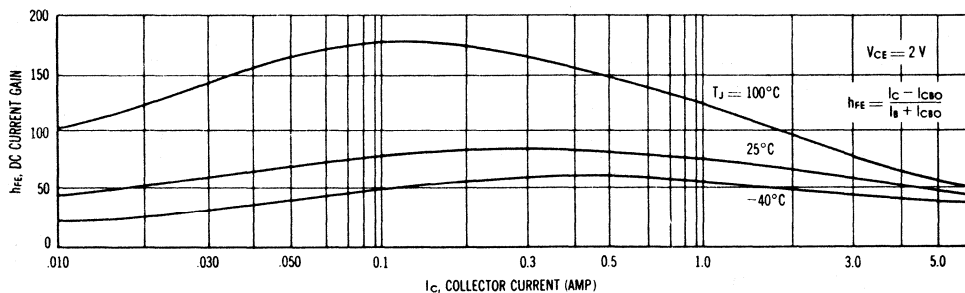
COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE



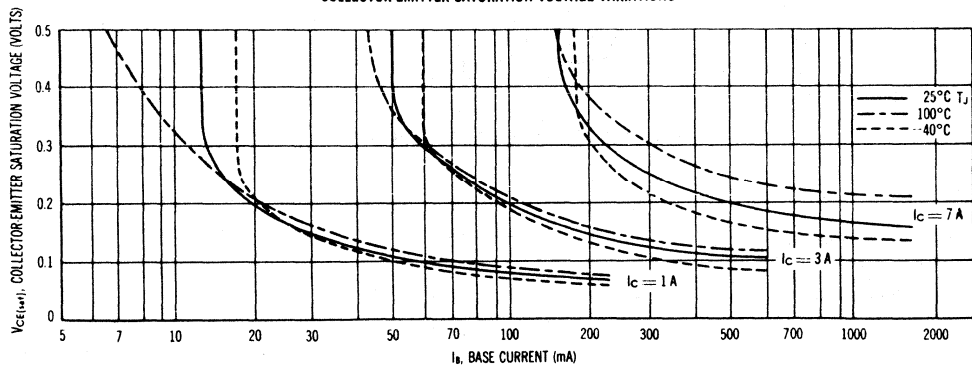
TYPICAL SWITCHING TIMES



DC CURRENT GAIN versus COLLECTOR CURRENT

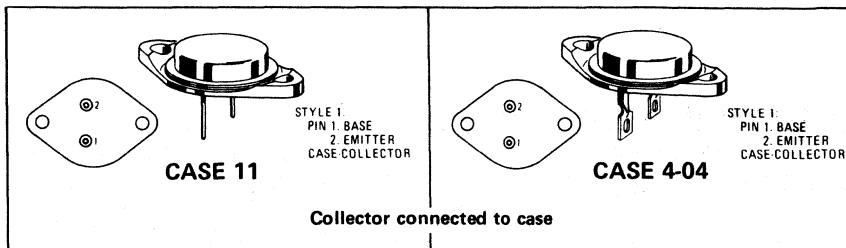


COLLECTOR-EMITTER SATURATION VOLTAGE VARIATIONS



2N3615 thru 2N3618 (GERMANIUM)

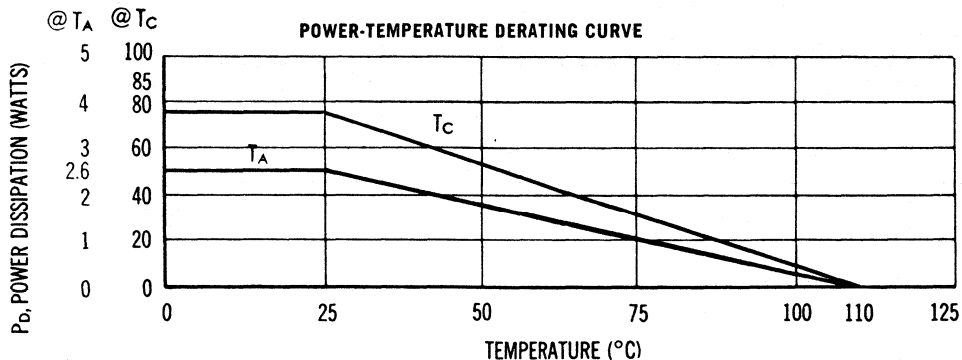
PNP germanium power transistors for switching and amplifier applications.



For units with solder lugs attached, specify devices MP3615 etc (Case 4-04)

MAXIMUM RATINGS

Rating	Symbol	2N3615 2N3617	2N3616 2N3618	Unit
Collector-Emitter Voltage	V_{CES}	60	75	Vdc
Collector-Emitter Voltage (Open Base)	V_{CEO}	50	60	Vdc
Collector-Base Voltage	V_{CB}	80	100	Vdc
Emitter-Base Voltage	V_{EB}	40	50	Vdc
Collector Current (Continuous)	I_C	7.0		Adc
Peak Collector Current (PW $\leq$ 5 msec)	I_C	15		Adc
Base Current (Continuous)	I_B	2.0		Adc
Storage Temperature	T_{stg}	-65 to +110		$^{\circ}\text{C}$
Operating Case Temperature	T_C	-65 to +110		$^{\circ}\text{C}$
Total Device Dissipation @ $T_C = 25^{\circ}\text{C}$ Derate above 25°C	P_D	7.7 1.0		Watts W/ $^{\circ}\text{C}$
Thermal Resistance, Junction to Case	θ_{JC}	1.0		$^{\circ}\text{C}/\text{W}$
Thermal Resistance, Case to Ambient	θ_{CA}	32.7		$^{\circ}\text{C}/\text{W}$



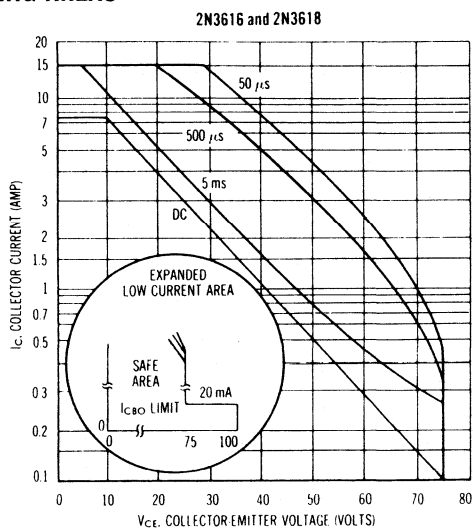
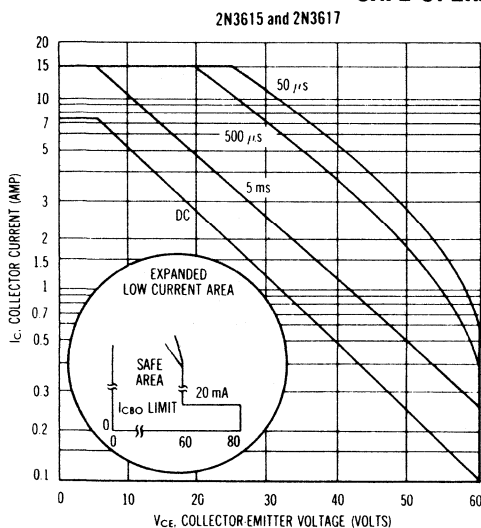
These transistors are also subject to safe area curves.
Both limits are applicable and must be observed.

2N3615 thru 2N3618 (continued)
ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Emitter Breakdown Voltage* ($I_C = 250 \text{ mAdc}$) 2N3615, 2N3617 2N3616, 2N3618	BV_{CES}^*	60 75	- -	Vdc
Collector-Emitter Breakdown Voltage* ($I_C = 300 \text{ mAdc}$) 2N3615, 2N3617 2N3616, 2N3618	BV_{CEO}^*	50 60	- -	Vdc
Floating Potential ($V_{CB} = V_{CB \text{ max}}$)	V_{EBF}	-	1.0	Vdc
Collector-Emitter Leakage Current ($V_{CE} = 1, 2 V_{CEO \text{ max}}$)	I_{CEO}	-	30	mAdc
Collector-Emitter Leakage Current ($V_{CE} = V_{CE \text{ max}}, V_{BE} = 1.0 \text{ Vdc}, T_C = +100^\circ\text{C}$)	I_{CEX}	-	10	mAdc
Collector-Base Cutoff Current ($V_{CB} = 2.0 \text{ Vdc}$) ($V_{CB} = 55 \text{ Vdc}$) ($V_{CB} = 65 \text{ Vdc}$) ($V_{CB} = V_{CB \text{ max}}$) 2N3615, 2N3617 2N3616, 2N3618	I_{CBO}	- - - -	0.060 1.0 1.0 5.0	mAdc
Emitter-Base Cutoff Current ($V_{EB} = V_{EB \text{ max}}$) ($V_{EB} = 12 \text{ Vdc}$)	I_{EBO}	-	500	μAdc
Collector-Emitter Saturation Voltage ($I_C = 3.0 \text{ Adc}, I_B = 300 \text{ mAdc}$) ($I_C = 7.0 \text{ Adc}, I_B = 700 \text{ mAdc}$)	$V_{CE(\text{sat})}$	- -	0.25 0.35	Vdc
Base Emitter Saturation Voltage ($I_C = 3.0 \text{ Adc}, I_B = 300 \text{ mAdc}$) ($I_C = 7.0 \text{ Adc}, I_B = 700 \text{ mAdc}$) 2N3615, 2N3616 2N3617, 2N3618 2N3615, 2N3616 2N3617, 2N3618	$V_{BE(\text{sat})}$	- - - -	0.7 0.6 1.1 0.9	Vdc
Transconductance ($I_C = 3.0 \text{ A}, V_{CE} = 2.0 \text{ V}$) 2N3615, 2N3616 2N3617, 2N3618	g_{FE}	3.0 3.5	- -	mhos
Small Signal Current Gain ($I_C = 0.5 \text{ A}, V_{CE} = 12 \text{ V}, f = 20 \text{ kHz}$) ($I_C = 0.5 \text{ A}, V_{CE} = 2.0 \text{ V}, f = 1.0 \text{ kHz}$) 2N3615, 2N3616 2N3617, 2N3618	h_{fe}	15 40 60	- 100 150	-
DC Current Gain ($I_C = 3.0 \text{ Adc}, V_{CE} = 2.0 \text{ Vdc}$) ($I_C = 7.0 \text{ Adc}, V_{CE} = 2.0 \text{ Vdc}$) 2N3615, 2N3616 2N3617, 2N3618 2N3615, 2N3616 2N3617, 2N3618	h_{FE}	30 45 20 30	60 90 - -	-
Current-Gain-Bandwidth Product ($I_C = 0.5 \text{ Adc}, V_{CE} = 2.0 \text{ Vdc}$)	f_T	Typ 600		kHz

*Sweep Test: 1/2 sine wave, 60 Hz

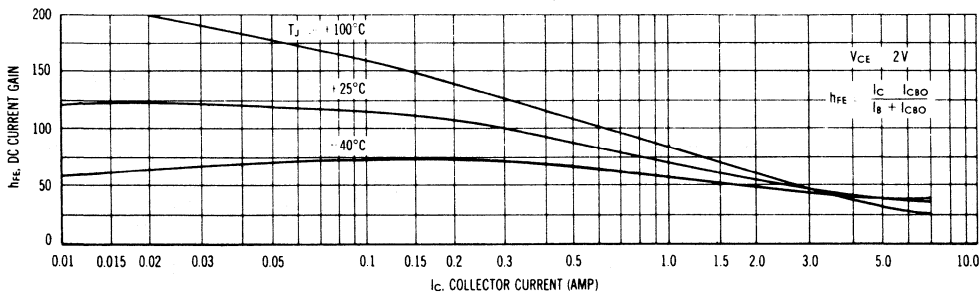
SAFE OPERATING AREAS



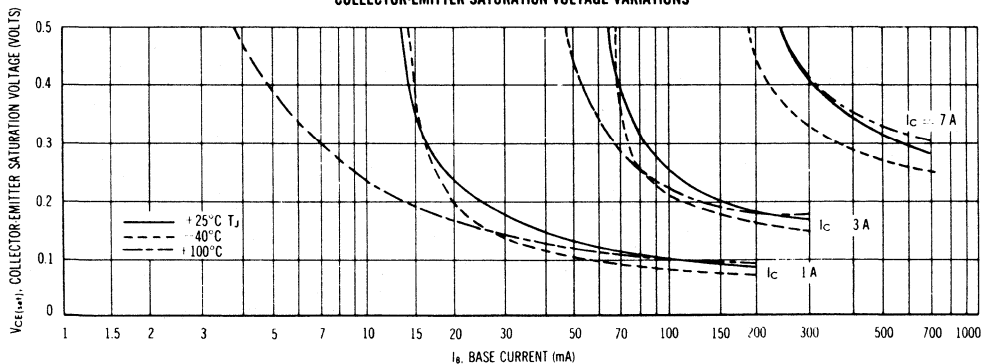
NOTE The Safe Operating Area Curves indicate I_C - V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Case temperature and duty cycle of the excursions make no significant change in these safe areas.) The load line may exceed the BV_{CES} voltage limit only if the collector

current has been reduced to 20 mA or less before or at the BV_{CES} limit; then and only then may the load line be extended to the absolute maximum voltage rating of BV_{CBO} . To insure operation below the maximum T_J , the power-temperature derating curve must be observed for both steady state and pulse power conditions.

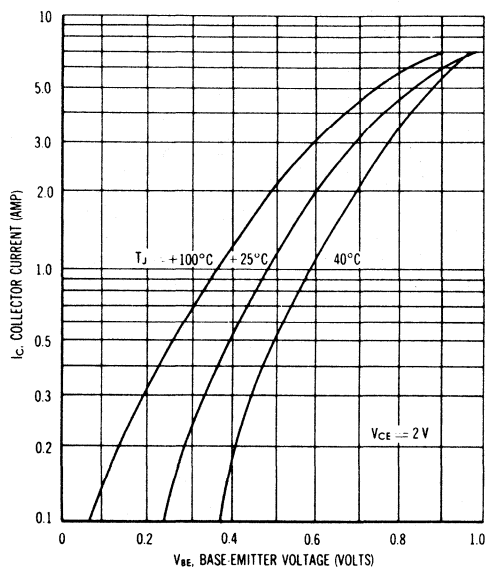
DC CURRENT GAIN versus COLLECTOR CURRENT



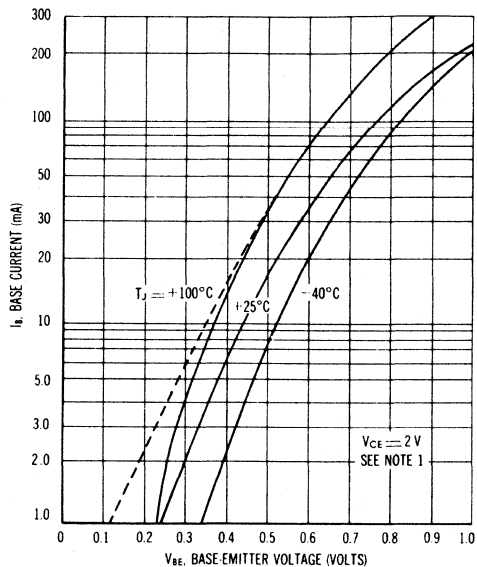
COLLECTOR-EMITTER SATURATION VOLTAGE VARIATIONS



COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE

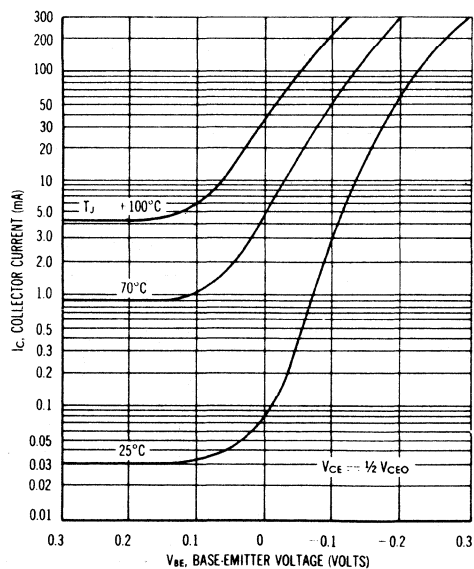


BASE CURRENT versus BASE-EMITTER VOLTAGE

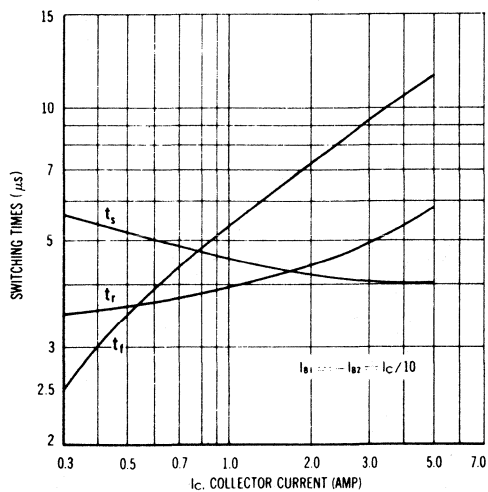


NOTE 1 — Dotted line indicates Metered Base Current plus the I_{CHW} of the transistor at 100°C .

COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE



TYPICAL SWITCHING TIMES



2N3632

For Specifications, See 2N3375 Data.

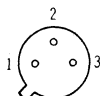
2N3634S thru 2N3637S (SILICON)

JAN, JTX AVAILABLE

JTXV AVAILABLE IN 2N3635S

PNP silicon annular transistors for high-voltage switching and low-power amplifier applications.

CASE 79
(TO-39)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

Collector connected to case

*MAXIMUM RATINGS

Rating	Symbol	2N3634 2N3635	2N3636 2N3637	Unit
Collector-Emitter Voltage	V_{CEO}	140	175	Vdc
Collector-Base Voltage	V_{CB}	140	175	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	1.0		Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 5.71		Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	5.0 28.6		Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

* Indicates JEDEC Registered Data

FIGURE 1 — JUNCTION CAPACITANCE VARIATIONS

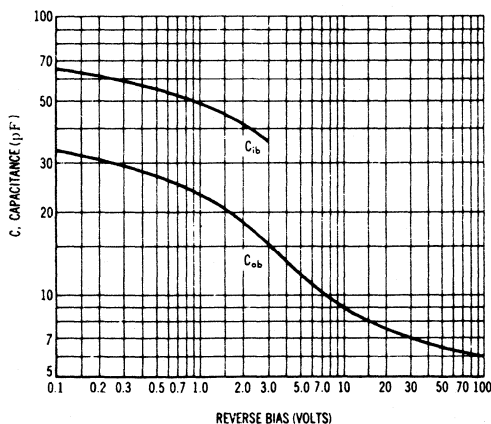
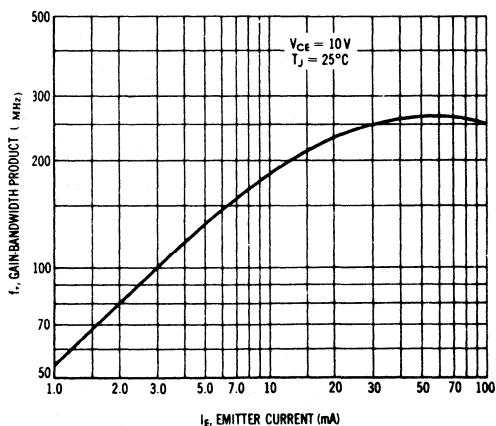


FIGURE 2 — GAIN-BANDWIDTH PRODUCT



2N3634S thru 2N3637S (continued)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (1) ($I_C = 10\text{ mAdc}$, $I_B = 0$)	2N3634, 2N3635 2N3636, 2N3637	-	BV_{CEO}	140 175	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\text{ }\mu\text{Adc}$, $I_E = 0$)	2N3634, 2N3635 2N3636, 2N3637	-	BV_{CBO}	140 175	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{Adc}$, $I_C = 0$)		-	BV_{EBO}	5.0	Vdc
Collector Cutoff Current ($V_{CB} = 100\text{ Vdc}$, $I_E = 0$)		-	I_{CBO}	-	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0\text{ Vdc}$, $I_C = 0$)		-	I_{EBO}	-	nAdc

ON CHARACTERISTICS

DC Current Gain (1) ($I_C = 0.1\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$)	2N3634, 2N3636 2N3635, 2N3637	3, 4, 5, 6	h_{FE}	40 80	-	-
($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$)	2N3634, 2N3636 2N3635, 2N3637			45 90	-	-
($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$)	2N3634, 2N3636 2N3635, 2N3637			50 100	-	-
($I_C = 50\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$)	2N3634, 2N3636 2N3635, 2N3637			50 100	150 300	-
($I_C = 150\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$)	2N3634, 2N3636 2N3635, 2N3637			25 50	-	-
Collector-Emitter Saturation Voltage (1) ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$) ($I_C = 50\text{ mAdc}$, $I_B = 5.0\text{ mAdc}$)		11, 12	$V_{CE(sat)}$	- -	0.3 0.5	Vdc
Base-Emitter Saturation Voltage (1) ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$) ($I_C = 50\text{ mAdc}$, $I_B = 5.0\text{ mAdc}$)		11, 12	$V_{BE(sat)}$	- 0.65	0.8 0.9	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product ($V_{CE} = 30\text{ Vdc}$, $I_C = 30\text{ mAdc}$, $f = 100\text{ MHz}$)	2N3634, 2N3636 2N3635, 2N3637	2	f_T	150 200	-	MHz
Output Capacitance ($V_{CB} = 20\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)		1	C_{ob}	-	10	pF
Input Capacitance ($V_{BE} = 1.0\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)		1	C_{ib}	-	75	pF
Input Impedance ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N3634, 2N3636 2N3635, 2N3637	7	h_{ie}	100 200	600 1200	ohms
Voltage Feedback Ratio ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)		10	h_{re}	-	3.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N3634, 2N3636 2N3635, 2N3637	9	h_{fe}	40 80	160 320	-
Output Admittance ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)		8	h_{oe}	-	200	μmhos
Noise Figure ($I_C = 0.5\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $R_S = 1.0\text{ k ohms}$, $f = 1.0\text{ kHz}$)		-	NF	-	3.0	dB

SWITCHING CHARACTERISTICS

Turn-On Time	$(V_{CC} = 100\text{ Vdc}$, $V_{BE} = 4.0\text{ Vdc}$, $I_C = 50\text{ mAdc}$, $I_{B1} = I_{B2} = 5.0\text{ mAdc}$)	13, 14	t_{on}	-	400	ns
Turn-Off Time		13, 15	t_{off}	-	600	ns

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$. Duty Cycle $\leq 2.0\%$.

*Indicates JEDEC Registered Data

FIGURE 3 — CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE

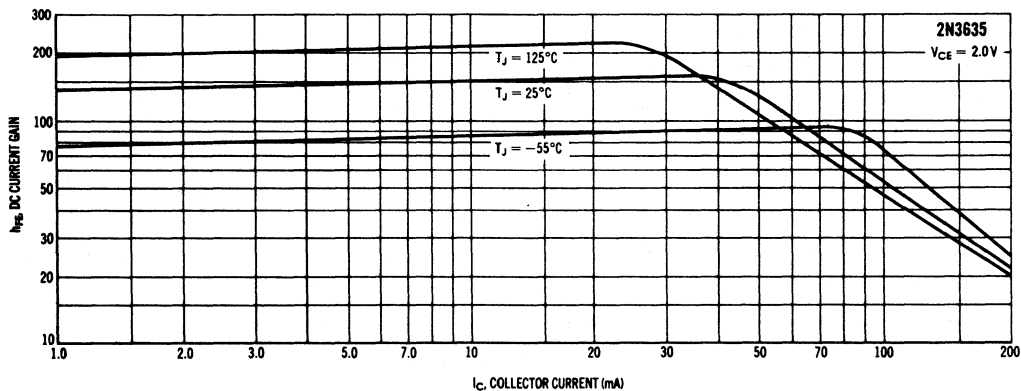
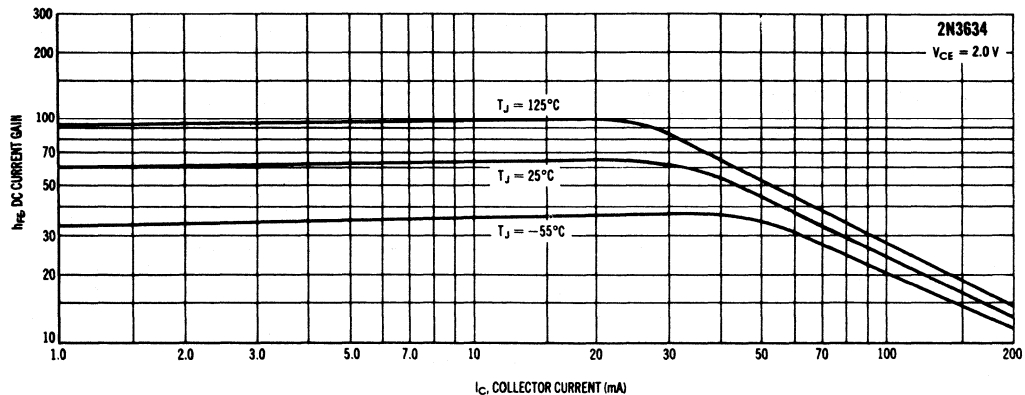


FIGURE 4 — CURRENT GAIN CHARACTERISTICS versus COLLECTOR EMITTER VOLTAGE

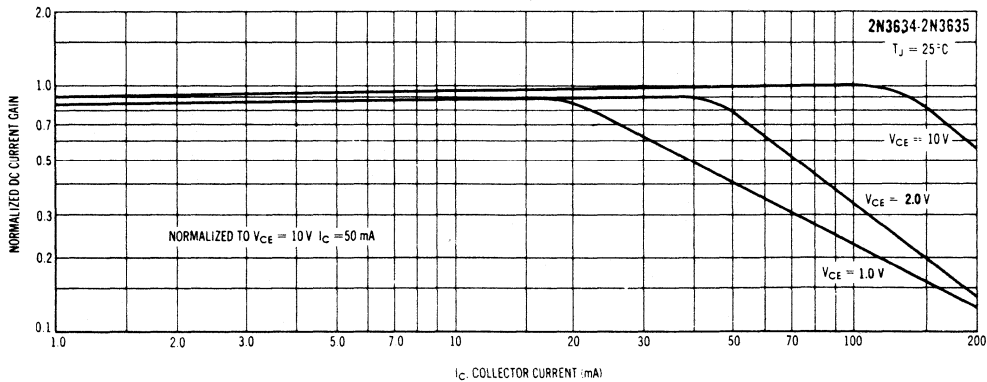


FIGURE 5 — CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE

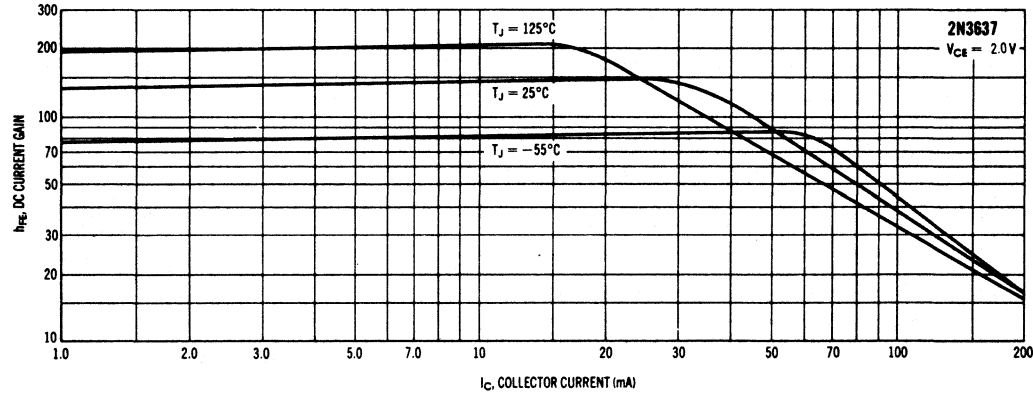
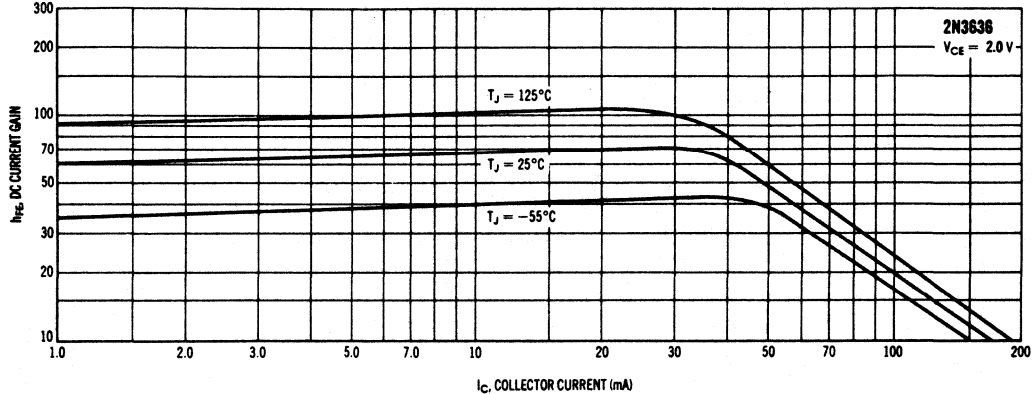


FIGURE 6 — CURRENT GAIN CHARACTERISTICS versus COLLECTOR EMITTER VOLTAGE

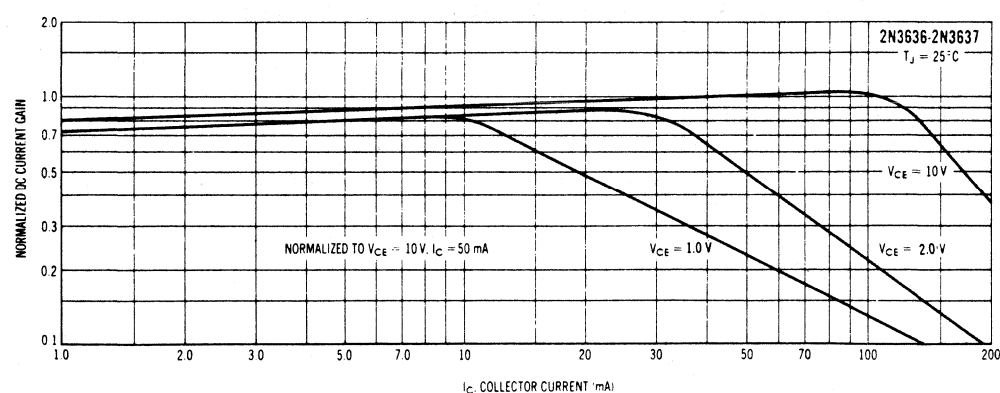


FIGURE 7 — INPUT IMPEDANCE

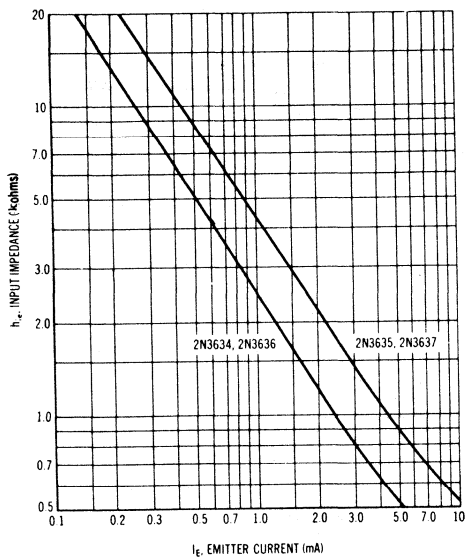


FIGURE 8 — OUTPUT IMPEDANCE

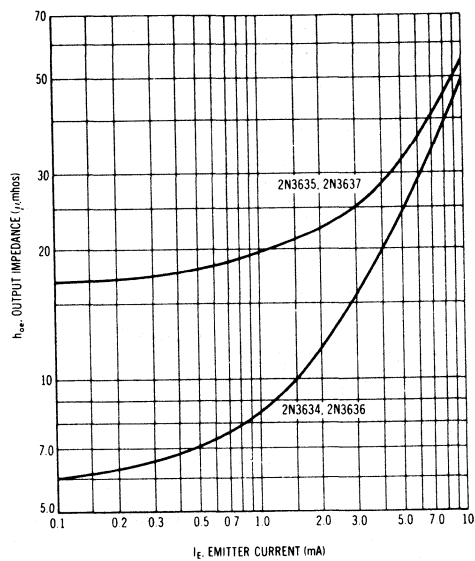


FIGURE 9 — CURRENT GAIN

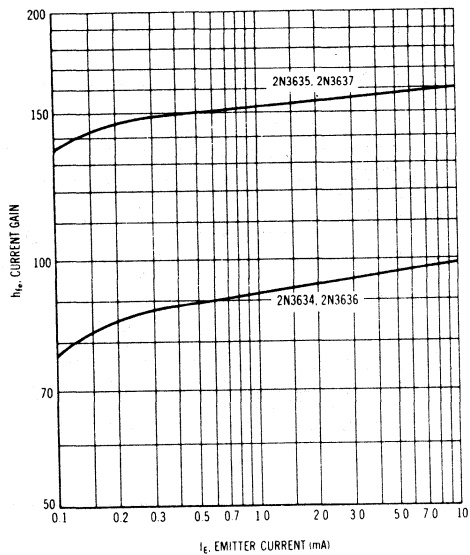


FIGURE 10 — VOLTAGE FEEDBACK RATIO

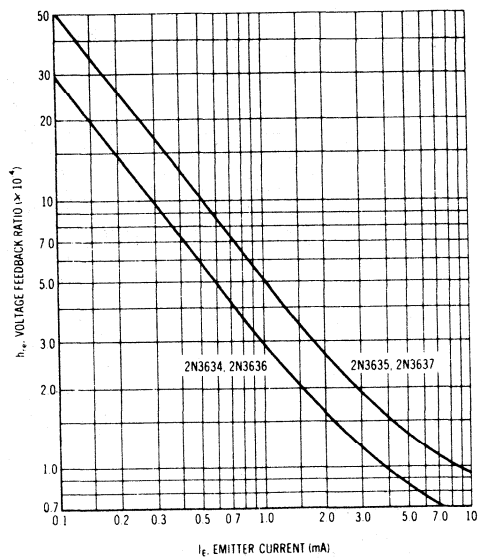


FIGURE 11 — SATURATION VOLTAGES

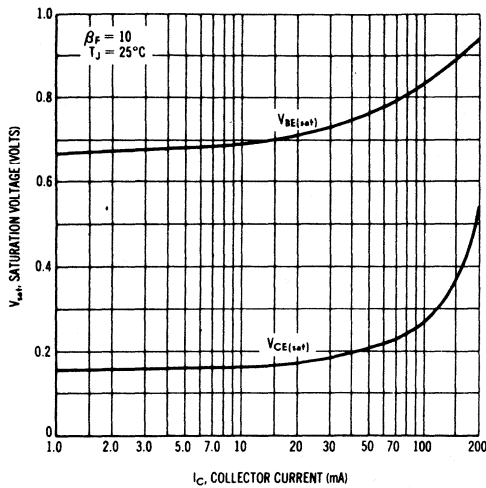


FIGURE 12 — TEMPERATURE COEFFICIENTS

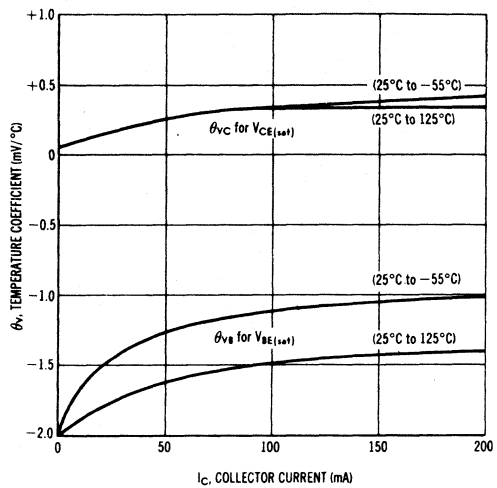
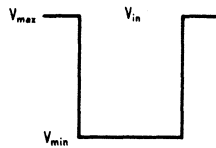


FIGURE 13 — SWITCHING TIME TEST CIRCUIT



P.W. $\approx 20 \mu s$
DUTY CYCLE $\leq 2\%$
RISE TIME $\leq 20 ns$

	V_{max}	V_{min}
TURN-ON	+4.0 V	-5.65 V
TURN-OFF	+4.1 V	-5.9 V

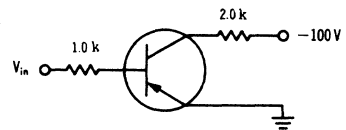


FIGURE 14 — TURN-ON TIME VARIATIONS WITH VOLTAGE

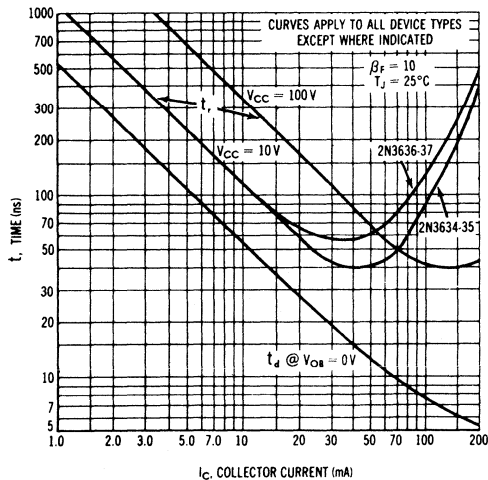
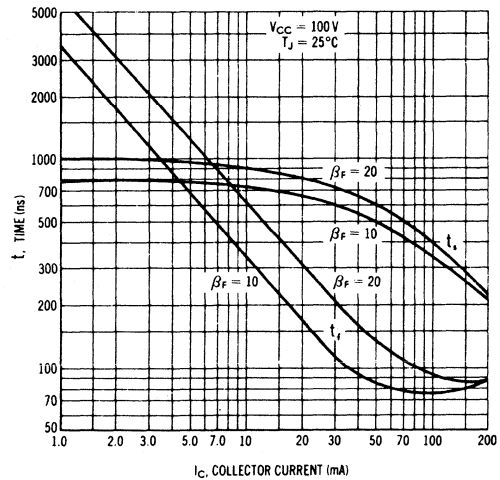


FIGURE 15 — TURN-OFF TIME VARIATIONS WITH CIRCUIT GAIN



2N3647 (SILICON)
2N3648

For Specifications, See 2N3510 Data.

NPN SILICON ANNULAR SWITCHING TRANSISTOR

... designed for use in high-speed low-current switching applications.

- Collector-Emitter Breakdown Voltage –
 $BV_{CEO} = 50 \text{ Vdc (Min) @ } I_C = 10 \text{ mAdc}$
- DC Current Gain – $100 \mu\text{Adc to } 500 \text{ mAdc}$
- Low Collector-Emitter Saturation Voltage –
 $V_{CE(sat)} = 0.3 \text{ Vdc (Typ) @ } I_C = 150 \text{ mAdc}$
- High Current-Gain-Bandwidth Product –
 $f_T = 350 \text{ MHz (Typ) @ } I_C = 50 \text{ mAdc}$

NPN SILICON SWITCHING TRANSISTOR



*MAXIMUM RATINGS

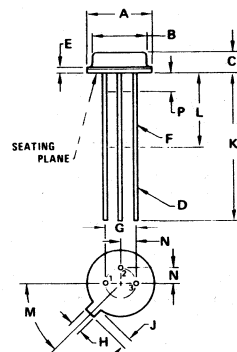
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	600	mAdc
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.0	mW mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	3.0 17.15	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA} (1)$	500	$^\circ\text{C/W}$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	58.3	$^\circ\text{C/W}$

*Indicates JEDEC Registered Data

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	1.65	2.16	0.065	0.085
D	0.406	0.533	0.016	0.021
E	—	1.02	—	0.040
F	0.305	0.483	0.012	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	—	1.27	—	0.050

All JEDEC dimensions and notes apply

CASE 26-03

TO-46

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 10\text{ mA}$, $I_B = 0$)	BV_{CEO}	50	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{A}$, $I_E = 0$)	BV_{CBO}	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{A}$, $I_C = 0$)	BV_{EBO}	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 50\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 50\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	— —	10 10	nA μA
Base Cutoff Current ($V_{CE} = 30\text{ Vdc}$, $V_{EB} = 0.5\text{ Vdc}$)	I_{BEV}	—	—	50	nA
Collector Cutoff Current ($V_{CE} = 30\text{ Vdc}$, $V_{EB} = 0.5\text{ Vdc}$)	I_{CEV}	—	—	50	nA

ON CHARACTERISTICS(1)

DC Current Gain ($I_C = 0.1\text{ mA}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 1.0\text{ mA}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 150\text{ mA}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 150\text{ mA}$, $V_{CE} = 0.6\text{ Vdc}$) ($I_C = 500\text{ mA}$, $V_{CE} = 10\text{ Vdc}$)	h_{FE}	55 75 75 75 20 40	75 90 90 150 50 50	— — — 225 — —	—
Collector-Emitter Saturation Voltage ($I_C = 150\text{ mA}$, $I_B = 15\text{ mA}$) ($I_C = 500\text{ mA}$, $I_B = 50\text{ mA}$)	$V_{CE(sat)}$	— —	0.3 0.8	0.4 1.6	Vdc
Base-Emitter Saturation Voltage ($I_C = 150\text{ mA}$, $I_B = 15\text{ mA}$) ($I_C = 500\text{ mA}$, $I_B = 50\text{ mA}$)	$V_{BE(sat)}$	— —	0.78 1.3	1.3 2.6	Vdc

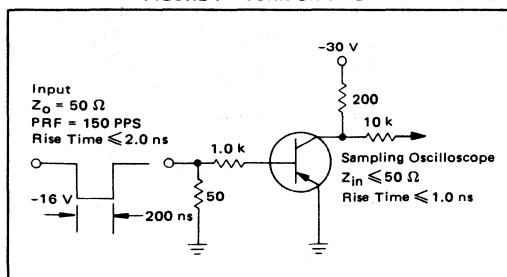
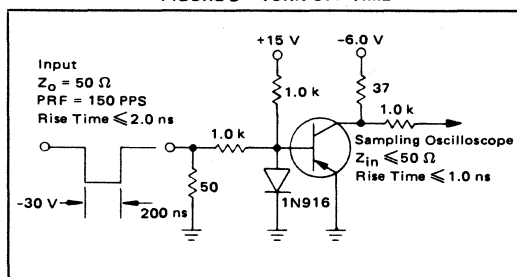
DYNAMIC CHARACTERISTICS

Current-Gain—Bandwidth Product (1) ($I_C = 50\text{ mA}$, $V_{CE} = 20\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	200	350	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)	C_{ob}	—	4.0	9.0	pF
Input Capacitance ($V_{EB} = 2.0\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)	C_{ib}	—	20	30	pF

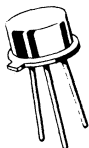
SWITCHING CHARACTERISTICS

Turn-On Time	$(V_{CC} = 30\text{ Vdc}$, $I_C = 150\text{ mA}$, $I_{B1} = 15\text{ mA}$) (Figure 1)	t_{on}	—	35	45	ns
Delay Time		t_d	—	5.0	10	ns
Rise Time		t_r	—	30	40	ns
Turn-Off Time	$(V_{CC} = 6.0\text{ Vdc}$, $I_C = 150\text{ mA}$, $I_{B1} = I_{B2} = 15\text{ mA}$) (Figure 2)	t_{off}	—	80	100	ns
Storage Time		t_s	—	60	80	ns
Fall Time		t_f	—	20	30	ns

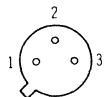
*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.**FIGURE 1 — TURN-ON TIME****FIGURE 2 — TURN-OFF TIME**

2N3712S(SILICON)



NPN silicon annular transistor designed for high-voltage DC to VHF amplifier applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 79
(TO-39)

Collector connected to case

* MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	150	Vdc
Collector-Base Voltage	V_{CB}	150	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 5.71	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	5.0 28.6	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

*Indicates JEDEC Registered Data

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
----------------	--------	-----	-----	------

OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 30\text{ mAdc}$, $I_B = 0$)	BV_{CEO}	150	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	150	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current ($V_{CB} = 75\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 75\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	-	0.1 50	μAdc
Emitter Cutoff Current ($V_{BE} = 4.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	-	0.1	μAdc

ON CHARACTERISTICS

DC Current Gain ⁽¹⁾ ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 30\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$)	h_{FE}	25 30	- 150	-
Collector-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 50\text{ mAdc}$, $I_B = 5.0\text{ mAdc}$)	$V_{CE(sat)}$	-	2.0	Vdc
Base-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 50\text{ mAdc}$, $I_B = 5.0\text{ mAdc}$)	$V_{BE(sat)}$	-	0.9	Vdc

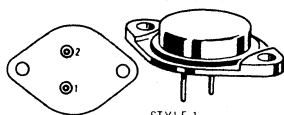
DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 30\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 20\text{ MHz}$)	f_T	40	240	MHz
Output Capacitance ($V_{CB} = 20\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{ob}	1.0	9.0	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 1.0\text{ MHz}$)	C_{ib}	-	80	pF
Small-Signal Current Gain ($I_C = 30\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	25	-	-
Collector-Base Time Constant ($I_E = 30\text{ mAdc}$, $V_{CB} = 10\text{ Vdc}$, $f = 31.9\text{ MHz}$)	$r_b'C_c$	-	100	ps

⁽¹⁾ Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.

* Indicates JEDEC Registered Data

2N3713 thru 2N3716 (SILICON)



STYLE 1
PIN 1 BASE
2 EMITTER
CASE COLLECTOR

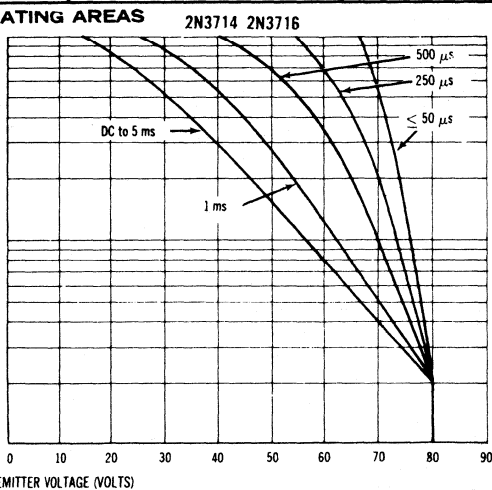
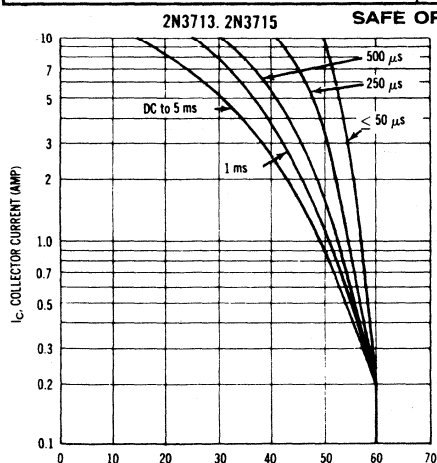
CASE 11

Collector connected to case

NPN silicon power transistors for medium-speed switching and amplifier applications. Complement to PNP types 2N3789 thru 2N3792.

MAXIMUM RATINGS

Rating	Symbol	2N3713 2N3715	2N3714 2N3716	Unit
Collector-Base Voltage	V_{CB}	80	100	Volts
Collector-Emitter Voltage	V_{CEO}	60	80	Volts
Emitter-Base Voltage	V_{EB}	7.0	7.0	Volts
Collector Current	I_C	10	10	Amp
Base Current	I_B	4.0	4.0	Amp
Power Dissipation	P_D	150	150	Watts
Thermal Resistance	θ_{JC}	1.17	1.17	$^{\circ}\text{C}/\text{W}$
Operating Junction and Storage Temperature Range	T_J and T_{stg}	-65 to +200		$^{\circ}\text{C}$



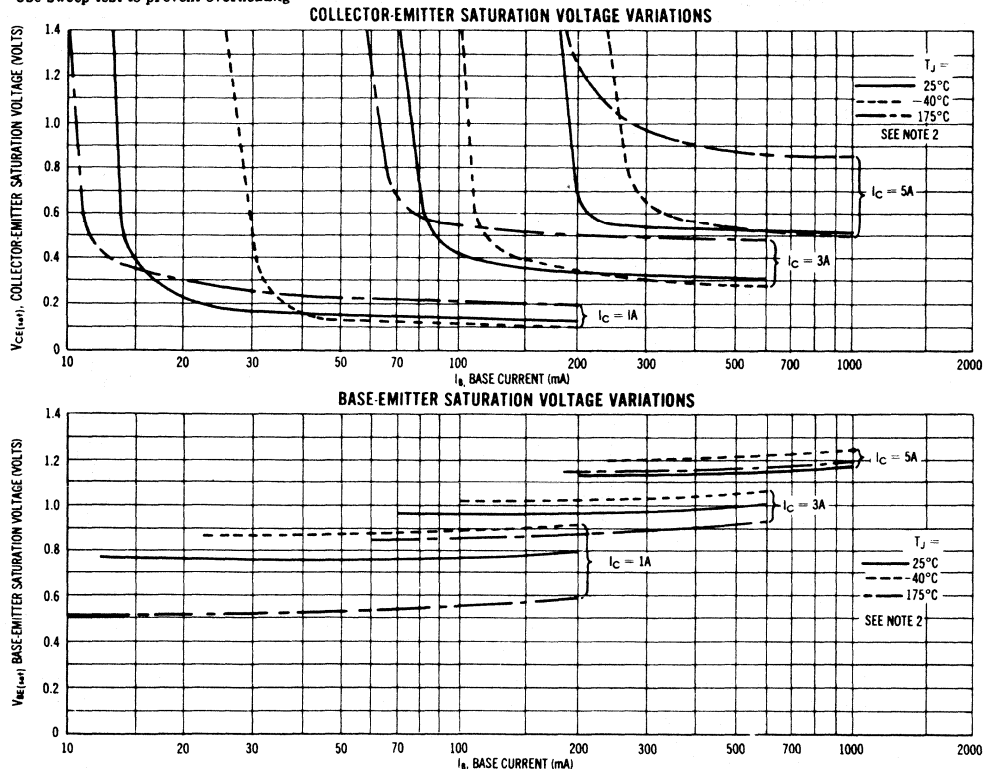
The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.)

To insure operation below the maximum T_J , the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N3713 thru 2N3716 (continued)
ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

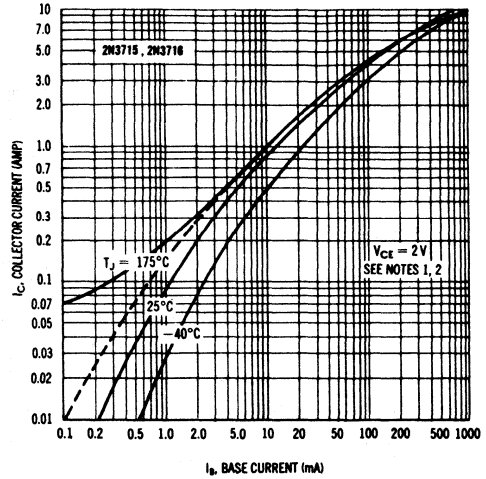
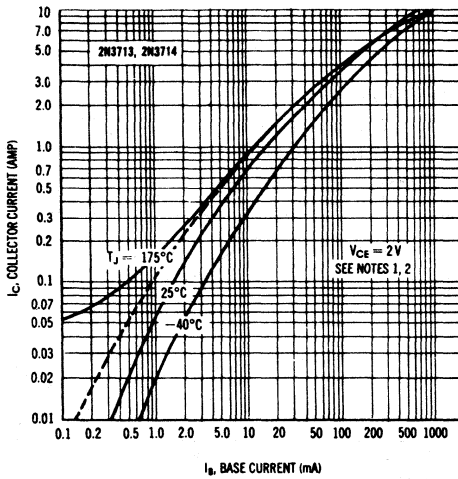
Characteristic	Types	Symbol	Min	Max	Unit
Emitter-Base Cutoff Current ($V_{EB} = 7 \text{ Vdc}$)		I_{EBO}	—	5.0	mAdc
Collector-Emitter Cutoff Current ($V_{CE} = 80 \text{ Vdc}$, $V_{BE} = -1.5 \text{ Vdc}$) ($V_{CE} = 100 \text{ Vdc}$, $V_{BE} = -1.5 \text{ Vdc}$) ($V_{CE} = 60 \text{ Vdc}$, $V_{BE} = -1.5 \text{ Vdc}$, $T_C = 150^\circ\text{C}$) ($V_{CE} = 80 \text{ Vdc}$, $V_{BE} = -1.5 \text{ Vdc}$, $T_C = 150^\circ\text{C}$)	2N3713, 2N3715 2N3714, 2N3716 2N3713, 2N3715 2N3714, 2N3716	I_{CEX}	— — — —	1.0 1.0 10 10	mAdc
Collector-Emitter Sustaining Voltage* ($I_C = 200 \text{ mAdc}$, $I_B = 0$)	2N3713, 2N3715 2N3714, 2N3716	$V_{CEO(sus)}^*$	60 80	— —	Vdc
DC Current Gain* ($I_C = 1 \text{ Adc}$, $V_{CE} = 2 \text{ Vdc}$) ($I_C = 3 \text{ Adc}$, $V_{CE} = 2 \text{ Vdc}$)	2N3713, 2N3714 2N3715, 2N3716 2N3713, 2N3714 2N3715, 2N3716	h_{FE}^*	25 50 15 30	90 150 — —	—
Collector-Emitter Saturation Voltage* ($I_C = 5 \text{ Adc}$, $I_B = 0.5 \text{ Adc}$)	2N3713, 2N3714 2N3715, 2N3716	$V_{CE(sat)}^*$	— —	1.0 0.8	Vdc
Base-Emitter Saturation Voltage* ($I_C = 5 \text{ Adc}$, $I_B = 0.5 \text{ Adc}$)	2N3713, 2N3714 2N3715, 2N3716	$V_{BE(sat)}^*$	— —	2.0 1.5	Vdc
Base-Emitter Voltage* ($I_C = 3 \text{ Adc}$, $V_{CE} = 2 \text{ Vdc}$)		V_{BE}^*	—	1.5	Vdc
Small Signal Current Gain ($V_{CE} = 10 \text{ Vdc}$, $I_C = 0.5 \text{ Adc}$, $f = 1 \text{ MHz}$)		h_{fe}	4.0	—	—
Switching Times ($I_C = 5 \text{ A}$, $I_{B1} = I_{B2} = 0.5 \text{ A}$) Rise Time Storage Time Fall Time		t_r t_s t_f	Typ		μs
				0.45 0.3 0.4	

*Use sweep test to prevent overheating

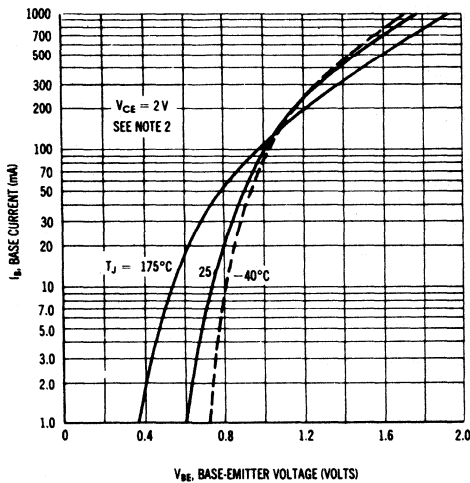


2N3713 thru 2N3716 (continued)

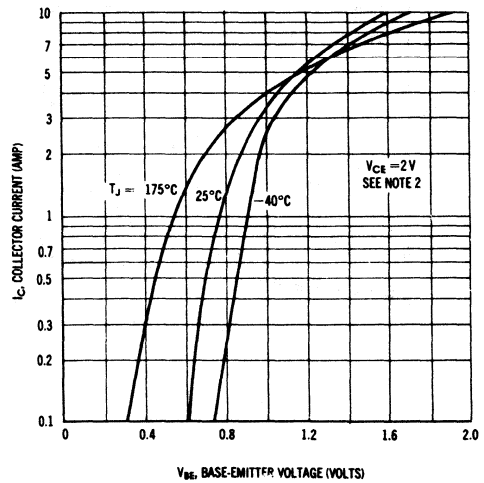
COLLECTOR CURRENT versus BASE CURRENT



BASE CURRENT-VOLTAGE VARIATIONS



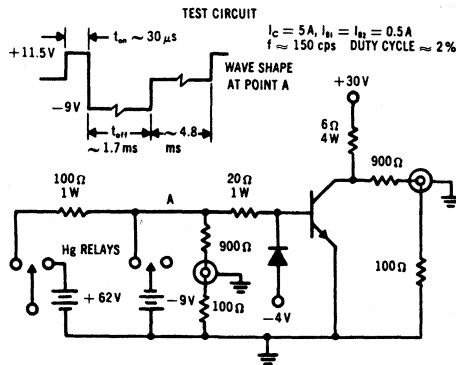
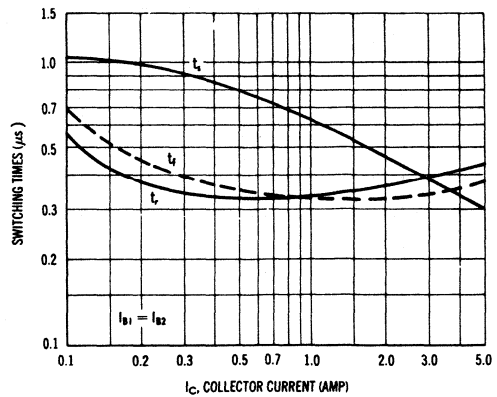
COLLECTOR CURRENT-VOLTAGE VARIATIONS



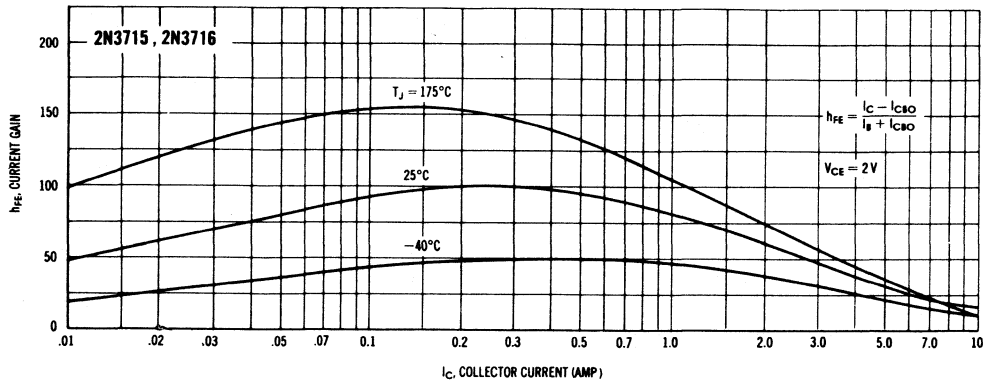
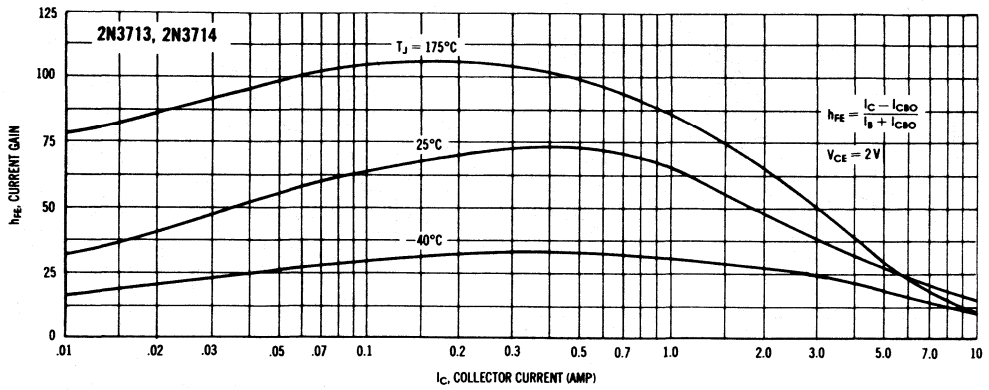
NOTE 1. Dotted line indicates metered base current plus the I_{CBO} of the transistor at 175°C .

NOTE 2. Pulse test: pulse width $\approx 200 \mu\text{s}$, duty cycle $\approx 1.5\%$

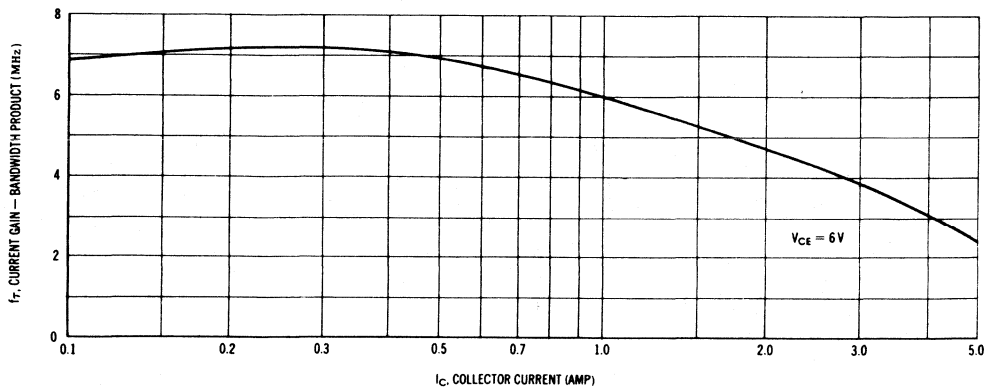
TYPICAL SWITCHING TIMES



CURRENT GAIN VARIATIONS



CURRENT-GAIN — BANDWIDTH PRODUCT versus COLLECTOR CURRENT



2N3719, 2N3720 (SILICON)

2N3867, 2N3868

2N6303

SILICON PNP POWER TRANSISTORS

... designed for high-speed, medium-current switching and high-frequency amplifier applications.

- Collector-Emitter Sustaining Voltage –
 $V_{CE(sus)} = 40 \text{ Vdc (Min)} - 2N3719, 2N3867$
 $= 60 \text{ Vdc (Min)} - 2N3720, 2N3868$
 $= 80 \text{ Vdc (Min)} - 2N6303$
- DC Current Gain –
 $h_{FE} = 25-180 @ I_C = 1.0 \text{ Adc} - 2N3719, 2N3720$
 $= 40-200 @ I_C = 1.5 \text{ Adc} - 2N3867$
 $= 30-150 @ I_C = 1.5 \text{ Adc} - 2N3868, 2N6303$
- Low Collector-Emitter Saturation Voltage –
 $V_{CE(sat)} = 0.75 \text{ Vdc} @ I_C = 1.0 \text{ Adc} - 2N3719, 2N3720$
 $= 0.75 \text{ Vdc} @ I_C = 1.5 \text{ Adc} - 2N3867, 2N3868, 2N6303$
- High Current-Gain – Bandwidth Product –
 $f_T = 90 \text{ MHz (Typ)}$
- 2N3867 JAN and 2N3868 JAN also Available

*MAXIMUM RATINGS

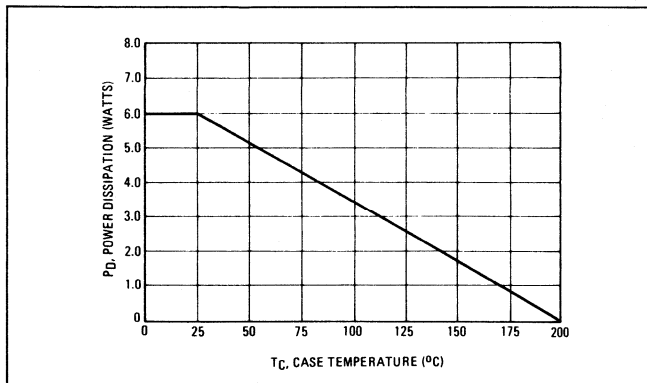
Rating	Symbol	2N3719 2N3867	2N3720 2N3868	2N6303	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	4.0			Vdc
Collector Current – Continuous	I_C	3.0			Adc
Peak		10			
Base Current	I_B	0.5			Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$	P_D	6.0			Watts
Derate above 25°C		34.3			mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_A = 25^\circ\text{C}$	P_D	1.0			Watt
Derate above 25°C		5.71			mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	65 to +200			$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	29	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	θ_{JA}	175	$^\circ\text{C/W}$

*Indicates JEDEC Registered Data

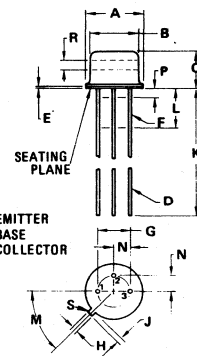
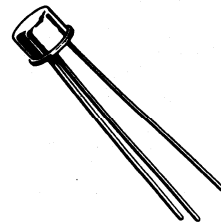
FIGURE 1 – POWER DERATING



3 AMPERE

POWER TRANSISTORS PNP SILICON

40,60,80 VOLTS
6 WATTS



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	5.08	BSC	0.200	BSC
H	0.711	0.864	0.028	0.034
J	0.734	1.14	0.029	0.045
K	38.10	—	1.500	—
L	6.35	—	0.250	—
M	45°	BSC	45°	BSC
N	2.54	BSC	0.100	BSC
P	—	1.27	—	0.050
R	2.54	—	0.100	—
S	—	0.179	—	0.007

All JEDEC dimensions and notes apply.

CASE 31-03
TO-5

***ELECTRICAL CHARACTERISTICS** ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) ($I_C = 20\text{ mAdc}$, $I_B = 0$)	$V_{CE(sus)}$	40 60 80	— — —	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	40 60 80	— — —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	4.0	—	Vdc
Collector Cutoff Current ($V_{CE} = \text{Rated } V_{CB}$, $V_{BE(off)} = 2.0\text{ Vdc}$)	I_{CEX}	—	1.0	μAdc
Collector Cutoff Current ($V_{CB} = \text{Rated } V_{CB}$, $I_E = 0$, $T_C = 150^\circ\text{C}$)	I_{CBO}	—	150	μAdc
ON CHARACTERISTICS (1)				
DC Current Gain ($I_C = 500\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$)	h_{FE}	50 35	— —	—
($I_C = 1.5\text{ Adc}$, $V_{CE} = 2.0\text{ Vdc}$)		40 30	200 150	
($I_C = 2.5\text{ Adc}$, $V_{CE} = 3.0\text{ Vdc}$)		25 20	— —	
($I_C = 3.0\text{ Adc}$, $V_{CE} = 5.0\text{ Vdc}$)		20	—	
Collector-Emitter Saturation Voltage ($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$) ($I_C = 1.5\text{ Adc}$, $I_B = 150\text{ mAdc}$) ($I_C = 2.5\text{ Adc}$, $I_B = 250\text{ mAdc}$)	$V_{CE(sat)}$	— — —	0.5 0.75 1.3	Vdc
Base-Emitter Saturation Voltage ($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$) ($I_C = 1.5\text{ Adc}$, $I_B = 150\text{ mAdc}$) ($I_C = 2.5\text{ Adc}$, $I_B = 250\text{ mAdc}$)	$V_{BE(sat)}$	— 0.9 —	1.0 1.4 2.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain – Bandwidth Product (2) ($I_C = 100\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$, $f_{test} = 20\text{ MHz}$)	f_T	60	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 0.1\text{ MHz}$)	C_{ob}	—	120	pF
Input Capacitance ($V_{EB} = 3.0\text{ Vdc}$, $I_C = 0$, $f = 0.1\text{ MHz}$)	C_{ib}	—	1000	pF
SWITCHING CHARACTERISTICS				
Delay Time ($V_{CC} = 30\text{ Vdc}$, $V_{BE(off)} = 0$, $I_C = 1.5\text{ Adc}$, $I_{B1} = 150\text{ mAdc}$)	t_d	—	35	ns
Rise Time	t_r	—	65	ns
Storage Time ($V_{CC} = 30\text{ Vdc}$, $I_C = 1.5\text{ Adc}$, $I_{B1} = I_{B2} = 150\text{ mAdc}$)	t_s	—	325	ns
Fall Time	t_f	—	75	ns

*Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.(2) $f_T = |h_{fe}| \cdot f_{test}$.

***ELECTRICAL CHARACTERISTICS** ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) ($I_C = 20\text{ mA}$, $I_B = 0$)	$V_{CE(sus)}$	40 60	— —	Vdc
Collector Cutoff Current ($V_{CE} = 40\text{ Vdc}$, $V_{BE(off)} = 2.0\text{ Vdc}$)	I_{CEX}	—	10	μAdc
($V_{CE} = 60\text{ Vdc}$, $V_{BE(off)} = 2.0\text{ Vdc}$)		—	10	
($V_{CE} = 40\text{ Vdc}$, $V_{BE(off)} = 2.0\text{ Vdc}$, $T_C = 150^\circ\text{C}$)		—	1.0	mA
($V_{CE} = 60\text{ Vdc}$, $V_{BE(off)} = 2.0\text{ Vdc}$, $T_C = 150^\circ\text{C}$)		—	1.0	
Collector Cutoff Current ($V_{CB} = 40\text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	10	μAdc
($V_{CB} = 60\text{ Vdc}$, $I_E = 0$)		—	10	
Emitter Cutoff Current ($V_{BE} = 4.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	1.0	mA
ON CHARACTERISTICS (1)				
DC Current Gain ($I_C = 500\text{ mA}$, $V_{CE} = 1.5\text{ Vdc}$)	h_{FE}	20 25 15	— 180 —	—
($I_C = 1.0\text{ A}$, $V_{CE} = 1.5\text{ Vdc}$)				
($I_C = 1.0\text{ A}$, $V_{CE} = 1.5\text{ Vdc}$, $T_C = -40^\circ\text{C}$)				
Collector-Emitter Saturation Voltage ($I_C = 1.0\text{ A}$, $I_B = 100\text{ mA}$, $T_C = -40^\circ\text{C}$ to $+100^\circ\text{C}$)	$V_{CE(sat)}$	— —	0.75 1.5	Vdc
($I_C = 3.0\text{ A}$, $I_B = 300\text{ mA}$, $T_C = -40^\circ\text{C}$ to $+100^\circ\text{C}$)				
Base-Emitter Saturation Voltage ($I_C = 1.0\text{ A}$, $I_B = 100\text{ mA}$, $T_C = -40^\circ\text{C}$ to $+100^\circ\text{C}$)	$V_{BE(sat)}$	— —	1.5 2.3	Vdc
($I_C = 3.0\text{ A}$, $I_B = 300\text{ mA}$, $T_C = -40^\circ\text{C}$ to $+100^\circ\text{C}$)				
DYNAMIC CHARACTERISTICS				
Current-Gain – Bandwidth Product (2) ($I_C = 500\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f_{test} = 30\text{ MHz}$)	f_T	60	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 0.1\text{ MHz}$)	C_{ob}	—	120	pF
Input Capacitance ($V_{EB} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 0.1\text{ MHz}$)	C_{ib}	—	1000	pF
SWITCHING CHARACTERISTICS				
Turn-On Time ($V_{CC} = 12\text{ Vdc}$, $V_{BE(off)} = 0$, $I_C = 1.0\text{ A}$, $I_{B1} = 0.1\text{ A}$)	t_{on}	—	100	ns
Turn-Off Time ($V_{CC} = 12\text{ Vdc}$, $I_C = 1.0\text{ A}$, $I_{B1} = I_{B2} = 100\text{ mA}$)	t_{off}	—	400	ns

*Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle = 2.0%.(2) $f_T = |h_{fe}| \bullet f_{test}$

FIGURE 2 – SWITCHING TIMES TEST CIRCUIT

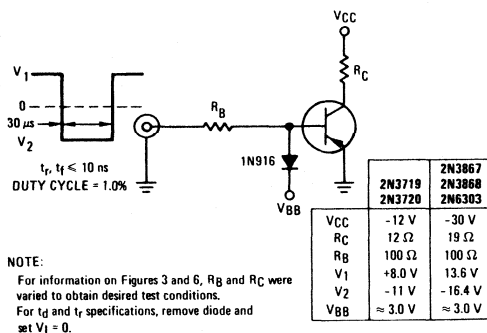


FIGURE 3 – TURN-ON TIME

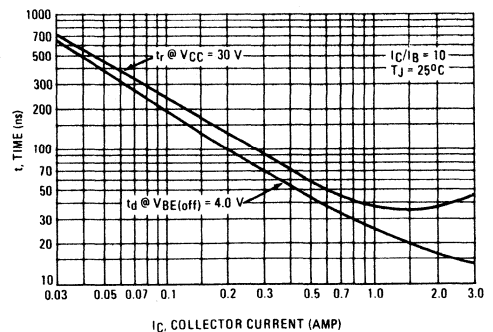


FIGURE 4 – THERMAL RESISTANCE

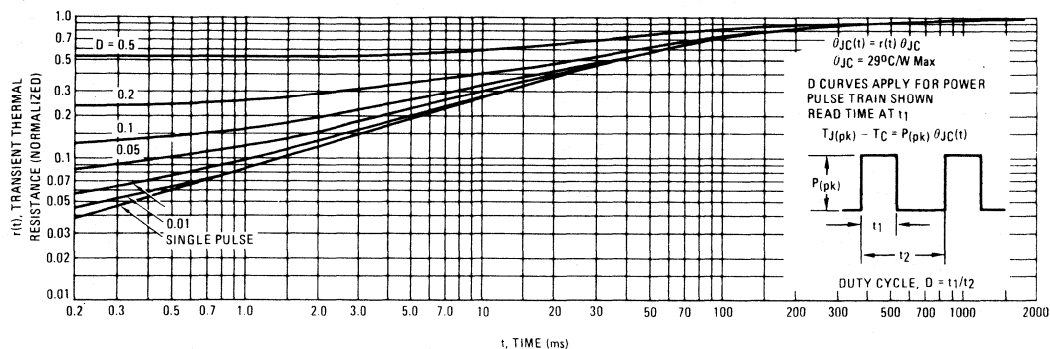
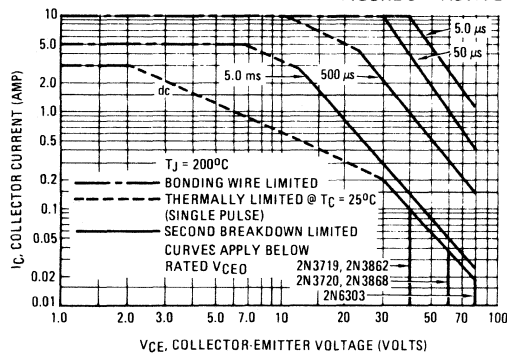


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_J(pk) = 200^\circ\text{C}$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_J(pk) \leq 200^\circ\text{C}$. $T_J(pk)$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

FIGURE 6 – TURN-OFF TIME

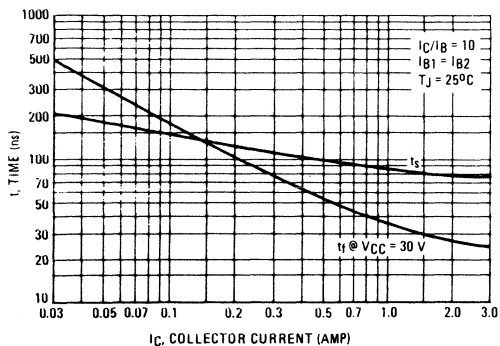


FIGURE 7 – CAPACITANCE

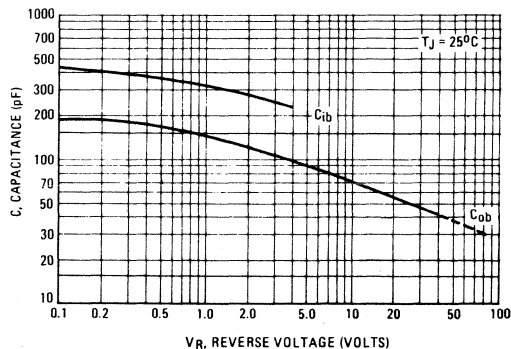


FIGURE 8 – DC CURRENT GAIN

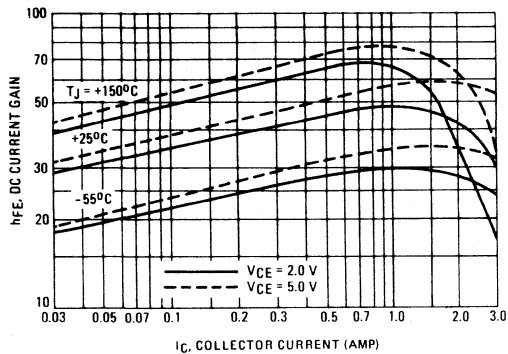


FIGURE 9 – COLLECTOR SATURATION REGION

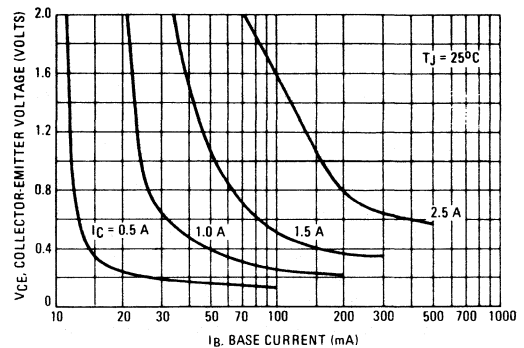


FIGURE 10 – "ON" VOLTAGES

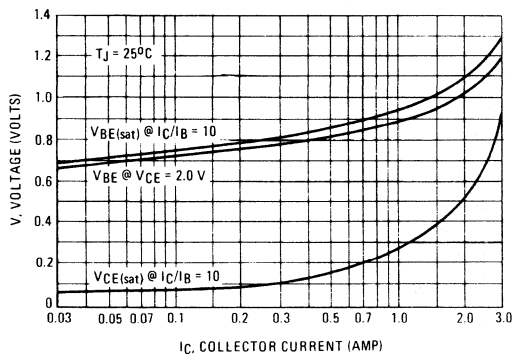


FIGURE 11 – TEMPERATURE COEFFICIENTS

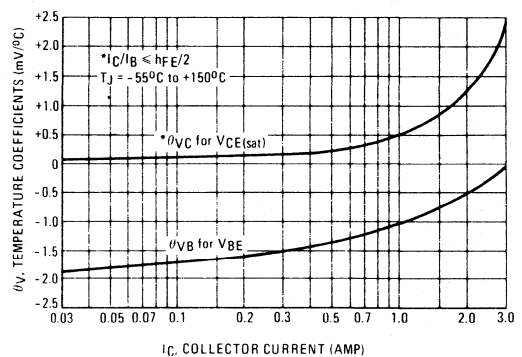


FIGURE 12 – COLLECTOR CUT-OFF REGION

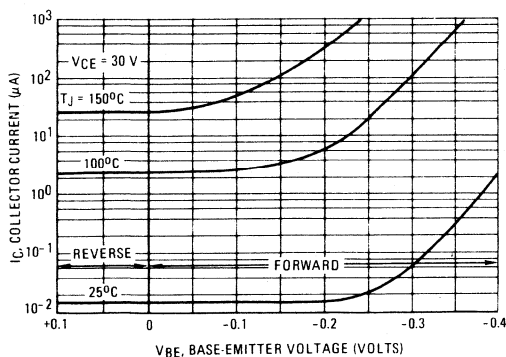
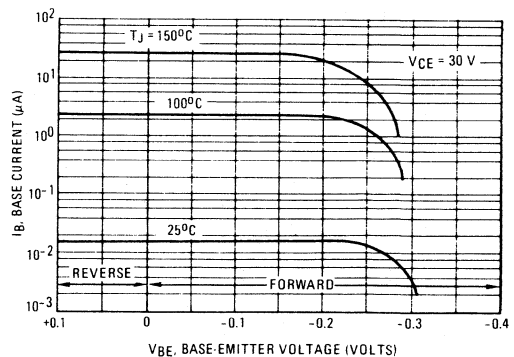


FIGURE 13 – BASE CUT-OFF REGION



2N3724 (SILICON)

2N3725

NPN SILICON ANNULAR MEMORY DRIVER

... designed for medium-current, high-speed switching applications.
Ideally suited for ferrite core memory driver circuits.

- High Collector-Emitter Breakdown Voltage –
BV_{CEO} = 50 Vdc (Min) @ I_C = 10 mAdc – 2N3725
= 30 Vdc (Min) @ I_C = 10 mAdc – 2N3724
- Guaranteed Fast Switching Times @ I_C = 500 mAdc
t_{on} = 20 ns (Typ) t_{off} = 50 ns (Typ)
= 35 ns (Max) = 60 ns (Max)
- Guaranteed High DC Current Gain –
h_{FE} = 35 (Min) @ I_C = 500 mAdc
- Design Curves and Applications Information Provided

NPN SILICON MEMORY DRIVER TRANSISTOR

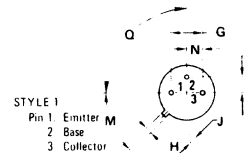
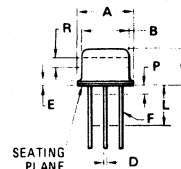
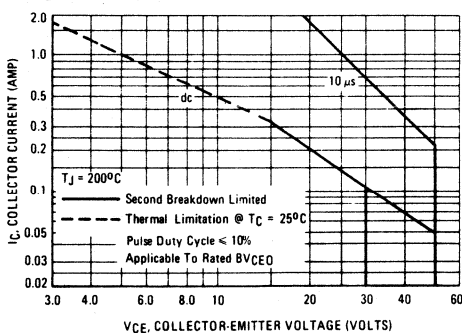


*MAXIMUM RATINGS

Rating	Symbol	2N3724	2N3725	Unit
Collector-Emitter Voltage	V _{CEO}	30	50	Vdc
Collector-Base Voltage	V _{CB}	50	80	Vdc
Emitter-Base Voltage	V _{EB}	6.0		Vdc
Collector Current – Continuous	I _C	2.0		Adc
Total Device Dissipation @ T _A = 25°C Derate above 25°C	P _D	1.0 5.71		Watts mW/°C
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200		°C

*Indicates JEDEC Registered Data

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	1.27		0.050	
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 10\text{ mAdc}$, $I_B = 0$)	BV_{CEO}	50 30	— —	— —	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $V_{BE} = 0$)	BV_{CES}	80 50	— —	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	80 50	— —	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	6.0	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 80\text{ Vdc}$, $V_{EB} = 0$) ($V_{CE} = 50\text{ Vdc}$, $V_{EB} = 0$)	I_{CES}	— —	0.15 0.15	10 10	μAdc
Collector Cutoff Current ($V_{CB} = 60\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 40\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 60\text{ Vdc}$, $I_E = 0$, $T_A = 100^\circ\text{C}$) ($V_{CB} = 40\text{ Vdc}$, $I_E = 0$, $T_A = 100^\circ\text{C}$)	I_{CBO}	— — — —	0.12 0.12 — —	1.7 1.7 120 120	μAdc
ON CHARACTERISTICS (1)					
DC Current Gain ($I_C = 10\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 100\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 100\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$, $T_A = -55^\circ\text{C}$) ($I_C = 300\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 500\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 500\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$, $T_A = -55^\circ\text{C}$) ($I_C = 800\text{ mAdc}$, $V_{CE} = 2.0\text{ Vdc}$) ($I_C = 1.0\text{ Adc}$, $V_{CE} = 5.0\text{ Vdc}$)	h_{FE}	30 60 30 40 35 20 25 30	— — — — — — — —	— 150 — — — — — —	—
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$) ($I_C = 100\text{ mAdc}$, $I_B = 10\text{ mAdc}$) ($I_C = 300\text{ mAdc}$, $I_B = 30\text{ mAdc}$) ($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$) ($I_C = 800\text{ mAdc}$, $I_B = 80\text{ mAdc}$) ($I_C = 1.0\text{ Adc}$, $I_B = 100\text{ mAdc}$)	$V_{CE(sat)}$	— — — — — —	0.17 0.17 0.19 0.19 0.25 0.25 0.30 0.30 0.43 0.43 0.55 0.55	0.25 0.25 0.26 0.20 0.40 0.32 0.52 0.42 0.80 0.65 0.95 0.75	Vdc
Base-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$) ($I_C = 100\text{ mAdc}$, $I_B = 10\text{ mAdc}$) ($I_C = 300\text{ mAdc}$, $I_B = 30\text{ mAdc}$) ($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$) ($I_C = 800\text{ mAdc}$, $I_B = 80\text{ mAdc}$) ($I_C = 1.0\text{ Adc}$, $I_B = 100\text{ mAdc}$)	$V_{BE(sat)}$	— — — 0.8 — —	— — — — — —	0.76 0.86 1.1 1.1 1.5 1.7	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current Gain – Bandwidth Product (2) ($I_C = 50\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	300	—	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{ob}	—	—	10 12	pF
Input Capacitance ($V_{EB} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 1.0\text{ MHz}$)	C_{ib}	—	—	55	pF

*Indicates JEDEC Registered Data

(1) Pulse test: Pulse Width = 300 μs , Duty Cycle = 1.0%.(2) $f_T = |h_{fe}| \cdot f_{test}$

Characteristic	Symbol	Min	Typ	Max	Unit
SWITCHING CHARACTERISTICS					
Delay Time	t_d	—	5.0	10	ns
Rise Time	t_r	—	15	30	ns
Turn-On Time	t_{on}	—	20	35	ns
Storage Time	t_s	—	35	50	ns
Fall Time	t_f	—	20	25	ns
Turn-Off Time	t_{off}	—	50	60	ns

*Indicates JEDEC Registered Data.

TYPICAL DC CHARACTERISTICS

FIGURE 2 – DC CURRENT GAIN

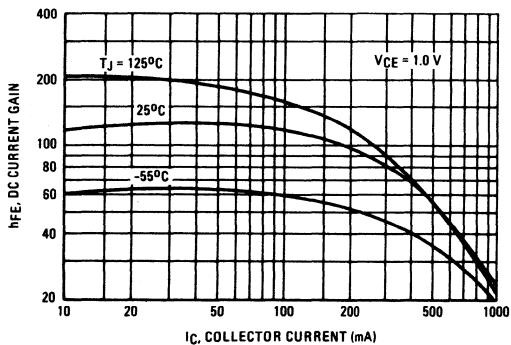


FIGURE 3 – “ON” VOLTAGES

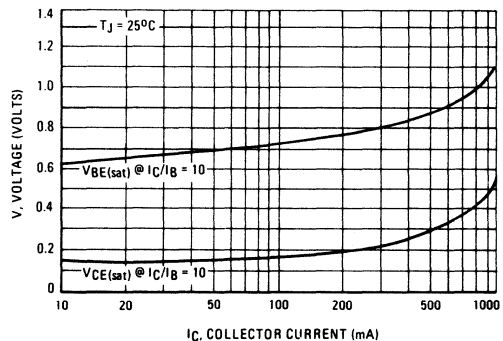


FIGURE 4 – COLLECTOR SATURATION REGION

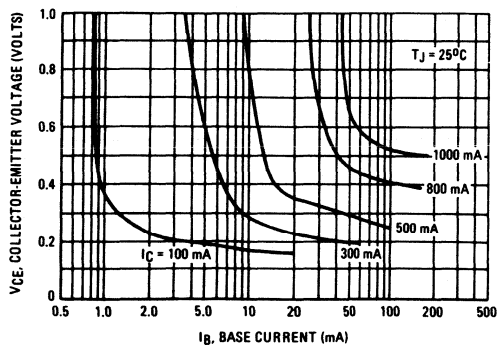
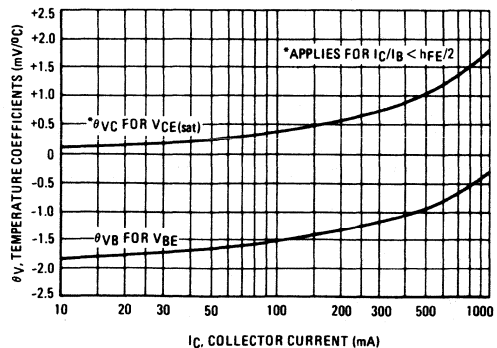


FIGURE 5 – TEMPERATURE COEFFICIENTS



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 6 – CURRENT-GAIN – BANDWIDTH PRODUCT

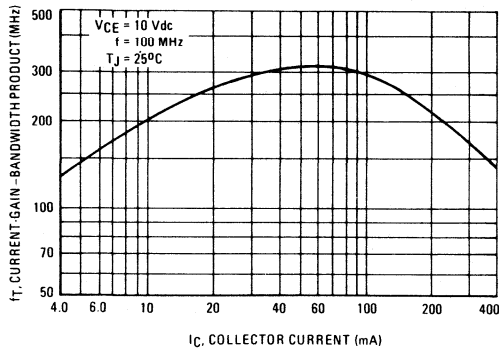


FIGURE 7 – CAPACITANCE

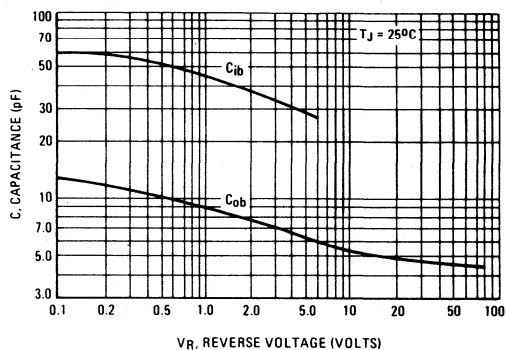


FIGURE 8 – TURN-ON TIME

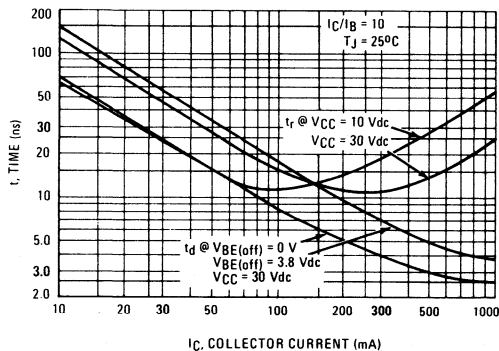


FIGURE 9 – TURN-OFF TIME

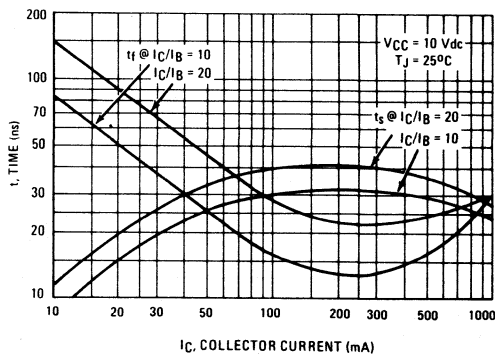


FIGURE 10 – SWITCHING TIME TEST CIRCUIT

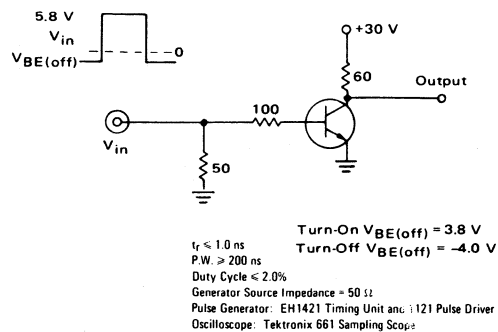
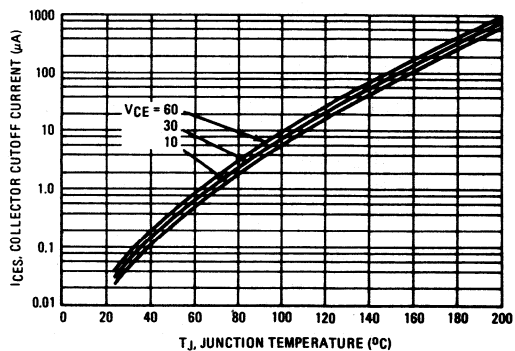


FIGURE 11 – COLLECTOR CUTOFF CURRENT



APPLICATIONS INFORMATION

Core Memory Systems are getting larger, and their cycle times are continually being reduced. These trends place an ever increasing burden on core drivers due to the increased current, additional line inductance, and faster switching requirements. Switching highly inductive lines can cause voltage breakdown problems due to the inductive "kickback" voltages. Unfortunately, both high voltage and fast switching transistors cannot be achieved simultaneously, however, the 2N3725 offers the optimum trade-off between high voltage breakdown and fast switching.

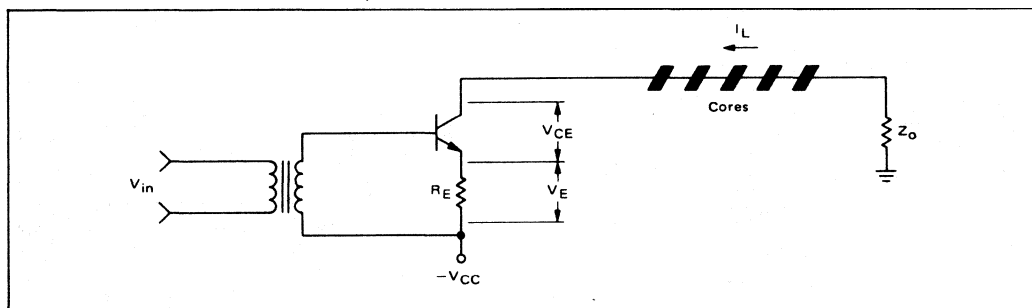
Both voltage and current type drivers are used in core

memory systems. The type of driver to be used is dependent on many factors, some of which are:

- (1) The characteristic impedance of the line and its variations
- (2) Maximum allowable driver power dissipation
- (3) Driver current tolerances

For example, a current driver would most likely be chosen if the drive current had tight tolerances and the line impedance varied greatly. With a voltage driver, the load impedance and the inductance of the line determine the amplitude and waveshape of the current pulse.

FIGURE 12 – Typical Core Driver Circuit



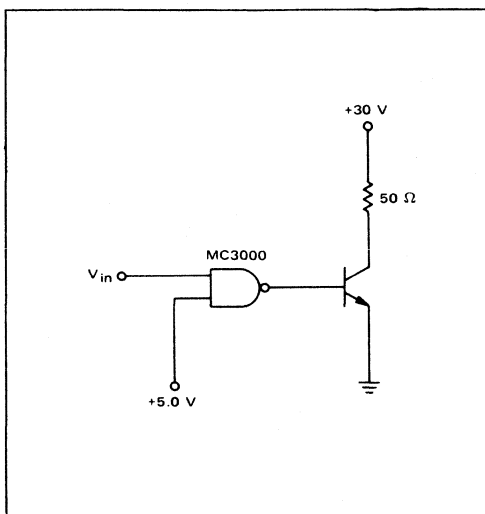
Considering the typical core driver circuit of Figure 12, note that the choice of input signal level determines whether the transistor will saturate or not. If the transistor in Figure 12 does not saturate, the circuit is a current switch and the load current (I_L) is given by: $I_L \approx \alpha V_{E\text{sat}}$, where α is the common base current gain. To insure R_E

that the transistor does not saturate during turn-on, the voltage generated in the line inductance due to the change in current ($V = L di/dt$) must be considered. The supply voltage required in this case becomes $V_{CC} > L di/dt + V_{CE(\text{min})} + I_L(R_E + Z_o)$.

When used as a voltage switch, the transistor saturates and the load current becomes:
$$I_L \approx \frac{V_{CC} - V_{CE(\text{sat})}}{R_E + Z_o}$$

Most core memory driver current requirements are under 500 mA. The 2N3725 has a minimum h_{FE} of 35 at this current level which is sufficient to permit direct coupling to a standard TTL logic in some switching arrangements, thereby eliminating the need for a predriver stage. For example, the output voltage and current levels of an MC3000 are sufficient to cause the 2N3725 to easily switch 600 mA load current (see Figure 13).

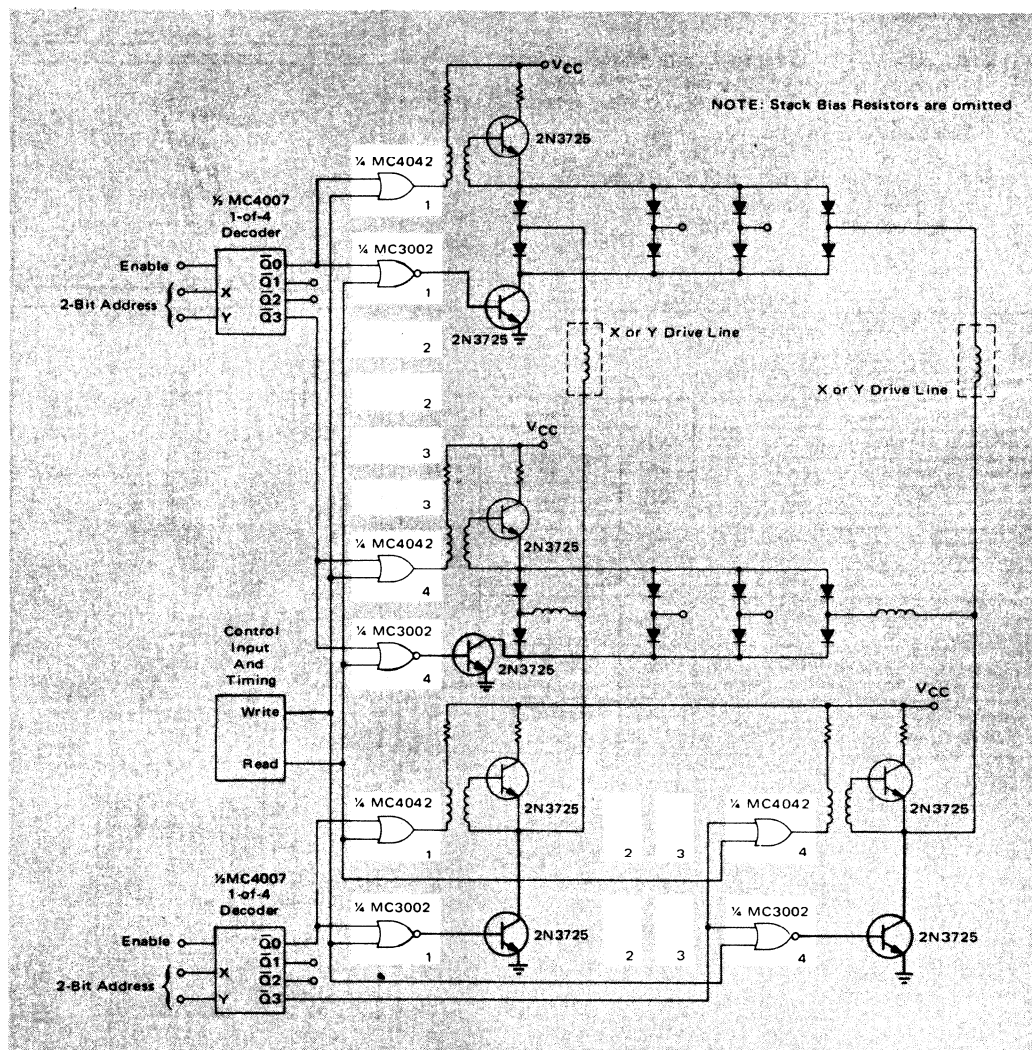
FIGURE 13 – 500 mA TTL Compatible Switch



To indicate how both voltage and current switches can be used in a circuit to reduce the electronics needed to drive core memories, a diode-matrix system such as illustrated in Figure 14 can be employed. Note that current is sent through a given line by selecting one floating current switch and the appropriate voltage switch. The diodes

steer the current through the proper line. There is one voltage and current switch pair at each end of the line causing current to be passed in either direction. In this system, the predriver transformer is required in some circuits in order to provide proper dc levels.

FIGURE 14 — X or Y Drive Selection Matrix



2N3726 (SILICON)

2N3727

MULTIPLE SILICON ANNULAR TRANSISTORS

... designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Excellent Temperature Tracking – Dual Devices – 2N3726
 $\Delta|V_{BE1} - V_{BE2}| = 1.6 \text{ mVdc (Max) @ } -55 \text{ to } +25^{\circ}\text{C}$
 $= 2.0 \text{ mVdc (Max) @ } +25 \text{ to } +125^{\circ}\text{C}$
- Low Collector-Emitter Saturation Voltage –
 $V_{CE(sat)} = 0.25 \text{ Vdc (Max) @ } I_C = 50 \text{ mAdc}$
- DC Current Gain Specified – 0.01 mAdc to 50 mAdc
- High Current-Gain-Bandwidth Product –
 $f_T = 200 \text{ MHz @ } I_C = 50 \text{ mAdc}$

PNP SILICON MULTIPLE TRANSISTORS



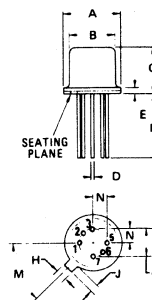
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CB}	45	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	300	mAdc
Base Current	I_B	100	mAdc
		One Die	Both Die
Total Power Dissipation @ $T_A = 25^{\circ}\text{C}$ Derate above 25°C	P_D	400 2.29	500 2.86 mW mW/ $^{\circ}\text{C}$
Total Power Dissipation @ $T_C = 25^{\circ}\text{C}$ Derate above 25°C	P_D	0.85 4.85	1.4 8.0 Watt mW/ $^{\circ}\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^{\circ}\text{C}$

*Indicates JEDEC Registered Data.

STYLE 1:

- PIN 1. COLLECTOR 5. EMITTER
2. BASE 6. BASE
3. EMITTER 7. COLLECTOR
4. OMITTED 8. OMITTED



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70		0.500	
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

*ELECTRICAL CHARACTERISTICS (each side) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) ($I_C = 10\text{ mAdc}$, $I_E = 0$)	BV_{CEO}	45	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.01\text{ mAdc}$, $I_E = 0$)	BV_{CBO}	45	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.01\text{ mAdc}$, $I_C = 0$)	BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 30\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 30\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	—	10 10	nAdc μAdc
Emitter Cutoff Current ($V_{BE} = 3.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	0.1	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 0.01\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 0.1\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 50\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$) (1)	h_{FE}	80 120 135 115	— — 350 —	—
Collector-Emitter Saturation Voltage (1) ($I_C = 50\text{ mAdc}$, $I_E = 2.5\text{ mAdc}$)	$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter Saturation Voltage (1) ($I_C = 50\text{ mAdc}$, $I_E = 2.5\text{ mAdc}$)	$V_{BE(sat)}$	—	1.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain—Bandwidth Product (2) ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 20\text{ MHz}$) ($I_C = 50\text{ mAdc}$, $V_{CE} = 20\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	60 200	— 600	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{ob}	—	8.0	pF
Input Capacitance ($V_{EB} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 1.0\text{ MHz}$)	C_{ib}	—	30	pF
Input Impedance ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ie}	—	11.5	k ohm
Voltage Feedback Ratio ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{re}	—	1500	$\times 10^{-6}$
Small-Signal Current Gain ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	135	420	—
Output Admittance ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{oe}	—	80	μmhos
Noise Figure ($I_C = 30\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$, $R_S = 10\text{ k ohms}$, $f = 1.0\text{ kHz}$, B.W. = 200 Hz)	NF	—	4.0	dB

MATCHING CHARACTERISTICS

DC Current Gain Ratio (3) ($I_C = 0.1\text{ mAdc}$ to 1.0 mAdc , $V_{CE} = 5.0\text{ Vdc}$)	h_{FE1}/h_{FE2}	0.9	1.0	—
Base-Emitter Voltage Differential ($I_C = 0.1\text{ mAdc}$ to 1.0 mAdc , $V_{CE} = 5.0\text{ Vdc}$) 2N3726 2N3727	$ V_{BE1} - V_{BE2} $	— —	5.0 2.5	mVdc
Base-Emitter Differential Change Due to Temperature ($I_C = 0.1\text{ mAdc}$ to 1.0 mAdc , $V_{CE} = 5.0\text{ Vdc}$, $T_A = -55^\circ\text{C}$ to $+25^\circ\text{C}$) 2N3726 2N3727 ($I_C = 0.1\text{ mAdc}$ to 1.0 mAdc , $V_{CE} = 5.0\text{ Vdc}$, $T_A = +25^\circ\text{C}$ to $+125^\circ\text{C}$) 2N3726 2N3727	$\Delta(V_{BE1} - V_{BE2})$	— — — —	1.6 0.8 2.0 1.0	mVdc

* Indicates JEDEC Registered Data.

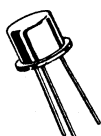
(1) Pulse Test: Pulse Length = 300 μs , Duty Cycle = 1.0%. (2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.(3) For purposes of this ratio, the lowest h_{FE} reading is taken as h_{FE1} .

2N3734S (SILICON)

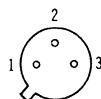
2N3735S

2N3736

2N3737



Medium current NPN silicon annular transistors designed for high-speed switching and driver applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 26
(TO-46)

2N3736
2N3737

CASE 79
(TO-39)

2N3734
2N3735

Collector connected to case

*MAXIMUM RATINGS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Rating	Symbol	2N3734 2N3736	2N3735 2N3737	Unit
Collector-Base Voltage	V_{CB}	50	75	Vdc
Collector-Emitter Voltage	V_{CEO}	30	50	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	1.5		Adc
		TO-39 2N3734 2N3735	TO-46 2N3736 2N3737	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derating Factor Above 25°C	P_D	1.0 5.71	0.5 2.86	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derating Factor Above 25°C	P_D	4.0 22.8	2.0 11.4	Watts mW/ $^\circ\text{C}$
Thermal Resistance Junction to Ambient Junction to Case	θ_{JA} θ_{JC}	0.175 0.044	0.35 0.088	$^\circ\text{C}/\text{mW}$
Junction Temperature, Operating	T_J	+200		$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200		$^\circ\text{C}$

* Indicates JEDEC Registered Data

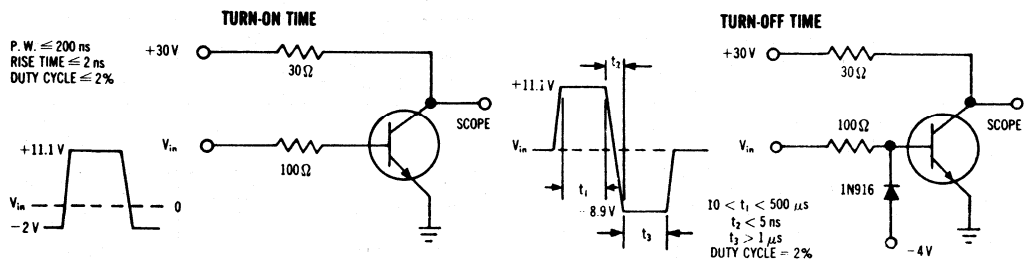
2N3734S, 2N3735S, 2N3736, 2N3737 (continued)
***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $I_E = 0$)	2N3734, 2N3736 2N3735, 2N3737	BV_{CBO}	50 75	—	Vdc
Collector-Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 10\text{ mAdc}$, $I_B = 0$)	2N3734, 2N3736 2N3735, 2N3737	BV_{CEO}	30 50	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{Adc}$, $I_C = 0$)		BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 25\text{ Vdc}$, $V_{EB} = 2\text{ Vdc}$) ($V_{CE} = 25\text{ Vdc}$, $V_{EB} = 2\text{ Vdc}$, $T_A = 100^\circ\text{C}$) ($V_{CE} = 40\text{ Vdc}$, $V_{EB} = 2\text{ Vdc}$) ($V_{CE} = 40\text{ Vdc}$, $V_{EB} = 2\text{ Vdc}$, $T_A = 100^\circ\text{C}$)	2N3734, 2N3736 2N3735, 2N3737	I_{CEX}	— — — —	0.20 20 0.20 20	μAdc
Base Cutoff Current ($V_{CE} = 25\text{ Vdc}$, $V_{EB} = 2\text{ Vdc}$) ($V_{CE} = 40\text{ Vdc}$, $V_{EB} = 2\text{ Vdc}$)	2N3734, 2N3736 2N3735, 2N3737	I_{BL}	— —	0.3 0.3	μAdc
ON CHARACTERISTICS					
DC Current Gain ⁽¹⁾ ($I_C = 10\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$) ($I_C = 150\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$) ($I_C = 500\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$) ($I_C = 1\text{ Adc}$, $V_{CE} = 1.5\text{ Vdc}$) ($I_C = 1.5\text{ Adc}$, $V_{CE} = 5\text{ Vdc}$)	2N3734, 2N3736 2N3735, 2N3737 2N3734, 2N3736 2N3735, 2N3737	h_{FE}	35 40 35 30 20 30 20	— — — 120 80 — —	—
Collector Saturation Voltage ⁽¹⁾ ($I_C = 10\text{ mAdc}$, $I_B = 1\text{ mAdc}$) ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$) ($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$) ($I_C = 1\text{ Adc}$, $I_B = 100\text{ mAdc}$)		$V_{CE(sat)}$	— — — —	0.2 0.3 0.5 0.9	Vdc
Base-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 10\text{ mAdc}$, $I_B = 1\text{ mAdc}$) ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$) ($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$) ($I_C = 1\text{ Adc}$, $I_B = 100\text{ mAdc}$)		$V_{BE(sat)}$	— — — 0.9	0.8 1.0 1.2 1.4	Vdc
DYNAMIC CHARACTERISTICS					
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)		C_{ob}	—	9.0	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)		C_{ib}	—	80	pF
High-Frequency Current Gain ($I_C = 50\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)		h_{fe}	2.5	—	—
Delay Time	(V _{CC} = 30 V, V _{BE(off)} = 2 V, I _C = 1 Amp, I _{B1} = 100 mA)	t_d	—	8.0	ns
Rise Time		t_r	—	40	ns
Storage Time		t_s	—	30	ns
Fall Time		t_f	—	30	ns
Total Control Charge ($I_C = 1\text{ Amp}$, $I_B = 100\text{ mA}$, $V_{CC} = 30\text{ V}$)		Q_T	—	10	nC

⁽¹⁾Pulse Test: PW ≤ 300 μs , Duty Cycle ≤ 2%

* Indicates JEDEC Registered Data

SWITCHING TIME EQUIVALENT TEST CIRCUITS



2N3738, 2N3739 NPN (SILICON)

2N6424, 2N6425 PNP

HIGH VOLTAGE COMPLEMENTARY SILICON POWER TRANSISTORS

... designed for high-speed switching, linear amplifier applications, high-voltage operational amplifiers, switching regulators, converters, inverters, deflection stages and high fidelity amplifiers.

- Collector-Emitter Sustaining Voltage –
 $V_{CE(sus)} = 225 \text{ Vdc @ } I_C = 5.0 \text{ mAdc (2N3738, 2N6424)}$
 $= 300 \text{ Vdc @ } I_C = 5.0 \text{ mAdc (2N3739, 2N6425)}$
- DC Current Gain –
 $h_{FE} = 40\text{-}200 @ I_C = 100 \text{ mAdc}$
- Current-Gain – Bandwidth Product –
 $f_T = 10 \text{ MHz (Min) @ } I_C = 100 \text{ mAdc}$
- I_S/b Rated to 2.0 Amperes

***MAXIMUM RATINGS**

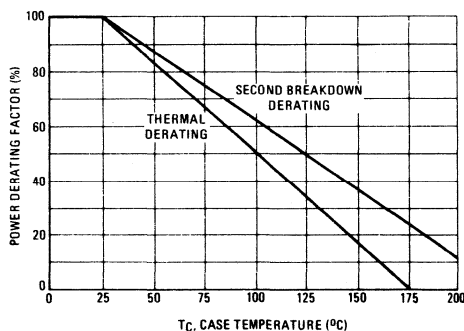
Rating	Symbol	2N3738 2N6424	2N3739 2N6425	Unit
Collector-Emitter Voltage	V_{CEO}	225	300	Vdc
Collector-Base Voltage	V_{CB}	250	325	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current – Continuous – Peak	I_C	1.0	2.0	Adc
		2.0	1.0	
Base Current – Continuous – Peak	I_B	0.50	1.0	Adc
		1.0	0.50	
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	20	0.133	Watts W/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	7.5	$^\circ\text{C/W}$

*Indicates JEDEC Registered Data

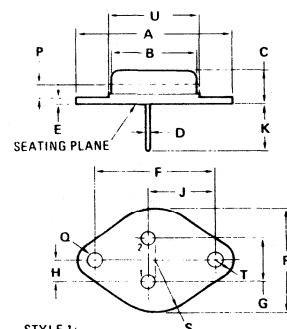
FIGURE 1 – POWER DERATING



2.0 AMPERE

**POWER TRANSISTORS
COMPLEMENTARY SILICON**

**225, 300 VOLTS
20 WATTS**



STYLE 1:
PIN 1: BASE
2: EMITTER
CASE: COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
B	11.94	12.70	0.470	0.500
C	6.35	8.64	0.250	0.340
D	0.71	0.86	0.028	0.034
E	1.27	1.91	0.050	0.075
F	24.33	24.43	0.958	0.962
G	4.83	5.33	0.190	0.210
H	2.41	2.67	0.095	0.105
J	14.48	14.99	0.570	0.590
K	9.14	—	0.360	—
P	—	1.27	—	0.050
Q	3.61	3.86	0.142	0.152
S	—	8.89	—	0.350
T	—	3.68	—	0.145
U	—	15.75	—	0.620

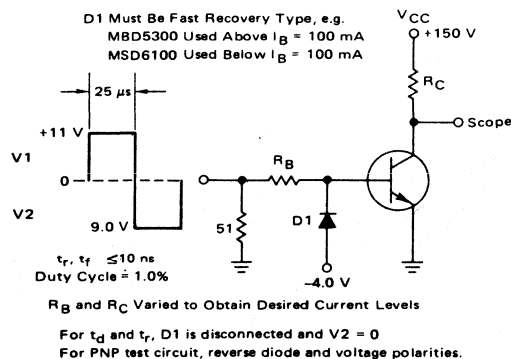
All JEDEC Dimensions and Notes Apply.

**CASE 80-02
TO-66**

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
*OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) ($I_C = 5.0\text{ mAdc}$, $I_B = 0$)	$V_{CE(sus)}$	225 300	— —	Vdc
Collector-Emitter Cutoff Current ($V_{CE} = 125\text{ Vdc}$, $I_B = 0$) ($V_{CE} = 200\text{ Vdc}$, $I_B = 0$)	I_{CEO}	— —	0.25 0.25	mAdc
Collector-Base Cutoff Current ($V_{CB} = 250\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 325\text{ Vdc}$, $I_E = 0$)	I_{CBO}	— —	0.1 0.1	mAdc
Collector Cutoff Current ($V_{CE} = 250\text{ Vdc}$, $V_{EB(off)} = 1.5\text{ Vdc}$) ($V_{CE} = 300\text{ Vdc}$, $V_{EB(off)} = 1.5\text{ Vdc}$) ($V_{CE} = 125\text{ Vdc}$, $V_{EB(off)} = 1.5\text{ Vdc}$, $T_C = 100^\circ\text{C}$) ($V_{CE} = 200\text{ Vdc}$, $V_{EB(off)} = 1.5\text{ Vdc}$, $T_C = 100^\circ\text{C}$)	I_{CEV}	— — — —	0.5 0.5 1.0 1.0	mAdc
Emitter-Base Cutoff Current ($V_{EB} = 6.0\text{ Vdc}$)	I_{EBO}	—	0.1	mAdc
*ON CHARACTERISTICS				
DC Current Gain (1) ($I_C = 50\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 100\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 250\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$)	h_{FE}	30 40 25	— 200 —	—
Collector-Emitter Saturation Voltage (1) ($I_C = 250\text{ mAdc}$, $I_B = 25\text{ mAdc}$)	$V_{CE(sat)}$	—	2.5	Vdc
Base-Emitter "ON" Voltage (1) ($I_C = 100\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$)	$V_{BE(on)}$	—	1.0	Vdc
SMALL SIGNAL CHARACTERISTICS				
Current-Gain – Bandwidth Product (2) ($I_C = 100\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 10\text{ MHz}$)	f_T	10	—	MHz
*Output Capacitance ($V_{CB} = 100\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)	C_{ob}	—	20	pF
*Small-Signal Current Gain ($I_C = 100\text{ mAdc}$, $V_{CE} = 20\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	35	—	—

* Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2\%$ (2) $f_T = |h_{fe}| \cdot \text{frequency}$ **FIGURE 2 – SWITCHING TIMES TEST CIRCUIT**

2N3738, 2N3739 NPN/2N6424, 2N6425 PNP (continued)

NPN
2N3738, 2N3739

PNP
2N6424, 2N6425

FIGURE 3 – TURN-ON TIME

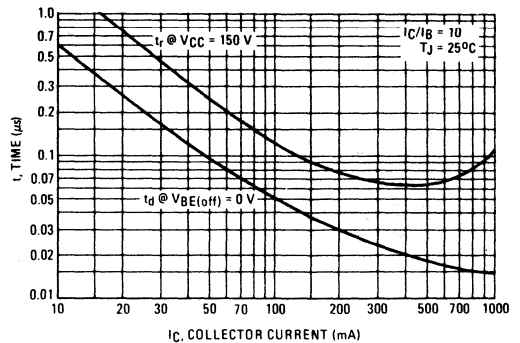
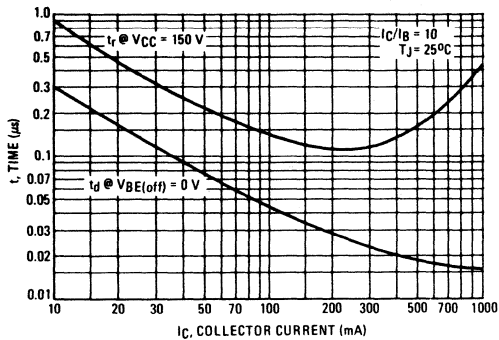


FIGURE 4 – TURN-OFF TIME

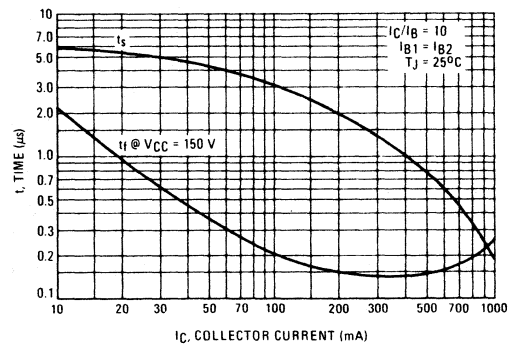
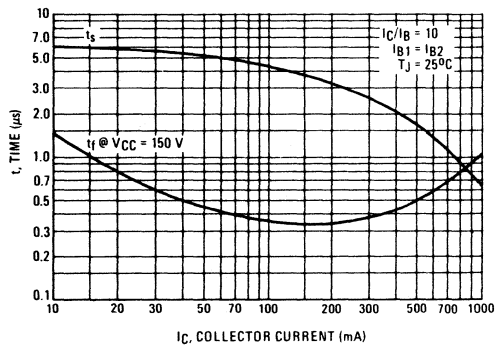


FIGURE 5 – CURRENT-GAIN – BANDWIDTH PRODUCT

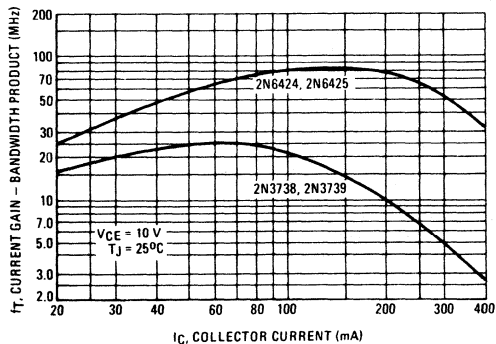


FIGURE 6 – CAPACITANCE

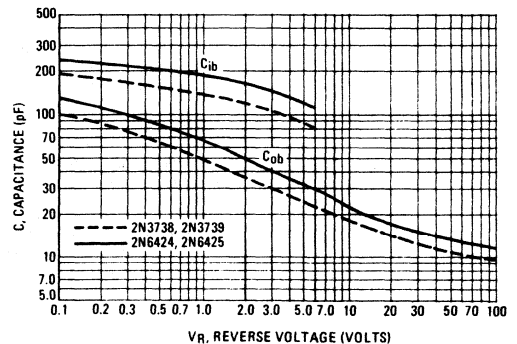
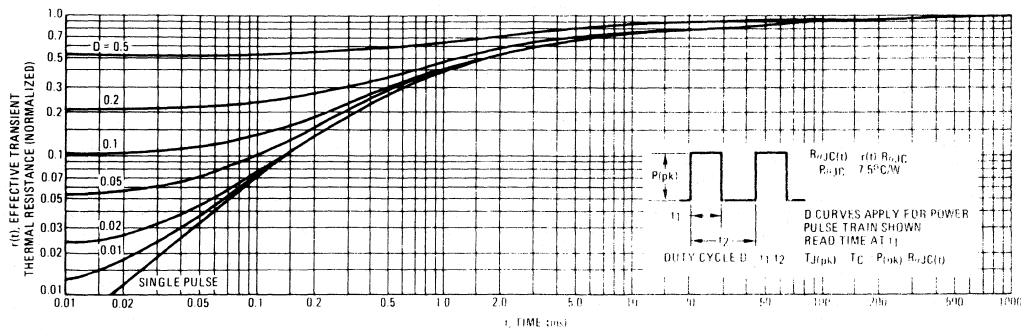


FIGURE 7 – THERMAL RESPONSE



ACTIVE-REGION SAFE OPERATING AREA

FIGURE 8 – 2N3738, 2N3739

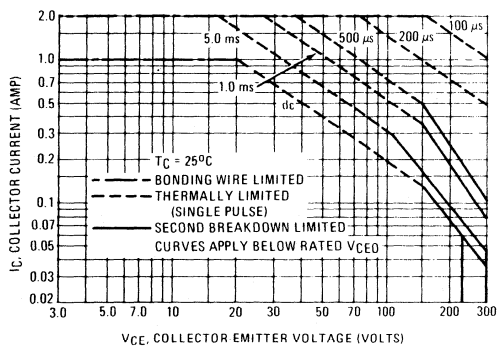
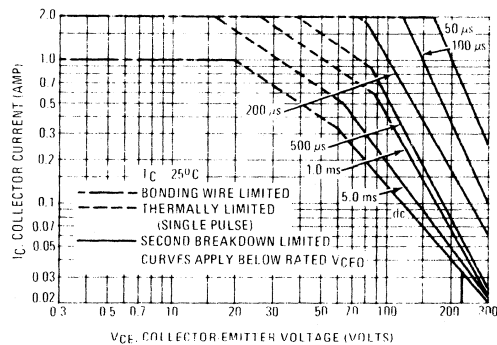


FIGURE 9 – 2N6424, 2N6425



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 8 and 9 is based on $T_C = 25^\circ\text{C}$; $T_{J(pk)}$ is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 175^\circ\text{C}$. $T_{J(pk)}$ may be calculated from the data in Figure 7. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figures 8 and 9 may be found at any case temperature by using the appropriate curve on Figure 1.

NPN
2N3738, 2N3739

PNP
2N6424, 2N6425

FIGURE 10 – DC CURRENT GAIN

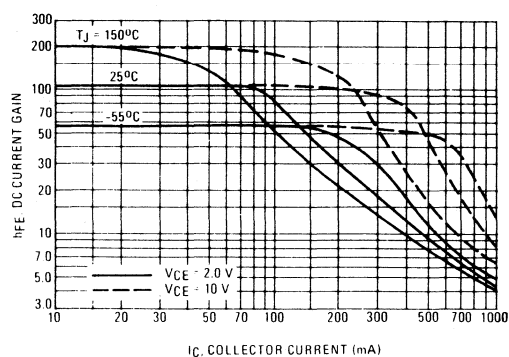
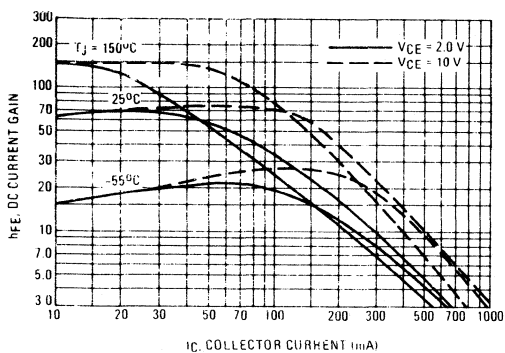


FIGURE 11 – COLLECTOR SATURATION REGION

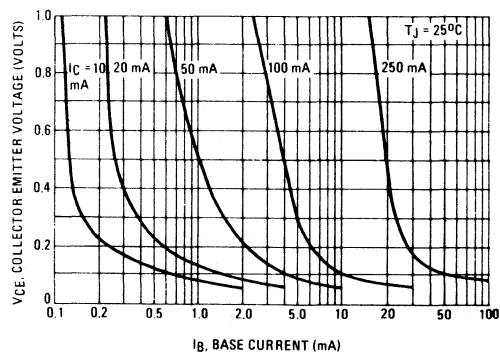
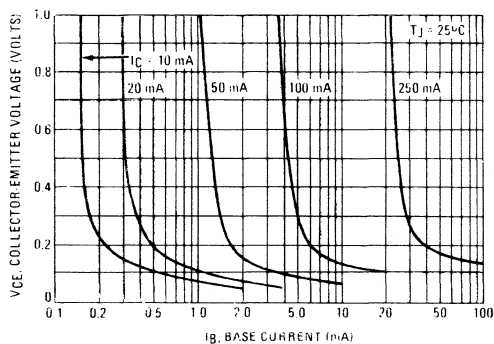
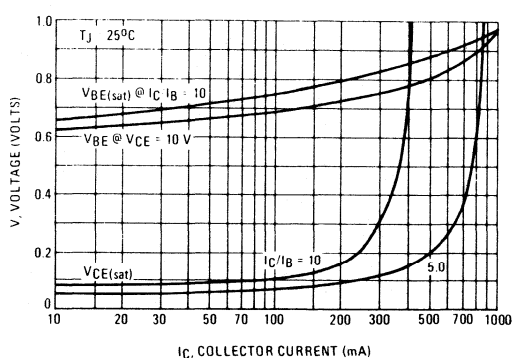
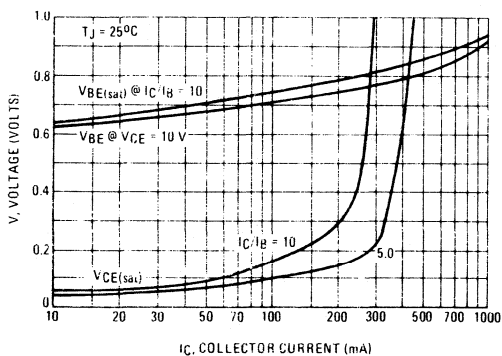


FIGURE 12 – "ON" VOLTAGE



NPN
2N3738, 2N3739

PNP
2N6424, 2N6425

FIGURE 13 – TEMPERATURE COEFFICIENTS

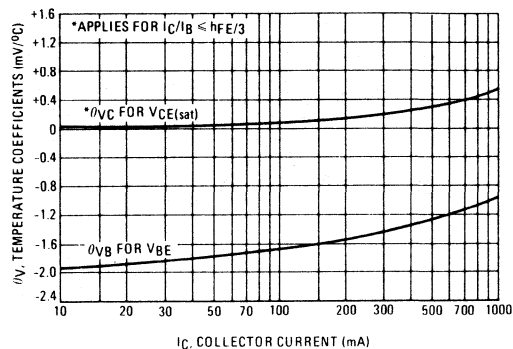
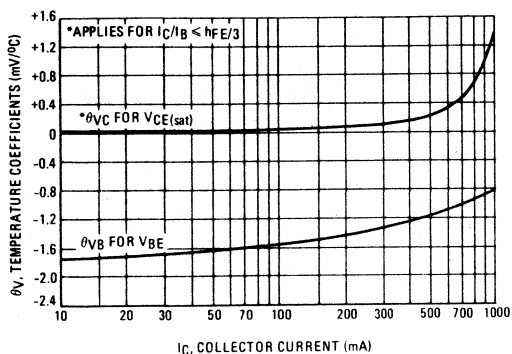


FIGURE 14 – COLLECTOR CUTOFF REGION

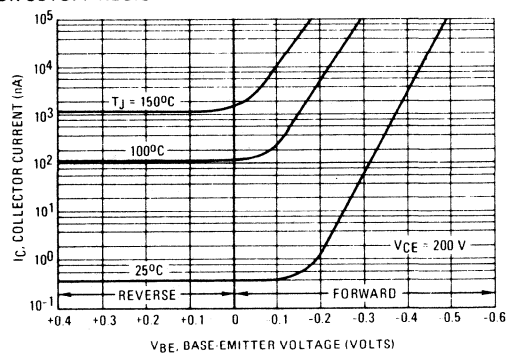
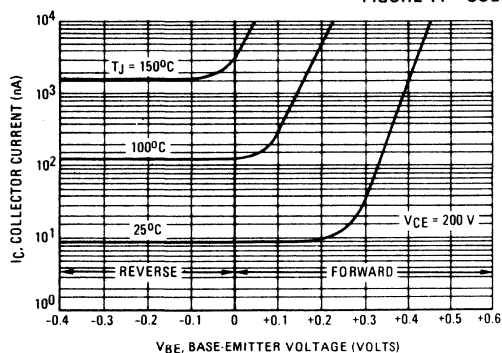
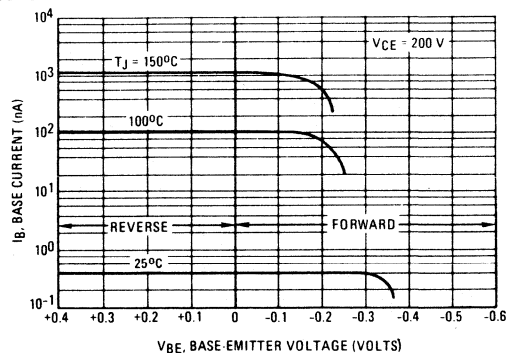
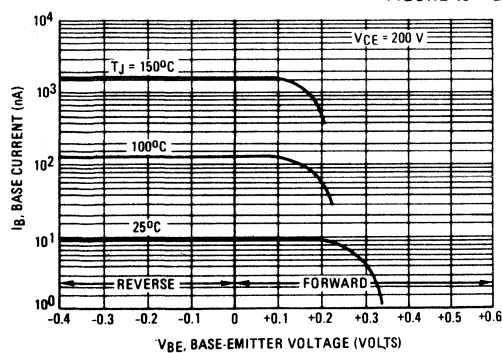


FIGURE 15 – BASE CUTOFF REGION



2N3740, A (SILICON)

2N3741, A

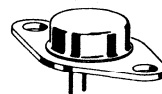
MEDIUM-POWER PNP TRANSISTORS

... ideal for use as drivers, switches and direct replacement of germanium medium-power devices. These devices feature:

- Low Saturation Voltage —
 $V_{CE(sat)} = 0.6 \text{ Vdc @ } I_C = 1.0 \text{ Amp}$
- High Gain Characteristics —
 $h_{FE} = 30\text{--}100 @ I_C = 250 \text{ mAdc}$
- Direct Substitution for Germanium Equivalents
- Excellent Safe Area Limits (See Figure 2)
- Low Collector Cutoff Current —
100 nA (Max) 2N3740A, 2N3741A
- Complementary to NPN 2N3766
(2N3740) and 2N3767 (2N3741)

POWER TRANSISTORS

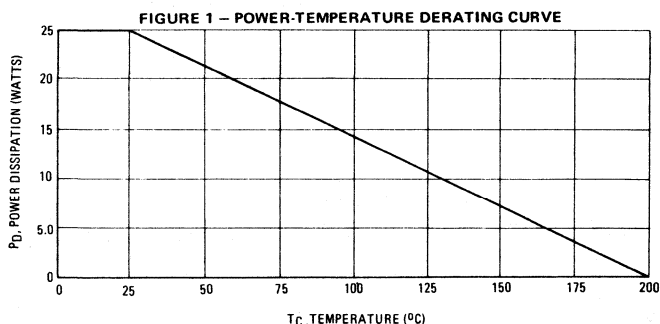
PNP SILICON
60–80 VOLTS
25 WATTS



*MAXIMUM RATINGS

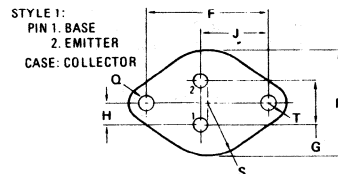
Rating	Symbol	2N3740 2N3740A	2N3741 2N3741A	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	7.0	7.0	Vdc
Collector-Base Voltage	V_{CB}	60	80	vdc
Collector Current — Continuous — Peak (Note 1)	I_C	4.0 10		Adc
Base Current	I_B		2.0	Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	25 0.143		Watts W/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

Note 1: See Figure 2



Safe Area Curves are indicated by Figure 2.
Both limits are applicable and must be observed.

*Indicates JEDEC Registered Data.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
B	11.94	12.70	0.470	0.500
C	6.35	8.64	0.250	0.340
D	0.71	0.86	0.028	0.034
E	1.27	1.51	0.050	0.075
F	24.33	24.43	0.958	0.962
G	4.83	5.33	0.190	0.210
H	2.41	2.67	0.095	0.105
J	14.48	14.99	0.570	0.590
K	9.14		0.360	
P		1.27		0.050
Q	3.61	3.86	0.142	0.152
S		8.89		0.350
T		3.68		0.145
U		15.75		0.620

All JEDEC Dimensions and Notes Apply.

CASE 80-02
TO-66

2N3740,A, 2N3741,A (continued)

*ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Figure No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage ^① ($I_C = 100 \text{ mAdc}$, $I_B = 0$)	2	$V_{CEO(sus)}$ ^①	60 80	— —	Vdc
Emitter Base Cutoff Current ($V_{EB} = 7.0 \text{ Vdc}$)	—	I_{EBO}	—	0.5 100	mA nA
Collector Cutoff Current ($V_{CE} = 60 \text{ Vdc}$, $V_{BE(off)} = 1.5 \text{ Vdc}$) ($V_{CE} = 80 \text{ Vdc}$, $V_{BE(off)} = 1.5 \text{ Vdc}$) ($V_{CE} = 40 \text{ Vdc}$, $V_{BE(off)} = 1.5 \text{ Vdc}$, $T_C = 150^\circ\text{C}$) ($V_{CE} = 60 \text{ Vdc}$, $V_{BE(off)} = 1.5 \text{ Vdc}$, $T_C = 150^\circ\text{C}$)	5, 6 ^②	I_{CEX}	— — — —	100 100 100 100	μA nA μA nA
Collector-Emitter Cutoff Current ($V_{CE} = 40 \text{ Vdc}$, $I_B = 0$) ($V_{CE} = 60 \text{ Vdc}$, $I_B = 0$)	5, 6 ^②	I_{CEO}	— — — —	1.0 1.0 1.0 1.0	mA μA mA μA
Collector Base Cutoff Current ($V_{CB} = 60 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 80 \text{ Vdc}$, $I_E = 0$)	—	I_{CBO}	— — — —	100 100 100 100	μA nA μA nA

ON CHARACTERISTICS

DC Current Gain ($I_C = 100 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 250 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 500 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 1.0 \text{ Adc}$, $V_{CE} = 1.0 \text{ Vdc}$)	7	h_{FE} ^①	40 30 20 10	— 100 — —	—
Collector-Emitter Saturation Voltage ($I_C = 1.0 \text{ Adc}$, $I_B = 125 \text{ mAdc}$)	8, 9, 10	$V_{CE(sat)}$ ^①	—	0.6	Vdc
Base-Emitter Voltage ($I_C = 250 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$)	3, 4, 9, 10	V_{BE} ^①	—	1.0	Vdc

TRANSIENT CHARACTERISTICS

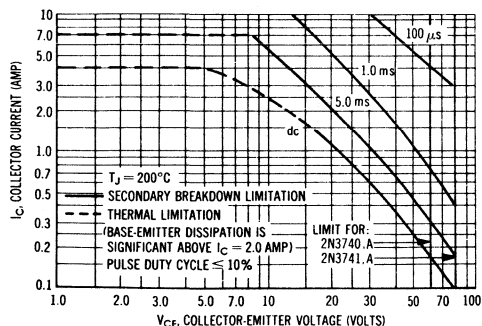
Current-Gain-Bandwidth Product ($I_C = 100 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)	—	f_T	4.0	—	MHz
Common Base Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_C = 0$, $f = 100 \text{ kHz}$)	14	C_{ob}	—	100	pF
Small-Signal Current Gain ($I_C = 50 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	—	h_{fe}	25	—	—

* Indicates JEDEC Registered Data.

① Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

② Figures 5 and 6 apply to 2N3740 and 2N3741 only.

FIGURE 2 — ACTIVE REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J , power-temperature derating must be observed for both steady state and pulse power conditions.

LARGE SIGNAL CHARACTERISTICS

FIGURE 3 – TRANSCONDUCTANCE

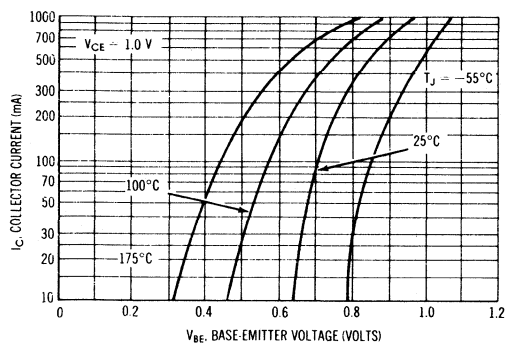
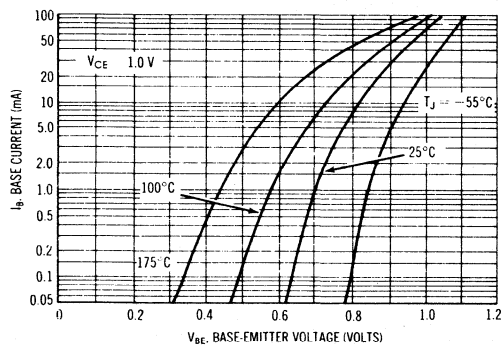


FIGURE 4 – INPUT ADMITTANCE



"OFF" REGION CHARACTERISTICS

FIGURE 5 – TRANSCONDUCTANCE

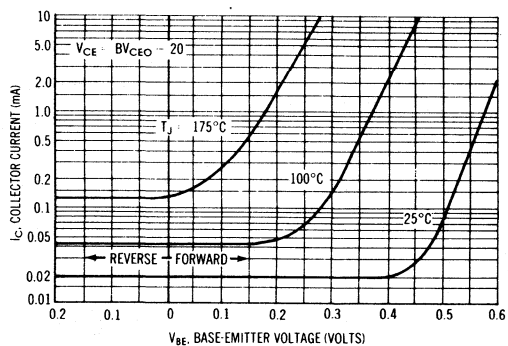
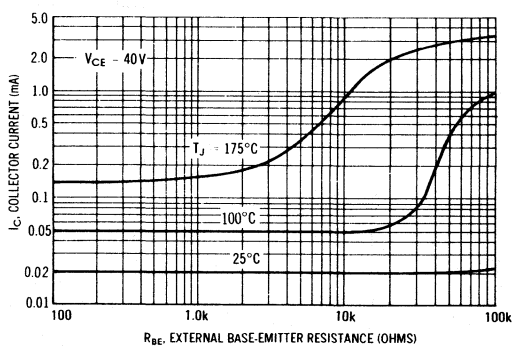


FIGURE 6 – EFFECTS OF BASE-EMITTER RESISTANCE



② Figures 5 and 6 apply to 2N3740 and 2N3741.

FIGURE 7 – THERMAL RESPONSE

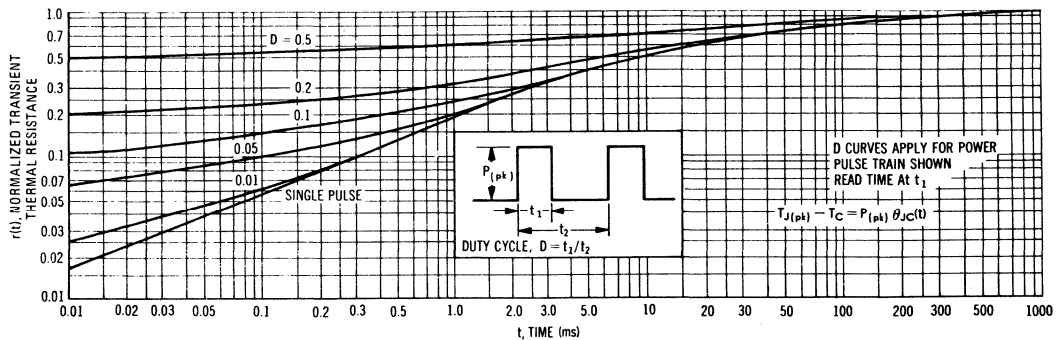
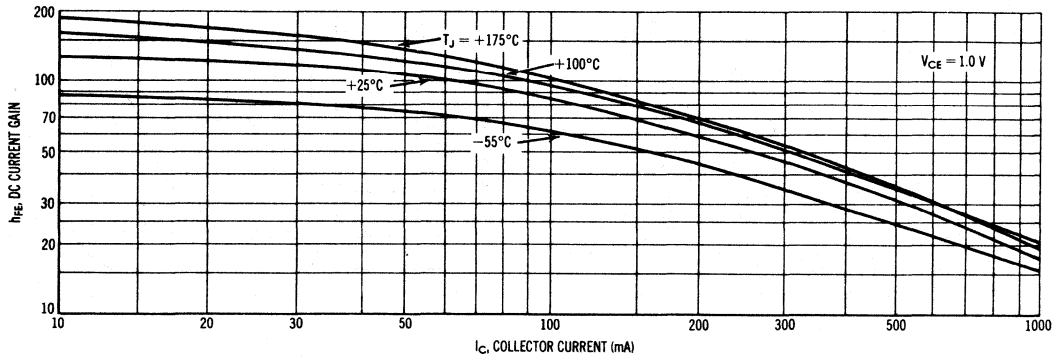


FIGURE 8 – CURRENT GAIN



SATURATION REGION CHARACTERISTICS

FIGURE 9 – COLLECTOR SATURATION REGION

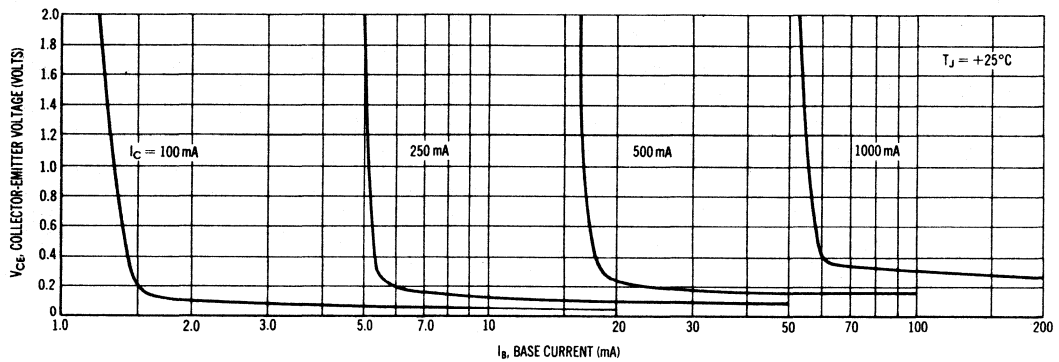


FIGURE 10 – "ON" VOLTAGES

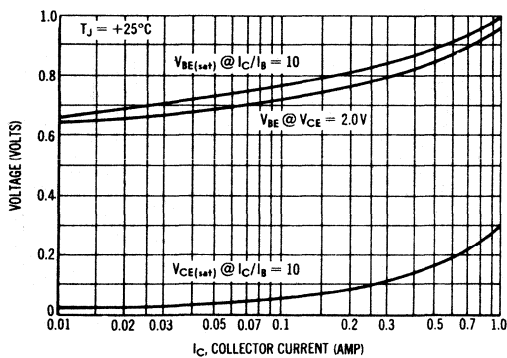


FIGURE 11 – TEMPERATURE COEFFICIENTS

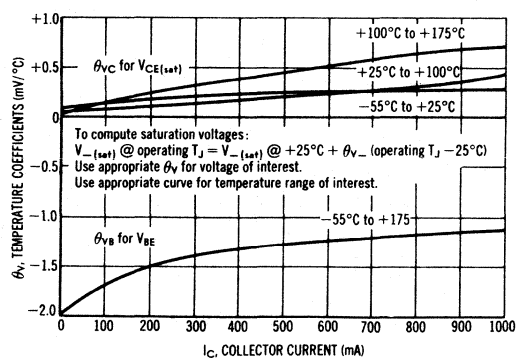


FIGURE 12 – TURN-ON TIME

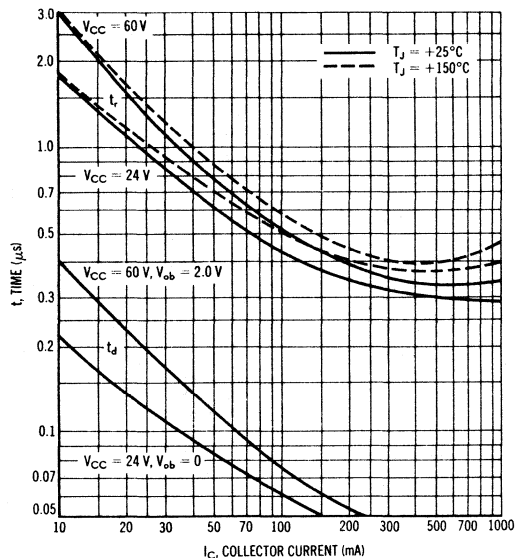


FIGURE 13 – CAPACITANCE

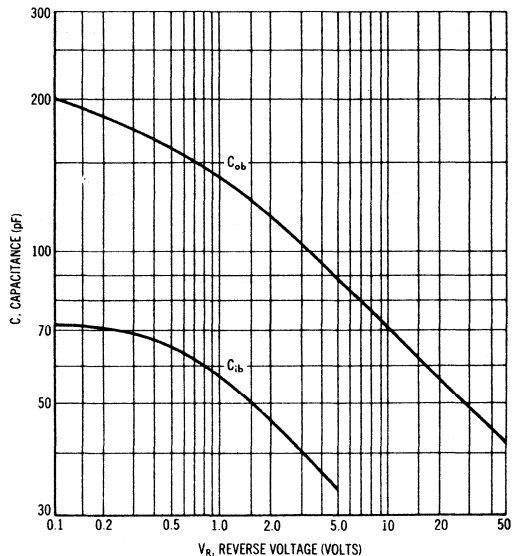


FIGURE 14 – STORAGE TIME

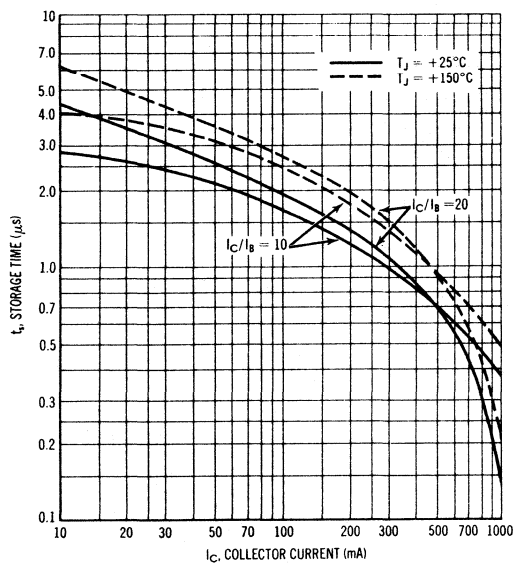
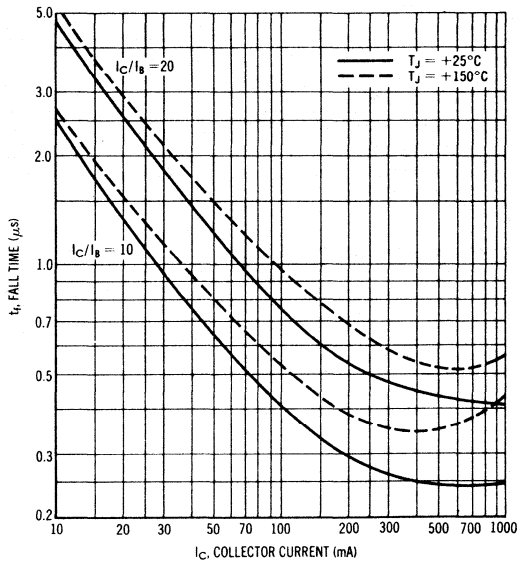


FIGURE 15 – FALL TIME

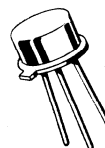


NPN SILICON ANNULAR* TRANSISTOR

... designed for high-voltage amplifier driver applications

- High Collector-Emitter Breakdown Voltage –
BV_{CEO} = 300 Vdc (Min) @ I_C = 10 mAdc
- Low Output Capacitance –
C_{Ob} = 6.0 pF (Max) @ V_{CB} = 10 Vdc
- DC Current Gain Specified – 3.0 mAdc to 50 mAdc

NPN SILICON HIGH - VOLTAGE AMPLIFIER TRANSISTOR



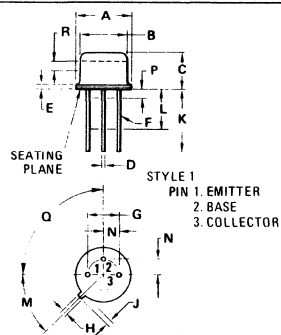
*MAXIMUM RATING

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	300	Vdc
Collector-Base Voltage	V _{CB}	300	Vdc
Emitter-Base Voltage	V _{EB}	7.0	Vdc
Collector Current - Continuous	I _C	50	mAdc
Total Power Dissipation @T _A = 25°C Derate above 25°C	P _D	1.0 5.71	Watt mW/°C
Total Power Dissipation @T _C = 25°C Derate above 25°C	P _D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	R _{θJA}	175	°C/W
Thermal Resistance, Junction to Case	R _{θJC}	35	°C/W

*Indicates JEDEC Registered Data



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° NOM	—	45° NOM	—
P	—	1.27	—	0.050
Q	90° NOM	—	90° NOM	—
R	2.54	—	0.100	—

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
----------------	--------	-----	-----	------

OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (1) ($I_C = 10\text{ mAdc}$, $I_E = 0$)	BV_{CEO}	300	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	300	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	7.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 200\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 200\text{ Vdc}$, $I_E = 0$, $T_A = 100^\circ\text{C}$)	I_{CBO}	—	0.2 20	μAdc
Emitter Cutoff Current ($V_{EB} = 6.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	0.2	μAdc

ON CHARACTERISTICS (2)

DC Current Gain ($I_C = 3.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 30\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 50\text{ mAdc}$, $V_{CE} = 20\text{ Vdc}$)	h_{FE}	10 15 20 20	200 —	—
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_E = 1.0\text{ mAdc}$) ($I_C = 30\text{ mAdc}$, $I_E = 3.0\text{ mAdc}$)	$V_{CE(sat)}$	— —	0.75 1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_E = 1.0\text{ mAdc}$) ($I_C = 30\text{ mAdc}$, $I_E = 3.0\text{ mAdc}$)	$V_{BE(sat)}$	— —	1.0 1.2	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product (3) ($I_C = 10\text{ mAdc}$, $V_{CE} = 20\text{ Vdc}$, $f = 20\text{ MHz}$)	f_T	30	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)	C_{ob}	—	6.0	pF
Input Capacitance ($V_{EB} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)	C_{ib}	—	80	pF
Input Impedance ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ie}	—	2.0	k ohms
Voltage Feedback Ratio ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{re}	—	2.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 10\text{ kHz}$)	h_{fe}	20	200	—
Output Admittance ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{oe}	—	50	mhos
Real Part of Input Impedance ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 5.0\text{ MHz}$)	$\text{Re}(h_{ie})$	—	200	Ohms

*Indicates JEDEC Registered Data

- (1) Pulse Test: Pulse Width $\leq 30\text{ }\mu\text{s}$, Duty Cycle $\leq 1.0\%$
- (2) Pulse Test: Pulse width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$
- (3) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 – DC CURRENT GAIN

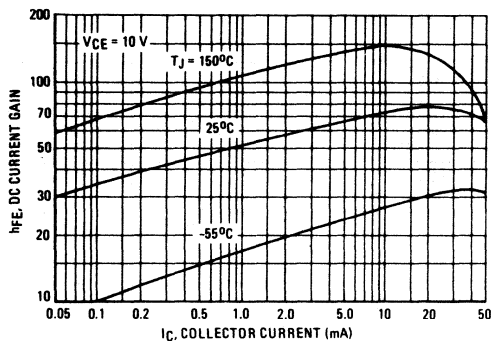


FIGURE 2 – DC SAFE OPERATING AREA

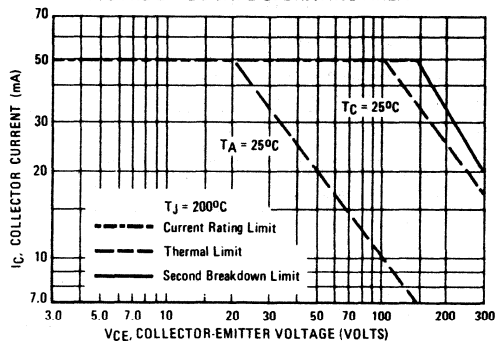


FIGURE 3 – "ON" VOLTAGES

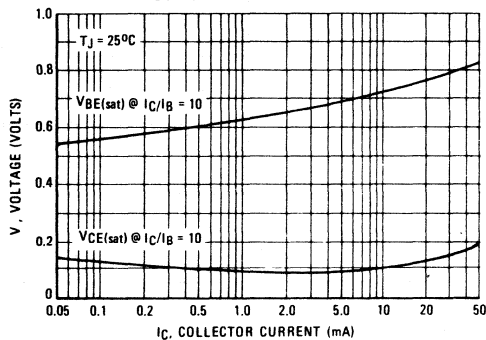


FIGURE 4 – TEMPERATURE COEFFICIENTS

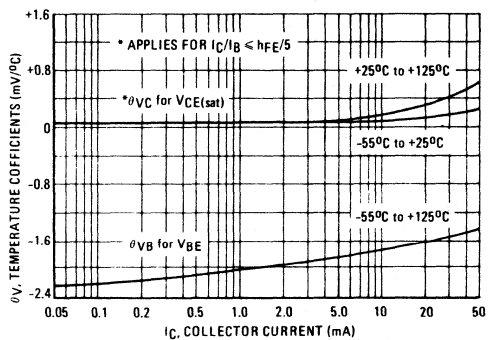


FIGURE 5 – CURRENT-GAIN-BANDWIDTH PRODUCT

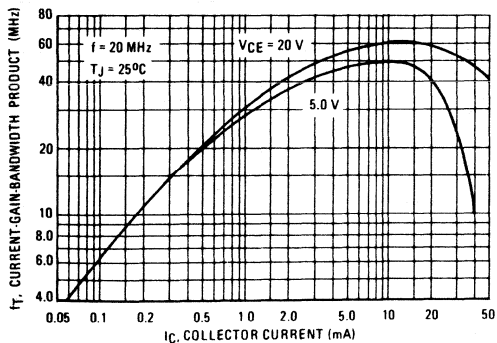
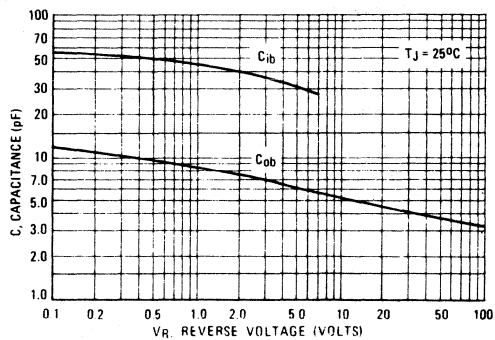
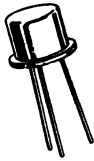


FIGURE 6 – CAPACITANCE

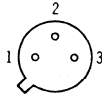


2N3743S (SILICON)

JAN, JTX AVAILABLE



CASE 79
(TO-39)



PNP silicon annular transistor for high-voltage amplifier applications from dc to VHF.

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

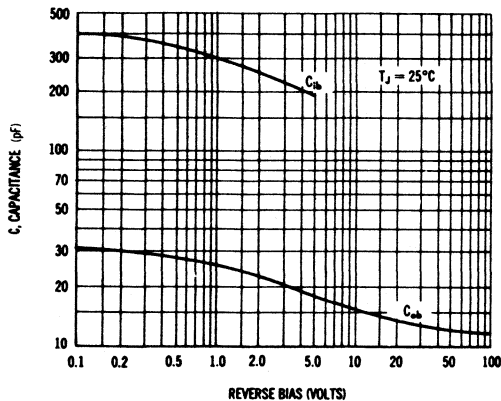
Collector connected to case

*MAXIMUM RATINGS

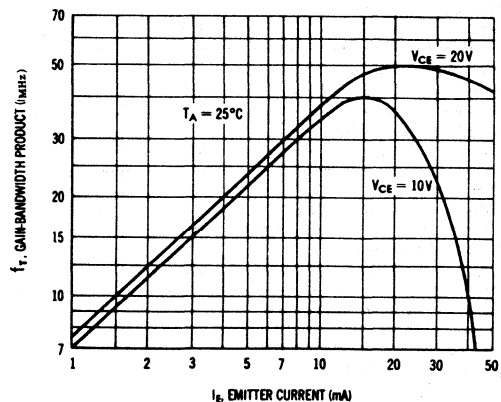
Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	300	Vdc
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$	P_D	1.0	Watt
Derate Above 25°C		5.7	mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$	P_D	5.0	Watts
Derate Above 25°C		28.6	mW/ $^\circ\text{C}$
Operating Junction Temperature	T_J	+200	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

* Indicates JEDEC Registered Data

JUNCTION CAPACITANCE



GAIN-BANDWIDTH PRODUCT



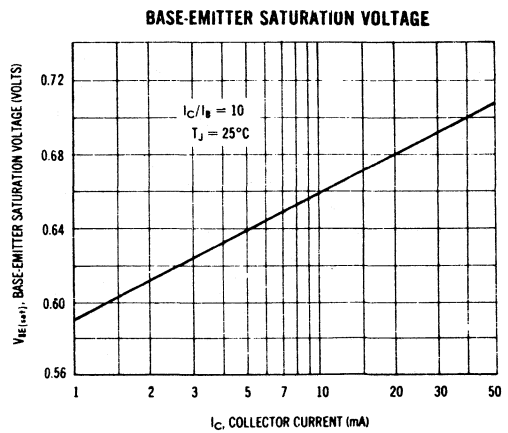
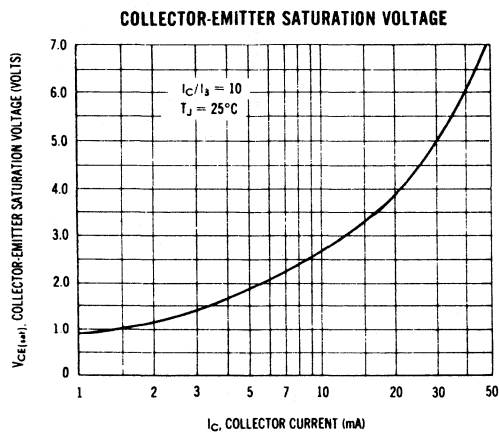
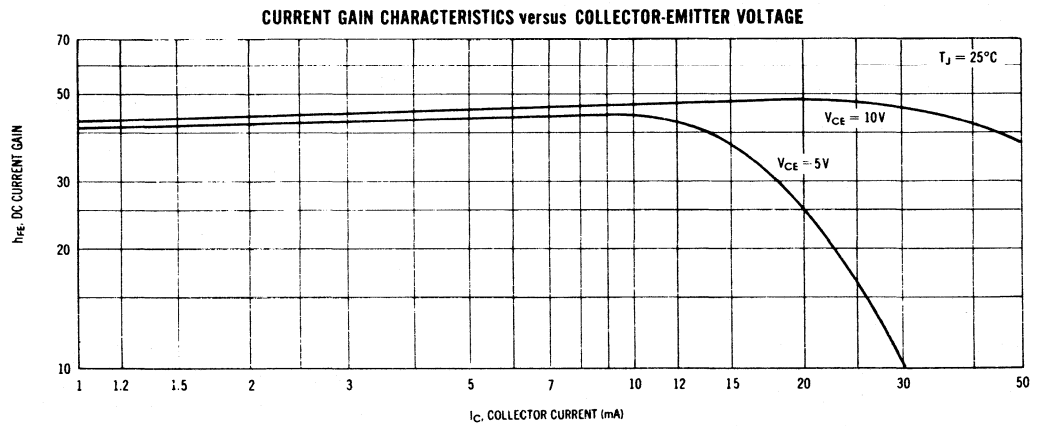
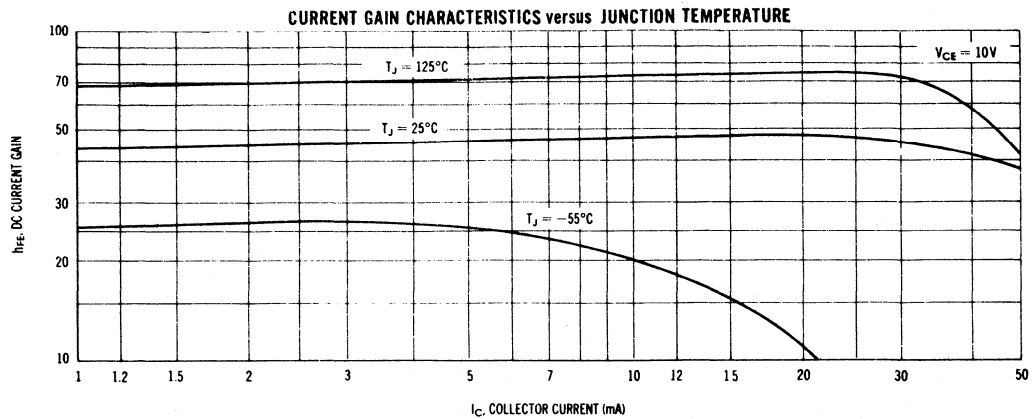
***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{A}$, $I_E = 0$)	BV_{CBO}	300	—	Vdc
Collector-Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 10 \text{ mA}$, $I_B = 0$)	BV_{CEO}	300	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{A}$, $I_C = 0$)	BV_{EBO}	5.0	—	Vdc
Collector Saturation Voltage ⁽²⁾ ($I_C = 10 \text{ mA}$, $I_B = 1 \text{ mA}$) ($I_C = 30 \text{ mA}$, $I_B = 3 \text{ mA}$)	$V_{CE(sat)}$	— —	5.0 8.0	Vdc
Base-Emitter Saturation Voltage ⁽²⁾ ($I_C = 10 \text{ mA}$, $I_B = 1 \text{ mA}$) ($I_C = 30 \text{ mA}$, $I_B = 3 \text{ mA}$)	$V_{BE(sat)}$	— —	1.0 1.2	Vdc
DC Forward Current Gain ⁽²⁾ ($I_C = 100 \mu\text{A}$, $V_{CE} = 10 \text{ Vdc}$) ($I_C = 1 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$) ($I_C = 10 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$) ($I_C = 30 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$) ($I_C = 50 \text{ mA}$, $V_{CE} = 20 \text{ Vdc}$)	h_{FE}	20 25 25 25 25	— — — 250 —	—
Collector Cutoff Current ($V_{CB} = 200 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 200 \text{ Vdc}$, $I_E = 0$, $T_A = 100^\circ\text{C}$)	I_{CBO}	— —	0.3 30	μA
Emitter-Base Leakage Current ($V_{EB} = 3 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	0.1	μA
Small-Signal Current Gain ($I_C = 10 \text{ mA}$, $V_{CE} = 20 \text{ Vdc}$, $f = 20 \text{ MHz}$)	$ h_{fe} $	1.5	—	—
Output Capacitance ($V_{CB} = 20 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)	C_{ob}	—	15	pF
Input Capacitance ($V_{EB} = 1 \text{ Vdc}$, $I_C = 0$, $f = 100 \text{ kHz}$)	C_{ib}	—	400	pF
Small Signal Current Gain ($V_{CE} = 10 \text{ V}$, $I_C = 10 \text{ mA}$, $f = 1 \text{ kHz}$)	h_{fe}	30	300	—
Voltage Feedback Ratio ($V_{CE} = 10 \text{ V}$, $I_C = 10 \text{ mA}$, $f = 1 \text{ kHz}$)	h_{re}	—	4.0	$\times 10^{-4}$
Input Impedance ($V_{CE} = 10 \text{ V}$, $I_C = 10 \text{ mA}$, $f = 1 \text{ kHz}$)	h_{ie}	—	1.0	kohms
Output Admittance ($V_{CE} = 10 \text{ V}$, $I_C = 10 \text{ mA}$, $f = 1 \text{ kHz}$)	h_{oe}	—	200	μmhos
Real Part of Input Impedance ($I_C = 10 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$, $f = 5 \text{ MHz}$)	$\text{Re}(h_{ie})$	—	40	ohms

(1) $PW \leq 30 \mu\text{s}$, Duty Cycle $\leq 1\%$

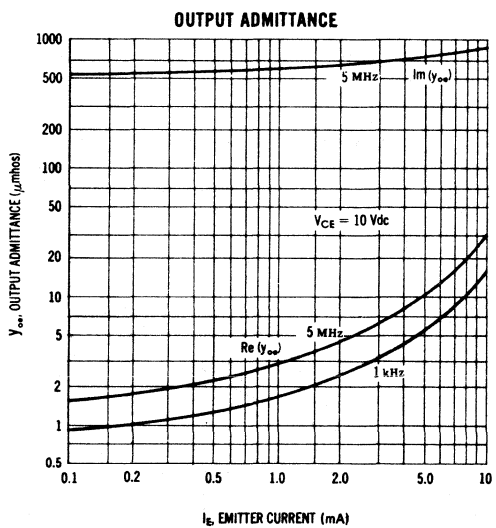
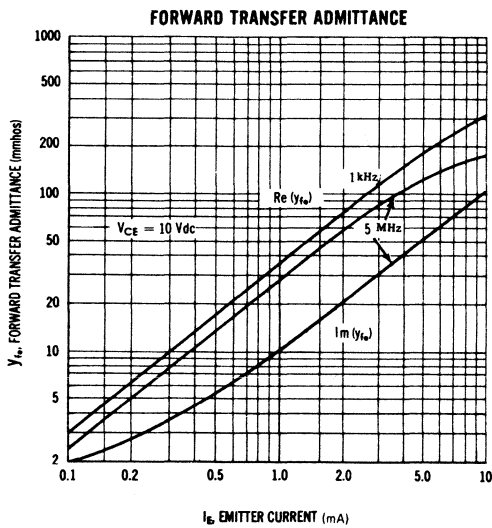
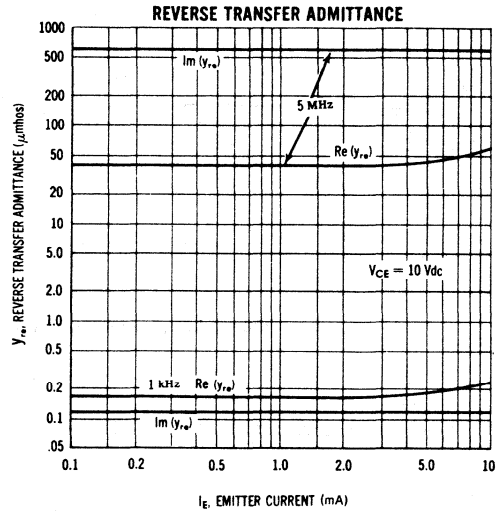
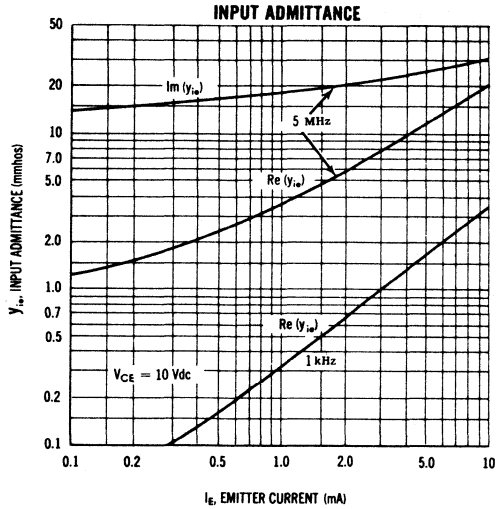
(2) $PW \leq 300 \mu\text{s}$, Duty Cycle $\leq 2\%$

* Indicates JEDEC Registered Data



SMALL SIGNAL Y PARAMETERS

$T_A = 25^\circ\text{C}$



2N3762S (SILICON)

2N3763S

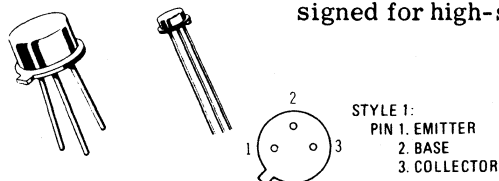
2N3763S JAN,JTX AVAILABLE

2N3764

2N3765

2N3765 JAN,JTX AVAILABLE

Medium-current PNP silicon annular transistor, designed for high-speed switching and driver applications.



CASE 79

(TO-39)

2N3762

2N3763

CASE 26

(TO-46)

2N3764

2N3765

Collector connected to case

*MAXIMUM RATINGS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Rating	Symbol	2N3762 2N3764	2N3763 2N3765	Unit
Collector-Base Voltage	V_{CB}	40	60	Vdc
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	1.5		Adc
		TO-5 2N3762 2N3763	TO-46 2N3764 2N3765	
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derating Factor Above 25°C	P_D	1.0 5.71	0.5 2.86	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derating Factor Above 25°C	P_D	4.0 22.8	2.0 11.4	Watts mW/ $^\circ\text{C}$
Thermal Resistance Junction to Ambient Junction to Case	θ_{JA} θ_{JC}	0.175 0.044	0.35 0.088	$^\circ\text{C}/\text{mW}$
Junction Temperature, Operating	T_J	+200		$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200		$^\circ\text{C}$

*Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $I_E = 0$)	2N3762, 2N3764 2N3763, 2N3765	BV_{CBO}	40 60	— —	Vdc
Collector-Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 10\text{ mAdc}$, $I_B = 0$)	2N3762, 2N3764 2N3763, 2N3765	BV_{CEO}	40 60	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{Adc}$, $I_C = 0$)		BV_{EBO}	5.0	—	Vac
Collector Cutoff Current ($V_{CE} = 20\text{ Vdc}$, $V_{EB} = 2\text{ Vdc}$) ($V_{CE} = 20\text{ Vdc}$, $V_{EB} = 2\text{ Vdc}$, $T_A = 100^\circ\text{C}$) ($V_{CE} = 30\text{ Vdc}$, $V_{EB} = 2\text{ Vdc}$) ($V_{CE} = 30\text{ Vdc}$, $V_{EB} = 2\text{ Vdc}$, $T_A = 100^\circ\text{C}$)	2N3762, 2N3764 2N3763, 2N3765	I_{CEX}	— — — —	0.10 10 0.10 10	μAdc
Base Cutoff Current ($V_{CE} = 20\text{ Vdc}$, $V_{EB} = 2\text{ Vdc}$) ($V_{CE} = 30\text{ Vdc}$, $V_{EB} = 2\text{ Vdc}$)	2N3762, 2N3764 2N3763, 2N3765	I_{BL}	— —	0.2 0.2	μAdc

ON CHARACTERISTICS

DC Current Gain ⁽¹⁾ ($I_C = 10\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$) ($I_C = 150\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$) ($I_C = 500\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$) ($I_C = 1\text{ Adc}$, $V_{CE} = 1.5\text{ Vdc}$) ($I_C = 1.5\text{ Adc}$, $V_{CE} = 5\text{ Vdc}$)	2N3762, 2N3764 2N3763, 2N3765 2N3762, 2N3764 2N3763, 2N3765	h_{FE}	35 40 35 30 20 30 20	— — — 120 80 — —	—
Collector Saturation Voltage ⁽¹⁾ ($I_C = 10\text{ mAdc}$, $I_B = 1\text{ mAdc}$) ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$) ($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$) ($I_C = 1\text{ Adc}$, $I_B = 100\text{ mAdc}$)		$V_{CE(sat)}$	— — — —	0.1 0.22 0.5 0.9	Vdc
Base-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 10\text{ mAdc}$, $I_B = 1\text{ mAdc}$) ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$) ($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$) ($I_C = 1\text{ Adc}$, $I_B = 100\text{ mAdc}$)		$V_{BE(sat)}$	— — — 0.9	0.8 1.0 1.2 1.4	Vdc

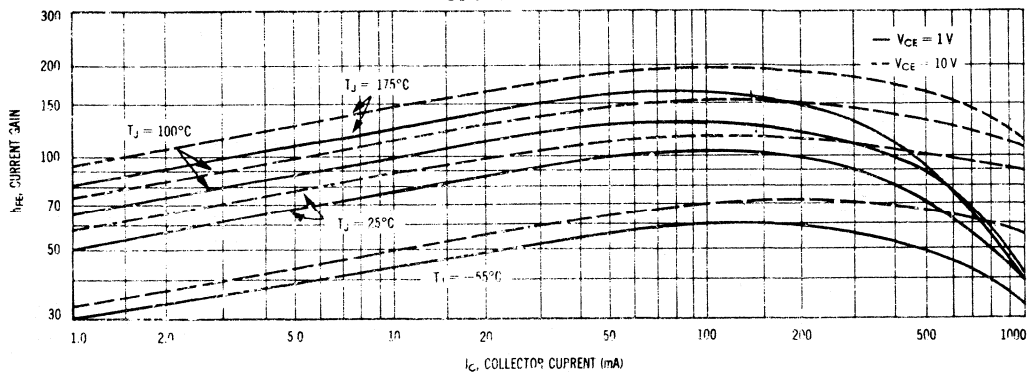
TRANSIENT CHARACTERISTICS

Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)	C_{ob}	—	15	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)	C_{ib}	—	80	pF
High Frequency Current Gain ($I_C = 50\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	$ h_{fe} $	1.8 1.5	— —	—
Delay Time ($V_{CC} = 30\text{ V}$, $V_{BE(off)} = 2\text{ V}$, $I_C = 1\text{ Amp}$, $I_{B1} = 100\text{ mA}$)	t_d	—	8.0	ns
Rise Time	t_r	—	35	ns
Storage Time	t_s	—	80	ns
Fall Time ($V_{CC} = 30\text{ V}$, $I_C = 1\text{ Amp}$, $I_{B1} = -I_{B2} = 100\text{ mA}$)	t_f	—	35	ns
Total Control Charge ($I_C = 1\text{ Amp}$, $I_B = 100\text{ mA}$, $V_{CC} = 30\text{ V}$)	Q_T	—	30	nC

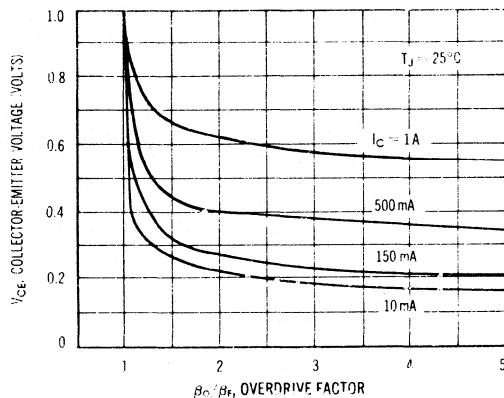
⁽¹⁾ Pulse Test: $PW \leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2\%$

* Indicates JEDEC Registered Data

FIGURE 1
"ON" CONDITION CHARACTERISTICS
DC CURRENT GAIN



COLLECTOR SATURATION REGION

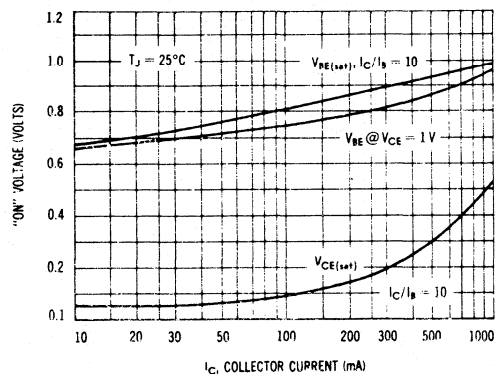


This graph shows the effect of base current on collector current. β_O (current gain at the edge of saturation) is the current gain of the transistor at 1 volt, and β_F (forced gain) is the ratio of I_C/I_{BF} in a circuit. EXAMPLE: For type 2N3734, estimate a base current (I_{BF}) to ensure saturation at a temperature of 25°C and a collector of 500 mA.

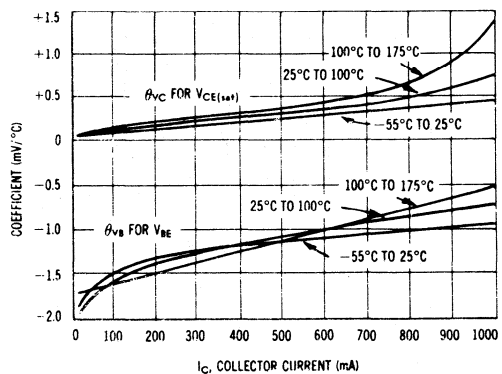
Observe that at $I_C = 500$ mA an overdrive factor of at least 2.0 is required to drive the transistor well into the saturation region. From Figure 1, it is seen that h_{FE} @ 1 volt is typically 54 (guaranteed limits from the Table of Characteristics can be used for "worst-case" design).

$$\frac{\beta_O}{\beta_F} = \frac{h_{FE} @ 1 \text{ Volt}}{I_C / I_{BF}} \quad 2 = \frac{54}{500 \text{ mA} / I_{BF}} \quad I_{BF} \approx 18.5 \text{ mA typ}$$

"ON" VOLTAGES



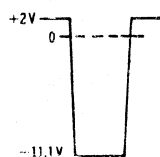
TEMPERATURE COEFFICIENTS



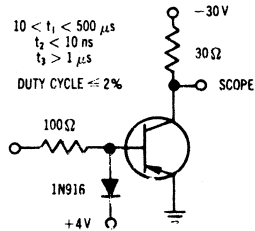
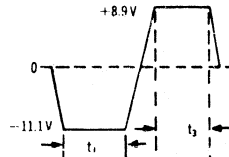
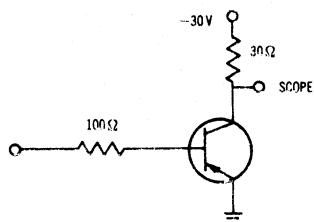
TURN-ON TIME

SWITCHING TIME EQUIVALENT TEST CIRCUITS

TURN-OFF TIME



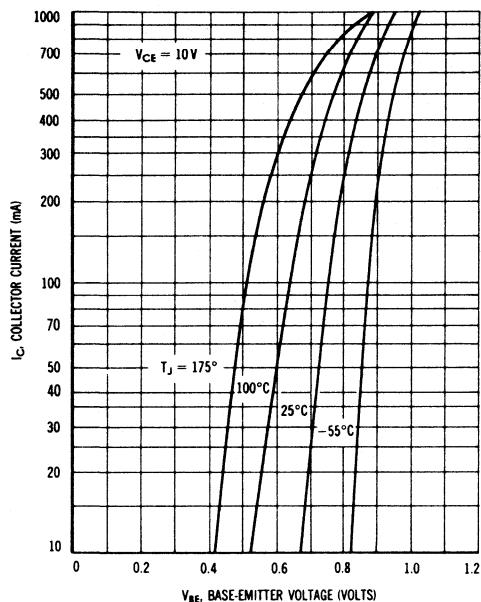
PW = 200 ns
RISE TIME ≤ 2 ns
DUTY CYCLE $\leq 2\%$



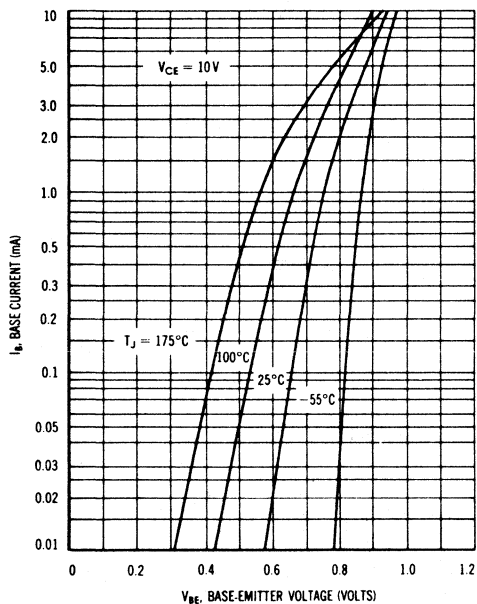
$10 < t_1 < 500 \mu\text{s}$
 $t_2 < 10 \text{ ns}$
 $t_3 > 1 \mu\text{s}$
DUTY CYCLE $\leq 2\%$

LARGE SIGNAL CHARACTERISTICS

TRANSCONDUCTANCE

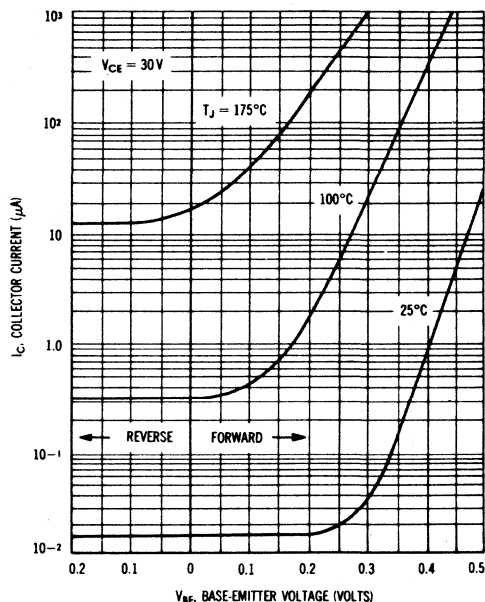


INPUT ADMITTANCE

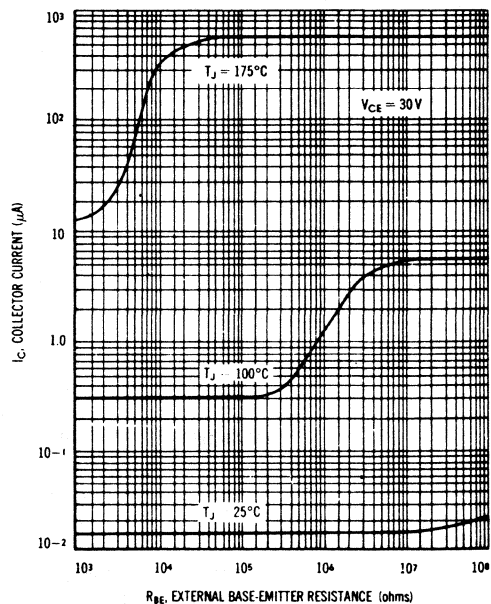


"OFF" CONDITION CHARACTERISTICS

TRANSCONDUCTANCE



EFFECT OF BASE-EMITTER RESISTANCE

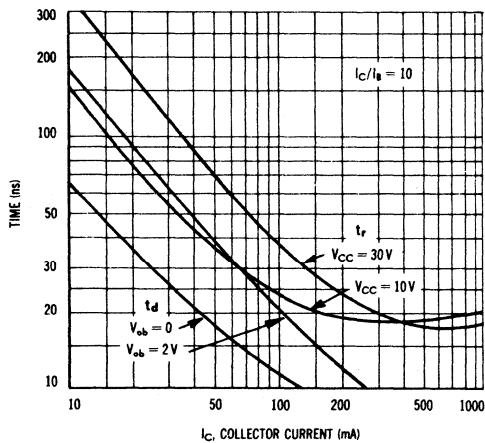


— $T_J = 25^\circ\text{C}$

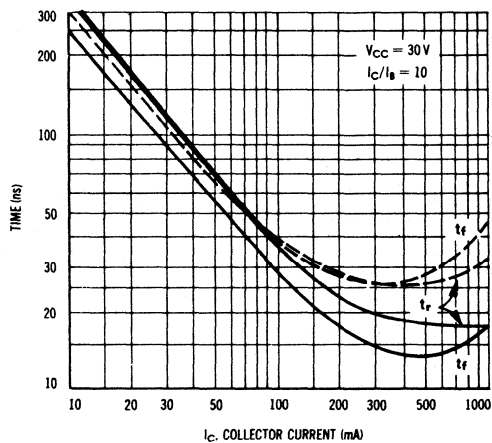
SWITCHING CHARACTERISTICS

-- $T_J = 150^\circ\text{C}$

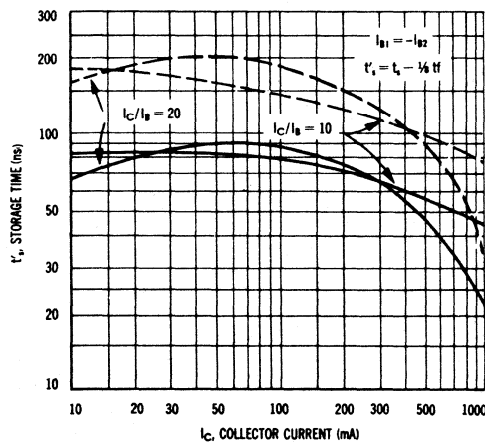
TURN-ON TIME



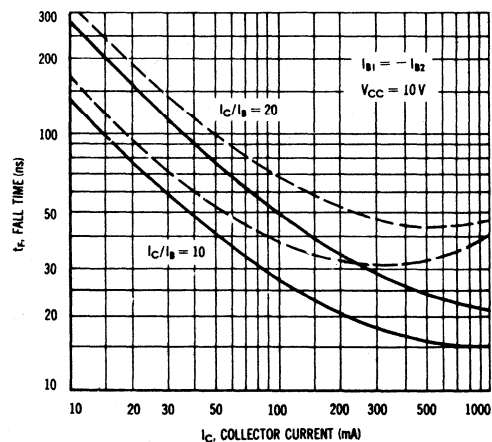
RISE AND FALL TIME



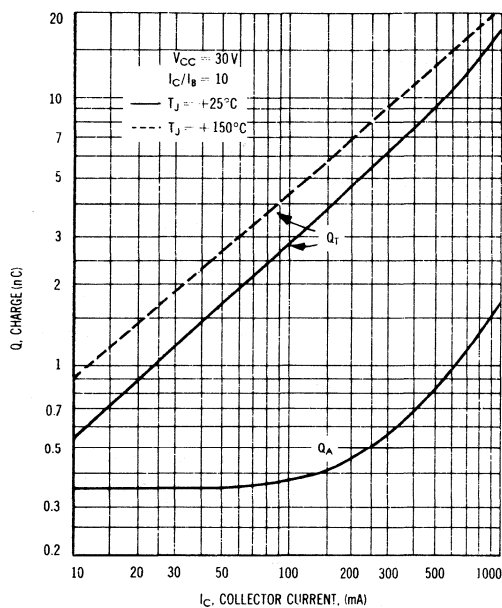
STORAGE TIME



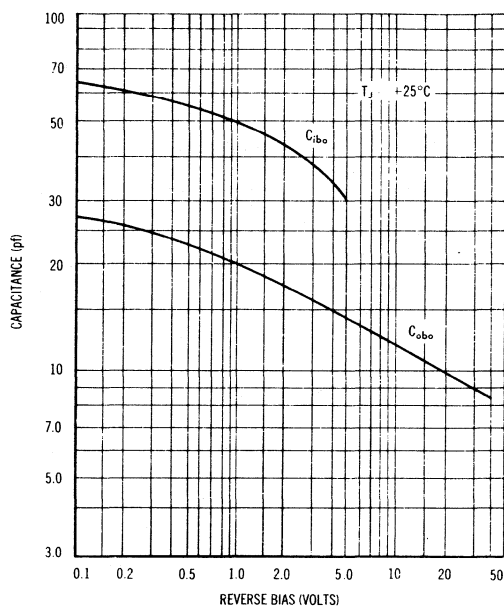
FALL TIME



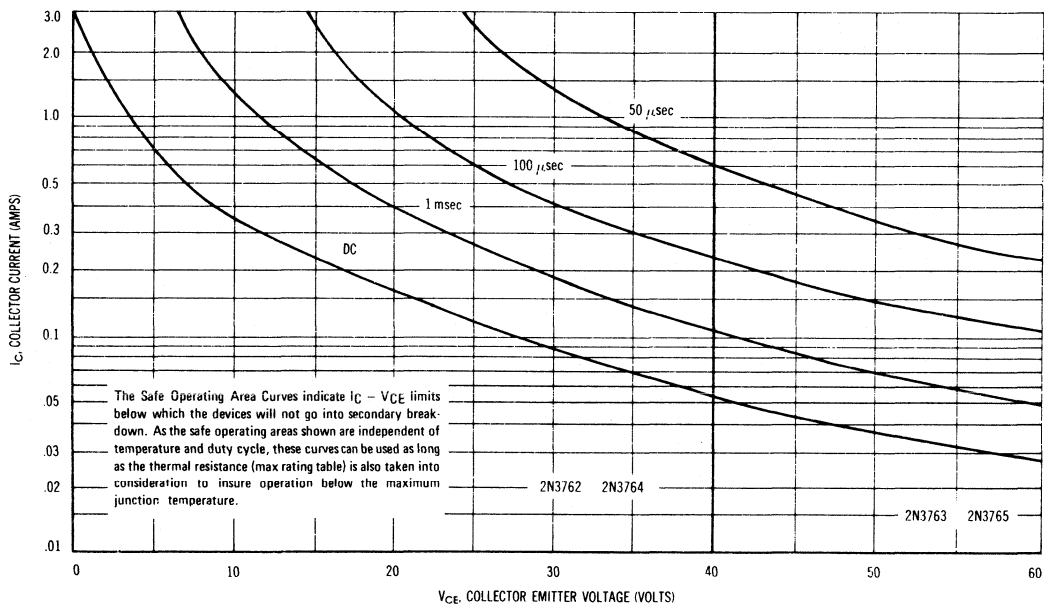
CHARGE DATA



CAPACITANCE



ACTIVE REGION SAFE OPERATING AREAS



2N3766 (SILICON)

2N3767

MEDIUM-POWER NPN SILICON TRANSISTORS

... for use in driver circuits, switching, and medium-power-amplifiers applications. These high performance devices feature:

- Low Saturation Voltage — $1.0 V_{CE(sat)}$ @ $I_C = 500 \text{ mA}$
- High Gain Characteristics — $h_{FE} = 40\text{-}160$ @ $I_C = 500 \text{ mA}$
- Packaged in the Compact, High-Efficiency TO-66 Case
- Recommended for use @ $I_C = 0$ to 500 mAdc
- Complementary to PNP 2N3740 (2N3766) and 2N3741 (2N3767)

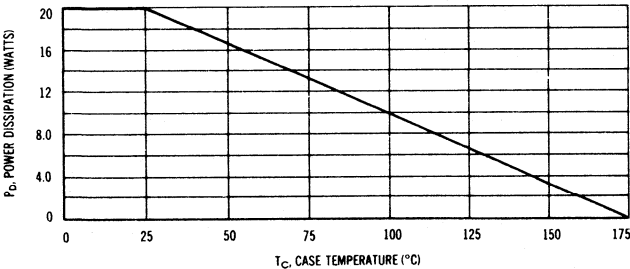
MAXIMUM RATINGS

Rating	Symbol	2N3766	2N3767	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	80	100	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current	I_C	4.0		Adc
Base Current	I_B	2.0		Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	20 0.133		Watts W/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175		$^\circ\text{C}$

THERMAL CHARACTERISTICS

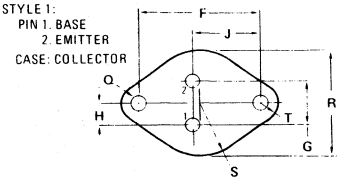
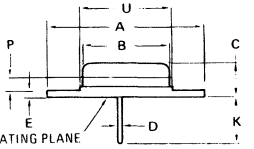
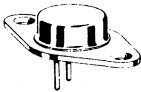
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	7.5	$^\circ\text{C/W}$

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



**4 AMPERE
POWER TRANSISTORS**

**NPN SILICON
60-80 VOLTS
20 WATTS**



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
B	11.94	12.70	0.470	0.500
C	6.35	8.64	0.250	0.340
D	0.71	0.86	0.028	0.034
E	1.27	1.91	0.050	0.075
F	24.33	24.43	0.958	0.962
G	4.83	5.33	0.190	0.210
H	2.41	2.67	0.095	0.105
J	14.48	14.99	0.570	0.590
K	9.14	—	0.360	—
P	—	1.27	—	0.050
Q	3.61	3.86	0.142	0.152
S	—	8.89	—	0.350
T	—	3.68	—	0.145
U	—	15.75	—	0.620

All JEDEC Dimensions and Notes Apply.

**CASE 80-02
TO-66**

2N3766, 2N3767 (continued)

ELECTRICAL CHARACTERISTICS (T_c = 25°C unless otherwise noted)

Characteristic	Figure No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Voltage ⁽¹⁾ (I _C = 100 mA, I _B = 0)	2	BV _{CEO}	60 80	— —	Vdc
Emitter-Base Cutoff Current (V _{EB} = 6.0 Vdc)	—	I _{EBO}	—	0.75	mA
Collector Cutoff Current (V _{CE} = 80 Vdc, V _{BE} = 1.5 Vdc) (V _{CE} = 100 Vdc, V _{BE} = 1.5 Vdc) (V _{CE} = 50 Vdc, V _{BE} = 1.5 Vdc, T _C = 150°C) (V _{CE} = 70 Vdc, V _{BE} = 1.5 Vdc, T _C = 150°C)	4, 6	I _{CEX}	— — — —	0.1 0.1 1.0 1.0	mA
Collector-Emitter Cutoff Current (V _{CE} = 60 Vdc, I _B = 0) (V _{CE} = 80 Vdc, I _B = 0)	6	I _{CEO}	— —	0.7 0.7	mA
Collector-Base Cutoff Current (V _{CB} = 80 Vdc, I _E = 0) (V _{CB} = 100 Vdc, I _E = 0)	4	I _{CBO}	— —	0.1 0.1	mA

ON CHARACTERISTICS

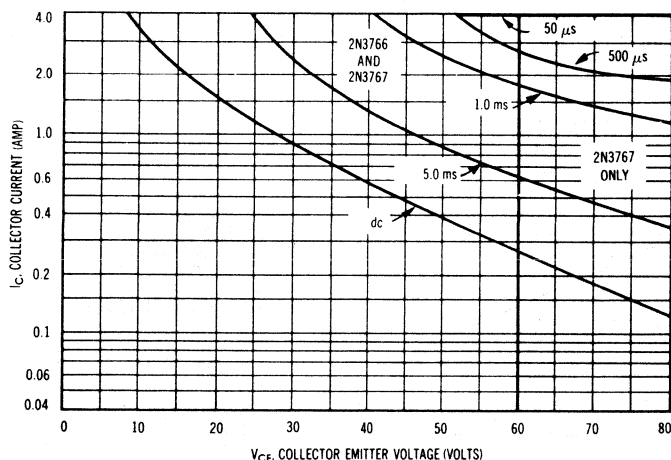
DC Current Gain (I _C = 50 mA, V _{CE} = 5.0 Vdc) (I _C = 500 mA, V _{CE} = 5.0 Vdc) (I _C = 1.0 A, V _{CE} = 10 Vdc)	7	h _{FE}	30 40 20	— 160 —	—
Collector-Emitter Saturation Voltage (I _C = 1.0 A, I _B = 0.1 A) (I _C = 500 mA, I _B = 50 mA)	8, 9	V _{CE(sat)}	— —	2.5 1.0	Vdc
Base-Emitter Voltage (I _C = 1.0 A, V _{CE} = 10 Vdc)	3, 5, 9	V _{BE}	—	1.5	Vdc

TRANSIENT CHARACTERISTICS

Current-Gain - Bandwidth Product (I _C = 500 mA, V _{CE} = 10 Vdc, f = 10 MHz)	—	f _T	10	—	MHz
Common-Base Output Capacitance (V _{CB} = 10 Vdc, I _C = 0 A, f = 100 kHz)	13	C _{ob}	—	50	pF
Small-Signal Current Gain (I _C = 100 mA, V _{CE} = 10 Vdc, f = 1.0 kHz)	—	h _{fe}	40	—	—

⁽¹⁾ Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

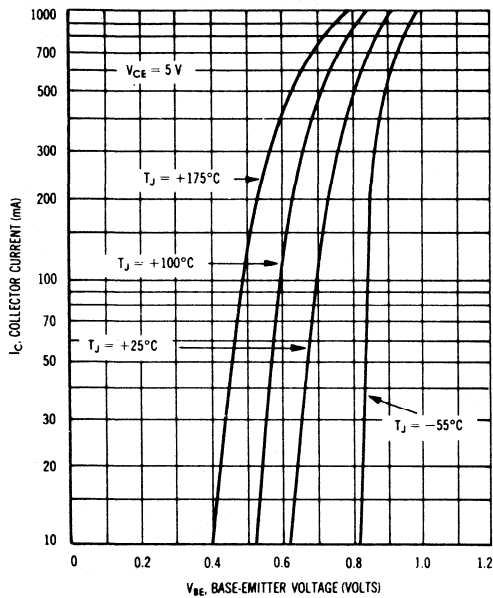
FIGURE 2 — ACTIVE REGION SAFE AREAS



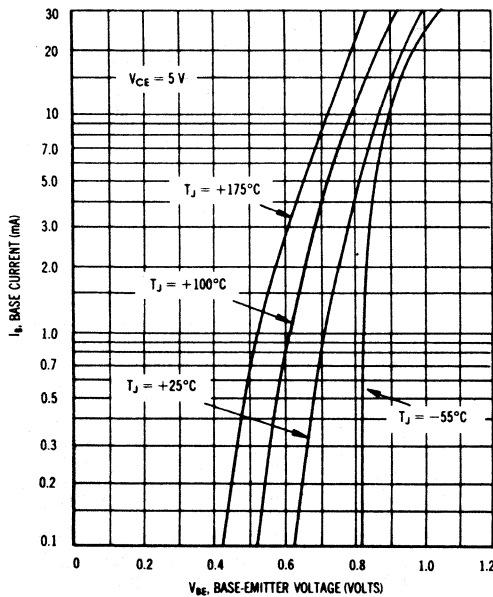
The Safe Operating Area Curves indicate I_C-V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Case temperature and duty cycle of the excursions make no significant change in these safe areas.) The load line may exceed the BV_{CEO} voltage limit only if the collector current has been reduced to 20 mA or less before or at the BV_{CE(sat)} limit; then and only then may the load line be extended to the absolute maximum voltage rating of BV_{CEO}. To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

LARGE SIGNAL CHARACTERISTICS

TRANSCONDUCTANCE

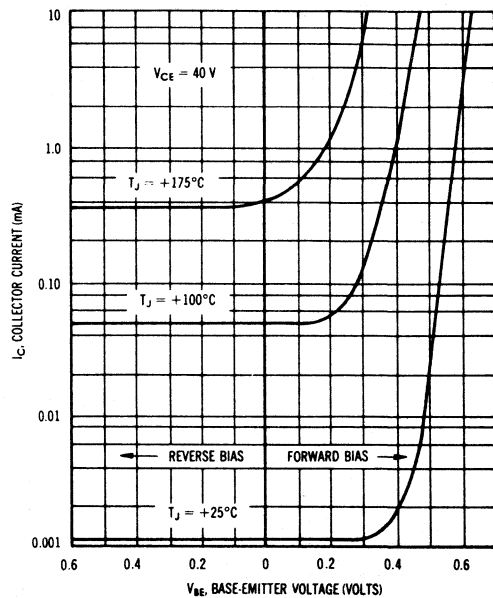


INPUT ADMITTANCE

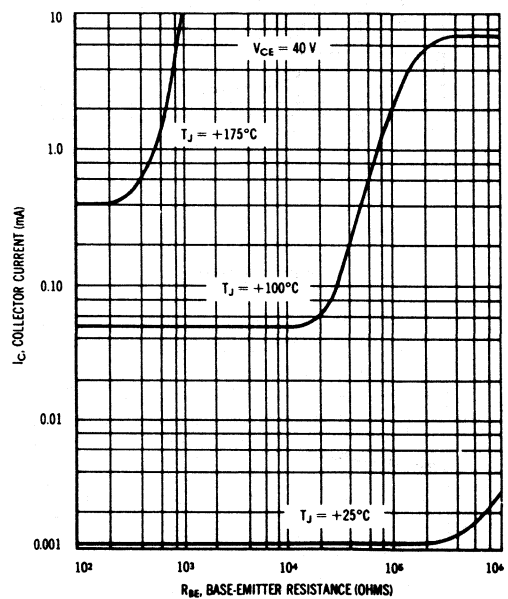


CUT-OFF CHARACTERISTICS

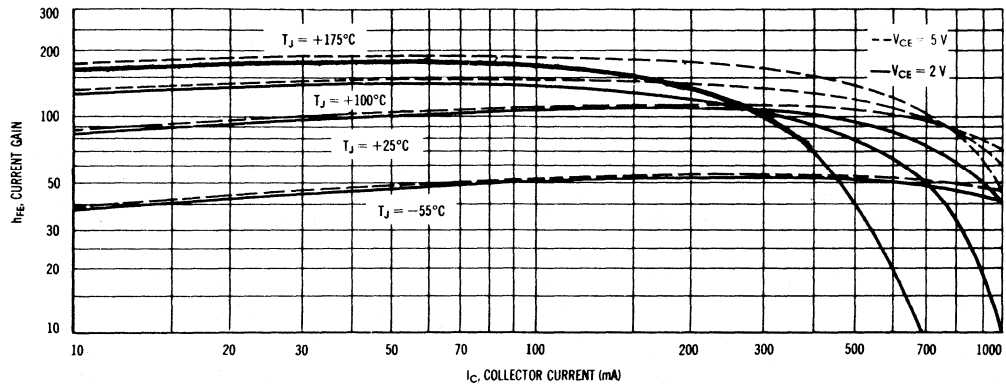
TRANSCONDUCTANCE



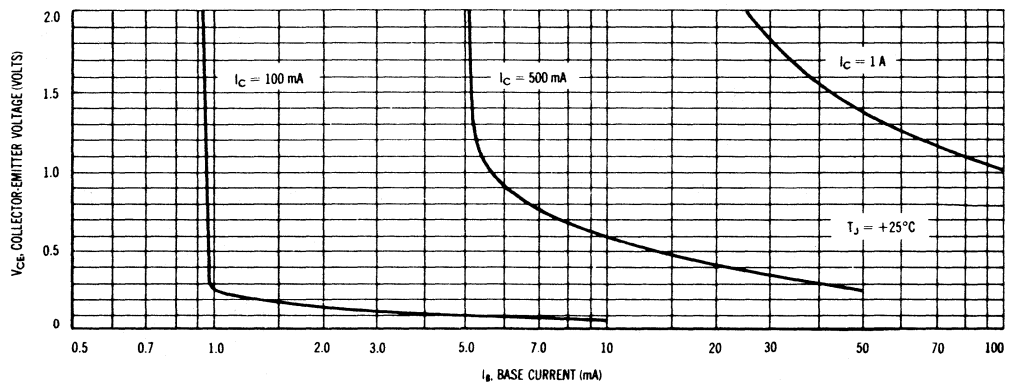
EFFECT OF BASE-EMITTER RESISTANCE



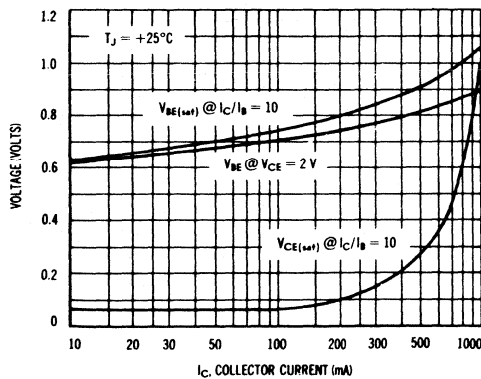
CURRENT GAIN



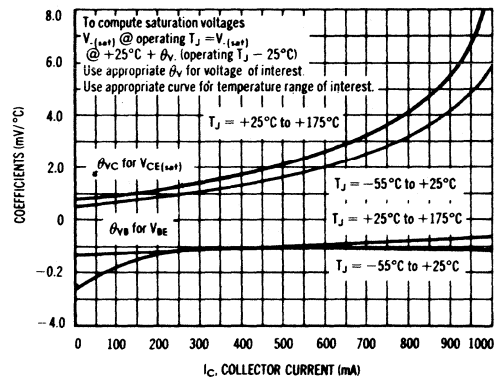
COLLECTOR SATURATION REGION



"ON" VOLTAGES



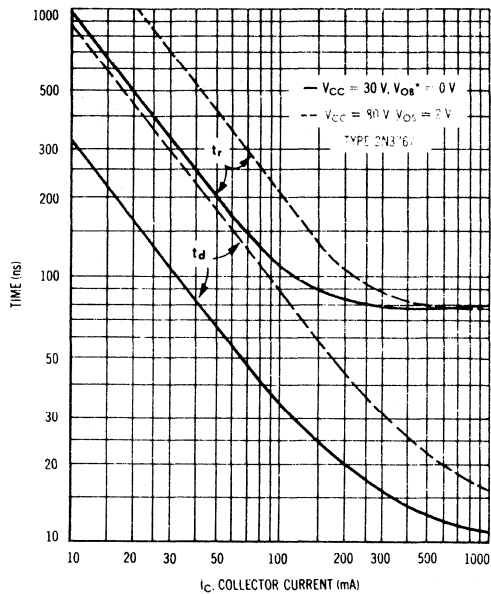
TEMPERATURE CO-EFFICIENTS



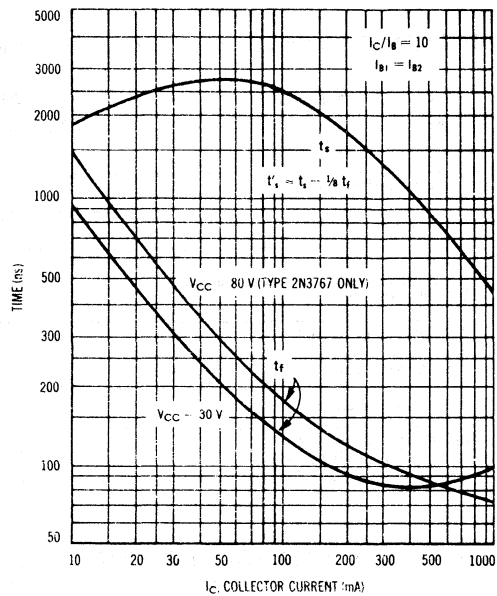
TRANSIENT CHARACTERISTICS

($T_J = 25^\circ\text{C}$)

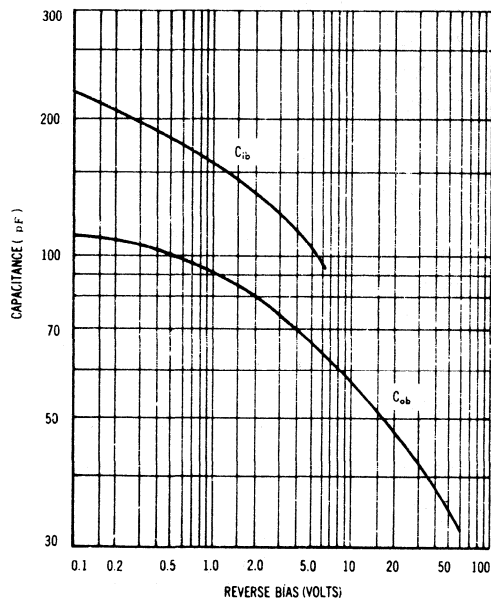
TURN-ON TIME



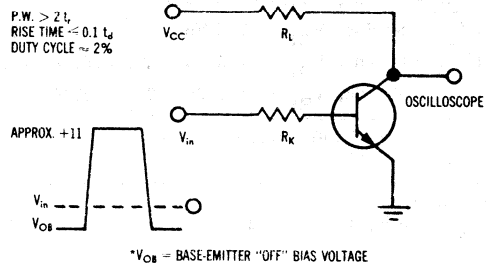
TURN-OFF TIME



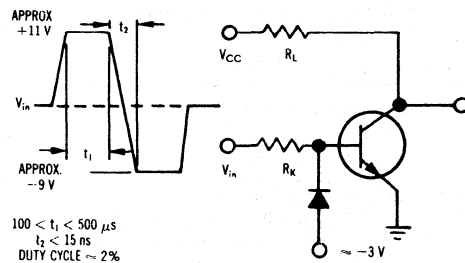
CAPACITANCE



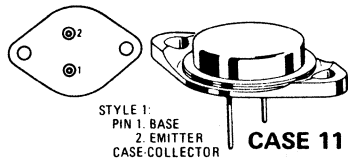
EQUIVALENT CIRCUIT FOR MEASURING DELAY AND RISE TIME



EQUIVALENT CIRCUIT FOR MEASURING STORAGE AND FALL TIMES



2N3789 thru 2N3792 (SILICON)



CASE 11

PNP silicon power transistors for medium-speed switching and amplifier applications. Complement to NPN type 2N3713 thru 2N3716.

Collector connected to case

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	2N3789 2N3791	2N3790 2N3792	Unit
Collector-Base Voltage	V _{CB}	60	80	Volts
Collector-Emitter Voltage	V _{CEO}	60	80	Volts
Emitter-Base Voltage	V _{EB}	7.0	7.0	Volts
Collector Current	I _C	10	10	Amp
Collector Current (Peak)	I _C	10	10	Amp
Base Current (Continuous)	I _B	4.0	4.0	Amp
Power Dissipation	P _D	150	150	Watts
Thermal Resistance	θ _{JC}	1.17	1.17	°C/W
Junction Operating and Storage Temperature Range	T _J , T _{stg}	-65 to +200		°C

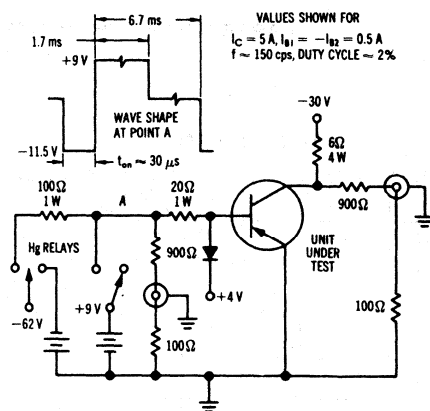
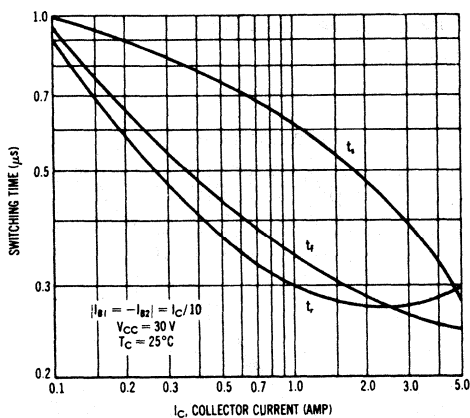
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Emitter Sustaining Voltage* (I _C = 200 mAdc, I _B = 0)	V _{CEO(sus)} *	60 80	— —	Vdc
Collector-Emitter Cutoff Current (V _{CE} = 60 Vdc, V _{BE} = -1.5 Vdc) (V _{CE} = 80 Vdc, V _{BE} = -1.5 Vdc) (V _{CE} = 60 Vdc, V _{BE} = -1.5 Vdc, T _C = 150°C) (V _{CE} = 80 Vdc, V _{BE} = -1.5 Vdc, T _C = 150°C)	I _{CEX}	— — — —	1.0 1.0 5.0 5.0	mAdc
Emitter-Base Cutoff Current (V _{EB} = 7 Vdc)	I _{EBO}	—	5.0	mAdc
DC Current Gain* (I _C = 1 Adc, V _{CE} = 2 Vdc) (I _C = 3 Adc, V _{CE} = 2 Vdc)	h _{FE} *	25 50 15 30	90 150 — —	—
Collector-Emitter Saturation Voltage* (I _C = 4 Adc, I _B = 0.4 Adc) (I _C = 5 Adc, I _B = 0.5 Adc)	V _{CE(sat)} *	— —	1.0 1.0	Vdc
Base-Emitter Saturation Voltage* (I _C = 4 Adc, I _B = 0.4 Adc) (I _C = 5 Adc, I _B = 0.5 Adc)	V _{BE(sat)} *	— —	2.0 1.5	Vdc
Current Gain — Bandwidth Product (V _{CE} = 10 Vdc, I _C = 0.5 Adc f = 1.0 MHz)	f _T	4.0	—	MHz

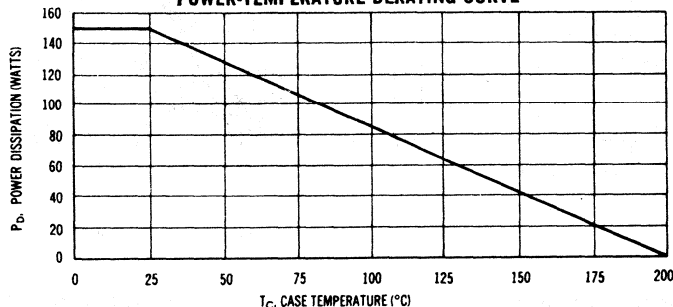
*Sweep Test: 1/2 sine wave cycle @ 60 Hz .

2N3789 thru 2N3792 (continued)

TYPICAL SWITCHING TIMES AND TEST CIRCUIT



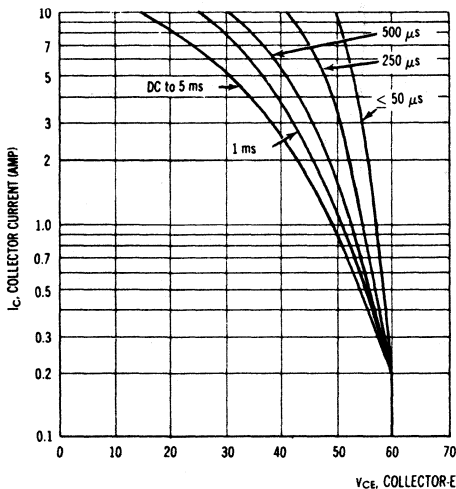
POWER-TEMPERATURE DERATING CURVE



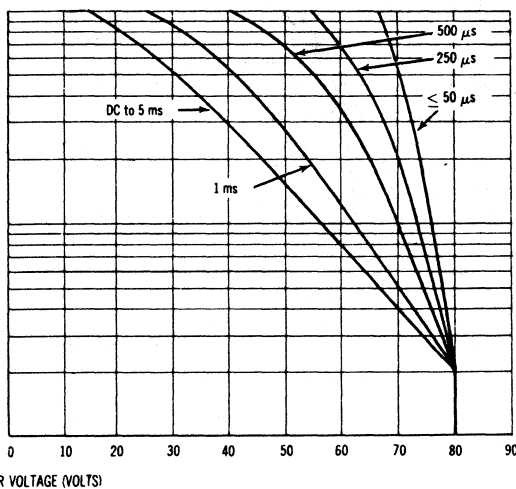
Safe area curves are indicated. Both limits are applicable and must be observed.

ACTIVE-REGION SAFE OPERATING AREAS

2N3789, 2N3791



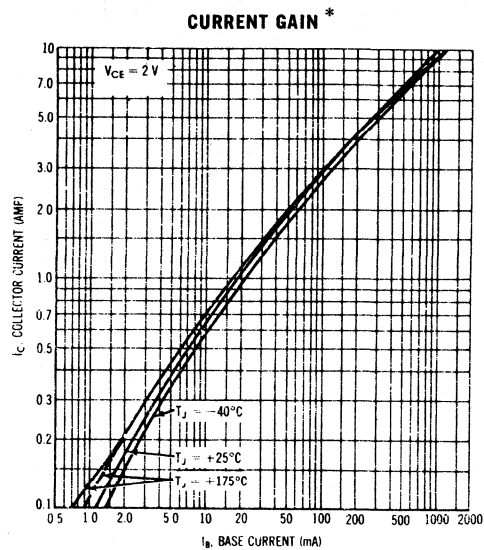
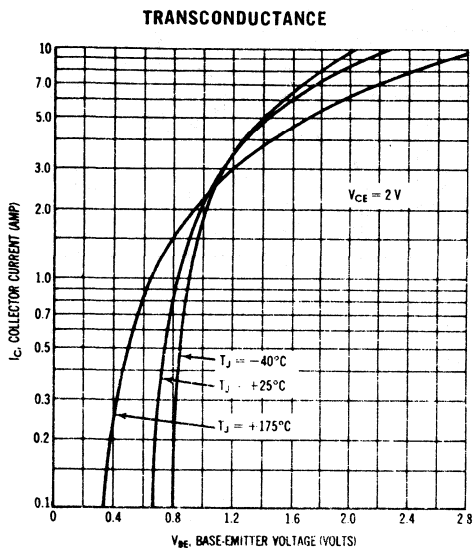
2N3790, 2N3792



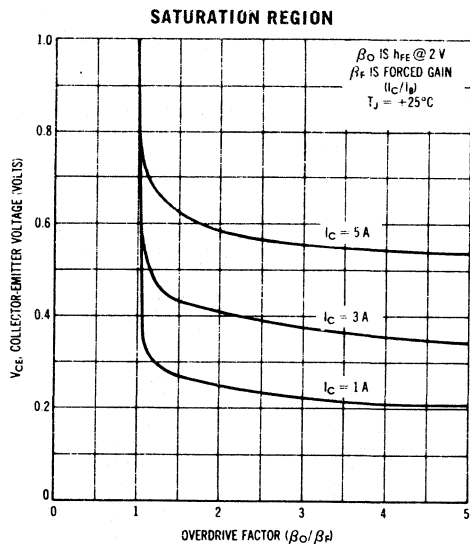
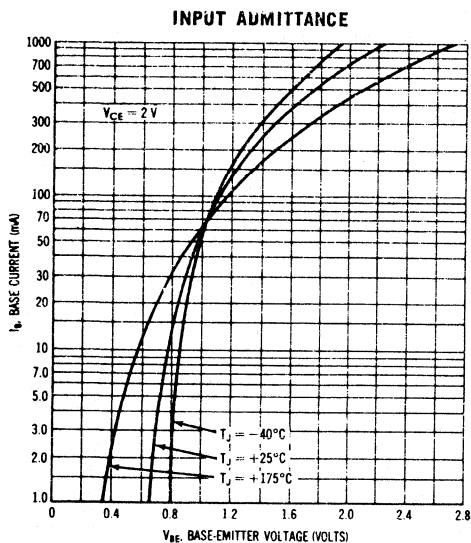
The Safe Operating Area Curves indicate I_C - V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursion make no significant change in these safe areas.) To insure operation below the maximum T_J , the power-temperature derating curve must be observed for both steady state and pulse power conditions.

LARGE SIGNAL CHARACTERISTICS - TYPE 2N3789, 2N3790

(PULSE TEST: pulse width $\approx 200 \mu s$, duty cycle $\approx 1\%$)



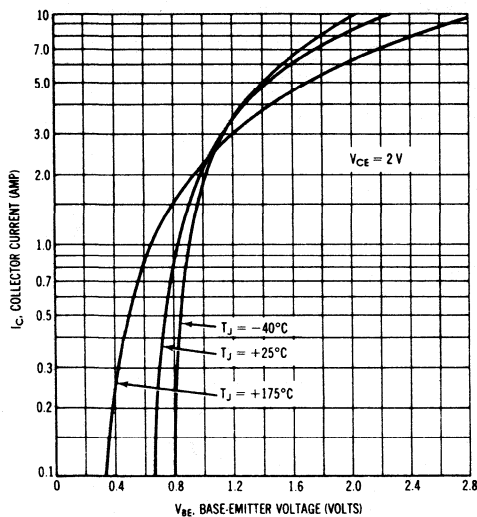
*Dashed line indicates metered base current minus I_{C80} of the transistor at $175^\circ C$.



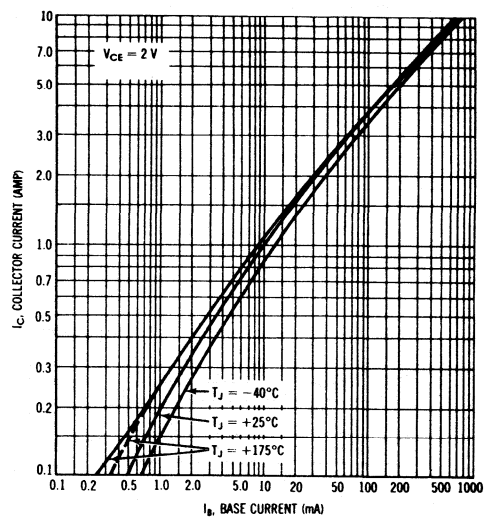
LARGE SIGNAL CHARACTERISTICS – TYPE 2N3791, 2N3792

(PULSE TEST: pulse width $\sim 200 \mu\text{sec}$, duty cycle $\sim 1\%$)

TRANSCONDUCTANCE

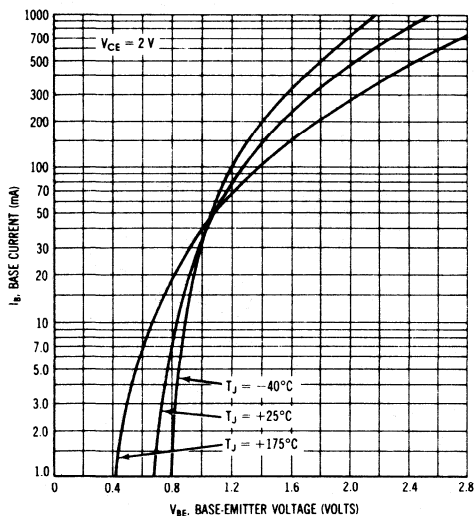


CURRENT GAIN

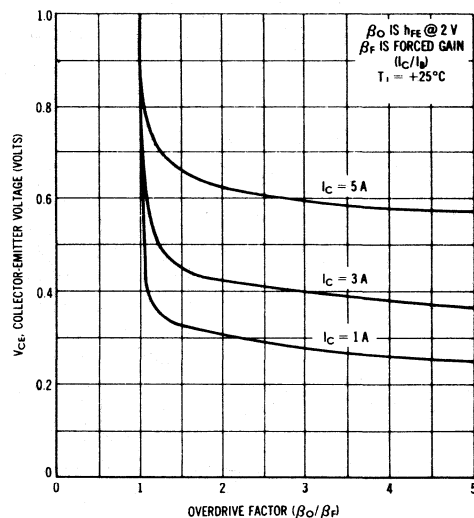


Dashed line indicates metered base current minus I_{CBO} of the transistor at 175°C .

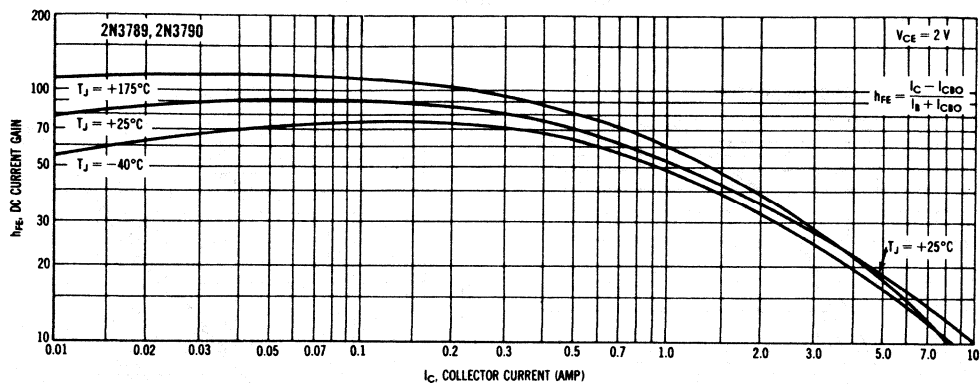
INPUT ADMITTANCE



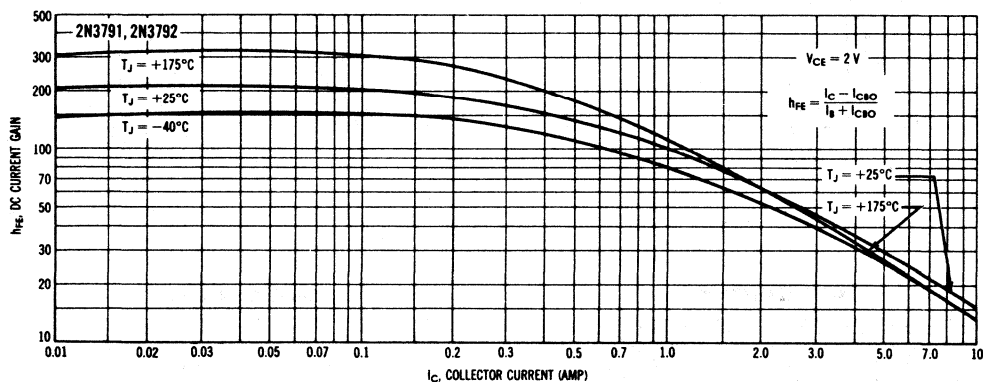
SATURATION REGION



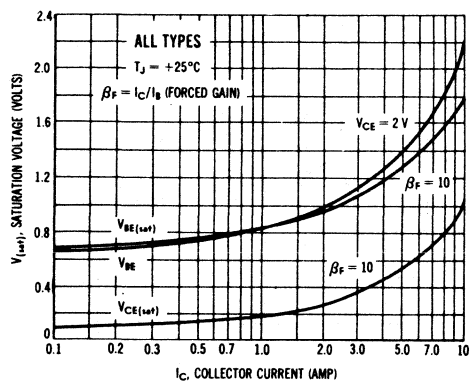
CURRENT GAIN VARIATIONS



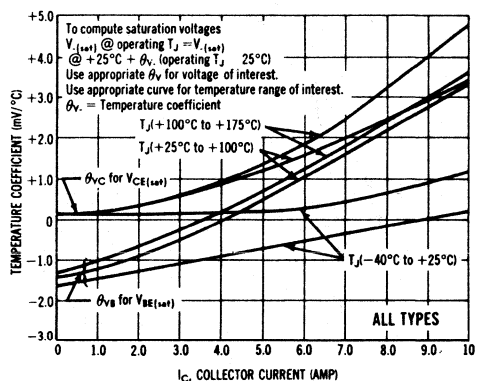
CURRENT GAIN VARIATIONS



SATURATION VOLTAGES



TEMPERATURE COEFFICIENTS

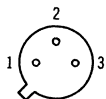


2N3796 (SILICON)

2N3797



CASE 22
(TO-18)



Silicon N-channel MOS field-effect transistor designed for low-power applications in the audio frequency range.

STYLE 2:
PIN 1. SOURCE, SUBSTRATE
AND CASE
2. GATE
3. DRAIN

MAXIMUM RATINGS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-Source Voltage 2N3796 2N3797	V_{DS}	25 20	Vdc
Gate-Source Voltage	V_{GS}	± 30	Vdc
Drain Current	I_D	20	mAdc
Power Dissipation at $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 1.7	mW mW/ $^\circ\text{C}$
Operating Junction Temperature	T_J	+200	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Drain-Source Breakdown Voltage ($V_{GS} = -4.0\text{ V}$, $I_D = 5.0\text{ }\mu\text{A}$) ($V_{GS} = -7.0\text{ V}$, $I_D = 5.0\text{ }\mu\text{A}$)	BV_{DSX}	25 20	30 25	— —	Vdc
Zero-Gate-Voltage Drain Current ($V_{DS} = 10\text{ V}$, $V_{GS} = 0$)	I_{DSS}	0.5 2.0	1.5 2.9	3.0 6.0	mAdc
Gate-Source Voltage Cutoff ($I_D = 0.5\text{ }\mu\text{A}$, $V_{DS} = 10\text{ V}$) ($I_D = 2.0\text{ }\mu\text{A}$, $V_{DS} = 10\text{ V}$)	$V_{GS(off)}$	— —	3.0 5.0	4.0 7.0	Vdc
"On" Drain Current ($V_{DS} = 10\text{ V}$, $V_{GS} = +3.5\text{ V}$)	$I_{D(on)}$	7.0 9.0	8.3 14	14 18	mAdc
Drain-Gate Reverse Current * ($V_{DG} = 10\text{ V}$, $I_S = 0$)	I_{DGO}^*	—	—	1.0	pAdc
Gate-Reverse Current * ($V_{GS} = -10\text{ V}$, $V_{DS} = 0$) ($V_{GS} = -10\text{ V}$, $V_{DS} = 0$, $T_A = 150^\circ\text{C}$)	I_{GSS}^*	— —	— —	1.0 200	pAdc
Small-Signal, Common-Source Forward Transfer Admittance ($V_{DS} = 10\text{ V}$, $V_{GS} = 0$, $f = 1.0\text{ kHz}$) ($V_{DS} = 10\text{ V}$, $V_{GS} = 0$, $f = 1.0\text{ MHz}$)	$ y_{fs} $	900 1500 900 1500	1200 2300 — —	1800 3000 — —	μmhos
Small-Signal, Common-Source, Output Admittance ($V_{DS} = 10\text{ V}$, $V_{GS} = 0$, $f = 1.0\text{ kHz}$)	$ y_{os} $	— —	12 27	25 60	μmhos
Small-Signal, Common-Source, Input Capacitance ($V_{DS} = 10\text{ V}$, $V_{GS} = 0$, $f = 1.0\text{ MHz}$)	C_{iss}	— —	5.0 6.0	7.0 8.0	pF
Small-Signal, Common-Source, Reverse Transfer Capacitance ($V_{DS} = 10\text{ V}$, $V_{GS} = 0$, $f = 1.0\text{ MHz}$)	C_{rss}	—	0.5	0.8	pF
Noise Figure ($V_{DS} = 10\text{ V}$, $V_{GS} = 0$, $f = 1.0\text{ kHz}$, $R_S = 3\text{ megohms}$)	NF	—	3.8	—	dB

* This value of current includes both the FET leakage current as well as the leakage current associated with the test socket and fixture when measured under best attainable conditions.

TYPICAL DRAIN CHARACTERISTICS

FIGURE 1 — 2N3796

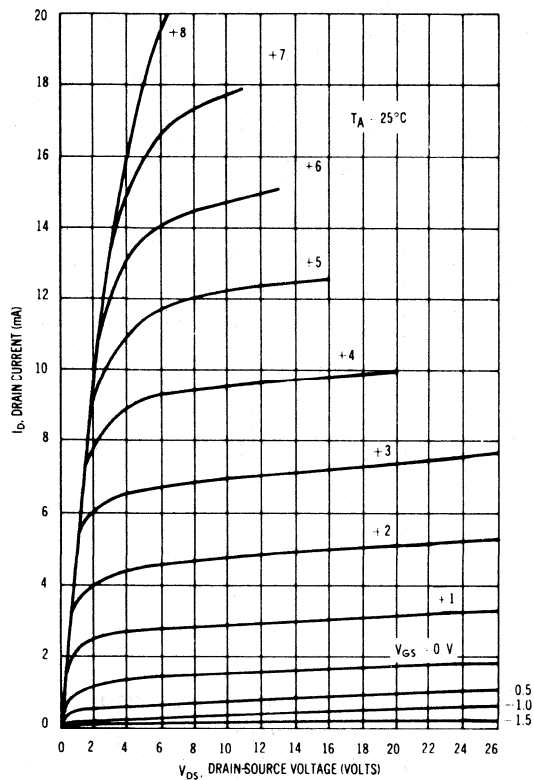
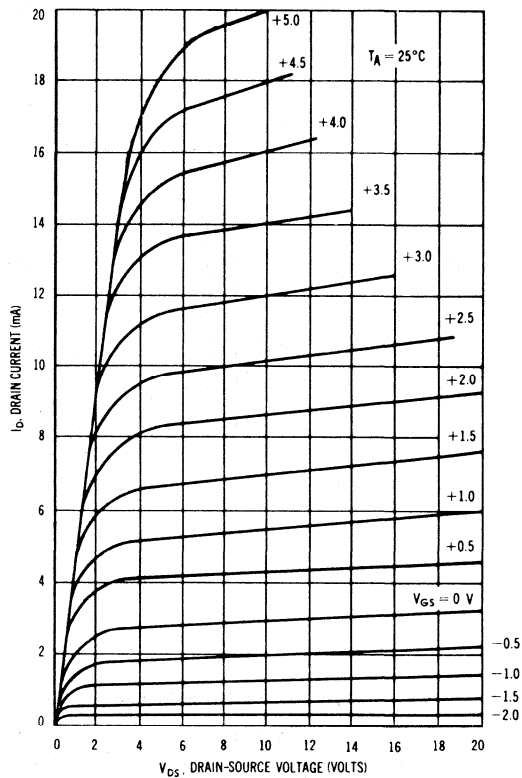


FIGURE 2 — 2N3797



COMMON SOURCE TRANSFER CHARACTERISTICS

FIGURE 3 — 2N3796

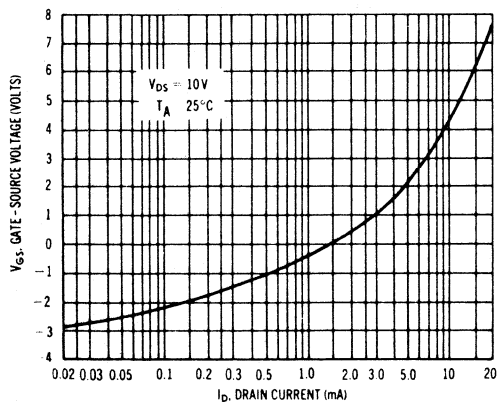


FIGURE 4 — 2N3797

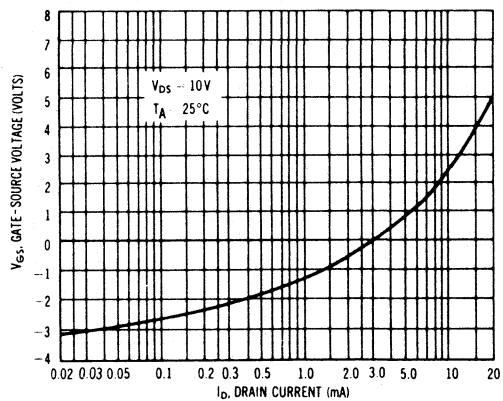


FIGURE 5 — FORWARD TRANSFER ADMITTANCE

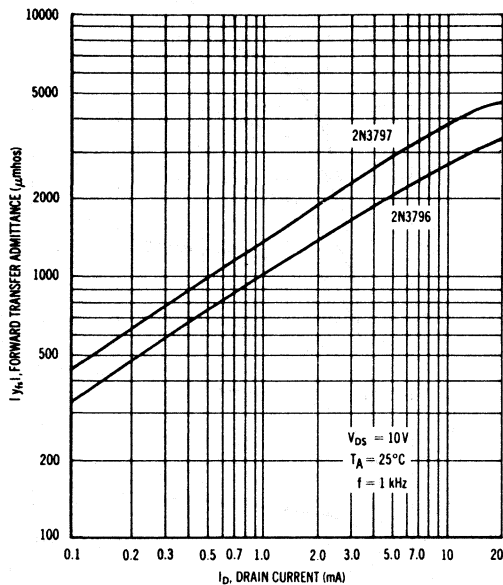


FIGURE 6 — AMPLIFICATION FACTOR

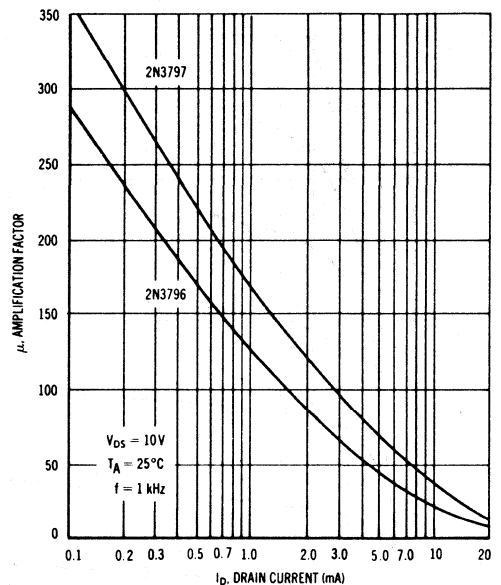


FIGURE 7 — OUTPUT ADMITTANCE

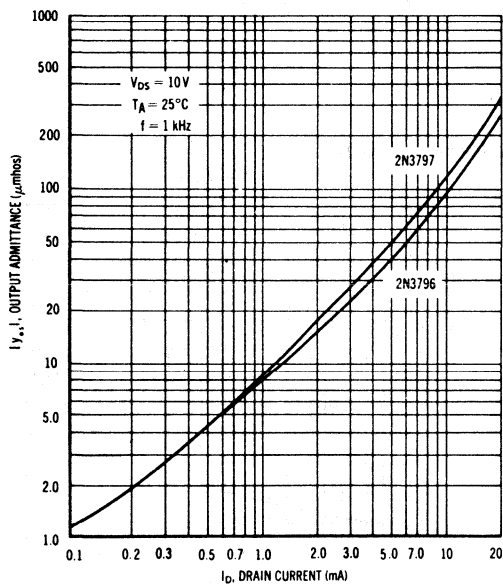
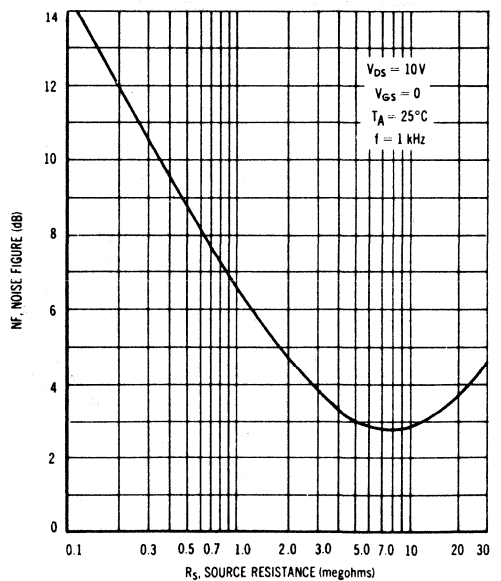


FIGURE 8 — NOISE FIGURE



2N3798, 2N3798A (SILICON)

2N3799, 2N3799A

PNP SILICON ANNULAR TRANSISTORS

... designed for low-level, low-noise amplifier applications.

- High Collector-Emitter Breakdown Voltages –
 $V_{CEO} = 60 \text{ Vdc (Min) – 2N3798, 2N3799}$
 $90 \text{ Vdc (Min) – 2N3798A, 2N3799A}$
- DC Current Gain – @ $I_C = 500 \mu\text{Adc}$
 $h_{FE} = 150\text{-}450 \text{ – 2N3798, 2N3798A}$
 $300\text{-}900 \text{ – 2N3799, 2N3799A}$
- Low Noise Figure –
 $NF = 1.5 \text{ dB (Max) @ } 1.0 \text{ kHz and } 10 \text{ kHz}$

*MAXIMUM RATINGS

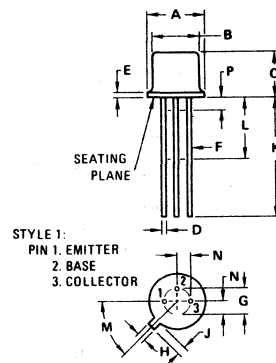
Rating	Symbol	2N3798 2N3799	2N3798A 2N3799A	Unit
Collector-Emitter Voltage	V_{CEO}	60	90	Vdc
Collector-Base Voltage	V_{CB}	60	90	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	50		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.36 2.06		Watt W/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.2 6.9		Watts W/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.15	$^\circ\text{C/mW}$
Thermal Resistance, Junction to Ambient	θ_{JA}	0.49	$^\circ\text{C/mW}$

*Indicates JEDEC Registered Data.

PNP SILICON AMPLIFIER TRANSISTORS



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	—	0.762	—	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	—	1.27	—	0.050

All JEDEC notes and dimensions apply.

CASE 22-03 |
(TO-18)

2N3798, 2N3798A, 2N3799, 2N3799A (continued)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10 \text{ mA}$, $I_B = 0$)	BV_{CEO}	60 90	— —	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \text{ } \mu\text{A}$, $I_E = 0$)	BV_{CBO}	60 90	— —	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \text{ } \mu\text{A}$, $I_C = 0$)	BV_{EBO}	5.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 50 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 50 \text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	— —	0.01 10	μA
Emitter Cutoff Current ($V_{BE} = 4.0 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	—	20	nA
ON CHARACTERISTICS					
DC Current Gain(1) ($I_C = 1.0 \text{ } \mu\text{A}$, $V_{CE} = 5.0 \text{ Vdc}$) ($I_C = 10 \text{ } \mu\text{A}$, $V_{CE} = 5.0 \text{ Vdc}$) ($I_C = 100 \text{ } \mu\text{A}$, $V_{CE} = 5.0 \text{ Vdc}$) ($I_C = 100 \text{ } \mu\text{A}$, $V_{CE} = 5.0 \text{ Vdc}$, $T_A = -55^\circ\text{C}$) ($I_C = 500 \text{ } \mu\text{A}$, $V_{CE} = 5.0 \text{ Vdc}$) ($I_C = 1.0 \text{ mA}$, $V_{CE} = 5.0 \text{ Vdc}$) ($I_C = 10 \text{ mA}$, $V_{CE} = 5.0 \text{ Vdc}$)	h_{FE}	75 100 225 150 300 75 150 150 300 150 300 125 250	— — — — — — —	— — — — 450 900	—
Collector-Emitter Saturation Voltage(1) ($I_C = 100 \text{ } \mu\text{A}$, $I_B = 10 \text{ } \mu\text{A}$) ($I_C = 1.0 \text{ mA}$, $I_B = 100 \text{ } \mu\text{A}$)	$V_{CE(sat)}$	—	—	0.2 0.25	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 100 \text{ } \mu\text{A}$, $I_B = 10 \text{ } \mu\text{A}$) ($I_C = 1.0 \text{ mA}$, $I_B = 100 \text{ } \mu\text{A}$)	$V_{BE(sat)}$	—	—	0.7 0.8	Vdc
Base-Emitter On Voltage ($I_C = 100 \text{ } \mu\text{A}$, $V_{CE} = 5.0 \text{ Vdc}$)	$V_{BE(on)}$	—	—	0.7	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current Gain-Bandwidth Product(2) ($I_C = 500 \text{ } \mu\text{A}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 30 \text{ MHz}$) ($I_C = 1.0 \text{ mA}$, $V_{CE} = 5.0 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	30 100	—	500	MHz
Output Capacitance ($V_{CB} = 5.0 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)	C_{ob}	—	—	4.0	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 100 \text{ kHz}$)	C_{ib}	—	—	8.0	pF
Input Impedance ($I_C = 1.0 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{ie}	3.0 10	—	15 40	k ohms
Voltage Feedback Ratio ($I_C = 1.0 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{re}	—	—	25	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{fe}	150 300	—	600 900	—
Output Admittance ($I_C = 1.0 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{oe}	5.0	—	60	μmhos
Noise Figure ($I_C = 100 \text{ } \mu\text{A}$, $V_{CE} = 10 \text{ Vdc}$, $R_G = 3.0 \text{ k ohms}$) Spot Noise f = 100 Hz, B.W. = 20 Hz f = 1.0 kHz, B.W. = 200 Hz f = 10 kHz, B.W. = 2.0 kHz Broadband Noise Bandwidth 10 Hz to 15.7 kHz	NF	— — — — —	4.0 2.5 1.5 0.8 1.0 0.8 2.5 1.5	7.0 4.0 3.0 1.5 2.5 1.5 3.5 2.5	dB

*Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width $\leq 300 \text{ } \mu\text{s}$, Duty Cycle $\leq 2.0\%$

(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

SPOT NOISE FIGURE
($V_{CE} = 10 \text{ Vdc}$, $T_A = 25^\circ\text{C}$)

FIGURE 1 – SOURCE RESISTANCE EFFECTS, $f = 1.0 \text{ kHz}$

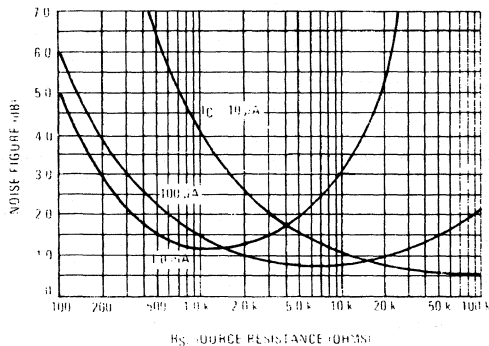


FIGURE 2 – SOURCE RESISTANCE EFFECTS, $f = 10 \text{ Hz}$

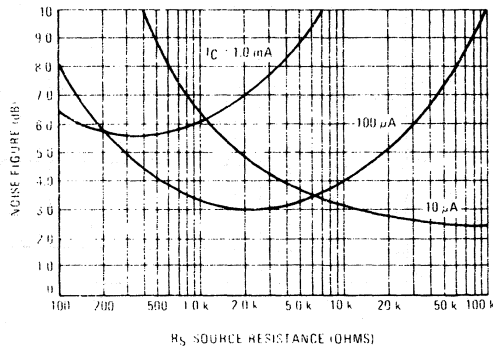


FIGURE 3 – FREQUENCY EFFECTS

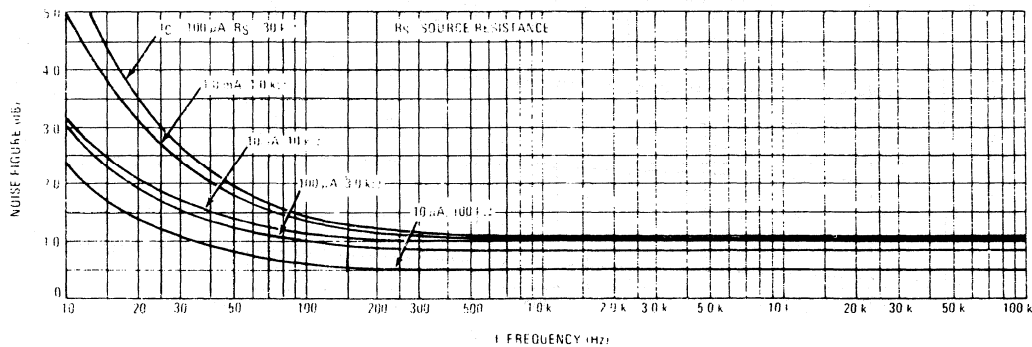
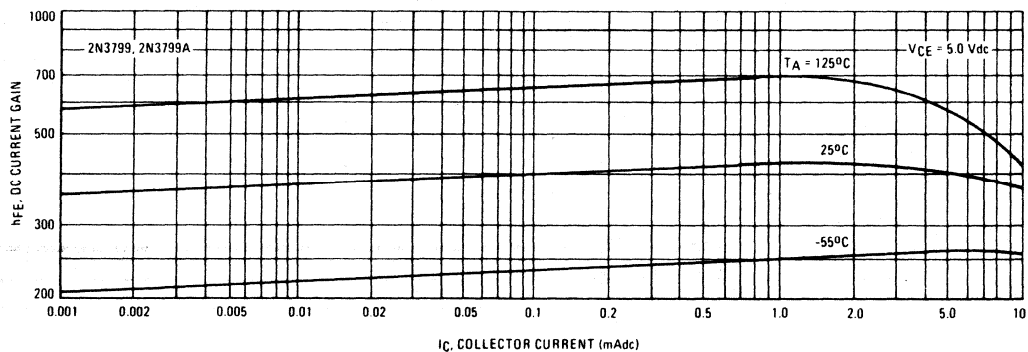
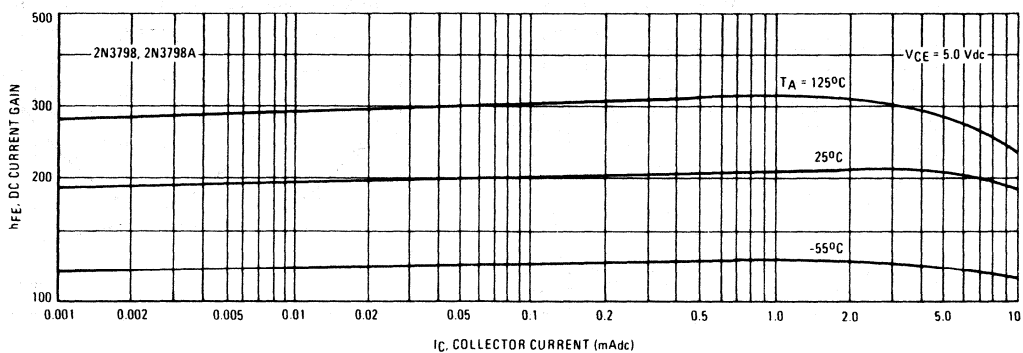


FIGURE 4 – TYPICAL CURRENT GAIN CHARACTERISTICS



2N3806 thru 2N3810,A (SILICON)

2N3811,A

2N3812 thru 2N3816,A, 2N3817,A

2N3810, 2N3811, JAN,JTX,JTXV AVAILABLE

MULTIPLE SILICON ANNULAR TRANSISTORS

... designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Excellent Temperature Tracking – Dual Devices
2N3808, 9, 14, 15
 $\Delta|V_{BE1} - V_{BE2}| = 1.6 \text{ mVdc (Max) @ } -55 \text{ to } +25^{\circ}\text{C}$
 $= 2.0 \text{ mVdc (Max) @ } +25 \text{ to } +125^{\circ}\text{C}$
- Low Collector-Emitter Saturation Voltage –
 $V_{CE(sat)} = 0.25 \text{ Vdc (Max) @ } I_C = 1.0 \text{ mAdc}$
- DC Current Gain Specified – $1.0 \mu\text{Adc to } 10 \text{ mAdc}$
- DC Current-Gain – Bandwidth Product –
 $f_T = 100 \text{ MHz @ } I_C = 1.0 \text{ mAdc}$

*MAXIMUM RATINGS

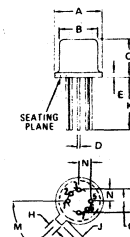
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	50	mAdc
		One Die	Both Die
Total Power Dissipation @ $T_A = 25^{\circ}\text{C}$ Metal Can (2N3806 thru 2N3810,A, 2N3811,A) Derate above 25°C	P_D	500	600
		2.86	3.43
Total Power Dissipation @ $T_C = 25^{\circ}\text{C}$ Flat Package (2N3812 thru 2N3816,A, 2N3817,A) Derate above 25°C	P_D	250	350
		1.43	2.06
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	
		$^{\circ}\text{C}$	

*Indicates JEDEC Registered Data.

PNP SILICON MULTIPLE TRANSISTORS

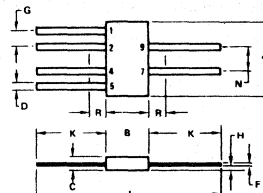


STYLE 1
PIN 1 COLLECTOR
2 BASE
3 EMITTER
4 OMMITTER
5 EMITTER
6 BASE
7 COLLECTOR
8 OMMITTER



DIM	MIN	MAX	MIN	MAX
A	8.51	8.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.88	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70		0.500	
N	45° BSC		45° BSC	
R	2.54 BSC		0.100 BSC	

CASE 654-07



STYLE 1
PIN 1 BASE
2 EMITTER
4 EMITTER
5 BASE
7 COLLECTOR
9 COLLECTOR

DIM	MIN	MAX	MIN	MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.38	0.48	0.014	0.019
F	0.68	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H		0.89		0.035
N	3.81		0.150	
R	2.54 BSC		0.100 BSC	
R		1.27		0.050

CASE 610A-03

*ELECTRICAL CHARACTERISTICS (each side) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) ($I_C = 10\text{ mAdc}$, $I_B = 0$)	BV_{CEO}	60	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 50\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 50\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	0.01 10	μAdc
Emitter Cutoff Current ($V_{BE(off)} = 4.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	20	nAdc

ON CHARACTERISTICS

DC Current Gain (1) ($I_C = 1.0\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 10\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 100\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 100\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$, $T_A = -55^\circ\text{C}$) ($I_C = 500\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$)	2N3807, 9,11,A,13,15,17,A 2N3806,8,10,A,12,14,16,A 2N3807,9,11,A,13,15,17,A 2N3806,8,10,A,12,14,16,A 2N3807,9,11,A,13,15,17,A 2N3806,8,10,A,12,14,16,A 2N3807,9,11,A,13,15,17,A 2N3806,8,10,A,12,14,16,A 2N3807,9,11,A,13,15,17,A 2N3806,8,10,A,12,14,16,A 2N3807,9,11,A,13,15,17,A 2N3806,8,10,A,12,14,16,A 2N3807,9,11,A,13,15,17,A	h_{FE}	75 100 225 150 300 75 150 150 300 150 300 125 250	— — — 450 900 — — 450 900 450 900 — —	Vdc
Collector-Emitter Saturation Voltage (1) ($I_C = 100\text{ }\mu\text{Adc}$, $I_B = 10\text{ }\mu\text{Adc}$) ($I_C = 1.0\text{ mAdc}$, $I_B = 100\text{ }\mu\text{Adc}$)		$V_{CE(sat)}$	— —	0.2 0.25	Vdc
Base-Emitter Saturation Voltage (1) ($I_C = 100\text{ }\mu\text{Adc}$, $I_B = 10\text{ }\mu\text{Adc}$) ($I_C = 1.0\text{ mAdc}$, $I_B = 100\text{ }\mu\text{Adc}$)		$V_{BE(sat)}$	— —	0.7 0.8	Vdc
Base-Emitter On Voltage ($I_C = 100\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$)		$V_{BE(on)}$	—	0.7	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current Gain — Bandwidth Product ($I_C = 500\text{ }\mu\text{Adc}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 30\text{ MHz}$) ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	30 100	— 500	MHz
Output Capacitance ($V_{CB} = 5.0\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)	C_{ob}	—	4.0	pF
Input Capacitance ($V_{BE(off)} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)	C_{ib}	—	8.0	pF
Input Impedance ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$) 2N3806,8,10,A,12,14,16,A 2N3807,9,11,A,13,15,17,A	h_{ie}	3.0 10	30 40	k Ω
Voltage Feedback Ratio ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{re}	—	25	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$) 2N3806,8,10,A,12,14,16,A 2N3807,9,11,A,13,15,17,A	h_{fe}	150 300	600 900	—

*Indicates JEDEC Registered Data.

2N3806 thru 2N3810,A, 2N3811,A, 2N3812 thru 2N3816,A, 2N3817,A (continued)

Characteristic	Symbol	Min	Max	Unit
----------------	--------	-----	-----	------

SMALL-SIGNAL CHARACTERISTICS (continued)

Output Admittance ($I_C = 1.0 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{oe}	5.0	60	μmhos
Noise Figure ($I_C = 100 \mu\text{A}$, $V_{CE} = 10 \text{ Vdc}$, $R_G = 3.0 \text{ k ohms}$)	NF			dB
Spot Noise $\left\{ \begin{array}{l} f = 100 \text{ Hz, BW} = 20 \text{ Hz} \\ f = 1.0 \text{ kHz, BW} = 2.0 \text{ kHz} \\ f = 10 \text{ kHz, BW} = 200 \text{ Hz} \end{array} \right.$	2N3806,8,10,A,12,14,16,A	—	7.0	
	2N3807,9,11,A,13,15,17,A	—	4.0	
	2N3806,8,10,A,12,14,16,A	—	3.0	
	2N3807,9,11,A,13,15,17,A	—	1.5	
	2N3806,8,10,A,12,14,16,A	—	2.5	
	2N3807,9,11,A,13,15,17,A	—	1.5	
Broadband Noise Bandwidth 10 Hz to 15.7 kHz	2N3806,8,10,A,12,14,16,A 2N3807,9,11,A,13,15,17,A	— —	3.5 2.5	

MATCHING CHARACTERISTICS

DC Current Gain Ratio (2) ($I_C = 100 \mu\text{A}$, $V_{CE} = 5.0 \text{ Vdc}$)	h_{FE1}/h_{FE2}	0.8 0.9 0.95	1.0 1.0 1.0	—
($I_C = 100 \mu\text{A}$, $V_{CE} = 50 \text{ Vdc}$, $T_A = -55 \text{ to } +125^\circ\text{C}$)		0.85	1.0	
Base-Emitter Voltage Differential ($I_C = 10 \mu\text{A}$ to 10 mA , $V_{CE} = 5.0 \text{ Vdc}$)	$ V_{BE1} - V_{BE2} $	—	8.0	mVdc
2N3808,9,14,15		—	5.0	
2N3810,A,11,A,16,A,17,A		—	5.0	
($I_C = 100 \mu\text{A}$, $V_{CE} = 5.0 \text{ Vdc}$)		—	3.0	
2N3808,9,14,15		—	1.5	
2N3810,11,16,17				
2N3810A,11A,16A,17A				
Base-Emitter Differential Change Due to Temperature ($I_C = 100 \mu\text{A}$, $V_{CE} = 5.0 \text{ Vdc}$, $T_A = -55 \text{ to } +25^\circ\text{C}$)	$\Delta V_{BE1} - V_{BE2} $	—	1.6	mVdc
2N3808,9,14,15		—	0.8	
2N3810,11,16,17		—	0.4	
2N3810A,11A,16A,17A				
($I_C = 100 \mu\text{A}$, $V_{CE} = 5.0 \text{ Vdc}$, $T_A = +25 \text{ to } +125^\circ\text{C}$)		—	2.0	
2N3808,9,14,15		—	1.0	
2N3810,11,16,17		—	0.5	
2N3810A,11A,16A,17A				

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

(2) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

The RF Line

NPN SILICON RF POWER TRANSISTOR

... designed for applications to 150 MHz.

- High Collector-Emitter Sustaining Voltage –
 $V_{CE(sus)} = 80 \text{ Vdc (Min)}$
- Power Output –
 $P_{out} = 15 \text{ Watts at 100 MHz}$
- Power Gain –
 $G_{pE} = 7.0 \text{ dB (Typ)}$ at 100 MHz with 15 Watts RF Power Output

15 W - 100 MHz
RF POWER
TRANSISTOR
NPN SILICON

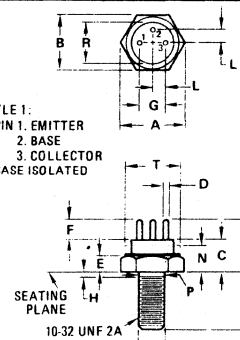


MAXIMUM RATINGS (Note 1)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	60	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	2.0	Adc
Base Current – Continuous	I_B	1.0	mAdc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	25 167	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	$^\circ\text{C}$
Power Input (Nominal)	P_{in}	5.0	Watts
Power Output (Nominal)	P_{out}	20	Watts

Note 1. The maximum ratings as given for dc conditions can be exceeded on a pulse basis. See electrical characteristics.

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR
CASE ISOLATED



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	12.57	13.08	0.495	0.515
B	10.77	11.10	0.424	0.437
C	5.46	8.13	0.215	0.320
D	0.762	1.17	0.030	0.046
E	2.29	3.43	0.090	0.135
F	4.70	5.46	0.185	0.215
G	—	1.98	—	0.078
H	9.53	11.56	0.375	0.455
I	9.02	12.19	0.355	0.480
J	2.29	2.79	0.090	0.110
K	—	4.19	—	0.165
L	4.14	4.80	0.163	0.189
M	8.13	9.14	0.320	0.360
N	9.14	11.10	0.360	0.437

All JEDEC dimensions and notes apply

CASE 36
TO-60

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) ($I_C = 0.25 \text{ A dc}$, $I_B = 0$)	$V_{CE(sus)}$	40	—	—	Vdc
Collector-Emitter Sustaining Voltage(1) ($I_C = 0.25 \text{ A dc}$, $R_{BE} = 0$)	$V_{CES(sus)}$	80	100	—	Vdc
Collector-Emitter Current ($V_{CE} = 60 \text{ Vdc}$, $V_{BE} = 0$) ($V_{CE} = 50 \text{ Vdc}$, $V_{BE} = 0$, $T_C = 175^\circ\text{C}$)	I_{CES}	— —	— —	0.5 1.0	mAdc
Collector Cutoff Current ($V_{CB} = 50 \text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	—	1.0	μAdc
Emitter Cutoff Current ($V_{EB} = 4.0 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	—	100	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 400 \text{ mAdc}$, $V_{CE} = 2.0 \text{ Vdc}$) ($I_C = 1.0 \text{ A dc}$, $V_{CE} = 2.0 \text{ Vdc}$)	h_{FE}	5.0 5.0	— —	50 —	—
Collector-Emitter Saturation Voltage ($I_C = 1.0 \text{ A dc}$, $I_B = 250 \text{ mAdc}$)	$V_{CE(sat)}$	—	—	0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 1.0 \text{ A dc}$, $I_B = 250 \text{ mAdc}$)	$V_{BE(sat)}$	—	—	2.0	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product ($V_{CE} = 2.0 \text{ Vdc}$, $I_C = 400 \text{ mAdc}$, $f = 50 \text{ MHz}$)	f_T	150	—	—	MHz
Output Capacitance ($V_{CB} = 25 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)	C_{ob}	—	—	40	pF

FUNCTIONAL TEST

Power Input	Test Circuit Figure 5 ($P_{out} = 15 \text{ W}$, $f = 100 \text{ MHz}$, $V_{CE} = 25 \text{ Vdc}$, $I_C(\text{max}) = 1.0 \text{ A dc}$)	P_{in}	—	3.0	3.75	Watts
Efficiency		η	60	70	—	%

(1) Pulse Test: Pulse Width $\leq 100 \mu\text{s}$, Duty Cycle = 2.0%.

FIGURE 1 – OUTPUT POWER versus FREQUENCY

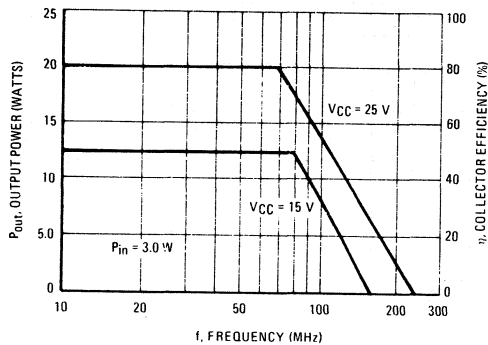


FIGURE 2 – OUTPUT CHARACTERISTICS versus INPUT POWER

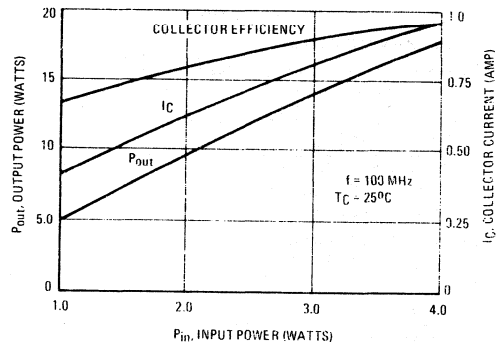


FIGURE 3 – OUTPUT POWER versus COLLECTOR VOLTAGE

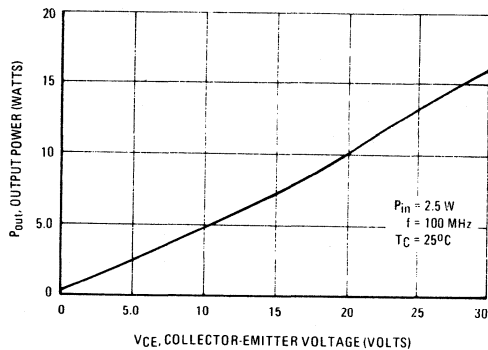


FIGURE 4 – OUTPUT POWER versus INPUT POWER

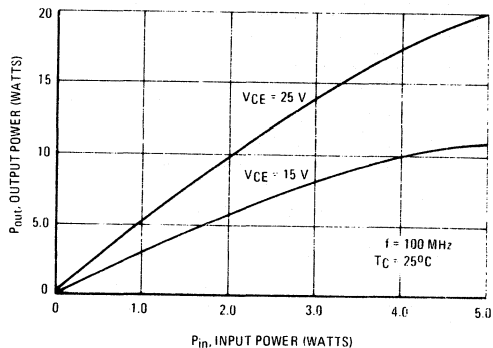
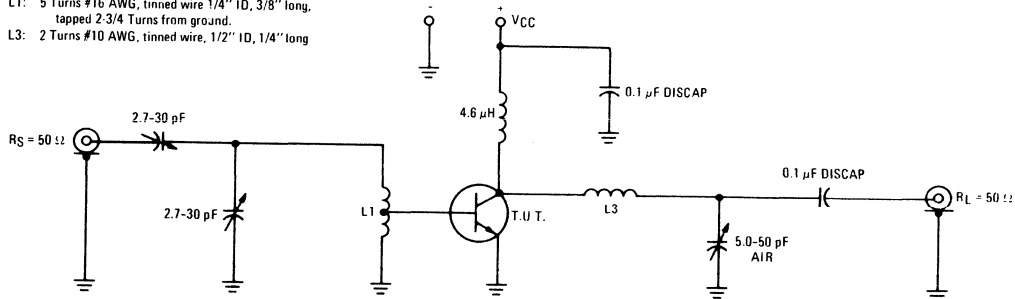


FIGURE 5 – TEST CIRCUIT

- L1: 5 Turns #16 AWG, tinned wire 1/4" ID, 3/8" long,
tapped 2-3/4 Turns from ground.
L3: 2 Turns #10 AWG, tinned wire, 1/2" ID, 1/4" long



2N3821 (SILICON)

2N3822

2N3824

SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

... designed for audio amplifier, chopper and switching applications.

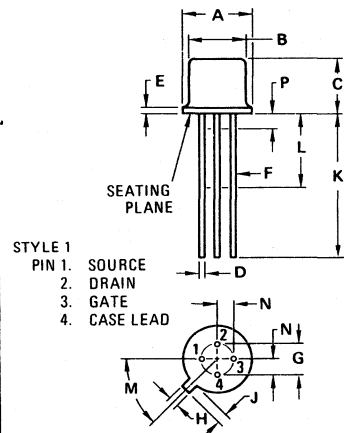
- Drain and Source Interchangeable
- Low Drain-Source Resistance –
 $r_{ds(on)} \leq 250 \text{ Ohms (Max)} - 2N3824$
- Low Noise Figure – $NF = 5.0 \text{ dB (Max)} - 2N3821, 2N3822$
- High AC Input Impedance – $C_{iss} = 6.0 \text{ pF (Max)}$
- High DC Input Resistance – $I_{GSS} = 0.1 \text{ nA (Max)}$
- Low Transfer Capacitance – $C_{rss} = 3.0 \text{ pF (Max)}$
- 2N3821 JAN and 2N3822 JAN also Available

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	50	Vdc
Drain-Gate Voltage	V_{DG}	50	Vdc
Gate-Source Voltage	V_{GS}	-50	Vdc
Drain Current	I_D	10	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 2.0	mW mW/ $^\circ\text{C}$
Operating Junction Temperature	T_J	175	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

*Indicates JEDEC Registered Data.

N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS SYMMETRICAL (Type A)



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	—	0.76	—	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	—	1.27	—	0.050

ALL JEDEC dimensions and notes apply

CASE 20-03
TO-72

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = -1.0 \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	-50	—	Vdc
Gate Reverse Current ($V_{GS} = -30 \text{ Vdc}$, $V_{DS} = 0$) ($V_{GS} = -30 \text{ Vdc}$, $V_{DS} = 0$, $T_A = 150^\circ\text{C}$)	I_{GSS}	— —	-0.1 -100	nAdc
Gate-Source Cutoff Voltage ($I_D = 0.5 \text{ nAdc}$, $V_{DS} = 15 \text{ Vdc}$)	$V_{GS(off)}$	— —	-4.0 -6.0	Vdc
Gate-Source Voltage ($I_D = 50 \mu\text{Adc}$, $V_{DS} = 15 \text{ Vdc}$) ($I_D = 200 \mu\text{Adc}$, $V_{DS} = 15 \text{ Vdc}$)	V_{GS}	-0.5 -1.0	-2.0 -4.0	Vdc
Drain Cutoff Current ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = -8.0 \text{ Vdc}$) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = -8.0 \text{ Vdc}$, $T_A = 150^\circ\text{C}$)	$I_{D(off)}$	— —	0.1 100	nAdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current(1) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$)	I_{DSS}	0.5 2.0	2.5 10	mAdc
DYNAMIC CHARACTERISTICS				
Forward Transfer Admittance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)(1) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 100 \text{ MHz}$)	$ y_{fs} $	1500 3000 1500 3000	4500 6500 — —	μmhos
Output Admittance(1) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)	$ y_{os} $	— —	10 20	μmhos
Drain-Source Resistance ($V_{GS} = 0$, $I_D = 0$, $f = 1.0 \text{ kHz}$)	$r_{ds(on)}$	—	250	Ohms
Input Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{iss}	—	6.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$) ($V_{GS} = -8.0 \text{ Vdc}$, $V_{DS} = 0$, $f = 1.0 \text{ MHz}$)	C_{rss}	— — —	3.0 3.0 3.0	pF
Average Noise Figure ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $R_S = 1.0 \text{ megohm}$, $f = 10 \text{ Hz}$, Noise Bandwidth = 5.0 Hz)	NF	—	5.0	dB
Equivalent Input Noise Voltage ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 10 \text{ Hz}$, Noise Bandwidth = 5.0 Hz)	e_n	—	200	$\text{nv}/\text{Hz}^{1/2}$

*Indicates JEDEC Registered Data.

(1)Pulse Test: Pulse Width $\leq 100 \text{ ms}$, Duty Cycle $\leq 10\%$.

2N3823 (SILICON)

SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR

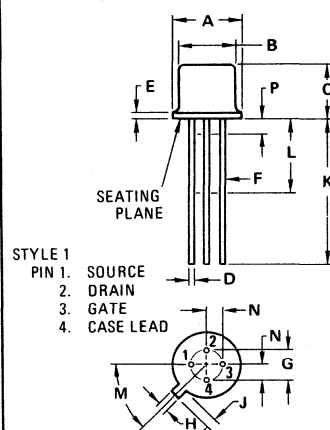
... designed for VHF amplifier and mixer applications.

- Low Cross-Modulation and Intermodulation Distortion
- Drain and Source Interchangeable
- Low 100-MHz Noise Figure – 2.5 dB (Max)
- Low Transfer and Input Capacitances –
 $C_{rss} = 2.0 \text{ pF (Max)}$
 $C_{iss} = 6.0 \text{ pF (Max)}$
- 2N3823 JAN also Available

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	-30	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 2.0	mW mW/ $^\circ\text{C}$
Operating Junction Temperature	T_J	175	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR SYMMETRICAL (Type A)



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	—	0.76	—	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	—	1.27	—	0.050

ALL JEDEC dimensions and notes apply
CASE 20-03
TO-72

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = -1.0 \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	-30		Vdc
Gate Reverse Current ($V_{GS} = -20 \text{ Vdc}$, $V_{DS} = 0$) ($V_{GS} = -20 \text{ Vdc}$, $V_{DS} = 0$, $T_A = 150^\circ\text{C}$)	I_{GSS}		-0.5 -500	nAdc
Gate-Source Cutoff Voltage ($I_D = 0.5 \text{ nAdc}$, $V_{DS} = 15 \text{ Vdc}$)	$V_{GS(off)}$		-8.0	Vdc
Gate-Source Voltage ($I_D = 0.4 \text{ mAdc}$, $V_{DS} = 15 \text{ Vdc}$)	V_{GS}	-1.0	-7.5	Vdc

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current(1) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$)	I_{DSS}	4.0	20	mAdc
--	-----------	-----	----	------

DYNAMIC CHARACTERISTICS

Forward Transfer Admittance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)(1) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 200 \text{ MHz}$)	$ y_{fs} $	3500 3200	6500	μmhos
Input Conductance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 200 \text{ MHz}$)	$\text{Re}(y_{is})$		800	μmhos
Output Conductance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)(1) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 200 \text{ MHz}$)	$ y_{os} $ $\text{Re}(y_{os})$		35 200	μmhos
Input Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{iss}		6.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{rss}		2.0	pF
Common-Source Spot Noise Figure ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $R_S = 1000 \text{ ohms}$, $f = 100 \text{ MHz}$)	NF		2.5	dB

*Indicates JEDEC Registered Data.

(1)Pulse Test: Pulse Width = 100 ms, Duty Cycle $\leq 10\%$.

MULTIPLE SILICON ANNULAR TRANSISTORS

... designed for use as differential amplifiers, dual general-purpose amplifiers and switches, front end detectors and temperature compensation applications.

- Low Collector-Emitter Saturation Voltage –
 $V_{CE(sat)} = 0.4 \text{ Vdc (Max) @ } I_C = 150 \text{ mAdc}$
- Fast Switching Times –
 $t_{on} = 50 \text{ ns (Max) and } t_{off} = 340 \text{ ns (Max)}$
- DC Current Gain Specified –
 $0.1 \text{ mAdc to } 150 \text{ mAdc}$
- High Current-Gain-Bandwidth Product –
 $f_T = 200 \text{ MHz @ } I_C = 20 \text{ mAdc}$

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector 1 to Collector 2 Voltage Voltage Rating any Lead to Case	V_{C1C2}	± 120 ± 120	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	600	mAdc
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	One Die 0.25	Watt mW/ $^\circ\text{C}$
		Both Die 1.67	
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	0.7	Watts
		4.67	
Operating and Storage Junction Temperature Range	T_J, T_{Stg}	-65 to +200	$^\circ\text{C}$

*Indicates JEDEC Registered Data.

FIGURE 1 – TURN-ON TIME TEST CIRCUIT

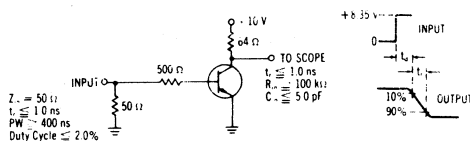
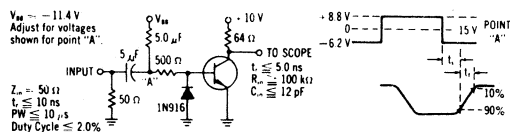
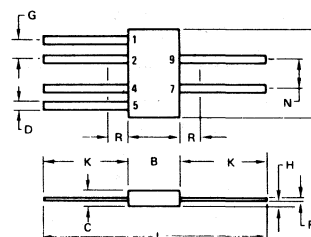


FIGURE 2 – TURN-OFF TIME TEST CIRCUIT



NPN SILICON MULTIPLE TRANSISTORS

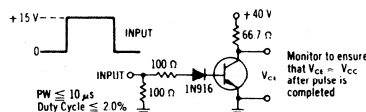


STYLE 1
PIN 1. BASE
2. EMITTER
4. EMITTER
5. BASE
7. COLLECTOR
9. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H		0.89		0.035
K	3.81		0.150	
N	2.54 BSC		0.100 BSC	
R		1.27		0.050

CASE 610A 03

FIGURE 3 – COLLECTOR-EMITTER NONLATCHING
VOLTAGE TEST CIRCUIT



2N3838 (continued)

* ELECTRICAL CHARACTERISTICS (each side) ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (†) ($I_C = 10 \text{ mA dc}$, $I_B = 0$)	BV_{CEO}	40	-	Vdc
Collector-Emitter Nonlatching Voltage (Figure 3) † ($I_{C(on)} = 600 \text{ mA dc}$, $I_{B(on)} = 120 \text{ mA dc}$, $I_{B(off)} = 0$)	$V_{CEO(NL)}^\dagger$	40	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \text{ } \mu\text{A dc}$, $I_E = 0$)	BV_{CBO}	60	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \text{ } \mu\text{A dc}$, $I_C = 0$)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current ($V_{CE} = 50 \text{ Vdc}$, $V_{BE(off)} = 0.5 \text{ Vdc}$) ($V_{CE} = 50 \text{ Vdc}$, $V_{BE(off)} = 0.5 \text{ Vdc}$, $T_A = 150^\circ\text{C}$)	I_{CEV}	-	0.01 10	$\mu\text{A dc}$
Emitter Cutoff Current ($V_{BE} = 3.0 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	-	10	nA dc
Base Cutoff Current ($V_{CE} = 50 \text{ Vdc}$, $V_{BE(off)} = 0.5 \text{ Vdc}$)	I_{BEV}	-	10	nA dc

ON CHARACTERISTICS

DC Current Gain ($I_C = 0.1 \text{ mA dc}$, $V_{CE} = 10 \text{ Vdc}$) ($I_C = 1.0 \text{ mA dc}$, $V_{CE} = 10 \text{ Vdc}$) ($I_C = 10 \text{ mA dc}$, $V_{CE} = 10 \text{ Vdc}$) (†) ($I_C = 150 \text{ mA dc}$, $V_{CE} = 10 \text{ Vdc}$) (†) ($I_C = 150 \text{ mA dc}$, $V_{CE} = 1.0 \text{ Vdc}$) (†)	h_{FE}	35 50 75 100 50	- - - 300 -	-
Collector-Emitter Saturation Voltage (†) ($I_C = 150 \text{ mA dc}$, $I_B = 15 \text{ mA dc}$)	$V_{CE(sat)}$	-	0.4	Vdc
Base-Emitter Saturation Voltage (†) ($I_C = 150 \text{ mA dc}$, $I_B = 15 \text{ mA dc}$)	$V_{BE(sat)}$	0.85	1.3	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 20 \text{ mA dc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	200	-	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 140 \text{ kHz}$)	C_{ob}	-	8.0	pF
Input Impedance ($I_C = 1.0 \text{ mA dc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{ie}	1.5	9.0	k ohm
Small-Signal Current Gain ($I_C = 1.0 \text{ mA dc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{fe}	60	300	-
Output Admittance ($I_C = 1.0 \text{ mA dc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{oe}	-	50	μmho
Noise Figure ($I_C = 100 \text{ } \mu\text{A dc}$, $V_{CE} = 10 \text{ Vdc}$, $R_S = 1.0 \text{ k ohm}$, $f = 1.0 \text{ kHz}$)	NF	-	8.0	dB
Delay Time ($V_{CC} = 10 \text{ Vdc}$, $V_{BE(off)} = 0 \text{ Vdc}$, $I_C = 150 \text{ mA dc}$, $I_{B1} = 15 \text{ mA dc}$, Figure 1)	t_d	-	10	ns
Rise Time	t_r	-	40	ns
Storage Time ($V_{CC} = 10 \text{ Vdc}$, $I_C = 150 \text{ mA dc}$, $I_{B1} = I_{B2} = 15 \text{ mA dc}$, Figure 2)	t_s	-	250	ns
Fall Time	t_f	-	90	ns

* Indicates JEDEC Registered Data

(†) Pulse Test: Pulse Width $\leq 300 \text{ } \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

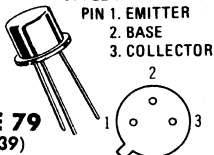
† The highest value of collector supply voltage that may be safely used with a resistive load switching circuit in which the collector current is 600 mA dc.

2N3839

For Specifications, See 2N2857 Data

2N3866 (SILICON)**2N3866A**

STYLE 1:

**CASE 79**
(TO-39)

Collector connected to case

NPN silicon transistor, designed for amplifier, frequency-multiplier, or oscillator applications in military and industrial equipment. Suitable for uses as output, driver, or pre-driver stages in VHF and UHF equipment.

MAXIMUM RATINGS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	55	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector Current	I_C	0.4	Amp
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	5.0 28.6	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
----------------	--------	-----	-----	-----	------

OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 5.0$ mAdc, $R_{BE} = 10$ ohms)	BV_{CER}	55	—	—	Vdc
Collector-Emitter Sustaining Voltage ($I_C = 5.0$ mAdc, $I_B = 0$)	$BV_{CEO(sus)}$	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_E = 0$, $I_C = 0.1$ mAdc)	BV_{CBO}	55	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mAdc, $I_C = 0$)	BV_{EBO}	3.5	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 28$ Vdc, $I_B = 0$)	I_{CEO}	—	—	20	μA
Collector Cutoff Current ($V_{CE} = 55$ Vdc, $V_{BE} = 1.5$ Vdc)	I_{CEX}	—	—	100	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 0.36$ Adc, $V_{CE} = 5.0$ Vdc) ($I_C = 0.05$ Adc, $V_{CE} = 5.0$ Vdc) 2N3866 ($I_C = 50$ mAdc, $V_{CE} = 5.0$ Vdc) 2N3866A	h_{FE}	5.0 10 25	— — —	— 200 200	—
Collector-Emitter Saturation Voltage ($I_C = 100$ mAdc, $I_B = 20$ mAdc)	$V_{CE(sat)}$	—	—	1.0	Vdc

DYNAMIC CHARACTERISTICS

Current Gain — Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 15$ Vdc, $f = 200$ MHz) 2N3866 2N3866A	f_T	500 800	800 —	— —	MHz
Output Capacitance ($V_{CB} = 30$ Vdc, $I_E = 0$, $f = 1.0$ MHz)	C_{ob}	—	2.0	3.0	pF

FUNCTIONAL TEST

Power Gain	Test Circuit-Figure 1 $P_{in} = 0.1$ W, $V_{CE} = 28$ Vdc $f = 400$ MHz, $T_C = 25^\circ\text{C}$	G_{pe}	10	—	—	dB
Power Output		P_{out}	1.0	—	—	Watts
Collector Efficiency		η	45	—	—	%

FIGURE 1 — 400 MHz RF AMPLIFIER CIRCUIT FOR POWER-OUTPUT TEST

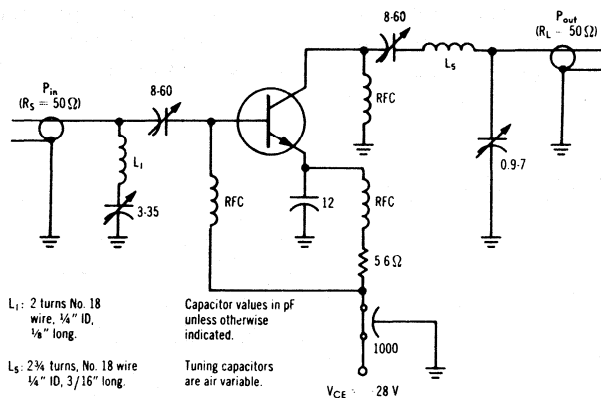


FIGURE 2 — POWER OUTPUT versus FREQUENCY (Class C)

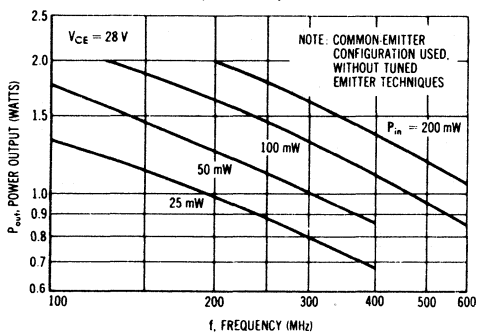


FIGURE 4 — PARALLEL INPUT RESISTANCE AND CAPACITANCE versus FREQUENCY (Class C)

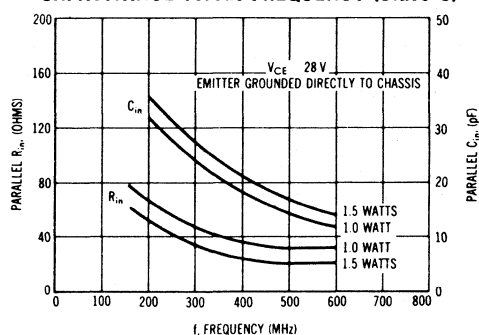


FIGURE 3 — POWER OUTPUT versus POWER INPUT (Class C)

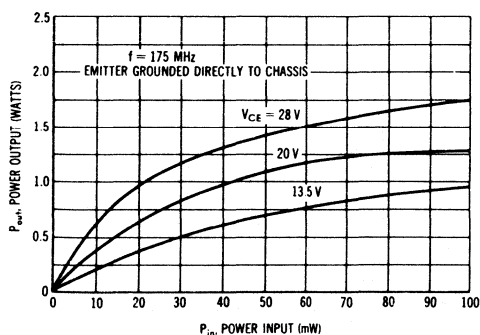
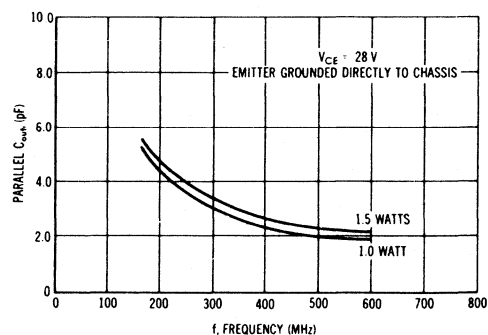
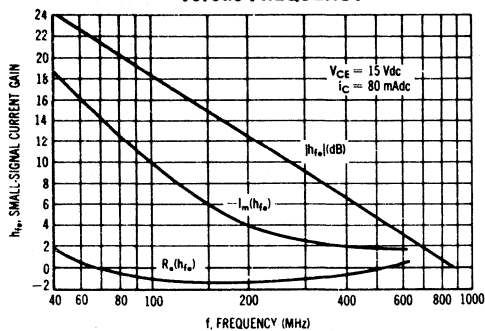


FIGURE 5 — PARALLEL OUTPUT CAPACITANCE versus FREQUENCY (Class C)



**FIGURE 6 — SMALL-SIGNAL CURRENT GAIN
versus FREQUENCY**



**FIGURE 7 — OUTPUT CAPACITANCE
versus COLLECTOR VOLTAGE**

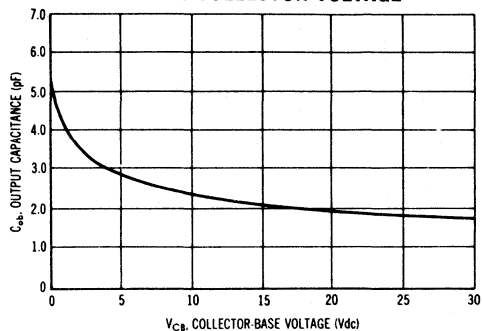


FIGURE 8 — f_T versus COLLECTOR CURRENT

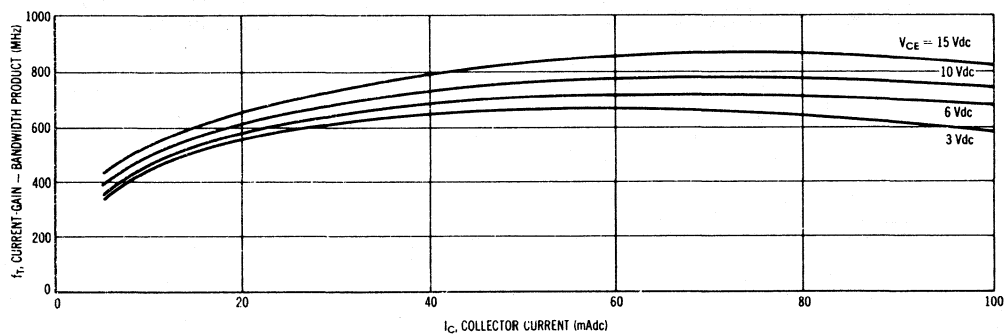
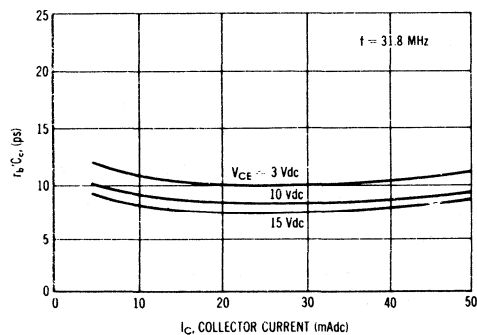
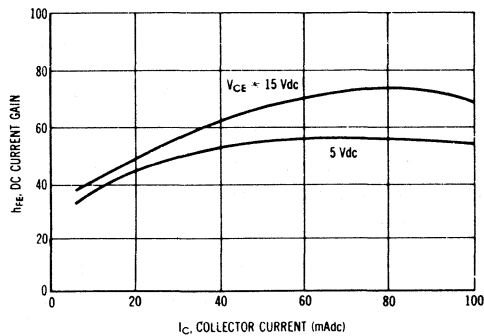


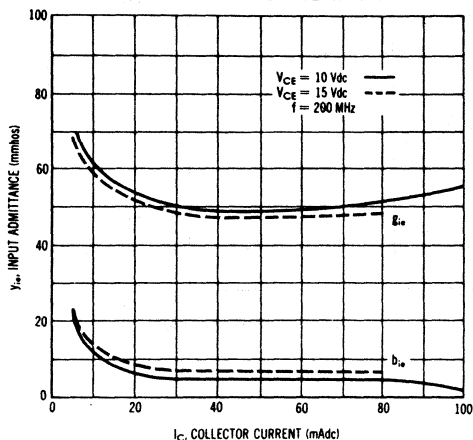
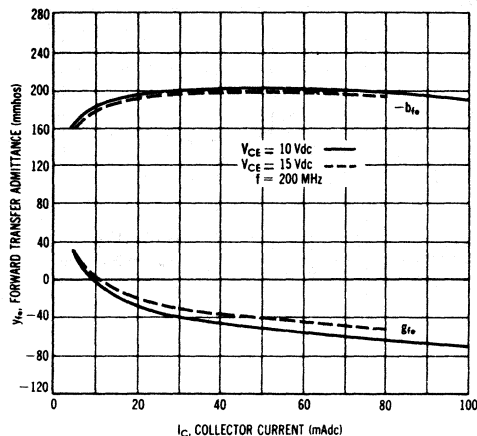
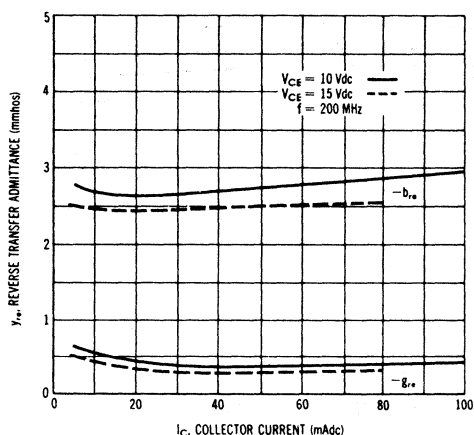
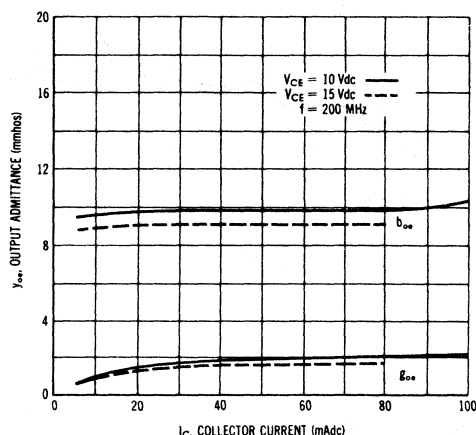
FIGURE 9 — $r_b' C_c$ versus COLLECTOR CURRENT



**FIGURE 10 — DC CURRENT GAIN
versus COLLECTOR CURRENT**



y PARAMETER VARIATIONS

FIGURE 11 — SMALL-SIGNAL INPUT ADMITTANCE versus COLLECTOR CURRENT**FIGURE 13 — SMALL-SIGNAL FORWARD TRANSFER ADMITTANCE versus COLLECTOR CURRENT****FIGURE 12 — SMALL-SIGNAL REVERSE TRANSFER ADMITTANCE versus COLLECTOR CURRENT****FIGURE 14 — SMALL-SIGNAL OUTPUT ADMITTANCE versus COLLECTOR CURRENT****DESIGN NOTE**

Figures 11 through 18 show small-signal admittance-parameter data. This data can be used for Class A amplifier designs.

For Class C power-amplifier designs, the small-signal parameters are not applicable. Figures 4 and 5 give parallel output capacitance and the parallel input resistance and capacitance for Class C power-amplifier operation.

The parallel resistive portion of the collector load impedance for a power amplifier, R_L' , may be computed by assuming a peak voltage swing equal to V_{CC} , and using the expression

$$R_L' = \frac{V_{CC}^2}{2P}$$

where P = RF power output. The computed R_L' may then be combined with the data in Figures 2 and 3 to comprise complete device impedance data for Class C power amplifier design.

y PARAMETER VARIATIONS

($V_{CE} = 15 \text{ Vdc}$, $I_C = 80 \text{ mAdc}$, $T_A = 25^\circ \text{C}$)

FIGURE 15 — SMALL-SIGNAL INPUT ADMITTANCE versus FREQUENCY

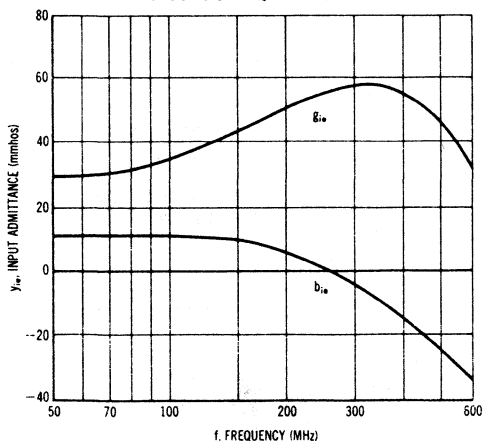


FIGURE 17 — SMALL-SIGNAL FORWARD TRANSFER ADMITTANCE versus FREQUENCY

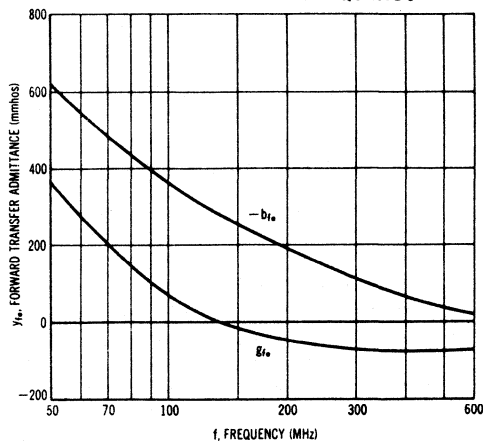


FIGURE 16 — SMALL-SIGNAL REVERSE TRANSFER ADMITTANCE versus FREQUENCY

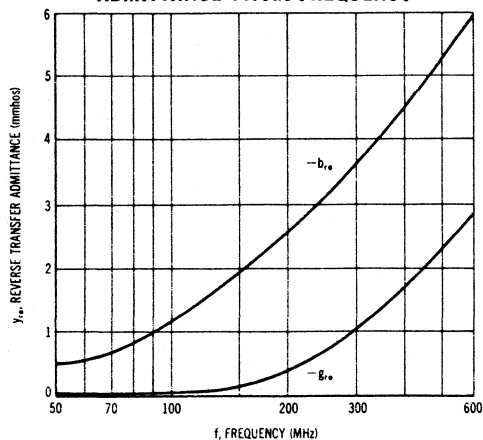
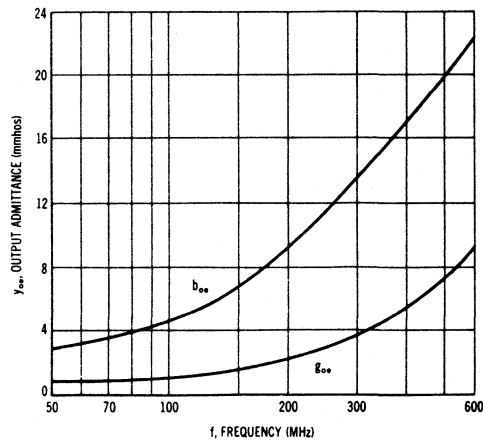


FIGURE 18 — SMALL-SIGNAL OUTPUT ADMITTANCE versus FREQUENCY



2N3867

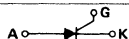
2N3868

For Specifications, See 2N3719 Data

2N3870 thru 2N3873 (SILICON)

2N3896 thru 2N3899

2N6171 thru 2N6174



THYRISTORS SILICON CONTROLLED RECTIFIERS

... designed for industrial and consumer applications such as power supplies; battery chargers; temperature, motor, light and welder controls.

- Economical for a Wide Range of Uses
- High Surge Current — $I_{TSM} = 350$ Amp
- Practical Level Triggering and Holding Characteristics — 4.0 and 5.2 mA (Typ) @ $T_C = 25^\circ\text{C}$
- Rugged Construction in Either Pressfit, Stud or Isolated Stud Package

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*Repetitive Peak Reverse Blocking Voltage (1) ($T_J = -40$ to $+100^\circ\text{C}$, 1/2 Sine Wave, 50 to 400 Hz, Gate Open)	V_{RRM}		Volts
2N3870, 2N3896, 2N6171		100	
2N3871, 2N3897, 2N6172		200	
2N3872, 2N3898, 2N6173		400	
2N3873, 2N3899, 2N6174		600	
*Non Repetitive Peak Reverse Blocking Voltage ($t \leq 5.0$ ms)	V_{RSM}		Volts
2N3870, 2N3896, 2N6171		150	
2N3871, 2N3897, 2N6172		330	
2N3872, 2N3898, 2N6173		660	
2N3873, 2N3899, 2N6174		700	
*Average On-State Current ($T_C = -40$ to $+65^\circ\text{C}$) ($T_C = +85^\circ\text{C}$)	$I_{T(AV)}$	22 11	Amp
Peak Non-Repetitive Surge Current (One cycle, 60 Hz) ($T_C = +65^\circ\text{C}$)	I_{TSM}	350	Amp
Circuit Fusing Considerations ($T_J = -40$ to $+100^\circ\text{C}$) ($t = 1.0$ to 8.3 ms)	I^2t	510	A^2s
*Peak Gate Power	P_{GM}	20	Watts
*Average Gate Power	$P_{G(AV)}$	0.5	Watt
*Peak Forward Gate Current	I_{GM}	2.0	Amp
Peak Gate Voltage	V_{GM}	10	Volts
*Operating Junction Temperature Range	T_J	-40 to $+100$	$^\circ\text{C}$
*Storage Temperature Range	T_{stg}	-40 to $+150$	$^\circ\text{C}$
Stud Torque 2N3896 thru 2N3899 2N6171 thru 2N6174		30	in lb

*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case 2N3870 thru 2N3873, 2N3896 thru 2N3899 2N6171 thru 2N6174	$R_{\theta JC}$	0.9 1.0	$^\circ\text{C}/\text{W}$

*Indicates JEDEC Registered Data

(1) Ratings apply for zero or negative gate voltage. Devices shall not have a positive bias applied to the gate concurrently with a negative potential on the anode. Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

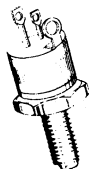
THYRISTORS PNPN

35 AMPERES RMS
100-600 VOLTS



CASE 174
TO-203

2N3870
thru
2N3873



CASE 235
(Stud Isolated)

2N6171
thru
2N6174

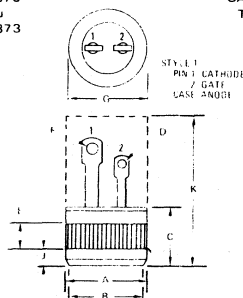


CASE 175

2N3896
thru
2N3899

2N3870
thru
2N3873

CASE 174
TO-203



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	12.26	12.82	0.50	0.50
B	11.81	12.05	0.465	0.475
C	8.38	8.65	0.330	0.340
D	8.60	8.75	0.35	0.36
E	2.40	—	0.100	—
F	1.68	2.78	0.065	0.090
G	—	12.95	—	0.510
J	2.040	2.450	0.080	0.097
K	—	20.325	—	0.800

A: JEDEC dimensions and units apply

(continued on page 4)

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
* Peak Forward Blocking Voltage ($T_J = 100^\circ\text{C}$) 2N3870, 2N3896, 2N6171 2N3871, 2N3897, 2N6172 2N3872, 2N3898, 2N6173 2N3873, 2N3899, 2N6174	V_{DRM}	100 200 400 600	— — — —	— — — —	Volts
* Peak Forward Blocking Current (Rated V_{DRM} , with gate open, $T_J = 100^\circ\text{C}$) 2N3870, 2N3896, 2N6171 2N3871, 2N3897, 2N6172 2N3872, 2N3898, 2N6173 2N3873, 2N3899, 2N6174	I_{DRM}	— — — —	1.0 1.0 1.0 1.0	2.0 2.5 3.0 4.0	mA
* Peak Reverse Blocking Current (Rated V_{RRM} , with gate open, $T_J = 100^\circ\text{C}$) 2N3870, 2N3896, 2N6171 2N3871, 2N3897, 2N6172 2N3872, 2N3898, 2N6173 2N3873, 2N3899, 2N6174	I_{RRM}	— — — —	1.0 1.0 1.0 1.0	2.0 2.5 3.0 4.0	mA
* Peak On-State Voltage ($I_{TM} = 69$ A Peak)	V_{TM}	—	1.5	1.85	Volts
Gate Trigger Current, Continuous dc ($V_{AK} = 12$ V, $R_L = 24$ ohms) * $T_C = -40^\circ\text{C}$ $T_C = 25^\circ\text{C}$	I_{GT}	— —	9.0 4.0	80 40	mA
Gate Trigger Voltage, Continuous dc ($V_{AK} = 12$ V, $R_L = 24$ ohms) * $T_C = -40^\circ\text{C}$ $T_C = 25^\circ\text{C}$	V_{GT}	— —	0.9 0.69	3.0 1.6	Volts
Holding Current (Gate Open) ($V_{AK} = 12$ V, $I_{TM} = 200$ mA) * $T_C = -40^\circ\text{C}$ $T_C = 25^\circ\text{C}$	I_H	— —	14 5.2	90 50	mA
* Gate Controlled Turn-On Time ($t_d + t_r$) ($I_{TM} = 41$ Adc, $V_{AK} = \text{rated } V_{DRM}$, $I_{GT} = 40$ mAdc, Rise Time = $0.05 \mu\text{s}$, Pulse Width = $10 \mu\text{s}$)	t_{gt}	—	—	1.5	μs
Circuit Commutated Turn-Off Time ($I_{TM} = 10$ A, $I_R = 10$ A) ($I_{TM} = 10$ A, $I_R = 10$ A, $T_J = 100^\circ\text{C}$)	t_q	— —	15 25	— —	μs
Forward Voltage Application Rate ($T_J = 100^\circ\text{C}$)	dv/dt	—	50	—	V/ μs

* Indicates JEDEC Registered Data.

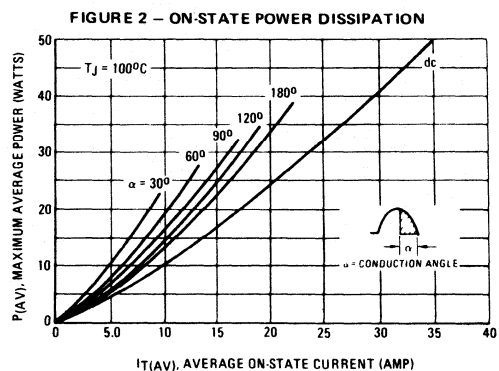
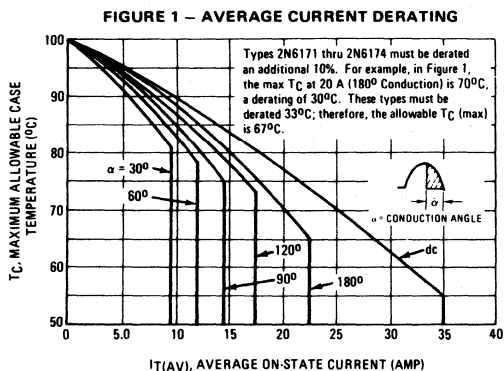


FIGURE 3 – MAXIMUM ON-STATE CHARACTERISTICS

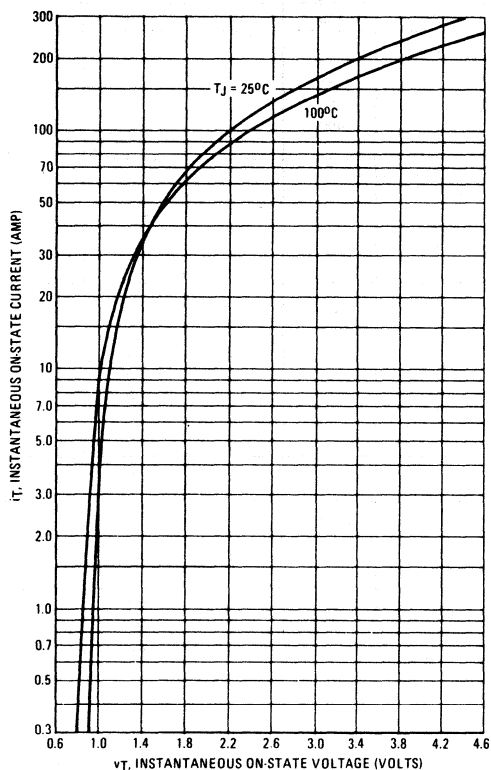


FIGURE 4 – MAXIMUM NON-REPETITIVE SURGE CURRENT

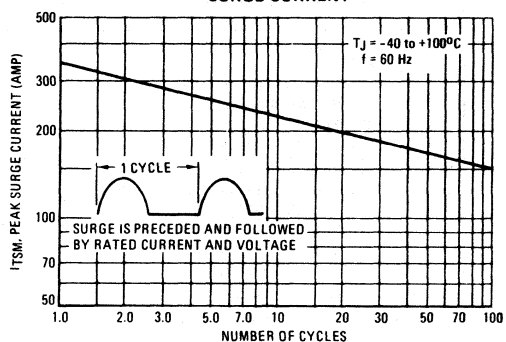


FIGURE 5 – CHARACTERISTICS AND SYMBOLS

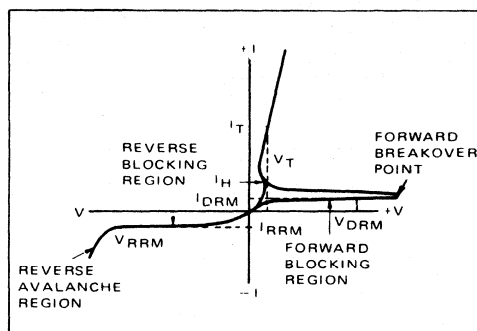


FIGURE 6 – TYPICAL THERMAL RESPONSE

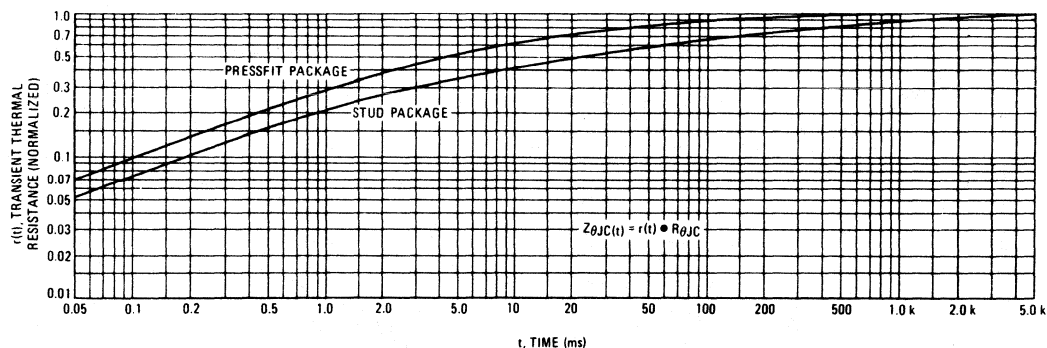


FIGURE 7 – TYPICAL GATE TRIGGER CURRENT

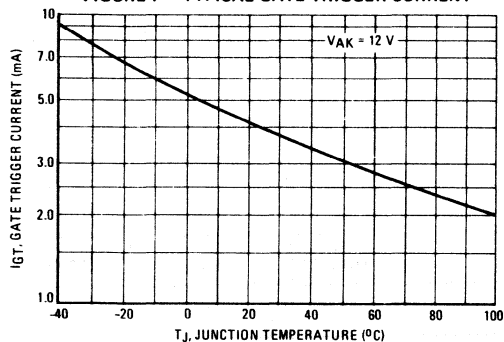


FIGURE 8 – TYPICAL GATE TRIGGER VOLTAGE

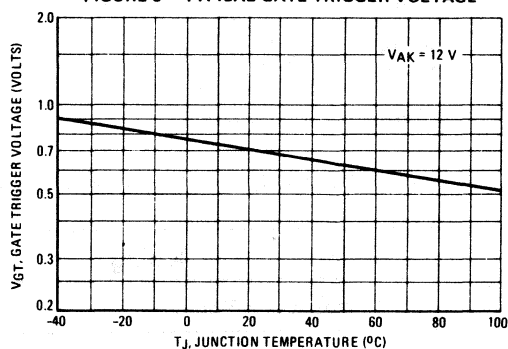
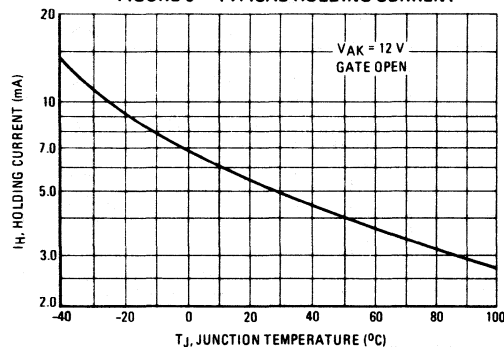


FIGURE 9 – TYPICAL HOLDING CURRENT



SELECTED THYRISTOR-TRIGGER APPLICATION NOTES

- AN-240 – SCR Power Control Fundamentals
- AN-295 – Suppressing RFI in Thyristor Circuits
- AN-422 – Testers for Thyristors and Trigger Diodes
- AN-453 – Zero Point Switching Techniques

To obtain copies of these notes list the AN number(s) on your company letterhead and send your request to:

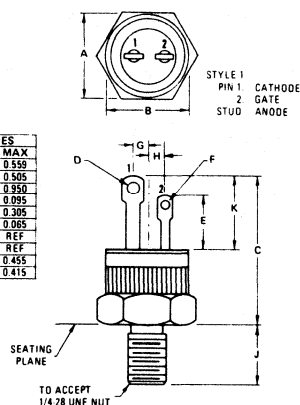
Technical Information Center
Motorola Semiconductor Products, Inc.
P.O. Box 20924
Phoenix, Arizona 85036

PACKAGE DIMENSIONS

CASE 175

2N3896
thru
2N3899

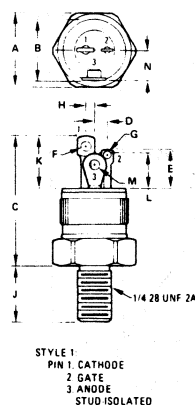
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	14.000	14.200	0.551	0.559
B	12.730	12.830	0.501	0.505
C	—	74.130	—	0.950
D	2.030	2.410	0.080	0.095
E	—	7.750	—	0.305
F	1.400	1.650	0.055	0.065
G	1.650	REF	0.065	REF
H	2.290	REF	0.090	REF
J	10.670	11.560	0.420	0.455
K	—	10.540	—	0.415



CASE 235

2N6171
thru
2N6174

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	14.000	14.200	0.551	0.559
B	12.730	12.830	0.501	0.505
C	—	28.160	—	1.100
D	2.290	REF	0.090	REF
E	—	7.750	—	0.305
F	2.030	2.410	0.080	0.095
G	1.400	1.650	0.055	0.065
H	1.650	REF	0.065	REF
J	10.670	11.560	0.420	0.455
K	—	10.540	—	0.415
L	6.480	7.000	0.255	0.275
M	3.430	3.810	0.135	0.150
N	—	6.480	—	0.255





Medium-current, germanium PNP high-speed switching transistor.

CASE 79-02
(TO-39)

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

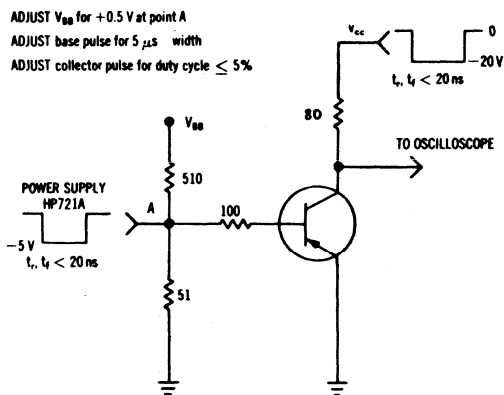
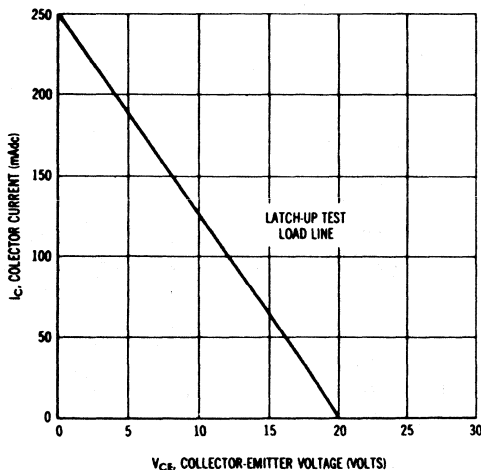
Collector connected to case

* **MAXIMUM RATINGS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Rating	Symbol	Value	Units
Collector-Base Voltage	V_{CB}	25	Vdc
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current - Continuous	I_C	300	mA dc
Junction Temperature	T_J	100	$^\circ\text{C}$
Storage Temperature	T_{stg}	-65 to +100	$^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	750 10	mW mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 4.0	mW mW/ $^\circ\text{C}$

*Indicates JEDEC Registered Data

FIGURE 1-COLLECTOR LATCH-UP VOLTAGE AND TEST CIRCUIT



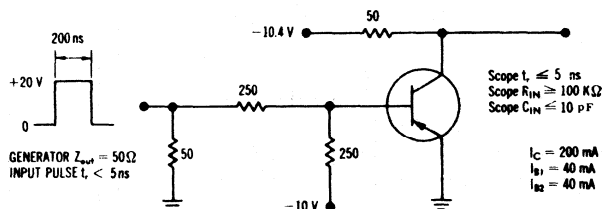
2N3883 (continued)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage ($I_C = 100\mu\text{A}$, $I_E = 0$)	BV_{CBO}	25	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10\text{mA}$, $I_B = 0$)	BV_{CEO}	15	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\mu\text{A}$, $I_C = 0$)	BV_{EBO}	3.0	—	Vdc
Latch-Up Voltage	LV_{CEX}	20	—	Vdc
Collector-Emitter Leakage Current ($V_{CE} = 15\text{Vdc}$, $V_{EB} = 0$)	I_{CES}	—	100	μA
Base Cutoff Current ($V_{CE} = 15\text{Vdc}$, $V_{EB} = 0$)	I_B	—	100	μA
DC Current Gain ($I_C = 20\text{mA}$, $V_{CE} = 1.0\text{Vdc}$)	h_{FE}	30	—	—
Collector-Emitter Saturation Voltage ($I_C = 200\text{mA}$, $I_B = 40\text{mA}$)	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Voltage ($I_C = 200\text{mA}$, $I_B = 40\text{mA}$)	V_{BE}	0.4	0.9	Vdc
Output Capacitance ($V_{CB} = 10\text{Vdc}$, $I_E = 0$, $f = 100\text{kHz}$)	C_{ob}	—	8.0	pF
Input Capacitance ($V_{BE} = 1\text{Vdc}$, $I_C = 0$, $f = 100\text{kHz}$)	C_{ib}	—	25	pF
Current-Gain — Bandwidth Product ($V_{CE} = 10\text{Vdc}$, $I_C = 40\text{mA}$, $f = 100\text{MHz}$)	f_T	100	—	MHz
Delay Time (Figure 2)	t_d	—	15	ns
Rise Time (Figure 2)	t_r	—	40	ns
Storage Time (Figure 2)	t_s	—	70	ns
Fall Time (Figure 2)	t_f	—	40	ns

*Indicates JEDEC Registered Data

FIGURE 2—SWITCHING TIME TEST CIRCUIT



2N3896 thru 2N3899 (SILICON)

For Specifications, See 2N3870 Data

2N3902 NPN (SILICON)

2N5157

HIGH VOLTAGE NPN SILICON TRANSISTORS

... designed for use in high-voltage inverters, converters, switching regulators and line operated amplifiers.

- High Collector-Emitter Voltage — $V_{CEX} = 700 \text{ Vdc}$
- Excellent DC Current Gain —
 $h_{FE} = 10 \text{ (Min) @ } I_C = 2.5 \text{ Adc}$
- Low Collector-Emitter Saturation Voltage —
 $V_{CE(sat)} = 0.8 \text{ Vdc (Max.) @ } I_C = 1.0 \text{ Adc}$

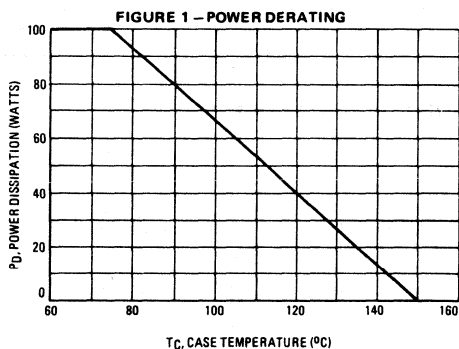
*MAXIMUM RATINGS

Rating	Symbol	2N3902	2N5157	Unit
Collector-Emitter Voltage	V_{CEO}	400	500	Vdc
Collector-Emitter Voltage	V_{CEX}	700		Vdc
Emitter-Base Voltage	V_{EB}	5.0	6.0	Vdc
Collector Current — Continuous	I_C	3.5		Adc
Base Current	I_B	2.0		Adc
Total Device Dissipation @ $T_C = 75^\circ\text{C}$ Derate above 75°C	P_D	100	1.33	Watts W/ $^\circ\text{C}$
Operating Junction Temperature Range	T_J	-65 to +150		$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200		$^\circ\text{C}$

THERMAL CHARACTERISTICS

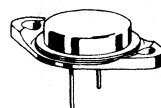
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.75	$^\circ\text{C/W}$

*Indicates JEDEC Registered Data

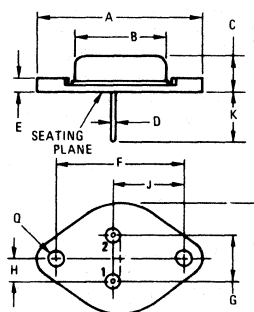


3.5 AMPERE POWER TRANSISTORS NPN SILICON

400 and 500 VOLTS
100 WATTS



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	—	39.37	—	1.550
B	—	21.08	—	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	—	3.43	—	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	—	26.67	—	1.050

Collector connected to case.
CASE 11

2N3902, 2N5157 (continued)

*ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage ($I_C = 100 \text{ mA}$, $I_B = 0$) (See Figure 12)	$V_{CE(sus)}$	325 400	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 3.5 \text{ A}$, $R_{BE} = 10 \text{ Ohms}$) (See Figure 12)	BV_{CEr}	500	—	Vdc
Collector Cutoff Current ($V_{CE} = 400 \text{ Vdc}$, $I_B = 0$)	I_{CEO}	0.25	—	mA
Collector Cutoff Current ($V_{CE} = 500 \text{ Vdc}$, $I_B = 0$)		0.25	—	
Collector Cutoff Current ($V_{CE} = 700 \text{ Vdc}$, $V_{EB(off)} = 1.5 \text{ Vdc}$)	I_{CEX}	—	2.5	mA
($V_{CE} = 400 \text{ Vdc}$, $V_{EB(off)} = 1.5 \text{ Vdc}$, $T_C = 125^\circ\text{C}$)		—	0.5	
Emitter Cutoff Current ($V_{BE} = 5.0 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	5.0	mA
($V_{BE} = 6.0 \text{ Vdc}$, $I_C = 0$)		—	5.0	

ON CHARACTERISTICS(1)

DC Current Gain ($I_C = 1.0 \text{ A}$, $V_{CE} = 5.0 \text{ Vdc}$)	2N3902, 2N5157	h_{FE}	30	90	—
($I_C = 2.5 \text{ A}$, $V_{CE} = 5.0 \text{ Vdc}$)	2N3902, 2N5157		10	—	
($I_C = 1.0 \text{ A}$, $V_{CE} = 5.0 \text{ Vdc}$, $T_C = -55^\circ\text{C}$)	2N5157		10	—	
Collector-Emitter Saturation Voltage ($I_C = 1.0 \text{ A}$, $I_B = 0.1 \text{ A}$)	2N3902, 2N5157	$V_{CE(sat)}$	—	0.8	Vdc
($I_C = 2.5 \text{ A}$, $I_B = 0.5 \text{ A}$)	2N3902		—	2.5	
($I_C = 3.5 \text{ A}$, $I_B = 0.7 \text{ A}$)	2N5157		—	2.5	
Base-Emitter Saturation Voltage ($I_C = 1.0 \text{ A}$, $I_B = 0.1 \text{ A}$)	2N3902, 2N5157	$V_{BE(sat)}$	—	1.5	Vdc
($I_C = 2.5 \text{ A}$, $I_B = 0.5 \text{ A}$)	2N3902		—	2.0	
($I_C = 3.5 \text{ A}$, $I_B = 0.7 \text{ A}$)	2N5157		—	2.0	

DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 0.2 \text{ A}$, $V_{CE} = 10 \text{ Vdc}$)	2N3902	f_T	2.8	—	MHz
($I_C = 0.2 \text{ A}$, $V_{CE} = 12 \text{ Vdc}$)	2N5157		2.8	—	
Output Capacitance ($V_{CB} = 20 \text{ Vdc}$, $f = 0$, $f = 1.0 \text{ MHz}$)	2N5157	C_{ob}	—	150	pF

SWITCHING CHARACTERISTICS

Turn-On Time ($V_{CC} = 125 \text{ Vdc}$, $I_C = 1.0 \text{ A}$, $I_{B1} = 0.1 \text{ A}$)	2N5157	t_{on}	—	0.8	μs
Turn-Off Time ($V_{CC} = 125 \text{ Vdc}$, $I_C = 1.0 \text{ A}$, $I_{B1} = 0.1 \text{ A}$, $I_{B2} = 0.5 \text{ A}$)	2N5157	t_{off}	—	1.7	μs

*Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

FIGURE 2 — SWITCHING TIMES TEST CIRCUIT

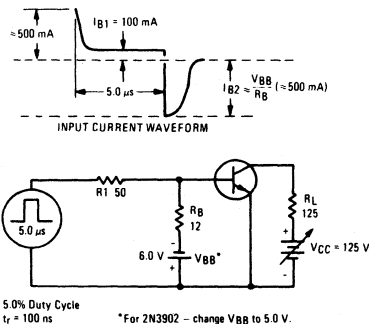


FIGURE 3 — TURN-ON TIME

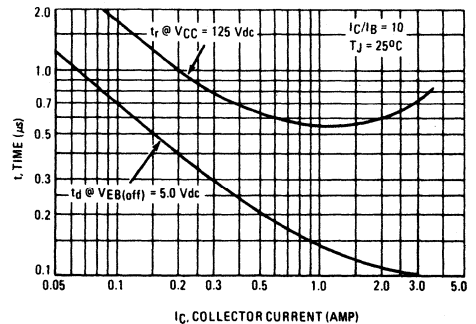


FIGURE 4 – THERMAL RESPONSE

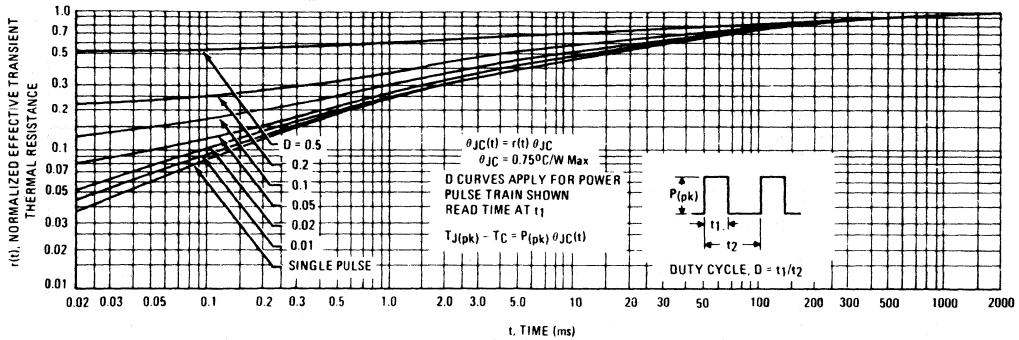
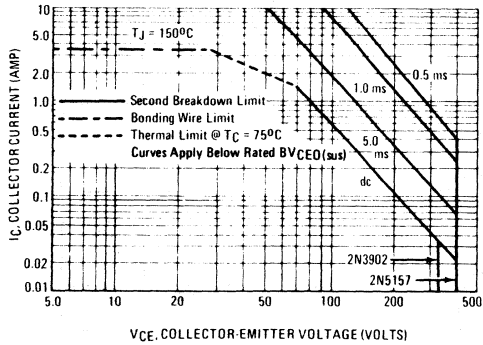


FIGURE 5 – ACTIVE-REGION SAFE-OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 150^\circ\text{C}$; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 150^\circ\text{C}$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown. (See AN-415)

FIGURE 6 – TURN-OFF TIME

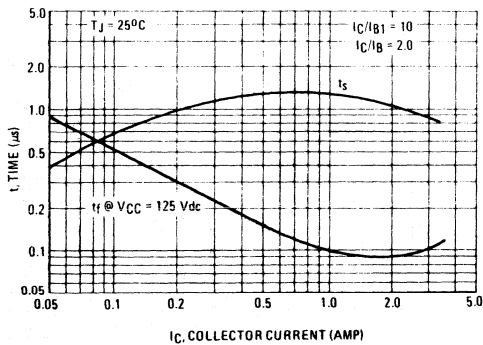


FIGURE 7 – CAPACITANCE

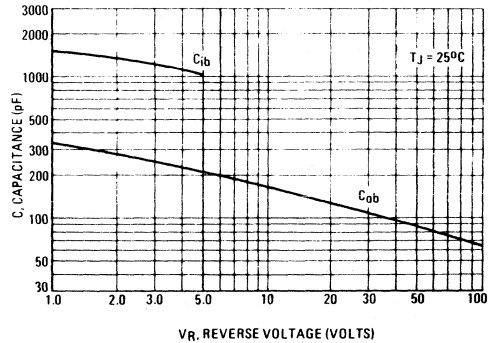


FIGURE 8 – DC CURRENT GAIN

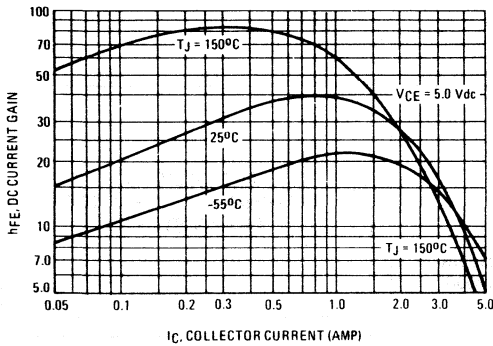


FIGURE 9 – "ON" VOLTAGES

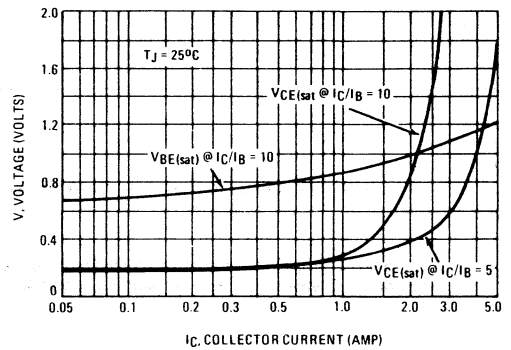


FIGURE 10 – COLLECTOR CUT-OFF REGION

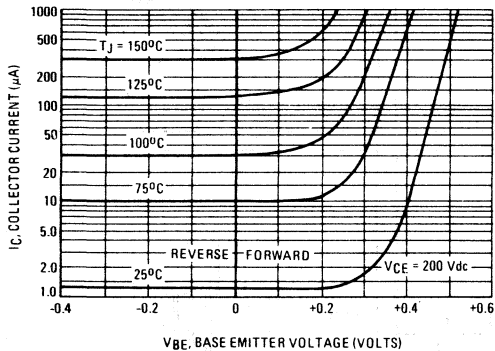


FIGURE 11 – TEMPERATURE COEFFICIENTS

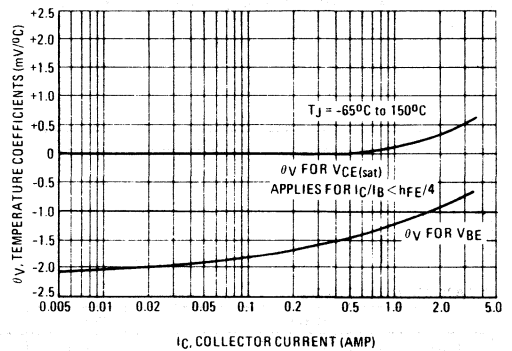
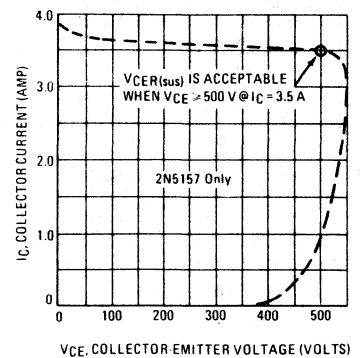
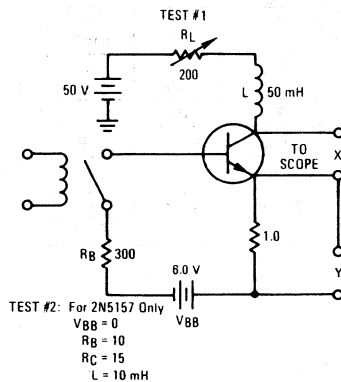
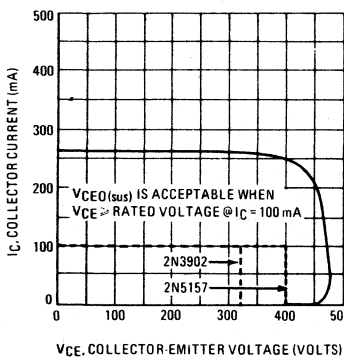


FIGURE 12 – COLLECTOR-EMITTER SUSTAINING VOLTAGE TEST CIRCUITS AND LOAD LINES



2N3903 (SILICON)

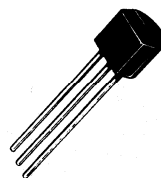
2N3904

NPN SILICON ANNULAR TRANSISTORS

... designed for general purpose switching and amplifier applications and for complementary circuitry with types 2N3905 and 2N3906.

- Collector-Emitter Breakdown Voltage – $BV_{CEO} = 40 \text{ Vdc (Min)}$
- Current Gain Specified from $100 \mu\text{A}$ to 100 mA
- Complete Switching and Amplifier Specifications
- Low Capacitance – $C_{ob} = 4.0 \text{ pF (Max)}$

NPN SILICON SWITCHING & AMPLIFIER TRANSISTORS



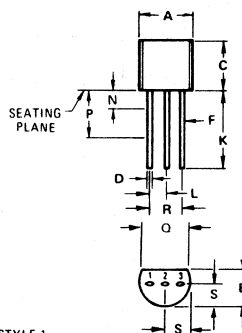
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	60	Vdc
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current – Continuous	I_C	200	mA dc
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 8.0	Watts mW/ $^\circ\text{C}$
Junction Operating Temperature	T_J	150	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-55 to +150	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	$^\circ\text{C/W}$

*Indicates JEDEC Registered Data



STYLE 1:
PIN 1: EMITTER
2: BASE
3: COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
E	0.407	0.482	0.016	0.019
F	12.700	—	0.500	—
G	1.150	1.390	0.045	0.055
H	—	1.270	—	0.050
I	6.350	—	0.250	—
J	3.430	—	0.135	—
K	2.410	2.670	0.095	0.105
L	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

2N3903, 2N3904 (continued)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{A}$, $I_E = 0$)		BV_{CBO}	60	-	Vdc
Collector-Emitter Breakdown Voltage (1) ($I_C = 1.0\text{ mA}$, $I_B = 0$)		BV_{CEO}	40	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{A}$, $I_C = 0$)		BV_{EBO}	6.0	-	Vdc
Collector Cutoff Current ($V_{CE} = 30\text{ Vdc}$, $V_{EB(off)} = 3.0\text{ Vdc}$)		I_{CEV}	-	50	nAdc
Base Cutoff Current ($V_{CE} = 30\text{ Vdc}$, $V_{EB(off)} = 3.0\text{ Vdc}$)		I_{BEV}	-	50	nAdc

ON CHARACTERISTICS

DC Current Gain (1) ($I_C = 0.1\text{ mA}$, $V_{CE} = 1.0\text{ Vdc}$)	2N3903 2N3904	15	h_{FE}	20 40	-	-
($I_C = 1.0\text{ mA}$, $V_{CE} = 1.0\text{ Vdc}$)	2N3903 2N3904			35 70	-	-
($I_C = 10\text{ mA}$, $V_{CE} = 1.0\text{ Vdc}$)	2N3903 2N3904			50 100	150 300	-
($I_C = 50\text{ mA}$, $V_{CE} = 1.0\text{ Vdc}$)	2N3903 2N3904			30 60	-	-
($I_C = 100\text{ mA}$, $V_{CE} = 1.0\text{ Vdc}$)	2N3903 2N3904			15 30	-	-
Collector-Emitter Saturation Voltage (1) ($I_C = 10\text{ mA}$, $I_B = 1.0\text{ mA}$) ($I_C = 50\text{ mA}$, $I_B = 5.0\text{ mA}$)		16, 17	$V_{CE(sat)}$	- -	0.2 0.3	Vdc
Base-Emitter Saturation Voltage (1) ($I_C = 10\text{ mA}$, $I_B = 1.0\text{ mA}$) ($I_C = 50\text{ mA}$, $I_B = 5.0\text{ mA}$)		17	$V_{BE(sat)}$	0.65 -	0.85 0.95	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 10\text{ mA}$, $V_{CE} = 20\text{ Vdc}$, $f = 100\text{ MHz}$)	2N3903 2N3904		f_T	250 300	-	MHz
Output Capacitance ($V_{CE} = 5.0\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)		3	C_{ob}	-	4.0	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)		3	C_{ib}	-	8.0	pF
Input Impedance ($I_C = 1.0\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N3903 2N3904	13	h_{ie}	0.5 1.0	8.0 10	k ohms
Voltage Feedback Ratio ($I_C = 1.0\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N3903 2N3904	14	h_{re}	0.1 0.5	5.0 8.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N3903 2N3904	11	h_{fe}	50 100	200 400	-
Output Admittance ($I_C = 1.0\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)		12	h_{oe}	1.0	40	μmhos
Noise Figure ($I_C = 100\text{ }\mu\text{A}$, $V_{CE} = 5.0\text{ Vdc}$, $R_S = 1.0\text{ k ohms}$, $f = 10\text{ Hz to }15.7\text{ kHz}$)	2N3903 2N3904	9, 10	NF	- -	6.0 5.0	dB

SWITCHING CHARACTERISTICS

Delay Time	($V_{CC} = 3.0\text{ Vdc}$, $V_{BE(off)} = 0.5\text{ Vdc}$, $I_C = 10\text{ mA}$, $I_{B1} = 1.0\text{ mA}$)	1, 5	t_d	-	35	ns
Rise Time		1, 5, 6	t_r	-	35	ns
Storage Time	($V_{CC} = 3.0\text{ Vdc}$, $I_C = 10\text{ mA}$, $I_{B1} = I_{B2} = 1.0\text{ mA}$)	2, 7	t_s	-	175 200	ns
Fall Time		2, 8	t_f	-	50	ns

(1) Pulse Test: Pulse Width = $300\text{ }\mu\text{s}$, Duty Cycle = 2.0%.

*Indicates JEDEC Registered Data

FIGURE 1 - DELAY AND RISE TIME
EQUIVALENT TEST CIRCUIT

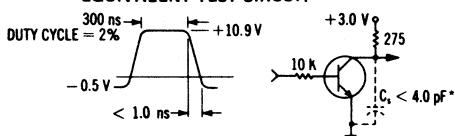
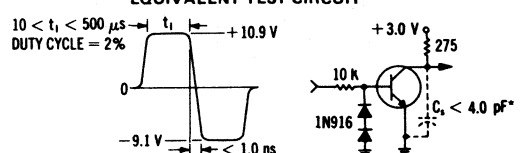


FIGURE 2 - STORAGE AND FALL TIME
EQUIVALENT TEST CIRCUIT



*Total shunt capacitance of test jig and connectors

TYPICAL TRANSIENT CHARACTERISTICS

— $T_J = 25^\circ\text{C}$ --- $T_J = 125^\circ\text{C}$

FIGURE 3 – CAPACITANCE

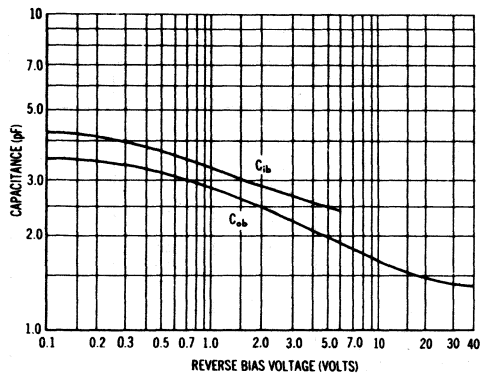


FIGURE 4 – CHARGE DATA

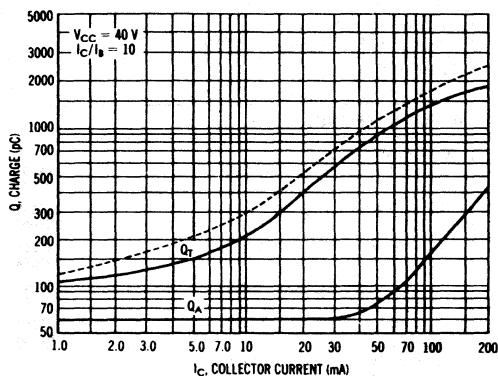


FIGURE 5 – TURN-ON TIME

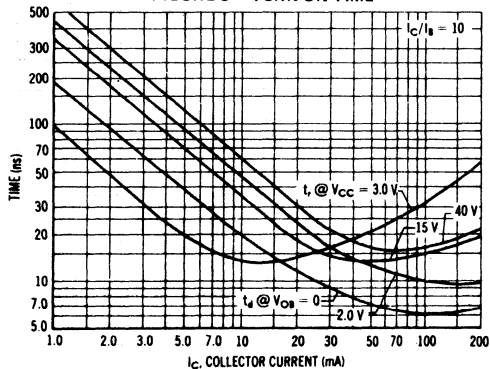


FIGURE 6 – RISE TIME

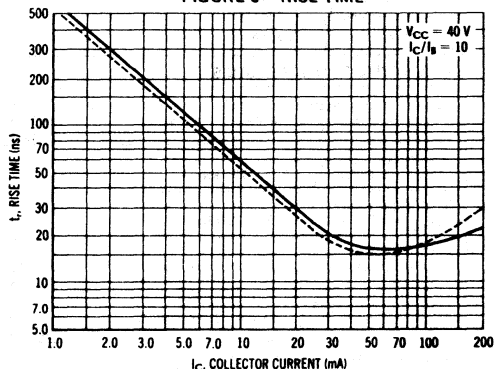


FIGURE 7 – STORAGE TIME

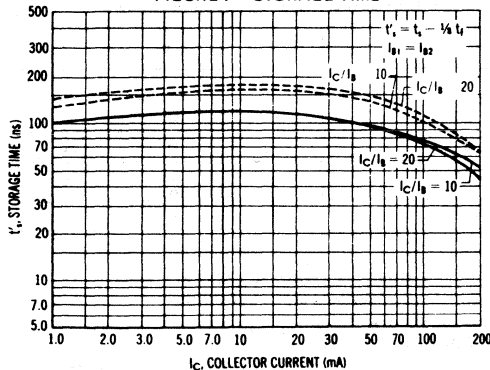
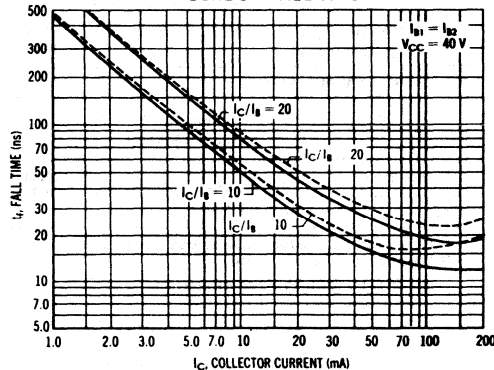
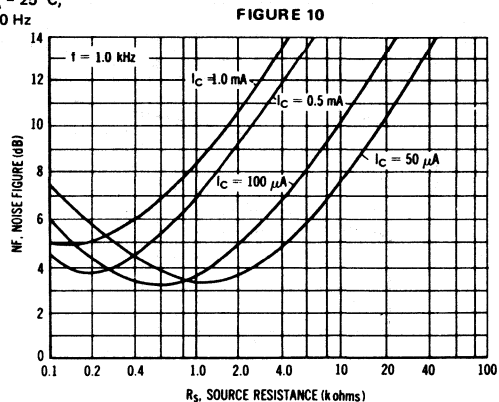
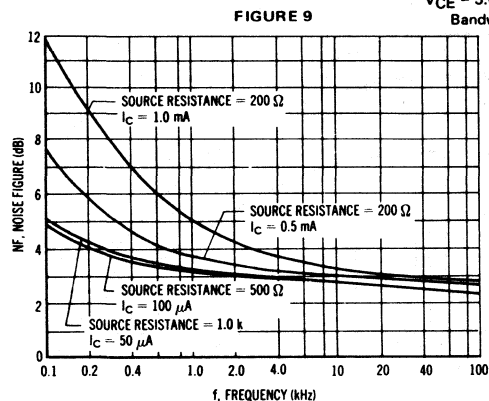


FIGURE 8 – FALL TIME



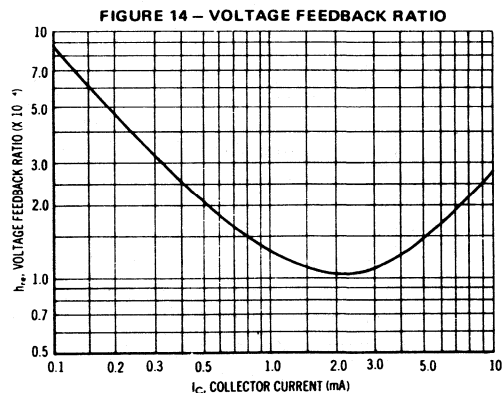
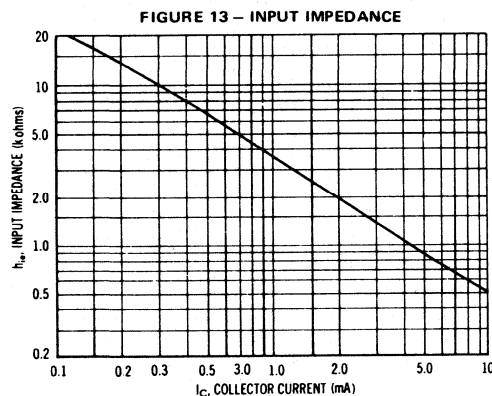
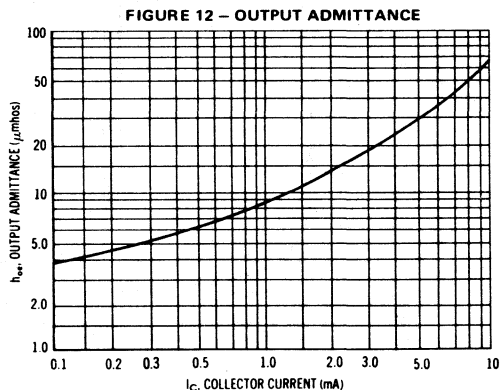
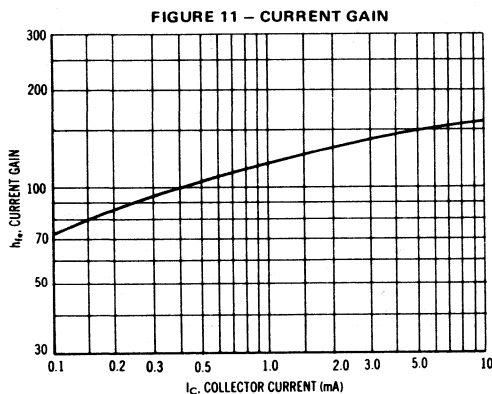
TYPICAL AUDIO SMALL-SIGNAL CHARACTERISTICS
NOISE FIGURE VARIATIONS

$V_{CE} = 5.0 \text{ Vdc}$, $T_A = 25^\circ\text{C}$,
Bandwidth = 1.0 Hz



h PARAMETERS

($V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$, $T_A = 25^\circ\text{C}$)



TYPICAL STATIC CHARACTERISTICS

FIGURE 15 – DC CURRENT GAIN

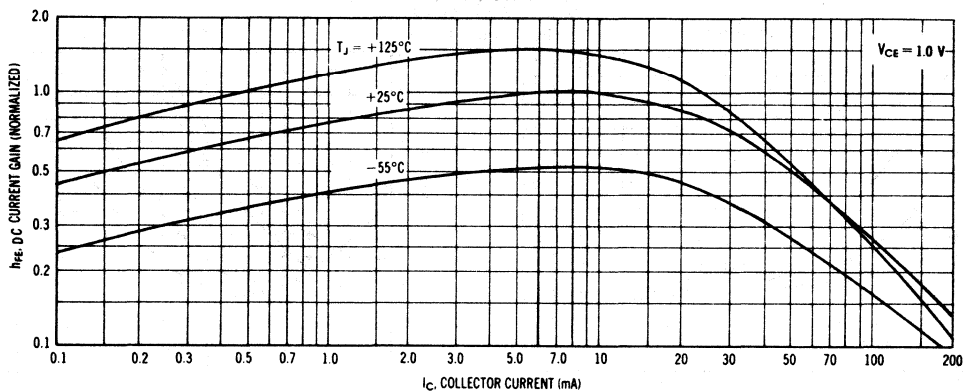


FIGURE 16 – COLLECTOR SATURATION REGION

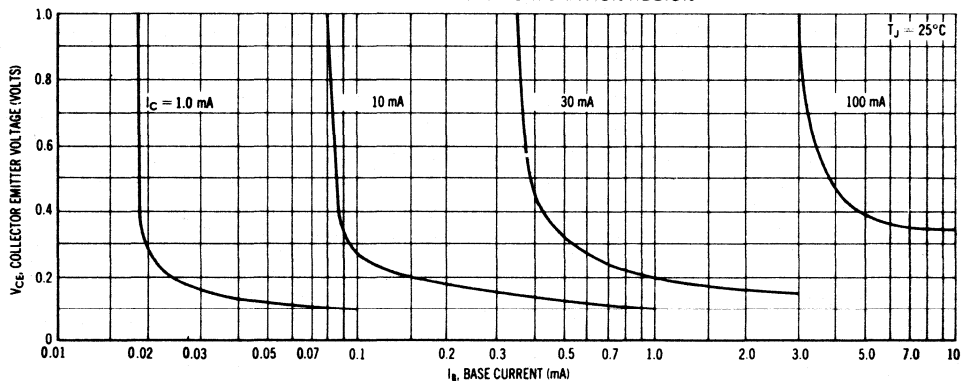


FIGURE 17 – "ON" VOLTAGES

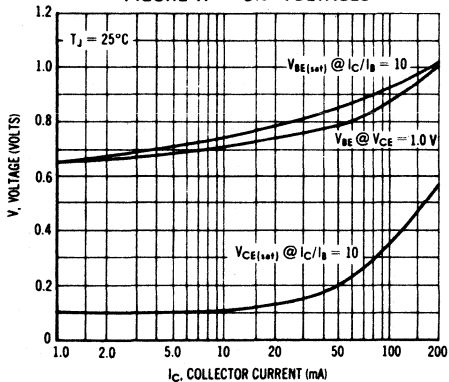
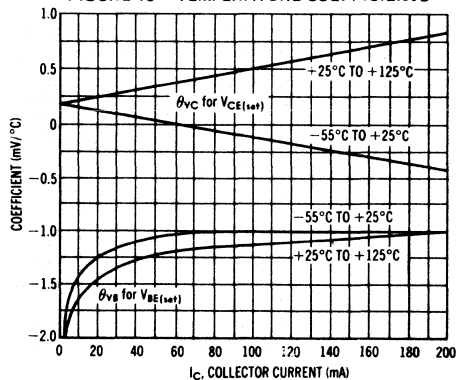


FIGURE 18 – TEMPERATURE COEFFICIENTS



2N3905 (SILICON)

2N3906

PNP SILICON ANNULAR TRANSISTORS

.... designed for general purpose switching and amplifier applications and for complementary circuitry with types 2N3903 and 2N3904.

- Collector-Emitter Breakdown Voltage — $BV_{CEO} = 40 \text{ Vdc (Min)}$
- Current Gain Specified from $100 \mu\text{A}$ to 100 mA
- Complete Switching and Amplifier Specifications
- Low Capacitance — $C_{ob} = 4.5 \text{ pF (Max)}$

*MAXIMUM RATINGS

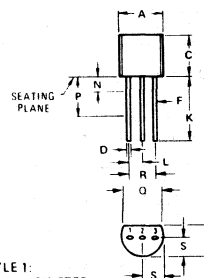
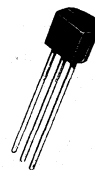
Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	40	Vdc
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	200	mA dc
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 8.0	Watt mW/ $^\circ\text{C}$
Junction Operating Temperature	T_J	+150	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-55 to +150	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	$^\circ\text{C/W}$

*Indicates JEDEC Registered Data.

PNP SILICON SWITCHING & AMPLIFIER TRANSISTORS



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	0.500		
L	1.150	1.390	0.045	0.055
N		1.270		0.050
P	0.250		0.010	
Q	1.430		0.055	
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO. 92

2N3905, 2N3906 (continued)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{A}$, $I_E = 0$)		BV_{CBO}	40	—	Vdc
Collector-Emitter Breakdown Voltage (1) ($I_C = 1.0\text{ mA}$, $I_B = 0$)		BV_{CEO}	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{A}$, $I_C = 0$)		BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 30\text{ Vdc}$, $V_{BE(\text{off})} = 3.0\text{ Vdc}$)		I_{CEV}	—	50	nAdc
Base Cutoff Current ($V_{CE} = 30\text{ Vdc}$, $V_{BE(\text{off})} = 3.0\text{ Vdc}$)		I_{BEV}	—	50	nAdc

ON CHARACTERISTICS (1)					
DC Current Gain ($I_C = 0.1\text{ mA}$, $V_{CE} = 1.0\text{ Vdc}$)	2N3905 2N3906	15	h_{FE}	30 60	—
($I_C = 1.0\text{ mA}$, $V_{CE} = 1.0\text{ Vdc}$)	2N3905 2N3906			40 80	—
($I_C = 10\text{ mA}$, $V_{CE} = 1.0\text{ Vdc}$)	2N3905 2N3906			50 100	150 300
($I_C = 50\text{ mA}$, $V_{CE} = 1.0\text{ Vdc}$)	2N3905 2N3906			30 60	—
($I_C = 100\text{ mA}$, $V_{CE} = 1.0\text{ Vdc}$)	2N3905 2N3906			15 30	—
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mA}$, $I_B = 1.0\text{ mA}$) ($I_C = 50\text{ mA}$, $I_B = 5.0\text{ mA}$)		16, 17	$V_{CE(\text{sat})}$	— —	0.25 0.4
Base-Emitter Saturation Voltage ($I_C = 10\text{ mA}$, $I_B = 1.0\text{ mA}$) ($I_C = 50\text{ mA}$, $I_B = 5.0\text{ mA}$)		17	$V_{BE(\text{sat})}$	0.65 —	0.85 0.95

SMALL-SIGNAL CHARACTERISTICS					
Current-Gain – Bandwidth Product ($I_C = 10\text{ mA}$, $V_{CE} = 20\text{ Vdc}$, $f = 100\text{ MHz}$)	2N3905 2N3906		f_T	200 250	—
Output Capacitance ($V_{CB} = 5.0\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)		3	C_{ob}	—	4.5
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)		3	C_{ib}	—	10
Input Impedance ($I_C = 1.0\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N3905 2N3906	13	h_{ie}	0.5 2.0	8.0 12
Voltage Feedback Ratio ($I_C = 1.0\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N3905 2N3906	14	h_{re}	0.1 1.0	5.0 10
Small-Signal Current Gain ($I_C = 1.0\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N3905 2N3906	11	h_{fb}	50 100	200 400
Output Admittance ($I_C = 1.0\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N3905 2N3906	12	h_{oe}	1.0 3.0	40 60
Noise Figure ($I_C = 100\text{ }\mu\text{A}$, $V_{CE} = 5.0\text{ Vdc}$, $R_S = 1.0\text{ k ohm}$, $f = 10\text{ Hz to }15.7\text{ kHz}$)	2N3905 2N3906	9, 10	NF	— —	5.0 4.0

SWITCHING CHARACTERISTICS					
Delay Time ($V_{CC} = 3.0\text{ Vdc}$, $V_{BE(\text{off})} = 0.5\text{ Vdc}$)		1, 5	t_d	—	35
Rise Time ($I_C = 10\text{ mA}$, $I_{B1} = 1.0\text{ mA}$)		1, 5, 6	t_r	—	35
Storage Time ($V_{CC} = 3.0\text{ Vdc}$, $I_C = 10\text{ mA}$, $I_{B1} = I_{B2} = 1.0\text{ mA}$)	2N3905 2N3906	2, 7	t_s	— —	200 225
Fall Time ($I_{B1} = I_{B2} = 1.0\text{ mA}$)	2N3905 2N3906	2, 8	t_f	— —	60 75

*Indicates JEDEC Registered Data. (1) Pulse Width = 300 μs , Duty Cycle = 2.0 %.

FIGURE 1 – DELAY AND RISE TIME
EQUIVALENT TEST CIRCUIT

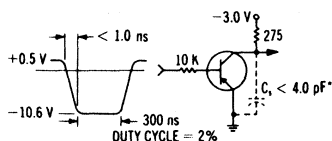
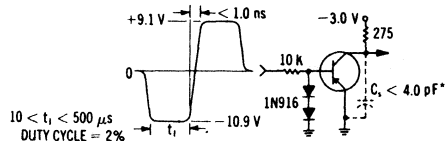


FIGURE 2 – STORAGE AND FALL TIME
EQUIVALENT TEST CIRCUIT



*Total shunt capacitance of test jig and connectors

TRANSIENT CHARACTERISTICS

— $T_j = 25^\circ\text{C}$ --- $T_j = 125^\circ\text{C}$

FIGURE 3 – CAPACITANCE

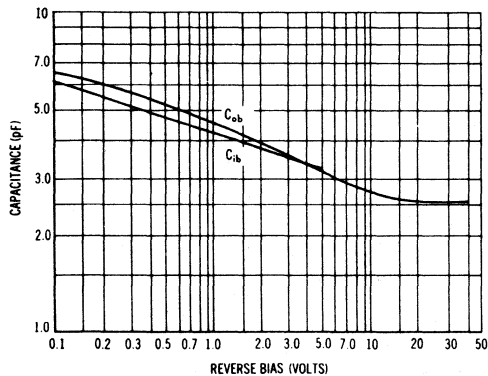


FIGURE 4 – CHARGE DATA

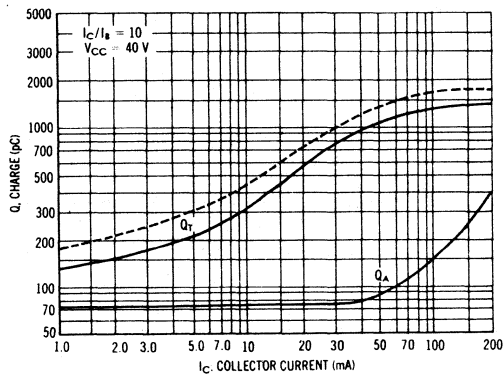


FIGURE 5 – TURN-ON TIME

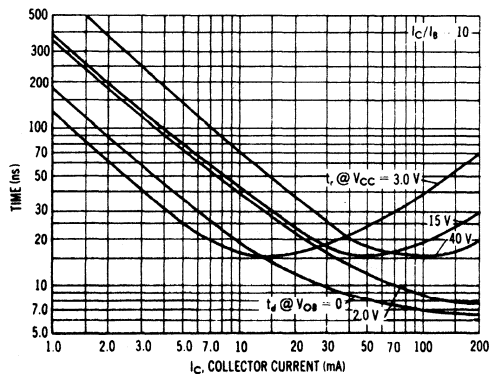


FIGURE 6 – RISE TIME

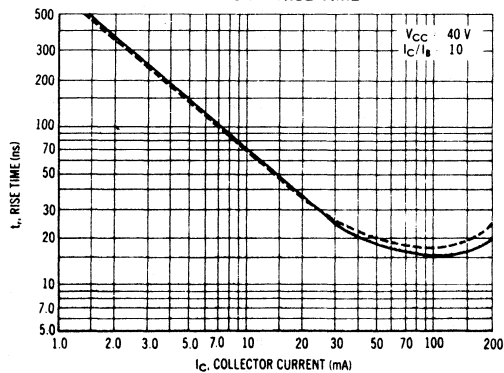


FIGURE 7 – STORAGE TIME

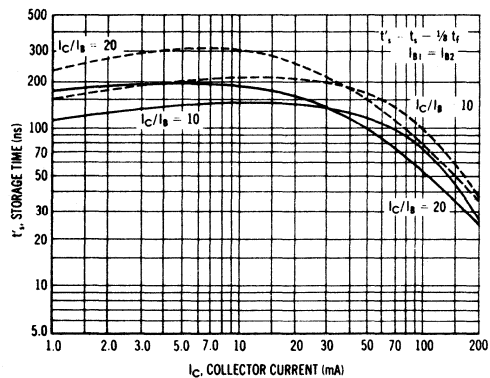
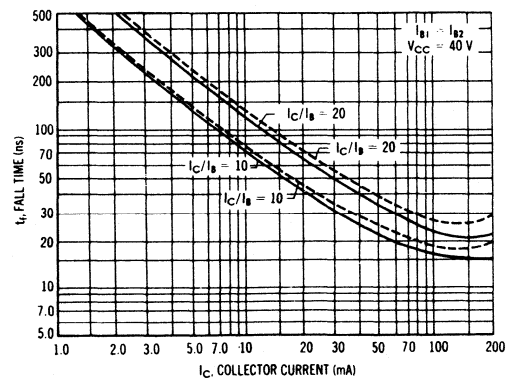


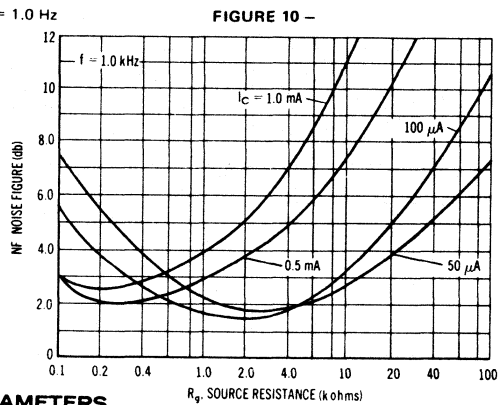
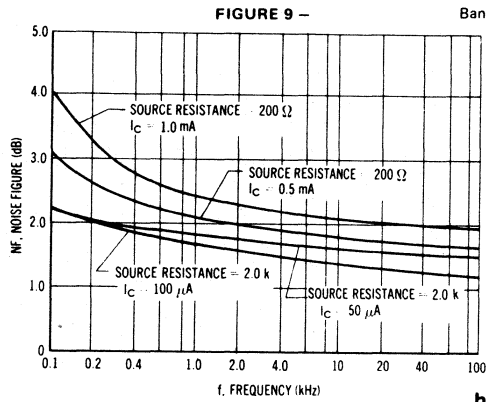
FIGURE 8 – FALL TIME



AUDIO SMALL SIGNAL CHARACTERISTICS NOISE FIGURE VARIATIONS

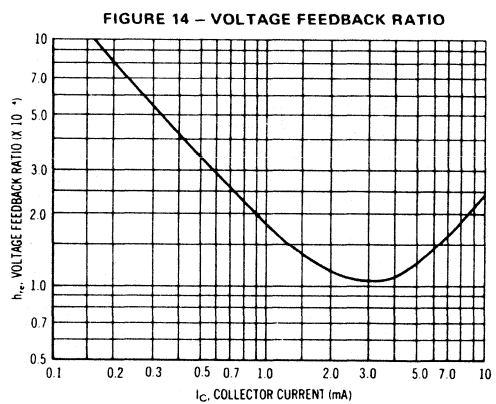
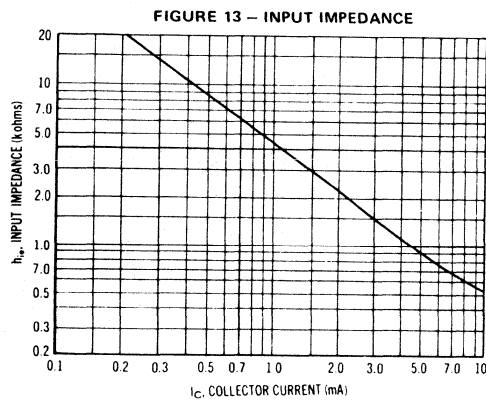
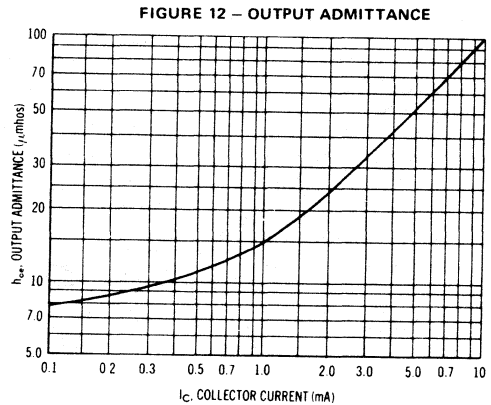
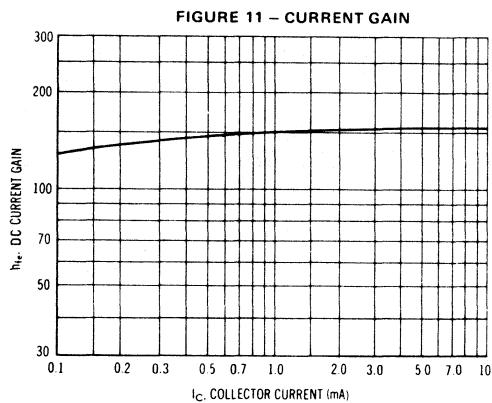
$V_{CE} = 5.0 \text{ Vdc}$, $T_A = 25^\circ\text{C}$,

Bandwidth = 1.0 Hz



h PARAMETERS

($V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$, $T_A = 25^\circ\text{C}$)



STATIC CHARACTERISTICS

FIGURE 15 – DC CURRENT GAIN

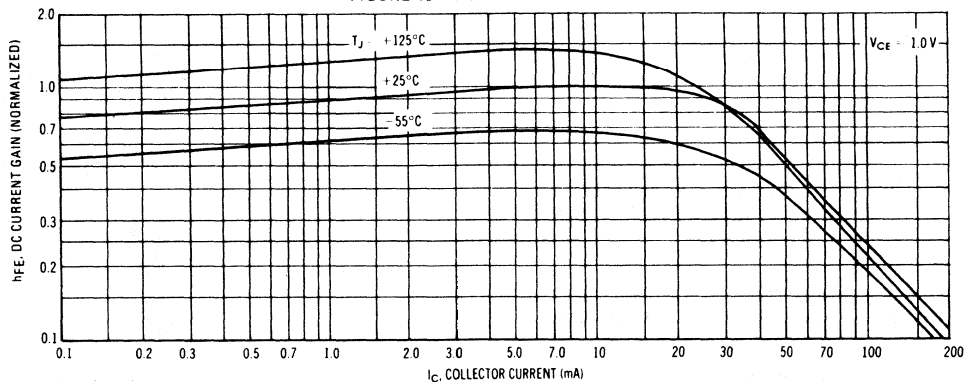


FIGURE 16 – COLLECTOR SATURATION REGION

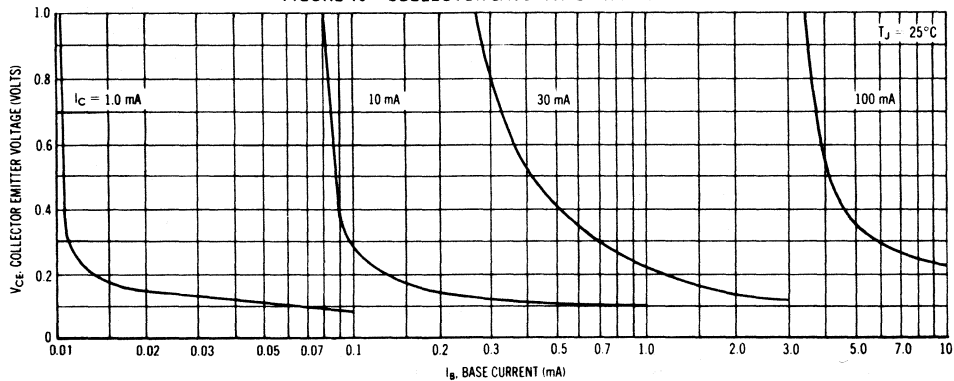


FIGURE 17 – "ON" VOLTAGES

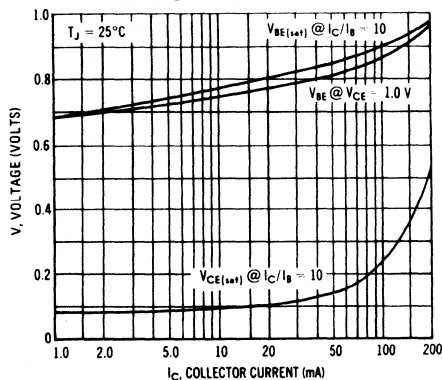
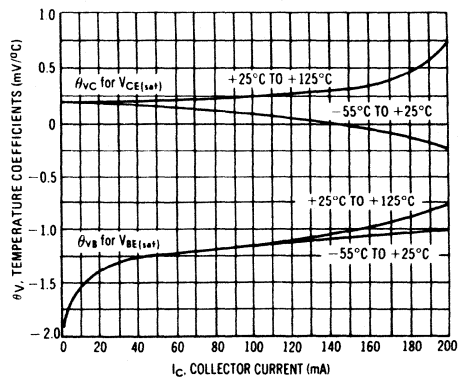


FIGURE 18 – TEMPERATURE COEFFICIENTS



2N3909 (SILICON)

2N3909A

SILICON P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode (Type A) Junction Field-Effect Transistors designed primarily for low-power audio amplifier applications.

- High AC Input Resistance —
Typically > 30 Megohms @ $f = 1.0 \text{ kHz}$
- Drain and Source Interchangeable
- Active Elements Isolated from Case

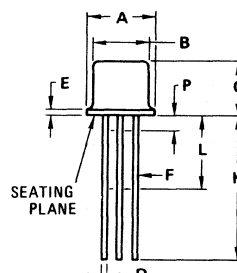
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	-20	Vdc
Drain-Gate Voltage	V_{DG}	-20	Vdc
Reverse Gate-Source Voltage	V_{GSR}	20	Vdc
Forward Gate-Source Voltage	V_{GSF}	20	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 2.0	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.

P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

(Type A)



STYLE 5
PIN 1.

- SOURCE
- GATE 1
- DRAIN
- CASE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	—	0.76	—	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC		45° BSC	
N	1.27	1.27	0.050	0.050
P	—	1.27	—	0.050

ALL JEDEC dimensions and notes apply

CASE 20-03
TO-72

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted) (Note 1)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Gate-Source Breakdown Voltage ($I_G = 10\ \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	20	—	Vdc
Gate-Source Cutoff Voltage ($V_{DS} = 10\ \text{Vdc}$, $I_D = 10\ \mu\text{Adc}$)	$V_{GS(off)}$	— —	8.0 8.0	Vdc
Gate Reverse Current ($V_{GS} = 10\ \text{Vdc}$, $V_{DS} = 0$) ($V_{GS} = 10\ \text{Vdc}$, $V_{DS} = 0$, $T_A = 100^\circ\text{C}$)	I_{GSS}	— —	10 1.0	nAdc μAdc

ON CHARACTERISTICS

Zero-Gate Voltage Drain Current (Note 2) ($V_{DS} = -10\ \text{Vdc}$, $V_{GS} = 0$)	I_{DSS}	0.3 1.0	15 15	mAdc
Gate-Source Voltage ($V_{DS} = -10\ \text{Vdc}$, $I_D = 30\ \mu\text{Adc}$)	V_{GS}	0.3	7.9	Vdc

SMALL-SIGNAL CHARACTERISTICS

Forward Transadmittance (Note 2) ($V_{DS} = -10\ \text{Vdc}$, $V_{GS} = 0$, $f = 1.0\ \text{kHz}$)	$ y_{fs} $	1000 2200	5000 5000	μmhos
($V_{DS} = -10\ \text{Vdc}$, $V_{GS} = 0$, $f = 10\ \text{MHz}$)		900 2000	— —	
Output Admittance ($V_{DS} = -10\ \text{Vdc}$, $V_{GS} = 0$, $f = 1.0\ \text{kHz}$)	$ y_{os} $	—	100	μmhos
Input Capacitance ($V_{DS} = -10\ \text{Vdc}$, $V_{GS} = 0$, $f = 1.0\ \text{MHz}$)	C_{iss}	— —	32 9.0	pF
Reverse Transfer Capacitance ($V_{DS} = -10\ \text{Vdc}$, $V_{GS} = 0$, $f = 1.0\ \text{MHz}$)	C_{rss}	— —	16 3.0	pF

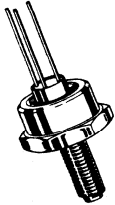
*Indicates JEDEC Registered Data.

Note 1: The fourth lead (case) is connected to the source for all measurements.

Note 2: Pulse Test: Pulse Width $\leq 630\ \text{ms}$, Duty Cycle $\leq 10\%$.

2N3924 (SILICON) thru 2N3927

NPN silicon annular RF power transistors, optimized for large-signal power-amplifier and driver applications to 300 MHz.

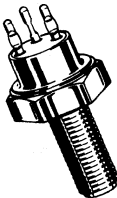


Collector electrically connected to case; stud electrically isolated from case

CASE 24
2N3925
(TO-102)



PIN 1. EMITTER
2. BASE
3. COLLECTOR

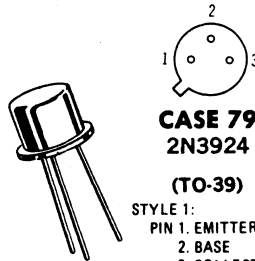


CASE 36
2N3926
2N3927
(TO-60)

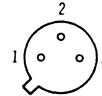


STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR
CASE ISOLATED

Stud and case electrically connected to emitter



CASE 79
2N3924
(TO-39)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

Collector connected to case

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	2N3924	2N3925	2N3926	2N3927	Unit
Collector-Emitter Voltage	V _{CEO}	18	18	18	18	Vdc
Collector-Base Voltage	V _{CB}	36	36	36	36	Vdc
Emitter-Base Voltage	V _{EB}	4.0	4.0	4.0	4.0	Vdc
Collector Current	I _C	0.5	1.0	1.5	3.0	Adc
Power Dissipation @ T _C = 25°C	P _D	7.0	10	11.6	23.2	Watts
Derate above 25°C		40	57.1	66.3	132.5	mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200				°C

2N3924 thru 2N3927 (continued)

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Conditions	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (1)	$I_C = 200 \text{ mA dc}$	$BV_{CEO(sus)}$	18	-	-	Vdc
Collector-Base Breakdown Voltage	$I_C = 0.25 \text{ mA dc}, I_E = 0$	BV_{CBO}	36	-	-	Vdc
	$I_C = 0.50 \text{ mA dc}, I_E = 0$		36	-	-	
Emitter-Base Breakdown Voltage	$I_E = 1.0 \text{ mA dc}, I_C = 0$	BV_{EBO}	4.0	-	-	Vdc
	$I_E = 2.0 \text{ mA dc}, I_C = 0$		4.0	-	-	
Collector Cutoff Current	$V_{CB} = 15 \text{ Vdc}, I_E = 0$	I_{CBO}	-	-	0.1	mA dc
	$V_{CB} = 15 \text{ Vdc}, I_E = 0, T_A = 150^\circ\text{C}$		-	-	5.0	
			-	-	10	

DYNAMIC CHARACTERISTICS

Current-Gain - Bandwidth Product	$I_C = 100 \text{ mA dc}, V_{CE} = 13.6 \text{ Vdc}, f = 100 \text{ MHz}$	f_T	-	350	-	MHz
	$I_C = 200 \text{ mA dc}, V_{CE} = 13.6 \text{ Vdc}, f = 100 \text{ MHz}$		-	350	-	
Output Capacitance	$V_{CB} = 13.6 \text{ Vdc}, I_E = 0, f = 100 \text{ kHz}$	C_{ob}	-	12.5	20	pF
			-	25	45	

FUNCTIONAL TESTS 2N3924

Power Input	Test Circuit Figure 1	P_{in}	-	-	1.0	Watt
Common-Emitter Amplifier Power Gain	$V_{CE} = 13.6 \text{ Vdc}, R_S = 50 \text{ ohms}, R_L = 50 \text{ ohms}, f = 175 \text{ MHz}$	G_{pe}	6.0	7.3	-	dB
Collector Efficiency	$P_{out} = 4.0 \text{ Watts}$	η	70	-	-	%

2N3925

Power Input	Test Circuit Figure 1	P_{in}	-	-	1.3	Watts
Common-Emitter Amplifier Power Gain	$V_{CE} = 13.6 \text{ Vdc}, R_S = 50 \text{ ohms}, R_L = 50 \text{ ohms}, f = 175 \text{ MHz}$	G_{pe}	5.84	6.5	-	dB
Collector Efficiency	$P_{out} = 5.0 \text{ Watts}$	η	70	-	-	%

2N3926

Power Input	Test Circuit Figure 1	P_{in}	-	-	2.0	Watts
Common-Emitter Amplifier Power Gain	$V_{CE} = 13.6 \text{ Vdc}, R_S = 50 \text{ ohms}, R_L = 50 \text{ ohms}, f = 175 \text{ MHz}$	G_{pe}	5.44	6.0	-	dB
Collector Efficiency	$P_{out} = 7.0 \text{ Watts}$	η	70	-	-	%

2N3927

Power Input	Test Circuit Figure 1	P_{in}	-	-	4.0	Watts
Common-Emitter Amplifier Power Gain	$V_{CE} = 13.6 \text{ Vdc}, R_S = 50 \text{ ohms}, R_L = 50 \text{ ohms}, f = 175 \text{ MHz}$	G_{pe}	4.77	5.0	-	dB
Collector Efficiency	$P_{out} = 12 \text{ Watts}$	η	80	-	-	%

(1) Pulsed thru a 25-mH inductor (See Figure 2)

FIGURE 1 — 175 MHz TEST CIRCUIT

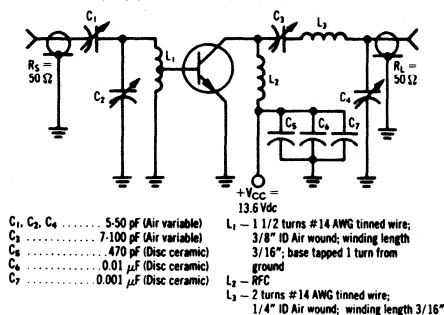
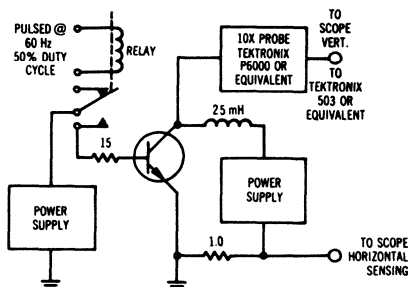


FIGURE 2 — PULSE TEST CIRCUIT



CLASS C DESIGN DATA FOR $V_{CE} = 13.6 \text{ Vdc}$, $T_C = 25^\circ\text{C}$

(Emitter Grounded Directly to the Chassis — No Tuned-Emitter Techniques Used)

2N3924

FIGURE 3 — POWER OUTPUT vs FREQUENCY

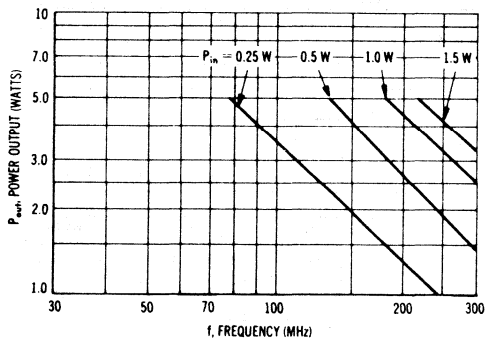


FIGURE 4 — POWER OUTPUT vs POWER INPUT

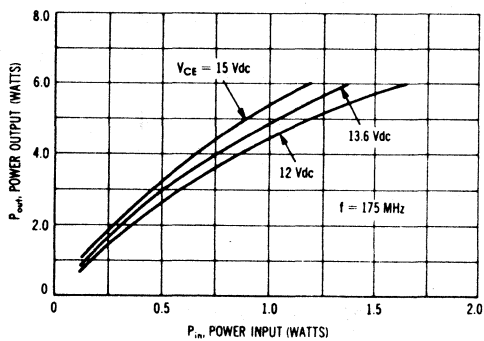


FIGURE 5 — PARALLEL EQUIVALENT INPUT RESISTANCE

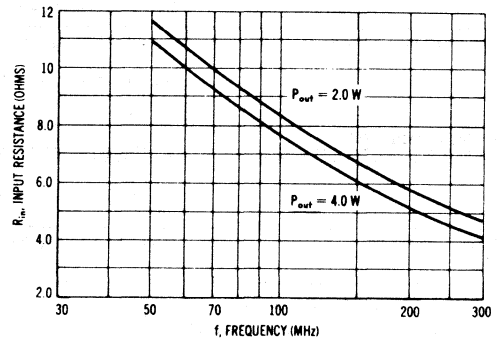


FIGURE 6 — PARALLEL EQUIVALENT INPUT CAPACITANCE

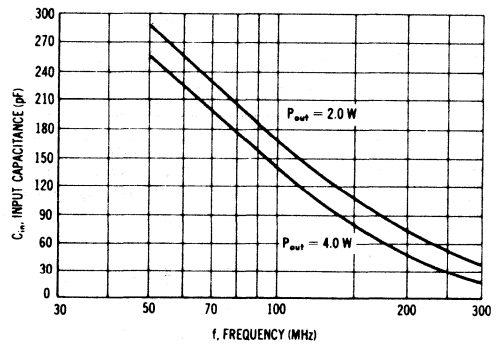
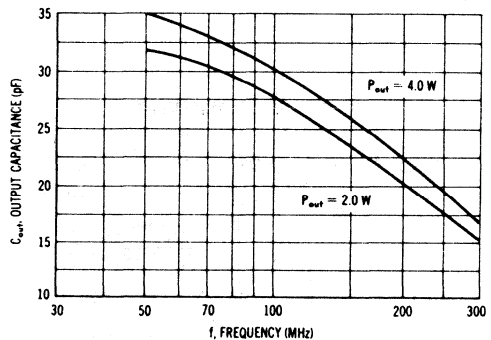


FIGURE 7 — PARALLEL EQUIVALENT OUTPUT CAPACITANCE



2N3925

FIGURE 8 — POWER OUTPUT vs FREQUENCY

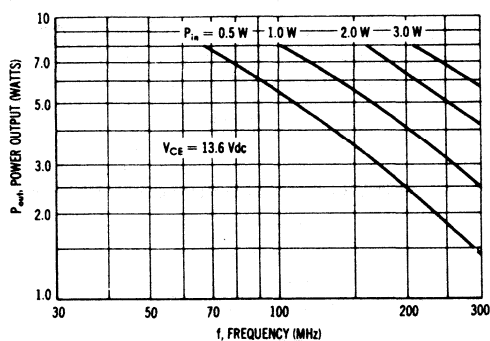


FIGURE 9 — POWER OUTPUT vs POWER INPUT

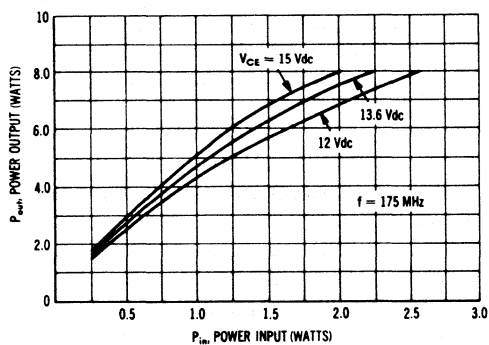


FIGURE 10 — PARALLEL EQUIVALENT INPUT RESISTANCE

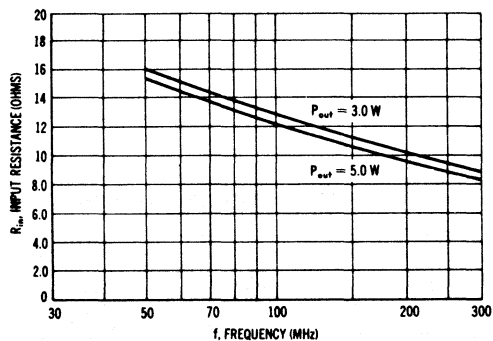


FIGURE 11 — PARALLEL EQUIVALENT INPUT CAPACITANCE

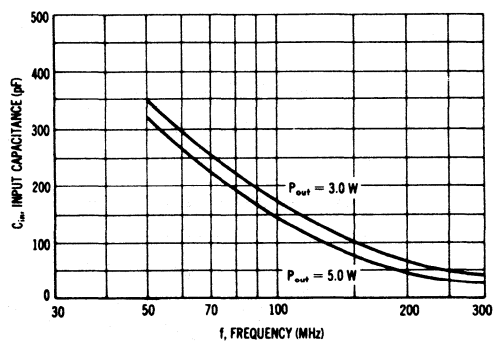
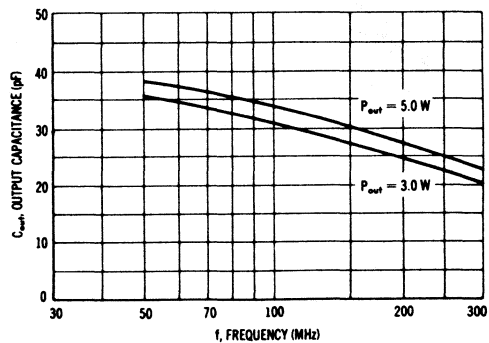


FIGURE 12 — PARALLEL EQUIVALENT OUTPUT CAPACITANCE



2N3926

FIGURE 13 — POWER OUTPUT vs FREQUENCY

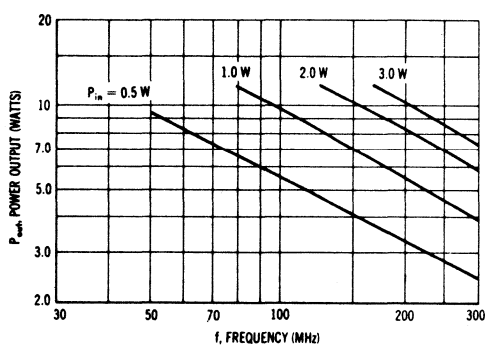


FIGURE 14 — POWER OUTPUT vs POWER INPUT

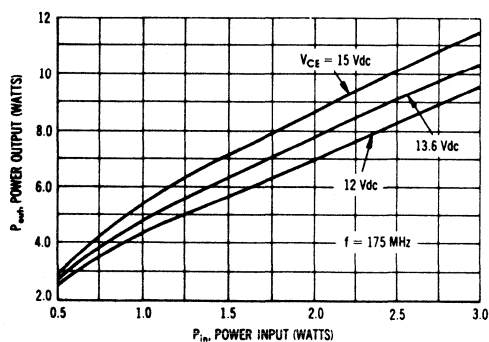


FIGURE 15 — PARALLEL EQUIVALENT INPUT RESISTANCE

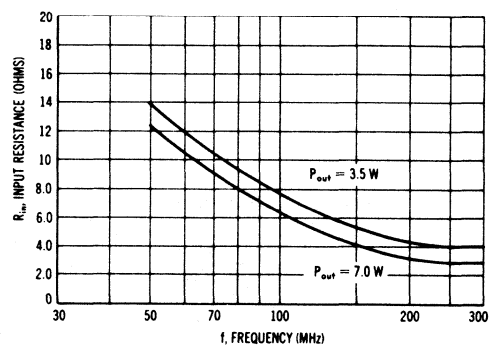


FIGURE 16 — PARALLEL EQUIVALENT INPUT CAPACITANCE

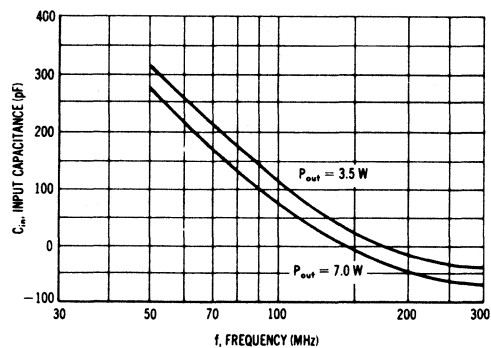
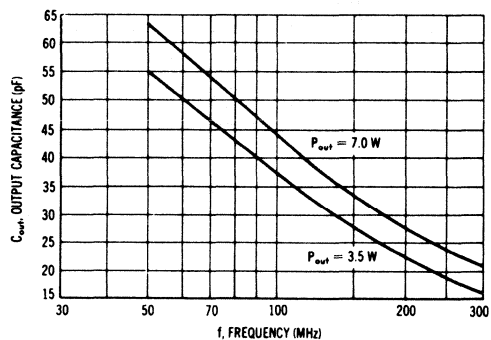


FIGURE 17 — PARALLEL EQUIVALENT OUTPUT CAPACITANCE



2N3927

FIGURE 18 — POWER INPUT vs FREQUENCY

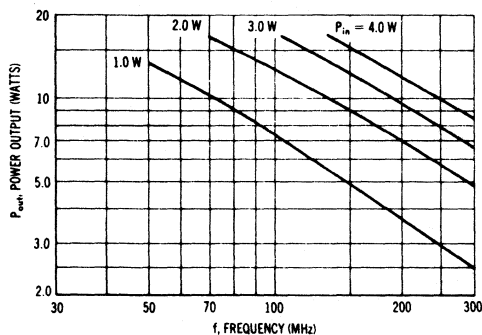


FIGURE 20 — PARALLEL EQUIVALENT INPUT RESISTANCE

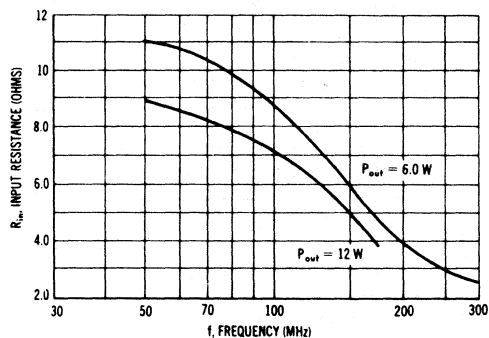


FIGURE 19 — POWER OUTPUT vs POWER INPUT

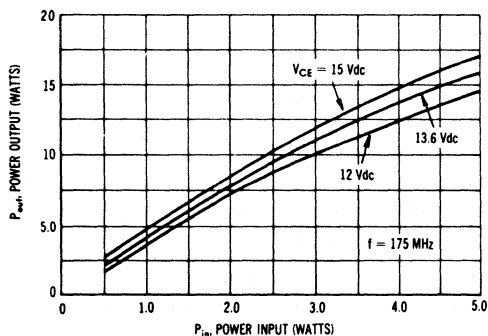


FIGURE 21 — PARALLEL EQUIVALENT INPUT CAPACITANCE

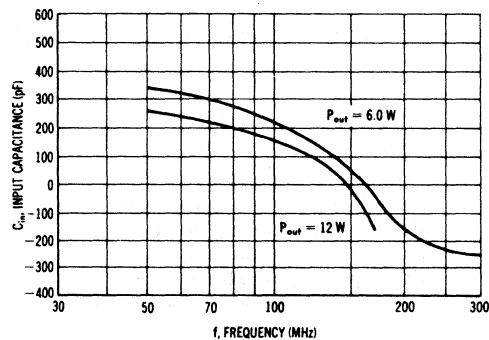
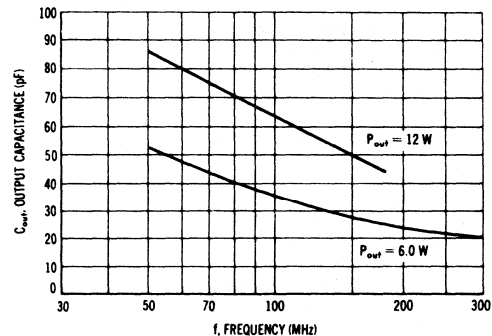


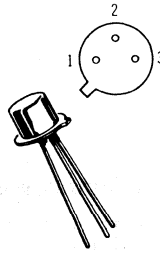
FIGURE 22 — PARALLEL EQUIVALENT OUTPUT CAPACITANCE



DESIGN NOTE

For Class C power-amplifier designs, small-signal parameters are not applicable. The parallel equivalent output capacitance and input resistance and capacitance for Class C power-amplifier design are used.

The parallel resistive portion of the collector load impedance for a power amplifier, R_L' , may be computed by assuming a peak voltage swing equal to V_{CC} , and using the expression $R_L' = V_{CC}^2/2P$ where $P = RF$ power output. The computed R_L' may then be combined with the data for Class C design to complete device impedance data.

2N3946 (SILICON)**2N3947**

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 22
(TO-18)

NPN silicon annular transistors, designed for general purpose switching and amplifier applications. The 2N3946 and 2N3947 are complementary with PNP types 2N3250 and 2N3251, respectively.

Collector connected to case

***MAXIMUM RATINGS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	60	Vdc
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current	I_C	200	mA dc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$	P_D	1.2	Watts
Derating Factor Above 25°C		6.9	mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_A = 25^\circ\text{C}$	P_D	0.36	Watt
Derating Factor Above 25°C		2.06	mW/ $^\circ\text{C}$
Thermal Resistance Junction to Ambient	θ_{JA}	0.49	$^\circ\text{C}/\text{mW}$
Junction to Case	θ_{JC}	0.15	$^\circ\text{C}/\text{mW}$
Junction Operating Temperature	T_J	200	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{A dc}$, $I_E = 0$)	BV_{CBO}	60	—	Vdc
Collector-Emitter Breakdown Voltage(1) ($I_C = 10 \text{ mA dc}$)	BV_{CEO}^*	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{A dc}$, $I_C = 0$)	BV_{EBO}	6.0	—	Vdc
Collector-Cutoff Current ($V_{CE} = 40 \text{ Vdc}$, $V_{OB} = 3 \text{ Vdc}$) ($V_{CE} = 40 \text{ Vdc}$, $V_{OB} = 3 \text{ Vdc}$, $T_A = 150^\circ\text{C}$)	I_{CEX}	—	.010 15	$\mu\text{A dc}$
Base Cutoff Current ($V_{CE} = 40 \text{ Vdc}$, $V_{OB} = 3 \text{ Vdc}$)	I_{BL}	—	.025	$\mu\text{A dc}$

(1) Pulse Test: $PW \leq 300 \mu\text{s}$, Duty Cycle $\leq 2\%$

V_{OB} = Base-Emitter Reverse Bias

* Indicates JEDEC Registered Data

2N3946, 2N3947 (continued)***ELECTRICAL CHARACTERISTICS (continued)**(T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
DC Current Gain ⁽¹⁾ (I _C = 0.1 mA, V _{CE} = 1 Vdc) (I _C = 1.0 mA, V _{CE} = 1 Vdc) (I _C = 10 mA, V _{CE} = 1 Vdc) (I _C = 50 mA, V _{CE} = 1 Vdc)	h _{FE}	30 60 45 90 50 100 20 40	— — — — 150 300 — —	—
Collector Saturation Voltage ⁽¹⁾ (I _C = 10 mA, I _B = 1 mA) (I _C = 50 mA, I _B = 5 mA)	V _{CE(sat)}	— —	0.2 0.3	Vdc
Base-Emitter Saturation Voltage ⁽¹⁾ (I _C = 10 mA, I _B = 1 mA) (I _C = 50 mA, I _B = 5 mA)	V _{BE(sat)}	0.6 —	0.9 1.0	Vdc

TRANSIENT CHARACTERISTICS

Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)		C_{ob}	—	4.0	pF
Input Capacitance ($V_{BE} = 1\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)		C_{ib}	—	8.0	pF
Current-Gain - Bandwidth Product ($I_C = 10\text{ mA}$, $V_{CE} = 20\text{ Vdc}$, $f = 100\text{ MHz}$)		f_T	250 300	— —	MHz
Delay Time	$V_{CC} = 3\text{ Vdc}$, $V_{OB} = 0.5\text{ Vdc}$ $I_C = 10\text{ mA}$, $I_{B1} = 1\text{ mA}$	t_d	—	35	ns
Rise Time		t_r	—	35	ns
Storage Time	$V_{CC} = 3\text{ V}$, $I_C = 10\text{ mA}$, $I_{B1} = -I_{B2} = 1\text{ mA}$	t_s	— —	300 375	ns
Fall Time		t_f	—	75	ns

SMALL SIGNAL CHARACTERISTICS

Small-Signal Current Gain (I _C = 1.0 mA, V _{CE} = 10 V, f = 1 kHz)	h _{fe}	50 100	250 700	—
Voltage Feedback Ratio (I _C = 1.0 mA, V _{CE} = 10 V, f = 1 kHz)	h _{re}	— —	10 20	X10 ⁻⁴
Input Impedance (I _C = 1.0 mA, V _{CE} = 10 V, f = 1 kHz)	h _{ie}	0.5 2.0	6.0 12	kohms
Output Admittance (I _C = 1.0 mA, V _{CE} = 10 V, f = 1 kHz)	h _{oe}	1.0 5.0	30 50	μmhos
Collector-Base Time Constant (I _C = 10 mA, V _{CE} = 20 V, f = 31.8 MHz)	r _b 'C _C	—	200	ps
Wide Band Noise Figure (I _C = 100 μA, V _{CE} = 5 V, R _g = 1 kΩ, f = 10 Hz to 15.7 kHz)	NF	—	5.0	dB

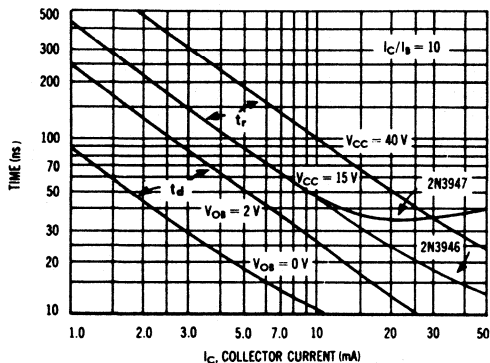
⁽¹⁾ Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2%V_{OB} = Base-Emitter Reverse Bias

* Indicates JEDEC Registered Data

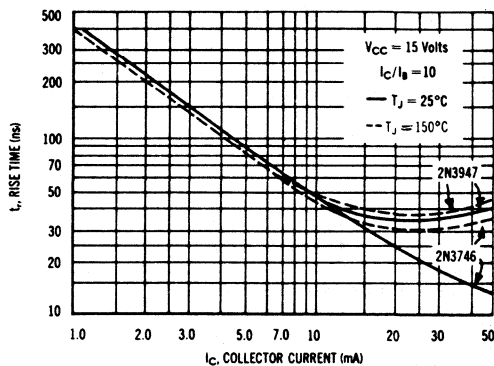
TYPICAL SWITCHING CHARACTERISTICS

($T_A = 25^\circ\text{C}$ unless otherwise noted)

DELAY AND RISE TIME

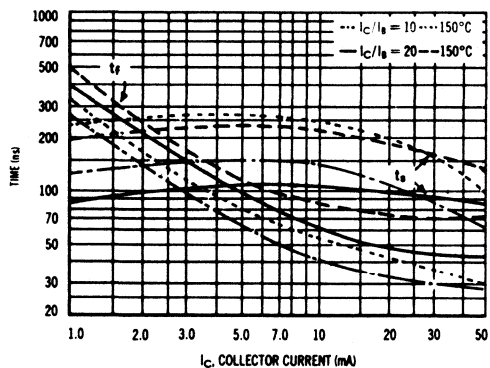


RISE TIME

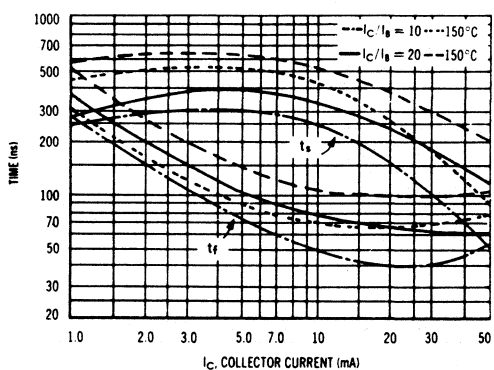


STORAGE AND FALL TIMES

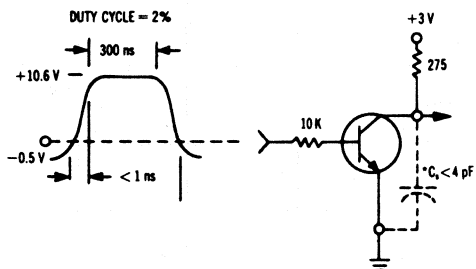
2N3946



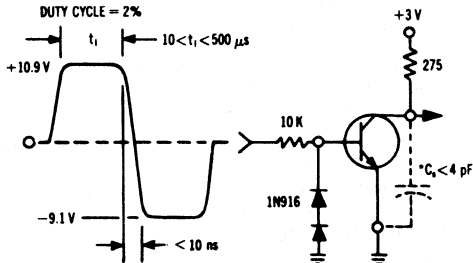
2N3947



TURN-ON TIME EQUIVALENT TEST CIRCUIT



TURN-OFF TIME EQUIVALENT TEST CIRCUIT

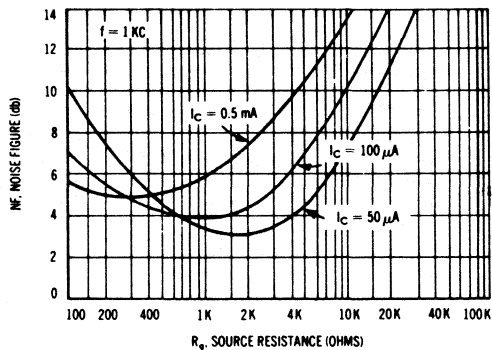
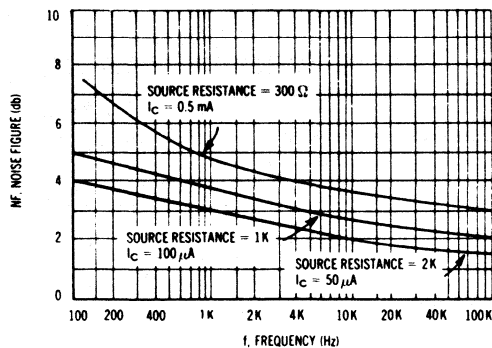


*TOTAL SHUNT CAPACITANCE OF TEST JIG AND CONNECTORS

AUDIO SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE VARIATIONS

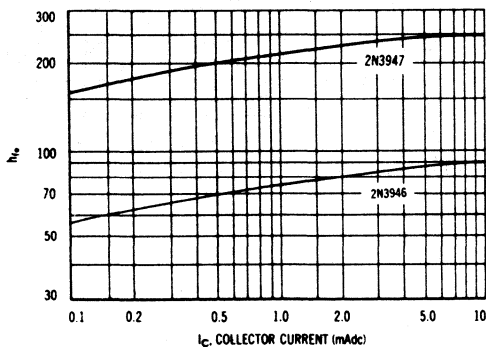
$V_{CE} = 5 \text{ V}$, $T_A = 25^\circ\text{C}$



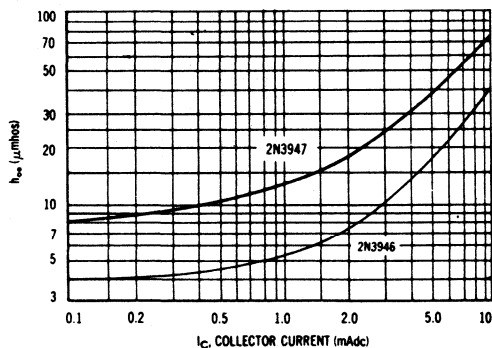
h PARAMETERS

$V_{CE} = 10 \text{ V}$, $T_A = 25^\circ\text{C}$, $f = 1 \text{ Kc}$

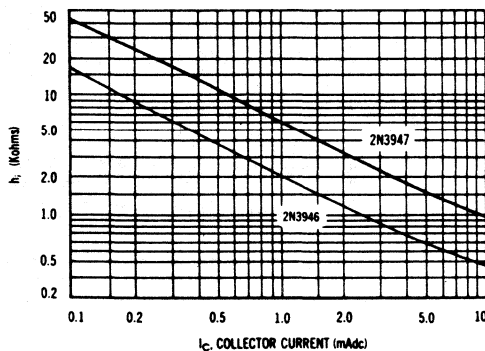
CURRENT GAIN



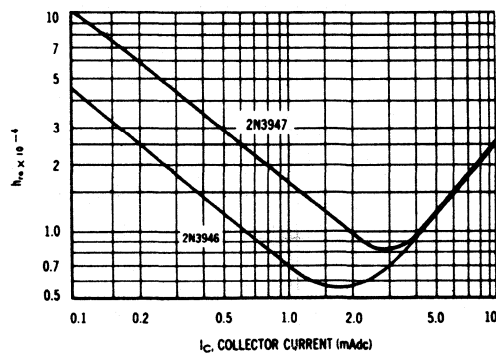
OUTPUT ADMITTANCE



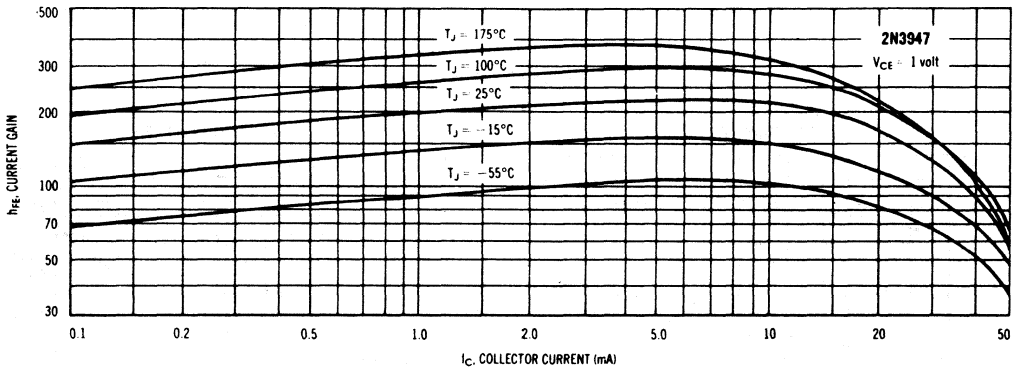
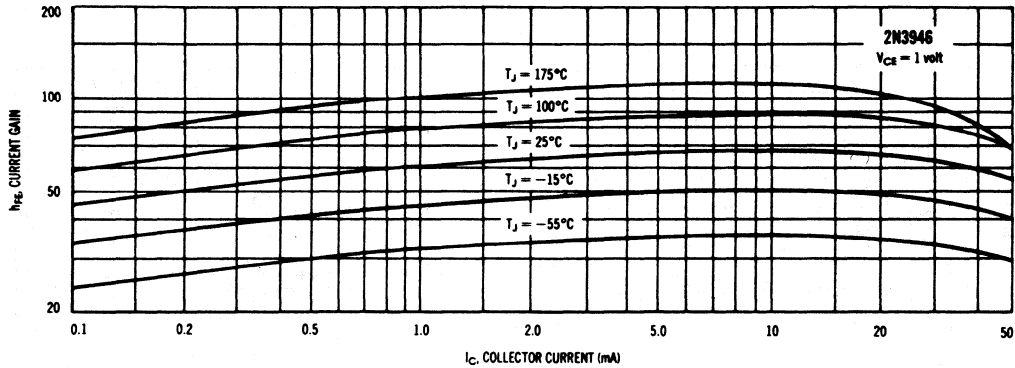
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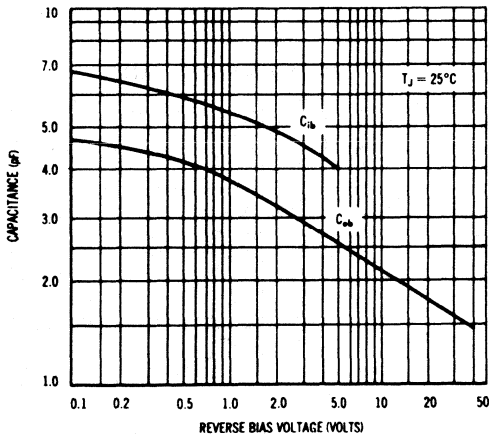
VOLTAGE FEEDBACK RATIO



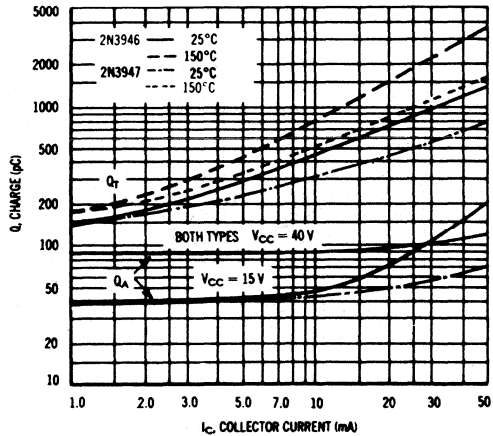
CURRENT GAIN CHARACTERISTICS



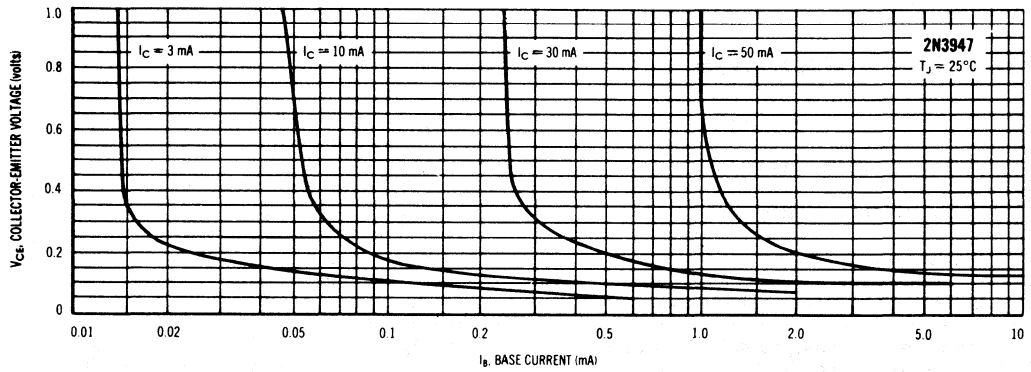
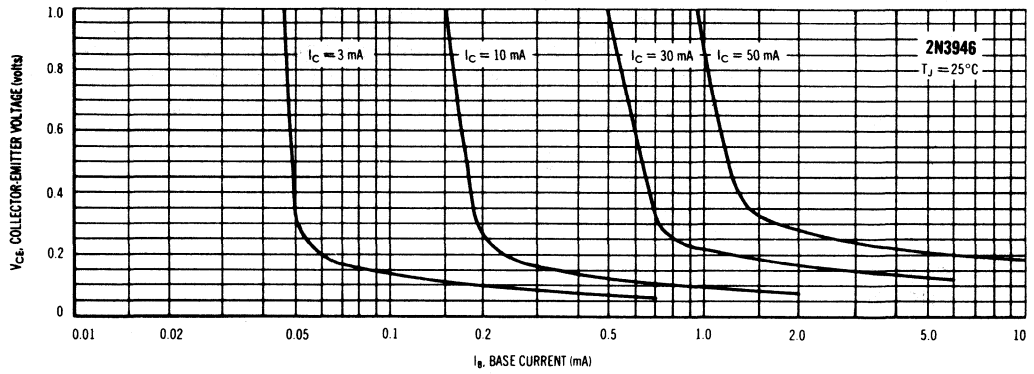
CAPACITANCE



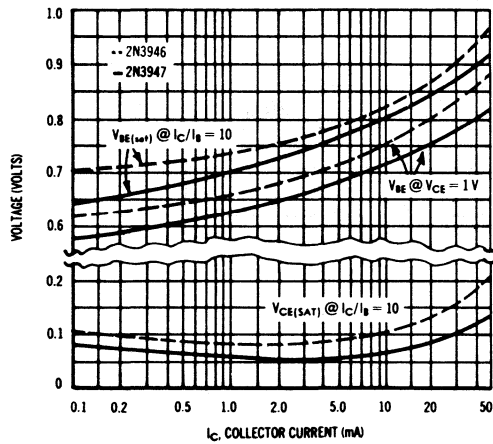
CHARGE DATA



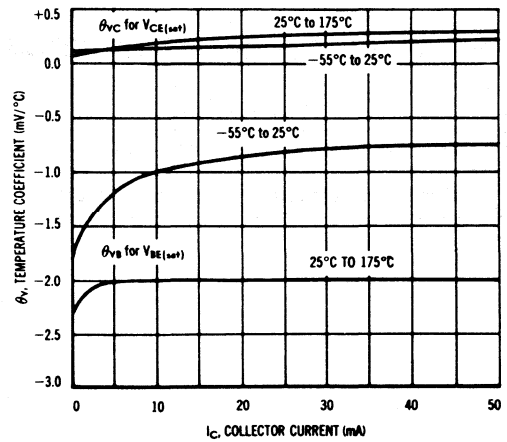
COLLECTOR SATURATION REGION



"ON" VOLTAGES

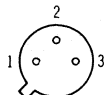
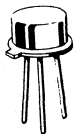


TEMPERATURE COEFFICIENTS



2N3948 (SILICON)

NPN silicon RF power transistor designed for amplifier, frequency multiplier, or oscillator applications in military and industrial equipment. Suitable for use as output, driver, or pre-driver stages in VHF and UHF equipment. Ideal for CATV applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 79
(TO-39)

MAXIMUM RATINGS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	36	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector Current — Continuous	I_C	400	mA dc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 5.71	Watt mW/ $^\circ\text{C}$
Operating Junction and Storage Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	35	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	θ_{JA}	175	$^\circ\text{C}/\text{W}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage ($I_C = 5\text{ mAdc}$, $I_E = 0$)	$BV_{CEO(sus)}$	30	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1\text{ mAdc}$, $I_E = 0$)	BV_{CBO}	36	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1\text{ mAdc}$, $I_C = 0$)	BV_{EBO}	3.5	—	Vdc
Collector Cutoff Current ($V_{CB} = 15\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 15\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	—	0.1 100	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 50\text{ mAdc}$, $V_{CE} = 5\text{ Vdc}$)	h_{FE}	15	—	—
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product ($I_E = 50\text{ mAdc}$, $V_{CE} = 15\text{ Vdc}$, $f = 200\text{ MHz}$)	f_T	700	—	MHz
Output Capacitance ($V_{CB} = 15\text{ Vdc}$, $I_E = 0$, $f = 1\text{ MHz}$)	C_{ob}	—	4.5	pF
FUNCTIONAL TEST				
Power Gain	$V_{CE} = 13.6\text{ Vdc}$, $R_D = 50\text{ ohms}$,	C_{PE}	6.0	dB
Power Output	$R_L = 50\text{ ohms}$, $f = 400\text{ MHz}$,	P_{out}	1.0	Watt
Collector Efficiency	$P_{in} = 0.25\text{ W}$	η	45	%

SMALL-SIGNAL ADMITTANCE PARAMETERS VERSUS FREQUENCY

($I_C = 80\text{ mAdc}$, $V_{CE} = 15\text{ Vdc}$, $T_A = 25^\circ\text{C}$)

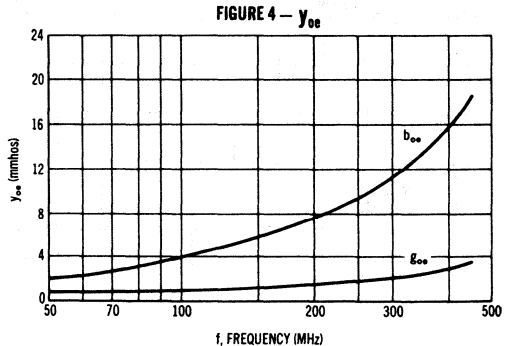
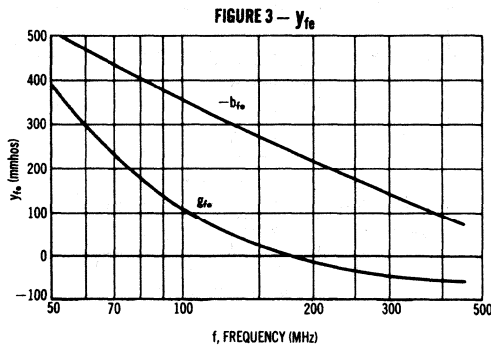
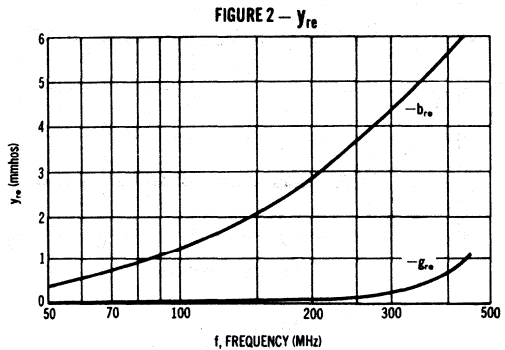
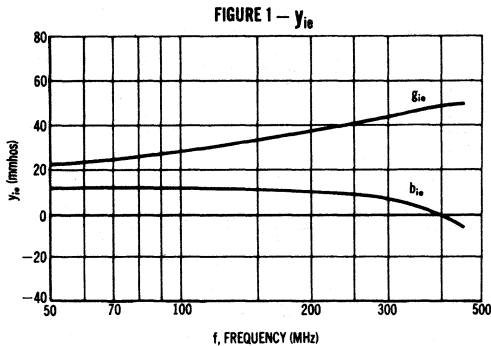


FIGURE 5 — SMALL-SIGNAL CURRENT GAIN

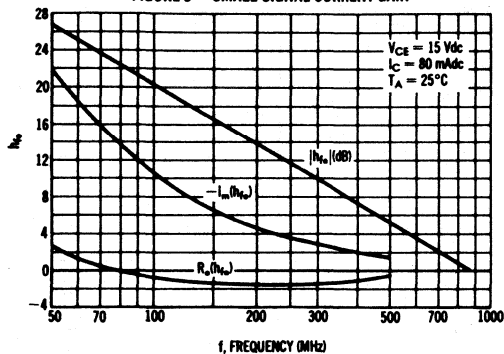
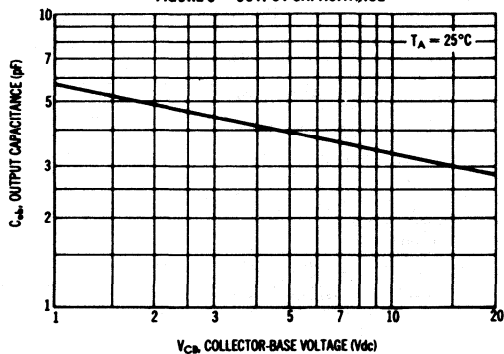


FIGURE 6 — OUTPUT CAPACITANCE



SMALL-SIGNAL ADMITTANCE PARAMETERS VERSUS COLLECTOR CURRENT

($f = 200 \text{ MHz}$, $T_A = 25^\circ\text{C}$)

— $V_{CE} = 10 \text{ V}$

— $V_{CE} = 15 \text{ V}$

FIGURE 7 — y_{ie}

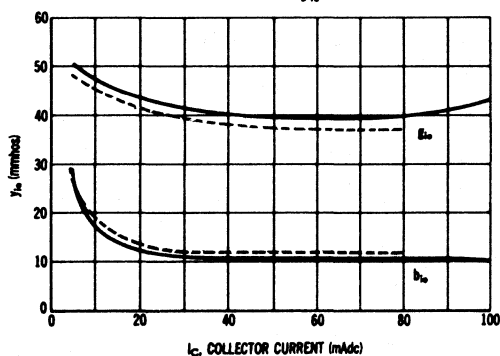


FIGURE 8 — y_{re}

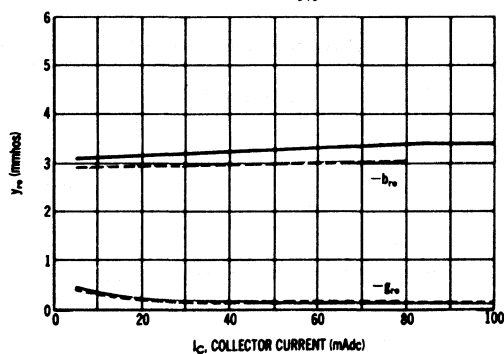


FIGURE 9 — y_{fs}

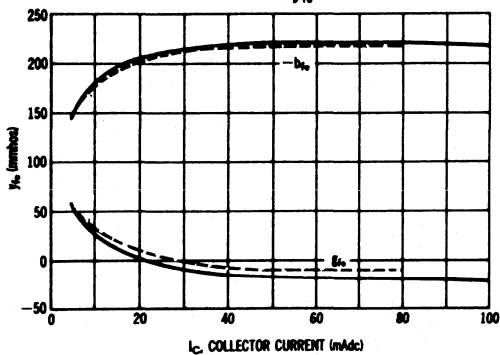


FIGURE 10 — y_{os}

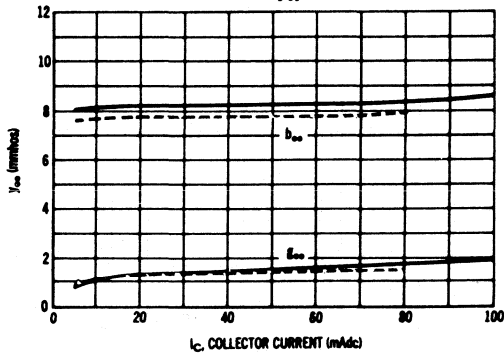


FIGURE 11 — 400 MHz RF AMPLIFIER TEST CIRCUIT

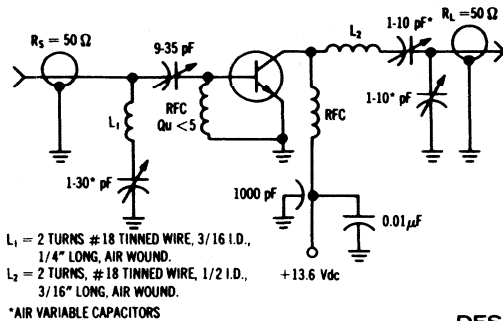
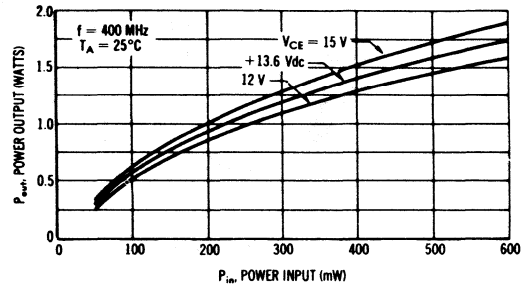


FIGURE 12 — POWER GAIN



DESIGN NOTE

Figures 1 through 4 and 7 through 10 show small-signal admittance-parameter data. This data can be used for Class A amplifier designs.

For Class C power-amplifier designs, the small-signal parameters are not applicable. The parallel equivalent output capacitance and input resistance and capacitance for Class C power-amplifier operation are used.

The parallel resistive portion of the collector load impedance for a power amplifier, R_L' , may be computed by assuming a peak voltage swing equal to V_{CC} , and using the expression $R_L' = V_{CC}^2/2P$ where $P = RF$ power output. The computed R_L' may then be combined with the data in Figures 14, 15 and 16 to comprise complete device impedance data for Class C power amplifier design.

CLASS C DESIGN DATA (EMITTER GROUNDED DIRECTLY TO CHASSIS)

($V_{CE} = 13.6$ V, $T_A = 25^\circ\text{C}$)

FIGURE 13 — POWER OUTPUT

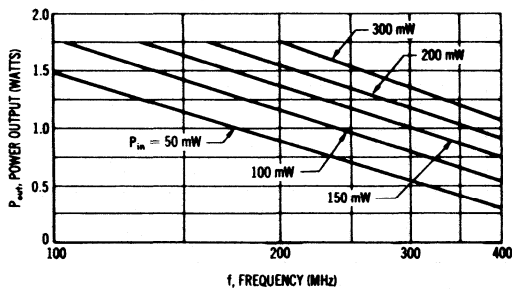


FIGURE 14 — PARALLEL EQUIVALENT OUTPUT CAPACITANCE

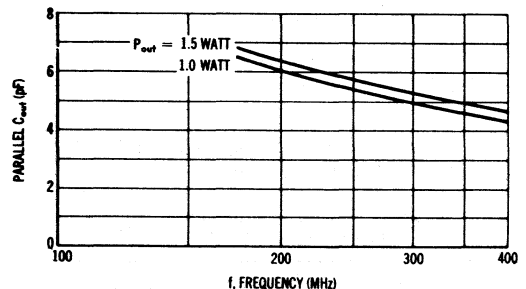


FIGURE 15 — PARALLEL EQUIVALENT INPUT RESISTANCE

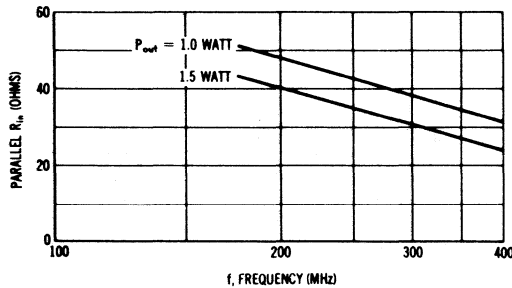
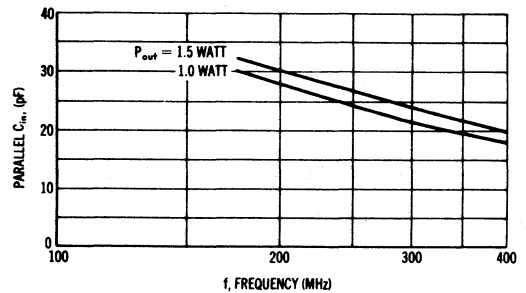


FIGURE 16 — PARALLEL EQUIVALENT INPUT CAPACITANCE



2N3950 (SILICON)

NPN silicon RF power transistor designed for high-power RF amplifier applications in military and industrial equipment.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR
CASE ISOLATED

CASE 36
(TO-60)

Emitter common to stud and case

MAXIMUM RATINGS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Collector-Base Voltage	V_{CB}	65	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector-Current — Continuous	I_C	3.3	Amp
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	2.8 16	Watts mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	70 0.4	Watts W/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	62.5	$^\circ\text{C/W}$
Thermal Resistance, Junction to Case	θ_{JC}	2.5	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
----------------	--------	-----	-----	-----	------

OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage (1) ($I_C = 200 \text{ mA dc}$, $I_E = 0$)	$BV_{CEO(sus)}$	35	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10 \text{ mA dc}$, $V_{BE} = 0$)	BV_{CES}	65	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \text{ mA dc}$, $I_C = 0$)	BV_{EBO}	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 65 \text{ V dc}$, $I_E = 0$) ($V_{CB} = 28 \text{ V dc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	— —	10 10	mA dc

DYNAMIC CHARACTERISTICS

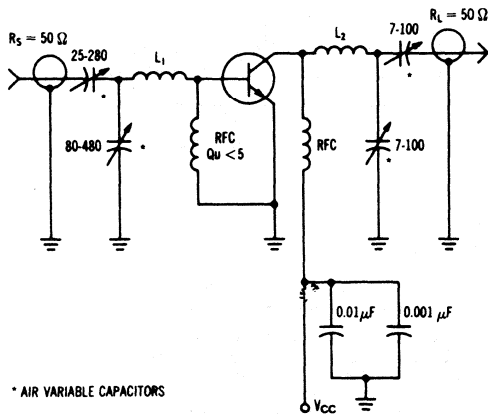
Current-Gain — Bandwidth Product ($I_E = 500 \text{ mAdc}$, $V_{CE} = 28 \text{ Vdc}$, $f = 50 \text{ MHz}$)	f_T	—	150	—	MHz
Output Capacitance ($V_{CB} = 28 \text{ Vdc}$, $I_E = 0$, $f = 1 \text{ MHz}$)	C_{ob}	—	80	120	pF

FUNCTIONAL TEST

Power Gain	Test Circuit - Figure 1, P _{out} = 50 W, V _{CC} = 28 Vdc, R _S = 50 ohms, f = 50 MHz	G _{PE}	8.0	—	—	dB
Collector-Efficiency		"	60	—	—	%

(1) Pulsed through a 25 mH inductor; Duty factor = 50%, Rep. Rate $\leq$ 60 Hz.

FIGURE 1 — 50 MHz TEST CIRCUIT

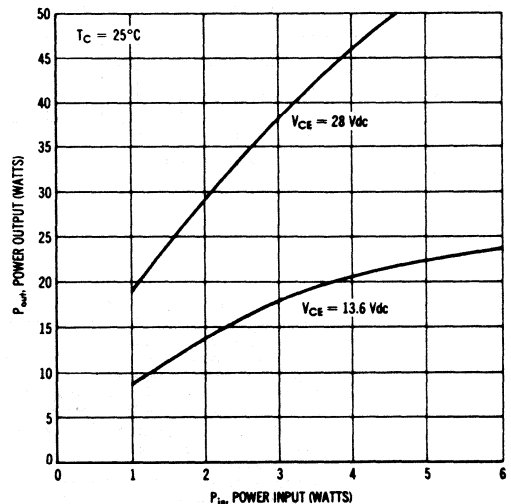


* AIR VARIABLE CAPACITORS

L₁ = 2 TURNS #18 TINNED WIRE, 1/4" I.D., AIR WOUND,
WINDING LENGTH 1/2".

$L_2 = 5$ TURNS #16 TINNED WIRE, $\frac{3}{8}$ " I.D., AIR WOUND,
WINDING LENGTH $\frac{3}{8}$ ".

FIGURE 2 — 50 MHz POWER GAIN



CLASS C DESIGN DATA FOR $V_{ce} = 28 \text{ Vdc}$, $T_C = 25^\circ\text{C}$
(EMITTER GROUNDING DIRECTLY TO THE CHASSIS — NO TUNED-EMITTER TECHNIQUES USED)

FIGURE 3 — POWER OUTPUT

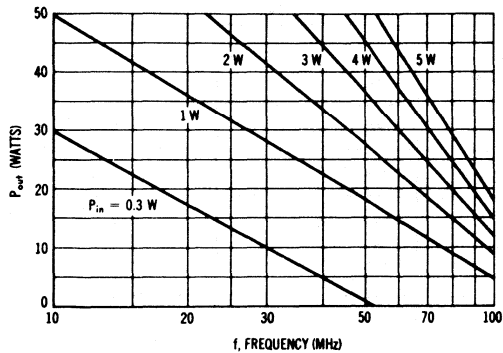


FIGURE 4 — PARALLEL EQUIVALENT OUTPUT CAPACITANCE

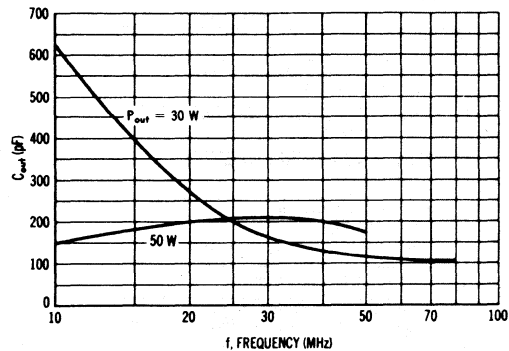


FIGURE 5 — PARALLEL EQUIVALENT INPUT RESISTANCE

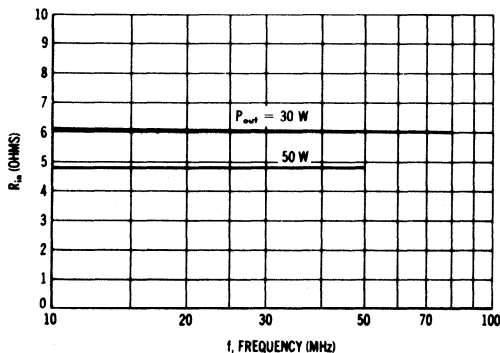
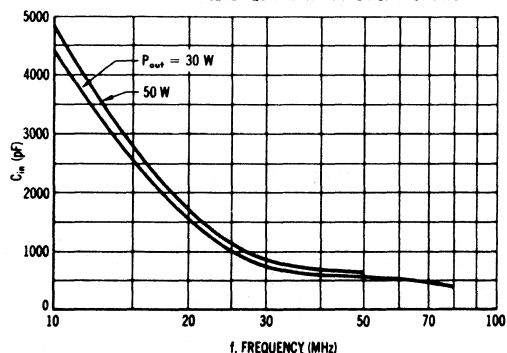


FIGURE 6 — PARALLEL EQUIVALENT INPUT CAPACITANCE



DESIGN NOTES

For Class-C power-amplifier designs, the small-signal parameters are not applicable. Figures 4 thru 6 and 8 thru 10 give the parallel equivalent output capacitance and input capacitance and resistance for Class-C power-amplifier operation.

The parallel resistive portion of the collector load impedance for a power amplifier, R_L' , may be computed by assuming a peak voltage swing equal to V_{cc} , and using the expression $R_L' = V_{cc}^2/2P$ where $P = \text{RF power output}$. The computed R_L' may then be combined with the data in Figures 4 through 10 to comprise complete device impedance data for Class-C power-amplifier design.

Due to the high performance capabilities of the 2N3950, care should be exercised during initial tuning of prototype circuits.

Input power should be increased gradually, while stopping at intermediate levels to tune. If tuning difficulties are experienced, or if the power or collector current are abnormal at any intermediate power input level, the difficulties should be resolved before increasing power levels further.

The 2N3950 is designed to provide maximum ruggedness commensurate with its high performance. Operation at loads with high SWR may produce dangerous voltage and current excursions, a condition which should be avoided. In addition, disconnecting the load at full power output could increase device dissipation to over 70 watts which could result in device failure due to dissipation beyond safe limits set by the junction to ambient thermal resistance, regardless of the internal construction and safe area of the device.

CLASS C DESIGN DATA FOR $V_{CE} = 13.6 \text{ Vdc}$, $T_C = 25^\circ\text{C}$
(EMITTER GROUNDED DIRECTLY TO THE CHASSIS - NO TUNED-EMITTER TECHNIQUES USED)

FIGURE 7 — POWER OUTPUT

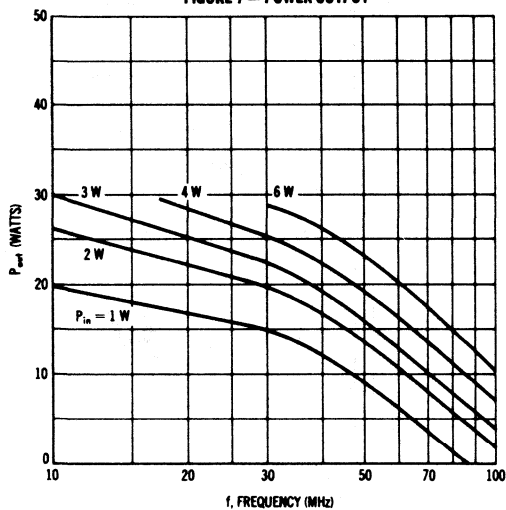


FIGURE 8 — PARALLEL EQUIVALENT OUTPUT CAPACITANCE

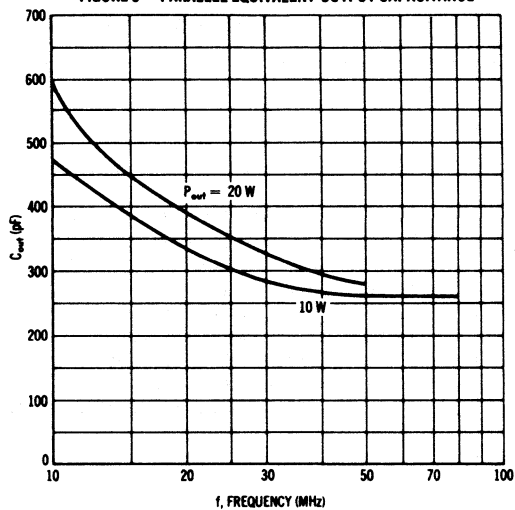


FIGURE 9 — PARALLEL EQUIVALENT INPUT RESISTANCE

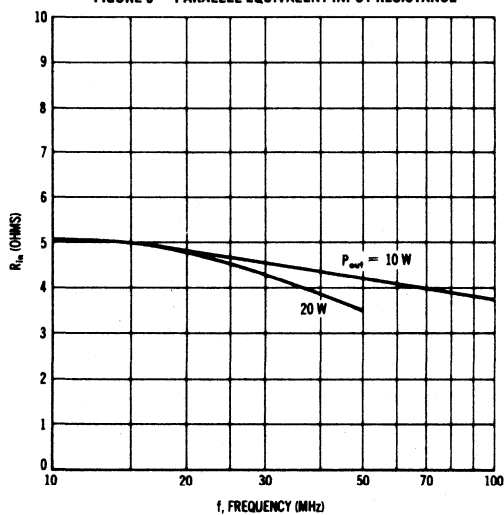
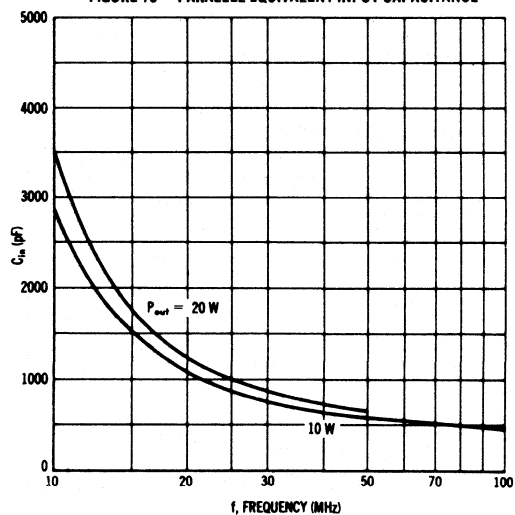


FIGURE 10 — PARALLEL EQUIVALENT INPUT CAPACITANCE



2N3959 (SILICON)

2N3960

The RF Line

NPN SILICON HIGH-FREQUENCY TRANSISTORS

... designed for high-speed current-mode logic switching applications.

- High Current-Gain-Bandwidth Product —
 $f_T = 1800 \text{ MHz (Typ) @ } I_C = 10 \text{ mAdc}$
- Low Input and Output Capacitance —
 C_{ib} and $C_{ob} = 2.5 \text{ pF (Max)}$
- Excellent Current-Mode Performance —
 $\tau_r = 1.7 \text{ ns (Typ) @ } I_C = 30 \text{ mAdc}$
- Low Collector-Base Time Constant —
 $r_b'C_c = 25 \text{ ps (Max) @ } I_C = 10 \text{ mAdc} - 2N3959$

Current-Mode logic operation, because of the absence of storage time, offers improved high-speed performance for digital applications. In addition, the low impedance drive circuit offers improved delay, rise, and fall times.

The basic characteristics of importance in current-mode logic applications are Current-Gain-Bandwidth Product (f_T), Input and Output Capacitance (C_{ib} and C_{ob}), and Base Spreading Resistance (r_b').

The 2N3959 and 2N3960 offer a combination of extremely high f_T values, low capacitances, and low base spreading resistance which results in exceptionally high speed in current-mode logic circuits.

*MAXIMUM RATINGS

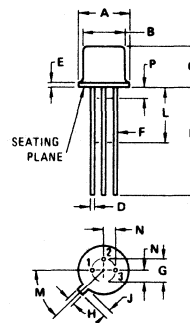
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	400 2.3	mW mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	750 4.3	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.436	$^\circ\text{C/mW}$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.233	$^\circ\text{C/mW}$

*Indicates JEDEC Registered Data.

1.8 GHz — 10 mAdc
HIGH FREQUENCY
TRANSISTORS
NPN SILICON



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	—	0.762	—	0.030
F	0.406	0.483	0.016	0.019
G	2.54	BSC	0.100	BSC
H	0.914	1.17	0.035	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45°	BSC	45°	BSC
N	1.27	BSC	0.050	BSC
P	—	1.27	—	0.050

All JEDEC notes and dimensions apply.

CASE 22-03
(TO-18)

2N3959, 2N3960 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
*OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I _C = 10 mA _{dc} , I _B = 0)	—	BV _{CEO}	12	—	—	V _{dc}
Collector-Base Breakdown Voltage (I _C = 10 μA _{dc} , I _E = 0)	—	BV _{CBO}	20	—	—	V _{dc}
Emitter-Base Breakdown Voltage (I _E = 10 μA _{dc} , I _C = 0)	—	BV _{EBO}	4.5	—	—	V _{dc}
Collector Reverse Current (V _{CE} = 10 V _{dc} , V _{EB} = 2.0 V _{dc}) (V _{CE} = 10 V _{dc} , V _{EB} = 2.0 V _{dc} , T _A = 150°C)	—	I _{CEX}	—	—	0.005 5.0	μA _{dc}
Base Cutoff Current (V _{CE} = 10 V _{dc} , V _{EB} = 2.0 V _{dc})	—	I _{BL}	—	—	0.005	μA _{dc}
Collector Forward Current (V _{CE} = 5.0 V _{dc} , V _{BE} = 0.4 V _{dc})	—	I _{CEX}	—	—	1.0	μA _{dc}

*ON CHARACTERISTICS

DC Current Gain (I _C = 1.0 mA _{dc} , V _{CE} = 1.0 V _{dc}) (I _C = 10 mA _{dc} , V _{CE} = 1.0 V _{dc}) (I _C = 30 mA _{dc} , V _{CE} = 1.0 V _{dc})	1	h _{FE}	25 40 25	— — —	— 400 —	—
Collector-Emitter Saturation Voltage (I _C = 1.0 mA _{dc} , I _B = 0.1 mA _{dc}) (I _C = 30 mA _{dc} , I _B = 3.0 mA _{dc})	—	V _{CE(sat)}	— —	— —	0.2 0.3	V _{dc}
Base-Emitter "on" Voltage (I _C = 1.0 mA _{dc} , V _{CE} = 1.0 V _{dc}) (I _C = 30 mA _{dc} , V _{CE} = 1.0 V _{dc})	—	V _{BE(on)}	— —	— —	0.8 1.0	V _{dc}

*DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product (I _C = 5.0 mA _{dc} , V _{CE} = 4.0 V _{dc} , f = 100 MHz) (I _C = 10 mA _{dc} , V _{CE} = 10 V _{dc} , f = 100 MHz) (I _C = 30 mA _{dc} , V _{CE} = 4.0 V _{dc} , f = 100 MHz)	2N3959 2N3960 2N3959 2N3960 2N3959 2N3960	2	f _T	1000 1300 1300 1600 1000 1200	— — — — — —	— — — — — —	MHz
Output Capacitance (V _{CB} = 4.0 V _{dc} , I _E = 0, f = 1.0 MHz)		4	C _{ob}	—	2.0	2.5	pF
Input Capacitance (V _{EB} = 0.5 V _{dc} , I _C = 0, f = 100 MHz)		4	C _{ib}	—	1.5	2.5	pF
Collector-Base Time Constant (I _C = 5.0 mA _{dc} , V _{CE} = 4.0 V _{dc}) (I _C = 10 mA _{dc} , V _{CE} = 10 V _{dc}) (I _C = 30 mA _{dc} , V _{CE} = 4.0 V _{dc})	2N3959 2N3960 2N3959 2N3960 2N3959 2N3960	3	r _b 'C _c	— — — — — —	— — — — — —	30 50 25 40 30 50	ps

SWITCHING CHARACTERISTICS (Figure 7)

Turn-On Delay Time (I _C = 10 mA _{dc} , V _{out} = 1.0 V _{dc}) (I _C = 30 mA _{dc} , V _{out} = 1.0 V _{dc})		—	t _{d(on)}	— —	2.4 2.0	— —	ns
Rise Time (I _C = 10 mA _{dc} , V _{out} = 1.0 V _{dc}) (I _C = 30 mA _{dc} , V _{out} = 1.0 V _{dc})	Both Devices 2N3959 2N3960	—	t _r	— — —	3.0 2.2 1.7	— — —	ns
Turn-Off Delay Time (I _C = 10 mA _{dc} , V _{out} = 1.0 V _{dc}) (I _C = 30 mA _{dc} , V _{out} = 1.0 V _{dc})		—	t _{d(off)}	— —	1.6 1.6	— —	ns
Fall Time (I _C = 10 mA _{dc} , V _{out} = 1.0 V _{dc}) (I _C = 30 mA _{dc} , V _{out} = 1.0 V _{dc})	Both Devices 2N3959 2N3960	—	t _f	— — —	3.3 2.3 1.9	— — —	ns

*Indicates JEDEC Registered Data.

FIGURE 1 – TYPICAL DC CURRENT GAIN

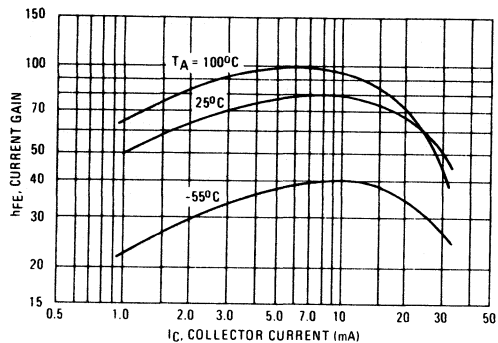


FIGURE 2 – TYPICAL CURRENT-GAIN – BANDWIDTH PRODUCT

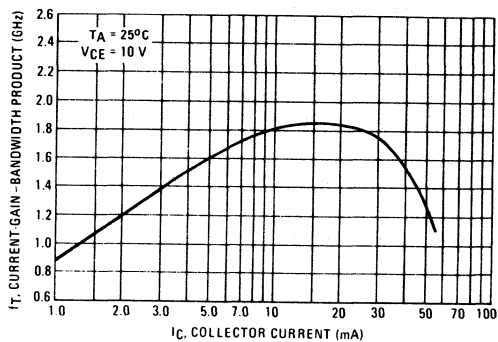


FIGURE 3 – TYPICAL COLLECTOR-BASE TIME CONSTANT

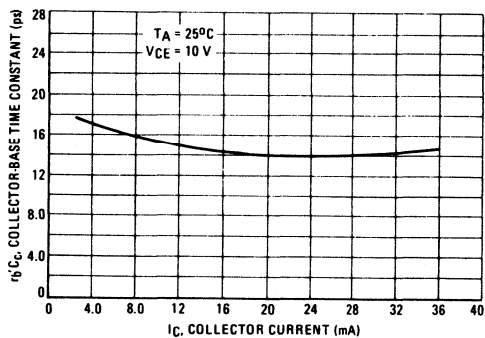
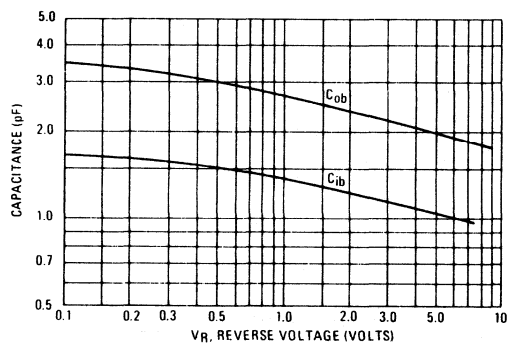


FIGURE 4 – TYPICAL JUNCTION CAPACITANCE



TURN-ON AND TURN-OFF TIMES

FIGURE 5 — $V_{out} = 1.0 \text{ Vdc}$

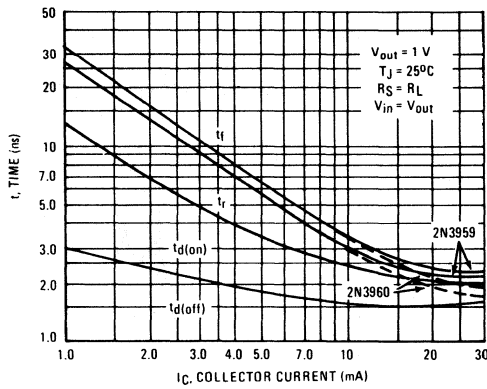


FIGURE 6 — $V_{out} = 2.0 \text{ Vdc}$

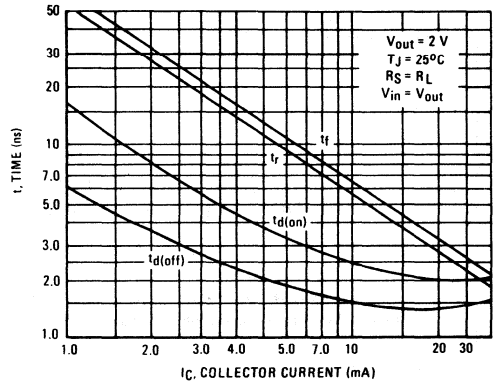
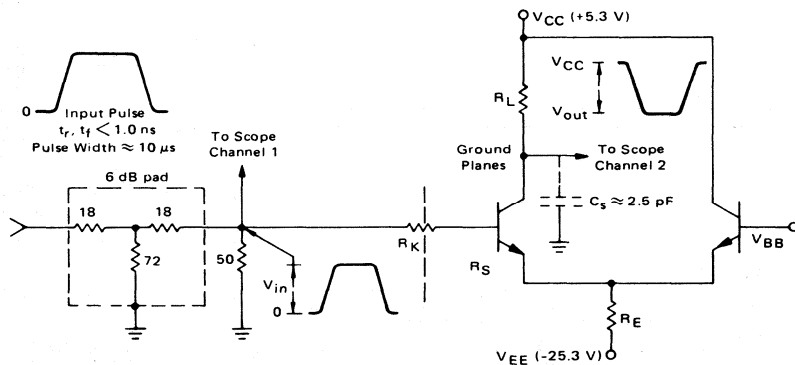


FIGURE 7 — SWITCHING TIMES TEST CIRCUIT



This test set up is designed to simulate a cascade of identical stages. The source resistance (R_S) equals the load resistance (R_L). Values used in the test are shown in the table.

For $V_{in} = V_{out} = 1 \text{ V}$, $V_{BB} = +0.5 \text{ V}$.
 R_L & R_K values appropriately reduced.

$V_{in} = V_{out} = 2 \text{ volts}$, $V_{BB} = +1.0 \text{ V}$			
I_C (mA)	R_E (k Ω)	R_L (Ω)	R_K (Ω)
1.0	24.0	2.0 k	2.0 k
3.0	8.2	680	680
10	2.4	200	180
30	0.8	68	36

2N3961

For Specifications, See 2N3375 Data

2N3970 (SILICON)

2N3971

2N3972

SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode (Type A) Junction Field-Effect Transistors designed primarily for chopper and high-speed switching applications.

- High Input Impedance —
 $I_{GSS} = 250 \text{ pAdc (Max) @ } V_{GS} = 20 \text{ Vdc}$
- Low Drain-Source "ON" Resistance —
 $r_{ds(on)} = 30 \text{ Ohms (Max) @ } f = 1.0 \text{ kHz (2N3970)}$
- Guaranteed Switching Characteristics

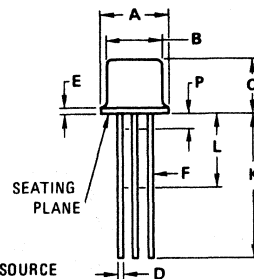
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	40	Vdc
Forward Gate Current	I_{GF}	50	mAdc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.8 10	Watts mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.

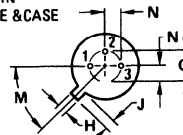
N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

(Type A)



STYLE 4:

- PIN 1. SOURCE
2. DRAIN
3. GATE & CASE



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	—	0.762	—	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC*	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	—	1.27	—	0.050

All JEDEC notes and dimensions apply.

CASE 22-03
(TO-18)

2N3970, 2N3971, 2N3972 (continued)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 1.0 \mu\text{A}$, $V_{GS} = 0$)	$V_{(BR)GSS}$	40	—	Vdc
Gate Reverse Current ($V_{GS} = 20 \text{ Vdc}$, $V_{DS} = 0$)	I_{GSS}	—	250	pAdc
Drain Reverse Current ($V_{DG} = 20 \text{ Vdc}$, $I_S = 0$) ($V_{DG} = 20 \text{ Vdc}$, $I_S = 0$, $T_A = 150^\circ\text{C}$)	I_{DGO}	— —	250 500	pAdc nAdc
Drain Cutoff Current ($V_{DS} = 20 \text{ Vdc}$, $V_{GS} = -12 \text{ Vdc}$) ($V_{DS} = 20 \text{ Vdc}$, $V_{GS} = -12 \text{ Vdc}$, $T_A = 150^\circ\text{C}$)	$I_{D(off)}$	— —	250 500	pAdc nAdc

ON CHARACTERISTICS

Zero-Gate Voltage Drain Current (Note 1) ($V_{DS} = 20 \text{ Vdc}$, $V_{GS} = 0$)	2N3970 2N3971 2N3972	I_{DSS}	50 25 5.0	150 75 30	mAdc
Gate-Source Voltage ($V_{DS} = 20 \text{ Vdc}$, $I_D = 1.0 \text{ nAdc}$)	2N3970 2N3971 2N3972	V_{GS}	4.0 2.0 0.5	10 5.0 3.0	Vdc
Drain-Source "ON" Voltage ($I_D = 20 \text{ mAdc}$, $V_{GS} = 0$) ($I_D = 10 \text{ mAdc}$, $V_{GS} = 0$) ($I_D = 5.0 \text{ mAdc}$, $V_{GS} = 0$)	2N3970 2N3971 2N3972	$V_{DS(on)}$	— — —	1.0 1.5 2.0	Vdc
Static Drain-Source "ON" Resistance ($I_D = 1.0 \text{ mAdc}$, $V_{GS} = 0$)	2N3970 2N3971 2N3972	$r_{DS(on)}$	— — —	30 60 100	Ohms

SMALL-SIGNAL CHARACTERISTICS

Drain-Source "ON" Resistance ($V_{GS} = 0$, $I_D = 0$, $f = 1.0 \text{ kHz}$)	2N3970 2N3971 2N3972	$r_{ds(on)}$	— — —	30 60 100	Ohms
Input Capacitance ($V_{DS} = 20 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)		C_{iss}	—	25	pF
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = -12 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)		C_{rss}	—	6.0	pF

SWITCHING CHARACTERISTICS

Turn-On Delay Time	Test Condition for 2N3970: ($V_{DD} = 10 \text{ Vdc}$, $V_{GS(on)} = 0$, $I_{D(on)} = 20 \text{ mAdc}$, $V_{GS(off)} = 10 \text{ Vdc}$)	2N3970 2N3971 2N3972	$t_{d(on)}$	— — —	10 15 40	ns
Rise Time	Test Condition for 2N3971: ($V_{DD} = 10 \text{ Vdc}$, $V_{GS(on)} = 0$, $I_{D(on)} = 10 \text{ mAdc}$, $V_{GS(off)} = 5.0 \text{ Vdc}$)	2N3970 2N3971 2N3972	t_r	— — —	10 15 40	ns
Turn-Off Time	Test Condition for 2N3972: ($V_{DD} = 10 \text{ Vdc}$, $V_{GS(on)} = 0$, $I_{D(on)} = 5.0 \text{ mAdc}$, $V_{GS(off)} = 3.0 \text{ Vdc}$)	2N3970 2N3971 2N3972	t_{off}	— — —	30 60 100	ns

*Indicates JEDEC Registered Data.

Note 1: Pulse Test: Pulse Width = 300 μs , Duty Cycle = 3.0%.

PNP SILICON ANNULAR CHOPPER TRANSISTOR

...designed for use in high emitter-base breakdown voltage and chopper applications.

- High Emitter-Base Breakdown Voltage –
 $BVEBO = 25 \text{ Vdc (Min) @ } I_C = 10 \mu\text{Adc}$
- Low Offset Voltage –
 $VEC(ofs) = 1.0 \text{ mVdc @ } I_B = 1.0 \text{ mAdc}$

PNP SILICON CHOPPER TRANSISTOR



MAXIMUM RATINGS

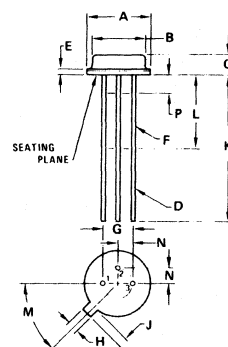
Rating	Symbol	Value	Unit
*Collector-Emitter Voltage	V_{CEO}	20	Vdc
*Collector-Base Voltage	V_{CB}	25	Vdc
*Emitter-Base Voltage	V_{EB}	25	Vdc
*Collector Current – Continuous	I_C	100	mAdc
*Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	400 2.28	mW mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	2.0 11.4	Watts mW/ $^\circ\text{C}$
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Thermal Resistance, Junction to Ambient	$R_{\theta JA}(1)$	438	$^\circ\text{C/W}$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	87.5	$^\circ\text{C/W}$

*Indicates JEDEC Registered Data

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1:
PIN 1. EMITTER
PIN 2. BASE
PIN 3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	1.65	2.16	0.065	0.085
D	0.406	0.533	0.016	0.021
E	—	1.02	—	0.040
F	0.305	0.483	0.012	0.019
G	2.54 BSC	—	0.100 BSC	—
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC	—	45° BSC	—
N	1.27 BSC	—	0.050 BSC	—
P	—	1.27	—	0.050

All JEDEC dimensions and notes apply

CASE 26-03
TO-46

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
*Collector-Emitter Breakdown Voltage ($I_C = 1.0\ \mu\text{Adc}$, $I_B = 0$)	BV_{CEO}	20	—	—	Vdc
*Emitter-Collector Breakdown Voltage ($I_E = 1.0\ \mu\text{Adc}$, $I_B = 0$)	BV_{ECO}	20	—	—	Vdc
*Collector-Base Breakdown Voltage ($I_C = 10\ \mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	25	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	25	—	—	Vdc
*Collector Cutoff Current ($V_{CB} = 25\ \text{Vdc}$, $I_E = 0$)	I_{CBO}	—	—	1.0	nAdc
*Emitter Cutoff Current ($V_{BE} = 25\ \text{Vdc}$, $I_C = 0$)	I_{EBO}	—	—	1.0	nAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 5.0\ \text{mAdc}$, $V_{CE} = 0.5\ \text{Vdc}$)	h_{FE}	30	50	—	—
Collector-Emitter Saturation Voltage ($I_C = 5.0\ \text{mA}$, $I_B = 0.5\ \text{mA}$)	$V_{CE(sat)}$	—	—	0.15	Vdc
Emitter-Collector Saturation Voltage ($I_E = 10\ \mu\text{A}$, $I_B = 200\ \mu\text{A}$)	$V_{EC(sat)}$	—	—	5.0	mVdc
Base-Emitter Saturation Voltage ($I_C = 5.0\ \text{mAdc}$, $I_B = 0.5\ \text{mAdc}$)	$V_{BE(sat)}$	0.65	0.8	1.0	Vdc
Offset Voltage ($I_B = 200\ \mu\text{Adc}$, $I_E = 0$) ($I_B = 1.0\ \text{mAdc}$, $I_E = 0$)	$V_{EC(ofs)}$	— —	1.2 1.0	2.0 1.5	mVdc
*DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product ($I_C = 1.0\ \text{mAdc}$, $V_{CE} = 6.0\ \text{Vdc}$, $f = 1.0\ \text{MHz}$)	f_T	1.0	—	—	MHz
Output Capacitance ($V_{CB} = 6.0\ \text{Vdc}$, $I_E = 0$, $f = 4.0\ \text{MHz}$)	C_{ob}	—	10	14	pF
Input Capacitance ($V_{BE} = 6.0\ \text{Vdc}$, $I_C = 0$, $f = 4.0\ \text{MHz}$)	C_{ib}	—	6.0	8.0	pF
"On" Series Resistance ($I_B = 1.0\ \text{mAdc}$, $I_E = 0$, $I_C = 100\ \mu\text{A RMS}$, $f = 1.0\ \text{kHz}$)	$r_{ec(on)}$	—	—	35	Ohms

*Indicates JEDEC Registered Data.

2N3980 (SILICON)



CASE 22 A
(TO-18 Modified)
(Lead 3 connected to case)



STYLE 1:
PIN 1. EMITTER
2. BASE 1
3. BASE 2

Silicon annular PN unijunction transistor designed for military and industrial use in pulse, timing, sensing, and oscillator circuits.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
RMS Power Dissipation*	P _D	360*	mW
RMS Emitter Current	I _e	50	mA
Peak Pulse Emitter Current**	i _e	1.0**	Amp
Emitter Reverse Voltage	V _{B2E}	30	Volts
Interbase Voltage	V _{B2B1}	35	Volts
Storage Temperature Range	T _{stg}	-65 to +200	°C

* Derate 2.4 mW/°C increase in ambient temperature. Total power dissipation (available power to Emitter and Base-Two) must be limited by external circuitry.

**Capacitance discharge current must fall to 0.37 Amp within 3.0 ms and PRR ≤ 10 PPS.

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Intrinsic Standoff Ratio ($V_{B2B1} = 10\text{ V}$) Note 1	η	0.68	—	0.82	—
Interbase Resistance ($V_{B2B1} = 3.0\text{ V}$, $I_E = 0$)	R_{BB}	4.0	6.0	8.0	k ohms
Interbase Resistance Temperature Coefficient ($V_{B2B1} = 3.0\text{ V}$, $I_E = 0$, $T_A = -65^\circ\text{C}$ to $+100^\circ\text{C}$)	αR_{BB}	0.4	—	0.9	%/ $^\circ\text{C}$
Emitter Saturation Voltage ($V_{B2B1} = 10\text{ V}$, $I_E = 50\text{ mA}$) Note 2	$V_{EB1(\text{sat})}$	—	2.5	3.0	Volts
Modulated Interbase Current ($V_{B2B1} = 10\text{ V}$, $I_E = 50\text{ mA}$)	$I_{B2(\text{mod})}$	12	15	—	mA
Emitter Reverse Current ($V_{B2E} = 30\text{ V}$, $I_{B1} = 0$) ($V_{B2E} = 30\text{ V}$, $I_{B1} = 0$, $T_A = 125^\circ\text{C}$)	I_{EO}	—	5.0 —	10 1.0	nA μA
Peak Point Emitter Current ($V_{B2B1} = 25\text{ V}$)	I_P	—	0.6	2.0	μA
Valley Point Current ($V_{B2B1} = 20\text{ V}$, $R_{B2} = 100\text{ ohms}$) Note 2	I_V	1.0	4.0	10	mA
Base-One Peak Pulse Voltage (Note 3, Figure 3)	V_{OB1}	6.0	8.0	—	Volts
Maximum Oscillation Frequency (Figure 4)	$f(\text{max})$	1.0	1.25	—	MHz

NOTES

1. Intrinsic standoff ratio,

η , is defined by equation:

$$\eta = \frac{V_P - V_{EB1}}{V_{B2B1}}$$

Where V_P = Peak Point Emitter Voltage

V_{B2B1} = Interbase Voltage

V_{EB1} = Emitter to Base-One Junction Diode Drop
($\sim 0.5\text{ V}$ @ $10\text{ }\mu\text{A}$)

2. Use pulse techniques: PW $\sim 300\text{ }\mu\text{s}$ duty cycle $\leq 2\%$ to avoid internal heating due to interbase modulation which may result in erroneous readings.

3. Base-One Peak Pulse Voltage is measured in circuit of Figure 3. This specification is used to ensure minimum pulse amplitude for applications in SCR firing circuits and other types of pulse circuits.

FIGURE 1 — UNIJUNCTION TRANSISTOR SYMBOL AND NOMENCLATURE

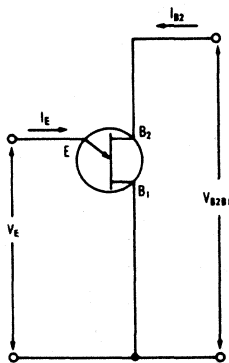


FIGURE 2 — STATIC EMITTER CHARACTERISTICS CURVES

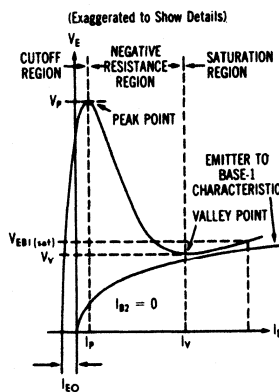


FIGURE 3 — V_{OB1} TEST CIRCUIT
(Typical Relaxation Oscillator)

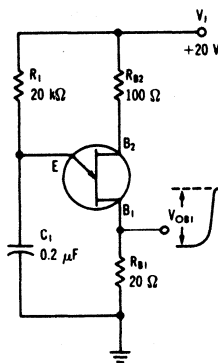
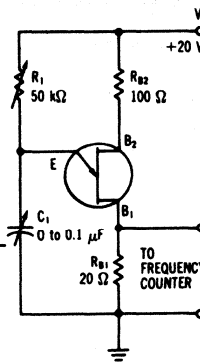


FIGURE 4 — $f(\text{max})$ MAXIMUM FREQUENCY TEST CIRCUIT



2N3993, 2N3994 (SILICON)
2N3994A

SILICON P-CHANNEL
JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode Junction Field-Effect Transistors designed primarily for chopper and high-speed switching applications.

- Low Leakage Current
 $I_{DGO} = 1.2 \text{ nAdc (Max) @ } V_{DG} = 15 \text{ Vdc}$
- Low Reverse Transfer Capacitance -
 $C_{rss} = 4.5 \text{ pF (Max) @ } V_{GS} = 10 \text{ Vdc (2N3993)}$
- Low Drain-Source "ON" Resistance
 $r_{ds(on)} = 150 \text{ Ohms (Max) @ } f = 1.0 \text{ kHz (2N3993)}$

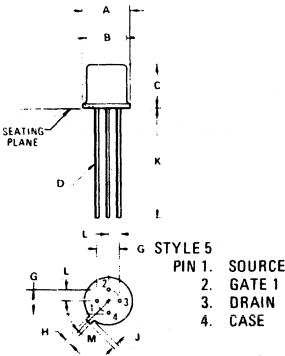
P-CHANNEL
JUNCTION FIELD-EFFECT
TRANSISTORS



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	-25	Vdc
Drain-Gate Voltage	V_{DG}	-25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	25	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 2.0	mW mW/ $^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

*Indicates JEDEC Registered Data.



DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.209	0.230	5.310	5.840
B	0.178	0.195	4.520	4.950
C	0.170	0.210	4.320	5.330
D	0.016	0.019	0.406	0.483
E	0.100 TYP		2.54 TYP	
H	0.036	0.045	0.914	1.140
J	0.028	0.048	0.711	1.220
K	0.500		12.700	
L	0.050 TYP		1.270 TYP	
M	45° TYP		45° TYP	

All JEDEC dimensions and notes apply
CASE 20-01
TO 72

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 1.0\ \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	25	—	Vdc
Drain Reverse Current ($V_{DG} = -15\ \text{Vdc}$, $I_S = 0$)	I_{DGO}	—	1.2	nAdc
($V_{DG} = -15\ \text{Vdc}$, $I_S = 0$, $T_A = 150^\circ\text{C}$)		—	1.2	μAdc
Drain Cutoff Current ($V_{DS} = -10\ \text{Vdc}$, $V_{GS} = 10\ \text{Vdc}$)	$I_{D(off)}$	—	1.2	nAdc
($V_{DS} = -10\ \text{Vdc}$, $V_{GS} = 6.0\ \text{Vdc}$)		—	1.2	nAdc
($V_{DS} = -10\ \text{Vdc}$, $V_{GS} = 10\ \text{Vdc}$, $T_A = 150^\circ\text{C}$)		—	1.0	μAdc
($V_{DS} = -10\ \text{Vdc}$, $V_{GS} = 6.0\ \text{Vdc}$, $T_A = 150^\circ\text{C}$)		—	1.0	μAdc
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current (1) ($V_{DS} = -10\ \text{Vdc}$, $V_{GS} = 0$)	I_{DSS}	10 2.0	—	mAdc
($V_{DS} = -10\ \text{Vdc}$, $I_D = -1.0\ \mu\text{Adc}$)	V_{GS}	4.0 1.0	9.5 5.5	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Drain-Source "ON" Resistance ($V_{GS} = 0$, $I_D = 0$, $f = 1.0\ \text{kHz}$)	$r_{ds(on)}$	— —	150 300	Ohms
Forward Transadmittance (1) ($V_{DS} = -10\ \text{Vdc}$, $V_{GS} = 0$, $f = 1.0\ \text{kHz}$)	$ y_{fs} $	6.0 4.0 5.0	12 10 10	mmhos
Input Capacitance ($V_{DS} = -10\ \text{Vdc}$, $V_{GS} = 0$, $f = 1.0\ \text{MHz}$)	C_{iss}	— —	16 12	pF
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = 10\ \text{Vdc}$, $f = 1.0\ \text{MHz}$)	C_{rss}	—	4.5	pF
($V_{DS} = 0$, $V_{GS} = 6.0\ \text{Vdc}$, $f = 1.0\ \text{MHz}$)		— —	5.0 3.5	pF

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width = 100 ms, Duty Cycle $\leq 10\%$

2N4012 (SILICON)



stud isolated from case



CASE 36 (TO-60)

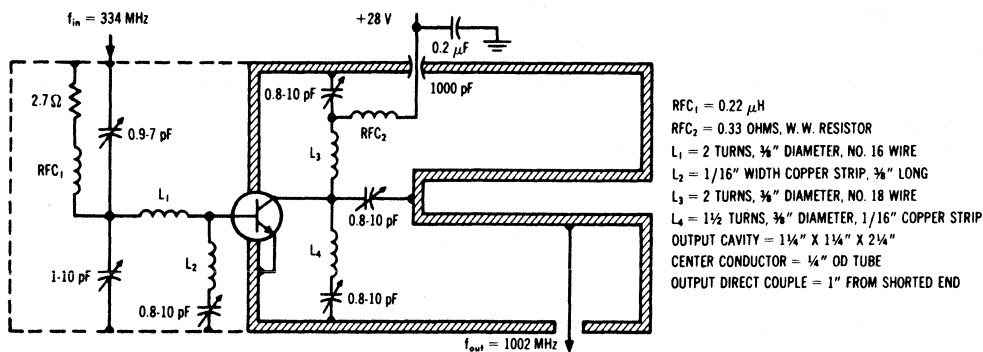
STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR
CASE ISOLATED

NPN silicon annular transistor, designed for frequency - multiplication applications.

MAXIMUM RATINGS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Emitter Voltage ($V_{EB(off)} = 1.5 \text{ Vdc}$)	V_{CEV}	65	Vdc
Collector-Base Voltage	V_{CB}	65	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	1.5	Amps
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate Above 25°C	P_D	11.6 66.3	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

FIGURE 1 — TRIPLER TEST CIRCUIT



2N4012 (continued)

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 0$ to 200 mA dc, $I_B = 0$)	BV_{CEO}	40	-	-	Vdc
Collector-Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 0$ to 200 mA dc, $V_{EB(off)} = 1.5$ Vdc)	BV_{CEV}	65	-	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1$ mA dc, $I_E = 0$)	BV_{CBO}	65	-	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1$ mA dc, $I_C = 0$)	BV_{EBO}	4	-	-	Vdc
Collector Cutoff Current ($V_{CE} = 30$ Vdc, $I_B = 0$)	I_{CEO}	-	-	0.1	mA dc

ON CHARACTERISTICS

DC Current-Gain ($I_C = 1.0$ A dc, $V_{CE} = 5.0$ Vdc) ($I_C = 125$ mA dc, $V_{CE} = 5.0$ Vdc)	h_{FE1} h_{FE2}	4.0 10	- -	40 -	- -
Collector-Emitter Saturation Voltage ($I_C = 500$ mA dc, $I_B = 100$ mA dc)	$V_{CE(sat)}$	-	-	1.0	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 125$ mA dc, $V_{CE} = 28$ Vdc, $f = 100$ MHz)	f_T	-	350	-	MHz
Collector-Base Cutoff Frequency † ($V_{CE} = 28$ Vdc, $I_C = 0$)	f_c	-	25	-	GHz
Output Capacitance ($V_{CB} = 30$ Vdc, $I_E = 0$)	C_{ob}	-	-	10	pF
Base-Spreading Resistance ($I_C = 250$ mA dc, $V_{CE} = 28$ Vdc, $f = 400$ MHz)	r_{bb}	-	10	-	Ohms

FUNCTIONAL TEST

Power Output	Tripler (Test Circuit Figure 1) $V_{CE} = 28$ Vdc, $P_{in} = 1$ W, $f_{in} = 334$ MHz, $f_{out} = 1002$ MHz	P_{out}	2.5	-	-	Watts
Efficiency		η	25	-	-	%
Power Output	Doubler $V_{CE} = 28$ Vdc, $P_{in} = 1$ W, $f_{in} = 400$ MHz, $f_{out} = 800$ MHz	P_{out}	-	3.0	-	Watts
Efficiency		η	-	35	-	%

⁽¹⁾ Pulsed through a 25 mH inductor; duty cycle = 50%

† f_c is determined from Q measured at 210 MHz. $f_c = Q \times 210$ MHz.

2N4013 (SILICON)

2N4014

NPN SILICON ANNULAR MEMORY DRIVER

... designed for medium-current, high-speed switching applications. Ideally suited for ferrite core memory driver circuits.

- High Collector-Emitter Breakdown Voltage –
BVCEO = 50 Vdc (Min) @ IC = 10 mAdc – 2N4013
= 30 Vdc (Min) @ IC = 10 mAdc – 2N4014
- Guaranteed Fast Switching Times @ IC = 500 mAdc
ton = 20 ns (Typ) toff = 50 ns (Typ)
= 35 ns (Max) = 60 ns (Max)
- Guaranteed High DC Current Gain –
hFE = 35 (Min) @ IC = 500 mAdc

NPN SILICON MEMORY DRIVER TRANSISTOR

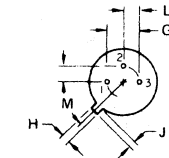
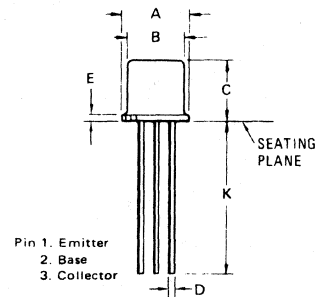
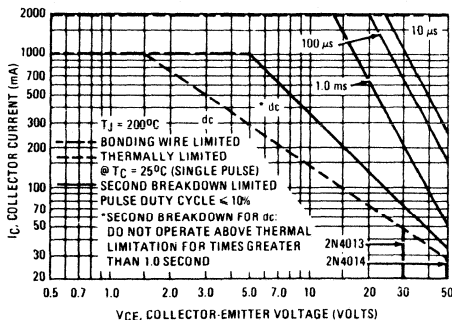


* MAXIMUM RATINGS

Rating	Symbol	2N4013	2N4014	Unit
Collector-Emitter Voltage	VCEO	30	50	Vdc
Collector-Base Voltage	VCB	50	80	Vdc
Emitter-Base Voltage	VEB	6.0		Vdc
Collector Current – Continuous	IC	1.0		A dc
– Peak		2.0		
Total Device Dissipation @ TA = 25°C	PD	0.5	28.6	Watt
Derate above 25°C				mW/°C
Total Device Dissipation @ TC = 25°C	PD	1.4	8.0	Watts
Derate above 25°C				mW/°C
Operating and Storage Junction Temperature Range	TJ, Tstg	-65 to +200		°C

* Indicates JEDEC Registered Data.

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



All JEDEC dimensions and notes apply

CASE 22 TO-18

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.209	0.230	5.310	5.840
B	0.178	0.185	4.520	4.690
C	0.170	0.210	4.320	5.330
D	0.016	0.019	0.406	0.483
E		0.030		0.762
G	0.100 NOM		2.540 NOM	
H	0.036	0.046	0.914	1.170
J	0.028	0.048	0.711	1.220
K	0.500		12.700	
L	0.050 NOM		1.270 NOM	
M	45° NOM		45° NOM	

2N4013, 2N4014 (continued)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 10\text{ mAdc}$, $I_B = 0$)	BV_{CEO}	50 30	— —	— —	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $V_{BE} = 0$)	BV_{CES}	80 50	— —	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	80 50	— —	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	6.0	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 80\text{ Vdc}$, $V_{EB} = 0$) ($V_{CE} = 50\text{ Vdc}$, $V_{EB} = 0$)	I_{CES}	— —	0.15 0.15	10 10	μAdc
Collector Cutoff Current ($V_{CB} = 60\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 40\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 60\text{ Vdc}$, $I_E = 0$, $T_A = 100^{\circ}\text{C}$) ($V_{CB} = 40\text{ Vdc}$, $I_E = 0$, $T_A = 100^{\circ}\text{C}$)	I_{CBO}	— — — —	0.12 0.12 — —	1.7 1.7 120 120	μAdc
ON CHARACTERISTICS (1)					
DC Current Gain ($I_C = 10\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 100\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 100\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$, $T_A = -55^{\circ}\text{C}$) ($I_C = 300\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 500\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 500\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$, $T_A = -55^{\circ}\text{C}$) ($I_C = 800\text{ mAdc}$, $V_{CE} = 2.0\text{ Vdc}$) ($I_C = 1.0\text{ Adc}$, $V_{CE} = 5.0\text{ Vdc}$)	h_{FE}	30 60 30 40 35 20 20 25 25 30	— — — — — — — — — —	— 150 — — — — — — — —	—
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$) ($I_C = 100\text{ mAdc}$, $I_B = 10\text{ mAdc}$) ($I_C = 300\text{ mAdc}$, $I_B = 30\text{ mAdc}$) ($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$) ($I_C = 800\text{ mAdc}$, $I_B = 80\text{ mAdc}$) ($I_C = 1.0\text{ Adc}$, $I_B = 100\text{ mAdc}$)	$V_{CE(sat)}$	— — — — — —	0.17 0.17 0.19 0.19 0.25 0.25 0.30 0.30 0.43 0.43 0.55 0.55	0.25 0.25 0.26 0.20 0.40 0.32 0.52 0.42 0.80 0.65 0.95 0.75	Vdc
Base-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$) ($I_C = 100\text{ mAdc}$, $I_B = 10\text{ mAdc}$) ($I_C = 300\text{ mAdc}$, $I_B = 30\text{ mAdc}$) ($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$) ($I_C = 800\text{ mAdc}$, $I_B = 80\text{ mAdc}$) ($I_C = 1.0\text{ Adc}$, $I_B = 100\text{ mAdc}$)	$V_{BE(sat)}$	— — — 0.8 — —	— — — — — —	0.76 0.86 1.1 1.1 1.5 1.7	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (2) ($I_C = 50\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	300	—	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{ob}	— —	— —	10 12	pF
Input Capacitance ($V_{EB} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 1.0\text{ MHz}$)	C_{ib}	—	—	55	pF

* Indicates JEDEC Registered Data. (1) Pulse test: Pulse Width = 300 μs , Duty Cycle = 1.0%. (2) $f_T = |h_{fe}| \cdot f_{test}$

Characteristic		Symbol	Min	Typ	Max	Unit
*SWITCHING CHARACTERISTICS						
Delay Time	(V _{CC} = 30 Vdc, V _{BE(off)} = 3.8 Vdc, I _C = 500 mAdc, I _{B1} = 50 mAdc) (Figures 8, 10)	t _d	—	5.0	10	ns
Rise Time		t _r	—	15	30	ns
Turn-On Time		t _{on}	—	20	35	ns
Storage Time	(V _{CC} = 30 Vdc, I _C = 500 mAdc, I _{B1} = I _{B2} = 50 mAdc) 2N4014 2N4013 (Figures 9, 10)	t _s	—	30	50	ns
Fall Time		t _f	—	20	25	ns
Turn-Off Time		t _{off}	—	25	30	ns
			—	50	60	ns

* Indicates JEDEC Registered Data.

TYPICAL DC CHARACTERISTICS

FIGURE 2 – DC CURRENT GAIN

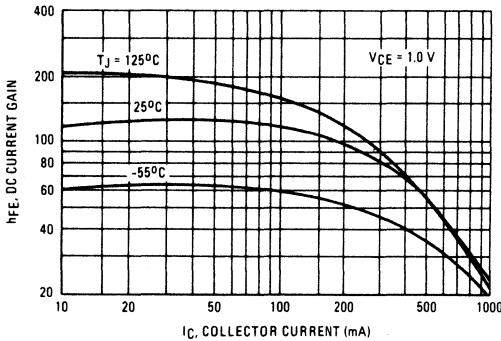


FIGURE 3 – "ON" VOLTAGES

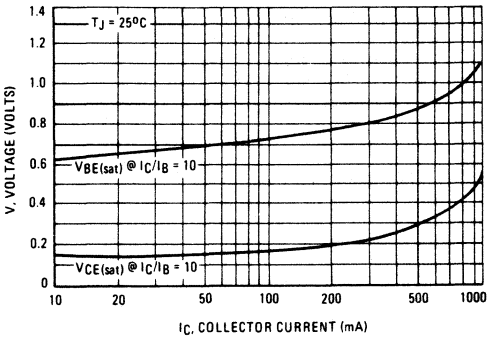


FIGURE 4 – COLLECTOR SATURATION REGION

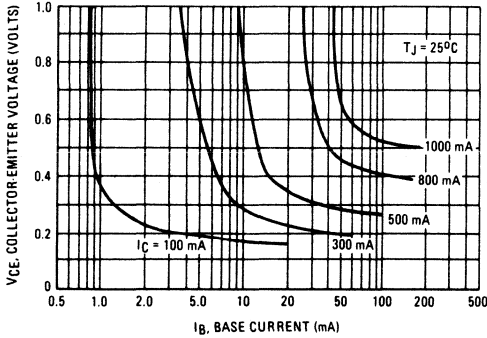
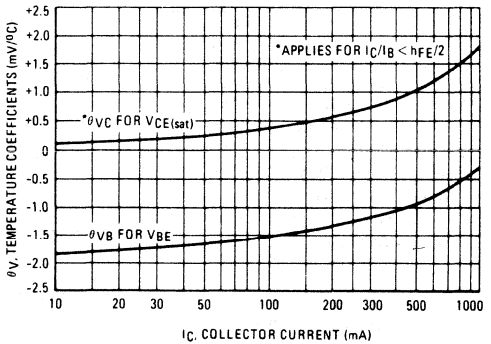


FIGURE 5 – TEMPERATURE COEFFICIENTS



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 6 – CURRENT-GAIN – BANDWIDTH PRODUCT

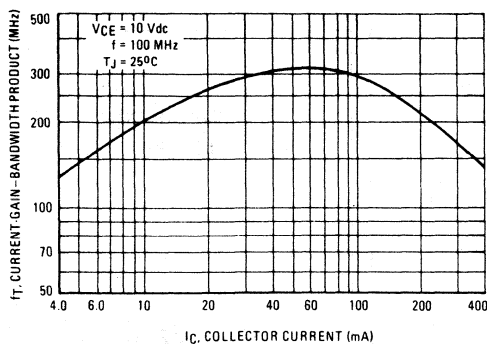


FIGURE 7 – CAPACITANCE

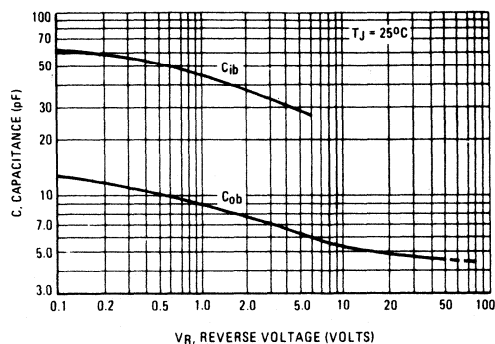


FIGURE 8 – TURN-ON TIME

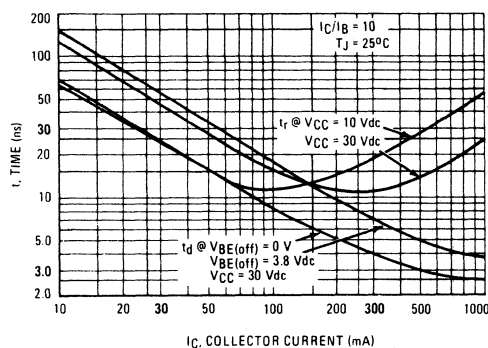


FIGURE 9 – TURN-OFF TIME

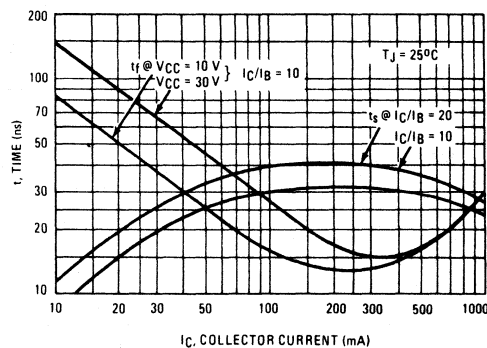


FIGURE 10 – SWITCHING TIME TEST CIRCUIT

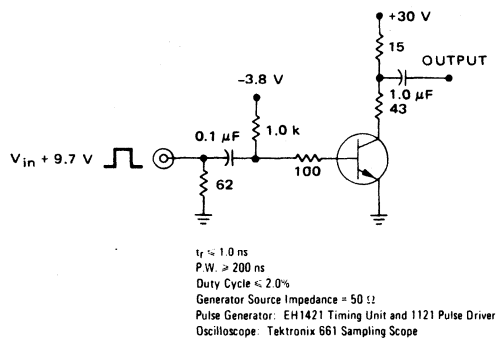
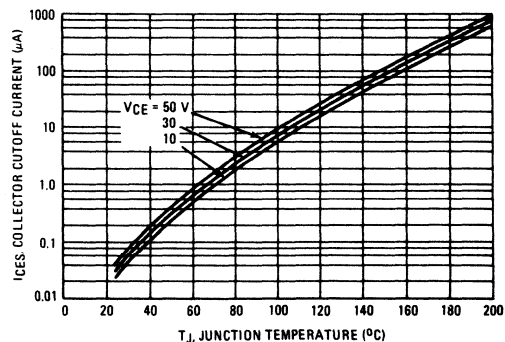


FIGURE 11 – COLLECTOR CUTOFF CURRENT



2N4015 (SILICON)

2N4016

MULTIPLE SILICON ANNULAR TRANSISTORS

... designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Excellent Temperature Tracking -- Dual Devices -- 2N4015
 $\Delta|V_{BE1} - V_{BE2}| = 1.6 \text{ mVdc (Max) @ } -55 \text{ to } +25^{\circ}\text{C}$
 $= 2.0 \text{ mVdc (Max) @ } +25 \text{ to } +125^{\circ}\text{C}$
- Low Collector-Emitter Saturation Voltage --
 $V_{CE(sat)} = 0.25 \text{ Vdc (Max) @ } I_C = 50 \text{ mAdc}$
- DC Current Gain Specified -- 0.01 mAdc to 50 mAdc
- High Current-Gain-Bandwidth Product --
 $f_T = 200 \text{ MHz @ } I_C = 50 \text{ mAdc}$

*MAXIMUM RATINGS

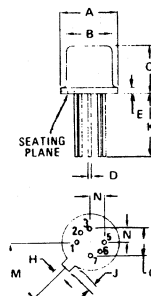
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector 1 to Collector 2 Voltage Voltage Rating and Lead to Case	V_{C1C2}	± 200 ± 200	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current -- Continuous	I_C	300	mAdc
Base Current	I_B	100	mAdc
		One Die	Both Die
Total Power Dissipation @ $T_A = 25^{\circ}\text{C}$ Derate above 25°C	P_D	400 2.29	500 2.86 mW mW/ $^{\circ}\text{C}$
Total Power Dissipation @ $T_C = 25^{\circ}\text{C}$ Derate above 25°C	P_D	0.85 4.85	1.4 8.0 Watts mW/ $^{\circ}\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^{\circ}\text{C}$

*Indicates JEDEC Registered Data

PNP SILICON
MULTIPLE TRANSISTORS

STYLE 1

- PIN 1: COLLECTOR 5. EMITTER
 2. BASE 6. BASE
 3. EMITTER 7. COLLECTOR
 4. OMITTED 8. OMITTED



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	-	0.500	-
M	45 $^{\circ}$ BSC		45 $^{\circ}$ BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

2N4015, 2N4016 (continued)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) ($I_C = 10 \text{ mAdc}$, $I_B = 0$)	BV_{CEO}	60	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 50 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 50 \text{ Vdc}$, $I_E = 0$, $T_A = +150^{\circ}\text{C}$)	I_{CBO}	— —	10 10	nAdc μAdc
Emitter Cutoff Current ($V_{EB} = 3.0 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	0.1	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 0.01 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$) ($I_C = 0.1 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$) ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$) ($I_C = 50 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$)(1)	h_{FE}	80 120 135 115	— — 350 —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 50 \text{ mAdc}$, $I_B = 2.5 \text{ mAdc}$)	$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter Saturation Voltage(1) ($I_C = 50 \text{ mAdc}$, $I_B = 2.5 \text{ mAdc}$)	$V_{BE(sat)}$	—	1.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product(2) ($I_C = 50 \text{ mAdc}$, $V_{CE} = 20 \text{ Vdc}$, $f = 100 \text{ MHz}$) ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 20 \text{ MHz}$)	f_T	200 60	600 —	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 1.0 \text{ MHz}$)	C_{ob}	—	8.0	pF
Input Capacitance ($V_{EB} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 1.0 \text{ MHz}$)	C_{ib}	—	25	pF
Input Impedance ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{ie}	—	11.5	k ohms
Voltage Feedback Ratio ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{re}	—	15	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{fe}	135	420	—
Output Admittance ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	h_{oe}	—	80	μmhos
Noise Figure ($I_C = 0.03 \text{ mAdc}$, $V_{CE} = 5.0 \text{ Vdc}$, $R_S = 10 \text{ k ohms}$, $f = 1.0 \text{ kHz}$, $BW = 200 \text{ Hz}$)	NF	—	4.0	dB

MATCHING CHARACTERISTICS

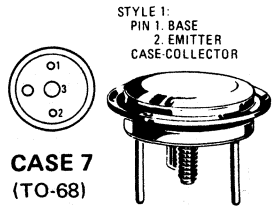
DC Current Gain Ratio ($I_C = 0.1$ to 1.0 mAdc , $V_{CE} = 5.0 \text{ Vdc}$)	h_{FE1}/h_{FE2}	0.9	1.0	—
Base-Emitter Voltage Differential ($I_C = 0.1$ to 1.0 mAdc , $V_{CE} = 5.0 \text{ Vdc}$)	$ V_{BE1} - V_{BE2} $	— —	5.0 2.5	mVdc
Base-Emitter Voltage Differential Gradient ($I_C = 0.1$ to 1.0 mAdc , $V_{CE} = 5.0 \text{ Vdc}$, $T_A = -55^{\circ}\text{C}$ to $+25^{\circ}\text{C}$)	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	— —	1.6 0.8	mVdc
($I_C = 0.1$ to 1.0 mAdc , $V_{CE} = 5.0 \text{ Vdc}$, $T_A = +25^{\circ}\text{C}$ to $+125^{\circ}\text{C}$)		— —	2.0 1.0	

*Indicates JEDEC Registered Data.

(1)Pulse Test: Pulse Width = 300 μs , Duty Cycle = 1.0%.

(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

2N4048 thru 2N4053 (GERMANIUM)



PNP germanium power transistors designed for high-current applications requiring high gain and extremely low saturation voltage.

Collector connected to case

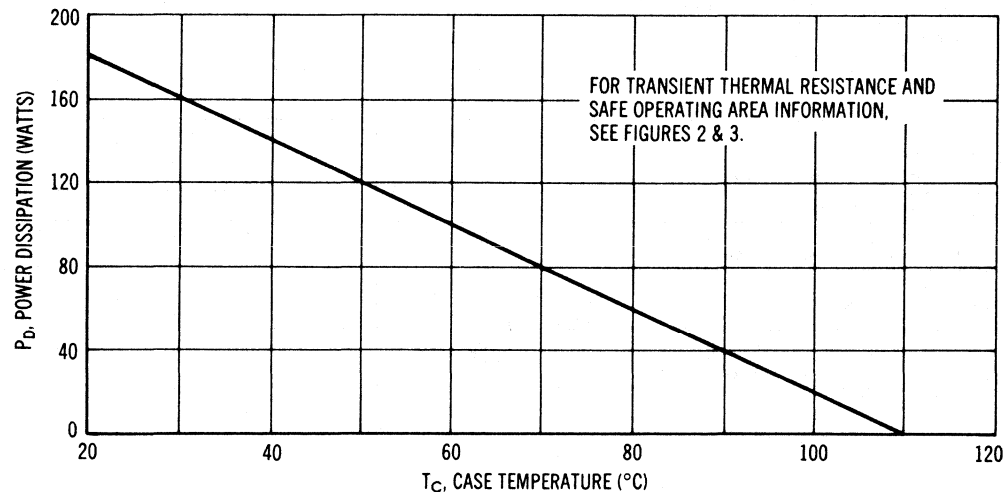
MAXIMUM RATINGS

Rating	Symbol	2N4048 2N4051	2N4049 2N4052	2N4050 2N4053	Unit
Collector-Emitter Voltage	V_{CEO}	30	45	60	Vdc
Collector-Emitter Voltage	V_{CES}	45	60	75	Vdc
Collector-Base Voltage	V_{CB}	45	60	75	Vdc
Emitter-Base Voltage	V_{EB}	25	30	40	Vdc
Collector Current – Continuous	I_C^*	60			Ade
Total Device Dissipation @ $T_C = 25^\circ\text{C}$	P_D	170			Watts
Derate above 25°C		2.0			W/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110			$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.5	$^\circ\text{C}/\text{W}$

FIGURE 1 – AVERAGE POWER-TEMPERATURE DERATING CURVE



* JEDEC Registered Values, For True Capability See Figure 3

2N4048 thru 2N4053 (continued)

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage† ($I_C = 1.0 \text{ A dc}$, $I_B = 0$)	2N4048, 2N4051 2N4049, 2N4052 2N4050, 2N4053	$BV_{CEO}^\dagger$	30 45 60	- - -	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 300 \text{ mA dc}$, $V_{BE} = 0$)	2N4048, 2N4051 2N4049, 2N4052 2N4050, 2N4053	BV_{CES}	45 60 75	- - -	Vdc
Floating Potential ($V_{CB} = 45 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 60 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 75 \text{ Vdc}$, $I_E = 0$)	2N4048, 2N4051 2N4049, 2N4052 2N4050, 2N4053	V_{EBF}	- - -	0.5 0.5 0.5	Vdc
Collector Cutoff Current ($V_{CE} = 30 \text{ Vdc}$, $V_{BE(\text{off})} = 2.0 \text{ Vdc}$, $T_C = +71^\circ\text{C}$) ($V_{CE} = 45 \text{ Vdc}$, $V_{BE(\text{off})} = 2.0 \text{ Vdc}$, $T_C = +71^\circ\text{C}$) ($V_{CE} = 60 \text{ Vdc}$, $V_{BE(\text{off})} = 2.0 \text{ Vdc}$, $T_C = +71^\circ\text{C}$)	2N4048, 2N4051 2N4049, 2N4052 2N4050, 2N4053	I_{CEX}	- - -	15 15 15	mA dc
Collector Cutoff Current ($V_{CB} = 2.0 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 45 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 60 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 75 \text{ Vdc}$, $I_E = 0$)	2N4048, 2N4051 2N4049, 2N4052 2N4050, 2N4053	I_{CBO}	- - - -	0.2 4.0 4.0 4.0	mA dc
Emitter Cutoff Current ($V_{BE} = 25 \text{ Vdc}$, $I_C = 0$) ($V_{BE} = 25 \text{ Vdc}$, $I_C = 0$, $T_C = +71^\circ\text{C}$) ($V_{BE} = 30 \text{ Vdc}$, $I_C = 0$) ($V_{BE} = 30 \text{ Vdc}$, $I_C = 0$, $T_C = +71^\circ\text{C}$) ($V_{BE} = 40 \text{ Vdc}$, $I_C = 0$) ($V_{BE} = 40 \text{ Vdc}$, $I_C = 0$, $T_C = +71^\circ\text{C}$)	2N4048, 2N4051 2N4049, 2N4052 2N4050, 2N4053	I_{EBO}	- - - - -	4.0 15 4.0 15 4.0 15	mA dc

ON CHARACTERISTICS

DC Current Gain† ($I_C = 15 \text{ A dc}$, $V_{CE} = 2.0 \text{ Vdc}$) ($I_C = 60 \text{ A dc}$, $V_{CE} = 2.0 \text{ Vdc}$)	2N4048, 2N4049, 2N4050 2N4051, 2N4052, 2N4053	$h_{FE}^\dagger$	60 120 15	180 240 -	-
Collector-Emitter Saturation Voltage† ($I_C = 15 \text{ A dc}$, $I_B = 1.0 \text{ A dc}$) ($I_C = 60 \text{ A dc}$, $I_B = 6.0 \text{ A dc}$)		$V_{CE(\text{sat})}^\dagger$	- -	0.15 0.3	Vdc
Base-Emitter Saturation Voltage† ($I_C = 15 \text{ A dc}$, $I_B = 1.0 \text{ A dc}$) ($I_C = 60 \text{ A dc}$, $I_B = 6.0 \text{ A dc}$)		$V_{BE(\text{sat})}^\dagger$	- -	0.6 1.0	Vdc

SMALL SIGNAL CHARACTERISTICS

Common-Emitter Cutoff Frequency ($I_C = 15 \text{ A dc}$, $V_{CE} = 2.0 \text{ Vdc}$)	$f_{\alpha e}$	2.0	-	kHz
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† To avoid excessive heating of the collector junction, perform test with pulse method.

The switching performance of this transistor is determined primarily by the gain-bandwidth product, f_T , and the behavior of the base-spreading resistance, r_b .

In the case of rise time, the base-spreading resistance plays a small part, and the test circuit delivers a constant current step of turn-on current to the transistor (I_{B1}). Therefore, the curve of t_r on Figure 6 follows theory closely, i.e.:

$$t_r = 0.8 \frac{I_C}{I_{B1}} \cdot \frac{1}{2\pi f_T}$$

From the curve, it can be seen that f_T is roughly constant with current; using the equation, its large signal value can be calculated to be approximately 120 kHz at the 20-Amp level. A lower supply voltage will increase rise time slightly.

Turn-off time is slow because of conductivity modulation which occurs in the base region. When the transistor is held "on" in saturation, the base region becomes filled with excess charge; i.e., charge in excess of that

$$* f_T = f_{\alpha e} \times h_{FE}$$

necessary to sustain the circuit limited value of I_C . As a result, the base resistivity and consequently r_b become very low. During turn off, as the excess charge is reduced, the accompanying increase in resistivity causes a marked reduction in the turn-off current, I_{B2} , as can be seen from the waveforms of Figure 5. During fall time, the I_{B2} current is very low causing an extended fall time.

Only a slight improvement in turn-off performance is achieved with a "speed-up" capacitor placed across R_B . This unusual behavior occurs because r_b limits the amount of reverse current which can be achieved. Also, it seems evident that r_b increases with applied reverse current, so that efforts to speed up the turn-off behavior are somewhat futile.

In most applications, switching time will be close to the values shown on Figure 6. Delay time is not shown as it is negligible in comparison to the other times.

FIGURE 2 — TRANSIENT THERMAL RESISTANCE

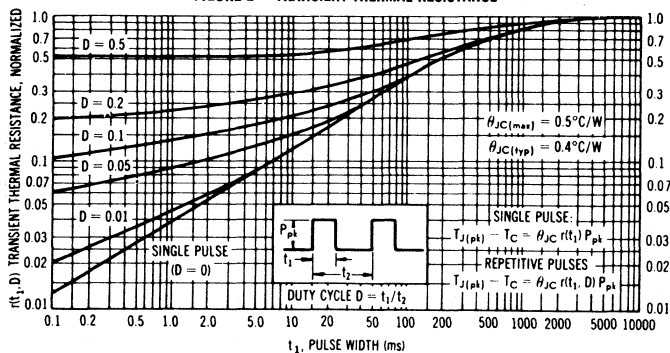


FIGURE 3 — ACTIVE REGION SAFE-OPERATING AREA

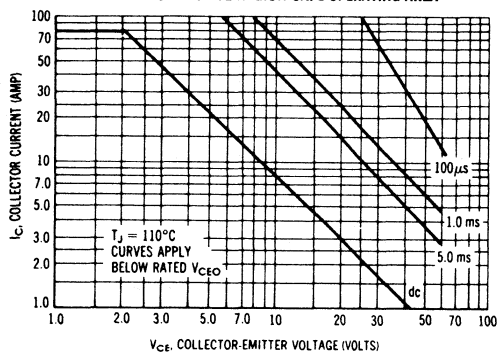


FIGURE 4 — SAFE OPERATING AREA TEST CIRCUIT

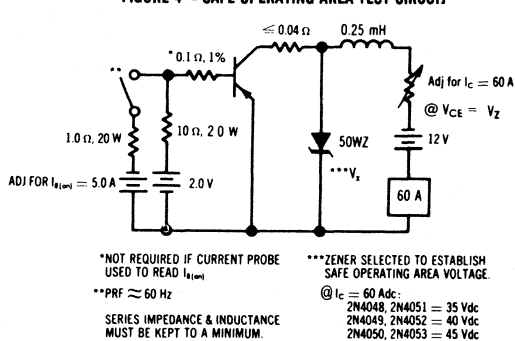


FIGURE 5 — SWITCHING TEST CIRCUIT

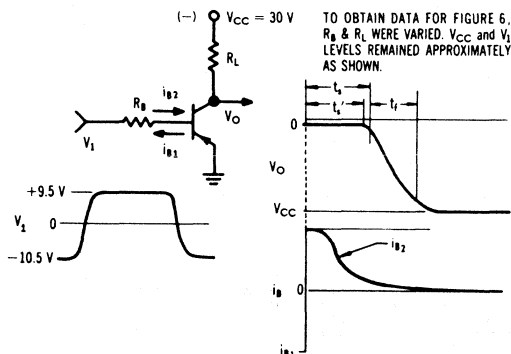
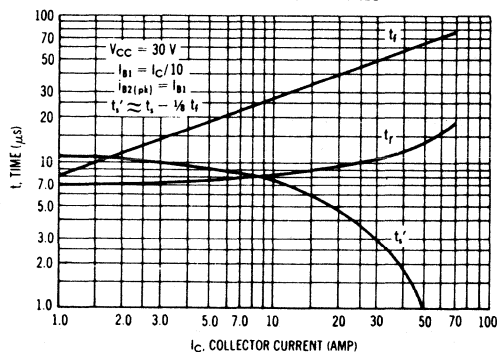


FIGURE 6 — SWITCHING TIMES



TYPICAL DC CHARACTERISTICS

FIGURE 7 — DC CURRENT GAIN

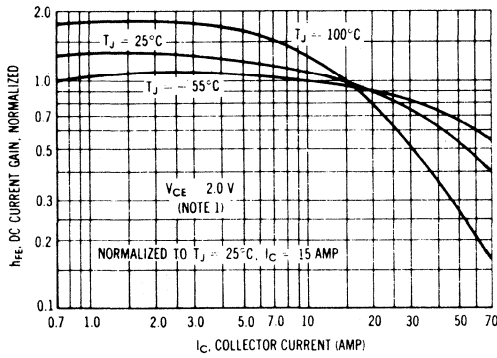


FIGURE 8 — COLLECTOR SATURATION REGION

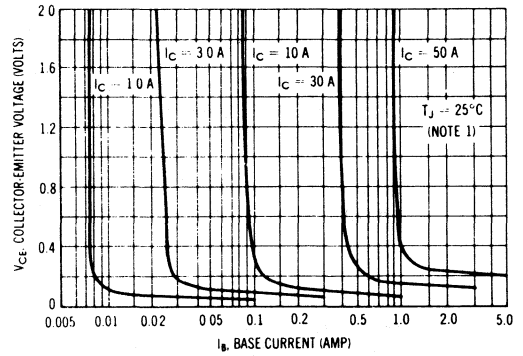


FIGURE 9 — EFFECTS OF BASE-EMITTER RESISTANCE

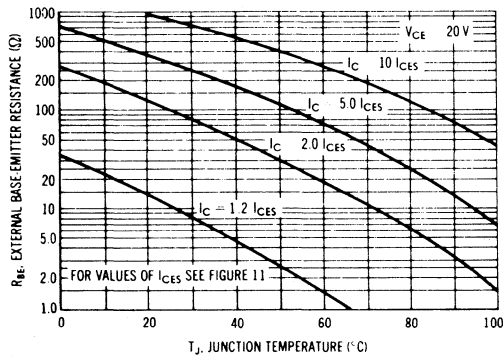


FIGURE 10 — "ON" VOLTAGES

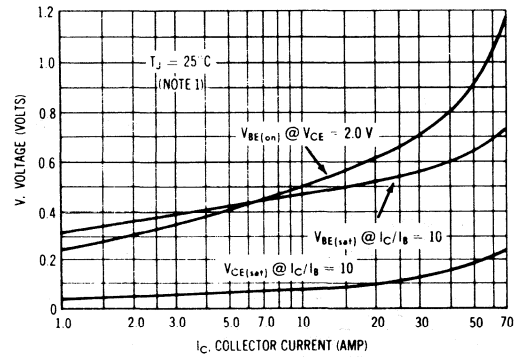


FIGURE 11 — COLLECTOR CUTOFF REGION

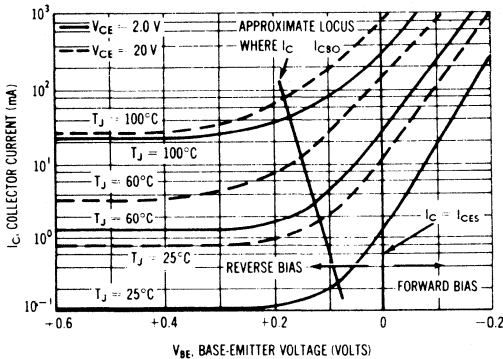
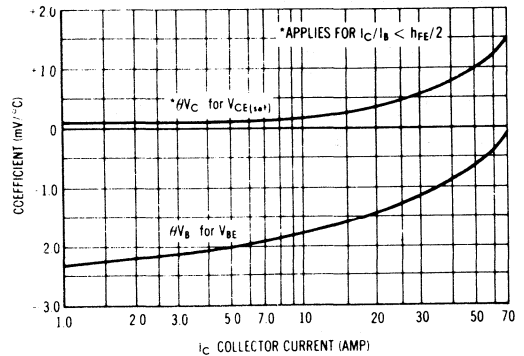


FIGURE 12 — TEMPERATURE COEFFICIENTS



NOTE 1: Data is obtained from pulse tests and adjusted to nullify the effect of I_{CBO}

2N4066 (SILICON)

2N4067

DUAL P-CHANNEL MOS FIELD-EFFECT TRANSISTORS

Enhancement Mode MOS Field-Effect Transistors designed primarily for low-power, chopper or switching applications.

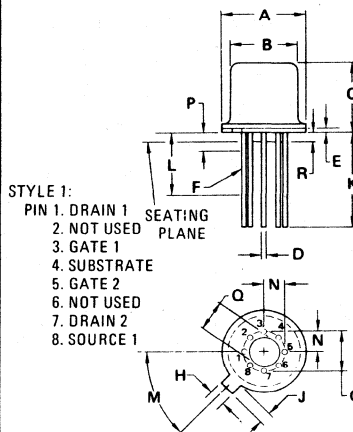
- High Forward Transadmittance –
 $|y_{fs}| = 2.5 \text{ mmhos (Min) @ } V_{DS} = -15 \text{ Vdc (2N4067)}$
- Low Forward Gate Current –
 $I_{GF} = 2.5 \text{ pAdc (Max) @ } V_{GS} = -25 \text{ Vdc}$
- Low Drain-Source "ON" Resistance –
 $r_{ds(on)} = 250 \text{ Ohms (Max) @ } V_{GS} = -15 \text{ Vdc (2N4067)}$

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	-30	Vdc
Drain-Gate Voltage	V_{DG}	-25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	+25	Vdc
Forward Gate-Source Voltage	V_{GSF}	-25	Vdc
Drain Current	I_D	200	mA dc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.6 4.0	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.7 11.3	Watts mW/ $^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$
Operating Junction Temperature Range	T_J	-65 to +175	$^\circ\text{C}$

*Indicates JEDEC Registered Data.

DUAL P-CHANNEL MOS FIELD-EFFECT TRANSISTORS



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	—	1.02	—	0.040
F	0.406	0.483	0.016	0.019
G	5.08 BSC		0.200 BSC	
H	0.711	0.864	0.028	0.034
J	0.737	1.14	0.029	0.045
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	
P	—	1.27	—	0.050
Q	3.05	4.06	0.120	0.160
R	0.254	1.02	0.010	0.040

All JEDEC dimensions and notes apply

CASE 642-02
(TO-76)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage ($I_D = 10\text{ }\mu\text{Adc}$, $V_{GS} = 0$)	$V_{(BR)DSS}$	-30	—	Vdc
Source-Drain Breakdown Voltage ($I_S = 10\text{ }\mu\text{Adc}$, $V_{GD} = 0$)	$V_{(BR)SDS}$	-30	—	Vdc
Zero-Gate Voltage Source Current ($V_{SD} = -15\text{ Vdc}$, $V_{GD} = 0$) ($V_{SD} = -15\text{ Vdc}$, $V_{GD} = 0$, $T_A = 150^\circ\text{C}$)	I_{SDS}	— —	1.0 2.0	nAdc μAdc
Zero-Gate Voltage Drain Current (Note 1) ($V_{DS} = -15\text{ Vdc}$, $V_{GS} = 0$) ($V_{DS} = -15\text{ Vdc}$, $V_{GS} = 0$, $T_A = 150^\circ\text{C}$)	I_{DSS}	— —	1.0 2.0	nAdc μAdc

ON CHARACTERISTICS

Gate-Source Threshold Voltage ($V_{DS} = -15\text{ Vdc}$, $I_D = 10\text{ }\mu\text{Adc}$)	$V_{GS(TH)}$	-3.0	-6.0	Vdc
Forward Gate Current ($V_{GS} = -25\text{ Vdc}$, $V_{DS} = 0$)	I_{GF}	—	2.5	pAdc
"ON" Drain Current ($V_{DS} = -15\text{ Vdc}$, $V_{GS} = -15\text{ Vdc}$)	$I_{D(on)}$	10	50	mAdc

SMALL-SIGNAL CHARACTERISTICS

Static Drain-Source "ON" Resistance ($V_{GS} = -15\text{ Vdc}$, $I_D = 0$, $f = 1.0\text{ kHz}$)	2N4066 2N4067	$r_{ds(on)}$	— —	500 250	Ohms
Forward Transadmittance (Note 1) ($V_{DS} = -15\text{ Vdc}$, $V_{GS} = -15\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N4066 2N4067	$ y_{fs} $	1.5 2.5	— —	mmhos
($V_{DS} = -15\text{ Vdc}$, $V_{GS} = -15\text{ Vdc}$, $f = 1.0\text{ kHz}$, $T_A = 100^\circ\text{C}$)	2N4066 2N4067		1.0 1.75	— —	
Output Admittance ($V_{DS} = -15\text{ Vdc}$, $V_{GS} = -15\text{ Vdc}$, $f = 1.0\text{ kHz}$)		$ y_{os} $	—	300	μmhos
Input Capacitance ($V_{DS} = -15\text{ Vdc}$, $V_{GS} = -15\text{ Vdc}$, $f = 1.0\text{ MHz}$)		C_{iss}	—	7.0	pF
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = 0$, $f = 1.0\text{ MHz}$)		C_{rss}	—	1.5	pF
Source-Substrate Capacitance ($V_{DU} = -15\text{ Vdc}$, $V_{GS} = 0$, $I_S = 0$, $f = 1.0\text{ MHz}$)		C_{SU}	—	5.0	pF
Drain-Substrate Capacitance ($V_{SU} = -15\text{ Vdc}$, $V_{GS} = 0$, $I_S = 0$, $f = 1.0\text{ MHz}$)		C_{DU}	—	5.0	pF

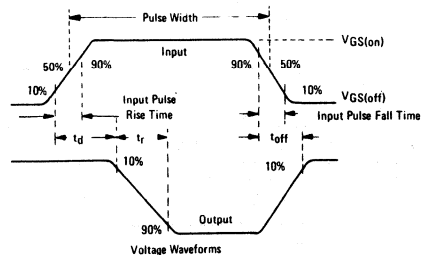
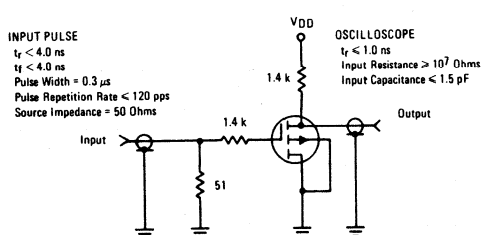
SWITCHING CHARACTERISTICS

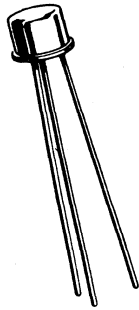
Delay Time	(VDD = -15 Vdc, $I_{D(on)} = 10\text{ mAdc}$, $V_{GS(on)} = -15\text{ Vdc}$, $V_{GS(off)} = 0$)	t_d	—	20	ns
Rise Time		t_r	—	30	ns
Turn-Off Time		t_{off}	—	50	ns

*Indicates JEDEC Registered Data.

Note 1: Pulse Test: Pulse Width $\leq 630\text{ ms}$, Duty Cycle $\leq 10\%$.

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



2N4072 (SILICON)**2N4073**

CASE 22
(TO-18)
2N4072

CASE 31
(TO-5)
2N4073



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

NPN silicon annular transistors designed as amplifiers and drivers for large-signal VHF and UHF applications.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	2N4072	2N4073	Unit
Collector-Emitter Voltage	V_{CEO}	20		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current-Continuous	I_C	100	150	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate Above 25°C	P_D	0.35 2.0	- -	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	- -	1.5 8.57	Watts mW/ $^\circ\text{C}$
Operating Junction and Storage Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
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STATIC CHARACTERISTICS

Collector-Emitter Sustaining Voltage ($I_C = 15 \text{ mAdc}$, $I_B = 0$)	$BV_{CEO(sus)}$	20	-	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1 \text{ mAdc}$, $I_E = 0$)	BV_{CBO}	40	-	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1 \text{ mAdc}$, $I_C = 0$)	BV_{EBO}	4.0	-	-	Vdc
Collector Cutoff Current ($V_{CB} = 15 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 15 \text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	- -	- -	0.1 100	μAdc
DC Current Gain ($I_C = 25 \text{ mAdc}$, $V_{CE} = 2 \text{ Vdc}$)	h_{FE}	10	-	-	-

DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 25 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	-	550	-	MHz
Output Capacitance ($V_{CB} = 15 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)	C_{ob}	-	3.0	4.0	pF

2N4072, 2N4073 (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Typ	Max	Unit
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FUNCTIONAL TEST

Power Gain	2N4072 Test Circuit - Figure 5 $P_{in} = 25 \text{ mW}$, $V_{CE} = 13.6 \text{ Vdc}$, $f = 175 \text{ MHz}$	G_{PE}	10	-	-	dB
Power Output		P_{out}	250	-	-	mW
Collector Efficiency		η	50	60	-	%
Power Gain	2N4073 Test Circuit - Figure 5 $P_{in} = 50 \text{ mW}$, $V_{CE} = 13.6 \text{ Vdc}$, $f = 175 \text{ MHz}$	G_{PE}	10	-	-	dB
Power Output		P_{out}	500	650	-	mW
Collector Efficiency		η	50	65	-	%

2N4072

FIGURE 1 — POWER OUTPUT versus FREQUENCY

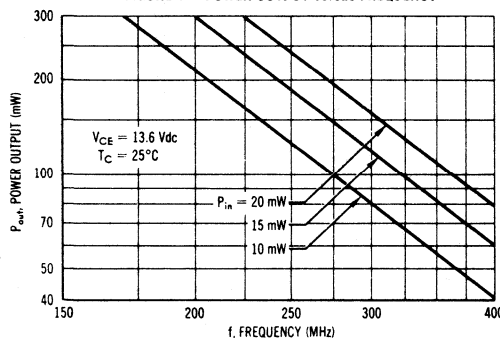
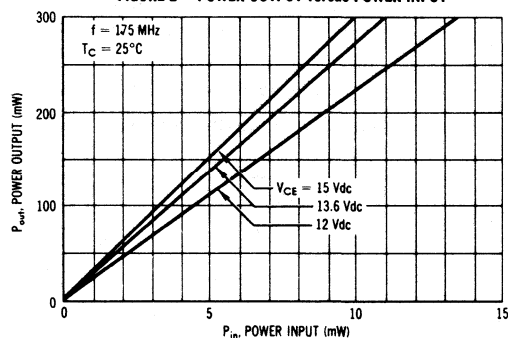


FIGURE 2 — POWER OUTPUT versus POWER INPUT



2N4073

FIGURE 3 — POWER OUTPUT versus FREQUENCY

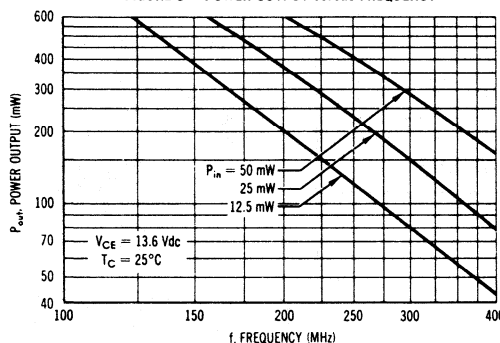


FIGURE 4 — POWER OUTPUT versus POWER INPUT

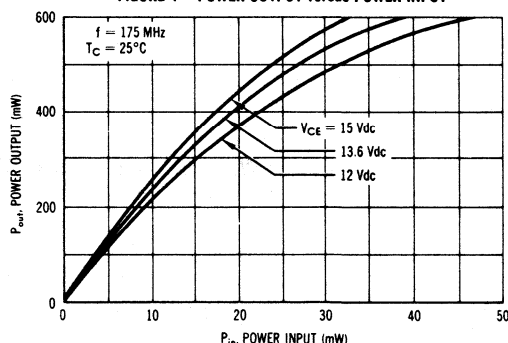
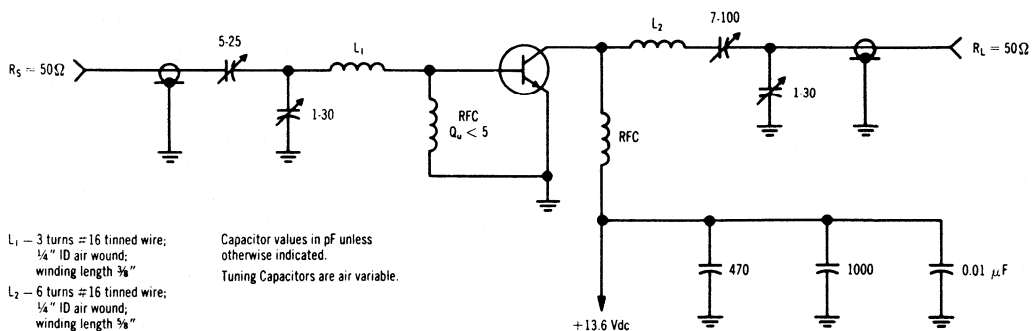


FIGURE 5 — 175 MHz TEST CIRCUIT



2N4091 (SILICON)

2N4092

2N4093

SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

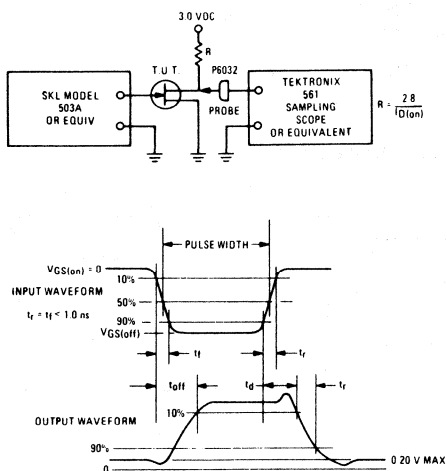
Depletion Mode (Type A) Junction Field-Effect Transistors designed for chopper and high-speed switching applications.

- Low Drain-Source "On" Resistance –
 $r_{ds(on)} = 30 \text{ Ohms (Max) @ } f = 1.0 \text{ kHz (2N4091)}$
- Low Source Reverse Current –
 $I_{SGO} = 0.2 \text{ nAdc (Max) @ } V_{SG} = 20 \text{ Vdc}$
- Guaranteed Switching Characteristics

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Gate-Source Voltage	V_{GS}	40	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.8 10	Watts mW/ $^\circ\text{C}$
Operating Junction Temperature Range	T_J	-65 to +175	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

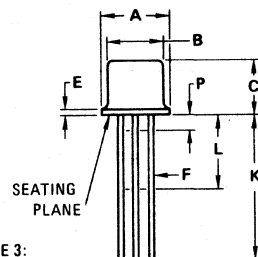
FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



N-CHANNEL

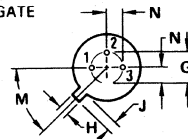
JUNCTION FIELD-EFFECT TRANSISTORS

(Type A)



STYLE 3:

PIN 1. SOURCE
2. DRAIN
3. GATE



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	—	0.762	—	0.030
F	0.406	0.483	0.016	0.019
G	2.54	BSC	0.100	BSC
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45°	BSC	45°	BSC
N	1.27	BSC	0.050	BSC
P	—	1.27	—	0.050

All JEDEC notes and dimensions apply.

CASE 22-03
(TO-18)

2N4091, 2N4092, 2N4093 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I _G = 1.0 μ Adc, V _{DS} = 0)	V _{(BR)GSS}	40	-	Vdc
Drain-Gate Breakdown Voltage (I _D = 1.0 μ Adc, I _S = 0)	V _{(BR)DGO}	40	-	Vdc
Gate-Source Cutoff Voltage (V _{DS} = 20 Vdc, I _D = 1.0 nAdc)	V _{GS(off)}	5.0 2.0 1.0	10 7.0 5.0	Vdc
Source Reverse Current (V _{SG} = 20 Vdc, I _D = 0)	I _{SGO}	-	0.2	nAdc
Drain Reverse Current (V _{DG} = 20 Vdc, I _S = 0)	I _{DGO}	-	0.2	nAdc
		-	0.4	μ Adc
Drain-Cutoff Current (V _{DS} = 20 Vdc, V _{GS} = 12 Vdc)	I _{D(off)}	-	0.2	nAdc
(V _{DS} = 20 Vdc, V _{GS} = 8.0 Vdc)		-	0.2	
(V _{DS} = 20 Vdc, V _{GS} = 6.0 Vdc)		-	0.2	
(V _{DS} = 20 Vdc, V _{GS} = 12 Vdc, T _A = 150°C)		-	0.4	μ Adc
(V _{DS} = 20 Vdc, V _{GS} = 8.0 Vdc, T _A = 150°C)		-	0.4	
(V _{DS} = 20 Vdc, V _{GS} = 6.0 Vdc, T _A = 150°C)		-	0.4	

ON CHARACTERISTICS

Zero-Gate Voltage Drain Current (1) (V _{DS} = 20 Vdc, V _{GS} = 0)	I _{DSS}	30 15 8.0	- - -	mAdc
Drain-Source "ON" Voltage (I _D = 6.6 mAdc, V _{GS} = 0)	V _{DS(on)}	-	0.2	Vdc
(I _D = 4.0 mAdc, V _{GS} = 0)		-	0.2	
(I _D = 2.5 mAdc, V _{GS} = 0)		-	0.2	
Static Drain-Source "ON" Resistance (I _D = 1.0 mAdc, V _{GS} = 0)	r _{DS(on)}	- - -	30 50 80	Ohms

SMALL-SIGNAL CHARACTERISTICS

Drain-Source "ON" Resistance (V _{GS} = 0, I _D = 0, f = 1.0 kHz)	r _{ds(on)}	- - -	30 50 80	Ohms
Input Capacitance (V _{DS} = 20 Vdc, V _{GS} = 0, f = 1.0 MHz)	C _{iss}	-	16	pF
Reverse Transfer Capacitance (V _{DS} = 0, V _{GS} = 20 Vdc, f = 1.0 MHz)	C _{rss}	-	5.0	pF

SWITCHING CHARACTERISTICS

Delay Time (See Figure 1) (I _{D(on)} = 6.6 mAdc)	t _d	-	15	ns
(I _{D(on)} = 4.0 mAdc)		-	15	
(I _{D(on)} = 2.5 mAdc)		-	20	
Rise Time (See Figure 1) (I _{D(on)} = 6.6 mAdc)	t _r	-	10	ns
(I _{D(on)} = 4.0 mAdc)		-	20	
(I _{D(on)} = 2.5 mAdc)		-	40	
Turn-Off Time (See Figure 1) (V _{GS(off)} = 12 Vdc)	t _{off}	-	40	ns
(V _{GS(off)} = 8.0 Vdc)		-	60	
(V _{GS(off)} = 6.0 Vdc)		-	80	

(1) Pulse Test: Pulse Width $\leq$ 300 μ s, Duty Cycle $\leq$ 3.0%.

2N4123 (SILICON)
2N4124

NPN SILICON ANNULAR TRANSISTORS

... designed for general-purpose amplifier applications and for complementary circuitry with types 2N4125 and 2N4126.

- Collector-Emitter Breakdown Voltage –
 $BV_{CEO} = 30 \text{ Vdc (Min) @ } I_C = 1.0 \text{ mAdc} - 2N4123$
- Current Gain Specified at 2.0 mAdc and 50 mAdc
- Low Output Capacitance –
 $C_{ob} = 40 \text{ pF (Max) @ } V_{CB} = 5.0 \text{ Vdc}$

NPN SILICON
AMPLIFIER
TRANSISTORS



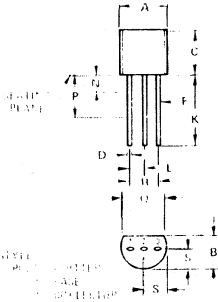
*MAXIMUM RATINGS

Rating	Symbol	2N4123	2N4124	Unit
Collector-Emitter Voltage	V_{CEO}	30	25	Vdc
Collector-Base Voltage	V_{CB}	40	30	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	200		mAdc
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350	2.8	mW mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0	8.0	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	$^\circ\text{C/W}$

*Indicates JEDEC Registered Data.



DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	5.180	4.190	0.125	0.165
C	4.370	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
E	0.407	0.482	0.016	0.019
F	12.700	—	0.500	—
G	1.150	1.390	0.045	0.055
H	1.270	—	0.050	—
I	6.350	—	0.250	—
J	5.430	—	0.135	—
K	2.410	2.770	0.095	0.105
L	2.030	2.670	0.080	0.105

CASE 29
TO-92

2N4123, 2N4124 (continued)

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (1) ($I_C = 1 \text{ mAdc}$, $I_E = 0$)	2N4123 2N4124	BV_{CEO}	30 25	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \text{ } \mu\text{Adc}$, $I_E = 0$)	2N4123 2N4124	BV_{CBO}	40 30	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \text{ } \mu\text{Adc}$, $I_C = 0$)		BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 20 \text{ Vdc}$, $I_E = 0$)		I_{CBO}	—	50	nAdc
Emitter Cutoff Current ($V_{BE} = 3 \text{ Vdc}$, $I_C = 0$)		I_{EBO}	—	50	nAdc

ON CHARACTERISTICS

DC Current Gain (1) ($I_C = 2 \text{ mAdc}$, $V_{CE} = 1 \text{ Vdc}$)	2N4123 2N4124	h_{FE}	50 120	150 360	—
($I_C = 50 \text{ mAdc}$, $V_{CE} = 1 \text{ Vdc}$)	2N4123 2N4124		25 60	— —	
Collector-Emitter Saturation Voltage (1) ($I_C = 50 \text{ mAdc}$, $I_B = 5 \text{ mAdc}$)		$V_{CE(sat)}$	—	0.3	Vdc
Base-Emitter Saturation Voltage (1) ($I_C = 50 \text{ mAdc}$, $I_B = 5 \text{ mAdc}$)		$V_{BE(sat)}$	—	0.95	Vdc

SMALL SIGNAL CHARACTERISTICS

High-Frequency Current Gain ($I_C = 10 \text{ mAdc}$, $V_{CE} = 20 \text{ Vdc}$, $f = 100 \text{ MHz}$)	2N4123 2N4124	$ h_{fe} $	2.5 3.0	— —	—
Current-Gain — Bandwidth Product ($I_C = 10 \text{ mAdc}$, $V_{CE} = 20 \text{ Vdc}$, $f = 100 \text{ MHz}$)	2N4123 2N4124	f_T	250 300	— —	MHz
Output Capacitance ($V_{CB} = 5 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)		C_{ob}	—	4.0	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 100 \text{ kHz}$)		C_{ib}	—	8.0	pF
Small-Signal Current Gain ($I_C = 2 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1 \text{ kHz}$)	2N4123 2N4124	h_{fe}	50 120	200 480	—
Noise Figure ($I_C = 100 \text{ } \mu\text{Adc}$, $V_{CE} = 5 \text{ Vdc}$, $R_S = 1 \text{ k ohm}$, Noise Bandwidth = 10 Hz to 15.7 kHz)	2N4123 2N4124	NF	— —	6.0 5.0	dB

(1) Pulse Test: Pulse Width = 300 μs , Duty Cycle = 2%

*Indicates JEDEC Registered Data

FIGURE 1 — CAPACITANCE

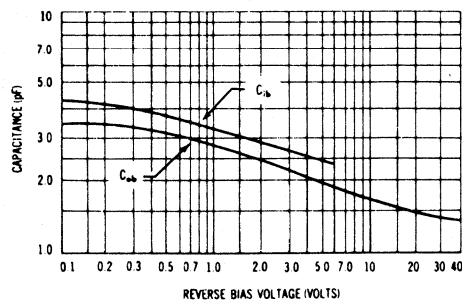
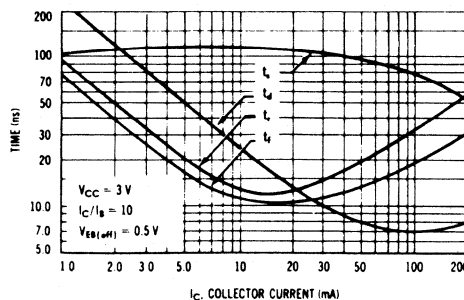


FIGURE 2 — SWITCHING TIMES



AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE

($V_{CE} = 5 \text{ Vdc}$, $T_A = 25^\circ\text{C}$)
Bandwidth = 1.0 Hz

FIGURE 3 — FREQUENCY VARIATIONS

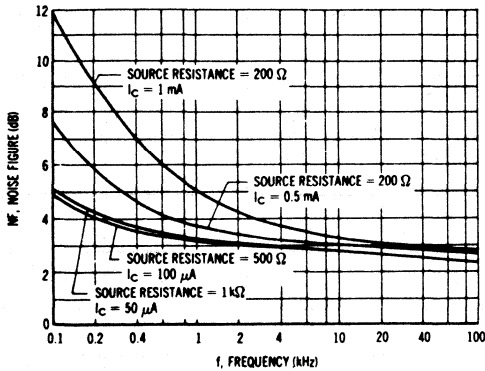
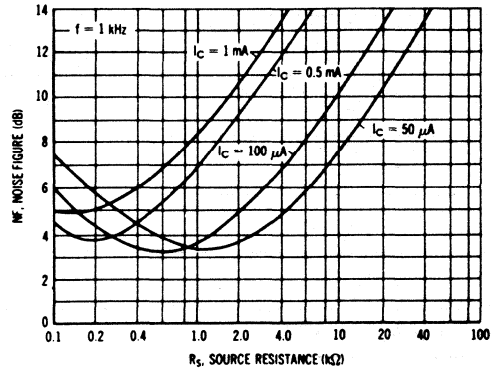


FIGURE 4 — SOURCE RESISTANCE



h PARAMETERS

$V_{CE} = 10 \text{ V}$, $f = 1 \text{ kHz}$, $T_A = 25^\circ\text{C}$

FIGURE 5 — CURRENT GAIN

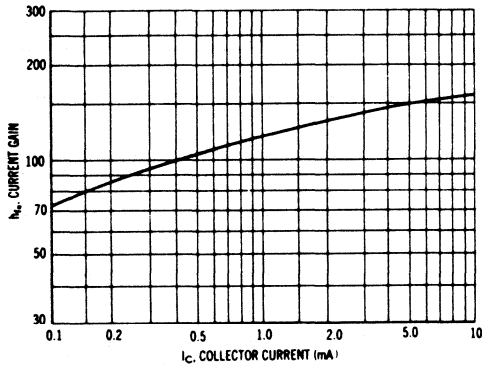


FIGURE 6 — OUTPUT ADMITTANCE

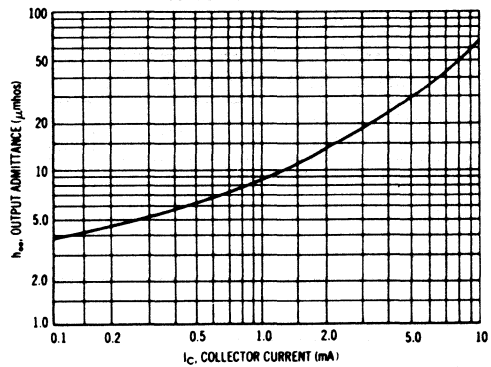


FIGURE 7 — INPUT IMPEDANCE

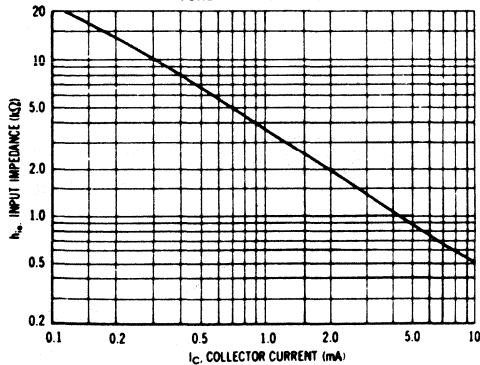
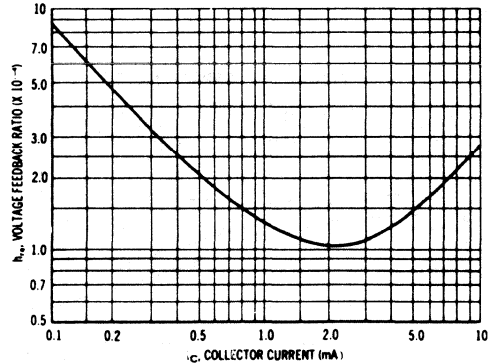


FIGURE 8 — VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 9 - DC CURRENT GAIN

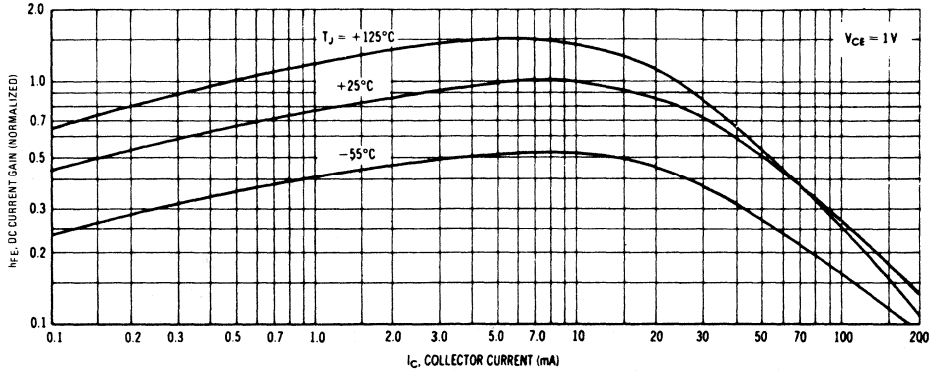


FIGURE 10 - COLLECTOR SATURATION REGION

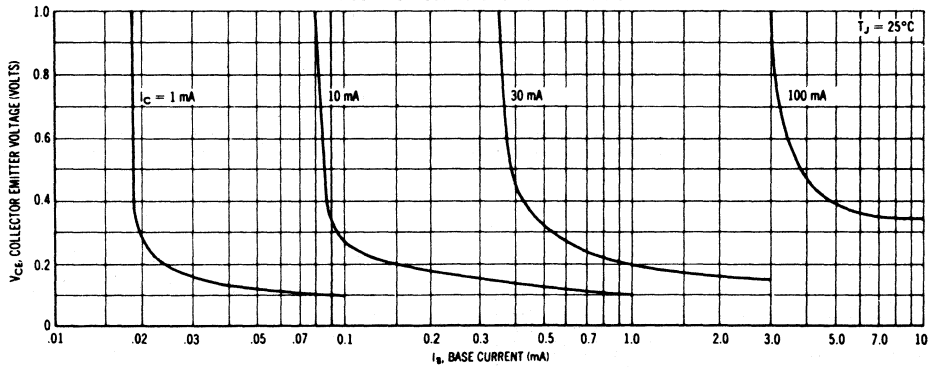


FIGURE 11 - "ON" VOLTAGES

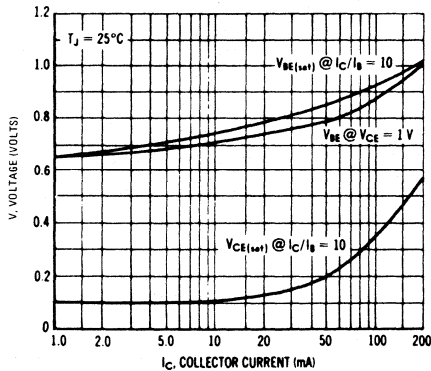
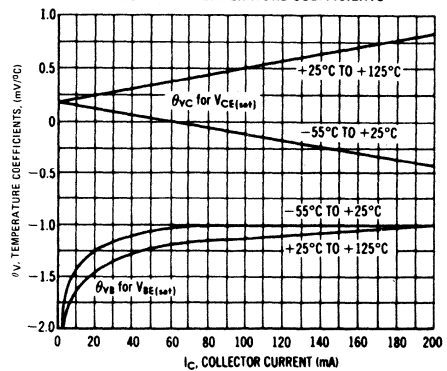


FIGURE 12 - TEMPERATURE COEFFICIENTS



2N4125 (SILICON)
2N4126

PNP SILICON ANNULAR TRANSISTORS

... designed for general-purpose amplifier applications and for complementary circuitry with types 2N4123 and 2N4124.

- Collector-Emitter Breakdown Voltage –
 $BV_{CEO} = 30 \text{ Vdc (Min) @ } I_C = 1.0 \text{ mAdc} - 2N4125$
- Current Gain Specified at 2.0 mAdc and 50 mAdc
- Collector-Base Capacitance –
 $C_{cb} = 4.5 \text{ pF (Max) @ } V_{CB} = 5.0 \text{ Vdc}$

PNP SILICON
AMPLIFIER
TRANSISTORS



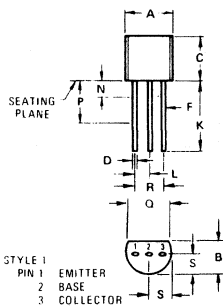
*MAXIMUM RATINGS

Rating	Symbol	2N4125	2N4126	Unit
Collector-Emitter Voltage	V_{CEO}	30	25	Vdc
Collector-Base Voltage	V_{CB}	30	25	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current – Continuous	I_C	200		mAdc
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350	2.8	mW mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0	8.0	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	$^\circ\text{C/W}$

*Indicates JEDEC Registered Data.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
E	0.407	0.482	0.016	0.019
F	12.700	–	0.500	–
G	1.150	1.390	0.045	0.055
H	–	1.270	–	0.050
I	6.350	–	0.250	–
J	3.430	–	0.135	–
K	2.410	2.670	0.095	0.105
L	2.030	2.670	0.080	0.105

CASE 29
TO-92

2N4125, 2N4126 (continued)

* ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 1 \text{ mAdc}$, $I_E = 0$)	2N4125 2N4126	BV_{CEO}	30 25	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \text{ } \mu\text{Adc}$, $I_E = 0$)	2N4125 2N4126	BV_{CBO}	30 25	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \text{ } \mu\text{Adc}$, $I_C = 0$)		BV_{EBO}	4.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 20 \text{ Vdc}$, $I_E = 0$)		I_{CBO}	—	50	nAdc
Emitter Cutoff Current ($V_{BE} = 3 \text{ Vdc}$, $I_C = 0$)		I_{EBO}	—	50	nAdc

ON CHARACTERISTICS

DC Current Gain ⁽¹⁾ ($I_C = 2 \text{ mAdc}$, $V_{CE} = 1 \text{ Vdc}$)	2N4125 2N4126	h_{FE}	50 120	150 360	—
($I_C = 50 \text{ mAdc}$, $V_{CE} = 1 \text{ Vdc}$)	2N4125 2N4126		25 60	—	
Collector-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 50 \text{ mAdc}$, $I_B = 5 \text{ mAdc}$)		$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 50 \text{ mAdc}$, $I_B = 5 \text{ mAdc}$)		$V_{BE(sat)}$	—	0.95	Vdc

SMALL SIGNAL CHARACTERISTICS

High-Frequency Current Gain ($I_C = 10 \text{ mAdc}$, $V_{CE} = 20 \text{ Vdc}$, $f = 100 \text{ MHz}$)	2N4125 2N4126	$ h_{fe} $	2.0 2.5	—	—
Current-Gain — Bandwidth Product ($I_C = 10 \text{ mAdc}$, $V_{CE} = 20 \text{ Vdc}$, $f = 100 \text{ MHz}$)	2N4125 2N4126	f_T	200 250	—	MHz
Collector-Base Capacitance ($V_{CB} = 5 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)		C_{cb}	—	4.5	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 100 \text{ kHz}$)		C_{ib}	—	10	pF
Small-Signal Current Gain ($I_C = 2 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1 \text{ kHz}$)	2N4125 2N4126	h_{fe}	50 120	200 480	—
Noise Figure ($I_C = 100 \text{ } \mu\text{Adc}$, $V_{CE} = 5 \text{ Vdc}$, $R_S = 1 \text{ k ohm}$, Noise Bandwidth = 10 Hz to 15.7 kHz)	2N4125 2N4126	NF	— —	5.0 4.0	dB

(1) Pulse Test: Pulse Width = 300 μsec , Duty Cycle = 2%

*Indicates JEDEC Registered Data

FIGURE 1 — CAPACITANCE

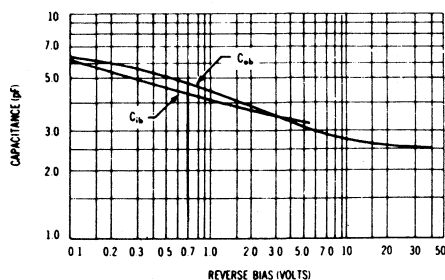
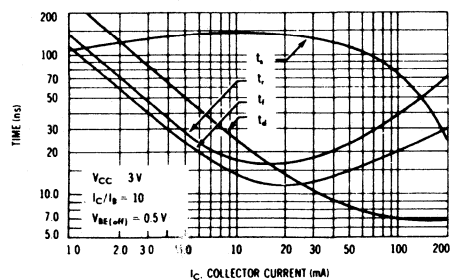


FIGURE 2 — SWITCHING TIMES



AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE

$V_{CE} = 5.0 \text{ Vdc}$, $T_A = 25^\circ\text{C}$,

Bandwidth = 1.0 Hz

FIGURE 3 — FREQUENCY VARIATIONS

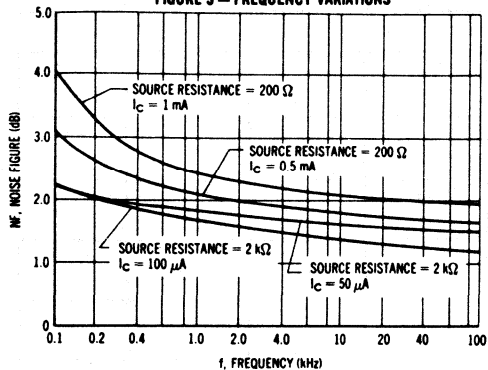
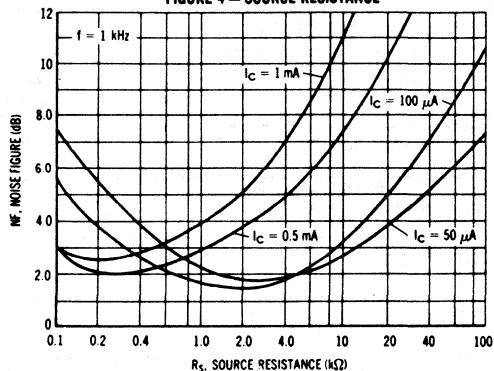


FIGURE 4 — SOURCE RESISTANCE



h PARAMETERS

$V_{CE} = 10 \text{ V}$, $f = 1 \text{ kHz}$, $T_A = 25^\circ\text{C}$

FIGURE 5 — CURRENT GAIN

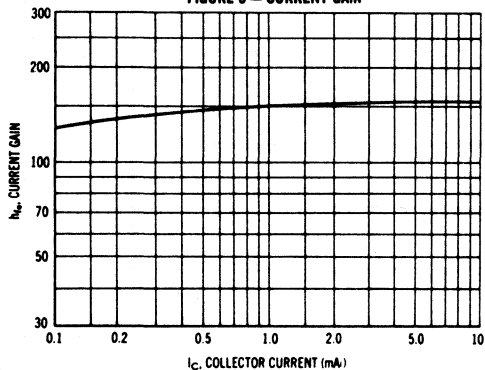


FIGURE 6 — OUTPUT ADMITTANCE

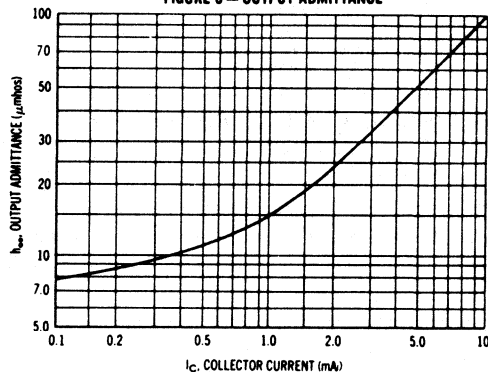


FIGURE 7 — INPUT IMPEDANCE

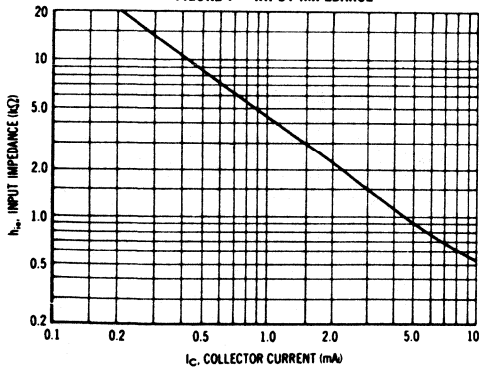
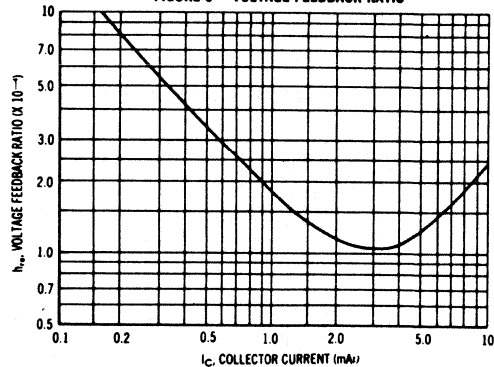


FIGURE 8 — VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 9 – DC CURRENT GAIN

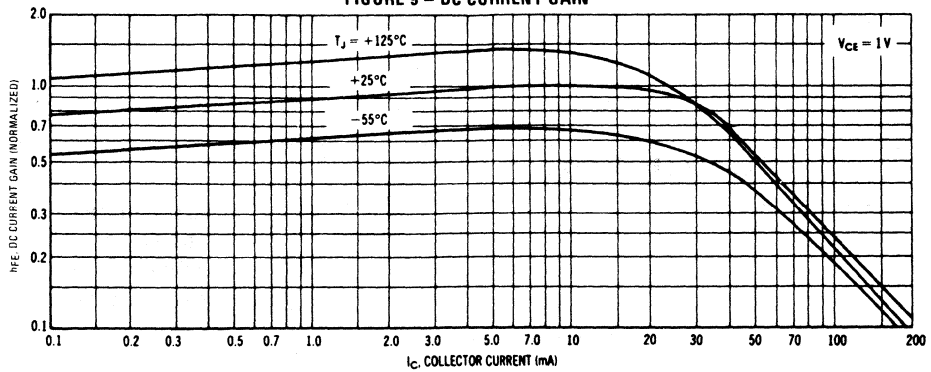


FIGURE 10 – COLLECTOR SATURATION REGION

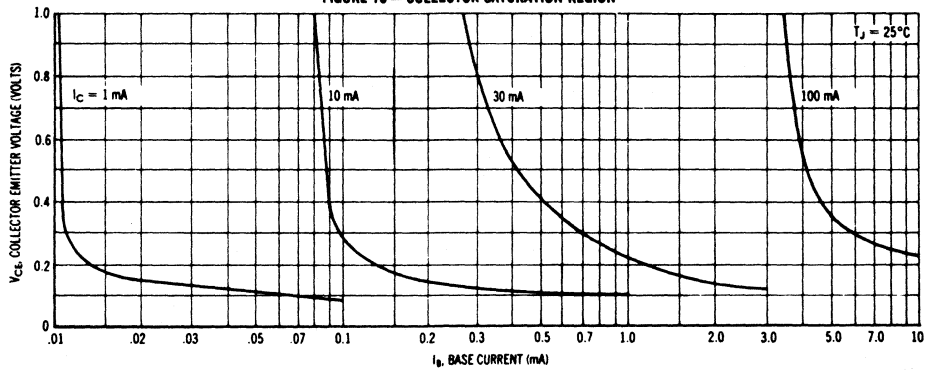


FIGURE 11 – "ON" VOLTAGES

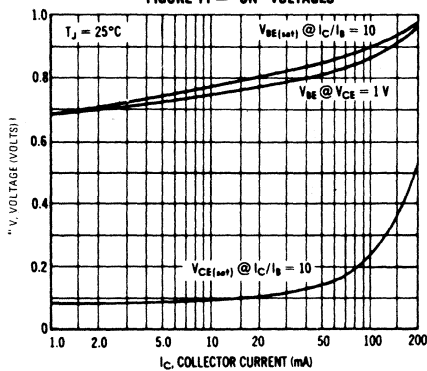
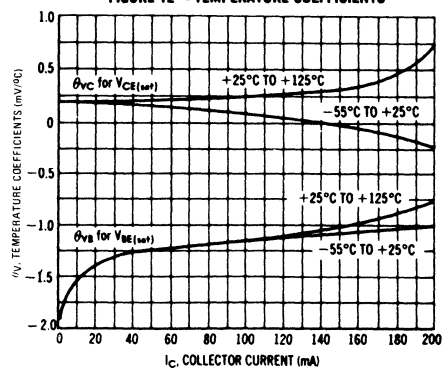


FIGURE 12 – TEMPERATURE COEFFICIENTS



2N4130 NPN (SILICON)

The RF Line

NPN SILICON RF POWER TRANSISTOR

... designed primarily for use in large-signal output amplifier stages. Intended for use in industrial communications equipment operating to 100 MHz. High breakdown voltages allow a high percentage of up-modulation in AM circuits operated at 28 volts.

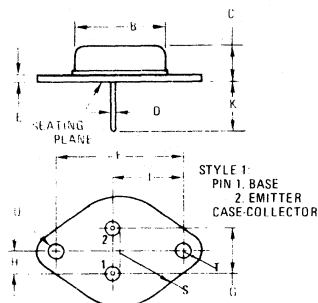
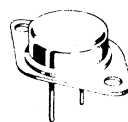
- Balanced Emitter Construction
- Power Output - $P_{out} = 50 \text{ W}$ @ 70 MHz
- Collector-Base Voltage 80 Vdc
- Case Common to Emitter

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	65	Vdc
Collector-Base Voltage	V_{CBO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current - Continuous	I_C	10	Adc
Base Current - Continuous	I_B	2.0	Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	120 0.8	Watts W/ $^\circ\text{C}$
Operating Junction Temperature	T_J	+175	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	65 to +200	$^\circ\text{C}$

*Indicates JEDEC Registered Data

50 W - 70 MHz
RF POWER
TRANSISTOR
NPN SILICON



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
B	—	22.23	—	0.875
C	6.35	11.43	0.250	0.450
D	0.97	1.09	0.038	0.043
E	—	3.43	—	0.125
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	7.92	—	0.312	—
Q	3.84	4.09	0.151	0.161
S	—	13.34	—	0.525
T	—	4.78	—	0.188

All JEDEC dimensions and codes apply

CASE 1 03
(TO 3)

*ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage ($I_C = 50\text{ mAdc}$, $I_B = 0$)	$V_{CEO(sus)}$	65	—	—	Vdc
Collector-Emitter Sustaining Voltage ($I_C = 50\text{ mAdc}$, $R_{BE} = 0$)	$V_{CES(sus)}$	80	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 75\text{ Vdc}$, $V_{BE} = -1.5\text{ Vdc}$) ($V_{CE} = 50\text{ Vdc}$, $V_{BE} = -1.5\text{ Vdc}$, $T_C = 150^\circ\text{C}$)	I_{CEV}	—	—	0.2 1.0	mAdc
Collector Cutoff Current ($V_{CB} = 80\text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	—	0.02	mAdc
Emitter Cutoff Current ($V_{EB} = 4.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	—	1.0	mAdc

ON CHARACTERISTICS

DC Current Gain(1) ($I_C = 2.0\text{ Adc}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 10\text{ Adc}$, $V_{CE} = 5.0\text{ Vdc}$)	h_{FE}	10 10	— —	60 —	—
Collector-Emitter Saturation Voltage(1) ($I_C = 10\text{ Adc}$, $I_B = 2.0\text{ Adc}$)	$V_{CE(sat)}$	—	—	2.0	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product(2) ($I_C = 2.0\text{ Adc}$, $V_{CE} = 10\text{ Vdc}$, $f = 50\text{ MHz}$)	f_T	125	—	—	MHz
Output Capacitance ($V_{CB} = 28\text{ Vdc}$, $I_E = 0$, $f = 0.13\text{ MHz}$)	C_{ob}	—	125	200	pF

FUNCTIONAL TEST (Figure 1)

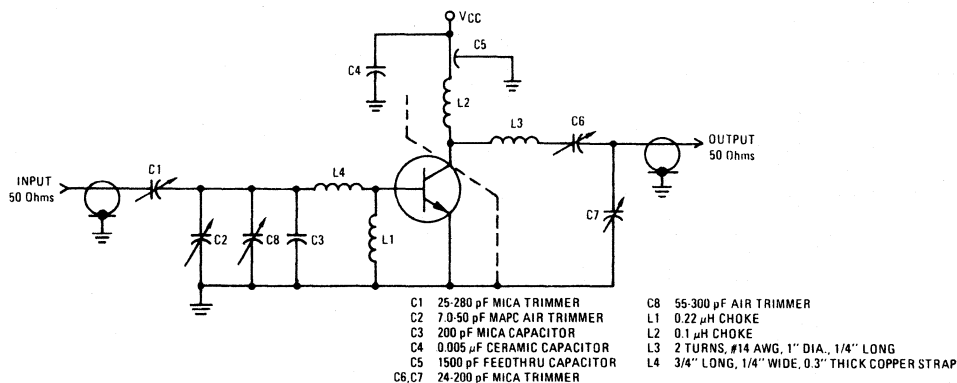
Power Input (Figure 1) ($P_{out} = 50\text{ W}$, $R_S = 50\text{ Ohms}$, $V_{CE} = 28\text{ Vdc}$, $f = 70\text{ MHz}$)	P_{in}	—	—	80	Watts
Collector Efficiency ($P_{out} = 50\text{ W}$, $R_S = 50\text{ Ohms}$, $V_{CE} = 28\text{ Vdc}$, $f = 70\text{ MHz}$)	η	50	—	—	%

*Indicates JEDEC Registered Data

Notes:

(1) Pulse Test: Pulse Width $\leq 100\text{ }\mu\text{s}$, Duty Cycle = 1.0%.(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 — 70 MHz POWER GAIN TEST CIRCUIT



2N4167 (SILICON)

thru

2N4198



THYRISTORS

... multi-purpose PNP silicon controlled rectifiers suited for industrial, consumer, and military applications. Offered in a choice of space-saving, economical packages for mounting versatility.

- Uniform Low-Level Noise-Immune Gate Triggering –
 $I_{GT} = 10 \text{ mA (Typ) @ } T_C = 25^\circ\text{C}$
- Low Forward "On" Voltage –
 $V_T = 1.0 \text{ V (Typ) @ } 5.0 \text{ Amp @ } 25^\circ\text{C}$
- High Surge-Current Capability –
 $I_{TSM} = 100 \text{ Amp Peak}$
- Fatigue-Free Solder Construction
- Shorted Emitter Construction

MAXIMUM RATINGS

(Apply over operating temperature range and for all case types unless otherwise noted)

Rating	Symbol	Value	Unit
*Peak Reverse Blocking Voltage (1)	V_{RRM}		Volts
2N4167, 75, 83, 91		25	
2N4168, 76, 84, 92		50	
2N4169, 77, 85, 93		100	
2N4170, 78, 86, 94		200	
2N4171, 79, 87, 95		300	
2N4172, 80, 88, 96		400	
2N4173, 81, 89, 97		500	
2N4174, 82, 90, 98		600	
Forward Current RMS	$I_T(\text{RMS})$	8.0	Amp
*Peak Forward Surge Current (One cycle, 60 Hz, $T_J = -40$ to $+100^\circ\text{C}$)	I_{TSM}	100	Amp
Circuit Fusing Considerations ($T_J = -40$ to $+100^\circ\text{C}$; $t \leq 8.3 \text{ ms}$)	I^2t	40	A^2s
*Peak Gate Power	P_{GM}	5.0	Watt
*Average Gate Power	$P_G(\text{AV})$	0.5	Watt
*Peak Gate Current	I_{GM}	2.0	Amp
Peak Gate Voltage (2)	V_{GM}	10	Volts
*Operating Temperature Range	T_J	-40 to $+100$	$^\circ\text{C}$
*Storage Temperature Range	T_{stg}	-40 to $+150$	$^\circ\text{C}$
Stud Torque	2N4167-2N4182	15	in. lb.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Typ	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.5	2.5*	$^\circ\text{C/W}$
Thermal Resistance, Case to Ambient (See Fig. 11) 2N4151-66, 2N4183-98	$R_{\theta CA}$	50	—	$^\circ\text{C/W}$

- (1) Ratings apply for zero or negative gate voltage. Devices should not be tested for blocking capability in a manner such that the voltage applied exceeds the rated blocking voltage.
 (2) Devices should not be operated with a positive bias applied to the gate concurrently with a negative potential applied to the anode.

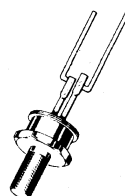
*Indicates JEDEC Registered Data

SILICON CONTROLLED RECTIFIERS

**8-AMPERE RMS
25 thru 600 VOLTS**



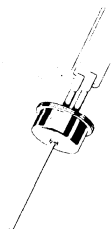
2N4167-74
CASE 86



2N4175-82
CASE 86L



2N4183-90
CASE 87L



2N4191-98
CASE 88L

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
*Peak Forward Blocking Voltage (1) ($T_J = 100^\circ\text{C}$) 2N4167, 75, 83, 91 2N4168, 76, 84, 92 2N4169, 77, 85, 93 2N4170, 78, 86, 94 2N4171, 79, 87, 95 2N4172, 80, 88, 96 2N4173, 81, 89, 97 2N4174, 82, 90, 98	V_{DRM}	25 50 100 200 300 400 500 600	— — — — — — — —	— — — — — — — —	Volts
*Peak Forward Blocking Current (Rated V_{DRM} @ $T_J = 100^\circ\text{C}$, gate open)	I_{DRM}	—	—	2.0	mA
*Peak Reverse Blocking Current (Rated V_{DRM} @ $T_J = 100^\circ\text{C}$, gate open)	I_{RRM}	—	—	2.0	mA
Gate Trigger Current (Continuous dc) (2) (Anode Voltage = 7.0 Vdc, $R_L = 100\ \Omega$) *(Anode Voltage = 7.0 Vdc, $R_L = 100\ \Omega$, $T_C = -40^\circ\text{C}$)	I_{GT}	— —	— —	30 60	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7.0 Vdc, $R_L = 100\ \Omega$) *(Anode Voltage = 7.0 Vdc, $R_L = 100\ \Omega$, $T_C = -40^\circ\text{C}$) *(Anode Voltage = 7.0 Vdc, $R_L = 100\ \Omega$, $T_J = 100^\circ\text{C}$)	V_{GT}	— — 0.2	— — —	1.5 2.5 —	Volts
*Forward "On" Voltage (pulsed, 1.0 ms max, duty cycle $\leq 1\%$) ($I_F = 15.7\ \text{A}$)	V_T	—	—	2.0	Volts
Holding Current (Anode Voltage = 7.0 Vdc, gate open) *(Anode Voltage = 7.0 Vdc, gate open, $T_C = -40^\circ\text{C}$)	I_H	— —	— —	30 60	mA
Turn-On Time ($t_d + t_r$) ($I_G = 20\ \text{mA}$, $I_F = 5.0\ \text{A}$)	t_{on}	—	1.0	—	μs
Turn-Off Time ($I_F = 5.0\ \text{A}$, $I_R = 5.0\ \text{A}$) ($I_F = 5.0\ \text{A}$, $I_R = 5.0\ \text{A}$, $T_J = 100^\circ\text{C}$) ($V_F \times t_M = \text{rated voltage}$) ($dv/dt = 30\ \text{V}/\mu\text{s}$)	t_{off}	— —	15 25	— —	μs
Forward Voltage Application Rate (Gate open, $T_J = 100^\circ\text{C}$)	dv/dt	—	50	—	$\text{V}/\mu\text{s}$

- (1) Ratings apply for zero or negative gate voltage. These devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.
- (2) For optimum operation, i.e. faster turn-on, lower switching losses, best di/dt capability, recommended $I_{GT} = 200\ \text{mA}$ minimum.

*Indicates JEDEC Registered Data

TYPICAL TRIGGER CHARACTERISTICS

FIGURE 1 – CONSTANT CURRENT TRIGGERING

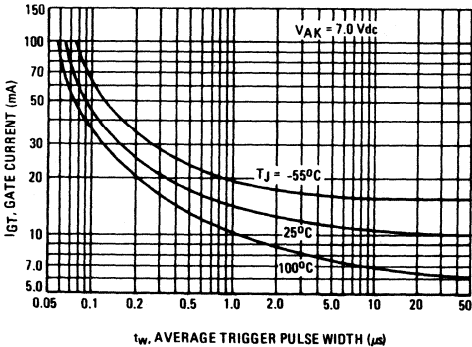
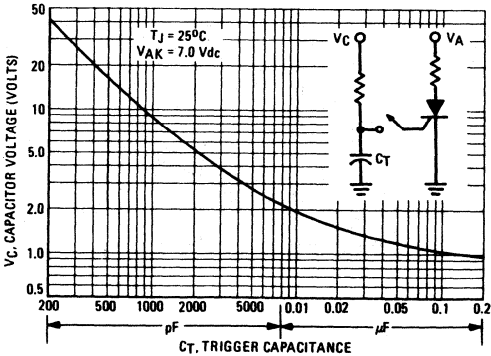


FIGURE 2 – CAPACITIVE DISCHARGE TRIGGERING



CURRENT DERATING

FIGURE 3 – MAXIMUM CASE TEMPERATURE

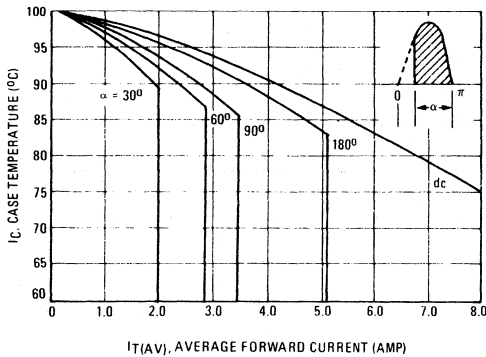


FIGURE 4 – MAXIMUM AMBIENT TEMPERATURE

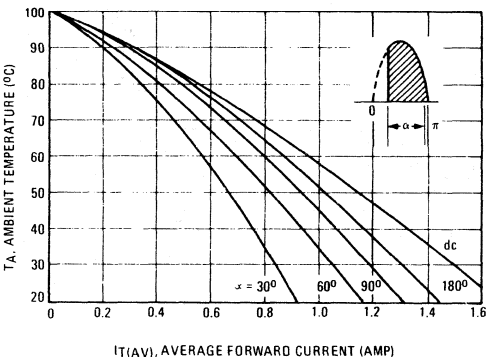


FIGURE 5 – FORWARD POWER DISSIPATION

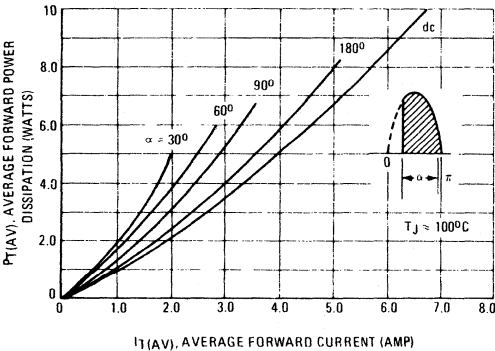


FIGURE 6 – MAXIMUM SURGE CAPABILITY

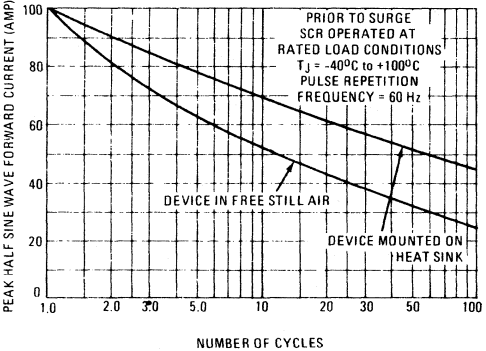


FIGURE 7 – THERMAL RESPONSE

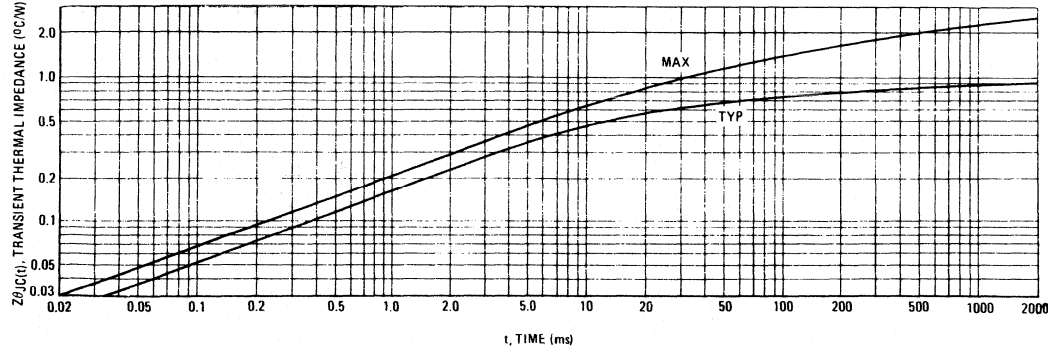


FIGURE 8 – FORWARD VOLTAGE

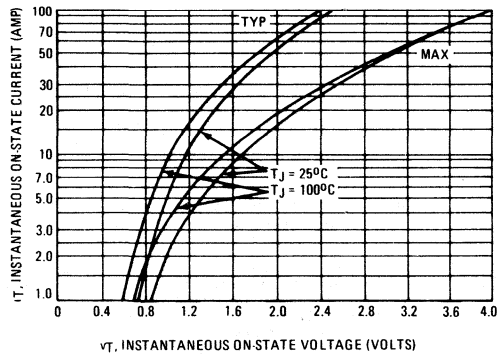


FIGURE 9 – HOLDING CURRENT

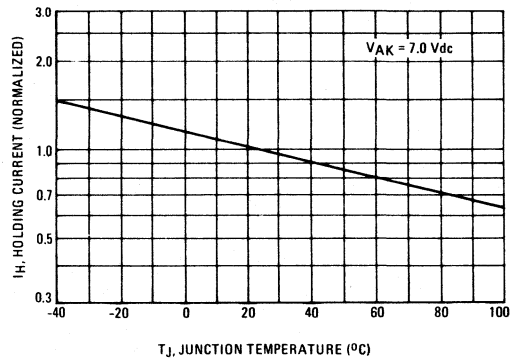


FIGURE 10 – TYPICAL THERMAL RESISTANCE OF PLATES

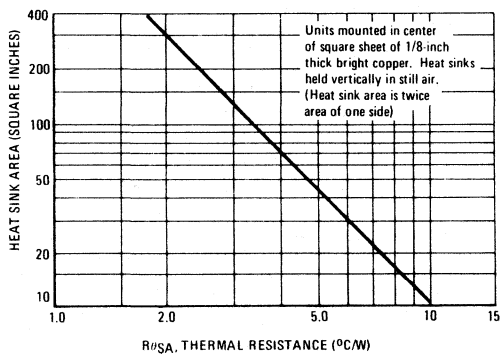
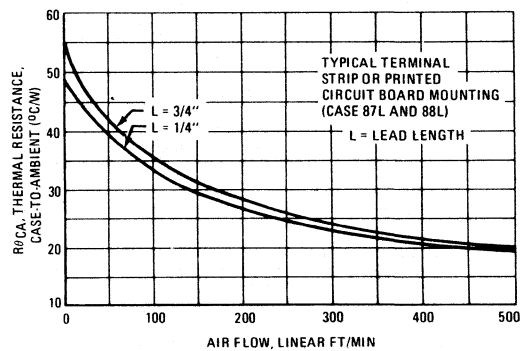


FIGURE 11 – CASE-TO-AMBIENT THERMAL RESISTANCE



MOUNTING and THERMAL INFORMATION

The versatility of the Motorola SCR can-type package affords a variety of mounting methods to meet individual requirements. Depending upon the thermal resistance value between the SCR case and a heat sink, any mounting method which satisfies the current derating curves may be used. Possible mounting media include: solder, epoxy cements, clips (fuse, resistor, transistor, special); clamps; commercial or special dissipators, retainers, coolers, and radiators.

When mounting the SCR's to a heat sink, the following recommendations apply:

A. Heat Sink Contact

1. Since the silicon die is located in the case bottom, (opposite end from tubed header point A as shown on the mechanical outline drawing, Figure 12.) the heat sink contact should be made with case bottom for proper heat transfer.

B. General Soldering Precautions

1. Solder — Use solder with melting points between +175°C and +225°C. The commonly-used tin-lead alloy solders have melting points of +188°C (60/40 alloy) and +214°C (50/50 alloy).
2. Flux (when used) — Non-corrosive resin preferred.
3. When soldering to the device terminals or leads, use of a heat dissipator between soldering point and SCR case is recommended.

C. Case Soldering Methods

1. Heat Sink Materials:

- a. Copper and most of its alloys present no problem in soldering and would probably be the most favorable heat sink material.
- b. Stainless steel is difficult to solder. However, using a strong acid-filled solder, satisfactory soldering can be achieved.
- c. In most cases where soldering is difficult, such as with aluminum, proper preparation with a tin coating on the material can bring about good results.

Depending on specific needs, soldering can be effected by using either hot plate, oven, or belt feed furnace. In all cases, temperature must be controlled.

2. Hot Plate — The hot plate is probably the most effective and flexible method of soldering. The following method is recommended:

- a. Set surface temperature of hot plate to a maximum of 225°C.
- b. Place heat sinks on hot plate for approximately 5 minutes.
- c. Place $\frac{1}{8}$ "- $\frac{1}{4}$ " diameter solder preform on area of heat sink to be soldered.
- d. After solder becomes liquid, place device on this area applying slight pressure and rotating the device slightly to assure good contact. Flux may be used here if required. Frequently, suitable wetting can be achieved mechanically when the device is rotated in the liquid solder, depending upon the device surface conditions.
- e. Remove heat sinks from heat source and free air cool.

3. Oven — When soldering is performed in an oven, use a solder preform (disc, 0.300" x 0.010") or flatten solder wire ($\frac{1}{8}$ "- $\frac{1}{4}$ "") before placing it on the heat sink. For an inert atmosphere such as N_2 , dry air, etc., a flux is recommended. If H_2N_2 is available and used, flux should not be required. Again, temperature must be controlled.

4. Belt Feed Furnace — The procedures are much the same as with the oven method, with the exception that possibly a jig would be required to hold the device and the heat sink in the proper position.

D. Epoxy Mounting Suggestions

1. There are many good commercial epoxies available today, such as Hysol's "HY-TAC" kit or 3M's "Scotch Cast #9". Suitable mounting may be obtained by following the epoxy manufacturer's recommendations for mixing and then cementing the thyristor to the mounting surface with a slight pressure and rotary movement. If improved thermal conductivity is desired, powdered alumina (325 mesh) may be mixed into the epoxy in a proportion of 70% (epoxy) to 30% (alumina). If electrical insulation is desired between the thyristor and a heat sink, thin fiberglass tape (course surface) or mica discs may be used.

The primary reason for specifying mounting details is to help maintain the junction temperature of the SCR at a safe level and hence provide satisfactory operation. The fundamental relationship between junction temperature and heat sinks can be expressed as follows:

$$T_J = T_A + R\theta_{JA} P_D$$

where:

T_J = junction temperature (100°C max operating for these devices)

T_A = ambient temperature

$R\theta_{JA}$ = junction-to-ambient thermal resistance
= $R\theta_{JC} + R\theta_{CA}$ (with $R\theta_{CA} = R\theta_{CS} + R\theta_{SA}$ when heat sink used)

$R\theta_{JC}$ = junction-to-case thermal resistance

$R\theta_{CA}$ = case-to-ambient thermal resistance

$R\theta_{CS}$ = case-to-heat sink thermal resistance

$R\theta_{SA}$ = heat sink-to-ambient thermal resistance

P_D = average power dissipated in the SCR

It is more accurate to base circuit designs upon the case temperature. The preferred method to determine case temperature is to place a thermocouple on the package at point A as shown on the mechanical outline drawing, Figure 12. Even when used in free air, the mass of the package is large enough so that it will not respond to heat surges generated at a 60 Hz rate or higher once steady-state conditions are achieved.

For operation with a heat sink, normally, the $R\theta_{CS}$ portion of $R\theta_{CA}$ will range between 0.2 and 1°C/W for the can type SCR's, depending upon the particular mounting. $R\theta_{CA}$ is approximately 0.2°C/W for the stud packages when used with a thermal grease. Likewise, the $R\theta_{SA}$ portion of $R\theta_{CA}$ will vary with the shape, material, and configuration of the heat sink as well as with the surrounding conditions. Figure 10 is a very basic guide to $R\theta_{SA}$.

For free air operation, in instances where the case temperature cannot be measured or for preliminary engineering work, the case temperature can be estimated by using values of case-to-ambient thermal resistance, obtained from Figure 11 and the relation:

$$T_C = R\theta_{CA} P_D + T_A$$

The graph of Figure 11 indicates that the lead length of the SCR and the thermal mass of the connection to the lead will influence the value of $R\theta_{CA}$.

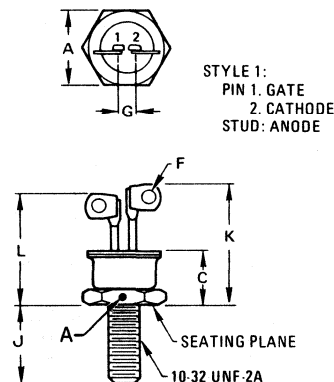
For convenience, Figure 4 shows derating information when the parts are in a still air ambient mounted on a typical P.C. board.

2N4167 thru 2N4198 (continued)

FIGURE 12 - OUTLINE DIMENSIONS

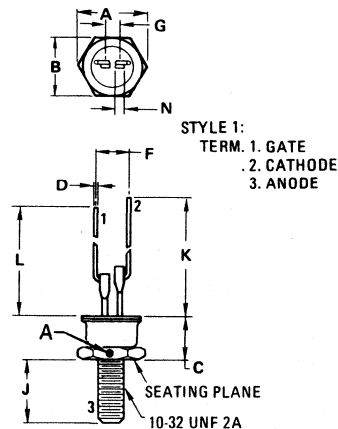
2N4167-74
CASE 86

NOTE:
1. DIM "G" MEASURED AT CAN.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	—	11.10	—	0.437
C	—	7.87	—	0.310
F	1.78 TYP		0.070 TYP	
G	2.29	2.79	0.090	0.110
J	10.72	11.48	0.422	0.452
K	—	16.76	—	0.660
L	—	15.49	—	0.610

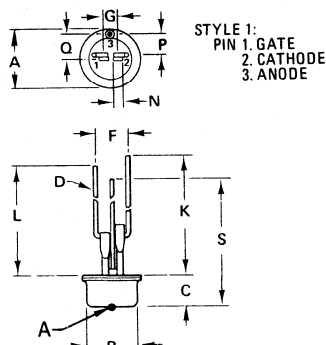
2N4175-82
CASE 86L



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	—	12.82	—	0.505
B	—	11.10	—	0.437
C	—	7.87	—	0.310
D	0.76	0.86	0.030	0.034
F	4.83	5.33	0.190	0.210
G	2.29	2.79	0.090	0.110
J	10.72	11.48	0.422	0.452
K	33.53	—	1.320	—
L	31.50 TYP	—	1.240 TYP	—
N	1.65	1.91	0.065	0.075

2N4183-90
CASE 87L

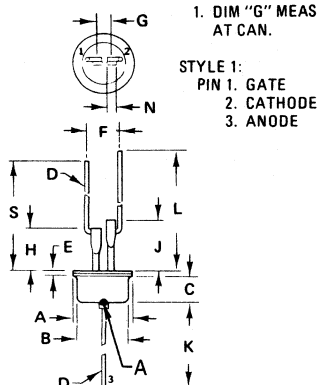
NOTES:
1. DIM. "G" MEASURED AT CAN.
2. LEAD NO. 3 $\pm 7.5^\circ$ DISPLACEMENT.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	—	10.92	—	0.430
B	—	8.89	—	0.350
C	—	5.97	—	0.235
D	0.76	0.86	0.030	0.034
F	4.83	5.33	0.190	0.210
G	2.29	2.79	0.090	0.110
K	33.53	—	1.320	—
L	31.50 TYP	—	1.240 TYP	—
N	1.65	1.91	0.065	0.075
P	3.43	3.68	0.135	0.145
Q	4.57	5.08	0.180	0.200
S	30.48	—	1.20	—

2N4191-98
CASE 88L

NOTE:
1. DIM "G" MEASURED AT CAN.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	—	10.92	—	0.430
B	—	8.89	—	0.350
C	—	4.70	—	0.185
D	0.76	0.86	0.030	0.034
E	0.76	1.27	0.030	0.050
F	4.83	5.33	0.190	0.210
G	2.29	2.79	0.090	0.110
H	—	6.86	—	0.270
J	—	8.13	—	0.320
K	22.86	—	0.900	—
L	33.53	—	1.320	—
N	1.65	1.91	0.065	0.075
S	31.50	—	1.240	—

1. The case (anode) leads for the 2N4183-90 and 2N4191-98 series may be attached by either soldering or welding techniques.

2. On all package types: Manufacturer may optionally use a small metal tab on the case perimeter opposite the gate terminal for terminal identification purposes.

3. Point A indicates temperature reference point

THYRISTORS
SILICON CONTROLLED RECTIFIERS

... fast switching, high-voltage Thyristors especially designed for pulse modulator applications in radar and other similar equipment.

- Guaranteed Limits on All Critical Parameters
- High-Voltage: $V_{FOM} = 300$ to 800 Volts
- Turn-On Times: in Nanosecond Range
- Repetitive Pulse Current to 100 Amperes
- Stable Switching Characteristics Over an Operating Temperature Range From -65 to $+105^{\circ}\text{C}$
- Pulse Repetition Rates as High as 20,000 pps
- 2N4199 JAN thru 2N4204 JAN Available

DESIGNERS DATA FOR "WORST CASE" CONDITIONS

The Designers Data Sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage* ($T_J -105^{\circ}\text{C}$)	$V_{ROM(rep)}$ *	50	Volts
Repetitive Peak Forward Current (PW 3.0 μs , Duty Cycle 0.6%, T_C 85°C max)	$I_{FM(rep)}$	100	Amp
Current Application Rate**	di/dt **	5000	A/ μs
Peak Gate Power-Forward	P_{GFM}	20	Watts
Average Gate Power-Forward	$P_{GF(AV)}$	1.0	Watt
Peak Gate Current-Forward	I_{GFM}	5.0	Amp
Peak Gate Voltage-Forward	V_{GFM}	10	Volts
Reverse ***	V_{GRM}^{***}	10	
Operating Junction Temperature Range Blocking State Conducting State	T_J	-65 to +105 -65 to +200	$^{\circ}\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^{\circ}\text{C}$
Stud Torque	—	15	m. lb.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JA}$	3.0	$^{\circ}\text{C/W}$

*Characterized for unilateral applications where reverse blocking capability is not important. Higher voltage units available upon request. $V_{ROM(rep)}$ may be applied as a continuous d c voltage for zero or negative gate voltage but positive gate voltage must not be applied concurrently with a negative potential on the anode. When checking blocking capability, do not permit the applied voltage to exceed the rated voltage.

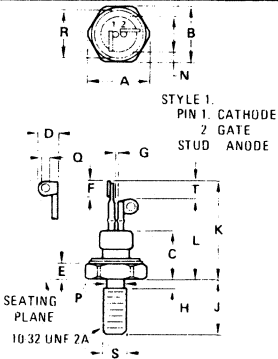
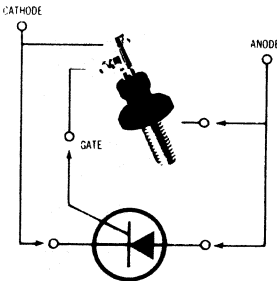
**Minimum Gate Trigger Pulse: $i_G = 200$ mA, PW = 1 μs , $t_r = 20$ ns.

***Do not reverse bias gate during forward conduction if anode current exceeds 10 amperes.

THYRISTORS

PNPN

100 AMPERE PULSE
300 thru 800 VOLTS



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	12.57	12.83	0.495	0.505
B	10.77	11.10	0.424	0.437
C	—	10.80	—	0.425
D	3.94	4.70	0.155	0.185
E	—	3.56	—	0.140
J	10.16	11.51	0.400	0.453
K	—	21.72	—	0.855
L	—	17.78	—	0.700
N	—	7.11	—	0.280
Q	1.02	1.91	0.040	0.075

CASE 63-02

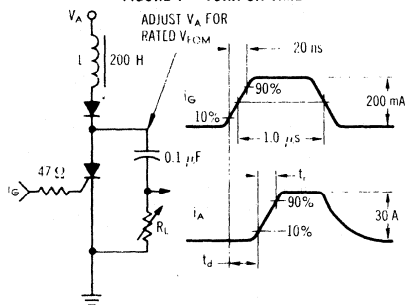
ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
Peak Forward Blocking Voltage* ($T_C = 105^\circ\text{C}$)	15	V_{FOM}^*	300 400 500 600 700 800	—	Volts
Peak Forward and Reverse Blocking Current (Rated V_{FOM} and V_{ROM} ; $T_C = 105^\circ\text{C}$, gate open)	17	I_{FOM} I_{ROM}	—	2.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7.0 Vdc, $R_L = 100$ ohms, $T_C = 25^\circ\text{C}$) (Anode Voltage = 7.0 Vdc, $R_L = 100$ ohms, $T_C = -65^\circ\text{C}$)	14	I_{GT}	—	50 100	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = rated V_{FOM} , $R_L = 100$ ohms, $T_C = 105^\circ\text{C}$) (Anode Voltage = 7.0 Vdc, $R_L = 100$ ohms, $T_C = 25^\circ\text{C}$) (Anode Voltage = 7.0 Vdc, $R_L = 100$ ohms, $T_C = -65^\circ\text{C}$)	12	V_{GT}	0.2 — —	— 1.5 2.0	Volts
Holding Current (Anode Voltage = 7.0 Vdc, gate open, $T_C = 105^\circ\text{C}$)	18	I_{HO}	3.0	—	mA
Forward "On" Voltage ($I_F = 2$ A dc, PW = 1.0 ms max, Duty cycle $\leq 1\%$)	8	V_F	—	1.5	Volts
Dynamic Forward "On" Voltage (0.5 μs after 50% decay point on dynamic forward voltage waveform.) Forward Current: 30 A pulse (PFN discharge circuit.) Gate Pulse: at 200 mA, PW = 1.0 μs , $t_r = 20$ ns	7	$V_{F(on)}$	—	25	Volts
Turn-On Time Delay Time	1, 9	t_d	—	200	ns
Rise Time	1.11	t_r	—	200 150 130 100	ns
Pulse Turn-Off Time Test Conditions: PFN discharge; Forward Current = 30 A pulse; Reverse Current = 5.0 A, $T_C = 85^\circ\text{C}$, $dv/dt = 250$ V/ μs to Rated V_{FOM} ; Reverse anode voltage during turn-off interval = 0 V; Reverse gate bias during turn-off interval = 6.0 V.	2, 13	$t_{off}(\text{pulse})$	—	20	μs
Forward Voltage Application Rate (Linear Rise of Voltage) ($T_C = 105^\circ\text{C}$, gate open)	16	dv/dt	250	—	V/ μs

* V_{FOM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. When checking forward or reverse blocking capability, these devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage. Other voltage units available upon request.

TEST CIRCUITS

FIGURE 1 — TURN-ON TIME



Two MK1337's fast recovery diodes in series (see voltage sharing test work as described in Chapter 8 of Motorola Silicon Rectifier Handbook)

FIGURE 2 — TURN-OFF TIME

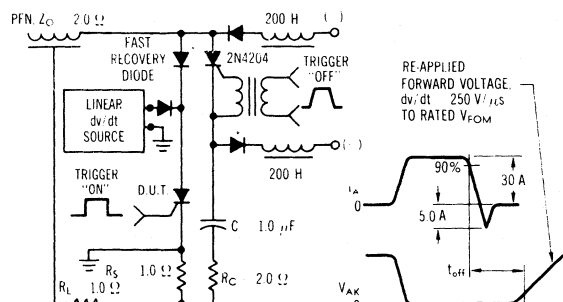
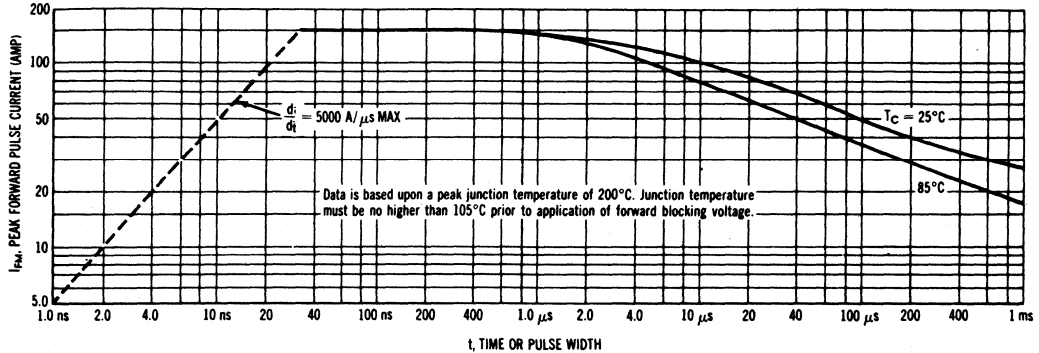


FIGURE 3 — MAXIMUM ALLOWABLE FORWARD PULSE CURRENT



CURRENT DERATING DATA

FIGURE 4 — DERATING USING NO SWITCHING LOSSES

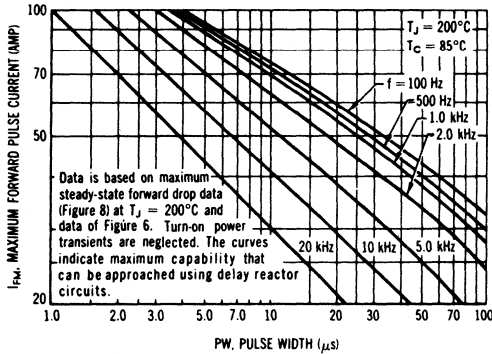
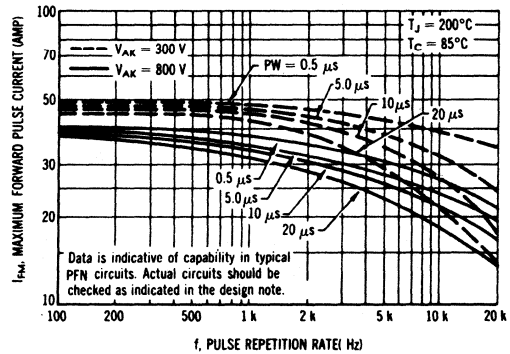


FIGURE 5 — DERATING USING TYPICAL SWITCHING LOSSES



DESIGN NOTE

Use of Transient Thermal Resistance Data

A train of periodical power pulses can be represented by the model shown in Fig. A. Using the model and the device thermal response, the normalized effective transient thermal resistance of Fig. 6 was calculated for various duty cycles from:

$$r(t) = D + (1 - D) \cdot r(t_A + t_p) + r(t_A) - r(t_p)$$

To find $\theta_{JC}(t)$ multiply the value obtained from Fig. 6 by the steady-state value $\theta_{JC}(\infty)$. Use 3°C/W for worst-case results; use 2°C/W for typical information.

DESIGN EXAMPLE

A 2N4199 discharging a PFN, transient power pulse shown in Fig. C. Conditions: $V_{AK} = 150$ V., $I_{PK} = 44$ A., $f = 5000$ Hz.

Determine: ΔT

Method 1: (See Fig. A) $P_A t_A$ is chosen to have the same energy as the actual power pulse, i.e.: the area under the curves are equal. P_A equals the peak of the actual power pulse. At a pulse repetition frequency of 5000 Hz and $t_A = 2.14$ μ s ($D = 0.0107$); the reading on Fig. 6 is 0.039.

$$\therefore \Delta T = r(t) \theta_{JC}(\infty) P_A = (0.039) (3) (1000) = 120^\circ\text{C}.$$

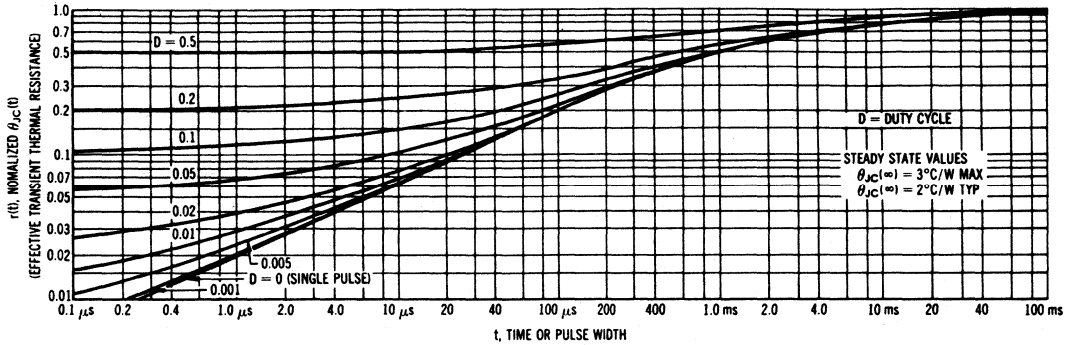
Method 2: For a power waveform where the time of the peak power is short compared to the total transient, the foregoing method results in an overly large safety factor. A pulse model closer to the real case is shown in Fig. B. Using the transient thermal resistance information for $D = 0$ in Fig. 6, $\Delta T(t_A)$ and $\Delta T(t_p)$ can be evaluated from

$$\Delta T(t_A) = \left[P_1 [r(t_1) + (1 - D_1) \cdot r(T + t_1) + D - r(T)] + P_2 [(1 - D_2) \cdot r(T) + D_2 - r(T - T_2)] \right] \theta_{JC}(\infty)$$

$$\Delta T(t_p) = \left[P_1 [r(t_1 + T_2) + (1 - D_1) \cdot r(T + t_1 + T_2) - r(T + T_2) - r(T_2)] + P_2 [r(T_2) + (1 - D_2) \cdot r(T + T_2) + D_2 - r(T)] \right] \theta_{JC}(\infty)$$

The two results are compared; the one with higher value is taken for worst-case design. For the problem, values for the equivalent pulses of Fig. B are $P_1 = 1000$ W, $P_2 = 700$ W, $T_1 = 1.05$ μ s, $T_2 = 1.55$ μ s, $D_1 = 5.25(10^{-3})$, $D_2 = 7.75(10^{-3})$.

FIGURE 6 — NORMALIZED EFFECTIVE TRANSIENT THERMAL RESISTANCE



FORWARD "ON" VOLTAGE DATA

FIGURE 7 — TYPICAL DYNAMIC FORWARD "ON" VOLTAGE

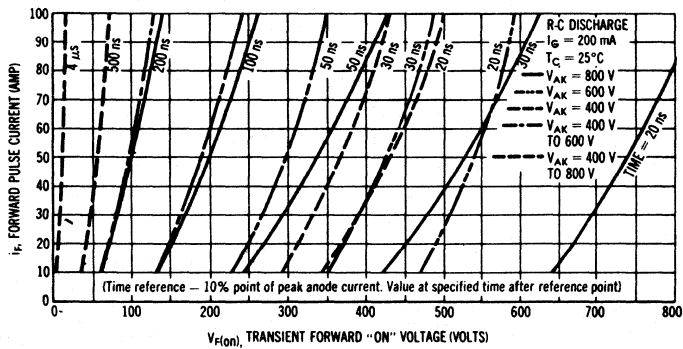
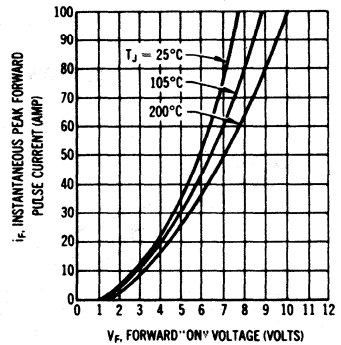


FIGURE 8 — MAXIMUM STEADY-STATE



$$\Delta T(t_0) = \left[1000 \{ 0.0205 + (1 - 5.25 \cdot 10^{-3}) \cdot 0.27 + 5.25 \cdot 10^{-3} \cdot 0.27 \} + 700 \{ (1 - 7.75 \cdot 10^{-3}) \cdot 0.27 + 7.75 \cdot 10^{-3} \cdot 0.27 \} \right] 3 = 93.51^\circ\text{C}$$

$$\Delta T(t_0) = \left[1000 \{ 0.032 + (1 - 5.25 \cdot 10^{-3}) \cdot 0.27 + 5.25 \cdot 10^{-3} \cdot 0.27 - 0.0205 \} + 700 \{ 0.025 + (1 - 7.75 \cdot 10^{-3}) \cdot 0.27 + 7.75 \cdot 10^{-3} \cdot 0.27 \} \right] 3 = 105.6^\circ\text{C}$$

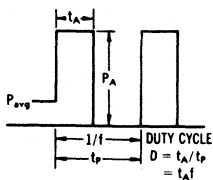


FIGURE A — SIMPLE MODEL

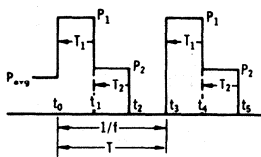


FIGURE B — MORE ACCURATE MODEL

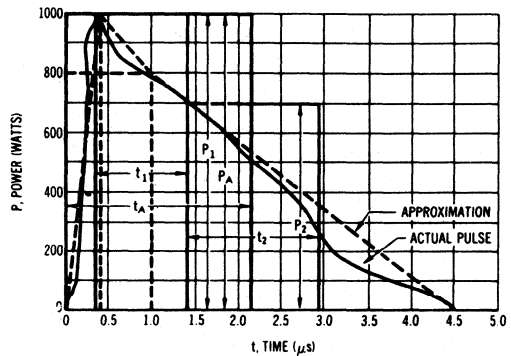


FIGURE C — AN ACTUAL TRANSIENT POWER PULSE

SWITCHING CHARACTERISTICS

FIGURE 9 — DELAY TIME

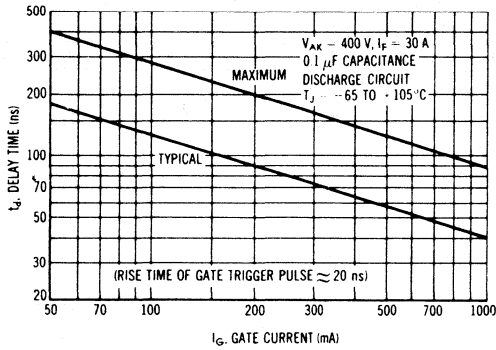


FIGURE 11 — CURRENT RISE TIME

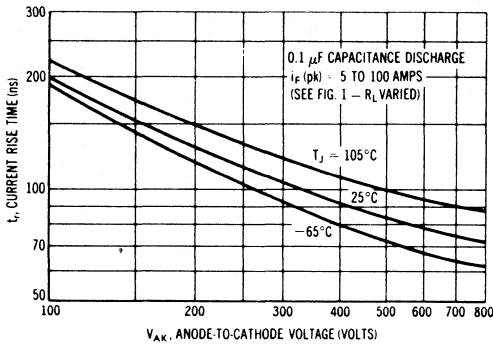
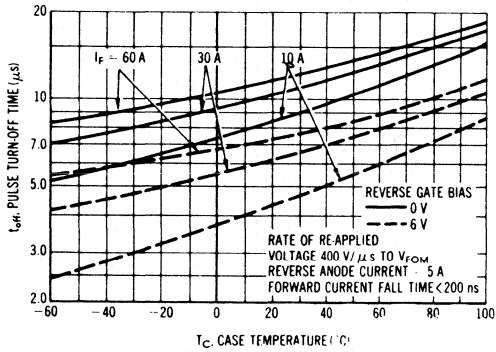


FIGURE 13 — TYPICAL TURN-OFF TIME



TRIGGERING CHARACTERISTICS

FIGURE 10 — TYPICAL PULSE TRIGGER CHARGE/CURRENT

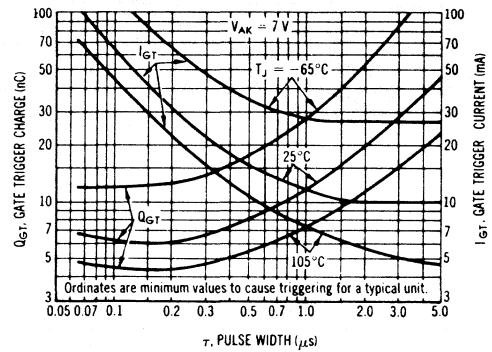


FIGURE 12 — DC GATE TRIGGER VOLTAGE

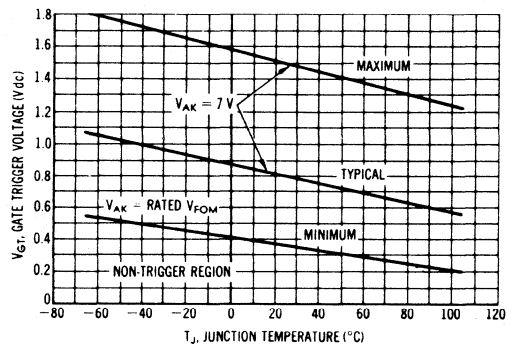
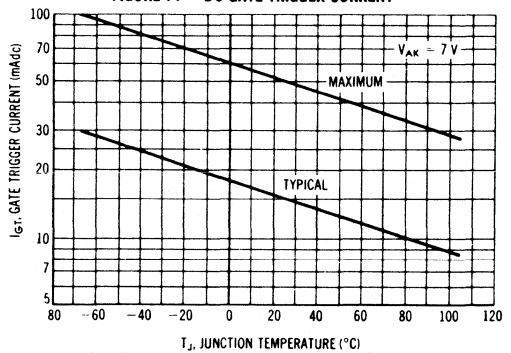
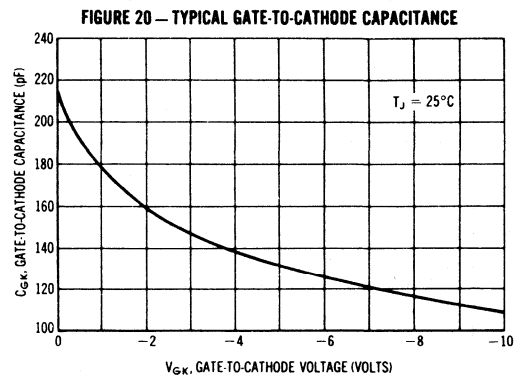
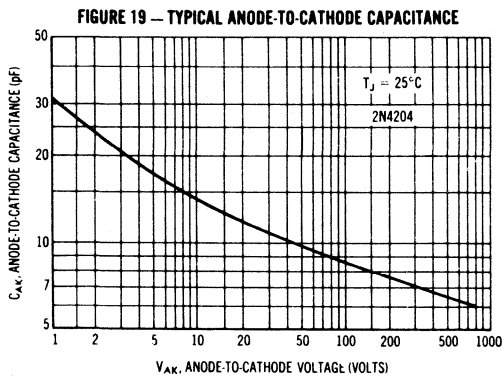
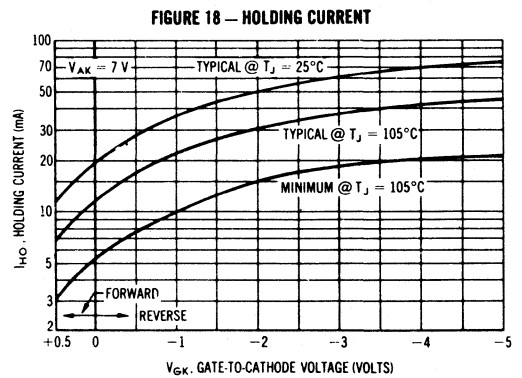
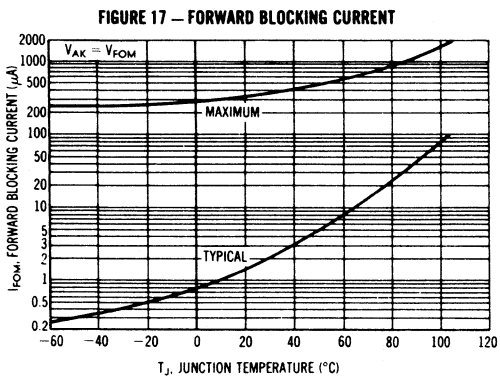
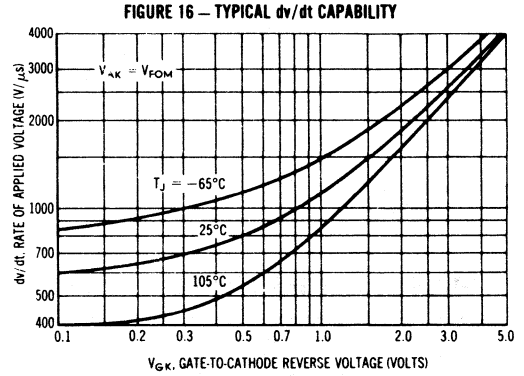
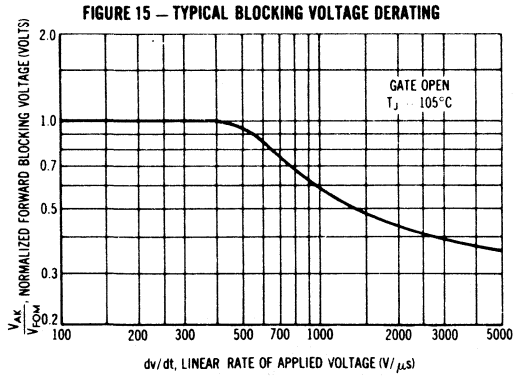
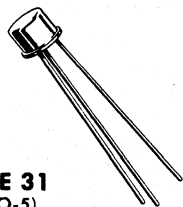


FIGURE 14 — DC GATE TRIGGER CURRENT

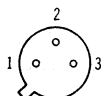




2N4212 thru 2N4216 (SILICON)



CASE 31
(TO-5)



STYLE 2
PIN 1. CATHODE
2. GATE
3. ANODE

PNPN thyristors (silicon controlled rectifiers) designed for operation in mA/ μ A signal or detection circuits.

MAXIMUM RATINGS * ($T_J = 125^\circ\text{C}$ unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage (Note 1) 2N4212 2N4213 2N4214 2N4215 2N4216	$V_{RSM(rep)}$	25 50 100 150 200	Volt
Forward Current RMS (All Conduction Angles)	I_T	1.6	Amp
Peak Surge Current (One Cycle, 60 Hz) No Repetition until Thermal Equilibrium is Restored	$I_{FM(surge)}$	15	Amp
Peak Gate Power - Forward	P_{GM}	0.1	Watt
Average Gate Power - Forward	$P_{G(AV)}$	0.01	Watt
Peak Gate Current - Forward	I_{GM}	0.1	Amp
Peak Gate Voltage - Forward	V_{GFM}	6.0	Volt
Reverse	V_{GRM}	6.0	
Operating Junction Temperature Range	T_J	-65 to +125	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +150	$^\circ\text{C}$
Lead Solder Temperature ($> 1/16''$ from case, 10 sec. max)	-	+230	$^\circ\text{C}$

* JEDEC Registered Values.

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted, $R_{GK} = 1000$ ohms)

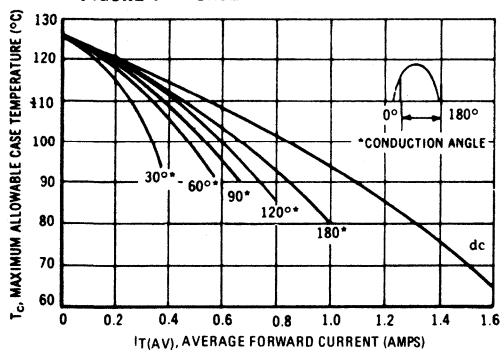
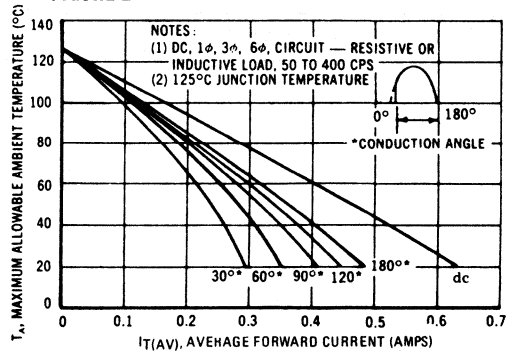
Characteristic	Symbol	Min	Max	Unit
Peak Forward Blocking Voltage (Note 1) 2N4212 2N4213 2N4214 2N4215 2N4216	V_{DRM}	25* 50* 100* 150* 200*	- - - - -	Volt
Peak Reverse Blocking Current (Rated V_{RSM} , $T_J = 125^\circ\text{C}$)	I_{RRM}	-	200*	μA
Peak Forward Blocking Current (Rated V_{DRM} , $T_J = 125^\circ\text{C}$)	I_{DRM}	-	200*	μA
Forward "On" Voltage ($I_F = 1.0$ A Peak) ($I_F = 3.14$ A Peak)	V_F	- -	1.5 2.0*	Volt
Gate Trigger Current (Note 2) (Anode Voltage = 7.0 V, $R_L = 100$ ohms) ($T_C = 25^\circ\text{C}$) ($T_C = -65^\circ\text{C}$)	I_{GT}	- -	100 300*	μA dc
Gate Trigger Voltage (Anode Voltage = 7.0 V, $R_L = 100$ ohms, $T_C = 25^\circ\text{C}$) (Anode Voltage = 7.0 V, $R_L = 100$ ohms, $T_C = -65^\circ\text{C}$) (Anode Voltage = Rated V_{DRM} , $R_L = 100$ ohms, $T_J = 125^\circ\text{C}$)	V_{GT} V_{GT} V_{GNT}	- - 0.1*	0.8 1.0* -	Volt
Holding Current (Anode Voltage = 7.0 V) $T_C = 25^\circ\text{C}$ $T_C = -65^\circ\text{C}$	I_{HX}		3.0 7.0*	mA
Turn-On Time	t_{gt}	Circuit dependent, consult manufacturer		
Turn-Off Time	t_q			

* JEDEC Registered Values

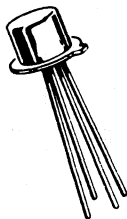
- Notes: 1. V_{RRM} and V_{DRM} can be applied for all types on a continuous dc basis without incurring damage.
2. R_{GK} current is not included in measurement.

Thyristor devices shall not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

Thyristor devices shall not have a positive bias applied to the gate concurrently with a negative potential applied to the anode.

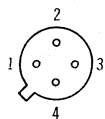
FIGURE 1 — CASE TEMPERATURE vs CURRENT**FIGURE 2 — AMBIENT TEMPERATURE vs CURRENT**

2N4220 thru 2N4222 (SILICON)
2N4220A thru 2N4222A



CASE 20-03
(TO-72)

N-channel junction silicon field-effect transistors designed for general purpose amplifier and switching applications. "A" types guarantee low noise figure (2.5 dB maximum @ 100 kHz).



STYLE 3
 PIN 1. DRAIN
 2. SOURCE
 3. GATE
 4. CASE LEAD

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Drain Current	I_D	15	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate Above 25°C	P_D	300 2.0	mW mW/ $^\circ\text{C}$
Operating Junction Temperature	T_J	175	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +175	$^\circ\text{C}$

2N4220,A thru 2N4222,A (continued)

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Gate-Source Breakdown Voltage ($I_G = -10 \mu\text{A}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	-30	-	-	Vdc
Gate Reverse Current ($V_{GS} = -15 \text{ Vdc}$, $V_{DS} = 0$) ($V_{GS} = -15 \text{ Vdc}$, $V_{DS} = 0$, $T_A = 150^\circ\text{C}$)	I_{GSS}	-	-	-0.1 -100	nAdc
Gate-Source Voltage ($I_D = 50 \mu\text{A}$, $V_{DS} = 15 \text{ Vdc}$) ($I_D = 200 \mu\text{A}$, $V_{DS} = 15 \text{ Vdc}$) ($I_D = 500 \mu\text{A}$, $V_{DS} = 15 \text{ Vdc}$)	V_{GS}	-0.5 -1.0 -2.0	-	-2.5 -5.0 -6.0	Vdc
Gate-Source Cutoff Voltage ($I_D = 0.1 \text{ nA}$, $V_{DS} = 15 \text{ Vdc}$)	$V_{GS(off)}$	-	-	-4.0 -6.0 -8.0	Vdc

ON CHARACTERISTICS

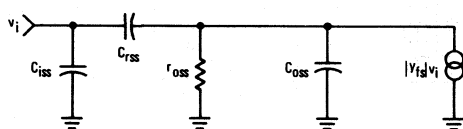
Zero-Gate-Voltage Drain Current ⁽¹⁾ ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$)	I_{DSS}	0.5 2.0 5.0	- - -	3.0 6.0 15	mAdc
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DYNAMIC CHARACTERISTICS

Forward Transfer Admittance ⁽¹⁾ ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)	$ y_{fs} $	1000 2000 2500	2500 3500 4500	4000 5000 6000	μmhos
Output Admittance ⁽¹⁾ ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)	$ y_{os} $	- - -	- - -	10 20 40	μmhos
Drain-Source Resistance ($V_{DS} = 0$, $V_{GS} = 0$)	$r_{ds(on)}$	- - -	500 400 300	- - -	Ohms
Input Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{iss}	-	4.5	6.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{rss}	-	1.2	2.0	pF
Common-Source Output Capacitance ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $f = 30 \text{ MHz}$)	C_{osp}	-	1.5	-	pF
Noise Figure ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$, $R_S = 1.0 \text{ Megohm}$, $f = 100 \text{ Hz}$)	NF	- - -	- - -	2.5 2.5 2.5	dB

⁽¹⁾ Pulse Test: Pulse Width = 630 ms, Duty Cycle = 10%

FIGURE 1 – EQUIVALENT LOW FREQUENCY CIRCUIT



* C_{osp} is C_{oss} in parallel with Series Combination of C_{iss} and C_{rss} .

Common Source
Y Parameters for Frequencies
Below 30 MHz

$$y_{is} = j\omega C_{iss}$$

$$y_{os} = j\omega C_{osp} + 1/r_{oss}$$

$$y_{fs} = |y_{fs}|$$

$$y_{rs} = -j\omega C_{rss}$$

FIGURE 2 – FORWARD TRANSFER ADMITTANCE
versus DRAIN CURRENT

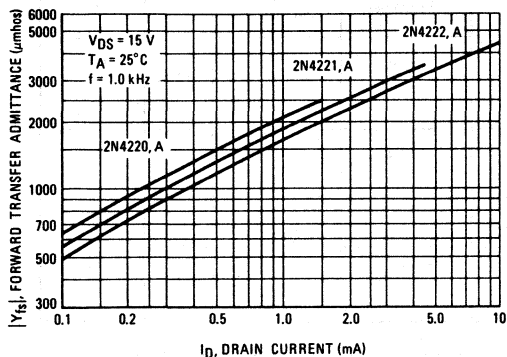


FIGURE 4 – OUTPUT RESISTANCE
versus DRAIN CURRENT

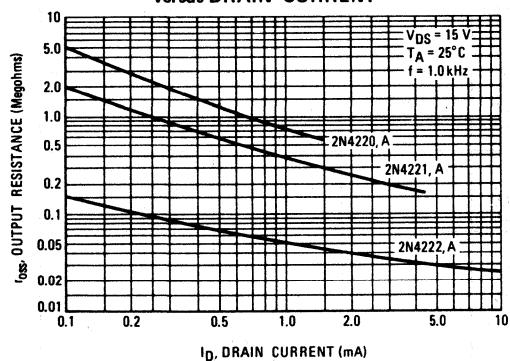


FIGURE 6 – NOISE FIGURE versus FREQUENCY

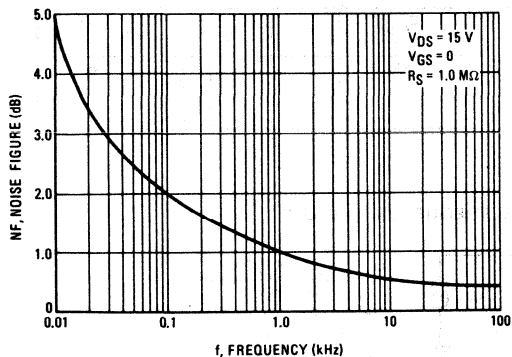


FIGURE 3 – TEMPERATURE COEFFICIENT OF Y_{fs}
versus DRAIN CURRENT

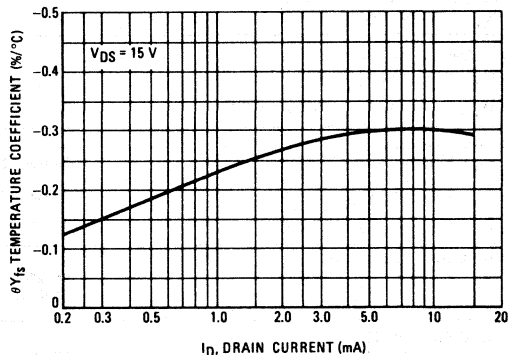


FIGURE 5 – CAPACITANCE
versus DRAIN-SOURCE VOLTAGE

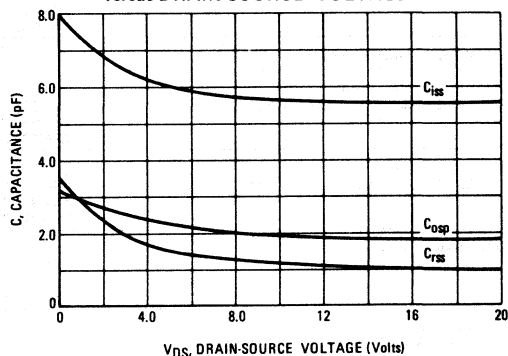
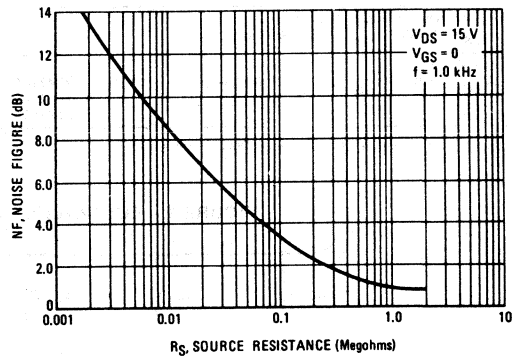
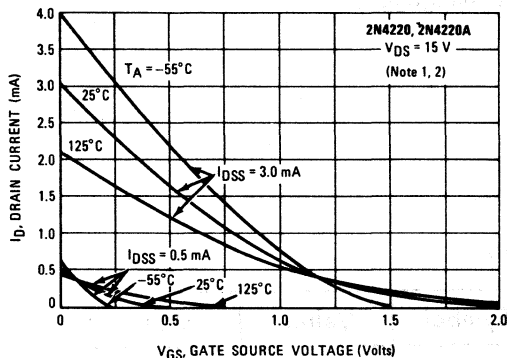


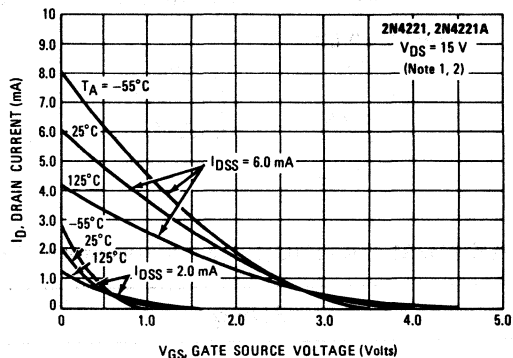
FIGURE 7 – NOISE FIGURE versus SOURCE RESISTANCE



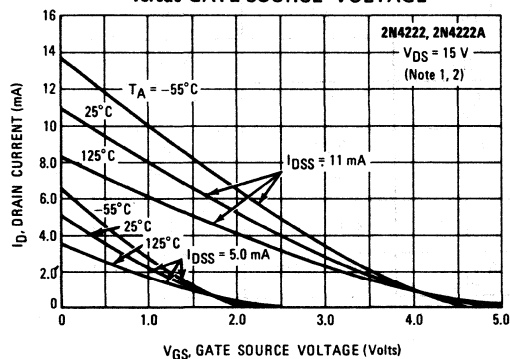
**FIGURE 8 – DRAIN CURRENT
versus GATE-SOURCE VOLTAGE**



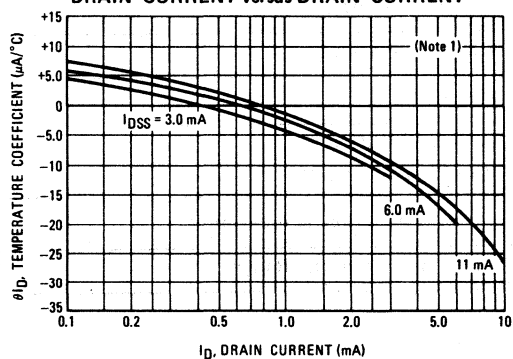
**FIGURE 9 – DRAIN CURRENT
versus GATE-SOURCE VOLTAGE**



**FIGURE 10 – DRAIN CURRENT
versus GATE-SOURCE VOLTAGE**



**FIGURE 11 – TEMPERATURE COEFFICIENT OF
DRAIN CURRENT versus DRAIN CURRENT**



NOTES:

1. Graphical data is presented for dc conditions. Tabular data is given for pulsed conditions (Pulse Width = 630 ms, Duty Cycle = 10%). Under dc conditions, self heating in higher I_{DSS} units reduces I_{DSS} (See Figure 10).
2. Figures 8, 9, 10: Data taken in a standard printed circuit with a TO-18 type socket mounting and 1/4" lead length.

2N4223 (SILICON)

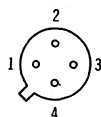
2N4224



Silicon N-channel junction field-effect transistors, designed for VHF amplifier and mixer applications. Drain and Source interchangeable.

CASE 20-03
(TO-72)

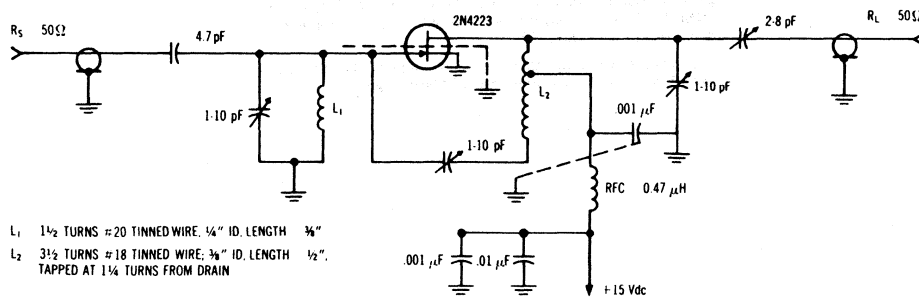
STYLE 3
PIN 1. DRAIN
2. SOURCE
3. GATE
4. CASE LEAD



MAXIMUM RATINGS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Drain Current	I_D	20	mAdc
Power Dissipation Derate above 25°C	P_D	300 2.0	mW mW/°C
Operating Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

FIGURE 1 — NOISE FIGURE AND POWER GAIN TEST CIRCUIT



2N4223, 2N4224 (continued)**ELECTRICAL CHARACTERISTICS** ($T_A = 25^{\circ}\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Gate-Source Breakdown Voltage ($I_G = 10\text{ }\mu\text{A}$, $V_{DS} = 0$)		$V_{(BR)GSS}$	30	-	Vdc
Gate Reverse Current ($V_{GS} = 20\text{ Vdc}$, $V_{DS} = 0$)	2N4223	I_{GSS}	-	0.25	nAdc
	2N4224		-	0.50	
($V_{GS} = 20\text{ Vdc}$, $V_{DS} = 0$, $T_A = 100^{\circ}\text{C}$)	2N4223		-	250	
	2N4224		-	500	
Gate-Source Cutoff Voltage ($I_D = 0.25\text{ nAdc}$, $V_{DS} = 15\text{ Vdc}$)	2N4223	$V_{GS(off)}$	-	8.0	Vdc
($I_D = 0.50\text{ nAdc}$, $V_{DS} = 15\text{ Vdc}$)	2N4224		-	8.0	
Gate-Source Voltage ($I_D = 0.3\text{ mAdc}$, $V_{DS} = 15\text{ Vdc}$)	2N4223	V_{GS}	1.0	7.0	Vdc
($I_D = 0.2\text{ mAdc}$, $V_{DS} = 15\text{ Vdc}$)	2N4224		1.0	7.5	

ON CHARACTERISTICS

Zero-Gate-Voltage Drain Current ⁽¹⁾ ($V_{DS} = 15\text{ Vdc}$, $V_{GS} = 0$)	2N4223	I_{DSS}	3.0	18	mAdc
	2N4224		2.0	20	

DYNAMIC CHARACTERISTICS

Forward Transfer Admittance ($V_{DS} = 15\text{ Vdc}$, $V_{GS} = 0$, $f = 1\text{ kHz}$) ⁽¹⁾	2N4223	$ y_{fs} $	3000	7000	μmhos
	2N4224		2000	7500	
($V_{DS} = 15\text{ Vdc}$, $V_{GS} = 0$, $f = 200\text{ MHz}$)	2N4223		2700	-	
	2N4224		1700	-	
Input Conductance ($V_{DS} = 15\text{ Vdc}$, $V_{GS} = 0$, $f = 200\text{ MHz}$)		$\text{Re}(y_{is})$	-	800	μmhos
Output Conductance ($V_{DS} = 15\text{ Vdc}$, $V_{GS} = 0$, $f = 200\text{ MHz}$)		$\text{Re}(y_{os})$	-	200	μmhos
Input Capacitance ($V_{DS} = 15\text{ Vdc}$, $V_{GS} = 0$, $f = 1\text{ MHz}$)		C_{iss}	-	6.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15\text{ Vdc}$, $V_{GS} = 0$, $f = 1\text{ MHz}$)		C_{rss}	-	2.0	pF
Noise Figure ($V_{DS} = 15\text{ Vdc}$, $V_{GS} = 0$, $R_S = 1\text{ k ohm}$, $f = 200\text{ MHz}$)	2N4223	NF	-	5.0	dB
Small-Signal Power Gain ($V_{DS} = 15\text{ Vdc}$, $V_{GS} = 0$, $f = 200\text{ MHz}$)	2N4223	G_{ps}	10	-	dB

⁽¹⁾ Pulse Test: Pulse Width $\leq 630\text{ ms}$, Duty Cycle $\leq 10\%$

FIGURE 2 —
DRAIN CURRENT versus GATE-SOURCE VOLTAGE

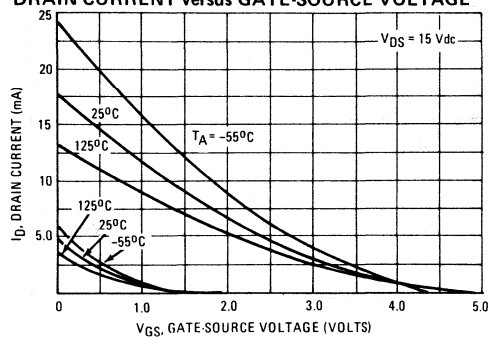


FIGURE 3 —
TEMPERATURE COEFFICIENT FOR DRAIN CURRENT

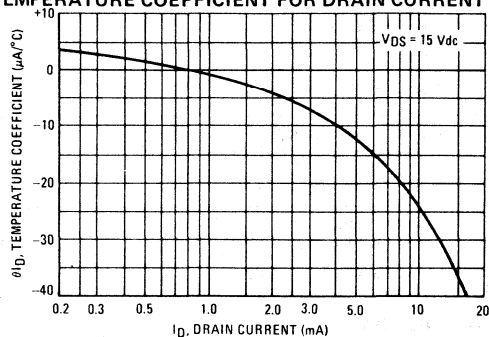


FIGURE 4 — FORWARD TRANSFER ADMITTANCE
versus GATE-SOURCE VOLTAGE

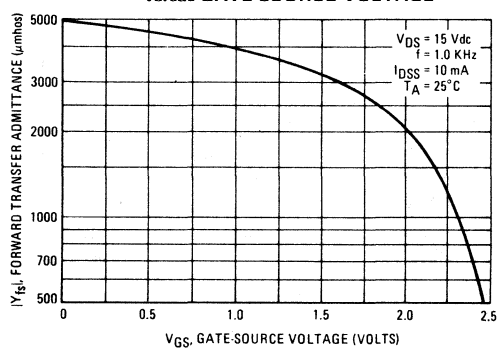


FIGURE 5 — TEMPERATURE COEFFICIENT FOR Y_{fs}
versus DRAIN CURRENT

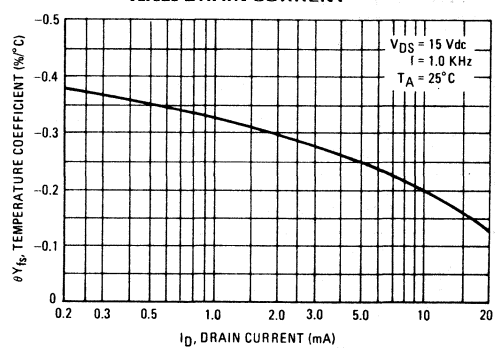


FIGURE 6 — CAPACITANCES

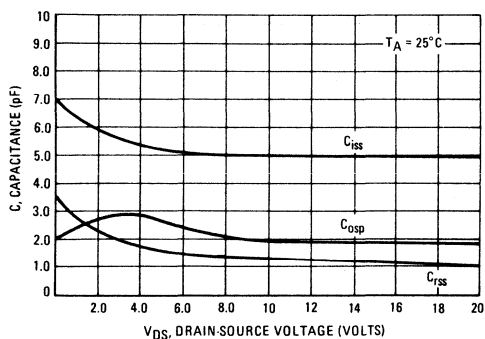


FIGURE 7 — COMMON SOURCE
NOISE FIGURE versus SOURCE RESISTANCE

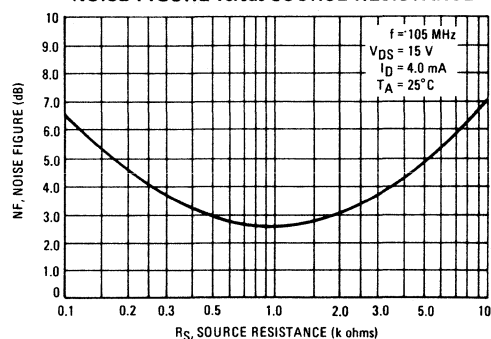


FIGURE 8 – INPUT ADMITTANCE
versus FREQUENCY

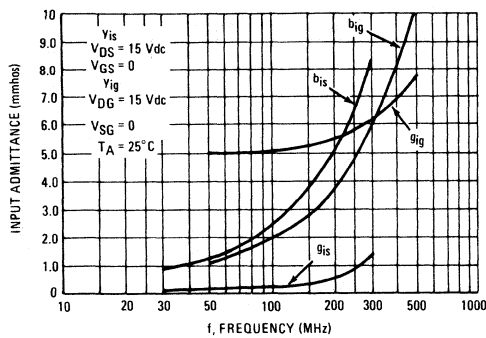


FIGURE 9 – FORWARD TRANSFER ADMITTANCE
versus FREQUENCY

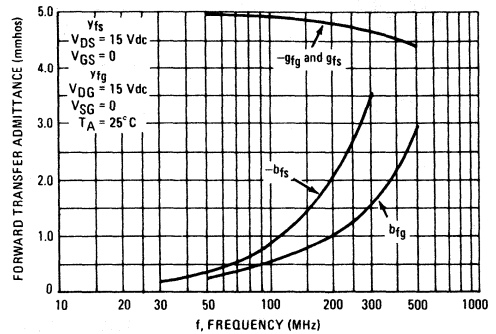


FIGURE 10 – OUTPUT ADMITTANCE
versus FREQUENCY

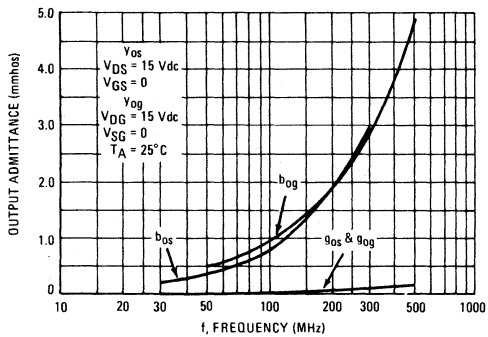


FIGURE 11 – REVERSE TRANSFER ADMITTANCE
versus FREQUENCY

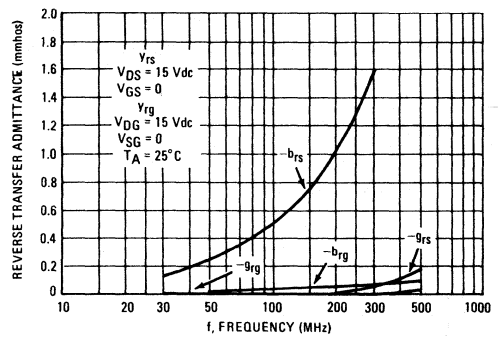


FIGURE 12 – POWER GAIN versus FREQUENCY

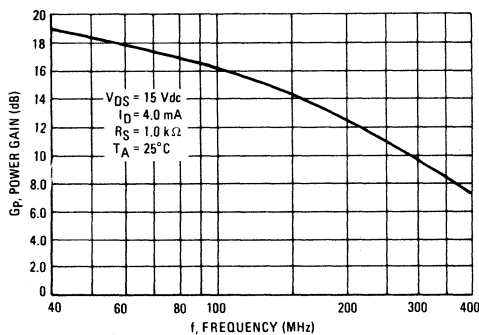
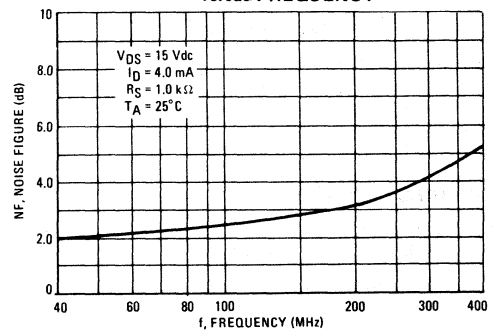


FIGURE 13 – COMMON SOURCE NOISE FIGURE
versus FREQUENCY



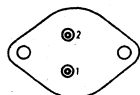
2N4231 thru 2N4233 (SILICON)

Medium-power NPN silicon transistors designed for driver circuits, switching, and amplifier applications.



CASE 80
(TO-66)

Collector
connected to case



STYLE 1
PIN 1: BASE
2: EMITTER
CASE: COLLECTOR

MAXIMUM RATINGS

Rating	Symbol	2N4231	2N4232	2N4233	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	50	70	90	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current - Continuous*	I_C^*	3.0 5.0			Adc
Base Current	I_B	1.0			Adc
Total Device Dissipation $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	35 0.2			Watts W/ $^\circ\text{C}$
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-55 to +200			$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	5.0	$^\circ\text{C/W}$

* The 3.0 Amp maximum I_C value is based upon JEDEC current gain requirements.

The 5.0 Amp maximum value is based upon actual current-handling capability of the device.

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
----------------	--------	-----	-----	------

OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage ⁽¹⁾ ($I_C = 100\text{ mAdc}$, $I_B = 0$)	2N4231 2N4232 2N4233	$BV_{CEO(sus)}$	40 60 80	- - -	Vdc
Collector Cutoff Current ($V_{CE} = 30\text{ Vdc}$, $I_B = 0$)	2N4231	I_{CEO}	-	1.0	mA
($V_{CE} = 50\text{ Vdc}$, $I_B = 0$)	2N4232		-	1.0	
($V_{CE} = 70\text{ Vdc}$, $I_B = 0$)	2N4233		-	1.0	
Collector Cutoff Current (V_{CE} @ rated V_{CEO} , $V_{EB(off)} = 1.5\text{ Vdc}$)		I_{CEX}	-	0.1	mA
(V_{CE} @ rated V_{CEO} , $V_{EB(off)} = 1.5\text{ Vdc}$, $T_C = 150^\circ\text{C}$)			-	1.0	
Collector Cutoff Current (V_{CB} @ rated V_{CB} , $I_E = 0$)		I_{CBO}	-	0.05	mA
Emitter Cutoff Current ($V_{BE} = 5.0\text{ Vdc}$, $I_C = 0$)		I_{EBO}	-	500	μA

ON CHARACTERISTICS

DC Current Gain ⁽¹⁾ ($I_C = 0.5\text{ Adc}$, $V_{CE} = 2.0\text{ Vdc}$)		h_{FE}	40	-	-
($I_C = 1.5\text{ Adc}$, $V_{CE} = 2.0\text{ Vdc}$)			25	100	
($I_C = 3.0\text{ Adc}$, $V_{CE} = 2.0\text{ Vdc}$)			10	-	
Collector-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 1.5\text{ Adc}$, $I_B = 0.15\text{ Adc}$)		$V_{CE(sat)}$	-	0.7	Vdc
($I_C = 3.0\text{ Adc}$, $I_B = 0.3\text{ Adc}$)			-	2.0	
Base-Emitter Voltage ⁽¹⁾ ($I_C = 1.5\text{ Adc}$, $V_{CE} = 2.0\text{ Vdc}$)		$V_{BE(on)}$	-	1.4	Vdc

⁽¹⁾ Pulse Test, $PW \approx 300\text{ }\mu\text{s}$, Duty Cycle $\approx 2.0\%$

2N4231 thru 2N4233 (continued)
ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Max	Unit
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SMALL-SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 0.5 \text{ A dc}$, $V_{CE} = 10 \text{ V dc}$, $f = 1.0 \text{ MHz}$)	f_T	4.0	-	MHz
Output Capacitance ($V_{CB} = 10 \text{ V dc}$, $I_E = 0$, $f = 1.0 \text{ kHz}$)	C_{ob}	-	200	pF
Small-Signal Current Gain ($I_C = 0.5 \text{ A dc}$, $V_{CE} = 10 \text{ V dc}$, $f = 1.0 \text{ kHz}$)	h_{fe}	20	-	-

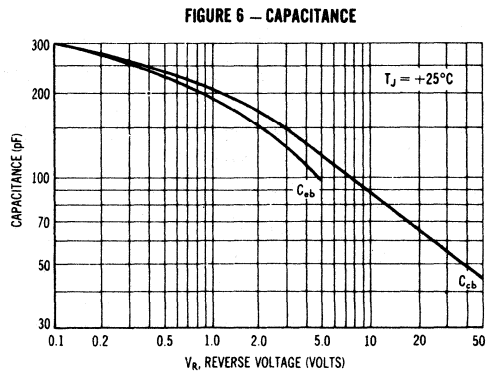
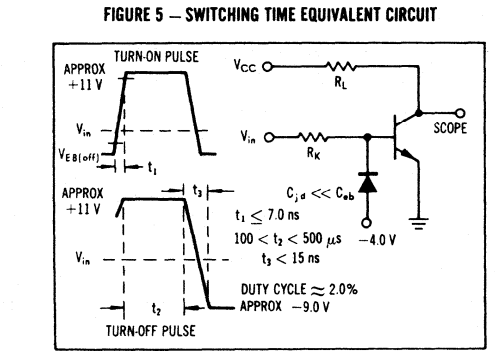
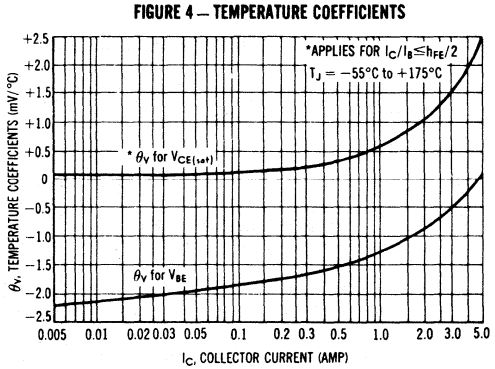
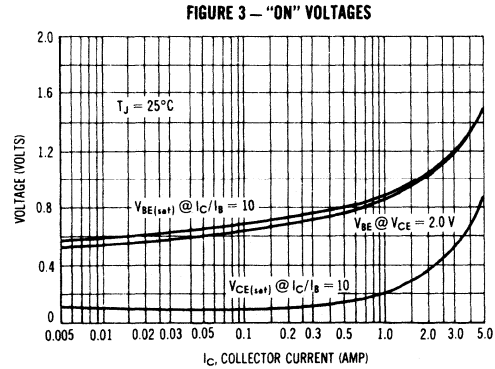
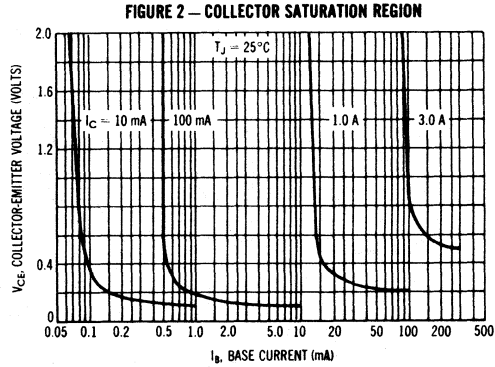
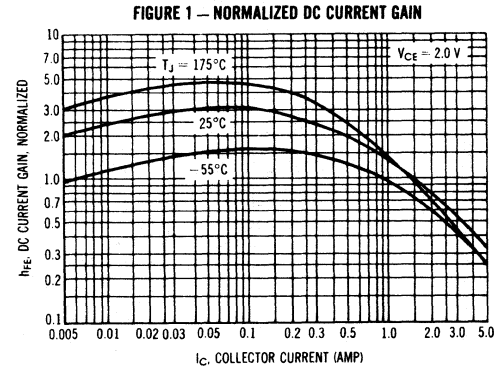


FIGURE 7 — TURN-ON TIME

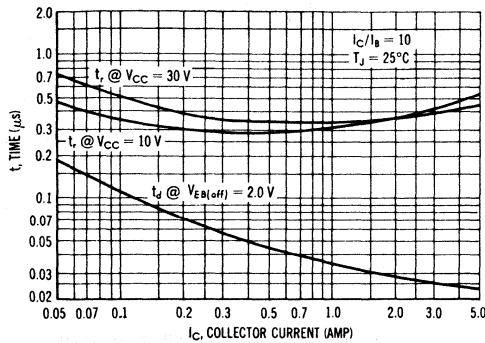
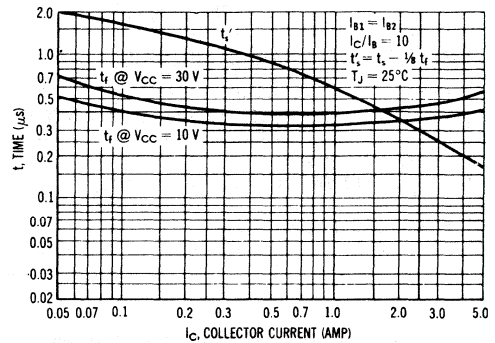


FIGURE 8 — TURN-OFF TIME



TYPICAL "OFF" REGION CHARACTERISTICS

FIGURE 9 — CUT-OFF REGION

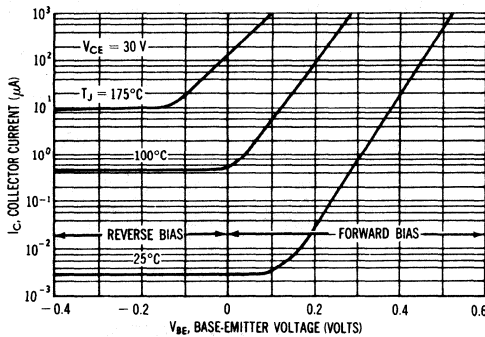


FIGURE 10 — EFFECTS OF BASE-EMITTER RESISTANCE

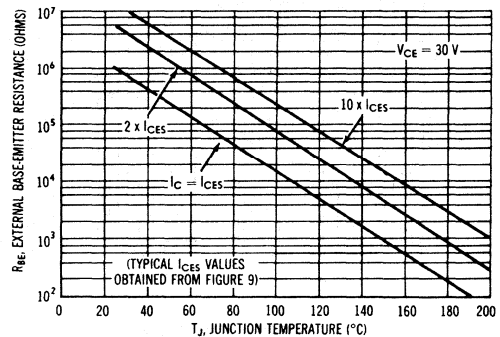
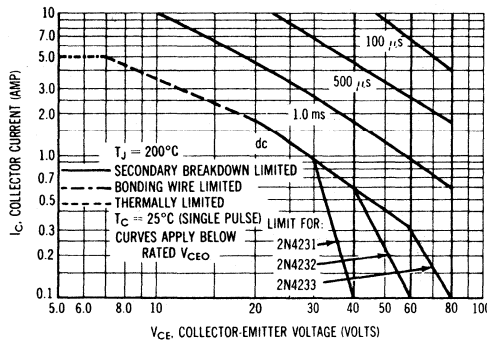


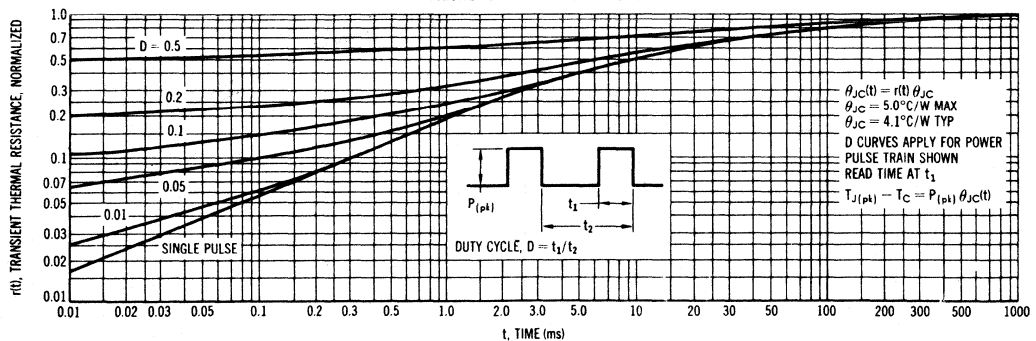
FIGURE 11 — ACTIVE-REGION SAFE-OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 11 is based on $T_{J(pk)} = 200^\circ\text{C}$; T_C is variable depending on conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} < 200^\circ\text{C}$. $T_{J(pk)}$ may be calculated from the data in Figure 12. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 12 — THERMAL RESPONSE



2N4231A thru 2N4233A NPN (SILICON)

2N6312 thru 2N6314 PNP

COMPLEMENTARY SILICON MEDIUM-POWER TRANSISTORS

... designed for general-purpose power amplifier and switching applications.

- Low Collector-Emitter Saturation Voltage –
 $V_{CE(sat)} = 0.7 \text{ Vdc (Max) @ } I_C = 1.5 \text{ Adc}$
- Low Leakage Current – $I_{CEX} = 0.1 \text{ mAdc (Max)}$
- Excellent DC Current Gain – $h_{FE} = 25\text{-}100 @ I_C = 1.5 \text{ Adc}$
- High Current Gain – Bandwidth Product –
 $f_T = 4.0 \text{ MHz @ } I_C = 0.25 \text{ Adc}$
- Aluminum TO-66 Package for Better Power Handling Capability

5.0 AMPERE COMPLEMENTARY SILICON POWER TRANSISTORS

40-60-80 VOLTS
75 WATTS

*MAXIMUM RATINGS

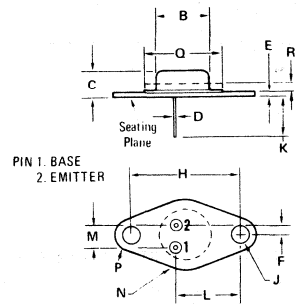
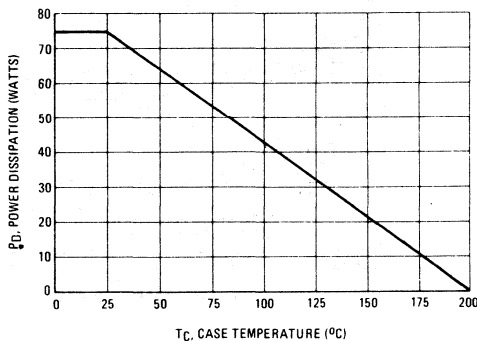
Rating	Symbol	2N4231A 2N6312	2N4232A 2N6313	2N4233A 2N6314	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current – Continuous Peak	I_C	5.0 10			Adc
Base Current	I_B	2.0			Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	75 0.43			Watts W/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			$^\circ\text{C}$

* THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.32	$^\circ\text{C/W}$

* Indicates JEDEC registered data. (All values meet or exceed JEDEC registered data).

FIGURE 1 – POWER DERATING



DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
B	.470	.500	11.94	12.70
C	.250	.340	6.35	8.64
D	.028	.034	.711	.864
E	.050	.075	1.27	1.91
F	.093	.107	2.36	2.72
H	.958	.962	24.33	24.43
J	.142	.152	3.61	3.86
K	.360		9.14	
L	.570	.590	14.48	14.99
M	.190	.210	4.83	5.33
N		.350		8.89
P		.145		3.68
Q		.620		15.75
R		.050		1.27

All JEDEC dimensions and notes apply

CASE 80-02
TO-66

2N4231A thru 2N4233A NPN, 2N6312 thru 2N6314 PNP (continued)

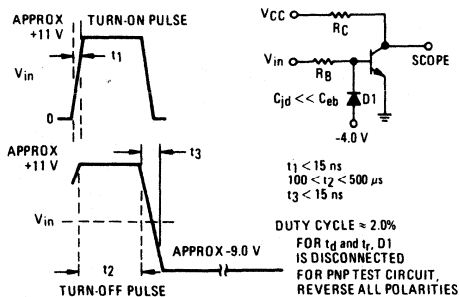
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
*OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I _C = 100 mA, I _B = 0)	V _{CE(sus)}	40 60 80	— — —	V _{dc}
Collector Cutoff Current (V _{CE} = 30 Vdc, I _B = 0) (V _{CE} = 50 Vdc, I _B = 0) (V _{CE} = 70 Vdc, I _B = 0)	I _{CEO}	— — —	1.0 1.0 1.0	mA _{dc}
Collector Cutoff Current (V _{CE} = 40 Vdc, V _{BE(off)} = 1.5 Vdc) (V _{CE} = 60 Vdc, V _{BE(off)} = 1.5 Vdc) (V _{CE} = 80 Vdc, V _{BE(off)} = 1.5 Vdc) (V _{CE} = 40 Vdc, V _{BE(off)} = 1.5 Vdc, T _C = 150°C) (V _{CE} = 60 Vdc, V _{BE(off)} = 1.5 Vdc, T _C = 150°C) (V _{CE} = 80 Vdc, V _{BE(off)} = 1.5 Vdc, T _C = 150°C)	I _{CX}	— — — — — —	0.1 0.1 0.1 1.0 1.0 1.0	mA _{dc}
Collector Cutoff Current (V _{CB} = 40 Vdc, I _E = 0) (V _{CB} = 60 Vdc, I _E = 0) (V _{CB} = 80 Vdc, I _E = 0)	I _{CBO}	— — —	0.05 0.05 0.05	mA _{dc}
Emitter Cutoff Current (V _{BE} = 5.0 Vdc, I _C = 0)	I _{EBO}	—	0.5	mA _{dc}
ON CHARACTERISTICS				
DC Current Gain (1) * (I _C = 0.5 A, V _{CE} = 2.0 Vdc) * (I _C = 1.5 A, V _{CE} = 2.0 Vdc) * (I _C = 3.0 A, V _{CE} = 2.0 Vdc) (I _C = 5.0 A, V _{CE} = 4.0 Vdc)	h _{FE}	40 25 10 4.0	— 100 — —	—
* Collector-Emitter Saturation Voltage (1) (I _C = 1.5 A, I _B = 0.15 A) (I _C = 3.0 A, I _B = 0.3 A) (I _C = 5.0 A, I _B = 1.25 A)	V _{CE(sat)}	— — —	0.7 2.0 4.0	V _{dc}
* Base-Emitter On Voltage (1) (I _C = 1.5 A, V _{CE} = 2.0 Vdc)	V _{BE(on)}	—	1.4	V _{dc}
*DYNAMIC CHARACTERISTICS				
Current-Gain - Bandwidth Product (I _C = 0.5 A, V _{CE} = 10 Vdc, f _{test} = 1.0 MHz)	f _T	4.0	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 0.1 MHz)	C _{ob}	—	300	pF
Small-Signal Current Gain (I _C = 0.5 A, V _{CE} = 10 Vdc, f = 1.0 kHz)	h _{fe}	20	—	—

* Indicates JEDEC registered data.

(1) Pulse Test. Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 — SWITCHING TIME TEST CIRCUIT



FOR CURVES OF FIGURES 3 AND 6, R_B AND R_C ARE VARIED TO OBTAIN DESIRED CURRENT LEVELS

D1 MUST BE FAST RECOVERY TYPE, eg
MBD5300 USED ABOVE I_B ≈ 100 mA
MSD6100 USED BELOW I_B ≈ 100 mA

FIGURE 3 — TURN "ON" TIME

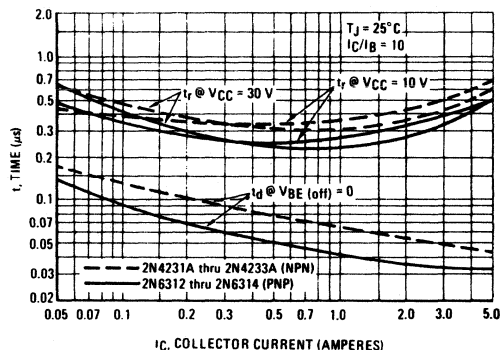


FIGURE 4 — THERMAL RESPONSE

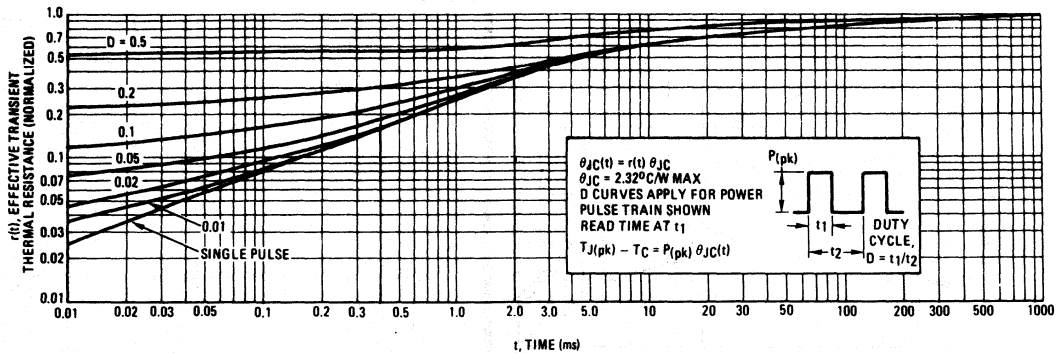
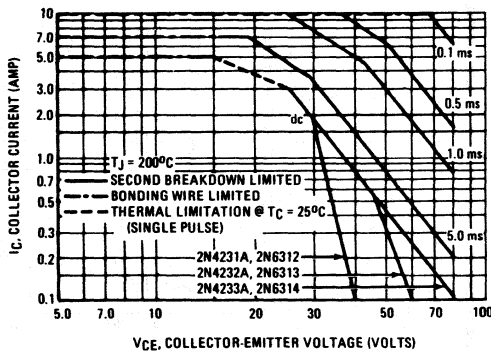


FIGURE 5 — ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor; average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_J(pk) = 200^\circ\text{C}$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_J(pk) < 200^\circ\text{C}$. $T_J(pk)$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power than can be handled to values less than the limitations imposed by second breakdown. (See Motorola Application Note AN-415).

FIGURE 6 — TURN "OFF" TIME

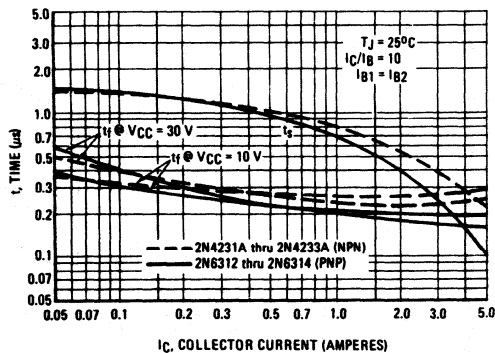
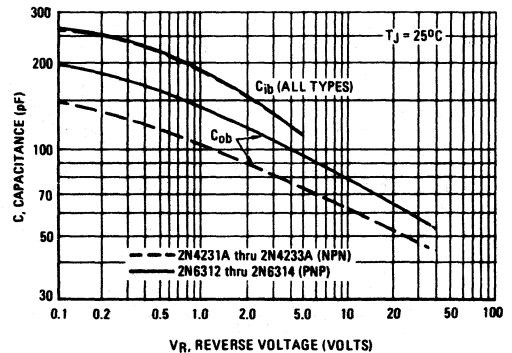


FIGURE 7 — CAPACITANCE



2N4231A thru 2N4233A NPN, 2N6312 thru 2N6314 PNP (continued)

NPN
2N4231A thru 2N4233A

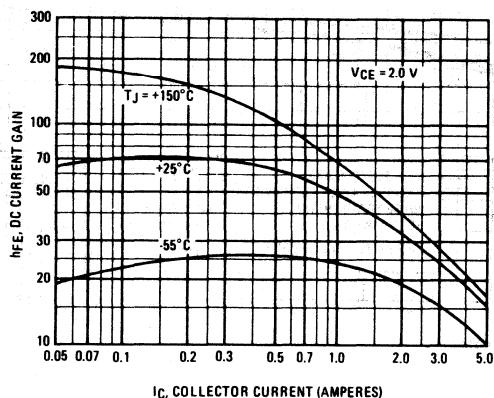


FIGURE 8 - DC CURRENT GAIN

PNP
2N6312 thru 2N6314

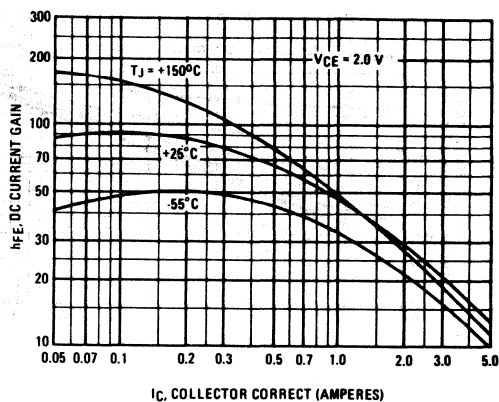


FIGURE 9 - COLLECTOR SATURATION REGION

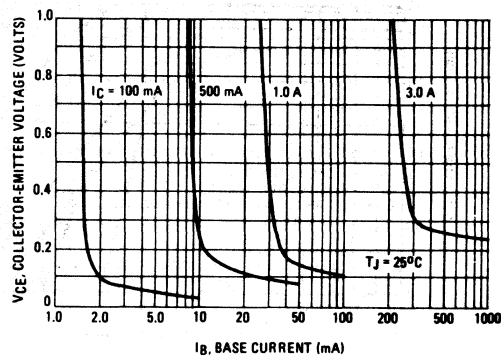
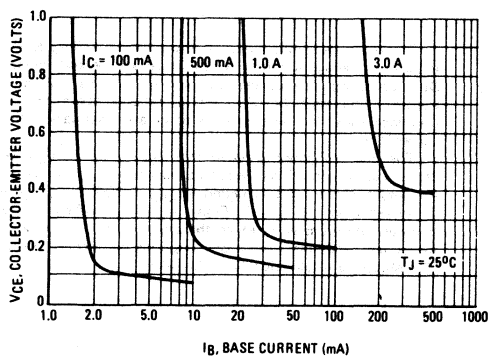
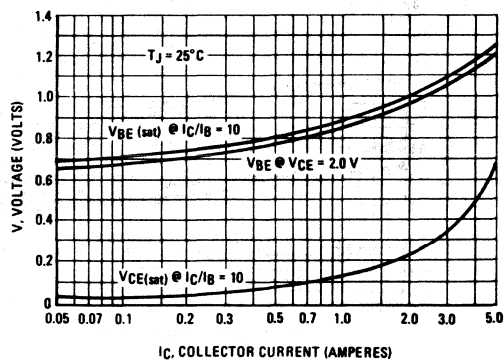
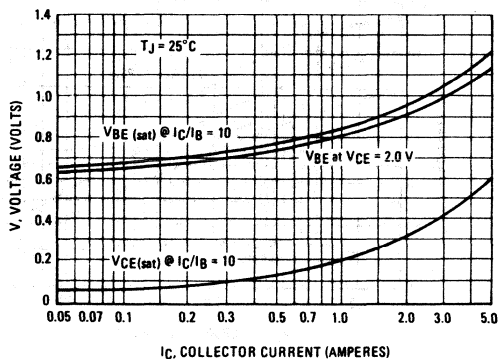
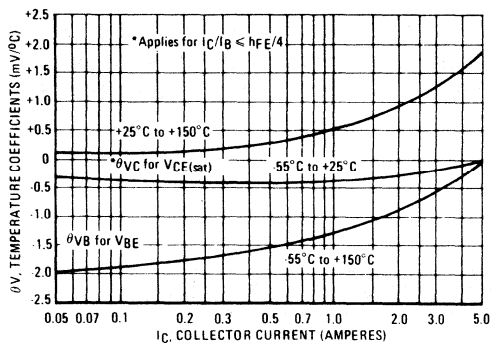


FIGURE 10 - "ON" VOLTAGES NPN PNP



NPN
2N4231A thru 2N4233A



PNP
2N6312 thru 2N6314

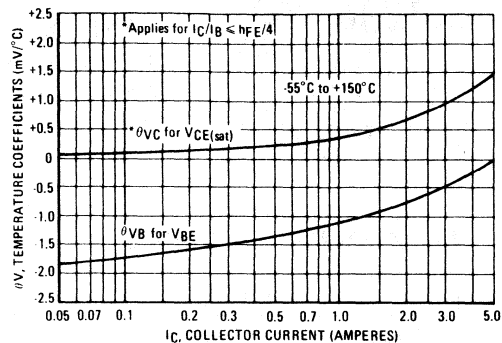


FIGURE 12 – COLLECTOR CUT-OFF REGION

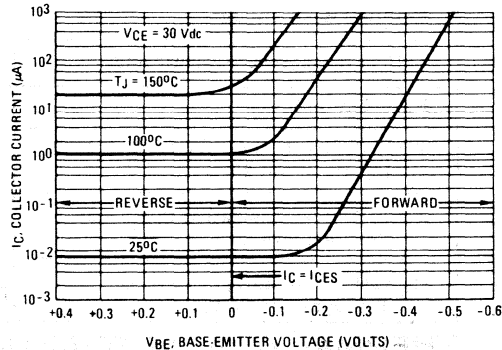
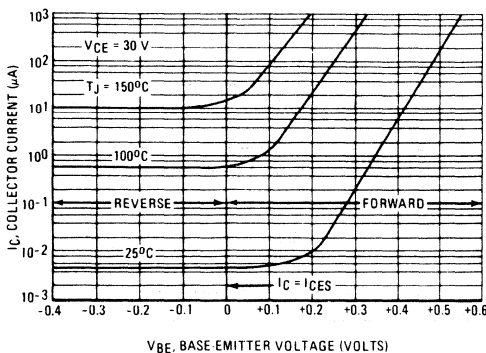
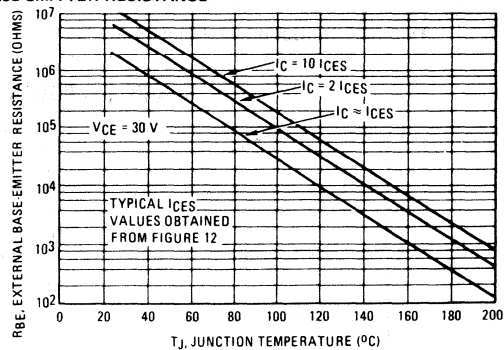
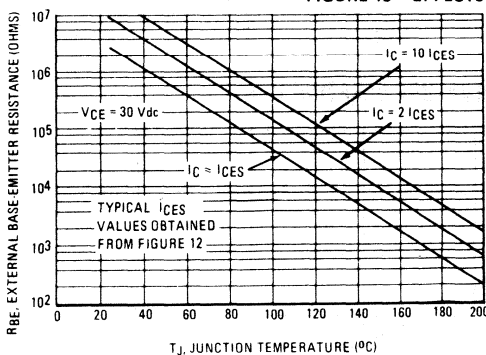


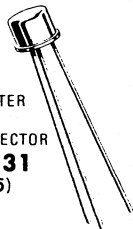
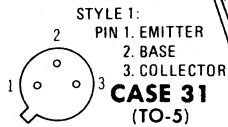
FIGURE 13 – EFFECTS OF BASE-EMITTER RESISTANCE



2N4234 (SILICON)

2N4235

2N4236



PNP silicon power transistors ideal for use as drivers, switches, and direct replacement of germanium medium-power devices. Complement to NPN 2N4237 thru 2N4239.

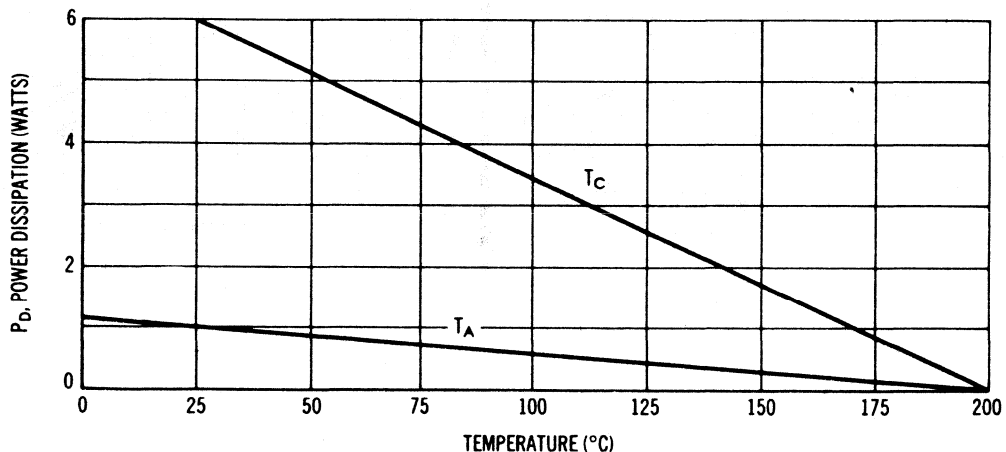
Collector connected to case
MAXIMUM RATINGS

Rating	Symbol	2N4234	2N4235	2N4236	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	7.0			Vdc
Collector Current — Continuous	I_C	3.0			Adc
Base Current	I_B	0.2			Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0			Watt
		5.7			mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	6.0			Watts
		34			mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	29	$^\circ\text{C/W}$

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 2.

All limits are applicable and must be observed.

2N4234, 2N4235, 2N4236 (continued)

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) ($I_C = 100\text{ mAdc}$, $I_B = 0$)	$BV_{CEO(sus)}$	40 60 80	— — —	Vdc
Collector Cutoff Current ($V_{CE} = 30\text{ Vdc}$, $I_B = 0$) ($V_{CE} = 40\text{ Vdc}$, $I_B = 0$) ($V_{CE} = 60\text{ Vdc}$, $I_B = 0$)	I_{CEO}	— — —	1.0 1.0 1.0	mA
Collector Cutoff Current ($V_{CE} = 40\text{ Vdc}$, $V_{BE(off)} = 1.5\text{ Vdc}$) ($V_{CE} = 60\text{ Vdc}$, $V_{BE(off)} = 1.5\text{ Vdc}$) ($V_{CE} = 80\text{ Vdc}$, $V_{BE(off)} = 1.5\text{ Vdc}$) ($V_{CE} = 30\text{ Vdc}$, $V_{BE(off)} = 1.5\text{ Vdc}$, $T_C = 150^\circ\text{C}$) ($V_{CE} = 40\text{ Vdc}$, $V_{BE(off)} = 1.5\text{ Vdc}$, $T_C = 150^\circ\text{C}$) ($V_{CE} = 60\text{ Vdc}$, $V_{BE(off)} = 1.5\text{ Vdc}$, $T_C = 150^\circ\text{C}$)	I_{CEX}	— — — — — —	0.1 0.1 0.1 1.0 1.0 1.0	mA
Collector Cutoff Current ($V_{CB} = 40\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 60\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 80\text{ Vdc}$, $I_E = 0$)	I_{CBO}	— — —	0.1 0.1 0.1	mA
Emitter Cutoff Current ($V_{BE} = 7\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	0.5	mA

ON CHARACTERISTICS

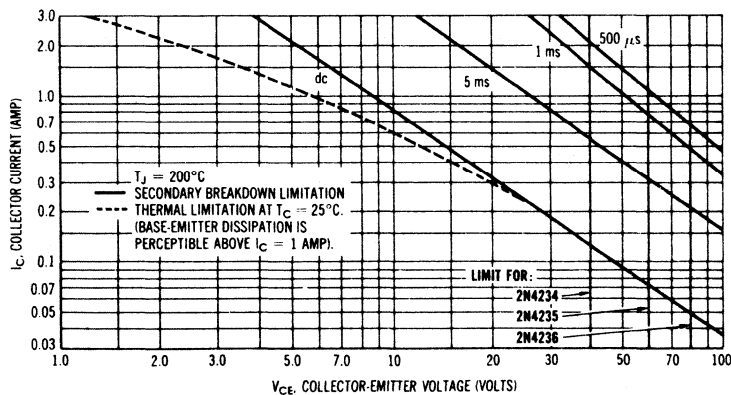
DC Current Gain (1) ($I_C = 100\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$) ($I_C = 250\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$) ($I_C = 500\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$) ($I_C = 1.0\text{ Adc}$, $V_{CE} = 1\text{ Vdc}$)	h_{FE}	40 30 20 10	— 150 — —	—
Collector-Emitter Saturation Voltage (1) ($I_C = 1.0\text{ Adc}$, $I_B = 125\text{ mAdc}$)	$V_{CE(sat)}$	—	0.6	Vdc
Base-Emitter Saturation Voltage (1) ($I_C = 1.0\text{ Adc}$, $I_B = 100\text{ mAdc}$)	$V_{BE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage ($I_C = 250\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$)	$V_{BE(on)}$	—	1.0	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 100\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ MHz}$)	f_T	3.0	—	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)	C_{ob}	—	100	pF
Small-Signal Current Gain ($I_C = 50\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	25	—	—

(1) Pulse Test: PW $\leq 300\mu\text{s}$, Duty Cycle $\leq 2\%$

FIGURE 2 — ACTIVE-REGION SAFE OPERATING AREAS



The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J , power-temperature derating must be observed for both steady state and pulse power conditions.

LARGE SIGNAL CHARACTERISTICS

FIGURE 3 — TRANSCONDUCTANCE

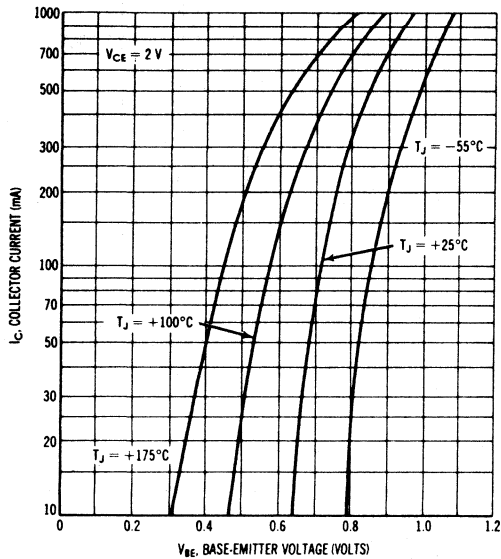
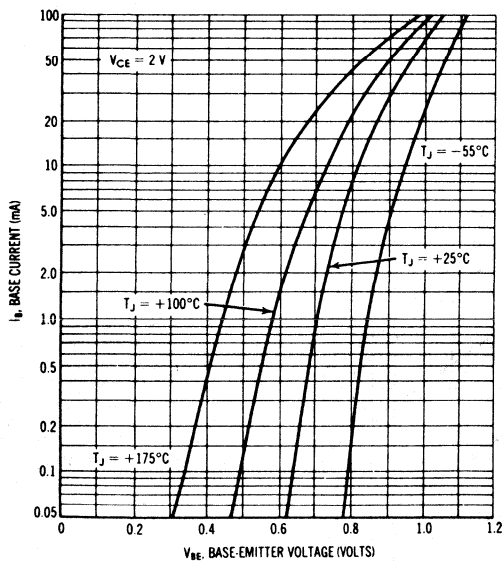


FIGURE 4 — INPUT ADMITTANCE



"OFF" REGION CHARACTERISTICS

FIGURE 5 — TRANSCONDUCTANCE

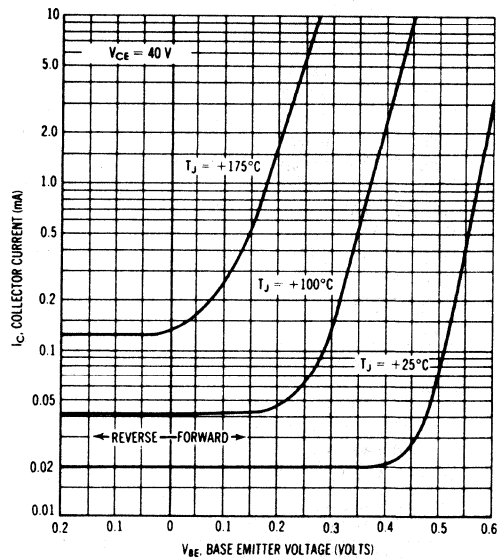


FIGURE 6 — EFFECTS OF BASE-EMITTER RESISTANCE

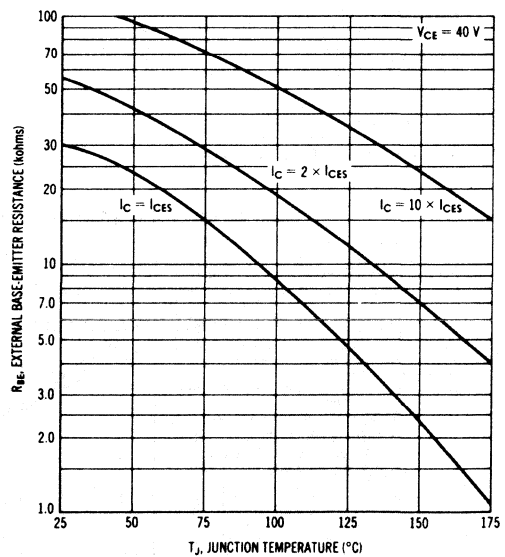
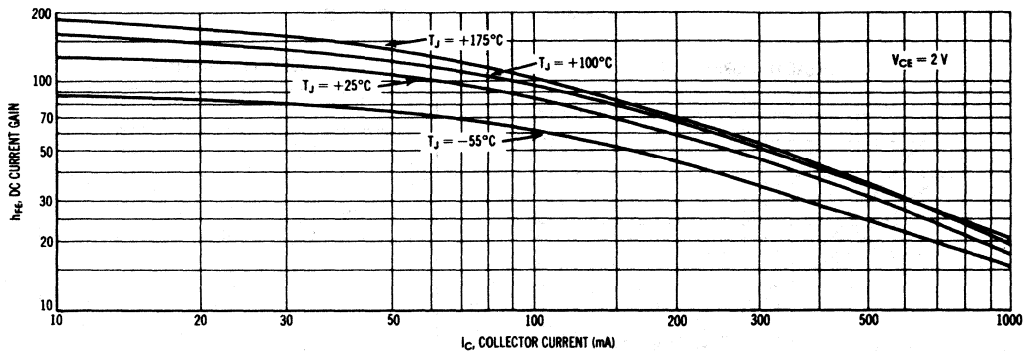


FIGURE 7 — CURRENT GAIN



SATURATION REGION CHARACTERISTICS

FIGURE 8 — COLLECTOR SATURATION REGION

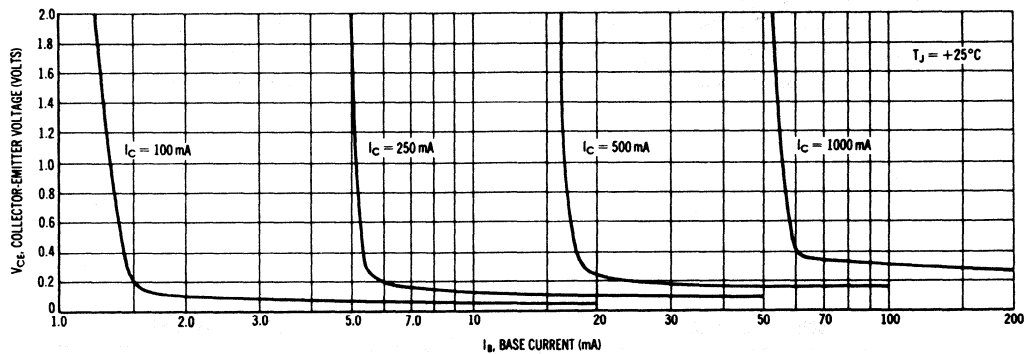


FIGURE 9 — "ON" VOLTAGES

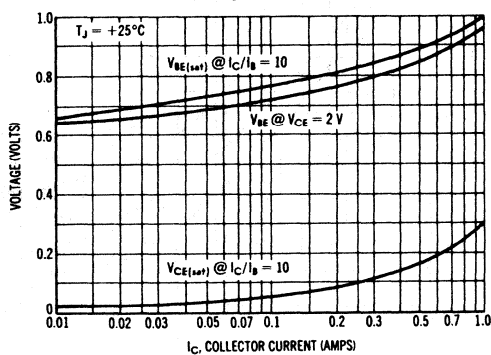
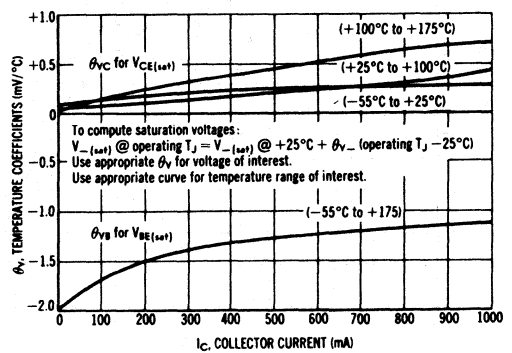


FIGURE 10 — TEMPERATURE COEFFICIENTS



DYNAMIC CHARACTERISTICS

FIGURE 11 — TURN-ON TIME

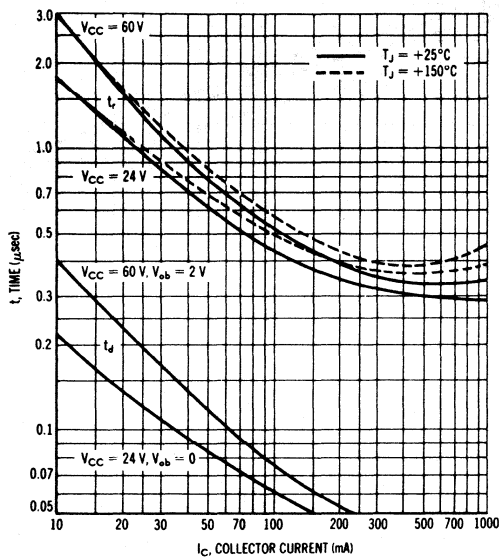


FIGURE 13 — CAPACITANCE

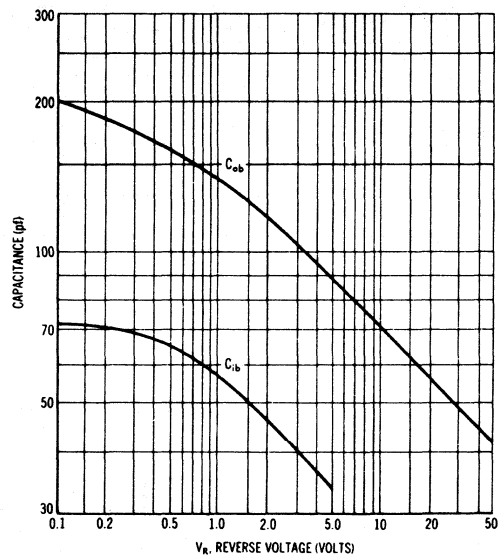


FIGURE 12 — STORAGE TIME

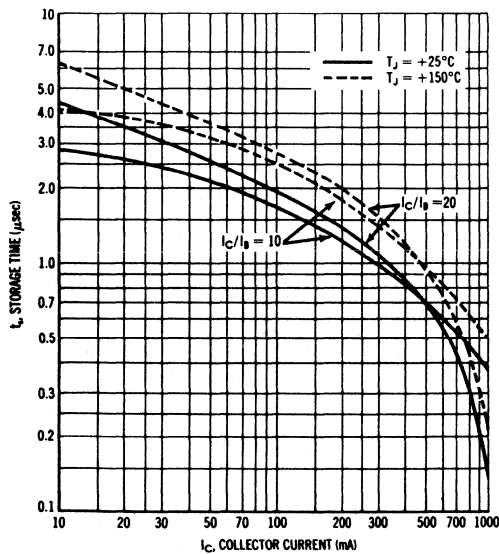
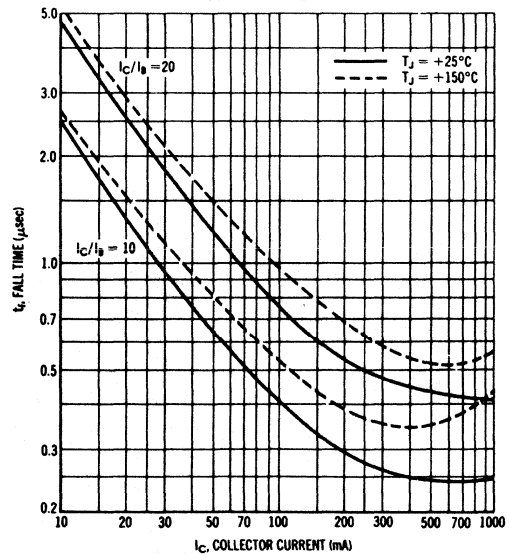


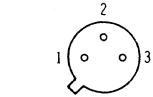
FIGURE 14 — FALL TIME



2N4237 (SILICON)

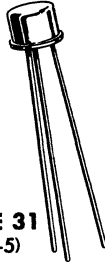
thru

2N4239



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 31
(TO-5)



Medium-power NPN silicon transistors designed for driver circuits, switching, and amplifier applications.

Collector connected to case

MAXIMUM RATINGS

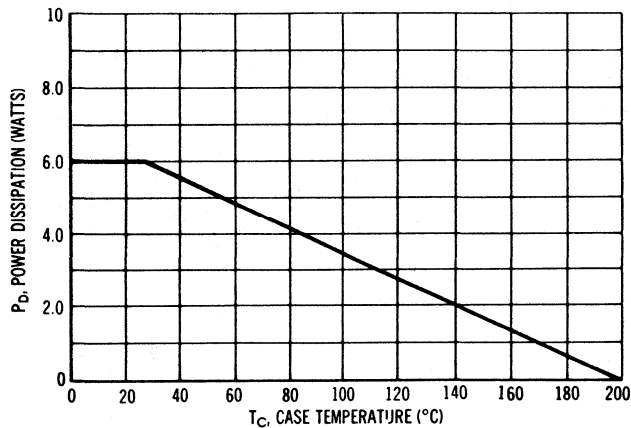
Rating	Symbol	2N4237	2N4238	2N4239	Unit
Collector-Emitter Voltage	V _{CEO}	40	60	80	Vdc
Collector-Base Voltage	V _{CB}	50	80	100	Vdc
Emitter-Base Voltage	V _{EB}	← 6.0 →			Vdc
Collector Current — Continuous*	I _C	← 1.0 →			Adc
		← 3.0 →			
Base Current — Continuous	I _B	← 500 →			mAdc
Total Device Dissipation @ T _C = 25°C Derate above 25°C	P _D	← 6.0 →			Watts mW/°C
		← 34 →			
Operating and Storage Junction Temperature Range	T _J , T _{stg}	← -65 to +200 →			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	29	°C/W

*The 1.0 Amp maximum I_C value is based upon JEDEC current gain requirements. The 3.0 Amp maximum value is based upon actual current-handling capability of the device (see Figure 5).

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 5. All limits are applicable and must be observed.

2N4237 thru 2N4239 (continued)

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (†) ($I_C = 100\text{ mAdc}$, $I_B = 0$)	-	$BV_{CEO(sus)}$	40 60 80	- - -	Vdc
Collector Cutoff Current ($V_{CE} = \text{Rated } V_{CEO}$, $I_B = 0$)	-	I_{CEO}	-	0.7	mA _{dc}
Collector Cutoff Current ($V_{CE} = 45\text{ Vdc}$, $V_{EB(off)} = 1.5\text{ Vdc}$) ($V_{CE} = 75\text{ Vdc}$, $V_{EB(off)} = 1.5\text{ Vdc}$) ($V_{CE} = 90\text{ Vdc}$, $V_{EB(off)} = 1.5\text{ Vdc}$) ($V_{CE} = 30\text{ Vdc}$, $V_{EB(off)} = 1.5\text{ Vdc}$, $T_C = 150^\circ\text{C}$) ($V_{CE} = 50\text{ Vdc}$, $V_{EB(off)} = 1.5\text{ Vdc}$, $T_C = 150^\circ\text{C}$) ($V_{CE} = 70\text{ Vdc}$, $V_{EB(off)} = 1.5\text{ Vdc}$, $T_C = 150^\circ\text{C}$)	12	I_{CEX}	- - - - - -	0.1 0.1 0.1 1.0 1.0 1.0	mA _{dc}
Collector Cutoff Current ($V_{CB} = \text{Rated } V_{CBO}$, $I_E = 0$)	-	I_{CBO}	-	0.1	mA _{dc}
Emitter Cutoff Current ($V_{EB} = 6.0\text{ Vdc}$, $I_C = 0$)	-	I_{EBO}	-	0.5	mA _{dc}

ON CHARACTERISTICS

DC Current Gain (†) ($I_C = 50\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 250\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 500\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 1.0\text{ Adc}$, $V_{CE} = 1.0\text{ Vdc}$)	8	h_{FE}	30 30 30 15	- 150 - -	-
Collector-Emitter Saturation Voltage (†) ($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$) ($I_C = 1.0\text{ Adc}$, $I_B = 0.1\text{ Adc}$)	9, 11, 13	$V_{CE(sat)}$	- -	0.3 0.6	Vdc
Base-Emitter Saturation Voltage (†) ($I_C = 1.0\text{ Adc}$, $I_B = 0.1\text{ Adc}$)		$V_{BE(sat)}$	-	1.5	Vdc
Base-Emitter On Voltage (†) ($I_C = 250\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$)	11, 13	$V_{BE(on)}$	-	1.0	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 100\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ MHz}$)	-	f_T	2.0	-	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 0.1\text{ MHz}$)	-	C_{ob}	-	100	pF
Small-Signal Current Gain ($I_C = 100\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	-	h_{fe}	30	-	-

(†) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.

SWITCHING CHARACTERISTICS

FIGURE 2 — SWITCHING TIME EQUIVALENT CIRCUIT

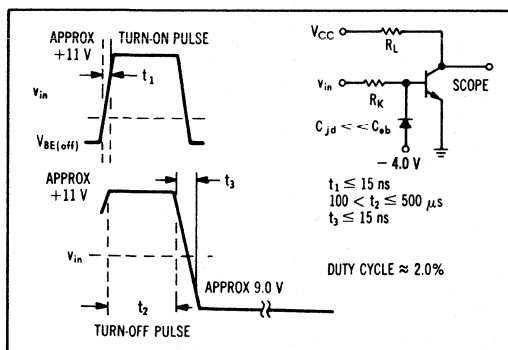


FIGURE 3 — TURN-ON TIME

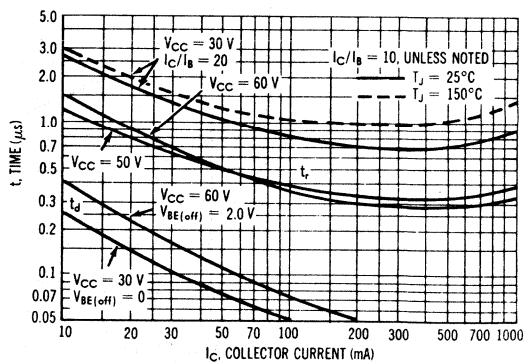


FIGURE 4 — THERMAL RESPONSE

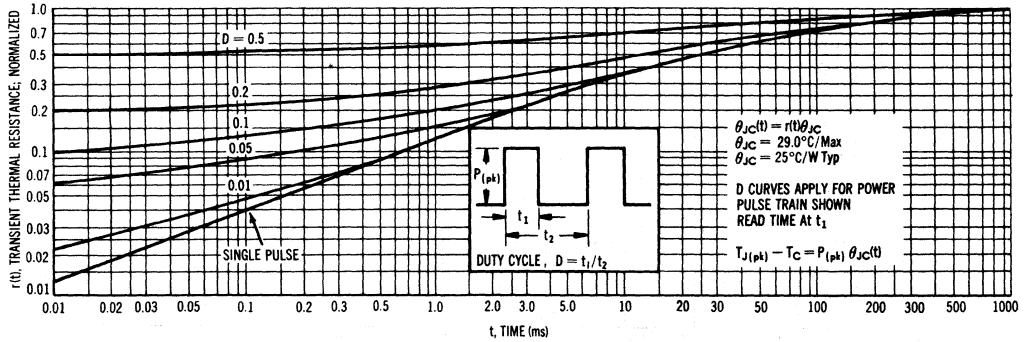
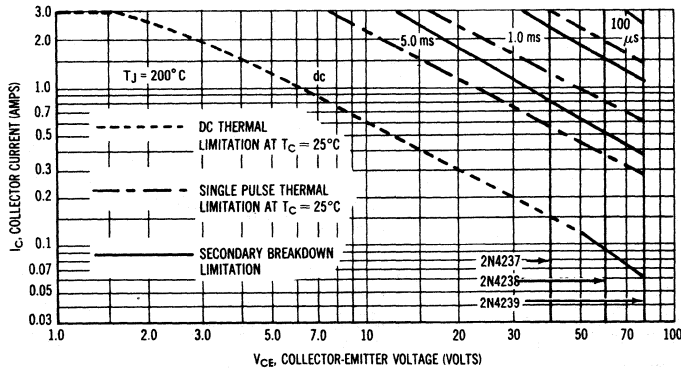


FIGURE 5 — ACTIVE-REGION SAFE OPERATING AREAS



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C — V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

For this particular transistor family, the thermal curves are the limiting design values, except for a small portion of the dc curve. The pulse secondary breakdown curves are shown for information only.

FIGURE 6 — STORAGE TIME

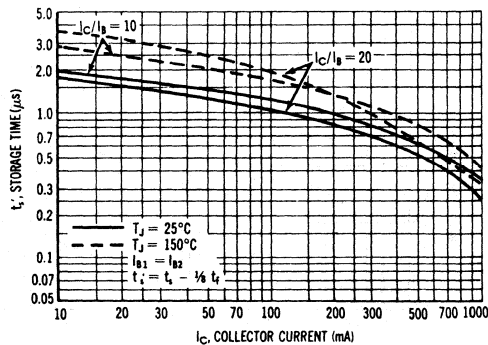
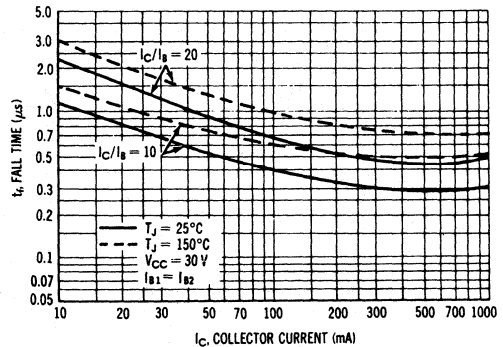


FIGURE 7 — FALL TIME



TYPICAL DC CHARACTERISTICS

FIGURE 8 — CURRENT GAIN

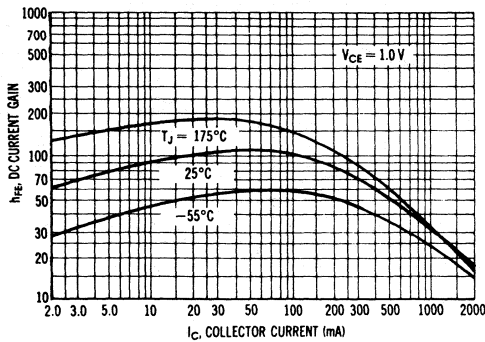


FIGURE 9 — COLLECTOR SATURATION REGION

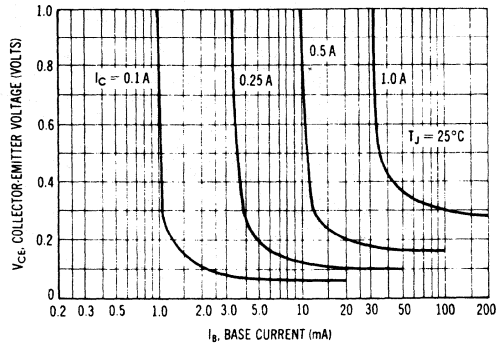


FIGURE 10 — EFFECTS OF BASE-EMITTER RESISTANCE

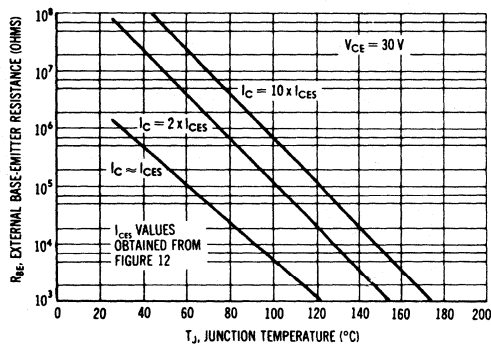


FIGURE 11 — "ON" VOLTAGE

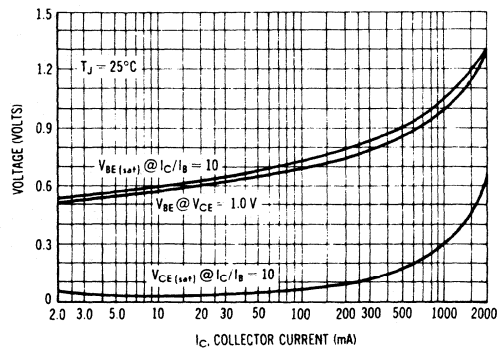


FIGURE 12 — COLLECTOR CUTOFF REGION

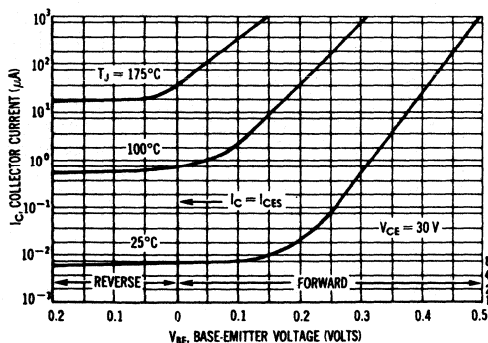
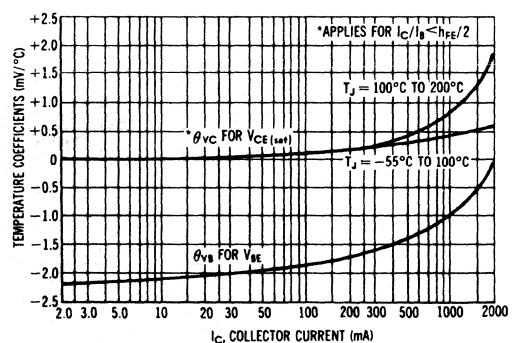


FIGURE 13 — TEMPERATURE COEFFICIENTS



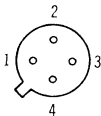
2N4260 (SILICON)

2N4261



PNP silicon annular transistors, designed for high-speed current-mode logic switching applications and for complementary circuitry with NPN types 2N3959 and 2N3960.

CASE 20
(TO-72)



STYLE 10
PIN 1. EMITTER
2. BASE
3. COLLECTOR
4. CASE

*MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V _{CEO}	15	Vdc
Collector-Base Voltage	V _{CB}	15	Vdc
Emitter-Base Voltage	V _{EB}	4.5	Vdc
Collector Current - Continuous	I _C	30	mAdc
Total Device Dissipation @ T _A = 25°C	P _D	200	mW
Derate above 25°C		1.14	mW/°C
Operating and Storage Junction Temperature Range	T _J , T _{stg}	-65 to +200	°C

* Indicates JEDEC Registered Data

2N4260, 2N4261 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (I _C = 10 mA, I _E = 0)		BV _{CEO}	15	-	Vdc
Collector-Base Breakdown Voltage (I _C = 10 μA, I _E = 0)		BV _{CBO}	15	-	Vdc
Emitter-Base Breakdown Voltage (I _E = 10 μA, I _C = 0)		BV _{EBO}	4.5	-	Vdc
Collector Cutoff Current (V _{CE} = 10 Vdc, V _{BE(off)} = 2 Vdc) (V _{CE} = 10 Vdc, V _{BE(off)} = 2 Vdc, T _A = 150°C) (V _{CE} = 10 Vdc, V _{EB(on)} = 0.4 Vdc)		I _{CEX}	- - -	0.005 5.0 0.05	μA
Base Cutoff Current (V _{CE} = 10 Vdc, V _{BE(off)} = 2 Vdc)		I _{BL}	-	0.005	μA

ON CHARACTERISTICS

DC Current Gain (I _C = 1 mA, V _{CE} = 1 Vdc) (I _C = 10 mA, V _{CE} = 1 Vdc) (I _C = 30 mA, V _{CE} = 2 Vdc)	1	h _{FE}	25 30 20	- 150 -	-
Collector-Emitter Saturation Voltage (I _C = 1 mA, I _B = 0.1 A) (I _C = 10 mA, I _B = 1 mA)	2, 3, 4	V _{CE(sat)}	- -	0.15 0.35	Vdc
Base-Emitter On Voltage (I _C = 1 mA, V _{CE} = 1 Vdc) (I _C = 10 mA, V _{CE} = 1 Vdc)	3, 4	V _{BE(on)}	- -	0.8 1.0	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain — Bandwidth Product (I _C = 5 mA, V _{CE} = 4 Vdc, f = 100 MHz) (I _C = 10 mA, V _{CE} = 10 Vdc, f = 100 MHz)	2N4260 2N4261 2N4260 2N4261	5	f _T	1200 1500 1600 2000	- - - -	MHz
High-Frequency Current Gain (I _C = 10 mA, V _{CE} = 10 Vdc, f = 100 MHz)	2N4260 2N4261		h _{fe}	16 20	- -	-
Output Capacitance (V _{CB} = 4 Vdc, I _E = 0, f = 100 kHz)		8	C _{ob}	-	2.5	pF
Input Capacitance (V _{BE} = 0.5 Vdc, I _C = 0, f = 100 kHz)		8	C _{ib}	-	2.5	pF
Collector-Base Time Constant (I _C = 5 mA, V _{CE} = 4 Vdc, f = 31.8 MHz) (I _C = 10 mA, V _{CE} = 10 Vdc, f = 31.8 MHz)	2N4260 2N4261 2N4260 2N4261	6	r _b 'C _c	- - - -	35 60 30 50	ps

Typical Performance
(v_{out} = 1 V)

TYPICAL SWITCHING TIMES

			@ 10 mA	@ 30 mA	
Turn-On Delay Time	Test Circuit Figure 7	t _{on(delay)}	1.0	1.2	ns
Rise Time		t _r	0.5	0.9	ns
Turn-Off Delay Time	Test Circuit Figure 7	t _{off(delay)}	1.0	1.2	ns
Fall-Time		t _f	1.0	1.2	ns

* Indicates JEDEC Registered Data

FIGURE 1 — DC CURRENT GAIN

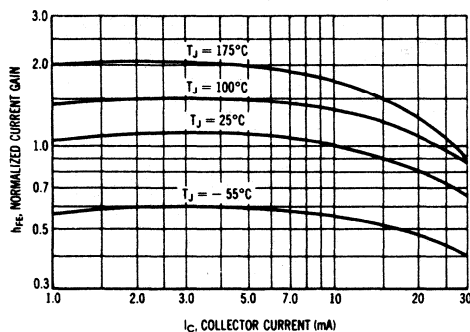


FIGURE 2 — COLLECTOR SATURATION REGION

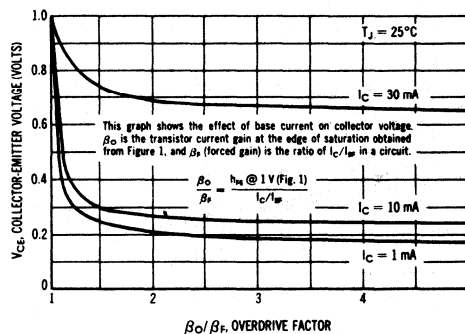


FIGURE 3 — "ON" VOLTAGES

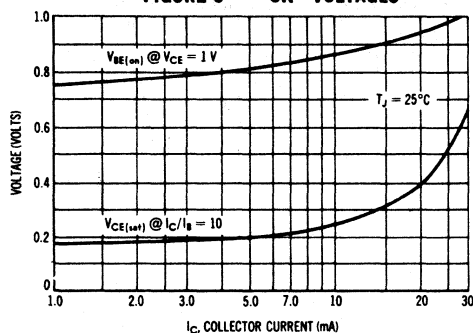


FIGURE 4 — TEMPERATURE COEFFICIENTS

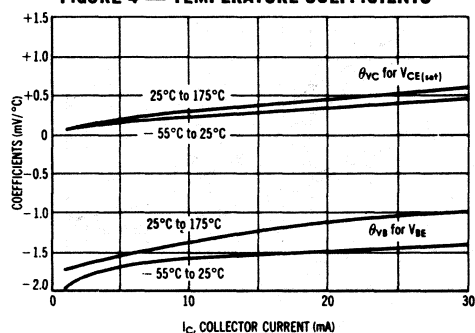


FIGURE 5 — CURRENT-GAIN — BANDWIDTH PRODUCT

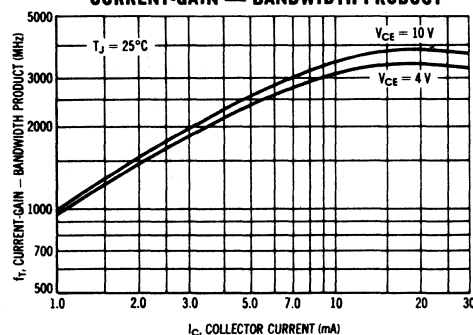


FIGURE 6 — COLLECTOR-BASE TIME CONSTANT

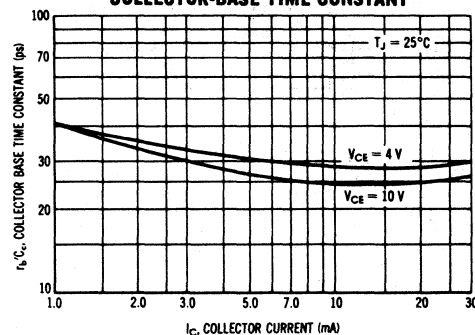
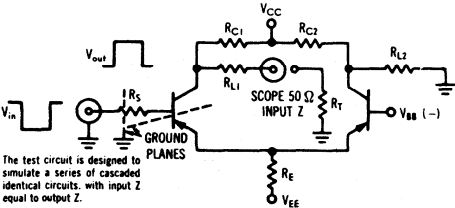
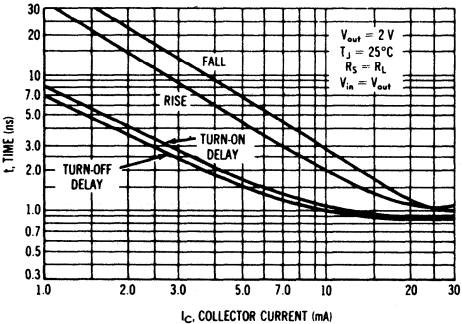
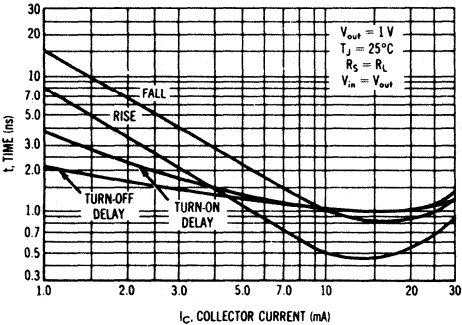


FIGURE 7 — SWITCHING TIMES



$V_{in} = V_{out} = 2\text{ V}$ $V_{BE} = 1\text{ V}$ $R_C = R_{C2}$											$V_{in} = V_{out} = 1\text{ V}$ $V_{BE} = 0.5\text{ V}$ $R_C = R_{C2}$										
I_C mA	R_S ohms	R_C ohms	R_L ohms	R_S ohms	R_C ohms	R_L ohms	V_{out} volts	V_{CC} volts	R_S ohms	R_C ohms	R_L ohms	R_S ohms	R_C ohms	R_L ohms	V_{out} volts	V_{CC} volts					
1	2	6	3	3	3	10	10	16	1	6	1.2	12	24	24	24	32					
5	360	3.56	400	400	450	2	10	47	175	1	200	250	3	3	15	27					
10	160	1	200	250	3	30	26.3	75	300	100	150	3	3	30	17	11					
20	62	300	100	150	1	20	16	25	150	25	75	1	20	11	20	11					
30	28	157	66	116	1	30	13	8	77	0	50	1	30	9	30	9					

FIGURE 8 — CAPACITANCE

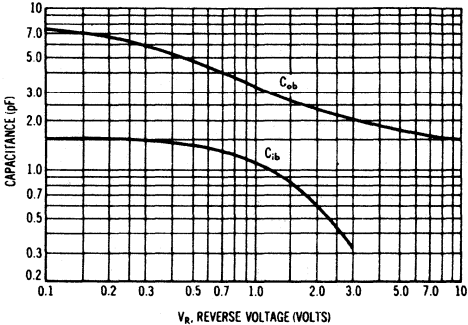
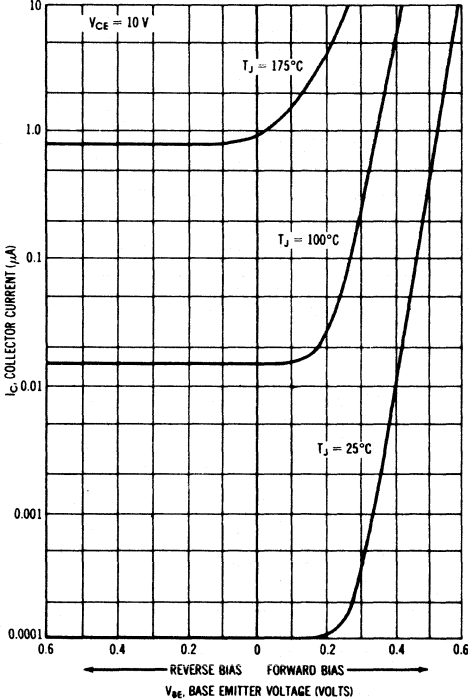


FIGURE 9 — CUT-OFF CHARACTERISTICS



2N4264 (SILICON)

2N4265

NPN SILICON ANNULAR TRANSISTORS

... designed for general-purpose switching and amplifier applications.

- Collector-Emitter Breakdown Voltage –
 $V_{CEO} = 15 \text{ Vdc (Min) @ } I_C = 1.0 \text{ mAdc} - 2N4264$
- Current Gain Specified from 0.1 mAdc to 200 mAdc
- Complete Switching and Amplifier Specifications
- Collector-Base Capacitance –
 $C_{cb} = 4.0 \text{ pF (Max) @ } V_{CB} = 5.0 \text{ Vdc}$

NPN SILICON SWITCHING AND AMPLIFIER TRANSISTORS



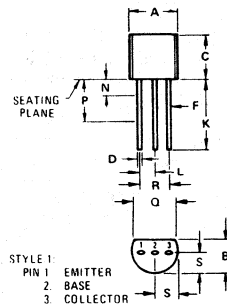
*MAXIMUM RATINGS

Rating	Symbol	2N4264	2N4265	Unit
Collector-Emitter Voltage	V_{CEO}	15	12	Vdc
Collector-Base Voltage	V_{CB}		30	Vdc
Emitter-Base Voltage	V_{EB}		6.0	Vdc
Collector Current – Continuous	I_C		200	mAdc
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8		mW mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 8.0		Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	$^\circ\text{C/W}$

*Indicates JEDEC Registered Data.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700		0.500	
L	1.150	1.390	0.045	0.055
N		1.270		0.050
P	6.350		0.250	
Q	3.430		0.135	
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29
TO-92

2N4264, 2N4265 (continued)

* ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ($I_C = 1 \text{ mA}$, $I_E = 0$)	2N4264 2N4265	BV_{CEO}	15 12	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{A}$, $I_E = 0$)		BV_{CBO}	30	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{A}$, $I_C = 0$)		BV_{EBO}	6.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 12 \text{ Vdc}$, $V_{EB(\text{off})} = 0.25 \text{ Vdc}$)		I_{CEV}	—	100	nAdc
Base Cutoff Current ($V_{CE} = 12 \text{ Vdc}$, $V_{EB(\text{off})} = 0.25 \text{ Vdc}$) ($V_{CE} = 12 \text{ Vdc}$, $V_{EB(\text{off})} = 0.25 \text{ Vdc}$, $T_A = 100^\circ\text{C}$)		I_{BEV}	—	0.1 10	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 1 \text{ mA}$, $V_{CE} = 1 \text{ Vdc}$)	2N4264 2N4265	h_{FE}	25 50	—	—
($I_C = 10 \text{ mA}$, $V_{CE} = 1 \text{ Vdc}$)	2N4264 2N4265		40 100	160 400	—
($I_C = 10 \text{ mA}$, $V_{CE} = 1 \text{ Vdc}$, $T_A = -55^\circ\text{C}$)	2N4264 2N4265		20 45	—	—
($I_C = 30 \text{ mA}$, $V_{CE} = 1 \text{ Vdc}$)	2N4264 2N4265		40 90	—	—
($I_C = 100 \text{ mA}$, $V_{CE} = 1 \text{ Vdc}$)	2N4264 2N4265		30 55	—	—
($I_C = 200 \text{ mA}$, $V_{CE} = 1 \text{ Vdc}$)	2N4264 2N4265		20 35	—	—
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mA}$, $I_B = 1 \text{ mA}$) ($I_C = 100 \text{ mA}$, $I_B = 10 \text{ mA}$)		$V_{CE(\text{sat})}$	—	0.22 0.35	Vdc
Base-Emitter Saturation Voltage ($I_C = 10 \text{ mA}$, $I_B = 1 \text{ mA}$) ($I_C = 100 \text{ mA}$, $I_B = 10 \text{ mA}$)		$V_{BE(\text{sat})}$	0.65 0.75	0.80 0.95	Vdc

SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 10 \text{ mA}$, $V_{CE} = 10 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	300	—	MHz
Collector-Base Capacitance ($V_{CB} = 5 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)	C_{cb}	—	4.0	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 100 \text{ kHz}$)	C_{ib}	—	8.0	pF

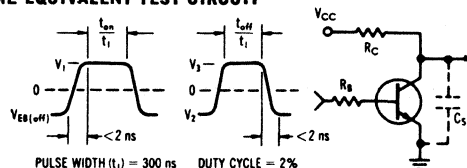
SWITCHING CHARACTERISTICS

Turn-On Time	Figure 1, Test Condition A $V_{CC} = 3 \text{ Vdc}$, $V_{EB(\text{off})} = 1.5 \text{ Vdc}$, $I_C = 10 \text{ mA}$, $I_{B1} = 3 \text{ mA}$	t_{on}	—	25	ns
Turn-Off Time	Figure 1, Test Condition A $V_{CC} = 3 \text{ Vdc}$, $I_C = 10 \text{ mA}$, $I_{B1} = 3 \text{ mA}$, $I_{B2} = 1.5 \text{ mA}$	t_{off}	—	35	ns
Storage Time	Figure 1, Test Condition B $V_{CC} = 10 \text{ Vdc}$, $I_C = 10 \text{ mA}$, $I_{B1} = I_{B2} = 10 \text{ mA}$	t_s	—	20	ns
Delay Time	Figure 1, Test Condition C $V_{CC} = 10 \text{ Vdc}$, $V_{EB(\text{off})} = 2 \text{ Vdc}$,	t_d	—	8.0	ns
Rise Time	$I_C = 100 \text{ mA}$, $I_{B1} = 10 \text{ mA}$	t_r	—	15	ns
Storage Time	Figure 1, Test Condition C $V_{CC} = 10 \text{ Vdc}$, $I_C = 100 \text{ mA}$,	t_s	—	20	ns
Fall Time	$I_{B1} = I_{B2} = 10 \text{ mA}$	t_f	—	15	ns
Total Control Charge	$V_{CC} = 3 \text{ Vdc}$, $I_C = 10 \text{ mA}$, $I_B = \text{mA}$	Q_T	—	80	pC

*Indicates JEDEC Registered Data

FIGURE 1 — SWITCHING TIME EQUIVALENT TEST CIRCUIT

TEST CONDITION	I_C mA	V_{CC} V	R_B Ω	R_C Ω	$C_S(\text{max})$ pF	$V_{EB(\text{off})}$ V	V_1 V	V_2 V	V_3 V
A	10	3	3300	270	4	-1.5	10.55	-4.15	10.70
B	10	10	560	960	4	—	—	-4.65	6.55
C	100	10	560	96	12	-2.0	6.35	-4.65	6.55



CURRENT GAIN CHARACTERISTICS

FIGURE 2 — MINIMUM CURRENT GAIN

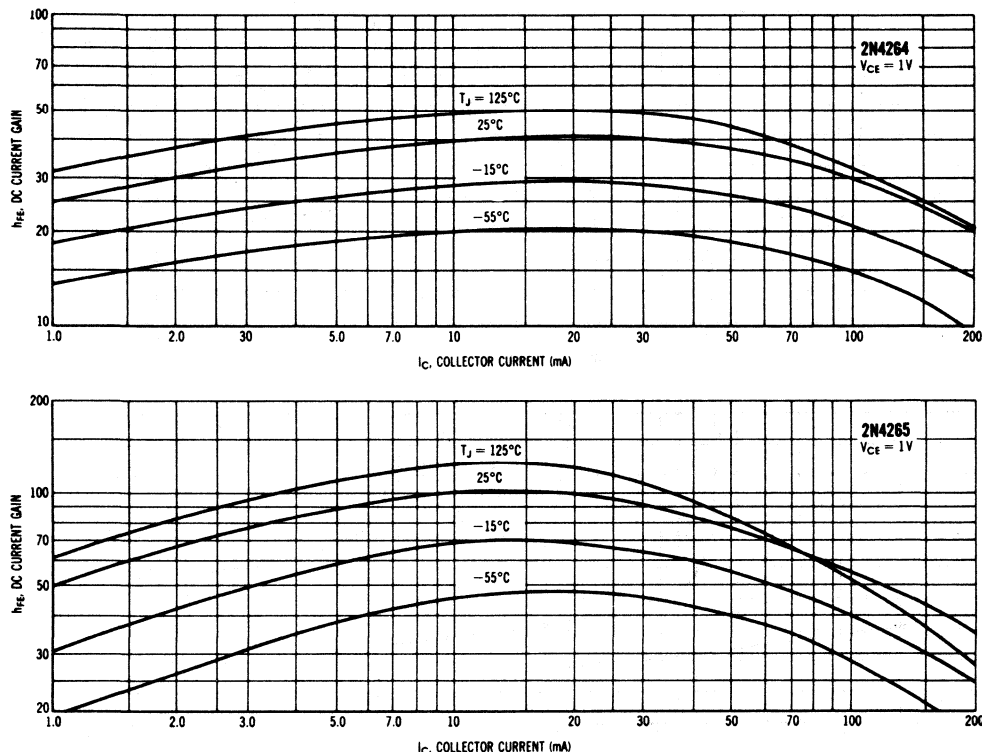


FIGURE 3 — Q_T TEST CIRCUIT

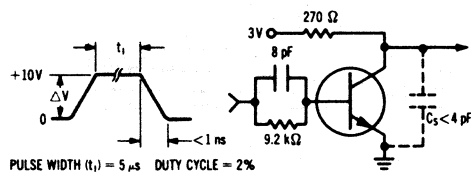
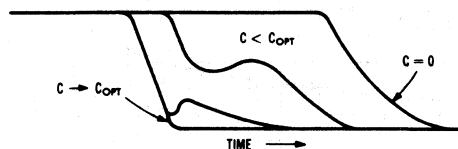


FIGURE 4 — TURN-OFF WAVEFORM



NOTE 1

When a transistor is held in a conductive state by a base current, I_b , a charge, Q_s , is developed or "stored" in the transistor. Q_s may be written: $Q_s = Q_i + Q_v + Q_x$.

Q_i is the charge required to develop the required collector current. This charge is primarily a function of alpha cutoff frequency. Q_v is the charge required to charge the collector-base feedback capacity. Q_x is excess charge resulting from overdrive, i.e., operation in saturation.

The charge required to turn a transistor "on" to the edge of saturation is the sum of Q_i and Q_v which is defined as the active region charge, Q_A . $Q_A = I_{b1}t$, when the transistor is driven by a constant current step (I_{b1}) and $I_{b1} < \frac{I_C}{h_{FE}}$.

If I_b were suddenly removed, the transistor would continue to conduct until Q_s is removed from the active regions through an external path or through internal recombination. Since the internal recombination time is long compared to the ultimate capability of a transistor, a charge, Q_r , of opposite polarity, equal in magnitude, can be stored on an external capacitor, C , to neutralize the internal charge and considerably reduce the turn-off time of the transistor. Figure 3 shows the test circuit and Figure 4 the turn-off waveform. Given Q_r from Figure 13, the external C for worst-case turn-off in any circuit is: $C = Q_r/\Delta V$, where ΔV is defined in Figure 3.

“ON” CONDITION CHARACTERISTICS

FIGURE 5 — COLLECTOR SATURATION REGION

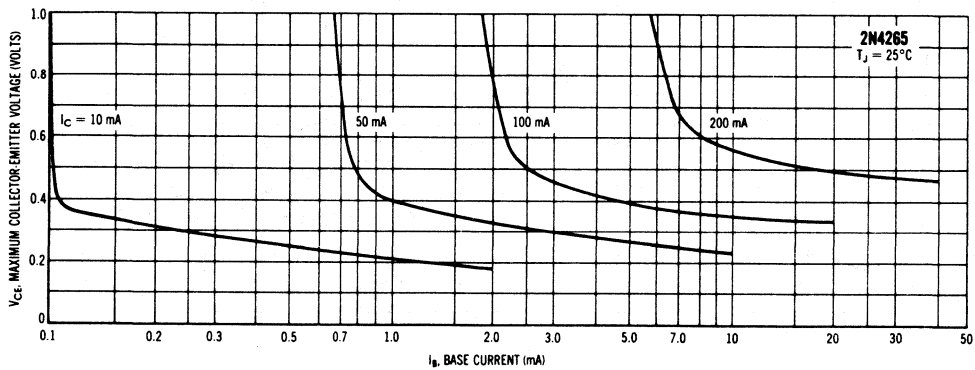
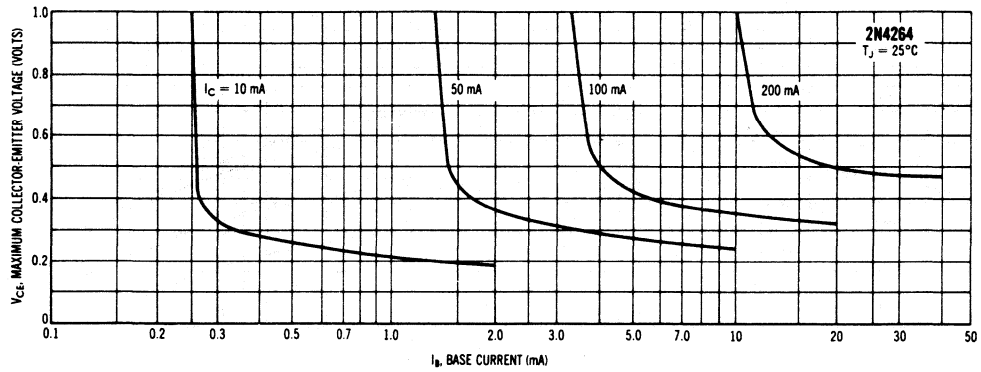


FIGURE 6 — SATURATION VOLTAGE LIMITS

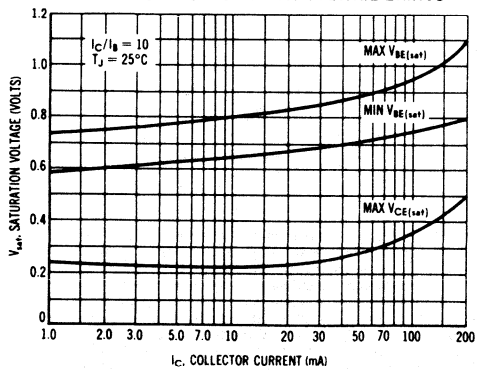
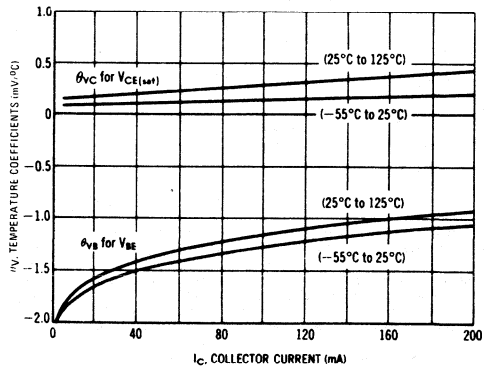


FIGURE 7 — TEMPERATURE COEFFICIENTS



DYNAMIC CHARACTERISTICS

FIGURE 8 — DELAY TIME

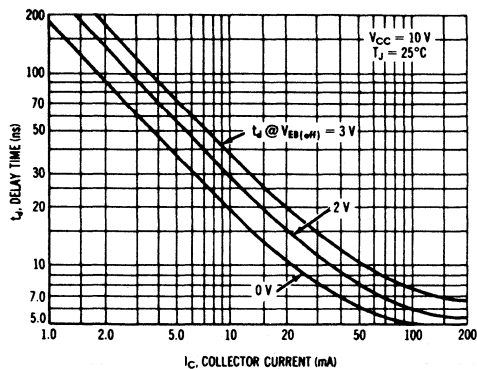


FIGURE 9 — RISE TIME

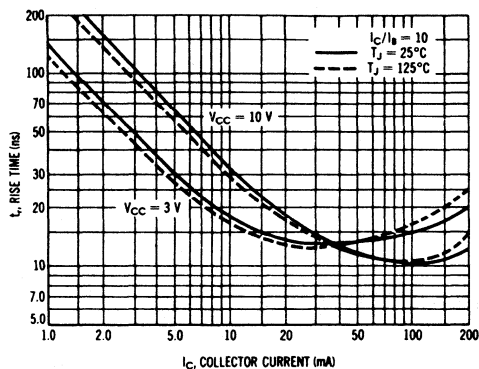


FIGURE 10 — STORAGE TIME

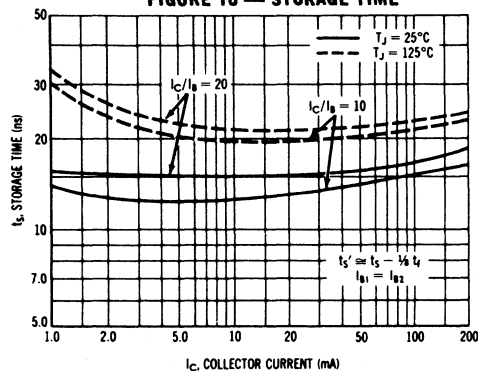


FIGURE 11 — FALL TIME

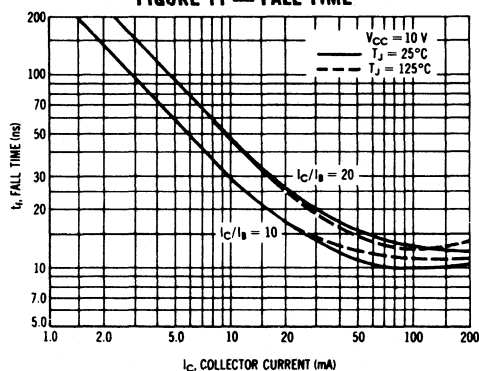


FIGURE 12 — JUNCTION CAPACITANCE

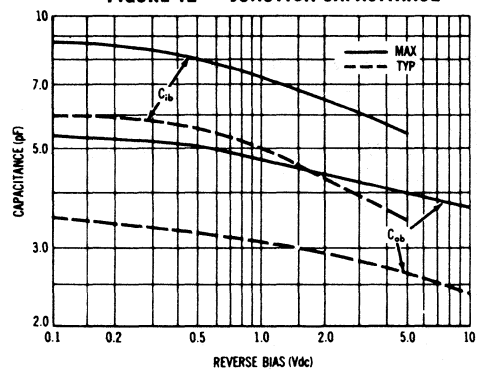
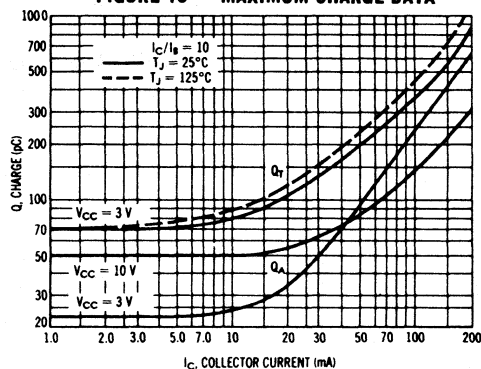


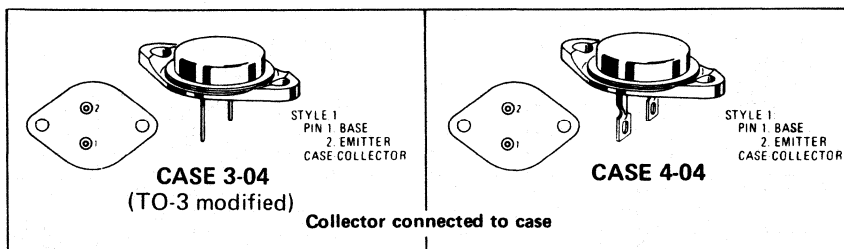
FIGURE 13 — MAXIMUM CHARGE DATA



2N4276 (GERMANIUM)

thru
2N4283

PNP germanium power transistors designed for high current applications requiring high-gain and low saturation voltages.



For units with solder lugs attached, specify devices MP 4276 etc (Case 4-04)

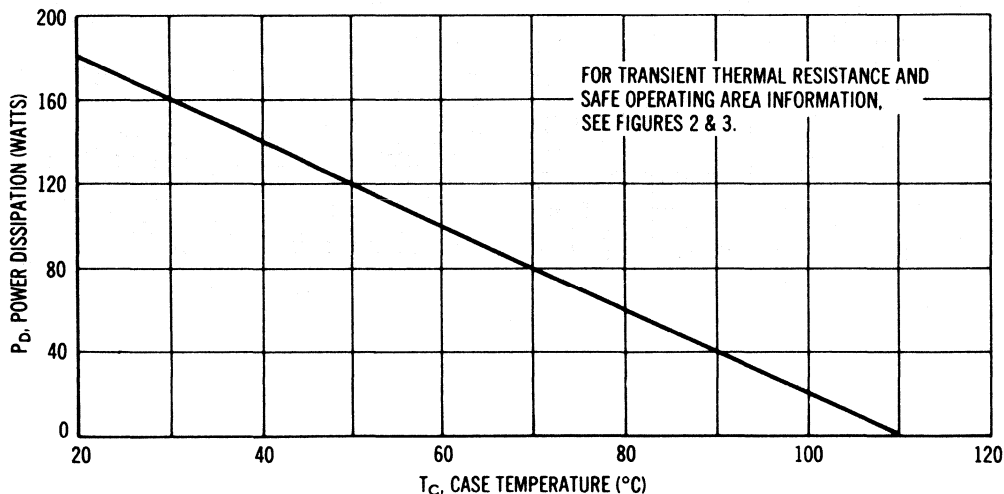
MAXIMUM RATINGS

Rating	Symbol	2N4276 2N4277	2N4278 2N4279	2N4280 2N4281	2N4282 2N4283	Unit
Collector-Emitter Voltage	V_{CEO}	20	30	45	60	Vdc
Collector-Emitter Voltage	V_{CES}	30	45	60	75	Vdc
Collector-Base Voltage	V_{CB}	30	45	60	75	Vdc
Emitter-Base Voltage	V_{EB}	20	25	30	40	Vdc
Collector Current – Continuous *	I_C^*	60				Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	170				Watts
		2.0				W/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110				$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.5	$^\circ\text{C/W}$

FIGURE 1 – AVERAGE POWER-TEMPERATURE DERATING CURVE



*JEDEC Registered Values, For True Capability See Figure 3.

2N4276 thru 2N4283 (continued)

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage† ($I_C = 1.0\text{ A dc}$, $I_B = 0$)	$BV_{CEO}^\dagger$	20 30 45 60	- - - -	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 300\text{ mA dc}$, $V_{BE} = 0$)	BV_{CES}	30 45 60 75	- - - -	Vdc
Floating Potential ($V_{CB} = 30\text{ Vdc}$, $I_E = 0$)	V_{EBF}	-	0.5	Vdc
($V_{CB} = 45\text{ Vdc}$, $I_E = 0$)		-	0.5	
($V_{CB} = 60\text{ Vdc}$, $I_E = 0$)		-	0.5	
($V_{CB} = 75\text{ Vdc}$, $I_E = 0$)		-	0.5	
Collector Cutoff Current ($V_{CE} = 20\text{ Vdc}$, $V_{BE(\text{off})} = 2.0\text{ Vdc}$, $T_C = +71^\circ\text{C}$)	I_{CEX}	-	15	mA dc
($V_{CE} = 30\text{ Vdc}$, $V_{BE(\text{off})} = 2.0\text{ Vdc}$, $T_C = +71^\circ\text{C}$)		-	15	
($V_{CE} = 45\text{ Vdc}$, $V_{BE(\text{off})} = 2.0\text{ Vdc}$, $T_C = +71^\circ\text{C}$)		-	15	
($V_{CE} = 60\text{ Vdc}$, $V_{BE(\text{off})} = 2.0\text{ Vdc}$, $T_C = +71^\circ\text{C}$)		-	15	
Collector Cutoff Current ($V_{CB} = 2.0\text{ Vdc}$, $I_E = 0$)	I_{CBO}	-	0.2	mA dc
($V_{CB} = 30\text{ Vdc}$, $I_E = 0$)		-	4.0	
($V_{CB} = 45\text{ Vdc}$, $I_E = 0$)		-	4.0	
($V_{CB} = 60\text{ Vdc}$, $I_E = 0$)		-	4.0	
($V_{CB} = 75\text{ Vdc}$, $I_E = 0$)		-	4.0	
Emitter Cutoff Current ($V_{BE} = 20\text{ Vdc}$, $I_C = 0$)	I_{EBO}	-	4.0	mA dc
($V_{BE} = 20\text{ Vdc}$, $I_C = 0$, $T_C = +71^\circ\text{C}$)		-	15	
($V_{BE} = 25\text{ Vdc}$, $I_C = 0$)		-	4.0	
($V_{BE} = 25\text{ Vdc}$, $I_C = 0$, $T_C = +71^\circ\text{C}$)		-	15	
($V_{BE} = 30\text{ Vdc}$, $I_C = 0$)		-	4.0	
($V_{BE} = 30\text{ Vdc}$, $I_C = 0$, $T_C = +71^\circ\text{C}$)		-	15	
($V_{BE} = 40\text{ Vdc}$, $I_C = 0$)		-	4.0	
($V_{BE} = 40\text{ Vdc}$, $I_C = 0$, $T_C = +71^\circ\text{C}$)		-	15	

ON CHARACTERISTICS

DC Current Gain† ($I_C = 15\text{ A dc}$, $V_{CE} = 2.0\text{ Vdc}$)	$h_{FE}^\dagger$	60 120 15	180 240 -	-
Collector-Emitter Saturation Voltage† ($I_C = 15\text{ A dc}$, $I_B = 1.0\text{ A dc}$)	$V_{CE(\text{sat})}^\dagger$	-	0.15	Vdc
($I_C = 60\text{ A dc}$, $I_B = 6.0\text{ A dc}$)		-	0.3	
Base-Emitter Saturation Voltage† ($I_C = 15\text{ A dc}$, $I_B = 1.0\text{ A dc}$)	$V_{BE(\text{sat})}^\dagger$	-	0.6	Vdc
($I_C = 60\text{ A dc}$, $I_B = 6.0\text{ A dc}$)		-	1.0	

SMALL SIGNAL CHARACTERISTICS

Common-Emitter Cutoff Frequency ($I_C = 15\text{ A dc}$, $V_{CE} = 2.0\text{ Vdc}$)	$f_{\alpha e}$	2.0	-	kHz
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† To avoid excessive heating of the collector junction, perform test with pulse method.

FIGURE 2 — TRANSIENT THERMAL RESISTANCE

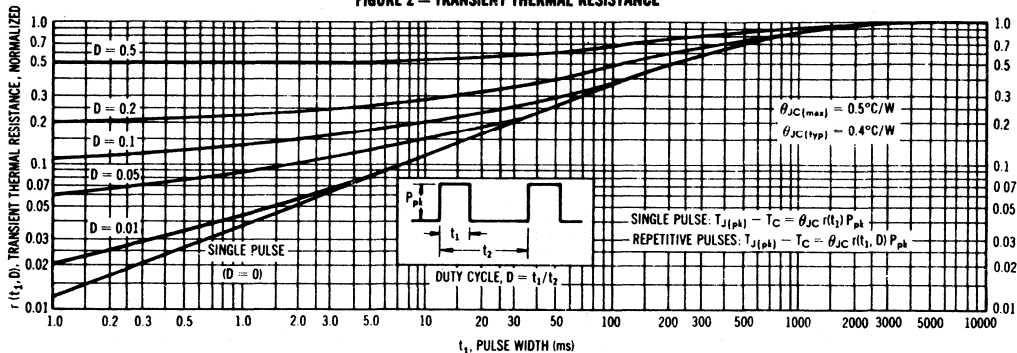


FIGURE 3 — ACTIVE REGION SAFE OPERATING AREA

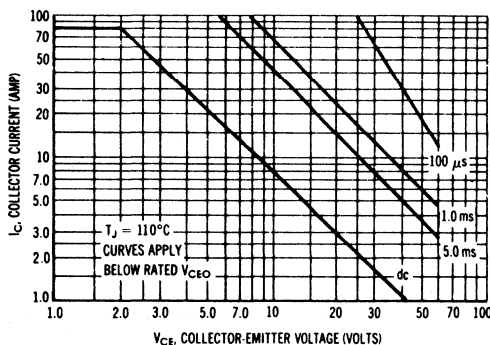
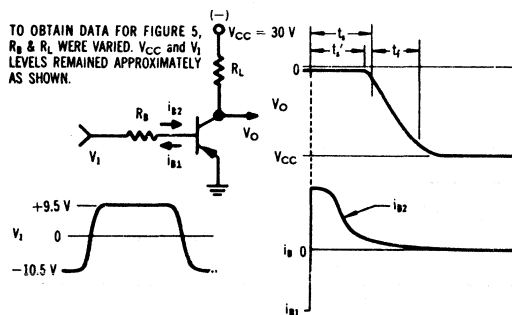


FIGURE 4 — SWITCHING TEST CIRCUIT



The switching performance of this transistor is determined primarily by the gain-bandwidth product, f_T , and the behavior of the base-spreading resistance, r_b .

In the case t_r , rise time, the base-spreading resistance plays a small part, and the test circuit delivers a constant current step of turn-on current to the transistor (i_{B1}). Therefore, the curve of t_r on Figure 5 follows theory closely, i.e.:

$$t_r \approx 0.8 \frac{V_{CC}}{i_{B1}} \cdot \frac{1}{2\pi f_T}$$

From the curve, it can be seen that t_r is roughly constant with current; using the equation, its large signal value can be calculated to be approximately 120 kHz at the 20-Amp level. A lower supply voltage will increase rise time slightly.

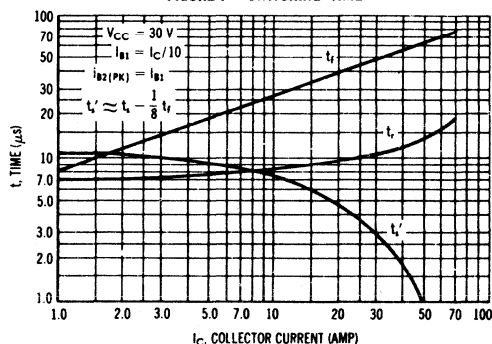
Turn-off time is slow because of conductivity modulation which occurs in the base region. When the transistor is held "on" in saturation, the base region becomes filled with excess charge; i.e., charge in excess of that

$$* q_1 \approx t_{on} \times i_{B1}$$

There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $i_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e. the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on $T_{J(pk)} = 110^\circ\text{C}$; T_C is variable depending on conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} < 110^\circ\text{C}$. $T_{J(pk)}$ may be calculated from the data in Figure 2. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 5 — SWITCHING TIMES



necessary to sustain the circuit limited value of i_C . As a result, the base resistivity and consequently r_b' become very low. During turn off, as the excess charge is reduced, the accompanying increase in resistivity causes a marked reduction in the turn-off current, i_{B2} , as can be seen from the waveforms of Figure 4. During fall time, the i_{B2} current is very low causing an extended fall time.

Only a slight improvement in turn off performance is achieved with a "speed-up" capacitor placed across R_B . This unusual behavior occurs because r_b' limits the amount of reverse current which can be achieved. Also, it seems evident that r_b' increases with applied reverse current, so that efforts to speed up the turn-off behavior are somewhat futile.

In most applications, switching time will be close to the values shown on Figure 5. Delay time is not shown as it is negligible in comparison to the other times.

TYPICAL DC CHARACTERISTICS

FIGURE 6 — DC CURRENT GAIN

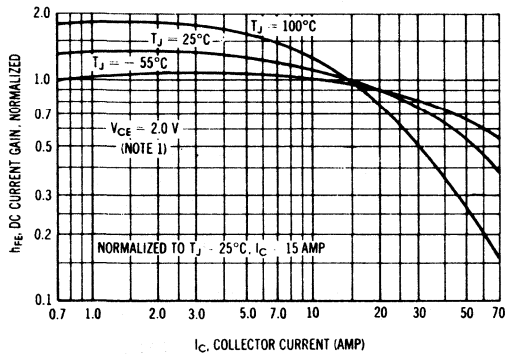


FIGURE 7 — COLLECTOR SATURATION REGION

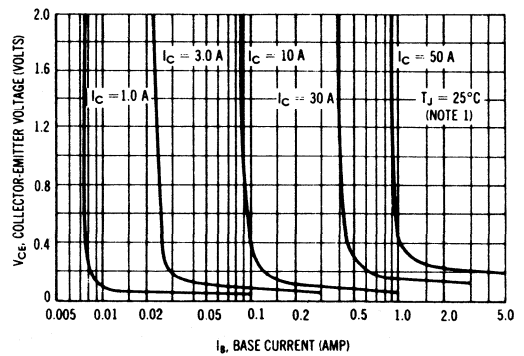


FIGURE 8 — EFFECTS OF BASE-EMITTER RESISTANCE

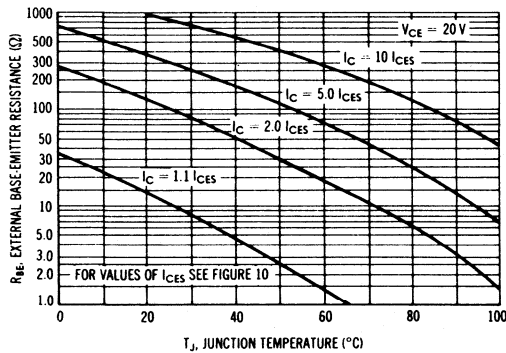


FIGURE 9 — "ON" VOLTAGES

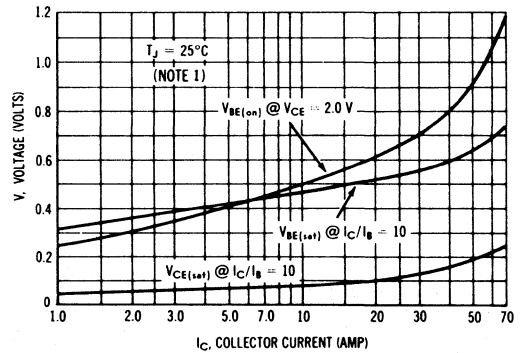
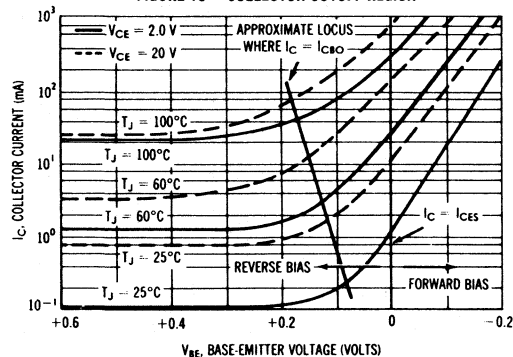
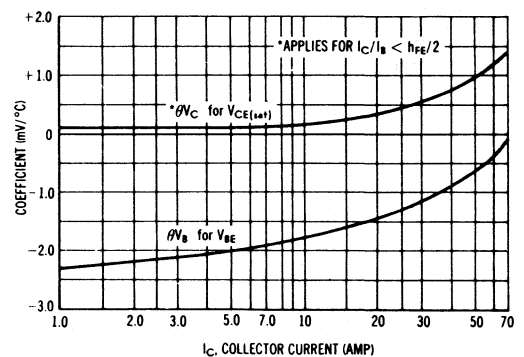


FIGURE 10 — COLLECTOR CUTOFF REGION



NOTE 1: Data is obtained from pulse tests and adjusted to nullify the effect of I_{CBO} .

FIGURE 11 — TEMPERATURE COEFFICIENTS



2N4342 (SILICON)

SILICON P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR

Depletion Mode (Type A) Junction Field-Effect Transistor designed primarily for high-gain audio frequency applications.

- High Forward Transadmittance –
 $|y_{fs}| = 2.0 \text{ mmhos (Min) @ } V_{DS} = -10 \text{ Vdc (2N4342)}$
- Low Noise Figure –
 $NF = 1.5 \text{ dB (Max) @ } f = 100 \text{ Hz}$
- Low Drain-Source "ON" Resistance –
 $r_{ds(on)} = 700 \text{ Ohms (Max) @ } f = 1.0 \text{ kHz (2N4342)}$

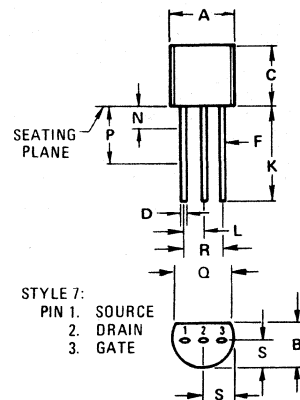
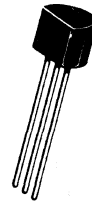
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	-25	Vdc
Drain-Gate Voltage	V_{DG}	-25	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	25	Vdc
Forward Gate Current	I_{GF}	50	mA _{dc}
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	200 2.0	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +125	$^\circ\text{C}$

*Indicates JEDEC Registered Data.

P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

(Type A)



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	—	0.500	—
L	1.150	1.390	0.045	0.055
N	—	1.270	—	0.050
P	6.350	—	0.250	—
Q	3.430	—	0.135	—
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

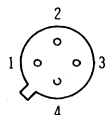
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 10\ \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	25	—	Vdc
Gate-Source Cutoff Voltage ($V_{DS} = -10\ \text{Vdc}$, $I_D = 1.0\ \mu\text{Adc}$)	$V_{GS(off)}$	1.0	5.5	Vdc
Gate Reverse Current ($V_{GS} = 15\ \text{Vdc}$, $V_{DS} = 0$) ($V_{GS} = 15\ \text{Vdc}$, $V_{DS} = 0$, $T_A = 65^\circ\text{C}$)	I_{GSS}	— —	10 0.5	nAdc μAdc
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current ($V_{DS} = -10\ \text{Vdc}$, $V_{GS} = 0$)	I_{DSS}	4.0	12	mAdc
Gate-Source Voltage ($V_{DS} = -10\ \text{Vdc}$, $I_D = 0.4\ \text{mAdc}$) ($V_{DS} = -10\ \text{Vdc}$, $I_D = 1.0\ \text{mAdc}$)	V_{GS}	0.7	5.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Drain-Source "ON" Resistance ($V_{GS} = 0$, $I_D = 0$, $f = 1.0\ \text{kHz}$)	$r_{ds(on)}$	—	700	Ohms
Forward Transadmittance ($V_{DS} = -10\ \text{Vdc}$, $V_{GS} = 0$, $f = 1.0\ \text{kHz}$)	Y_{fs}	2000	6000	μmhos
Forward Transconductance ($V_{DS} = -10\ \text{Vdc}$, $V_{GS} = 0$, $f = 1.0\ \text{MHz}$)	$Re(Y_{fs})$	1500	—	μmhos
Output Admittance ($V_{DS} = -10\ \text{Vdc}$, $V_{GS} = 0$, $f = 1.0\ \text{kHz}$)	Y_{os}	—	75	μmhos
Input Capacitance ($V_{DS} = -10\ \text{Vdc}$, $V_{GS} = 0$, $f = 1.0\ \text{MHz}$)	C_{iss}	—	20	pF
Reverse Transfer Capacitance ($V_{DS} = -10\ \text{Vdc}$, $V_{GS} = 0$, $f = 1.0\ \text{MHz}$)	C_{rss}	—	5.0	pF
Common-Source Noise Figure ($V_{DS} = -10\ \text{Vdc}$, $V_{GS} = 0$, $R_G = 1.0\ \text{Megohm}$, $f = 100\ \text{Hz}$, $BW = 15\ \text{Hz}$)	NF	— —	1.5	dB
Equivalent Short-Circuit Input Noise Voltage ($V_{DS} = -10\ \text{Vdc}$, $V_{GS} = 0$, $f = 100\ \text{Hz}$, $BW = 15\ \text{Hz}$)	E_n	—	0.08	$\mu\text{V}/\sqrt{\text{Hz}}$

*Indicates JEDEC Registered Data.

2N4351 (SILICON)



CASE 20-02
(TO-72)



STYLE 2
PIN 1. SOURCE
2. GATE
3. DRAIN
4. SUBSTRATE AND
CASE LEAD

Silicon N-channel MOS field effect transistors, designed for enhancement-mode operation in low power switching applications. The 2N4351 is complementary with type 2N4352.

MAXIMUM RATINGS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	± 30	Vdc
Drain Current	I_D	30	mAdc
Power Dissipation at $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 1.7	mW mW/ $^\circ\text{C}$
Power Dissipation at $T_C = 25^\circ\text{C}$ Derate about 25°C	P_D	800 4.56	mW mW/ $^\circ\text{C}$
Operating Junction Temperature	T_J	200	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

2N4351 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Substrate connected to source.

Characteristic	Figure No.	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Drain-Source Breakdown Voltage (I _D = 10 μA, V _{GS} = 0)	—	V _{(BR)DSS}	25	—	Vdc
Gate Leakage Current (V _{GS} = ±30 Vdc, V _{DS} = 0)	—	I _{GSS}	—	10	pAdc
Zero-Gate-Voltage Drain Current (V _{DS} = 10 V, V _{GS} = 0)	—	I _{DSS}	—	10	nAdc

ON CHARACTERISTICS

Gate-Source Threshold Voltage (V _{DS} = 10 V, I _D = 10 μA)	—	V _{GS(TH)}	1.0	5.0	Vdc
“ON” Drain Current (V _{GS} = 10 V, V _{DS} = 10 V)	3	I _{D(on)}	3.0	—	mAdc
Drain-Source “ON” Voltage (I _D = 2 mA, V _{GS} = 10 V)	—	V _{DS(on)}	—	1.0	Vdc

SMALL SIGNAL CHARACTERISTICS

Drain-Source Resistance (V _{GS} = 10 V, I _D = 0, f = 1 kHz)	4	r _{ds(on)}	—	300	ohms
Forward Transfer Admittance (V _{DS} = 10 V, I _D = 2 mA, f = 1 kHz)	1	y _{fs}	1000	—	μmho
Reverse Transfer Capacitance (V _{DS} = 0, V _{GS} = 0, f = 140 kHz)	2	C _{rss}	—	1.3	pF
Input Capacitance (V _{DS} = 10 V, V _{GS} = 0, f = 140 kHz)	2	C _{iss}	—	5.0	pF
Drain-Substrate Capacitance (V _{D(SUB)} = 10 V, f = 140 kHz)	—	C _{d(sub)}	—	5.0	pF

SWITCHING CHARACTERISTICS

Turn-On Delay	I _D = 2.0 mAdc, V _{DS} = 10 Vdc, V _{GS} = 10 Vdc (See Figure 10; Times Circuit Determined)	6, 10	t _{d1}	—	45	ns
Rise Time		7, 10	t _r	—	65	ns
Turn-Off Delay		8, 10	t _{d2}	—	60	ns
Fall Time		9, 10	t _f	—	100	ns

FIGURE 1 — FORWARD TRANSFER ADMITTANCE

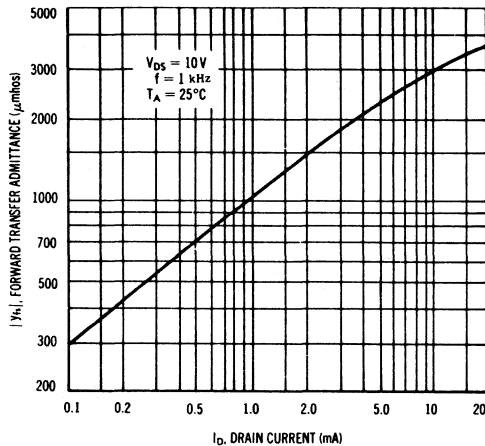


FIGURE 2 — CAPACITANCE

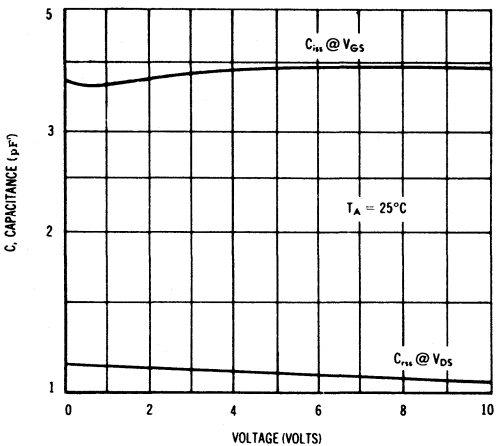


FIGURE 3 — TRANSFER CHARACTERISTICS

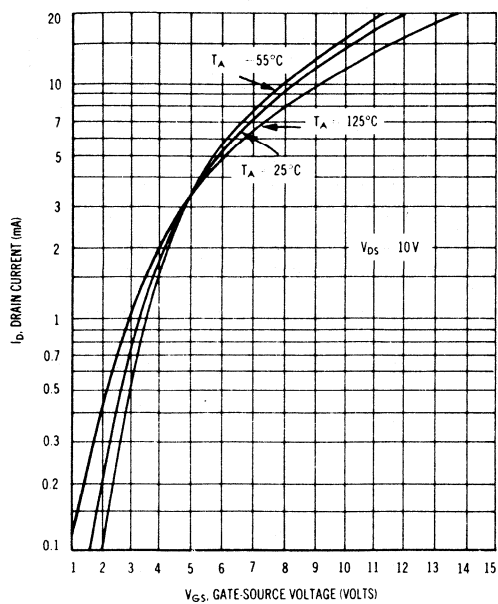


FIGURE 4 — DRAIN SOURCE "ON" RESISTANCE

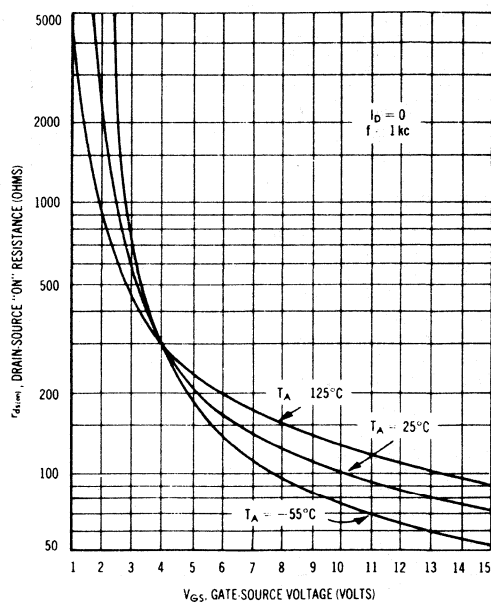
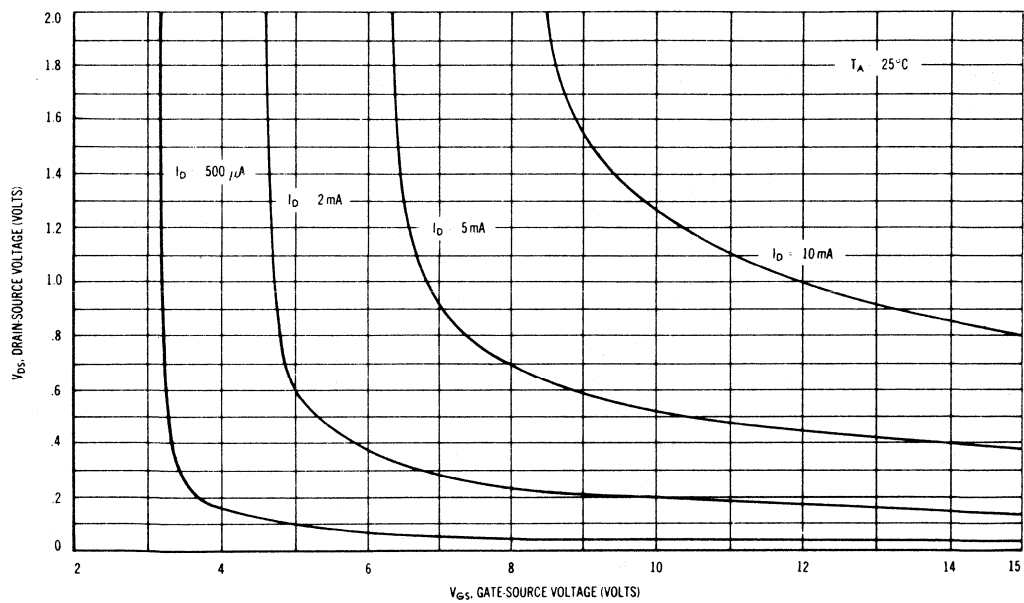


FIGURE 5 — "ON" DRAIN-SOURCE VOLTAGE



SWITCHING CHARACTERISTICS

(T_A = 25°C)

FIGURE 6 — TURN-ON DELAY TIME

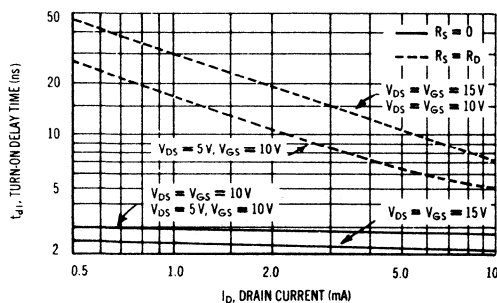


FIGURE 7 — RISE TIME

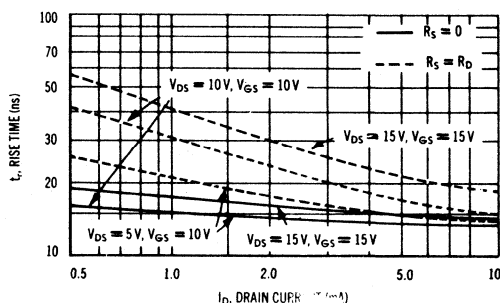


FIGURE 8 — TURN-OFF DELAY TIME

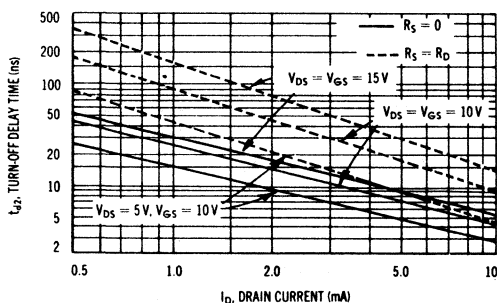


FIGURE 9 — FALL TIME

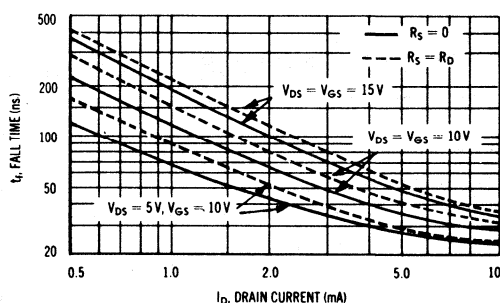


FIGURE 10 — SWITCHING CIRCUIT and WAVEFORMS

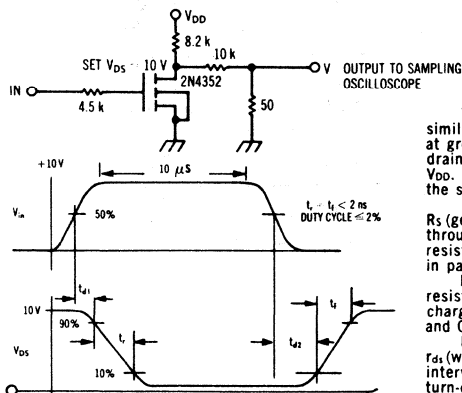
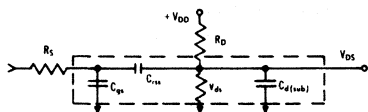


FIGURE 11 — SWITCHING CIRCUIT with MOSFET EQUIVALENT MODEL



The switching characteristics shown above were measured in a test circuit similar to Figure 10. At the beginning of the switching interval, the gate voltage is at ground and the gate-source capacitance ($C_{gs} = C_{iss} - C_{rss}$) has no charge. The drain voltage is at V_{DD} , and thus the feedback capacitance (C_{rss}) is charged to V_{DD} . Similarly, the drain-substrate capacitance ($C_{d(sub)}$) is charged to V_{DD} since the substrate and source are connected to ground.

During the turn-on interval, C_{gs} is charged to V_{GS} (the input voltage) through R_S (generator impedance) (Figure 11). C_{rss} must be discharged to $V_{GS} - V_{D(on)}$ through R_S and the parallel combination of the load resistor (R_D) and the channel resistance (r_{ds}). In addition, $C_{d(sub)}$ is discharged to a low value ($V_{D(on)}$) through R_D in parallel with r_{ds} . During turn-off this charge flow is reversed.

Predicting turn-on time proves to be somewhat difficult since the channel resistance (r_{ds}) is a function of the gate-source voltage (V_{GS}). As C_{gs} becomes charged V_{GS} is approaching V_{in} and r_{ds} decreases (see Figure 4) and since C_{rss} and $C_{d(sub)}$ are charged through r_{ds} , turn-on time is quite non-linear.

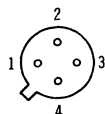
If the charging time of C_{gs} is short compared to that of C_{rss} and $C_{d(sub)}$, then r_{ds} (which is in parallel with R_D) will be low compared to R_D during the switching interval and will largely determine the turn-on time. On the other hand, during turn-off r_{ds} will be almost an open circuit requiring C_{rss} and $C_{d(sub)}$ to be charged through R_D and resulting in a turn-off time that is long compared to the turn-on time. This is especially noticeable for the curves where $R_S = 0$ and C_{gs} is charged through the pulse generator impedance only.

The switching curves shown with $R_S = R_D$ simulate the switching behavior of cascaded stages where the driving source impedance is normally the same as the load impedance. The set of curves with $R_S = 0$ simulates a low source impedance drive such as might occur in complementary logic circuits.

2N4352 (SILICON)



CASE 20-02
(TO-72)



STYLE 2
PIN 1. SOURCE
2. GATE
3. DRAIN
4. SUBSTRATE AND
CASE LEAD

Silicon P-channel MOS field-effect transistor designed for enhancement-mode operation in low-power switching applications. The 2N4352 is complementary with type 2N4351.

MAXIMUM RATINGS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	± 30	Vdc
Drain Current	I_D	30	mAdc
Power Dissipation at $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 1.7	mW mW/ $^\circ\text{C}$
Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	800 4.56	mW mW/ $^\circ\text{C}$
Operating Junction Temperature	T_J	200	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +175	$^\circ\text{C}$

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}\text{C}$ unless otherwise noted)
Substrate connected to source.

Characteristic	Figure No.	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Drain-Source Breakdown Voltage ($I_D = -10\text{ }\mu\text{A}$, $V_{GS} = 0$)	—	$V_{(BR)DSS}$	25	—	Vdc
Gate Leakage Current ($V_{GS} = \pm 30\text{ V}$, $V_{DS} = 0$)	—	I_{GSS}	—	10	pAdc
Zero-Gate Voltage Drain Current ($V_{DS} = -10\text{ V}$, $V_{GS} = 0$)	—	I_{DSS}	—	10	nAdc

ON CHARACTERISTICS

Gate-Source Threshold Voltage ($V_{DS} = -10\text{ V}$, $I_D = -10\text{ }\mu\text{A}$)	—	$V_{GS(TH)}$	1.0	5.0	Vdc
“ON” Drain Current ($V_{GS} = -10\text{ V}$, $V_{DS} = -10\text{ V}$)	3	$I_{D(on)}$	3.0	—	mA
Drain-Source “ON” Voltage ($I_D = -2.0\text{ mA}$, $V_{GS} = -10\text{ V}$)	5	$V_{DS(on)}$	—	1.0	V

SMALL SIGNAL CHARACTERISTICS

Drain-Source Resistance ($V_{GS} = -10\text{ V}$, $I_D = 0$, $f = 1\text{ kHz}$)	4	$r_{ds(on)}$	—	600	ohms
Forward Transfer Admittance ($V_{DS} = -10\text{ V}$, $I_D = 2\text{ mA}$, $f = 1\text{ kHz}$)	1	$ y_{fs} $	1000	—	$\mu\text{ mho}$
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = 0$, $f = 140\text{ kHz}$)	2	C_{rss}	—	1.3	pF
Input Capacitance ($V_{DS} = -10\text{ V}$, $V_{GS} = 0$, $f = 140\text{ kHz}$)	2	C_{iss}	—	5.0	pF
Drain-Substrate Capacitance ($V_{D(SUB)} = -10\text{ V}$, $f = 140\text{ kHz}$)	—	$C_{d(sub)}$	—	4.0	pF

SWITCHING CHARACTERISTICS

Turn-On Delay	$I_D = -2.0\text{ mAdc}$, $V_{DS} = -10\text{ Vdc}$, $V_{GS} = -10\text{ V}$ (See Figure 10, Times Circuit Determined)	6, 10	t_{d1}	—	45	ns
Rise Time		7, 10	t_r	—	65	ns
Turn-Off Delay		8, 10	t_{d2}	—	60	ns
Fall Time		9, 10	t_f	—	100	ns

FIGURE 1 — FORWARD TRANSFER ADMITTANCE

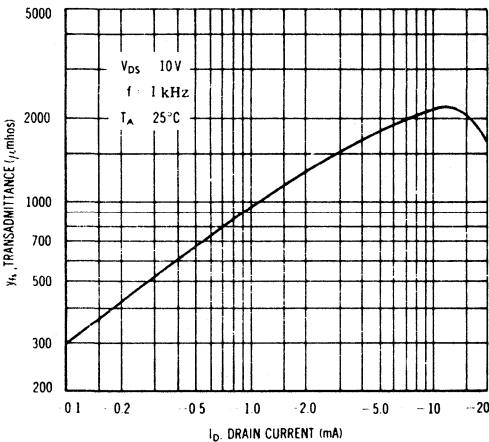


FIGURE 2 — CAPACITANCE

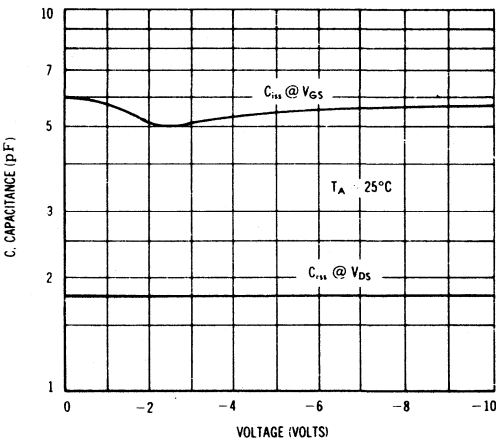


FIGURE 3 — TRANSFER CHARACTERISTICS

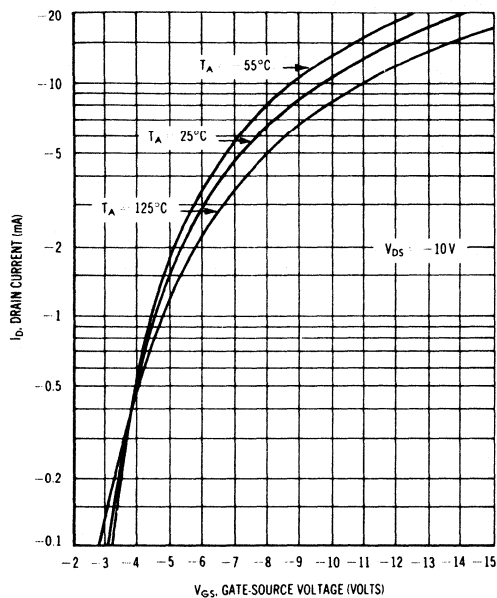


FIGURE 4 — DRAIN SOURCE "ON" RESISTANCE

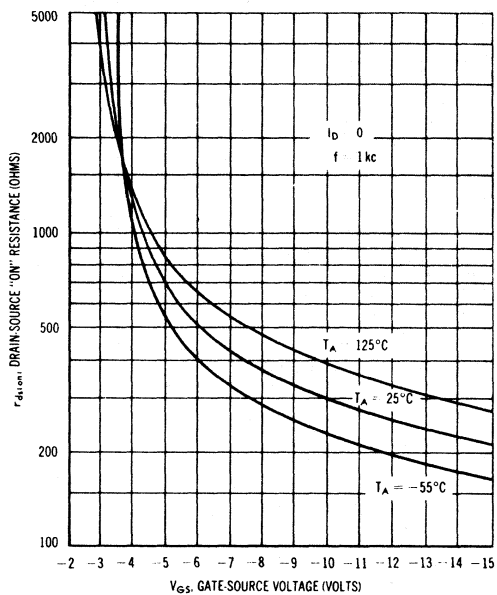
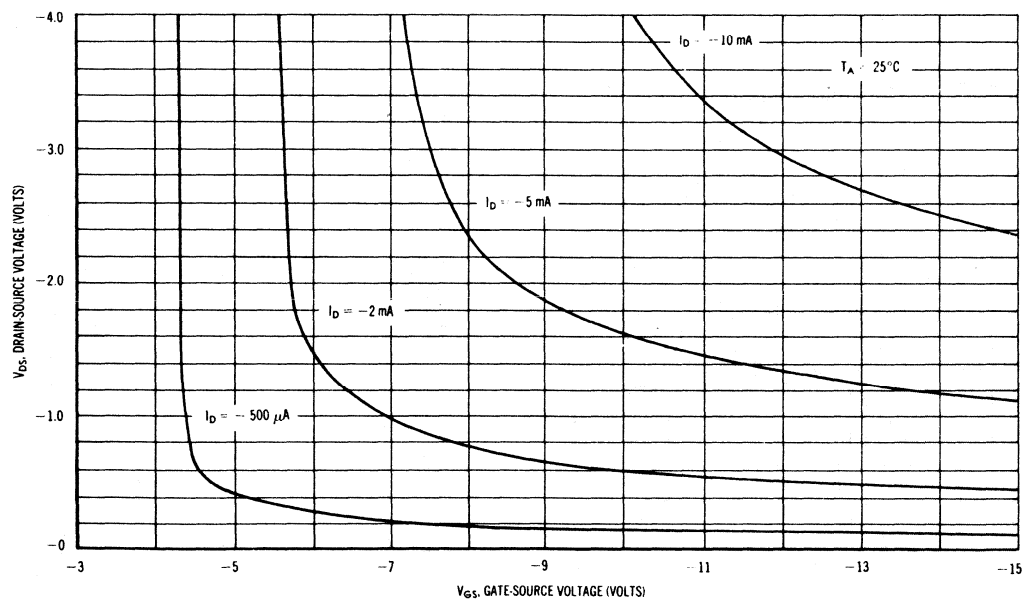


FIGURE 5 — "ON" DRAIN-SOURCE VOLTAGE



SWITCHING CHARACTERISTICS

(T_A = 25°C)

FIGURE 6 — TURN-ON DELAY TIME

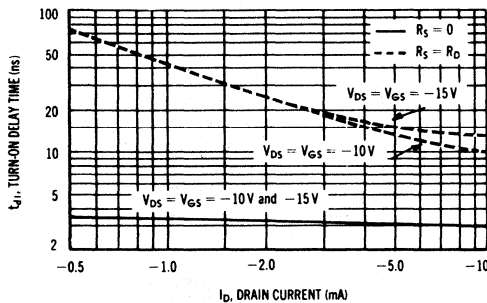


FIGURE 7 — RISE TIME

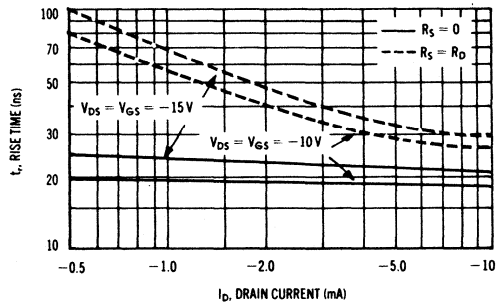


FIGURE 8 — TURN-OFF DELAY TIME

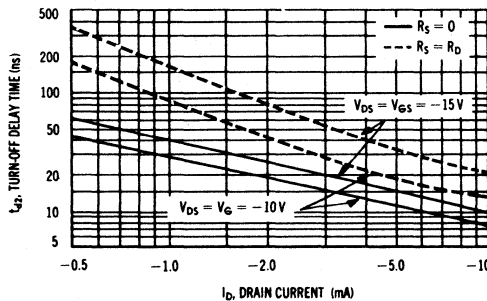


FIGURE 9 — FALL TIME

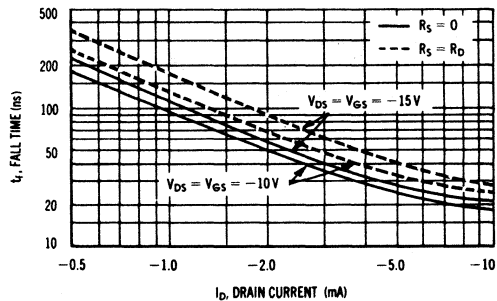
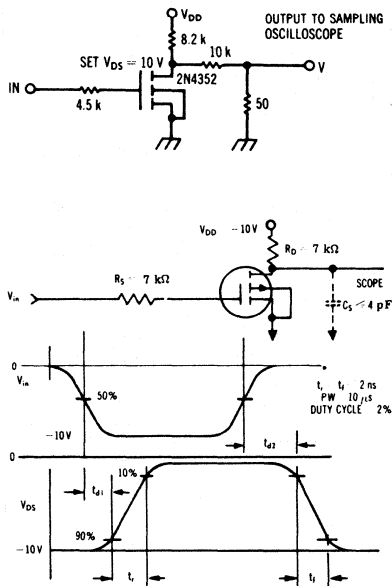


FIGURE 10 — SWITCHING CIRCUIT and WAVEFORMS



The switching characteristics shown above were measured in a test circuit similar to Figure 10. At the beginning of the switching interval, the gate voltage is at ground and the gate-source capacitance ($C_{gs} = C_{in} - C_{rss}$) has no charge. The drain voltage is at V_{DD} , and thus the feedback capacitance (C_{rss}) is charged to V_{DD} . Similarly, the drain-substrate capacitance ($C_{d(sub)}$) is charged to V_{DD} since the substrate and source are connected to ground.

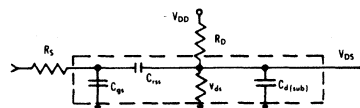
During the turn-on interval, C_{gs} is charged to V_{GS} (the input voltage) through R_S (generator impedance) (Figure 11). C_{rss} must be discharged to $V_{GS} - V_{D(on)}$ through R_S and the parallel combination of the load resistor (R_D) and the channel resistance (r_{ds}). In addition, $C_{d(sub)}$ is discharged to a low value ($V_{D(on)}$) through R_D in parallel with r_{ds} . During turn-off this charge flow is reversed.

Predicting turn-on time proves to be somewhat difficult since the channel resistance (r_{ds}) is a function of the gate-source voltage (V_{GS}). As C_{gs} becomes charged V_{GS} is approaching V_{in} and r_{ds} decreases (see Figure 4) and since C_{rss} and $C_{d(sub)}$ are charged through r_{ds} , turn-on time is quite non-linear.

If the charging time of C_{gs} is short compared to that of C_{rss} and $C_{d(sub)}$, then r_{ds} (which is in parallel with R_D) will be low compared to R_D during the switching interval and will largely determine the turn-on time. On the other hand, during turn-off r_{ds} will be almost an open circuit requiring C_{rss} and $C_{d(sub)}$ to be charged through R_D and resulting in a turn-off time that is long compared to the turn-on time. This is especially noticeable for the curves where $R_S = 0$ and C_{gs} is charged through the pulse generator impedance only.

The switching curves shown with $R_S = R_D$ simulate the switching behavior of cascaded stages where the driving source impedance is normally the same as the load impedance. The set of curves with $R_S = 0$ simulates a low source impedance drive such as might occur in complementary logic circuits.

FIGURE 11 — SWITCHING CIRCUIT with MOSFET EQUIVALENT MODEL



SILICON P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode (Type A) Junction Field-Effect Transistors designed primarily for low-power audio frequency applications

- Forward Transadmittance —
 $|y_{fs}| = 2.0 \text{ mmhos (Min) @ } V_{DS} = -10 \text{ Vdc}$
- Low Reverse Transfer Capacitance —
 $C_{rss} = 5.0 \text{ pF (Max) @ } V_{DS} = -10 \text{ Vdc}$

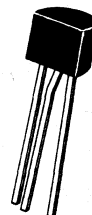
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	-20	Vdc
Drain-Gate Voltage	V_{DG}	-20	Vdc
Reverse Gate-Source Voltage	V_{GSR}	20	Vdc
Gate Current	I_G	50	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	200 2.0	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +125	$^\circ\text{C}$

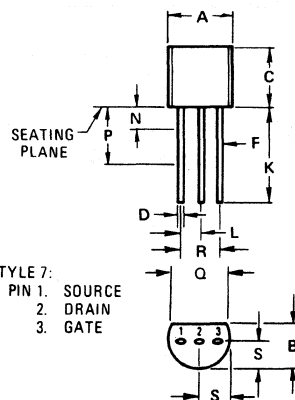
*Indicates JEDEC Registered Data.

P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

(Type A)



Case 29 with leads formed to a TO-18 configuration.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	—	0.500	—
L	1.150	1.390	0.045	0.055
N	—	1.270	—	0.050
P	6.350	—	0.250	—
Q	3.430	—	0.135	—
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 10\ \mu\text{A}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	20	—	Vdc
Gate-Source Cutoff Voltage ($V_{DS} = -10\ \text{Vdc}$, $I_D = 1.0\ \mu\text{A}$)	$V_{GS(off)}$	0.7	10	Vdc
Gate Reverse Current ($V_{GS} = 15\ \text{Vdc}$, $V_{DS} = 0$) ($V_{GS} = 15\ \text{Vdc}$, $V_{DS} = 0$, $T_A = 65^\circ\text{C}$)	I_{GSS}	— —	10 0.5	nA μA
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current (Note 1) ($V_{DS} = -10\ \text{Vdc}$, $V_{GS} = 0$)	I_{DSS}	3.0	30	mA
Gate-Source Voltage ($V_{DS} = -10\ \text{Vdc}$, $I_D = 0.3\ \text{mA}$)	V_{GS}	0.4	9.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Drain-Source "ON" Resistance ($V_{GS} = 0$, $I_D = 0$, $f = 1.0\ \text{kHz}$)	$r_{ds(on)}$	—	700	Ohms
Forward Transadmittance (Note 1) ($V_{DS} = -10\ \text{Vdc}$, $V_{GS} = 0$, $f = 1.0\ \text{kHz}$)	$ y_{fs} $	2000	8000	μmhos
Forward Transconductance ($V_{DS} = -10\ \text{Vdc}$, $V_{GS} = 0$, $f = 1.0\ \text{MHz}$)	$\text{Re}(y_{fs})$	1500	—	μmhos
Output Admittance ($V_{DS} = -10\ \text{Vdc}$, $V_{GS} = 0$, $f = 1.0\ \text{kHz}$)	$ y_{os} $	—	100	μmhos
Input Capacitance ($V_{DS} = -10\ \text{Vdc}$, $V_{GS} = 0$, $f = 1.0\ \text{MHz}$)	C_{iss}	—	20	pF
Reverse Transfer Capacitance ($V_{DS} = -10\ \text{Vdc}$, $V_{GS} = 0$, $f = 1.0\ \text{MHz}$)	C_{rss}	—	5.0	pF
Common-Source Noise Figure ($V_{DS} = -10\ \text{Vdc}$, $I_D = 1.0\ \text{mA}$, $R_G = 1.0\ \text{Megohm}$, $f = 100\ \text{Hz}$)	NF	—	5.0	dB
Equivalent Short-Circuit Input Noise Voltage ($V_{DS} = -10\ \text{Vdc}$, $I_D = 1.0\ \text{mA}$, $f = 100\ \text{Hz}$, BW = 15 Hz)	E_n	—	0.19	$\mu\text{V}/\sqrt{\text{Hz}}$

*Indicates JEDEC Registered Data.

Note 1: Pulse Test: Pulse Width $\leq 630\ \text{ms}$, Duty Cycle $\leq 10\%$.

2N4361 thru 2N4368 PNP (SILICON)

2N4371 thru 2N4378

THYRISTORS SILICON CONTROLLED RECTIFIERS

... designed for high power industrial and consumer applications in power and speed controls such as welders, furnaces, motors, space heaters and other equipment where control of high current is needed.

THYRISTORS PNPN

**110 AMPERES RMS
100 thru 1400 VOLTS****

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*Repetitive Peak Reverse Blocking Voltage	VRRM ⁽¹⁾		Volts
2N4361, 2N4371		100	
2N4362, 2N4372		200	
2N4363, 2N4373		400	
2N4364, 2N4374		600	
2N4365, 2N4375		800	
2N4366, 2N4376		1000	
2N4367, 2N4377		1200	
2N4368, 2N4378		1400	
Non-Repetitive Peak Reverse Blocking Voltage (t ≤ 5.0 ms)	VRSM		Volts
2N4361, 2N4371		200	
2N4362, 2N4372		300	
2N4363, 2N4373		500	
2N4364, 2N4374		700	
2N4365, 2N4375		900	
2N4366, 2N4376		1100	
2N4367, 2N4377		1300	
2N4368, 2N4378		1500	
Forward Current RMS, T _C = 75°C	I _T (RMS)	110	Amp
*Peak Surge Current (One cycle, 60 Hz) (T _J = -40 to +125°C)	I _{TSM}	1600	Amp
Circuit Fusing Considerations (T _J = -40 to +125°C)	I ² t		A ² s
(t = 1.5 ms)		8400	
(t = 8.3 ms)		10,700	
*Peak Gate Power	P _{GFM}	15	Watts
*Average Gate Power	P _{GF(AV)}	3.0	Watt
*Peak Forward Gate Current	I _{GFM}	4.0	Amp
*Peak Reverse Gate Voltage	V _{GRM}	5.0	Volts
*Operating Junction Temperature Range	T _J	-40 to +125	°C
*Storage Temperature Range	T _{stg}	-40 to +150	°C
Stud Torque	—	130	in. lb.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ _{JC}	0.28	°C/W

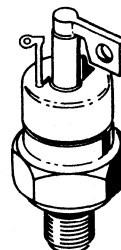
*Indicates JEDEC Registered Data.

**Consult factory for higher and intermediate voltages.

(1) Ratings apply for zero or negative gate voltage. Devices should not be tested for blocking capability in a manner such that the voltage applied exceeds the rated blocking voltage.

(2) Devices should not be operated with a positive bias applied to the gate concurrent with a negative potential applied to the anode.

(3) Reliable operation can be impaired if torque rating is exceeded, terminal tubes bent, or seal broken.



2N4371
SERIES
CASE 246
TO-83

2N4361
SERIES
CASE 219
TO-94

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
*Peak Forward Blocking Voltage ($T_J = 125^\circ\text{C}$)	$V_{DRM}^{(1)}$				Volts
2N4361, 2N4371		100	—	—	
2N4362, 2N4372		200	—	—	
2N4363, 2N4373		400	—	—	
2N4364, 2N4374		600	—	—	
2N4365, 2N4375		800	—	—	
2N4366, 2N4376		1000	—	—	
2N4367, 2N4377		1200	—	—	
2N4368, 2N4378		1400	—	—	
*Peak Forward Blocking Current (Rated V_{DRM} , with gate open, $T_J = 125^\circ\text{C}$)	I_{DRM}	—	—	10	mA
*Peak Reverse Blocking Current (Rated V_{RRM} , with gate open, $T_J = 125^\circ\text{C}$)	I_{RRM}	—	—	10	mA
Forward "On" Voltage ($I_T = 50$ A Peak, $T_J = 25^\circ\text{C}$)	V_T	—	—	1.6	Volts
Forward "On" Voltage ($I_{TM} = 500$ A Peak, $T_J = 25^\circ\text{C}$)	V_{TM}	—	—	2.5	Volts
Gate Trigger Current (Anode Voltage = 12 V, $R_L = 3.0$ ohms)	I_{GT}	—	—	200	mA
Gate Trigger Voltage (Anode Voltage = 12 V, $R_L = 3.0$ ohms)	V_{GT}	—	—	3.0	Volts
Holding Current (Anode Voltage = 12 V, gate open, $T_J = 125^\circ\text{C}$)	I_H	—	30	—	mA
*Non-Trigging Gate Voltage (Anode Voltage = Rated V_{DM} , $R_L = 100$ ohms, $T_J = 125^\circ\text{C}$)	V_{GD}	—	—	0.15	Volts
Turn-Off Time ($I_{TM} = 50$ A, $I_R = 20$ A, $T_J = 125^\circ\text{C}$)	t_q	—	40	—	μs
*Forward Voltage Application Rate (Exponential to V_{DRM})	dv/dt	100	—	—	V/ μs

* Indicates JEDEC Registered Data.

(1) Ratings apply for zero or negative gate voltage. Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

DERATING AND DISSIPATION FOR RESISTIVE AND INDUCTIVE LOADS ($f = 50$ to 400 Hz, SQUARE WAVE)

FIGURE 1 — CURRENT DERATING

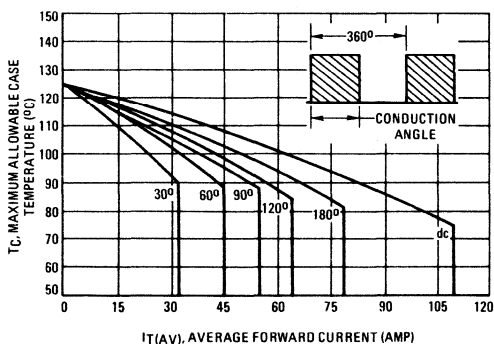
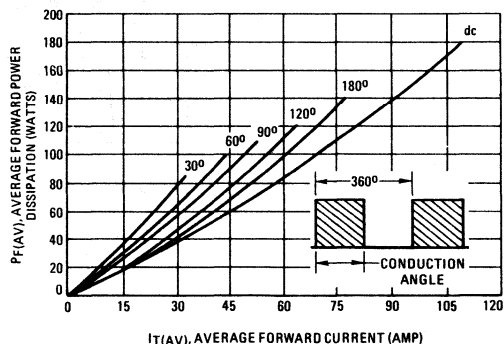


FIGURE 2 — FORWARD POWER DISSIPATION



DERATING AND DISSIPATION FOR RESISTIVE AND INDUCTIVE
LOADS (f = 50 to 400 Hz, SINE WAVE)

FIGURE 3 – CURRENT DERATING

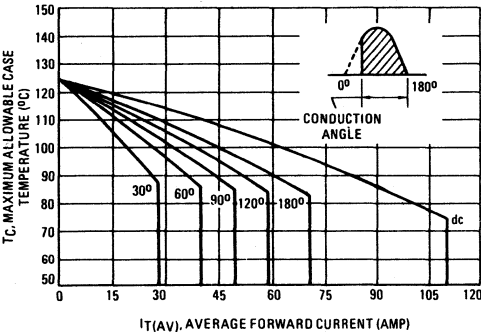


FIGURE 4 – FORWARD POWER DISSIPATION

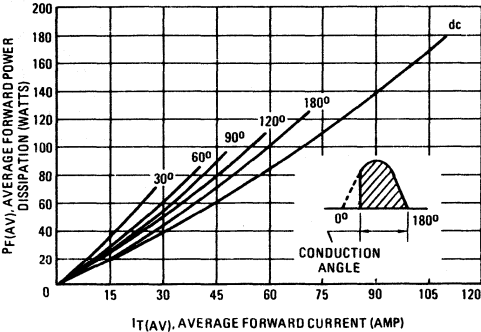
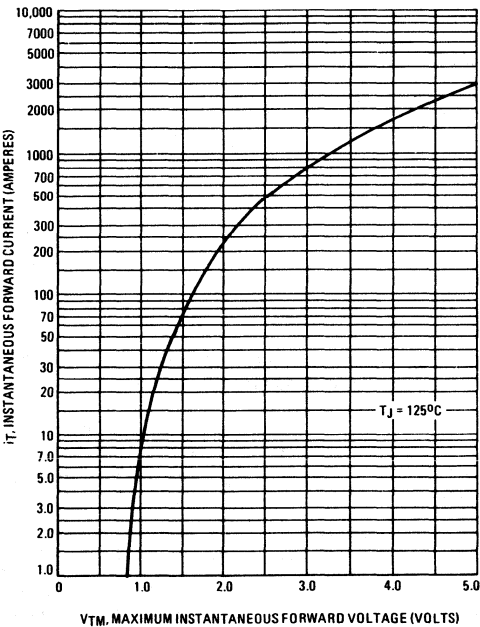
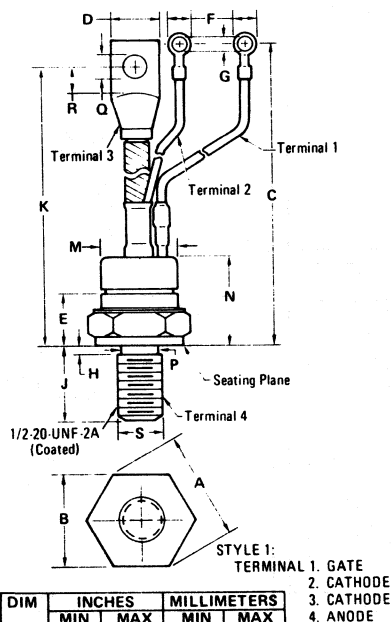


FIGURE 5 – FORWARD CONDUCTION CHARACTERISTIC



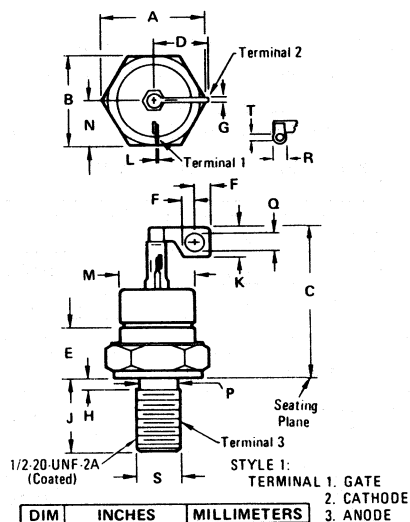
2N4361 thru 2N4368/2N4371 thru 2N4378 (continued)



DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	—	1.227	—	31.160
B	1.031	1.063	26.190	27.000
C	6.850	7.500	174.000	190.500
D	0.437	0.650	11.100	16.500
E	0.170	0.500	4.400	12.700
F	0.215	0.300	5.490	7.620
G	0.140	0.150	3.560	3.810
H	—	0.125	—	3.170
J	0.797	0.827	20.250	21.000
K	5.775	6.265	146.700	159.100
M	—	1.031	—	26.180
N	—	2.500	—	63.500
P	0.425	0.499	10.800	12.670
Q	0.260	0.310	6.610	7.870
R	0.250	—	6.350	—
S	0.4619	0.4675	11.733	11.874

All JEDEC dimensions and notes apply

CASE 219
TO-94



DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	—	1.227	—	31.160
B	1.031	1.063	26.190	27.000
C	—	1.810	—	45.970
D	—	0.650	—	16.510
E	0.170	0.500	4.320	12.700
F	0.180	—	4.580	—
G	0.060	0.115	1.530	2.920
H	—	0.125	—	3.170
J	0.797	0.827	20.250	21.000
K	0.360	0.470	9.200	11.900
L	0.012	0.050	0.310	1.270
M	—	1.031	—	26.180
N	—	0.575	—	14.600
P	0.425	0.499	10.800	12.670
Q	0.180	0.260	4.580	6.600
R	0.115	0.160	2.930	4.060
S	0.4619	0.4675	11.733	11.874
T	0.060	0.080	1.530	2.030

All JEDEC dimensions and notes apply

CASE 246
TO-83

2N4391 (SILICON)

2N4392

2N4393

SILICON N-CHANNEL JUNCTION FIELD EFFECT TRANSISTORS

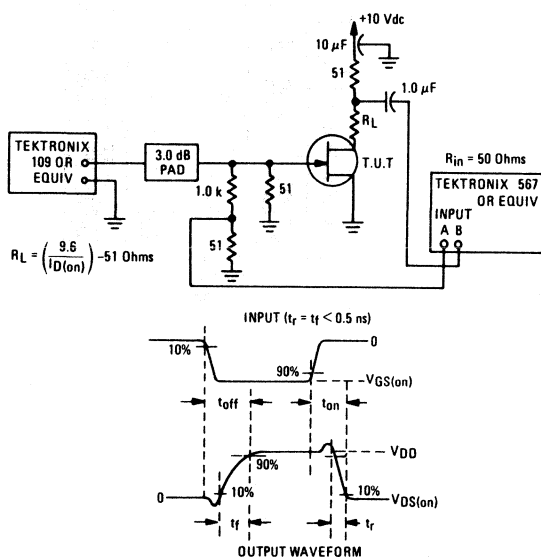
Depletion Mode (Type A) Junction Field-Effect Transistors designed for chopper and high-speed switching applications.

- Low Drain-Source "On" Resistance –
 $r_{ds(on)} = 30 \text{ Ohms (Max) @ } f = 1.0 \text{ kHz (2N4391)}$
- Low Gate Reverse Current –
 $I_{GSS} = 0.1 \text{ nAdc (Max) @ } V_{GS} = 20 \text{ Vdc}$
- Guaranteed Switching Characteristics

MAXIMUM RATINGS

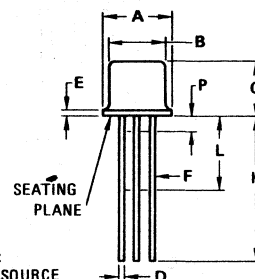
Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Gate-Source Voltage	V_{GS}	40	Vdc
Forward Gate Current	$I_{G(f)}$	50	mAdc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.8 10	Watts mW/ $^\circ\text{C}$
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



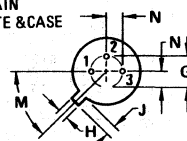
N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

(Type A)



STYLE 4:

- PIN 1. SOURCE
- PIN 2. DRAIN
- PIN 3. GATE & CASE



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	—	0.762	—	0.030
F	0.406	0.483	0.016	0.019
G	2.54	BSC	0.100	BSC
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45.0	BSC	45.0	BSC
N	1.27	BSC	0.050	BSC
P	—	1.27	—	0.050

All JEDEC notes and dimensions apply.

CASE 22-03
(TO-18)

2N4391, 2N4392, 2N4393 (continued)

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 1.0 \mu\text{A}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	40	-	Vdc
Gate-Source Forward Voltage ($I_G = 1.0 \text{ mA}$, $V_{DS} = 0$)	$V_{GS(f)}$	-	1.0	Vdc
Gate-Source Voltage ($V_{DS} = 20 \text{ Vdc}$, $I_D = 1.0 \text{ nA}$)	V_{GS}	4.0 2.0 0.5	10 5.0 3.0	Vdc
Gate Reverse Current ($V_{GS} = 20 \text{ Vdc}$, $V_{DS} = 0$) ($V_{GS} = 20 \text{ Vdc}$, $V_{DS} = 0$, $T_A = 150^\circ\text{C}$)	I_{GSS}	- -	0.1 0.2	nAdc μAdc
Drain-Cutoff Current ($V_{DS} = 20 \text{ Vdc}$, $V_{GS} = 12 \text{ Vdc}$) ($V_{DS} = 20 \text{ Vdc}$, $V_{GS} = 7.0 \text{ Vdc}$) ($V_{DS} = 20 \text{ Vdc}$, $V_{GS} = 5.0 \text{ Vdc}$) ($V_{DS} = 20 \text{ Vdc}$, $V_{GS} = 12 \text{ Vdc}$, $T_A = 150^\circ\text{C}$) ($V_{DS} = 20 \text{ Vdc}$, $V_{GS} = 7.0 \text{ Vdc}$, $T_A = 150^\circ\text{C}$) ($V_{DS} = 20 \text{ Vdc}$, $V_{GS} = 5.0 \text{ Vdc}$, $T_A = 150^\circ\text{C}$)	$I_{D(off)}$	- - - - - -	0.1 0.1 0.1 0.2 0.2 0.2	nAdc μAdc
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current (1) ($V_{DS} = 20 \text{ Vdc}$, $V_{GS} = 0$)	I_{DSS}	50 25 5.0	150 75 30	mAdc
Drain-Source "ON" Voltage ($I_D = 12 \text{ mAdc}$, $V_{GS} = 0$) ($I_D = 6.0 \text{ mAdc}$, $V_{GS} = 0$) ($I_D = 3.0 \text{ mAdc}$, $V_{GS} = 0$)	$V_{DS(on)}$	- - -	0.4 0.4 0.4	Vdc
Static Drain-Source "ON" Resistance ($I_D = 1.0 \text{ mAdc}$, $V_{GS} = 0$)	$r_{DS(on)}$	- - -	30 60 100	Ohms
SMALL-SIGNAL CHARACTERISTICS				
Drain-Source "ON" Resistance ($V_{GS} = 0$, $I_D = 0$, $f = 1.0 \text{ kHz}$)	$r_{ds(on)}$	- - -	30 60 100	Ohms
Input Capacitance ($V_{DS} = 20 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{iss}	-	14	pF
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = 12 \text{ Vdc}$, $f = 1.0 \text{ MHz}$) ($V_{DS} = 0$, $V_{GS} = 7.0 \text{ Vdc}$, $f = 1.0 \text{ MHz}$) ($V_{DS} = 0$, $V_{GS} = 5.0 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)	C_{rss}	- - -	3.5 3.5 3.5	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (See Figure 1) ($I_{D(on)} = 12 \text{ mAdc}$) ($I_{D(on)} = 6.0 \text{ mAdc}$) ($I_{D(on)} = 3.0 \text{ mAdc}$)	t_{on}	- - -	15 15 15	ns
Rise Time (See Figure 1) ($I_{D(on)} = 12 \text{ mAdc}$) ($I_{D(on)} = 6.0 \text{ mAdc}$) ($I_{D(on)} = 3.0 \text{ mAdc}$)	t_r	- - -	5.0 5.0 5.0	ns
Turn-Off Time (See Figure 1) ($V_{GS(off)} = 12 \text{ Vdc}$) ($V_{GS(off)} = 7.0 \text{ Vdc}$) ($V_{GS(off)} = 5.0 \text{ Vdc}$)	t_{off}	- - -	20 35 50	ns
Fall Time (See Figure 1) ($V_{GS(off)} = 12 \text{ Vdc}$) ($V_{GS(off)} = 7.0 \text{ Vdc}$) ($V_{GS(off)} = 5.0 \text{ Vdc}$)	t_f	- - -	15 20 30	ns

(1) Pulse Test: Pulse Width $\leq 100 \mu\text{s}$, Duty Cycle $\leq 1.0\%$.

2N4398 PNP (SILICON)

2N4399

2N5745

PNP SILICON HIGH-POWER TRANSISTORS

... designed for use in power amplifier and switching circuits; serves as direct replacements for Germanium high-power devices.

- Low Collector-Emitter Saturation Voltage —
 $V_{CE(sat)} = 1.0 \text{ Vdc (Max) @ } I_C = 15 \text{ Adc (2N4398, 2N4399)}$
- DC Current Gain Specified — 1.0 to 30 Adc
- Complements to NPN 2N5301, 2N5302, 2N5303

*MAXIMUM RATINGS

Rating	Symbol	2N4398	2N4399	2N5745	Unit
Collector-Emitter Voltage	V_{CE0}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current — Continuous Peak	I_C	30 50	30 50	20 50	Adc
Base Current — Continuous Peak	I_B	7.5 15			Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ *** Derate above 25°C	P_D	5.0 28.6			Watts mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	200 1.15			Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			°C

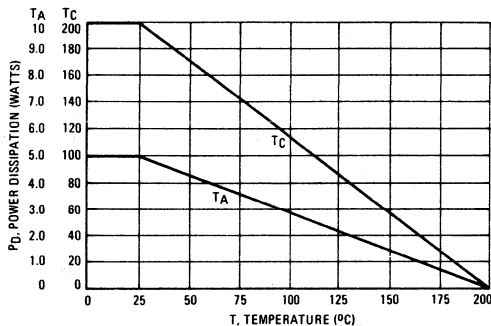
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.875	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	35	°C/W

*Indicates JEDEC Registered Data

**Motorola guarantees this data in addition to JEDEC Registered Data.

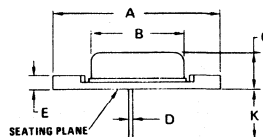
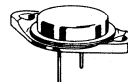
FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 13. All limits are applicable and must be observed.

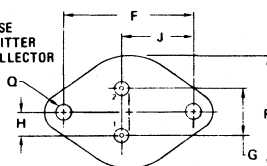
20, 30 AMPERE POWER TRANSISTORS PNP SILICON

40-60-80 VOLTS
200 WATTS



STYLE 1:

PIN 1: BASE
2: EMITTER
CASE - COLLECTOR



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	—	39.37	—	1.550
B	—	21.08	—	0.830
C	—	7.62	—	0.300
D	1.22	1.32	0.048	0.052
E	—	3.43	—	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	—	26.67	—	1.050

CASE 12-01

2N4398, 2N4399, 2N5745 (continued)

* ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) ($I_C = 200 \text{ mA dc}$, $I_B = 0$)	$V_{CEO(sus)}$	40 60 80	— — —	Vdc
Collector Cutoff Current ($V_{CE} = 40 \text{ Vdc}$, $I_B = 0$) ($V_{CE} = 60 \text{ Vdc}$, $I_B = 0$) ($V_{CE} = 80 \text{ Vdc}$, $I_B = 0$)	I_{CEO}	— — —	5.0 5.0 5.0	mA dc
Collector Cutoff Current ($V_{CE} = 40 \text{ Vdc}$, $V_{BE(off)} = 1.5 \text{ Vdc}$) ($V_{CE} = 60 \text{ Vdc}$, $V_{BE(off)} = 1.5 \text{ Vdc}$) ($V_{CE} = 80 \text{ Vdc}$, $V_{BE(off)} = 1.5 \text{ Vdc}$) ($V_{CE} = 30 \text{ Vdc}$, $V_{BE(off)} = 1.5 \text{ Vdc}$, $T_C = 150^\circ\text{C}$) ($V_{CE} = 80 \text{ Vdc}$, $V_{BE(off)} = 1.5 \text{ Vdc}$, $T_C = 150^\circ\text{C}$)	I_{CEX}	— — — — —	5.0 5.0 5.0 10 10	mA dc
Collector Cutoff Current ($V_{CB} = 40 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 60 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 80 \text{ Vdc}$, $I_E = 0$)	I_{CBO}	— — —	1.0 1.0 1.0	mA dc
Emitter Cutoff Current ($V_{EB} = 5.0 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	5.0	mA dc
ON CHARACTERISTICS				
DC Current Gain(1) ($I_C = 1.0 \text{ A dc}$, $V_{CE} = 2.0 \text{ Vdc}$) ($I_C = 10 \text{ A dc}$, $V_{CE} = 2.0 \text{ Vdc}$) ($I_C = 15 \text{ A dc}$, $V_{CE} = 2.0 \text{ Vdc}$) ($I_C = 20 \text{ A dc}$, $V_{CE} = 2.0 \text{ Vdc}$) ($I_C = 30 \text{ A dc}$, $V_{CE} = 4.0 \text{ Vdc}$)	All Types 2N5745 2N4398, 2N4399 2N5745 2N4398, 2N4399	h_{FE}	40 15 15 5.0 5.0	— — 60 60 —
Collector-Emitter Saturation Voltage(1) ($I_C = 10 \text{ A dc}$, $I_B = 1.0 \text{ A dc}$) ($I_C = 15 \text{ A dc}$, $I_B = 1.5 \text{ A dc}$) ($I_C = 20 \text{ A dc}$, $I_B = 2.0 \text{ A dc}$) ($I_C = 20 \text{ A dc}$, $I_B = 4.0 \text{ A dc}$) ($I_C = 30 \text{ A dc}$, $I_B = 6.0 \text{ A dc}$)	2N4398, 2N4399 2N5745 2N4398, 2N4399 2N5745 2N4398, 2N4399 2N5745	$V_{CE(sat)}$	— — — — —	0.75 1.0 1.0 1.5 2.0 2.0 4.0
Base-Emitter Saturation Voltage(1) ($I_C = 10 \text{ A dc}$, $I_B = 1.0 \text{ A dc}$)* ($I_C = 15 \text{ A dc}$, $I_B = 1.5 \text{ A dc}$) ($I_C = 20 \text{ A dc}$, $I_B = 2.0 \text{ A dc}$)* ($I_C = 20 \text{ A dc}$, $I_B = 4.0 \text{ A dc}$)	2N4398, 2N4399 2N5745 2N4398, 2N4399 2N5745 2N4398, 2N4399 2N5745	$V_{BE(sat)}$	— — — — —	1.6 1.7 1.85 2.0 2.5 2.5
Base-Emitter On Voltage(1) ($I_C = 10 \text{ A dc}$, $V_{CE} = 2.0 \text{ Vdc}$) ($I_C = 15 \text{ A dc}$, $V_{CE} = 2.0 \text{ Vdc}$) ($I_C = 20 \text{ A dc}$, $V_{CE} = 4.0 \text{ Vdc}$) ($I_C = 30 \text{ A dc}$, $V_{CE} = 4.0 \text{ Vdc}$)	2N5745 2N4398, 2N4399 2N5745 2N4398, 2N4399	$V_{BE(on)}$	— — — —	1.5 1.7 2.5 3.0
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product(2) ($I_C = 1.0 \text{ A dc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)	2N4398, 2N4399 2N5745	f_T	4.0 2.0	— — MHz
Small-Signal Current Gain ($I_C = 1.0 \text{ A dc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)		h_{fe}	40	— —
SWITCHING CHARACTERISTICS (See Figures 2 and 3)				
Rise Time ($V_{CC} = 30 \text{ Vdc}$, $I_C = 10 \text{ A dc}$, $I_{B1} = I_{B2} = 1.0 \text{ A dc}$)	2N4398, 2N4399 2N5745	t_r	— —	0.4 1.0 μs
Storage Time	2N4398, 2N4399 2N5745	t_s	— —	1.5 2.0 μs
Fall Time	2N4398, 2N4399 2N5745	t_f	— —	0.6 1.0 μs

* Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

** Motorola Guarantees this Data in Addition to JEDEC Registered Data. (2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 2 – TURN-ON TIME

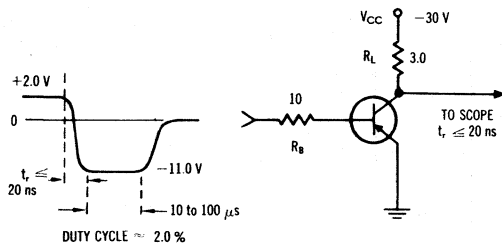
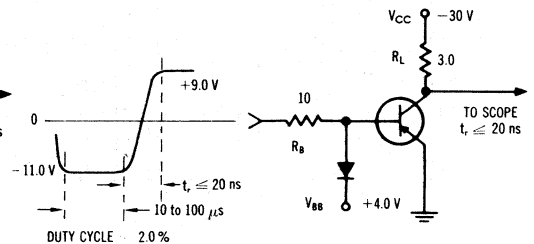


FIGURE 3 – TURN-OFF TIME



FOR CURVES OF FIGURES 5 & 6, R_B , R_L , & V_{CC} ARE VARIED.
INPUT LEVELS ARE APPROXIMATELY AS SHOWN.

TYPICAL TRANSIENT CHARACTERISTICS

FIGURE 4 – CAPACITANCES

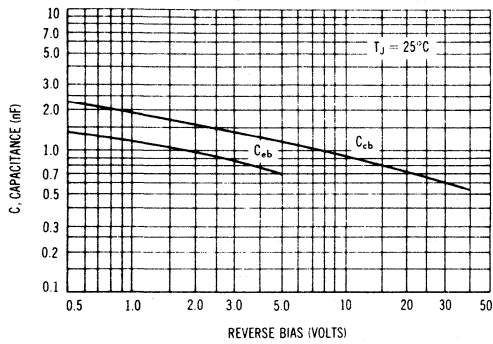


FIGURE 5 – TURN-ON TIME

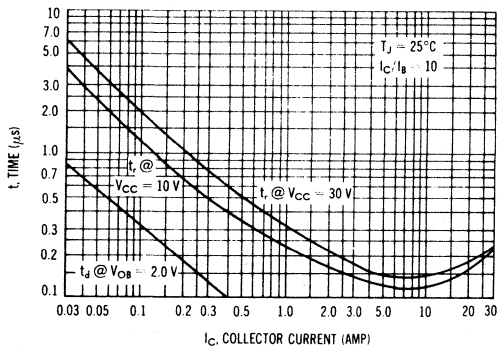
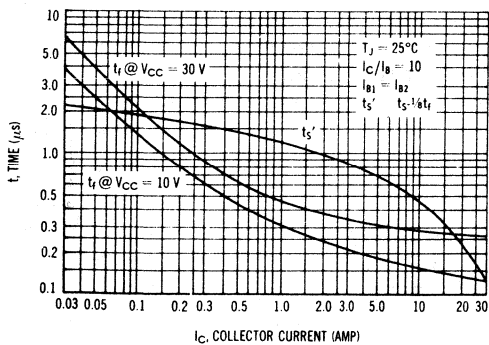


FIGURE 6 – TURN-OFF TIME



TYPICAL "OFF" REGION CHARACTERISTICS

FIGURE 7 – TRANSCONDUCTANCE

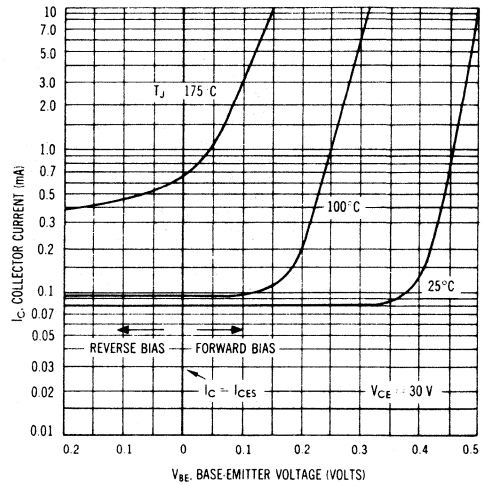
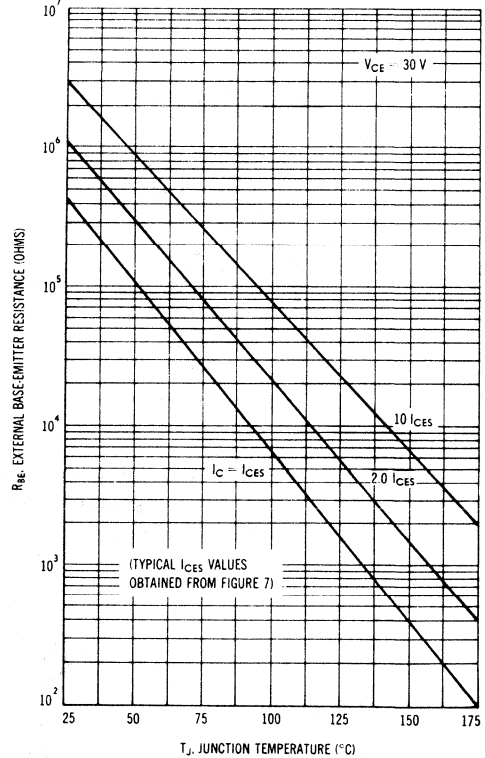


FIGURE 8 – EFFECT OF BASE-EMITTER RESISTANCE



TYPICAL "ON" REGION CHARACTERISTICS

FIGURE 9 – DC CURRENT GAIN

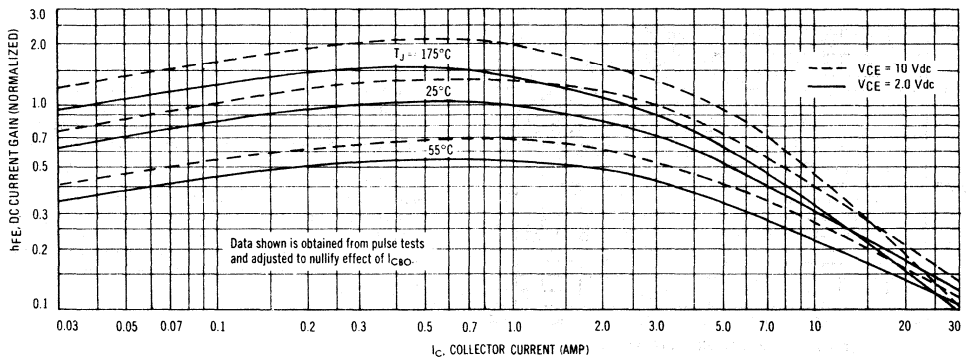


FIGURE 10 – COLLECTOR SATURATION REGION

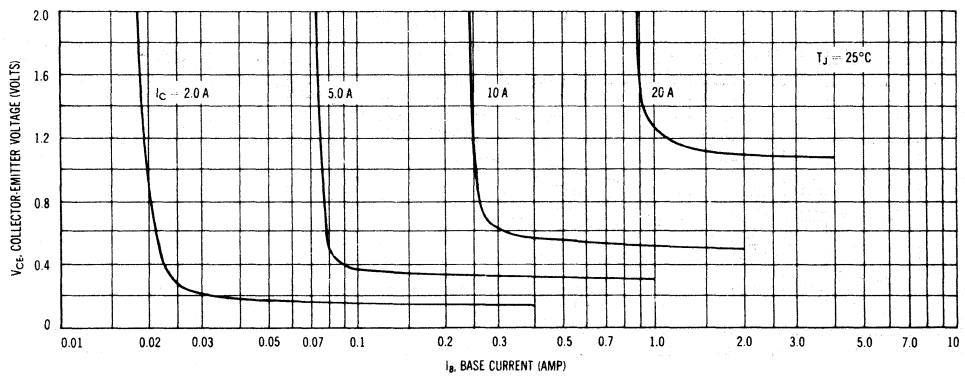


FIGURE 11 – "ON" VOLTAGES

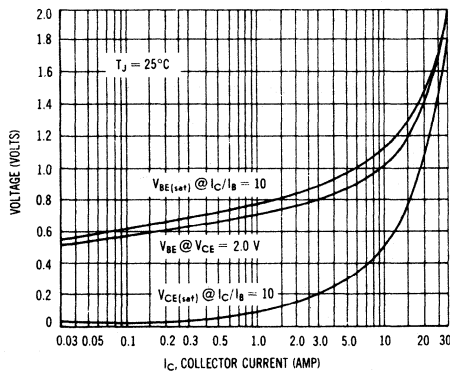
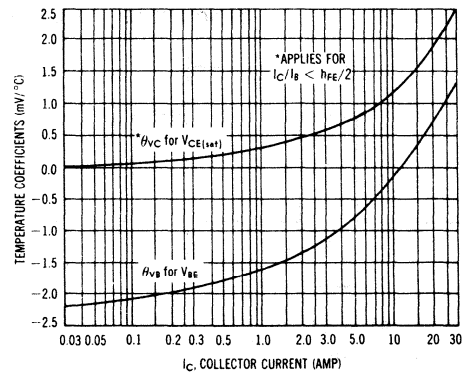
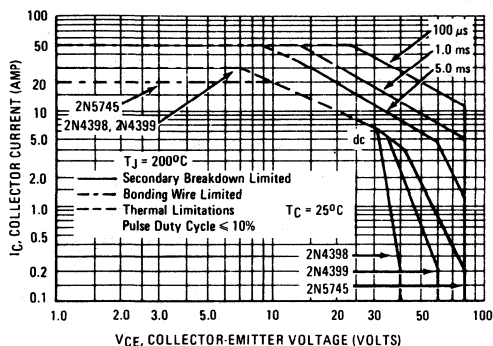


FIGURE 12 – TEMPERATURE COEFFICIENTS



RATINGS AND THERMAL DATA

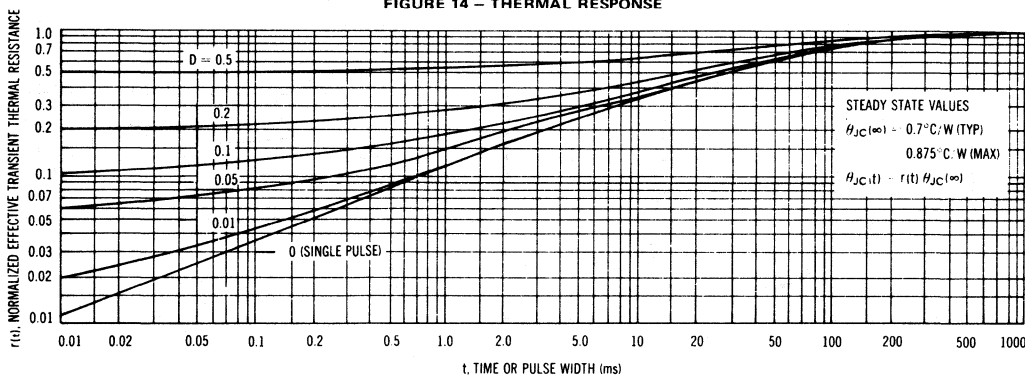
FIGURE 13 – ACTIVE-REGION SAFE OPERATING AREA



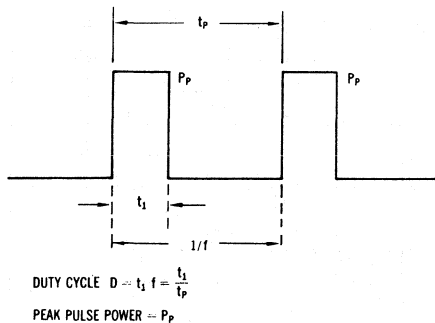
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 13 is based on $T_{J(pk)} = 200^\circ\text{C}$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200^\circ\text{C}$. $T_{J(pk)}$ may be calculated from the data in Figure 14. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 14 – THERMAL RESPONSE



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA



A train of periodical power pulses can be represented by the model as shown in Figure A. Using the model and the device thermal response, the normalized effective transient thermal resistance of Figure 14 was calculated for various duty cycles.

To find $\theta_{JC}(t)$, multiply the value obtained from Figure 14 by the steady state value $\theta_{JC}(\infty)$.

Example:

The 2N4398 is dissipating 100 watts under the following conditions:
 $t_1 = 1.0$ ms, $t_p = 5.0$ ms. ($D = 0.2$)

Using Figure 14, at a pulse width of 1.0 ms and $D = 0.2$, the reading of $r(t)$ is 0.28.

The peak rise in junction temperature is therefore

$$\Delta T = r(t) \times P_p \times \theta_{JC}(\infty) = 0.28 \times 100 \times 0.875 = 24.5^\circ\text{C}$$

2N4400 (SILICON)

2N4401

NPN SILICON ANNULAR TRANSISTORS

... designed for general-purpose switching and amplifier applications and for complementary circuitry with types 2N4402 and 2N4403.

- Collector-Emitter Breakdown Voltage –
BVCEO = 40 Vdc (Min) @ IC = 1.0 mAdc
- Current Gain Specified from 0.1 mAdc to 500 mAdc
- Complete Switching and Amplifier Specifications
- Collector-Base Capacitance –
Ccb = 6.5 pF (Max) @ VCB = 5.0 Vdc

NPN SILICON SWITCHING AND AMPLIFIER TRANSISTORS



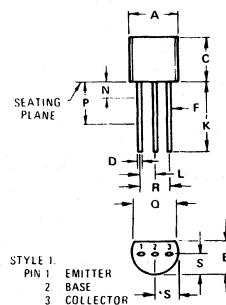
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	VCEO	40	Vdc
Collector-Base Voltage	VCB	60	Vdc
Emitter-Base Voltage	VEB	6.0	Vdc
Collector Current – Continuous	IC	600	mAdc
Total Power Dissipation @ TA = 25°C Derate above 25°C	PD	350 2.8	mW mW/°C
Total Power Dissipation @ TC = 25°C Derate above 25°C	PD	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	TJ, Tstg	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	RθJA	357	°C/W
Thermal Resistance, Junction to Case	RθJC	125	°C/W

*Indicates JEDEC Registered Data.



DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	6.350	–	0.250	0.050
P	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29
TO-92

2N4400, 2N4401 (continued)

* ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
----------------	--------	-----	-----	------

OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (1) ($I_C = 1 \text{ mAdc}$, $I_B = 0$)	BV_{CEO}	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1 \text{ mAdc}$, $I_E = 0$)	BV_{CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1 \text{ mAdc}$, $I_C = 0$)	BV_{EBO}	6.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 35 \text{ Vdc}$, $V_{EB}(\text{off}) = 0.4 \text{ Vdc}$)	I_{CEV}	—	0.1	μA
Base Cutoff Current ($V_{CE} = 35 \text{ Vdc}$, $V_{EB}(\text{off}) = 0.4 \text{ Vdc}$)	I_{BEV}	—	0.1	μA

ON CHARACTERISTICS (1)

DC Current Gain ($I_C = 0.1 \text{ mAdc}$, $V_{CE} = 1 \text{ Vdc}$)	2N4401	h_{FE}	20	—	—
($I_C = 1 \text{ mAdc}$, $V_{CE} = 1 \text{ Vdc}$)	2N4400 2N4401		20 40	— —	
($I_C = 10 \text{ mAdc}$, $V_{CE} = 1 \text{ Vdc}$)	2N4400 2N4401		40 80	— —	
($I_C = 150 \text{ mAdc}$, $V_{CE} = 1 \text{ Vdc}$)	2N4400 2N4401		50 100	150 300	
($I_C = 500 \text{ mAdc}$, $V_{CE} = 2 \text{ Vdc}$)	2N4400 2N4401		20 40	— —	
Collector-Emitter Saturation Voltage ($I_C = 150 \text{ mAdc}$, $I_B = 15 \text{ mAdc}$) ($I_C = 500 \text{ mAdc}$, $I_B = 50 \text{ mAdc}$)		$V_{CE(\text{sat})}$	— —	0.4 0.75	Vdc
Base-Emitter Saturation Voltage ($I_C = 150 \text{ mAdc}$, $I_B = 15 \text{ mAdc}$) ($I_C = 500 \text{ mAdc}$, $I_B = 50 \text{ mAdc}$)		$V_{BE(\text{sat})}$	0.75 —	0.95 1.2	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 20 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 100 \text{ MHz}$)	2N4400 2N4401	f_T	200 250	—	MHz
Collector-Base Capacitance ($V_{CB} = 5.0 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)		C_{cb}	—	6.5	pF
Emitter-Base Capacitance ($V_{BE} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 100 \text{ kHz}$)		C_{eb}	—	30	pF
Input Impedance ($I_C = 1 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1 \text{ kHz}$)	2N4400 2N4401	h_{ie}	0.5 1.0	7.5 15	k ohms
Voltage Feedback Ratio ($I_C = 1 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1 \text{ kHz}$)		h_{re}	0.1	8.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1 \text{ kHz}$)	2N4400 2N4401	h_{fe}	20 40	250 500	—
Output Admittance ($I_C = 1 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1 \text{ kHz}$)		h_{oe}	1.0	30	μmhos

SWITCHING CHARACTERISTICS

Delay Time	$V_{CC} = 30 \text{ Vdc}$, $V_{EB}(\text{off}) = 2 \text{ Vdc}$, $I_C = 150 \text{ mAdc}$, $I_{B1} = 15 \text{ mAdc}$	t_d	—	15	ns
Rise Time		t_r	—	20	ns
Storage Time	$V_{CC} = 30 \text{ Vdc}$, $I_C = 150 \text{ mAdc}$, $I_{B1} = I_{B2} = 15 \text{ mAdc}$	t_s	—	225	ns
Fall Time		t_f	—	30	ns

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

*Indicates JEDEC Registered Data

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 — TURN-ON TIME

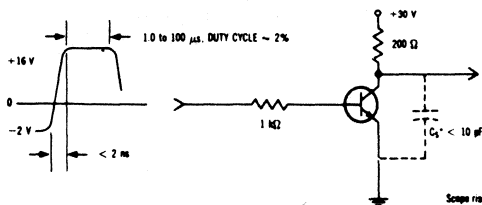
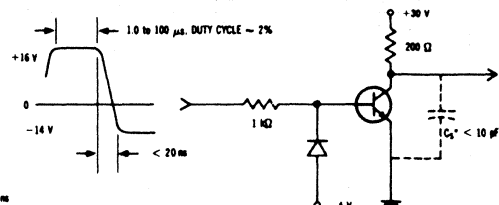


FIGURE 2 — TURN-OFF TIME



TRANSIENT CHARACTERISTICS

— 25°C - - - 100°C

FIGURE 3 — CAPACITANCES

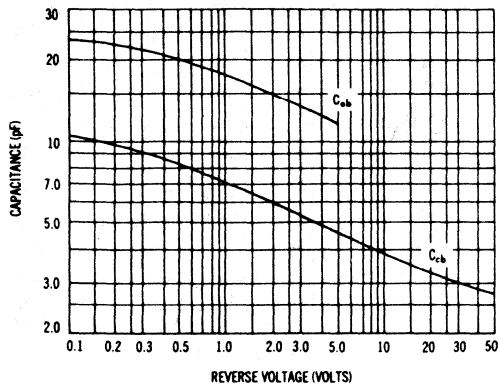


FIGURE 4 — CHARGE DATA

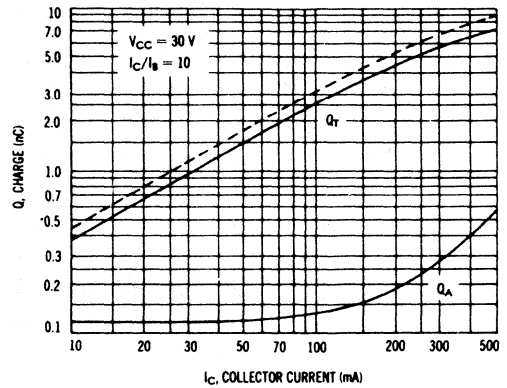


FIGURE 5 — TURN-ON TIME

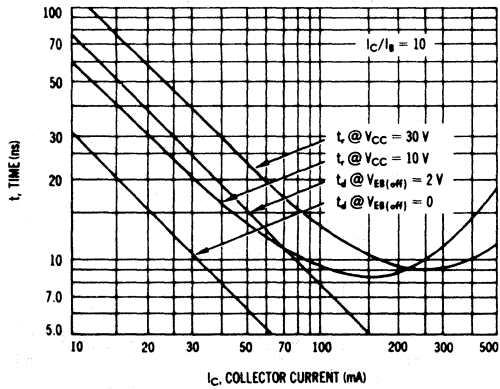


FIGURE 6 — RISE AND FALL TIMES

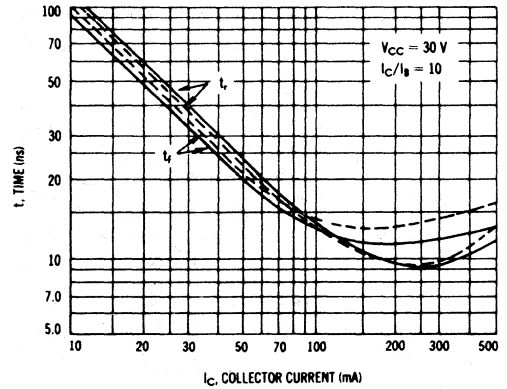


FIGURE 7 — STORAGE TIME

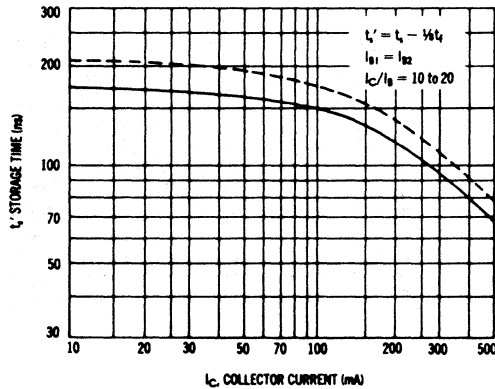
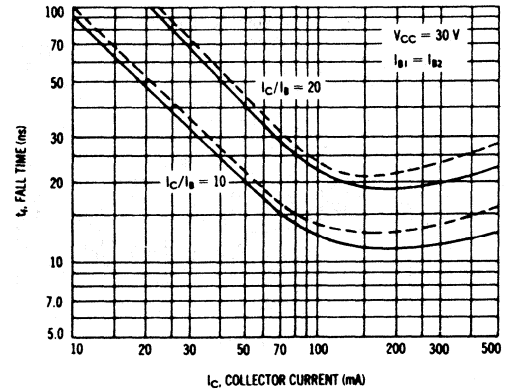


FIGURE 8 — FALL TIME



SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

$V_{CE} = 10 \text{ Vdc}$, $T_A = 25^\circ\text{C}$

Bandwidth = 1.0 Hz

FIGURE 9 — FREQUENCY EFFECTS

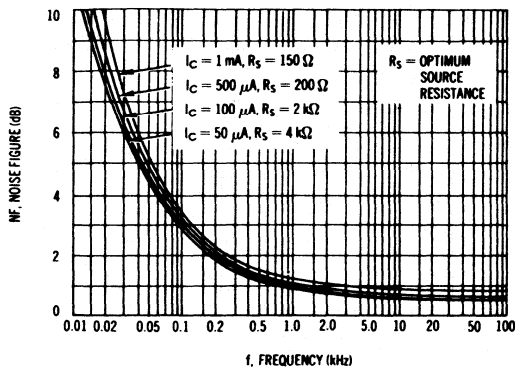
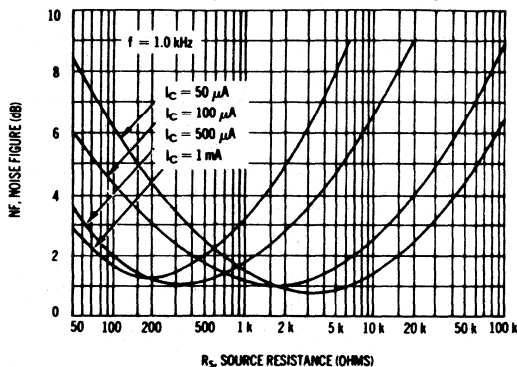


FIGURE 10 — SOURCE RESISTANCE EFFECTS



h PARAMETERS

$V_{CE} = 10 \text{ Vdc}$, $f = 1 \text{ kHz}$, $T_A = 25^\circ\text{C}$

This group of graphs illustrates the relationship between h_{fe} and other "h" parameters for this series of transistors. To obtain these curves, a high-gain and a low-gain unit were selected from both the

2N4400 and 2N4401 lines, and the same units were used to develop the correspondingly numbered curves on each graph.

FIGURE 11 — CURRENT GAIN

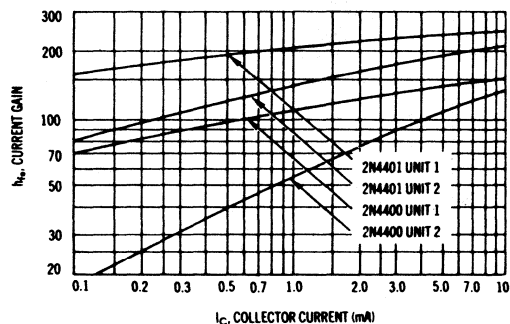


FIGURE 12 — INPUT IMPEDANCE

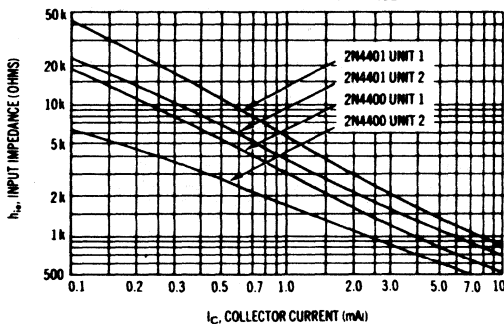


FIGURE 13 — VOLTAGE FEEDBACK RATIO

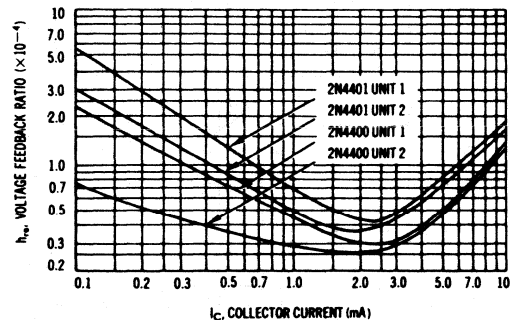
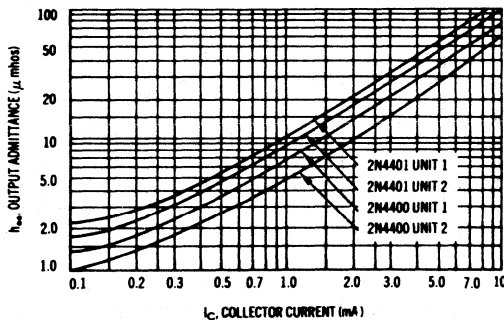


FIGURE 14 — OUTPUT ADMITTANCE



STATIC CHARACTERISTICS

FIGURE 15 — DC CURRENT GAIN

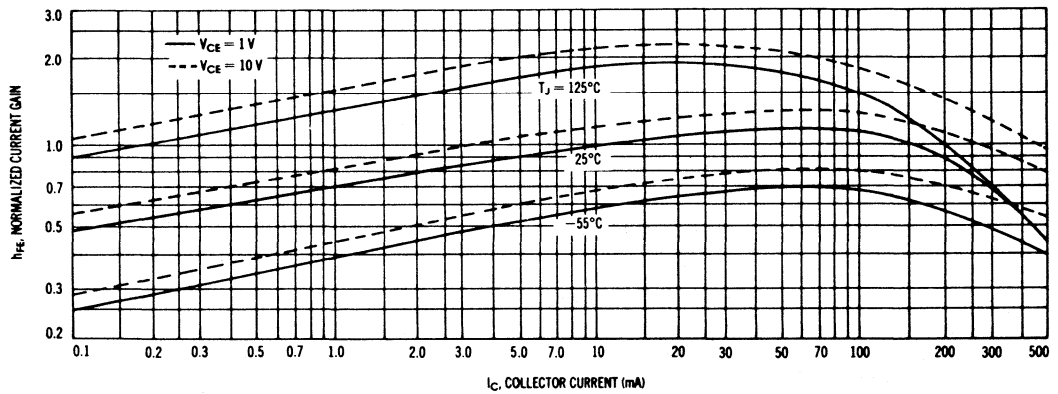


FIGURE 16 — COLLECTOR SATURATION REGION

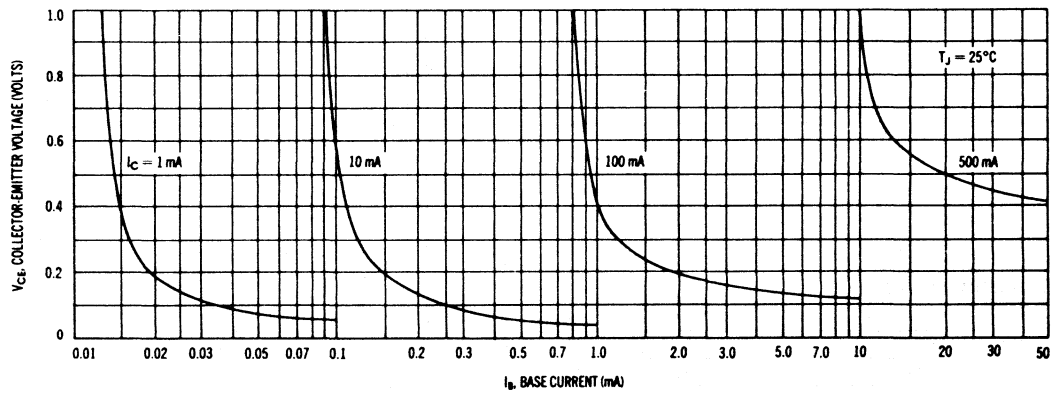


FIGURE 17 — "ON" VOLTAGES

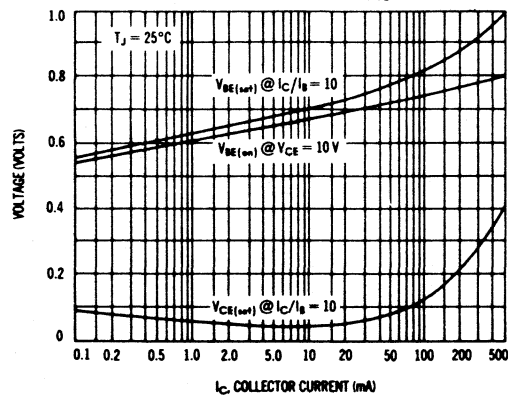
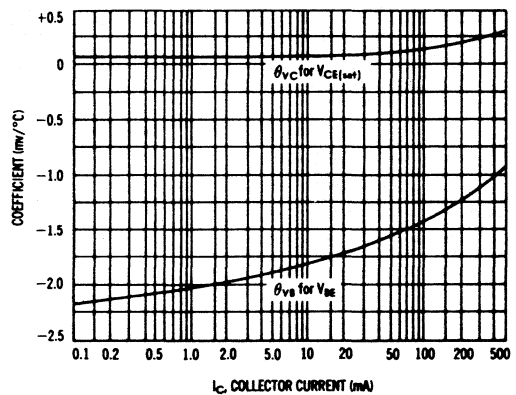


FIGURE 18 — TEMPERATURE COEFFICIENTS



2N4402 (SILICON)

2N4403

SILICON ANNULAR TRANSISTORS

... designed for general-purpose switching and amplifier applications and for complementary circuitry with types 2N4400 and 2N4401.

- Collector-Emitter Breakdown Voltage –
 $BV_{CEO} = 40 \text{ Vdc (Min) @ } I_C = 1.0 \text{ mAdc}$
- Current Gain Specified from 0.1 mAdc to 500 mAdc
- Complete Switching and Amplifier Specifications
- Collector-Base Capacitance –
 $C_{cb} = 8.5 \text{ pF (Max) @ } V_{CB} = 5.0 \text{ Vdc}$

PNP SILICON SWITCHING AND AMPLIFIER TRANSISTORS



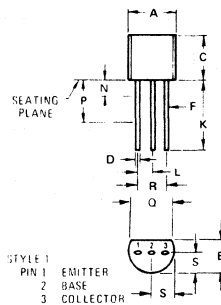
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	600	mAdc
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	350 2.8	mW mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 8.0	Watt mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	$^\circ\text{C/W}$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	$^\circ\text{C/W}$

*Indicates JEDEC Registered Data.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	—	0.500	—
L	1.150	1.390	0.045	0.055
N	—	1.270	—	0.050
P	6.350	—	0.250	—
Q	3.430	—	0.135	—
R	2.410	2.670	0.095	0.105
S	2.630	2.670	0.080	0.105

CASE 29
TO-92

2N4402, 2N4403 (continued)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 1\text{ mAdc}$, $I_B = 0$)	BV_{CEO}	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1\text{ mAdc}$, $I_E = 0$)	BV_{CBO}	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1\text{ mAdc}$, $I_C = 0$)	BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current ($V_{CE} = 35\text{ Vdc}$, $V_{BE(off)} = 0.4\text{ Vdc}$)	I_{CEV}	—	0.1	μA dc
Base Cutoff Current ($V_{CE} = 35\text{ Vdc}$, $V_{BE(off)} = 0.4\text{ Vdc}$)	I_{BEV}	—	0.1	μA dc

ON CHARACTERISTICS

DC Current Gain ($I_C = 0.1\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$) ($I_C = 1\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 1\text{ Vdc}$) ($I_C = 150\text{ mAdc}$, $V_{CE} = 2\text{ Vdc}$) ⁽¹⁾ ($I_C = 500\text{ mAdc}$, $V_{CE} = 2\text{ Vdc}$) ⁽¹⁾	2N4403 2N4402 2N4403 2N4402 2N4403	h_{FE}	30 30 60 50 100	— — — — —	—
Collector-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$) ($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$)		$V_{CE(sat)}$	— —	0.4 0.75	Vdc
Base-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$) ($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$)		$V_{BE(sat)}$	0.75 —	0.95 1.3	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 20\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	2N4402 2N4403	f_T	150 200	—	MHz
Collector-Base Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 100\text{ kHz}$)		C_{cb}	—	8.5	pF
Emitter-Base Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 100\text{ kHz}$)		C_{eb}	—	30	pF
Input Impedance ($I_C = 1\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1\text{ kHz}$)	2N4402 2N4403	h_{ie}	750 1.5k	7.5k 15k	ohms
Voltage Feedback Ratio ($I_C = 1\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1\text{ kHz}$)		h_{re}	0.1	8.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1\text{ kHz}$)	2N4402 2N4403	h_{fe}	30 60	250 500	—
Output Admittance ($I_C = 1\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1\text{ kHz}$)		h_{oe}	1.0	100	μmhos

SWITCHING CHARACTERISTICS

Delay Time	$V_{CC} = 30\text{ Vdc}$, $V_{BE(off)} = 2\text{ Vdc}$,	t_d	—	15	ns
Rise Time	$I_C = 150\text{ mAdc}$, $I_{B1} = 15\text{ mAdc}$	t_r	—	20	ns
Storage Time	$V_{CC} = 30\text{ Vdc}$, $I_C = 150\text{ mAdc}$,	t_s	—	225	ns
Fall Time	$I_{B1} = I_{B2} = 15\text{ mAdc}$	t_f	—	30	ns

⁽¹⁾ Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2\%$

*Indicates JEDEC Registered Data

SWITCHING TIME EQUIVALENT TEST CIRCUIT

FIGURE 1 — TURN-ON TIME

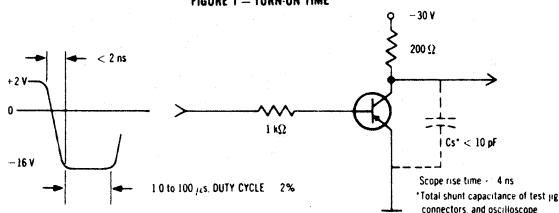
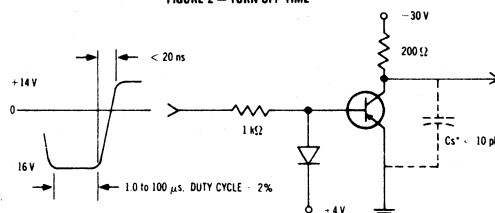


FIGURE 2 — TURN-OFF TIME



TRANSIENT CHARACTERISTICS

— 25°C — — 100°C

FIGURE 3 — CAPACITANCES

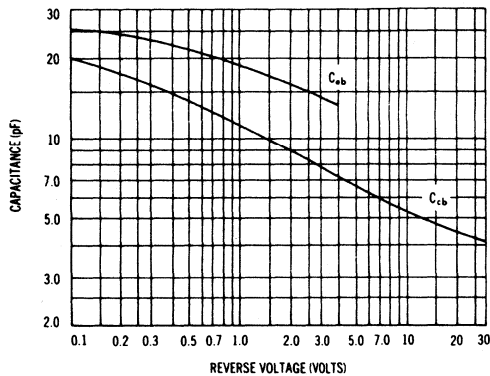


FIGURE 4 — CHARGE DATA

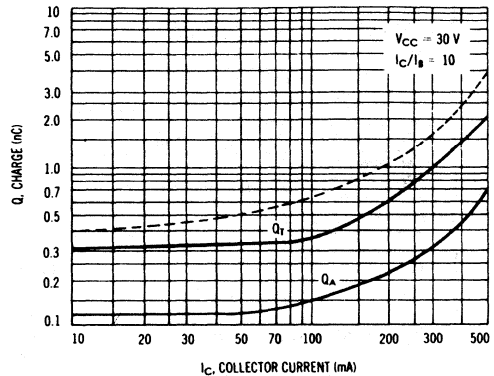


FIGURE 5 — TURN-ON TIME

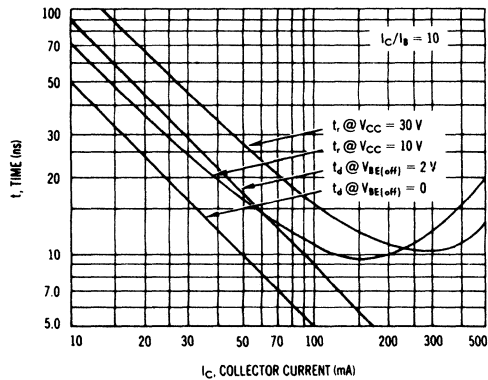


FIGURE 6 — RISE TIME

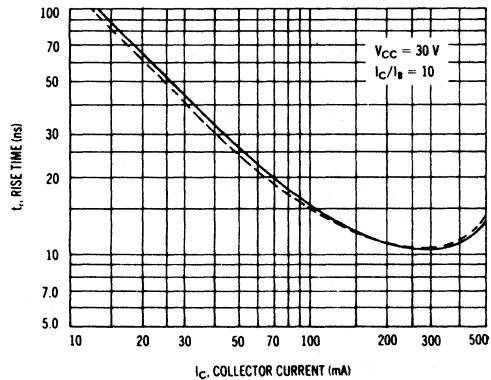


FIGURE 7 — STORAGE TIME

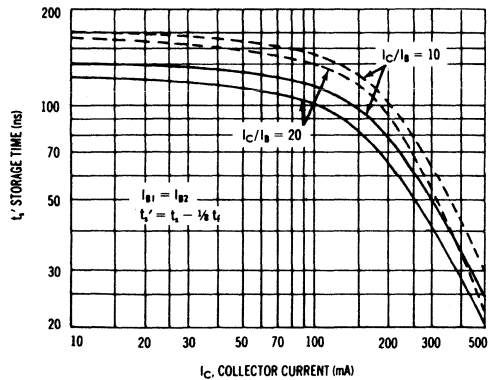
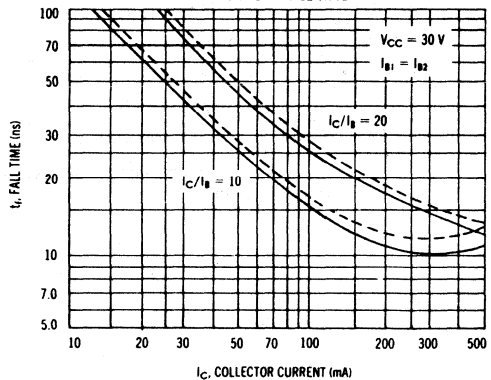


FIGURE 8 — FALL TIME



SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

$V_{CE} = 10 \text{ Vdc}$, $T_A = 25^\circ\text{C}$

Bandwidth = 1.0 Hz

FIGURE 9 — FREQUENCY EFFECTS

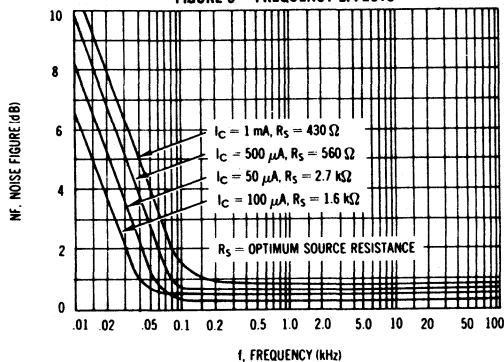
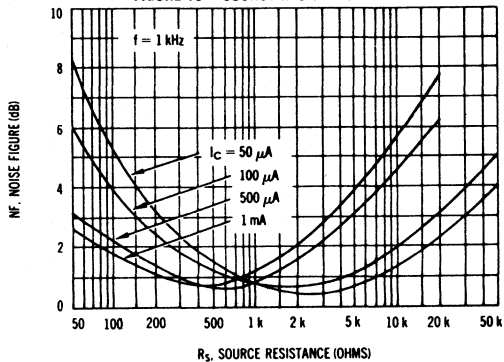


FIGURE 10 — SOURCE RESISTANCE EFFECTS



h PARAMETERS

$V_{CE} = 10 \text{ Vdc}$, $f = 1 \text{ kHz}$, $T_A = 25^\circ\text{C}$

This group of graphs illustrates the relationship between h_{re} and other " h " parameters for this series of transistors. To obtain these curves, a high-gain and a low-gain unit were selected from both the

2N4402 and 2N4403 lines, and the same units were used to develop the correspondingly-numbered curves on each graph.

FIGURE 11 — CURRENT GAIN

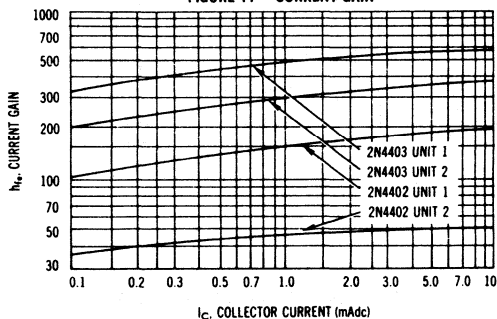


FIGURE 12 — INPUT IMPEDANCE

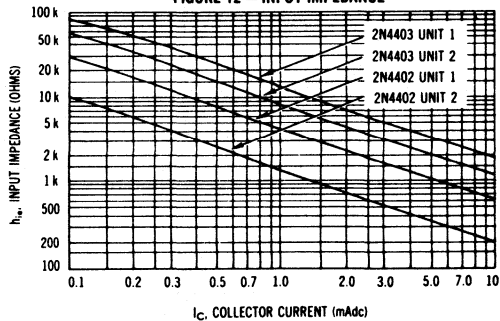


FIGURE 13 — VOLTAGE FEEDBACK RATIO

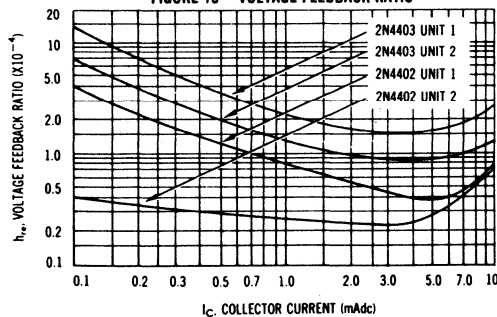
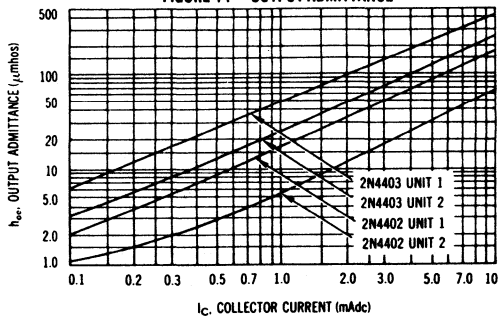


FIGURE 14 — OUTPUT ADMITTANCE



STATIC CHARACTERISTICS

FIGURE 15 — DC CURRENT GAIN

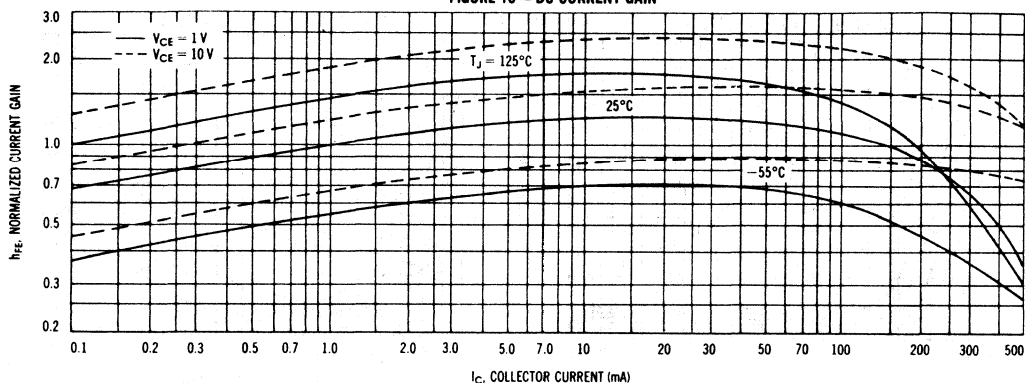


FIGURE 16 — COLLECTOR SATURATION REGION

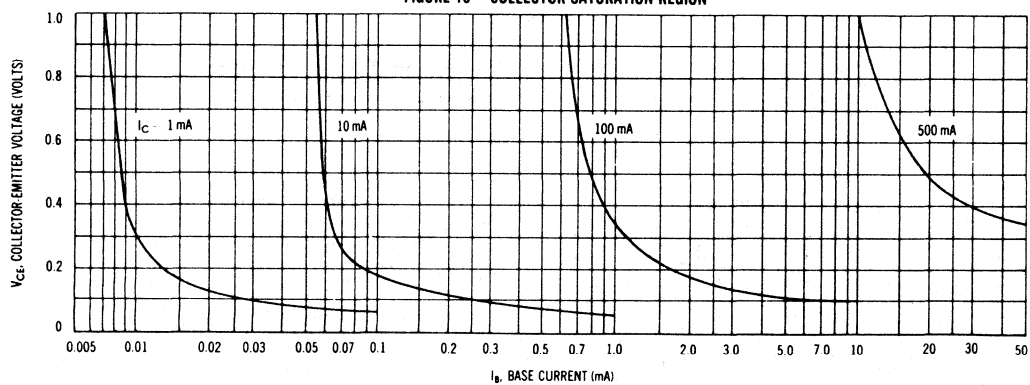


FIGURE 17 — "ON" VOLTAGE

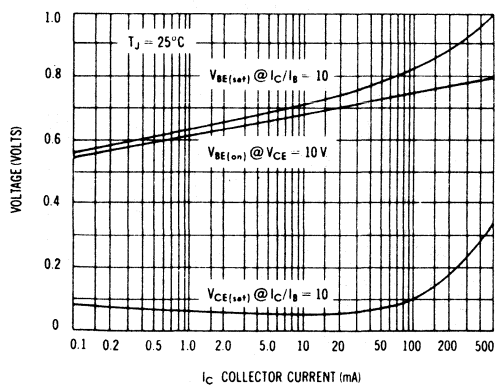
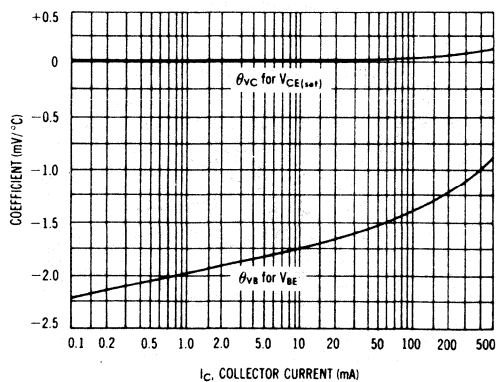
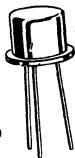


FIGURE 18 — TEMPERATURE COEFFICIENTS

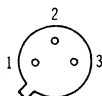


2N4404 (SILICON)

2N4405



CASE 79
(TO-39)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

PNP silicon annular transistors designed for general-purpose amplifier and switching applications.

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Base Voltage	V_{CB}	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	1.0	Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$	P_D	1.25	Watts
Derate above 25°C		7.15	mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$	P_D	7.0	Watts
Derate above 25°C		40	mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	25	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient (Lead Length 1/4")	θ_{JA}	140	$^\circ\text{C}/\text{W}$

* Indicates JEDEC Registered Data

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 – TURN-ON

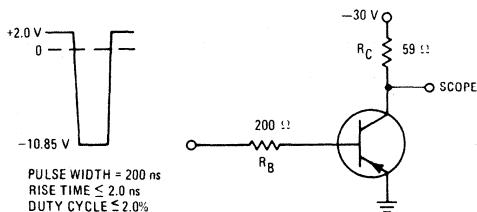
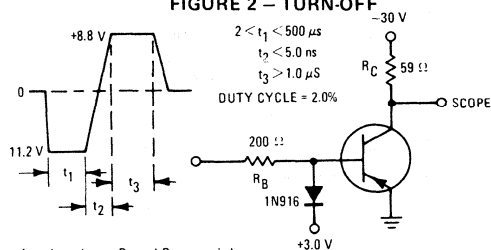


FIGURE 2 – TURN-OFF



To obtain data for curves, voltage levels are approximately as shown, R_B and R_C are varied.

2N4404, 2N4405 (continued)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 10\text{ mAdc}$, $I_B = 0$)	BV_{CEO}	80	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	80	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current ($V_{CB} = 60\text{ Vdc}$, $I_E = 0$)	I_{CBO}	-	25	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	-	25	nAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 0.1\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$)	2N4404 2N4405	h_{FE}	30 75	-	-
($I_C = 10\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$)	2N4404 2N4405		40 100	-	-
($I_C = 150\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$) ⁽¹⁾	2N4404 2N4405		40 100	120 300	
($I_C = 500\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$) ⁽¹⁾	2N4404 2N4405		15 25	-	-
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$)		$V_{CE(sat)}$	-	0.15	Vdc
($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$) ⁽¹⁾			-	0.2	
($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$) ⁽¹⁾			-	0.5	
Base-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$)		$V_{BE(sat)}$	-	0.8	Vdc
($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$) ⁽¹⁾			0.85	1.2	
Base-Emitter On Voltage* ($I_C = 150\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$)		$V_{BE(on)}$	-	0.9	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 50\text{ mAdc}$, $V_{CE} = 20\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	200	600	MHz
Collector-Base Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{cb}	-	10	pF
Emitter-Base Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 1.0\text{ MHz}$)	C_{eb}	-	75	pF

SWITCHING CHARACTERISTICS

Delay Time	(V _{CC} = 30 Vdc, V _{BE(off)} = 2.0 Vdc, I _C = 500 mAdc, I _{B1} = 50 mAdc) (Figure 1)	t _d	-	15	ns
Rise Time		t _r	-	25	ns
Storage Time	(V _{CC} = 30 Vdc, I _C = 500 mAdc, I _{B1} = I _{B2} = 50 mAdc) (Figure 2)	t _s	-	175	ns
Fall Time		t _f	-	35	ns

⁽¹⁾ Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.

* Indicates JEDEC Registered Data

TRANSIENT CHARACTERISTICS

———— 25°C - - - 100°C

FIGURE 3 – CAPACITANCES

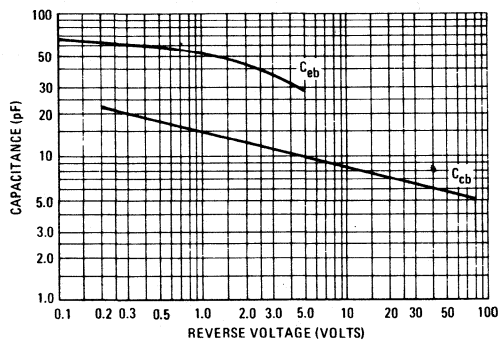


FIGURE 4 – CHARGE DATA

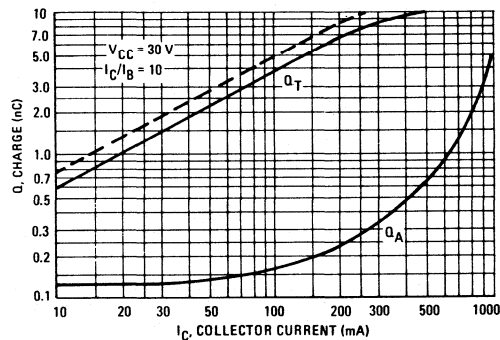


FIGURE 5 – DELAY TIME

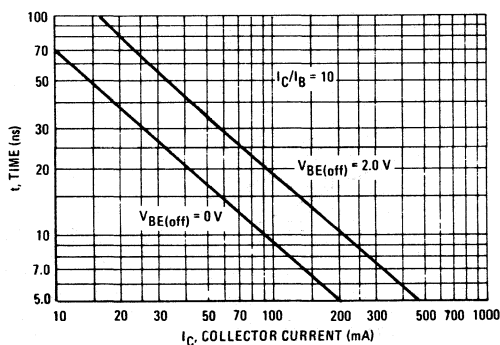


FIGURE 6 – RISE TIME

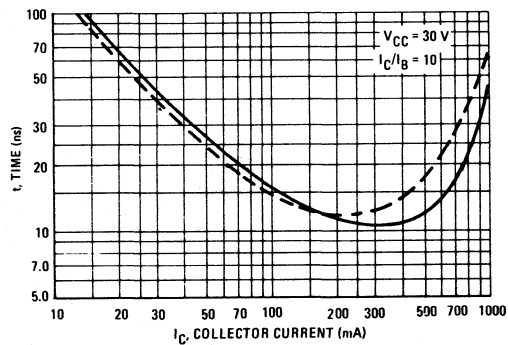


FIGURE 7 – STORAGE TIME

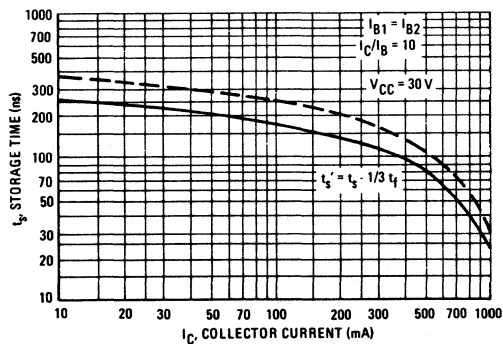
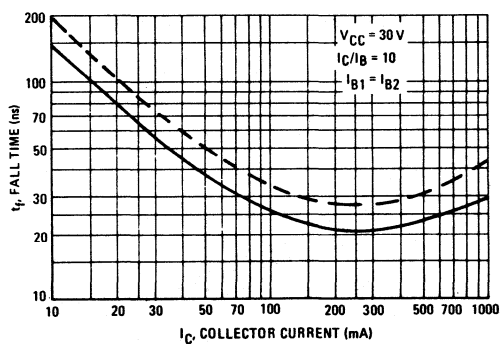


FIGURE 8 – FALL TIME



SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

$$V_{CE} = 10 \text{ Vdc}, T_A = 25^\circ\text{C}$$

FIGURE 9 – FREQUENCY EFFECTS

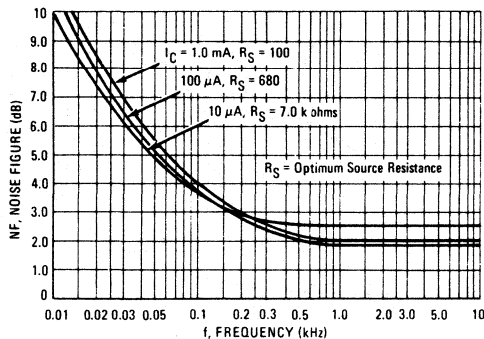
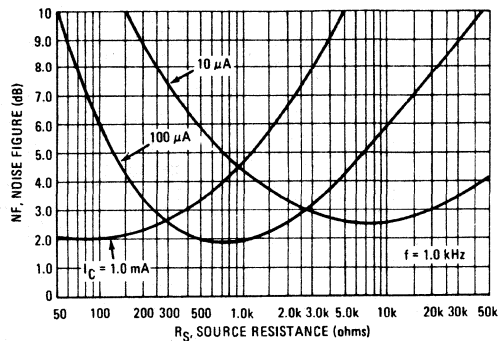


FIGURE 10 – SOURCE RESISTANCE EFFECTS



h PARAMETERS

$$V_{CE} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}, T_A = 25^\circ\text{C}$$

This group of graphs illustrates the relationship of the "h" parameters for this series of transistors. To obtain these curves, 4 units were selected and identified by number – the same units were used to develop curves on each graph.

FIGURE 11 – CURRENT GAIN

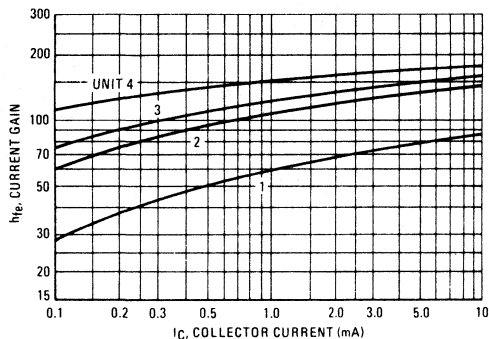


FIGURE 12 – INPUT IMPEDANCE

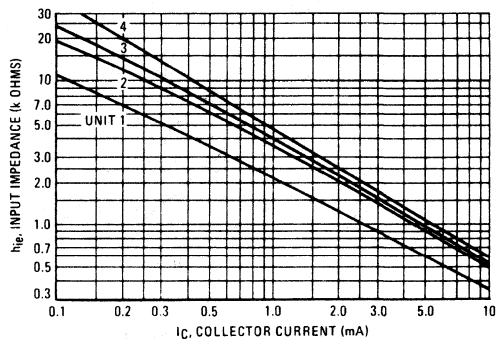


FIGURE 13 – VOLTAGE FEEDBACK RATIO

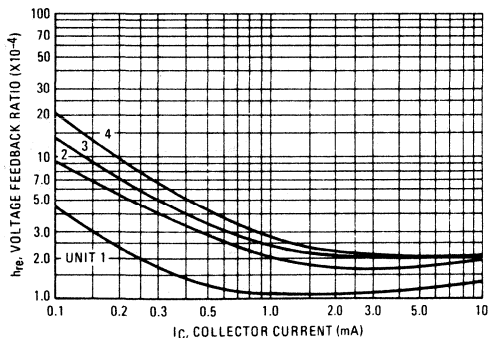
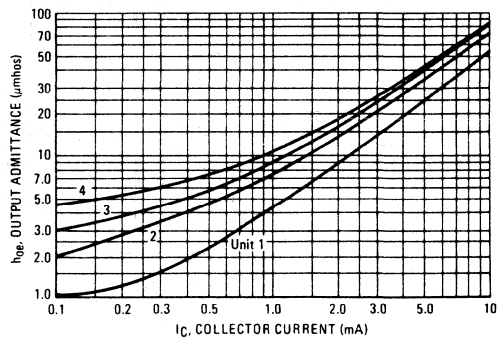


FIGURE 14 – OUTPUT ADMITTANCE



STATIC CHARACTERISTICS

FIGURE 15 – DC CURRENT GAIN

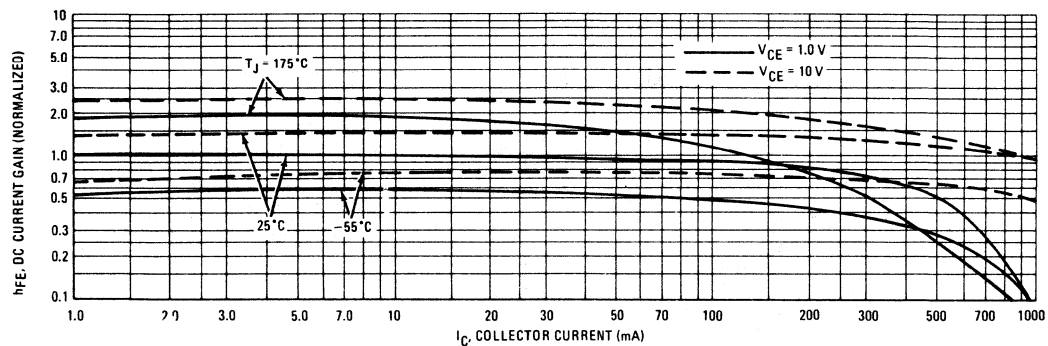


FIGURE 16 – COLLECTOR SATURATION REGION

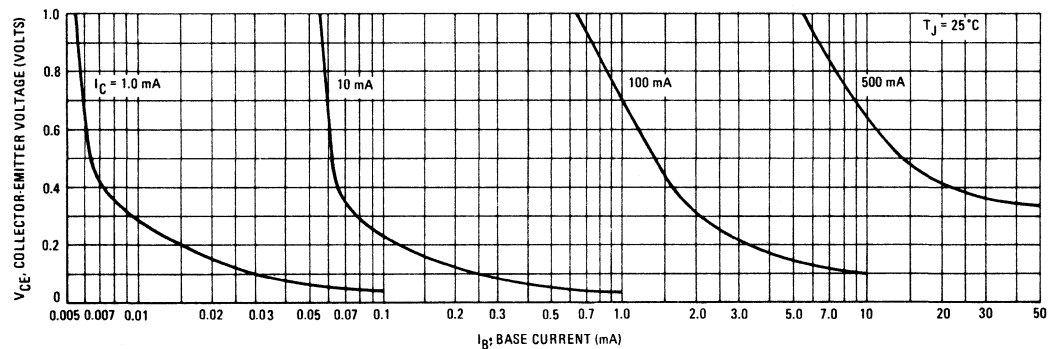


FIGURE 17 – "ON" VOLTAGES

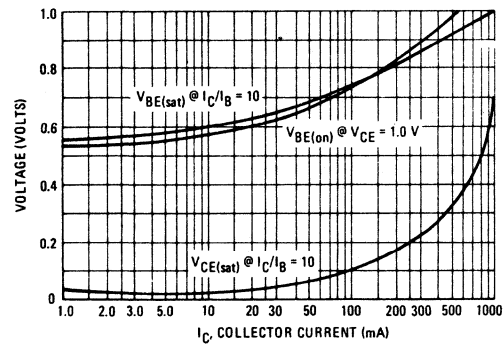
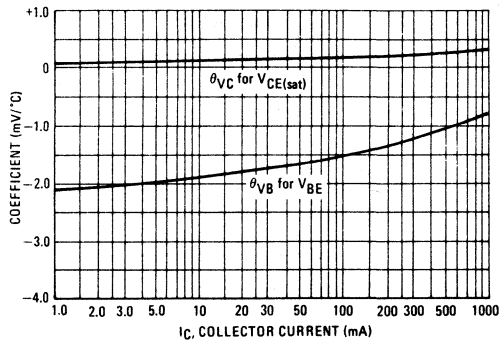
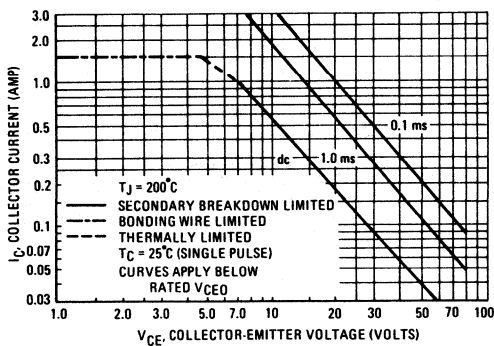


FIGURE 18 – TEMPERATURE COEFFICIENTS



RATINGS AND THERMAL DATA

FIGURE 19 — SAFE OPERATING AREA

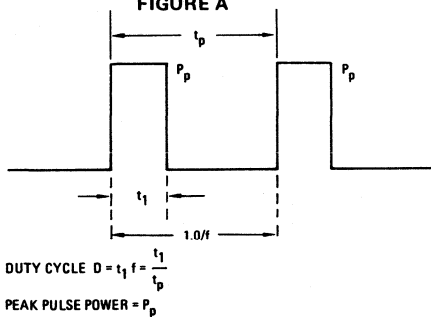


The safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 19 is based upon $T_{J(pk)} = 200^\circ\text{C}$; T_C is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200^\circ\text{C}$. $T_{J(pk)}$ may be calculated from the data in Figure 20. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA

FIGURE A



A train of periodical power pulses can be represented by the model as shown in Figure A. Using the model and the device thermal response, the normalized effective transient thermal resistance of Figure 20 was calculated for various duty cycles.

To find $\theta_{JC}(t)$, multiply the value obtained from Figure 20 by the steady state value $\theta_{JC}(\infty)$.

Example:

If the 2N4404 is dissipating 8.0 watts peak under the following conditions: $t_1 = 1.0$ ms, $t_p = 5.0$ ms, ($D = 0.2$), find ΔT .

Using Figure 20 at a pulse width of 1.0 ms and $D = 0.2$, the reading of $r(t_1 D)$ is 0.4.

The peak rise in junction temperature above case temperature is, therefore, $\Delta T = r(t_1 D) \times P_p \times \theta_{JC}(\infty) = 0.4 \times 8.0 \times 25 = 80^\circ\text{C}$.

2N4406 (SILICON)

2N4407



CASE 79
(TO-39)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

PNP silicon annular transistors designed for general-purpose amplifier and switching applications.

* MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Base Voltage	V_{CB}	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	2.0	Adc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$	P_D	1.25	Watts
Derate above 25°C		7.15	mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$	P_D	8.75	Watts
Derate above 25°C		50	mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	20	$^\circ\text{C}/\text{W}$
Thermal Resistance, Junction to Ambient	θ_{JA}	140	$^\circ\text{C}/\text{W}$

*Indicates JEDEC Registered Data

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 10\text{ mAdc}$, $I_B = 0$)	BV_{CEO}	80	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	80	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current ($V_{CB} = 60\text{ Vdc}$, $I_E = 0$)	I_{CBO}	-	25	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	-	25	nAdc

ON CHARACTERISTICS

DC Current Gain ⁽¹⁾ ($I_C = 10\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$)	2N4406 2N4407	h_{FE}	30 80	- -	-
($I_C = 150\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$)	2N4406 2N4407		25 75	100 225	
($I_C = 500\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$)	2N4406 2N4407		20 35	- -	
($I_C = 1.0\text{ Adc}$, $V_{CE} = 1.0\text{ Vdc}$)	2N4406 2N4407		10 15	- -	
($I_C = 1.5\text{ Adc}$, $V_{CE} = 5.0\text{ Vdc}$)	2N4406, 2N4407		10	-	
Collector-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$)		$V_{CE(sat)}$	-	0.2	Vdc
($I_C = 500\text{ mAdc}$, $I_B = 50\text{ mAdc}$)			-	0.4	
($I_C = 1.0\text{ Adc}$, $I_B = 100\text{ mAdc}$)			-	0.7	
($I_C = 1.5\text{ Adc}$, $I_B = 150\text{ mAdc}$)			-	1.5	
Base-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$)		$V_{BE(sat)}$	-	0.9	Vdc
($I_C = 1.0\text{ Adc}$, $I_B = 100\text{ mAdc}$)			0.9	1.3	
($I_C = 1.5\text{ Adc}$, $I_B = 150\text{ mAdc}$)			-	1.5	
Base-Emitter On Voltage ⁽¹⁾ ($I_C = 500\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$)		$V_{BE(on)}$	-	1.0	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 50\text{ mAdc}$, $V_{CE} = 20\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	150	750	MHz
Collector-Base Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{cb}	-	15	pF
Collector-Emitter Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 1.0\text{ MHz}$)	C_{eb}	-	160	pF

SWITCHING CHARACTERISTICS

Delay Time	$(V_{CC} = 30\text{ Vdc}$, $V_{BE(off)} = 2.0\text{ Vdc}$, $I_C = 1.0\text{ Adc}$, $I_{B1} = 100\text{ mAdc}$) (Figure 11)	t_d	-	15	ns
Rise Time		t_r	-	60	ns
Storage Time	$(V_{CC} = 30\text{ Vdc}$, $I_C = 1.0\text{ Adc}$, $I_{B1} = I_{B2} = 100\text{ mAdc}$) (Figure 12)	t_s	-	175	ns
Fall Time		t_f	-	50	ns

⁽¹⁾ Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.

* Indicates JEDEC Registered Data

STATIC CHARACTERISTICS

FIGURE 2 - DC CURRENT GAIN

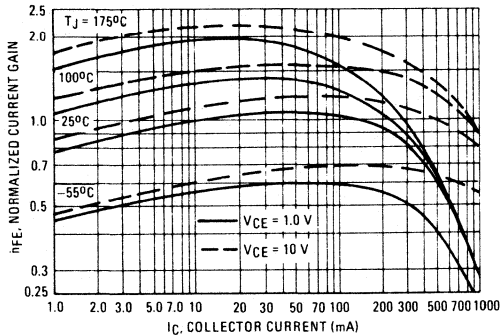


FIGURE 3 - COLLECTOR SATURATION REGION

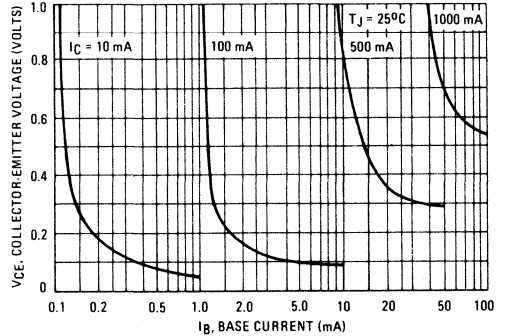


FIGURE 4 - "ON" VOLTAGES

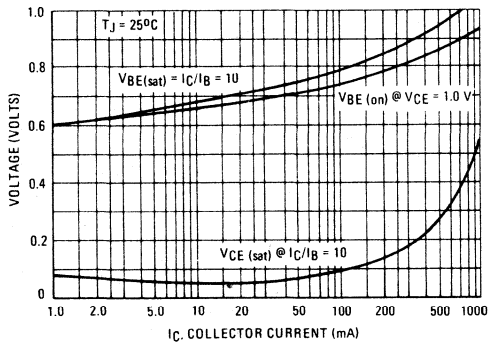


FIGURE 5 - TEMPERATURE COEFFICIENTS

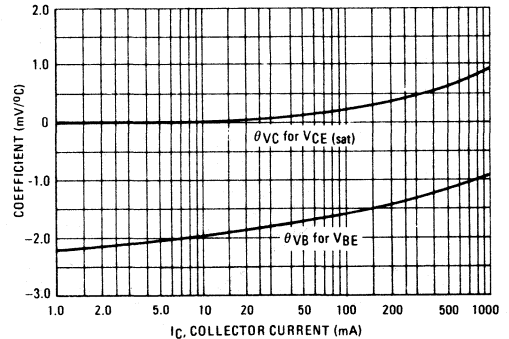
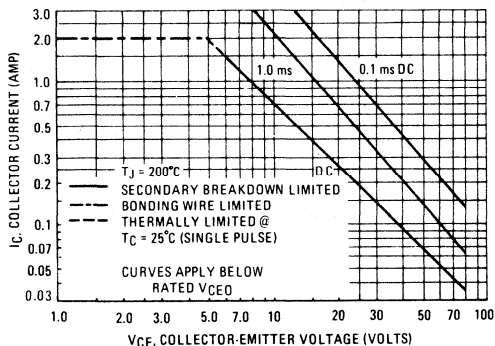


FIGURE 6 - SAFE OPERATING AREA



The safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 6 is based upon $T_{J(pk)} = 200^\circ\text{C}$; T_C is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200^\circ\text{C}$. $T_{J(pk)}$ may be calculated from the data in Figure 1. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

TRANSIENT CHARACTERISTICS

— 25°C — — 100°C

FIGURE 7 - CAPACITANCES

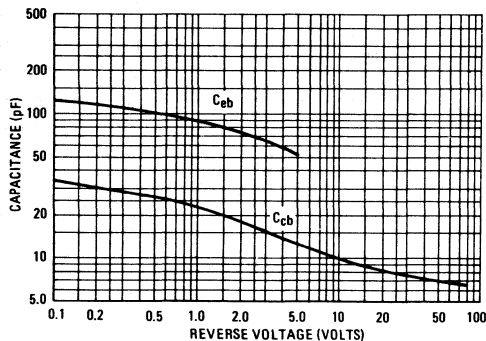


FIGURE 8 - CHARGE DATA

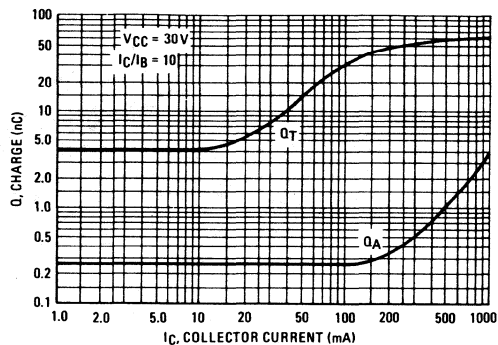


FIGURE 9 - TURN-ON TIME

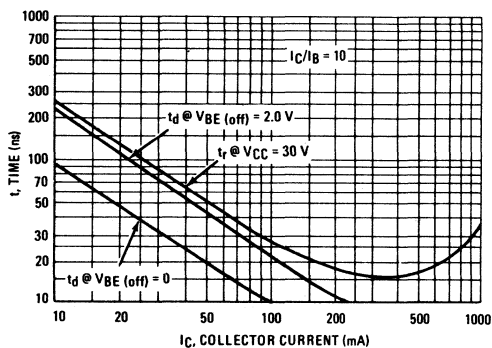
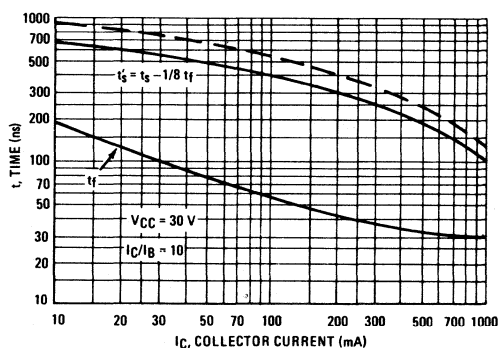


FIGURE 10 - TURN-OFF TIME



SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 11 - TURN-ON TIME

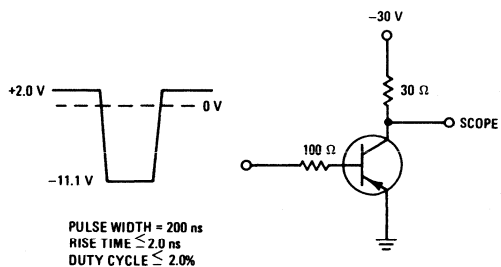
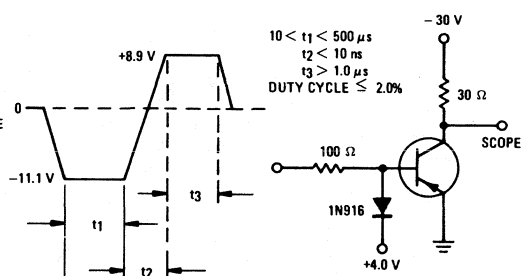


FIGURE 12 - TURN-OFF TIME



2N4409 (SILICON)

2N4410

NPN SILICON AMPLIFIER TRANSISTORS

... designed for high-voltage amplifier applications.

- High Collector-Emitter Breakdown Voltage –
 $V_{CEX} = 80 \text{ Vdc (Min)} - 2N4409$
 $= 120 \text{ Vdc (Min)} - 2N4410$
- Low Collector Cutoff Current –
 $I_{CBO} = 1.0 \mu\text{Adc (Max)} @ T_A = 100^\circ\text{C}$
- High DC Current Gain –
 $h_{FE} = 150 \text{ (Typ)} @ I_C = 1.0 \text{ mAdc}$

*MAXIMUM RATINGS

Rating	Symbol	2N4409	2N4410	Unit
Collector-Emitter Voltage	V_{CEO}	50	80	Vdc
Collector-Base Voltage	V_{CB}	80	120	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	250		mAdc
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	625	5.0	mW mW/°C
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	15	12	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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*OFF CHARACTERISTIC

Collector-Emitter Breakdown Voltage (1) ($I_C = 1.0 \text{ mAdc}, I_B = 0$)	2N4409 2N4410	V_{CEO}	50 80	–	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 500 \mu\text{Adc}, V_{BE}(\text{off}) = 5.0 \text{ Vdc},$ $R_{BE} = 8.2 \text{ kohms}$)	2N4409 2N4410	V_{CEX}	80 120	–	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \mu\text{Adc}, I_E = 0$)	2N4409 2N4410	V_{CBO}	80 120	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \mu\text{Adc}, I_C = 0$)		V_{EBO}	5.0	–	Vdc
Collector Cutoff Current ($V_{CB} = 60 \text{ Vdc}, I_E = 0$) ($V_{CB} = 60 \text{ Vdc}, I_E = 0, T_A = 100^\circ\text{C}$) ($V_{CB} = 100 \text{ Vdc}, I_E = 0$) ($V_{CB} = 100 \text{ Vdc}, I_E = 0, T_A = 100^\circ\text{C}$)	2N4409 2N4409 2N4410 2N4410	I_{CBO}	– – – –	0.01 1.0 0.01 1.0	μAdc
Emitter Cutoff Current ($V_{BE} = 4.0 \text{ Vdc}, I_C = 0$)		I_{EBO}	–	0.1	μAdc

*ON CHARACTERISTICS

DC Current Gain ($I_C = 1.0 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}, V_{CE} = 1.0 \text{ Vdc}$)	h_{FE}	60 60	– 400	–	
Collector-Emitter Saturation Voltage ($I_C = 1.0 \text{ mAdc}, I_B = 0.1 \text{ mAdc}$)	$V_{CE(\text{sat})}$	–	0.2		Vdc
Base-Emitter Saturation Voltage ($I_C = 1.0 \text{ mAdc}, I_B = 0.1 \text{ mAdc}$)	$V_{BE(\text{sat})}$	–	0.8		Vdc
Base-Emitter On Voltage ($I_C = 1.0 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}$)	$V_{BE(\text{on})}$	–	0.8		Vdc

DYNAMIC CHARACTERISTICS

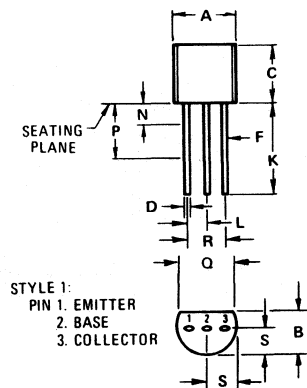
*Current-Gain – Bandwidth Product (2) ($I_C = 10 \text{ mAdc}, V_{CE} = 10 \text{ Vdc}, f = 30 \text{ MHz}$)	f_T	60	300		MHz
*Collector-Base Capacitance ($V_{CB} = 10 \text{ Vdc}, I_E = 0, f = 140 \text{ kHz}$)	C_{cb}	–	12		pF
Emitter-Base Capacitance ($V_{BE} = 0.5 \text{ Vdc}, I_C = 0, f = 140 \text{ kHz}$)	C_{eb}	–	50		pF

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width $\leq 300 \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

(2) $f_T = |h_{FE}| \cdot f_{\text{test}}$

NPN SILICON AMPLIFIER TRANSISTORS



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

TYPICAL DC CHARACTERISTICS

FIGURE 1 – DC CURRENT GAIN

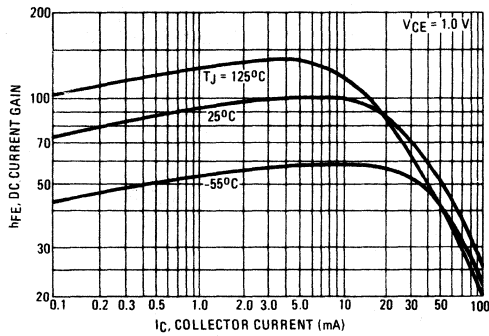


FIGURE 2 – ACTIVE-REGION SAFE OPERATING AREA

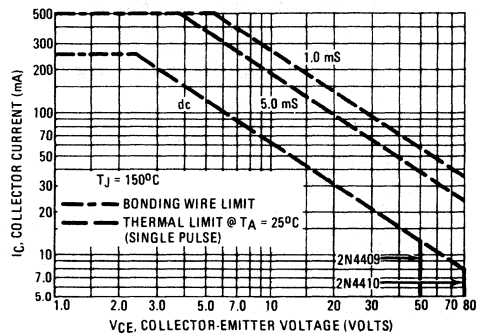


FIGURE 3 – "ON" VOLTAGE

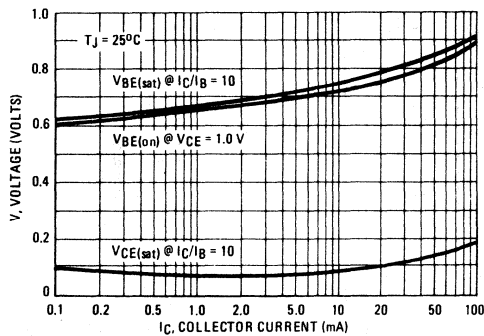
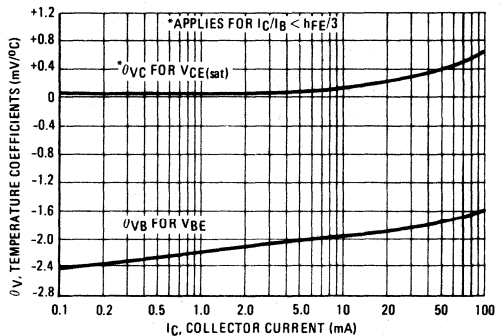


FIGURE 4 – TEMPERATURE COEFFICIENTS



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 5 – CURRENT-GAIN – BANDWIDTH PRODUCT

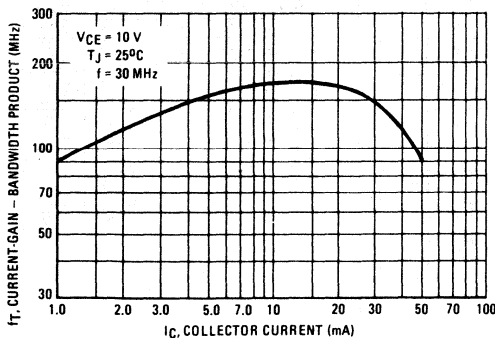
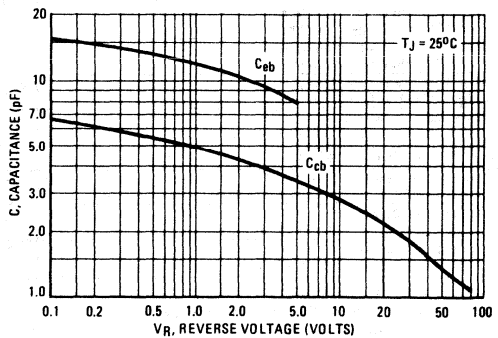


FIGURE 6 – CAPACITANCE



SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR

... designed for VHF/UHF amplifier applications.

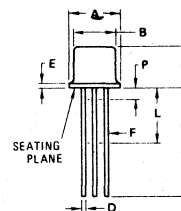
- Low Noise Figure —
NF = 2.0 dB (Max) @ 100 MHz
= 4.0 dB (Max) @ 400 MHz
- Low Feedback Capacitance —
C_{rss} = 0.8 pF (Max)
- Low Output Capacitance —
C_{oss} = 2.0 pF (Max)
- High Transfer Admittance —
Y_{fs(real)} = 4000 μmho (Min)
- High Power Gain —
G_{ps} = 18 dB (Min) @ 100 MHz
= 10 dB (Min) @ 400 MHz
- S and Y Parameter Curves Provided

*MAXIMUM RATINGS (T_A = 25°C unless otherwise noted.)

Rating	Symbol	Value	Unit
Drain-Source Voltage	V _{DS}	30	Vdc
Drain-Gate Voltage	V _{DG}	30	Vdc
Gate-Source Voltage	V _{GS}	30	Vdc
Gate Current	I _G	10	mAdc
Total Power Dissipation @ T _A = 25°C Derate above 25°C	P _D	300 1.71	mW mW/°C
Operating and Storage Channel Temperature Range	T _{channel} , T _{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.

N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR



STYLE 1
PIN 1. SOURCE
2. DRAIN
3. GATE
4. CASE LEAD

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	—	0.76	—	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	—	1.27	—	0.050

ALL JEDEC dimensions and notes apply

CASE 20-03
TO-72

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTIC				
Gate-Source Breakdown Voltage ($I_G = 1.0\ \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	30	—	Vdc
Gate-Source Cutoff Voltage ($I_D = 1.0\ \text{nAdc}$, $V_{DS} = 15\ \text{Vdc}$)	$V_{GS(off)}$	—	6.0	Vdc
Gate-Source Voltage ($I_D = 0.5\ \text{mAdc}$, $V_{DS} = 15\ \text{Vdc}$)	V_{GS}	1.0	5.5	Vdc
Gate-Source Forward Voltage ($I_G = 1.0\ \text{mAdc}$, $V_{DS} = 0$)	$V_{GS(F)}$	—	1.0	Vdc
Gate Reverse Current ($V_{GS} = 20\ \text{Vdc}$, $V_{DS} = 0$) ($V_{GS} = 20\ \text{Vdc}$, $V_{DS} = 0$, $T_A = +150^\circ\text{C}$)	I_{GSS}	— —	100 200	pAdc
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current (1) ($V_{DS} = 15\ \text{Vdc}$, $V_{GS} = 0$)	I_{DSS}	5.0	15	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (1) ($V_{DS} = 15\ \text{Vdc}$, $V_{GS} = 0$, $f = 1.0\ \text{kHz}$)	$ y_{fs} $	4500	7500	μmhos
Real Part of Forward Transfer Admittance ($V_{DS} = 15\ \text{Vdc}$, $V_{GS} = 0$, $f = 400\ \text{MHz}$)	$y_{fs(\text{real})}$	4000	—	μmhos
Real Part of Input Admittance ($V_{DS} = 15\ \text{Vdc}$, $V_{GS} = 0$, $f = 100\ \text{MHz}$) ($V_{DS} = 15\ \text{Vdc}$, $V_{GS} = 0$, $f = 400\ \text{MHz}$)	$y_{is(\text{real})}$	— —	100 1000	μmhos
Output Admittance ($V_{DS} = 15\ \text{Vdc}$, $V_{GS} = 0$, $f = 1.0\ \text{kHz}$)	$ y_{os} $	—	50	μmhos
Real Part of Output Admittance ($V_{DS} = 15\ \text{Vdc}$, $V_{GS} = 0$, $f = 100\ \text{MHz}$) ($V_{DS} = 15\ \text{Vdc}$, $V_{GS} = 0$, $f = 400\ \text{MHz}$)	$y_{os(\text{real})}$	— —	75 100	μmhos
Imaginary Part of Input Admittance ($V_{DS} = 15\ \text{Vdc}$, $V_{GS} = 0$, $f = 100\ \text{MHz}$) ($V_{DS} = 15\ \text{Vdc}$, $V_{GS} = 0$, $f = 400\ \text{MHz}$)	$y_{is(\text{imag})}$	— —	2500 10,000	μmhos
Imaginary Part of Output Admittance ($V_{DS} = 15\ \text{Vdc}$, $V_{GS} = 0$, $f = 100\ \text{MHz}$) ($V_{DS} = 15\ \text{Vdc}$, $V_{GS} = 0$, $f = 400\ \text{MHz}$)	$y_{os(\text{imag})}$	— —	1000 4000	μmhos
Input Capacitance ($V_{DS} = 15\ \text{Vdc}$, $V_{GS} = 0$, $f = 1.0\ \text{MHz}$)	C_{iss}	—	4.0	pF
Common-Source Output Capacitance ($V_{DS} = 15\ \text{Vdc}$, $V_{GS} = 0$, $f = 1.0\ \text{MHz}$)	C_{oss}	—	2.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15\ \text{Vdc}$, $V_{GS} = 0$, $f = 1.0\ \text{MHz}$)	C_{rss}	—	0.8	pF
Common-Source Spot Noise (Figures 3 and 4) ($V_{DS} = 15\ \text{Vdc}$, $I_D = 5.0\ \text{mAdc}$, $R_g \approx 1000\ \text{Ohms}$, $f = 100\ \text{MHz}$) ($V_{DS} = 15\ \text{Vdc}$, $I_D = 5.0\ \text{mAdc}$, $R_g \approx 1000\ \text{Ohms}$, $f = 400\ \text{MHz}$)	NF	— —	2.0 4.0	dB
Small-Signal Power Gain (Figure 1) ($V_{DS} = 15\ \text{Vdc}$, $I_D = 5.0\ \text{mAdc}$, $f = 100\ \text{MHz}$) ($V_{DS} = 15\ \text{Vdc}$, $I_D = 5.0\ \text{mAdc}$, $f = 400\ \text{MHz}$)	G_{ps}	18 10	— —	dB

(1) Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 1.0\%$.

* Indicates JEDEC Registered Data.

POWER GAIN

FIGURE 1 — EFFECTS OF DRAIN CURRENT

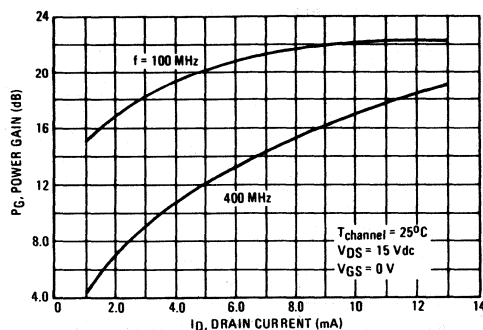
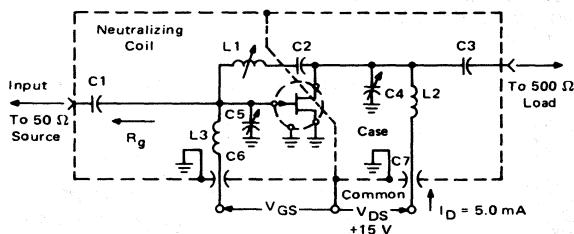


FIGURE 2 — 100 MHz and 400 MHz NEUTRALIZED TEST CIRCUIT



Adjust V_{GS} for
 $I_D = 5.0 \text{ mA}$
 $V_{GS} < 0 \text{ Volts}$

NOTE: The noise source is a hot-cold body
 (AIL type 70 or equivalent) with a
 test receiver (AIL type 136 or equivalent).

Reference Designation	VALUE	
	100 MHz	400 MHz
C1	7.0 pF	1.8 pF
C2	1000 pF	17 pF
C3	3.0 pF	1.0 pF
C4	1-12 pF	0.8-8.0 pF
C5	1-12 pF	0.8-8.0 pF
C6	0.0015 μF	0.001 μF
C7	0.0015 μF	0.001 μF
L1	3.0 μH^*	0.2 μH^{**}
L2	0.15 μH^*	0.03 μH^{**}
L3	0.14 μH^*	0.022 μH^{**}

- *L1 17 turns, (approx. — depends upon circuit layout) AWG #28 enameled copper wire, close wound on 9/32" ceramic coil form. Tuning provided by a powdered iron slug.
- L2 4-1/2 turns, AWG #18 enameled copper wire, 5/16" long, 3/8" I.D. (AIR CORE).
- L3 3-1/2 turns, AWG #18 enameled copper wire, 1/4" long, 3/8" I.D. (AIR CORE).

- **L1 6 turns, (approx. — depends upon circuit layout) AWG #24 enameled copper wire, close wound on 7/32" ceramic coil form. Tuning provided by an aluminum slug.
- L2 1 turn, AWG #16 enameled copper wire, 3/8" I.D. (AIR CORE).
- L3 1/2 turn, AWG #16 enameled copper wire, 1/4" I.D. (AIR CORE).

NOISE FIGURE

(T_{channel} = 25°C)

FIGURE 3 — EFFECTS OF DRAIN-SOURCE VOLTAGE

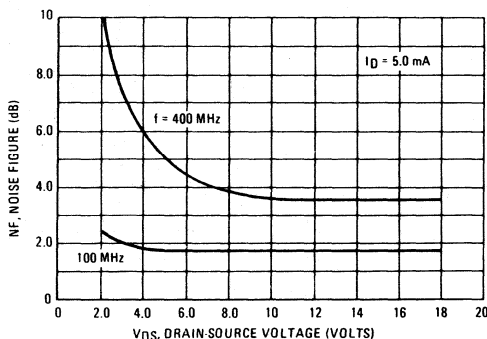
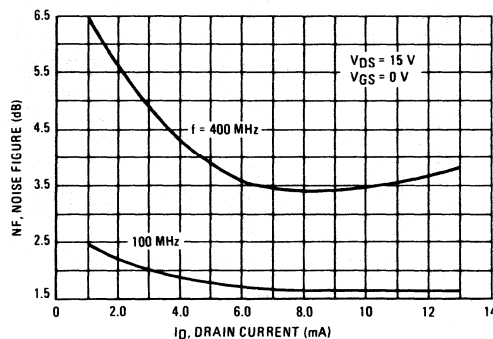
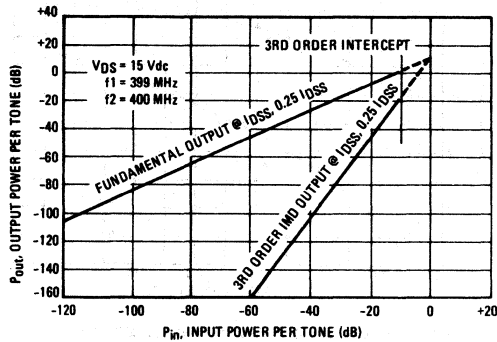


FIGURE 4 — EFFECTS OF DRAIN CURRENT



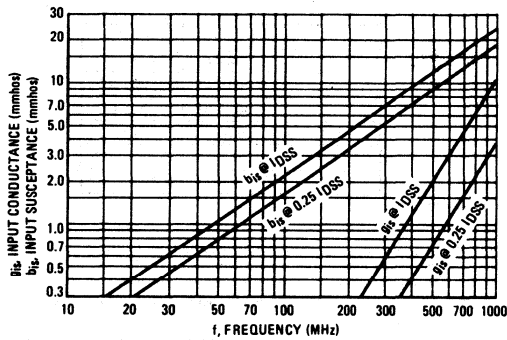
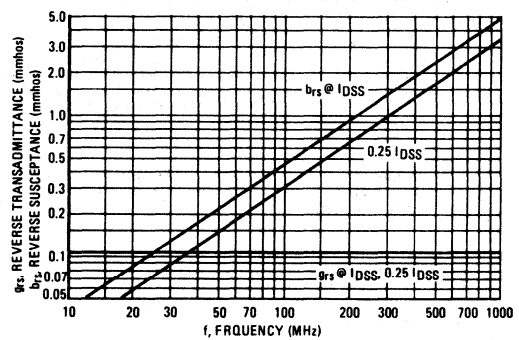
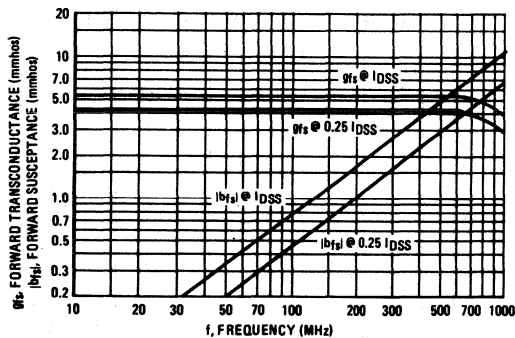
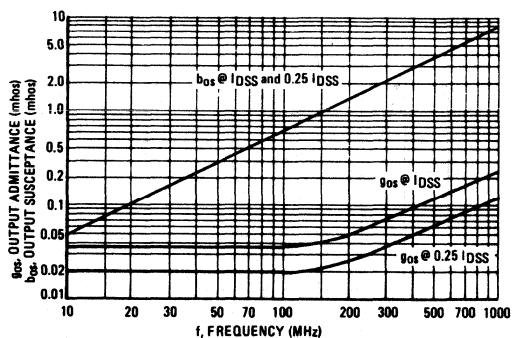
INTERMODULATION CHARACTERISTICS

FIGURE 5 – THIRD ORDER INTERMODULATION DISTORTION



COMMON SOURCE CHARACTERISTICS

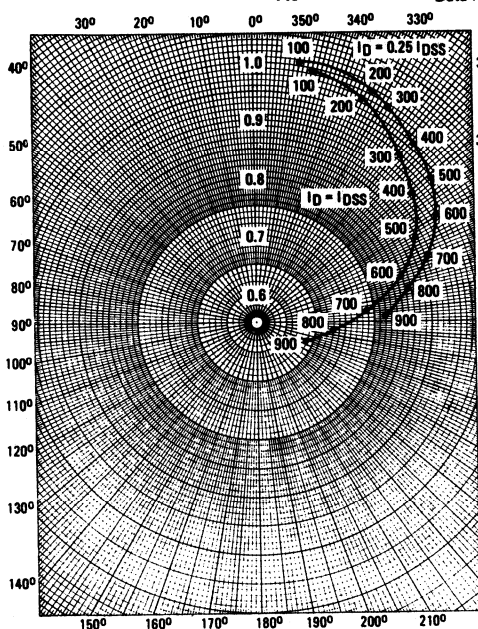
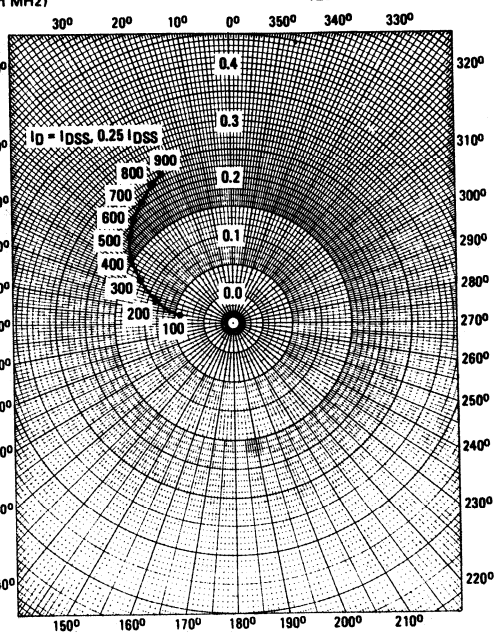
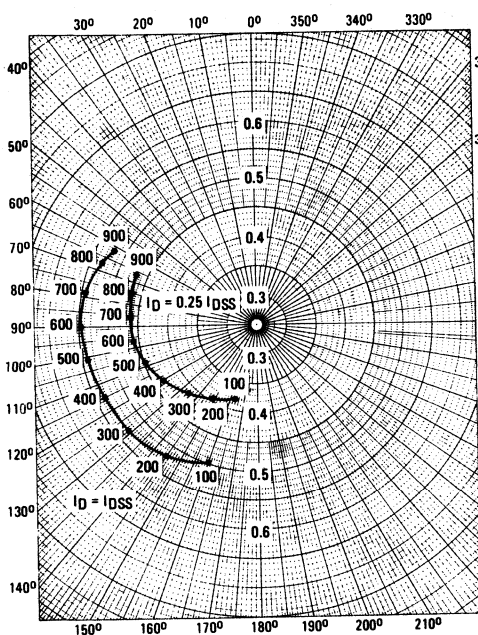
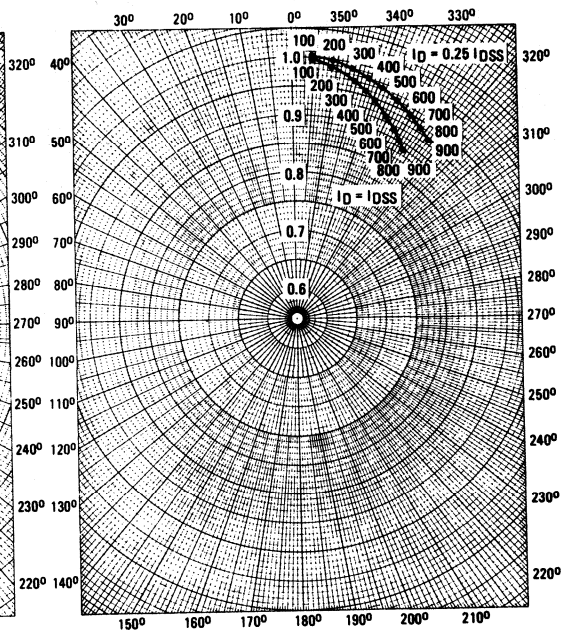
ADMITTANCE PARAMETERS

 $(V_{DS} = 15\text{ Vdc}, T_{channel} = 25^\circ\text{C})$ FIGURE 6 – INPUT ADMITTANCE (y_{is})FIGURE 7 – REVERSE TRANSFER ADMITTANCE (y_{rs})FIGURE 8 – FORWARD TRANSADMITTANCE (y_{fs})FIGURE 9 – OUTPUT ADMITTANCE (y_{os})

COMMON SOURCE CHARACTERISTICS

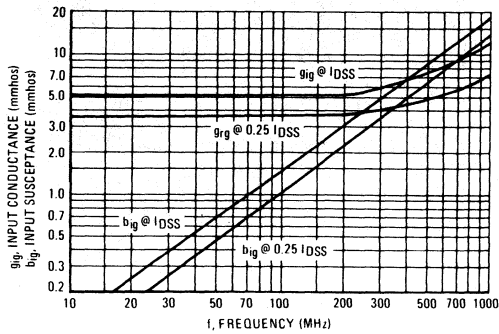
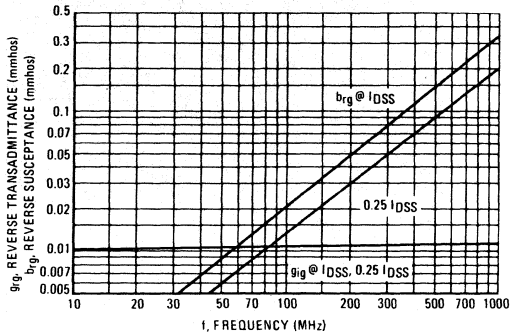
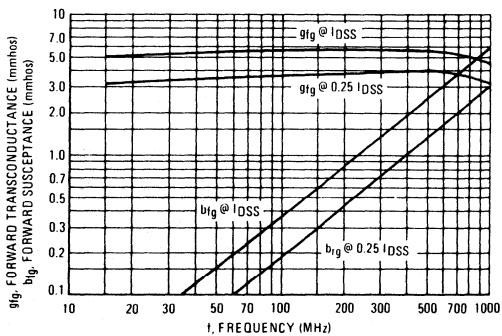
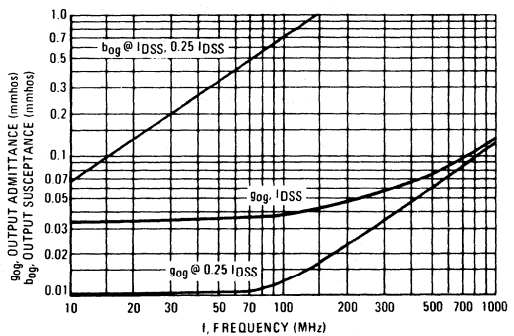
S-PARAMETERS

($V_{DS} = 15$ Vdc, $T_{channel} = 25^\circ\text{C}$,
Data Points in MHz)

FIGURE 10 — S_{11s} FIGURE 11 — S_{12s} FIGURE 12 — S_{21s} FIGURE 13 — S_{22s} 

COMMON GATE CHARACTERISTICS

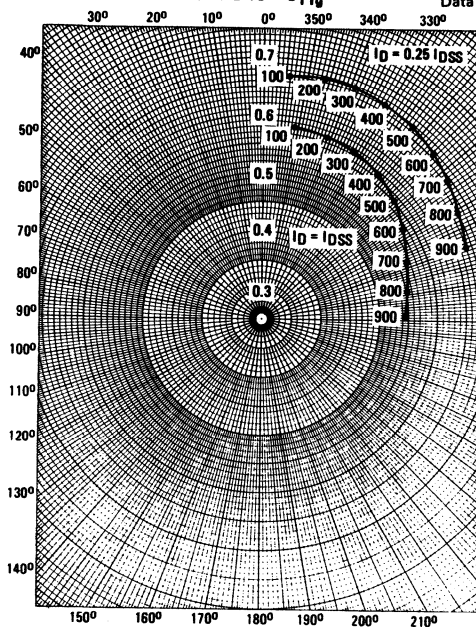
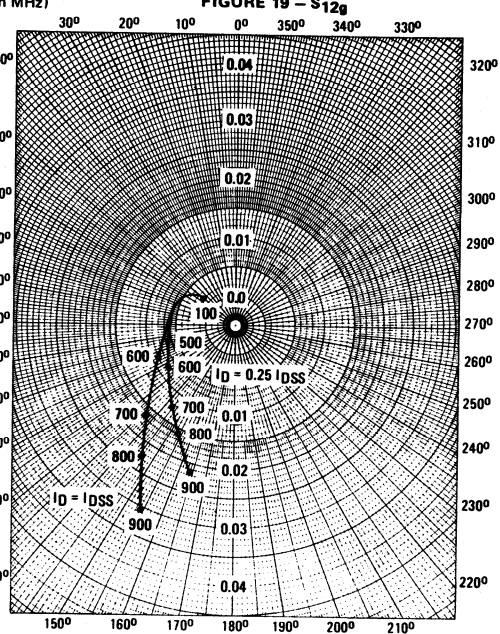
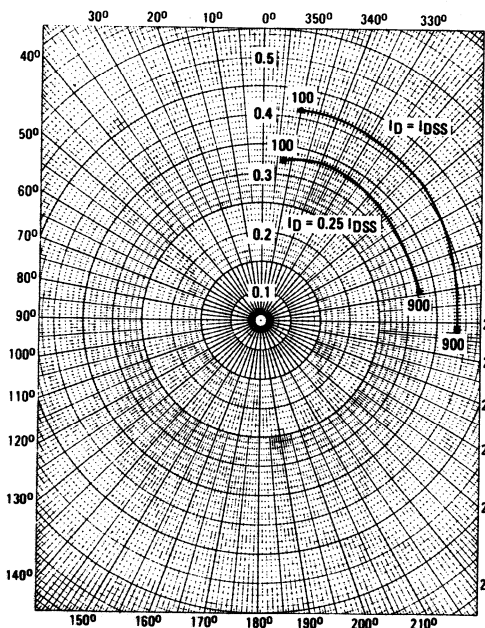
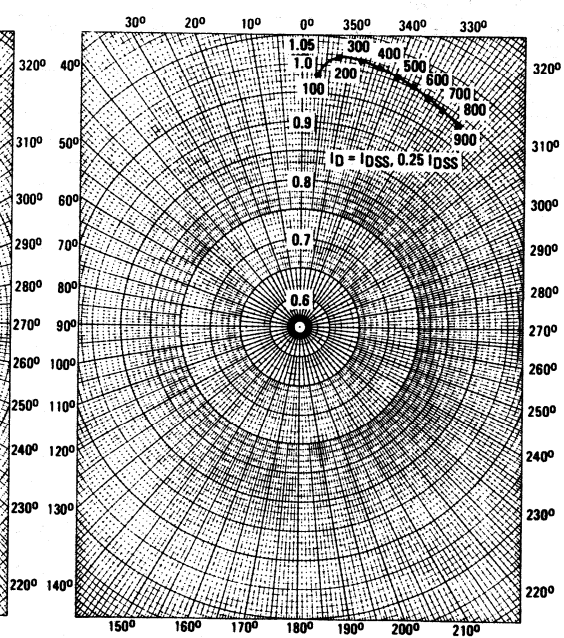
ADMITTANCE PARAMETERS

(V_{DG} = 15 Vdc, T_{channel} = 25°C)FIGURE 14 – INPUT ADMITTANCE (y_{ig})FIGURE 15 – REVERSE TRANSFER ADMITTANCE (y_{rg})FIGURE 16 – FORWARD TRANSFER ADMITTANCE (y_{fg})FIGURE 17 – OUTPUT ADMITTANCE (y_{og})

COMMON GATE CHARACTERISTICS

S-PARAMETERS

($V_{DG} = 15 \text{ Vdc}$, $T_{\text{channel}} = 25^\circ\text{C}$,
Data Points in MHz)

FIGURE 18 — S_{11g} FIGURE 19 — S_{12g} FIGURE 20 — S_{21g} FIGURE 21 — S_{22g} 

2N4427 (SILICON)

The RF Line

NPN SILICON RF POWER TRANSISTOR

... designed for amplifier, frequency multiplier, or oscillator applications in military and industrial equipment. Suitable for use as output driver or pre-driver stages in VHF and UHF equipment.

- Current-Gain-Bandwidth Product –
 $f_T = 500 \text{ MHz (Min) @ } I_C = 50 \text{ mAdc}$
- Power Gain –
 $G_{pe} = 10 \text{ dB (Min) @ } V_{CE} = 12 \text{ Vdc}$
- 1 Watt Minimum Power Output @ $f = 175 \text{ MHz}$
- Multiple-Emitter Construction for Excellent High-Frequency Performance

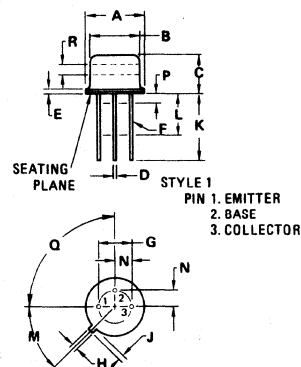
1 W – 175 MHz
RF POWER
TRANSISTOR
NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*Collector-Emitter Voltage	V_{CEO}	20	Vdc
*Collector-Base Voltage	V_{CB}	40	Vdc
*Emitter-Base Voltage	V_{EB}	2.0	Vdc
*Collector Current – Continuous	I_C	400	mAdc
*Base Current – Continuous	I_B	400	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 5.71	Watt mW/ $^\circ\text{C}$
*Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	3.5 20	Watts mW/ $^\circ\text{C}$
*Storage Temperature Range	T_{stg}	-65 to + 200	$^\circ\text{C}$

*Indicates JEDEC Registered Data

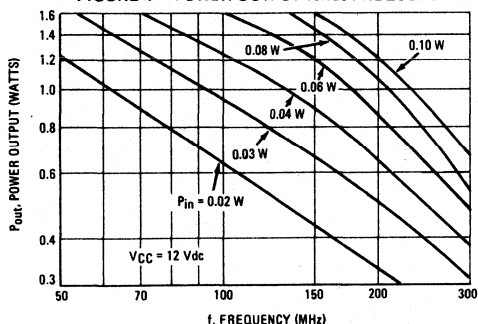


DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45°	NOM	45°	NOM
P	—	1.27	—	0.050
Q	90°	NOM	90°	NOM
R	2.54	—	0.100	—

CASE 79-02
TO-39

All JEDEC notes and dimensions apply.
Available in TO-46 Package as MRF604

FIGURE 1 – POWER OUTPUT versus FREQUENCY

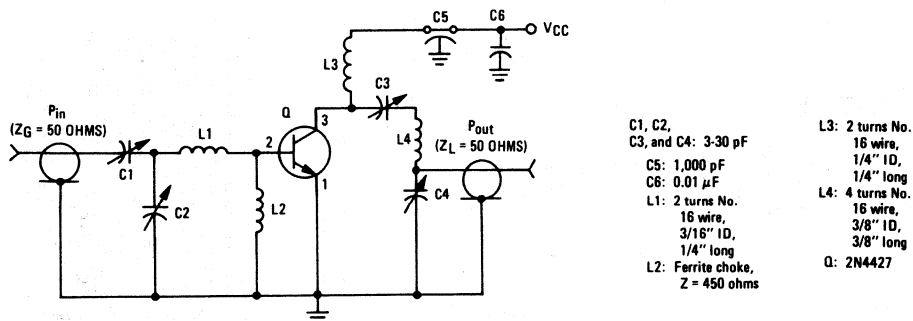


ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
*Collector-Emitter Sustaining Voltage ($I_C = 5.0\text{ mA}$, $I_B = 0$)	$V_{CE(sus)}$	20	—	Vdc
*Collector-Emitter Sustaining Voltage ($I_C = 5.0\text{ mA}$, $R_{BE} = 10\text{ ohms}$)	$V_{CER(sus)}$	40	—	Vdc
*Collector Cutoff Current ($V_{CE} = 12\text{ Vdc}$, $I_B = 0$)	I_{CEO}	—	0.02	mA
*Collector Cutoff Current ($V_{CE} = 40\text{ Vdc}$, $V_{BE} = -1.5\text{ Vdc}$) ($V_{CE} = 12\text{ Vdc}$, $V_{BE} = -1.5\text{ Vdc}$, $T_C = +150^\circ\text{C}$)	I_{CEV}	—	0.1 5.0	mA
*Emitter Cutoff Current ($V_{EB} = 2.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	0.1	mA
ON CHARACTERISTICS				
*DC Current Gain ($I_C = 100\text{ mA}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 360\text{ mA}$, $V_{CE} = 5.0\text{ Vdc}$)	h_{FE}	10 5.0	200 —	—
*Collector-Emitter Saturation Voltage ($I_C = 100\text{ mA}$, $I_B = 20\text{ mA}$)	$V_{CE(sat)}$	—	0.5	Vdc
DYNAMIC CHARACTERISTICS				
*Current-Gain — Bandwidth Product ($I_C = 50\text{ mA}$, $V_{CE} = 15\text{ Vdc}$, $f = 200\text{ MHz}$)	f_T	500	—	MHz
*Output Capacitance ($V_{CB} = 12\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{ob}	—	4.0	pF
FUNCTIONAL TEST				
*Power Input (Figure 1) ($P_{out} = 1.0\text{ W}$, $Z_S = 50\text{ Ohms}$, $V_{CC} = 12\text{ Vdc}$, $f = 175\text{ MHz}$)	P_{in}	—	100	mW
Common-Emitter Amplifier Power Gain ($P_{in} = 100\text{ mW}$, $Z_S = 50\text{ Ohms}$, $V_{CC} = 12\text{ Vdc}$, $f = 175\text{ MHz}$)	G_{pe}	10	—	dB
*Collector Efficiency (Figure 1) ($P_{out} = 1.0\text{ W}$, $Z_S = 50\text{ Ohms}$, $V_{CC} = 12\text{ Vdc}$, $f = 175\text{ MHz}$)	η	50	—	%

*Indicates JEDEC Registered Data

FIGURE 1 — 175 MHz RF AMPLIFIER CIRCUIT FOR POWER-OUTPUT TEST



NPN SILICON RF POWER TRANSISTOR

... designed primarily for use in large signal VHF and UHF amplifier output stages in military and industrial communications applications.

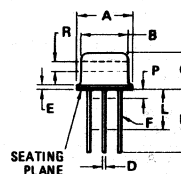
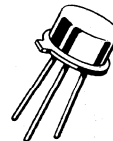
- High Power Output –
 $P_{out} = 0.75$ Watt with 10 dB Gain @ $f = 500$ MHz
- High Current-Gain-Bandwidth Product –
 $f_T = 1000$ MHz (Typ) @ $I_C = 50$ mA dc
- Multiple Emitter Construction for Excellent High Frequency Performance

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Collector-Base Voltage	V_{CB}	55	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector Current – Continuous	I_C	425	mA dc
Base Current – Continuous	I_B	150	mA dc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	3.5 20	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

*Indicates JEDEC Registered Data.

NPN SILICON RF POWER TRANSISTOR



STYLE 1
PIN 1. EMITTER
PIN 2. BASE
PIN 3. COLLECTOR

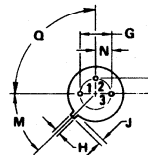
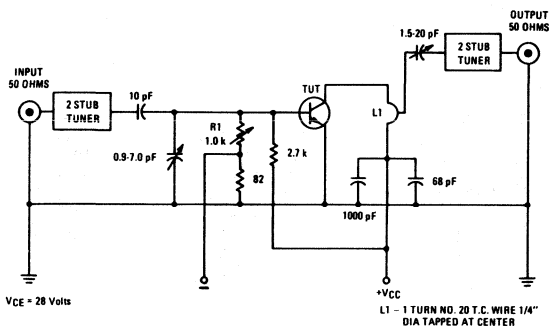


FIGURE 1 – 500 MHz TEST CIRCUIT



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.90	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45°	NOM	45°	NOM
P	—	1.27	—	0.050
Q	90°	NOM	90°	NOM
R	2.54	—	0.100	—

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

*ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage ($I_C = 20\text{ mAdc}$, $I_B = 0$)	$V_{CEO(sus)}$	35	—	—	Vdc
Collector-Emitter Sustaining Voltage ($I_C = 20\text{ mAdc}$, $R_{BE} = 10\text{ ohms}$)	$V_{CER(sus)}$	55	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 55\text{ Vdc}$, $V_{BE} = -1.5\text{ Vdc}$)	I_{CEX}	—	—	1.0	mAdc
Emitter Cutoff Current ($V_{EB} = 3.5\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	—	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 50\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$) ($I_C = 400\text{ mAdc}$, $V_{CE} = 5.0\text{ Vdc}$)	h_{FE}	20 5.0	— —	200 —	—
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product ($I_C = 50\text{ mAdc}$, $V_{CE} = 20\text{ Vdc}$, $f = 200\text{ MHz}$)	f_T	700	1000	—	MHz
Output Capacitance ($V_{CB} = 28\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{ob}	—	1.2	3.5	pF
FUNCTIONAL TEST					
Power Input (Figure 1) ($P_{out} = 750\text{ mW}$, $V_{CE} = 28\text{ Vdc}$, $R_S = 50\text{ Ohms}$, $f = 500\text{ MHz}$)	P_{in}	—	—	75	mW
Collector Efficiency (Figure 1) ($P_{out} = 750\text{ mW}$, $V_{CE} = 28\text{ Vdc}$, $R_S = 50\text{ Ohms}$, $f = 500\text{ MHz}$)	η	35	—	—	%

*Indicates JEDEC Registered Data.

FIGURE 2 — CURRENT-GAIN-BANDWIDTH PRODUCT

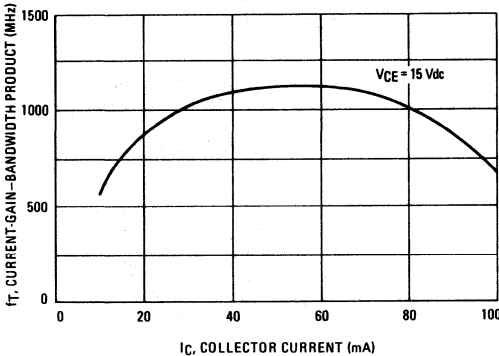
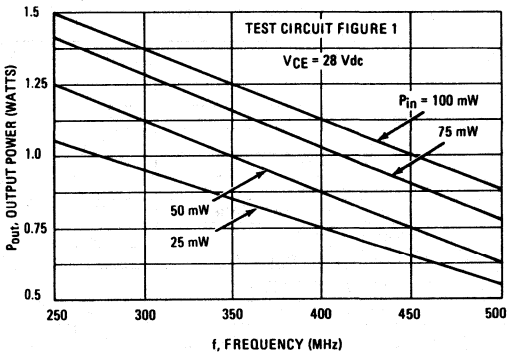


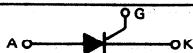
FIGURE 3 — OUTPUT POWER versus FREQUENCY



2N4441 (SILICON)

thru

2N4444



PLASTIC THYRISTORS

... designed for high-volume consumer phase-control applications such as motor speed, temperature, and light controls and for switching applications in ignition and starting systems, voltage regulators, vending machines, and lamp drivers requiring:

- Small, Rugged, Thermopad Construction — for Low Thermal Resistance, High Heat Dissipation, and Durability.
- Practical Level Triggering and Holding Characteristics @ 25°C
 $I_{GT} = 7.0 \text{ mA (Typ)}$
 $I_H = 6.0 \text{ mA (Typ)}$
- Low "On" Voltage — $V_{TM} = 1.0 \text{ Volt (Typ)}$ @ 5.0 Amp @ 25°C
- High Surge Current Rating — $I_{TSM} = 80 \text{ Amp}$

MAXIMUM RATING ($T_J = 100^\circ\text{C}$ unless otherwise noted.)

Rating	Symbol	Value	Unit
*Repetitive Peak Reverse Blocking Voltage (Note 1)	V_{RRM}	50 200 400 600	Volts
*Non-Repetitive Peak Reverse Blocking Voltage ($t = 5.0 \text{ ms (max)}$ duration)	V_{RSM}	75 300 500 700	Volts
*RMS On-State Current (All Conduction Angles)	$I_T(\text{RMS})$	8.0	Amp
Average On-State Current, $T_C = 73^\circ\text{C}$	$I_T(\text{AV})$	5.1	Amp
*Peak Non-Repetitive Surge Current (1/2 cycle, 60 Hz preceded and followed by rated current and voltage)	I_{TSM}	80	Amp
Circuit Fusing Considerations ($T_J = -40$ to $+100^\circ\text{C}$; $t = 1.0$ to 8.3 ms)	I^2t	25	A^2s
*Peak Gate Power	P_{GM}	5.0	Watts
*Average Gate Power	$P_G(\text{AV})$	0.5	Watt
*Peak Forward Gate Current	I_{GM}	2.0	Amp
*Peak Reverse Gate Voltage	V_{RGM}	10	Volts
*Operating Junction Temperature Range	T_J	-40 to +100	$^\circ\text{C}$
*Storage Temperature Range	T_{stg}	-40 to +150	$^\circ\text{C}$
Mounting Torque (6-32 screw) (Note 2)	—	8.0	in. lb.

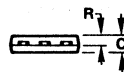
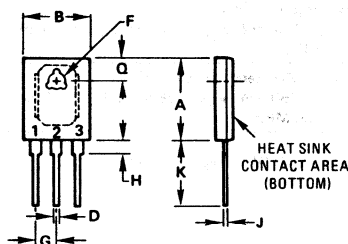
THERMAL CHARACTERISTICS

Characteristic	Symbol	Typ	Max	Unit
*Thermal Resistance, Junction to Case	$R_{\theta JC}$	—	2.5	$^\circ\text{C/W}$
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	40	—	$^\circ\text{C/W}$

*Indicates JEDEC Registered Data.

PLASTIC SILICON CONTROLLED RECTIFIERS

8.0 AMPERES RMS
50 thru 600 VOLTS



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	15.95	16.71	0.628	0.658
B	12.45	13.21	0.490	0.520
C	3.05	3.81	0.120	0.150
D	1.09	1.25	0.043	0.049
F	3.51	3.78	0.138	0.148
G	4.22	BSC	0.166	BSC
H	—	3.18	—	0.125
J	0.76	0.86	0.030	0.034
K	14.99	16.51	0.590	0.650
Q	4.50	5.00	0.177	0.197
R	1.91	2.16	0.075	0.085

CASE 90-04

STYLE 1:
PIN 1. CATHODE
2. ANODE
3. GATE

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
*Peak Forward Blocking Voltage ($T_J = 100^\circ\text{C}$) Note 1	V_{DRM}	50 200 400 600	— — — —	— — — —	Volts
Peak Forward Blocking Current (Rated V_{DRM} , $T_J = 100^\circ\text{C}$, gate open)	I_{DRM}	—	—	2.0	mA
Peak Reverse Blocking Current (Rated V_{DRM} , $T_J = 100^\circ\text{C}$, gate open)	I_{RRM}	—	—	2.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7.0 Vdc, $R_L = 100\ \Omega$) $T_C = 25^\circ\text{C}$ * $T_C = -40^\circ\text{C}$	I_{GT}	—	7.0	30 60	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7.0 Vdc, $R_L = 100\ \Omega$) $T_C = 25^\circ\text{C}$ * (Anode Voltage = 7.0 Vdc, $R_L = 100\ \Omega$) $T_C = -40^\circ\text{C}$ * (Anode Voltage = Rated V_{DRM} , $R_L = 100\ \Omega$) $T_J = 100^\circ\text{C}$	V_{GT}	— — 0.2	0.75 — —	1.5 2.5 —	Volts
Peak On-State Voltage (Pulse Width = 1.0 to 2.0 ms, Duty Cycle $\leq 2.0\%$) ($I_{\text{TM}} = 5.0\ \text{A}$ peak) * ($I_{\text{TM}} = 15.7\ \text{A}$ peak)	V_{TM}	— —	1.0 —	1.5 2.0	Volts
Holding Current (Anode Voltage = 7.0 Vdc, gate open) $T_C = 25^\circ\text{C}$ * $T_C = -40^\circ\text{C}$	I_{H}	— —	6.0 —	40 70	mA
Gate Controlled Turn-On Time ($I_{\text{TM}} = 5.0\ \text{A}$, $I_{\text{GT}} = 20\ \text{mA}$)	t_{gt}	—	1.0	—	μs
Circuit Commutated Turn-Off Time ($I_{\text{TM}} = 5.0\ \text{A}$, $I_{\text{R}} = 5.0\ \text{A}$) ($I_{\text{TM}} = 5.0\ \text{A}$, $I_{\text{R}} = 5.0\ \text{A}$, $T_J = 100^\circ\text{C}$)	t_{q}	— —	15 20	— —	μs
Critical Rate of Rise of Off-State Voltage (Rated V_{DRM} , Exponential Waveform, $T_J = 100^\circ\text{C}$, Gate Open)	dv/dt	—	50	—	V/ μs

*Indicates JEDEC Registered Data

Note 1. Ratings apply for zero or negative gate voltage but positive gate voltage shall not be applied concurrently with a negative potential on the anode. When checking forward or reverse blocking capability, thyristor devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage.

Note 2. Torque rating applies with use of torque washer (Shake-proof WD19522 #6 or equivalent). Mounting torque in excess of 8 in. lbs. does not appreciably lower case-to-sink thermal resistance. Anode lead and heatsink contact pad are common.

For soldering purposes (either terminal connection or device mounting), soldering temperatures shall not exceed $+225^\circ\text{C}$.

FIGURE 1 – MAXIMUM FORWARD VOLTAGE

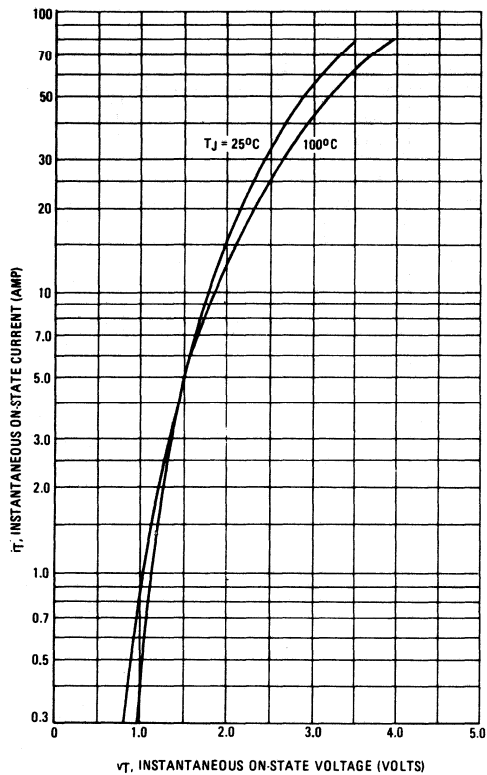


FIGURE 2 – MAXIMUM ON-STATE POWER DISSIPATION

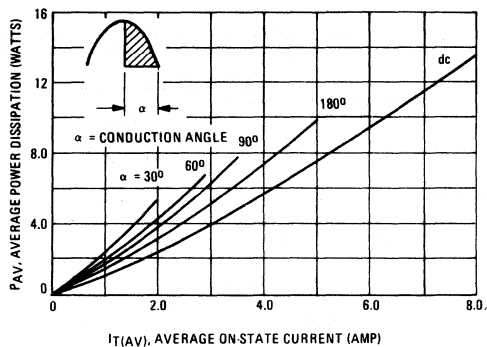


FIGURE 3 – AVERAGE CURRENT DERATING

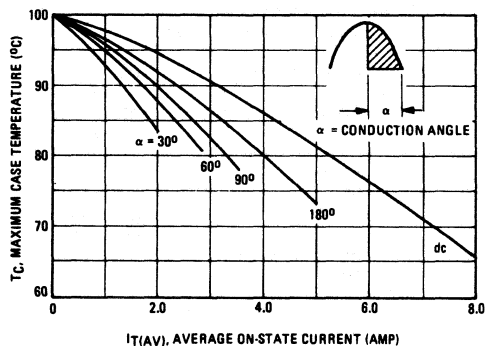


FIGURE 4 – THERMAL RESPONSE

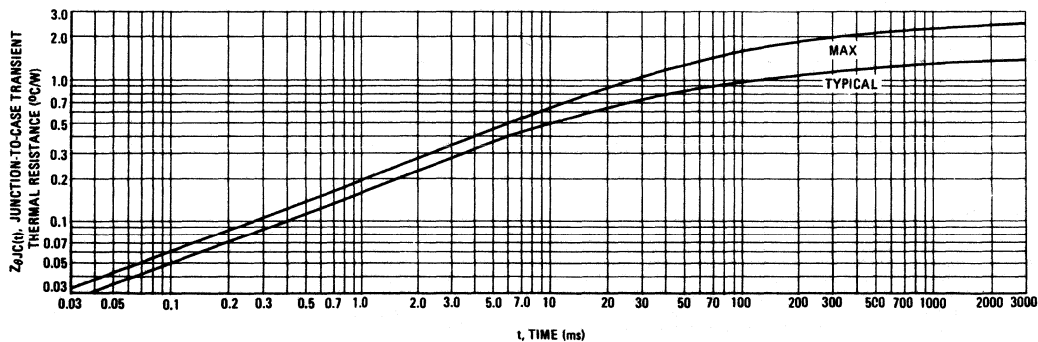


FIGURE 5 – MAXIMUM NON-REPETITIVE SURGE CURRENT

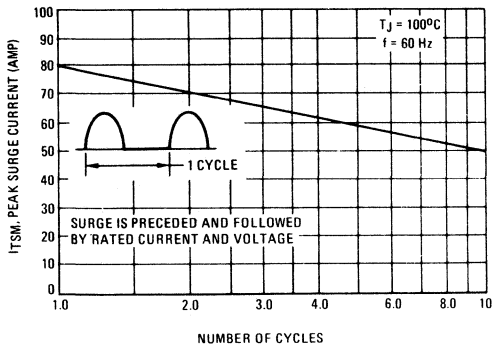


FIGURE 6 – TYPICAL HOLDING CURRENT

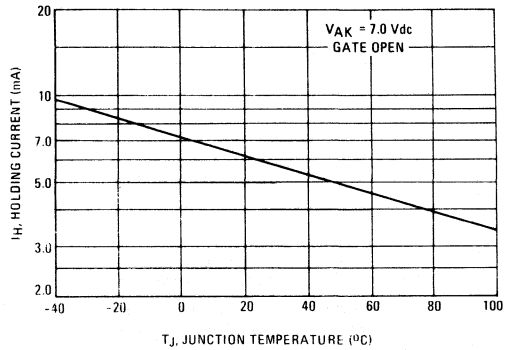


FIGURE 7 – TYPICAL GATE TRIGGER CURRENT

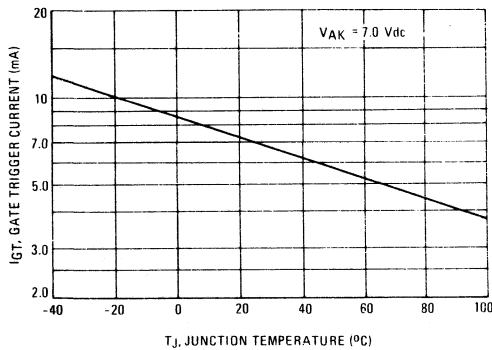
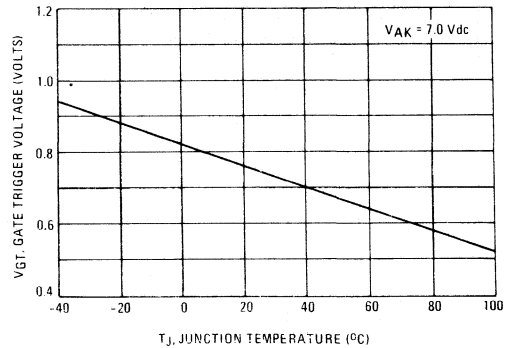


FIGURE 8 – TYPICAL GATE TRIGGER VOLTAGE



SELECTED THYRISTOR-TRIGGER APPLICATION NOTES

- AN-240 –SCR Power Control Fundamentals
- AN-290B –Mounting Procedure for, and Thermal Aspects of, Thermopad Plastic Power Devices
- AN-295 –Suppressing RFI in Thyristor Circuits
- AN-422 –Testers for Thyristors and Trigger Diodes
- AN-453 –Zero Point Switching Techniques

To obtain copies of these notes list the AN number(s) on your company letterhead and send your request to:

Technical Information Center
Motorola Semiconductor Products, Inc.
P.O. Box 20924
Phoenix, Arizona 85036

NPN SILICON ANNULAR TRANSISTOR

... designed for general-purpose amplifier and switching applications requiring TO-46 package configurations.

- Collector-Emitter Breakdown Voltage –
 $V_{CEO} = 30 \text{ Vdc (Min) @ } I_C = 10 \text{ mAdc}$
- DC Current Gain – 100 μAdc to 500 mAdc
- Low Collector-Emitter Saturation Voltage –
 $V_{CE(sat)} = 0.2 \text{ Vdc (Typ) @ } I_C = 150 \text{ mAdc}$
- High Current-Gain–Bandwidth Product –
 $f_T = 350 \text{ MHz (Typ) @ } I_C = 50 \text{ mAdc}$
- Fast Switching Time – (Figures 1 and 2)
 $t_{on} = 50 \text{ ns (Typ)}$
 $t_{off} = 125 \text{ ns (Typ)}$

NPN SILICON GENERAL PURPOSE TRANSISTOR



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage (1)	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	500	mAdc
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	0.36 2.06	Watt mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	3.0 17.2	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

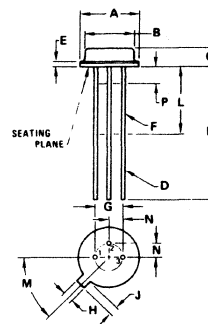
*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA} (2)$	485	$^\circ\text{C/W}$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	58	$^\circ\text{C/W}$
Lead Temperature 1/16" From Case for 60 Seconds	T_L	300	$^\circ\text{C}$

*Indicates JEDEC Registered Data.

(1) Applicable 0 to 100 mA, Pulse Width = 10 μs , Duty Cycle $\leq 2.0\%$.

(2) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1: EMITTER
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	1.65	2.16	0.065	0.085
D	0.406	0.533	0.016	0.021
E	—	1.02	—	0.040
F	0.305	0.483	0.012	0.019
G	2.54 BSC	—	0.100 BSC	—
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC	—	45° BSC	—
N	1.27 BSC	—	0.050 BSC	—
P	—	1.27	—	0.050

All JEDEC dimensions and notes apply

CASE 26-03
TO-46

2N4450 (continued)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) ($I_C = 10\text{ mA}$, $I_B = 0$)	BV_{CEO}	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{A}$, $I_E = 0$)	BV_{CBO}	60	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{A}$, $I_C = 0$)	BV_{EBO}	5.0	—	—	Vdc
Collector Cutoff Current (1) ($V_{CB} = 50\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 50\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	— —	— —	10 10	nAdc μAdc
Emitter Cutoff Current ($V_{EB} = 3.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	—	10	nAdc
Base Current ($V_{CE} = 50\text{ Vdc}$, $V_{BE} = 0$)	I_B	—	—	10	nAdc

ON CHARACTERISTICS (1)

DC Current Gain ($I_C = 100\text{ }\mu\text{A}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 1.0\text{ mA}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 10\text{ mA}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 150\text{ mA}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 500\text{ mA}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 150\text{ mA}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 300\text{ mA}$, $V_{CE} = 1.0\text{ Vdc}$) ($I_C = 150\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $T_A = -55^\circ\text{C}$) (1)	h_{FE}	35 50 75 100 50 50 35 30	75 90 125 200 — — — —	— — — 300 — — — —	—
Collector-Emitter Saturation Voltage ($I_C = 150\text{ mA}$, $I_B = 15\text{ mA}$) ($I_C = 300\text{ mA}$, $I_B = 30\text{ mA}$) ($I_C = 500\text{ mA}$, $I_B = 50\text{ mA}$)	$V_{CE(sat)}$	— — —	0.2 0.3 0.5	0.22 0.45 0.60	Vdc
Base-Emitter Saturation Voltage ($I_C = 150\text{ mA}$, $I_B = 15\text{ mA}$) ($I_C = 300\text{ mA}$, $I_B = 30\text{ mA}$) ($I_C = 500\text{ mA}$, $I_B = 50\text{ mA}$)	$V_{BE(sat)}$	— — —	0.7 0.9 1.2	1.1 1.3 1.5	Vdc
Base-Emitter On Voltage ($I_C = 150\text{ mA}$, $V_{CE} = 10\text{ Vdc}$)	$V_{BE(on)}$	—	0.8	1.1	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 50\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	250	350	—	MHz
Collector-Base Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 150\text{ kHz}$)	C_{cb}	—	40	8.0	pF
Collector-Emitter Capacitance ($V_{BE} = 2.0\text{ Vdc}$, $I_C = 0$, $f = 140\text{ kHz}$)	C_{eb}	—	15	20	pF

SWITCHING CHARACTERISTICS

Turn-On Time	$(V_{CC} = 25\text{ Vdc}$, $V_{BE(off)} = 0\text{ V}$, $I_C = 300\text{ mA}$, $I_{B1} = 30\text{ mA}$) (Figure 1)	t_{on}	—	50	60	ns
Delay Time		t_d	—	10	30	ns
Rise Time		t_r	—	40	55	ns
Turn-Off Time	$(V_{CC} = 25\text{ Vdc}$, $I_C = 300\text{ mA}$, $I_{B1} = I_{B2} = 30\text{ mA}$) (Figure 2)	t_{off}	—	125	150	ns
Storage Time		t_s	—	100	140	ns
Fall Time		t_f	—	25	100	ns

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.

FIGURE 1 — TURN-ON TIME

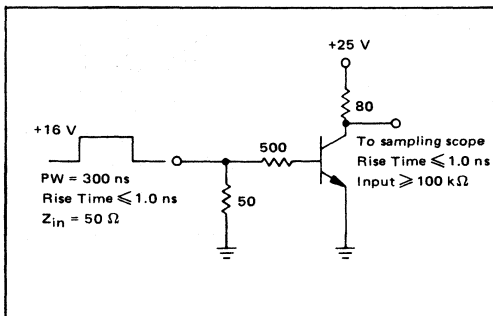
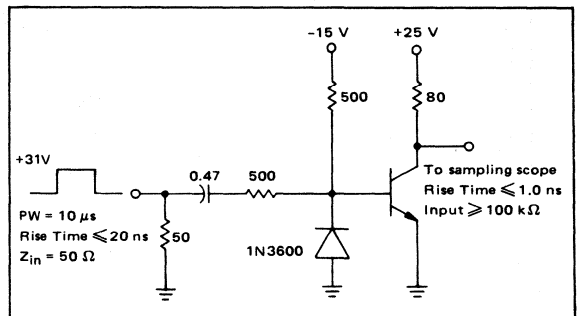


FIGURE 2 — TURN-OFF TIME



2N4851 thru 2N4853 (SILICON)

SILICON ANNULAR UNIJUNCTION TRANSISTORS

... designed for pulse and timing circuits, sensing circuits, and thyristor trigger circuits.

- Low Peak-Point Current — $I_p = 0.4 \mu\text{A}$ Max
- Low Emitter Reverse Current — $I_{e0} = 50 \text{ nA}$ Max
- Fast Switching — 1.0 MHz Min

*MAXIMUM RATINGS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Rating	Symbol	Value	Unit
RMS Power Dissipation (1)	P_D	300	mW
RMS Emitter Current	I_e	50	mA
Peak-Pulse Emitter Current (2)	i_e	1.5	Amp
Emitter Reverse Voltage	V_{B2E}	30	Volts
Interbase Voltage (3)	V_{B2B1}	35	Volts
Operating Junction Temperature Range	T_J	-65 to +125	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

- * Indicates JEDEC Registered Data
(1) Derate 3.0 mW/ $^\circ\text{C}$ increase in ambient temperature.
(2) Duty cycle < 1%, PRR = (see figure 6)
(3) Based upon power dissipation at $T_A = 25^\circ\text{C}$

FIGURE 1 — UNIJUNCTION TRANSISTOR SYMBOL AND NOMENCLATURE

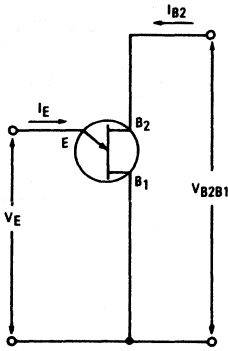
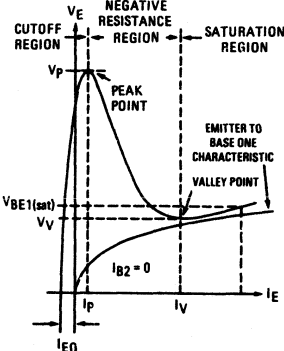
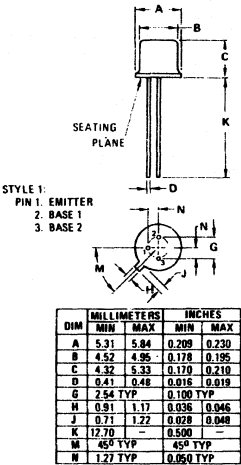


FIGURE 2 — STATIC EMITTER CHARACTERISTICS CURVES



PN UNIJUNCTION TRANSISTORS



2N4851 thru 2N4853 (continued)

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Rating	Figure No.	Symbol	Min	Typ	Max	Unit
* Intrinsic Standoff Ratio (1) ($V_{B2B1} = 10\text{ V}$) 2N4851 2N4852, 2N4853	4, 8	η	0.56 0.70	— —	0.75 0.85	—
* Interbase Resistance ($V_{B2B1} = 3.0\text{ V}$, $I_E = 0$)	11, 12	r_{BB}	4.7	—	9.1	k ohms
* Interbase Resistance Temperature Coefficient ($V_{B2B1} = 3.0\text{ V}$, $I_E = 0$, $T_A = -65$ to $+125^\circ\text{C}$)	12	αr_{BB}	0.2	—	0.8	%/ $^\circ\text{C}$
Emitter Saturation Voltage (2) ($V_{B2B1} = 10\text{ V}$, $I_E = 50\text{ mA}$)		$V_{EB1}(\text{sat})$	—	2.5	—	Volts
Modulated Interbase Current ($V_{B2B1} = 10\text{ V}$, $I_E = 50\text{ mA}$)		$I_{B2}(\text{mod})$	—	15	—	mA
* Emitter Reverse Current ($V_{B2E} = 30\text{ V}$, $I_{B1} = 0$) 2N4851, 2N4852 2N4853	7	I_{EB2O}	— —	— —	0.1 0.05	μA
* Peak-Point Emitter Current ($V_{B2B1} = 25\text{ V}$) 2N4851, 2N4852 2N4853	9, 10	I_P	— —	— —	2.0 0.4	μA
* Valley-Point Current (2) ($V_{B2B1} = 20\text{ V}$, $R_{B2} = 100\text{ ohms}$) 2N4851 2N4852 2N4853	13, 14	I_V	2.0 4.0 6.0	— — —	— — —	mA
* Base-One Peak Pulse Voltage 2N4851 2N4852 2N4853	3, 17	V_{OB1}	3.0 5.0 6.0	— — —	— — —	Volts
* Maximum Frequency of Oscillation	5	$f_{(\text{max})}$	1.0	1.25	—	MHz

* Indicates JEDEC Registered Data.

(1) η , Intrinsic standoff ratio, is defined in terms of the peak-point voltage, V_P , by means of the equation: $V_P = \eta V_{B2B1} + V_F$, where V_F is about 0.49 volt at 25°C @ $I_F = 10\text{ }\mu\text{A}$ and decreases with temperature at about $2.5\text{ mV}/^\circ\text{C}$. The test circuit is shown in Figure 4. Components R_1 , C_1 , and the UJT form a relaxation oscillator; the remaining circuitry serves as a peak-voltage detector. The forward drop of Diode D_1 compensates for V_F . To use, the "cal" button is pushed, and R_3 is adjusted to make the current meter, M_1 , read full scale. When the "cal" button is released, the value of η is read directly from the meter, if full scale on the meter reads 1.0.

(2) Use pulse techniques: $PW = 300\text{ }\mu\text{s}$, duty cycle $\leq 2.0\%$ to avoid internal heating, which may result in erroneous readings.

FIGURE 3 — V_{OB1} TEST CIRCUIT

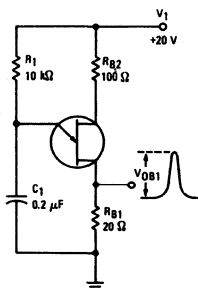


FIGURE 4 — η TEST CIRCUIT

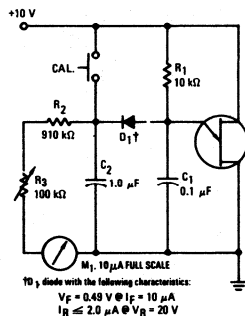


FIGURE 5 — $f_{(\text{max})}$ TEST CIRCUIT

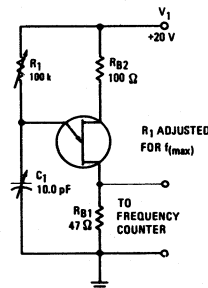
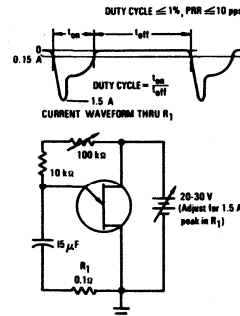
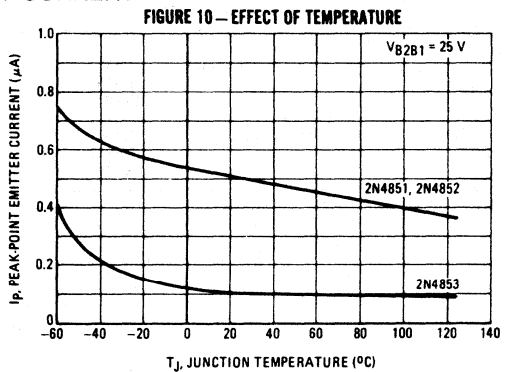
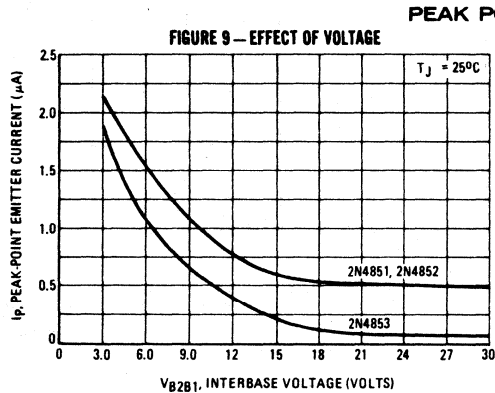
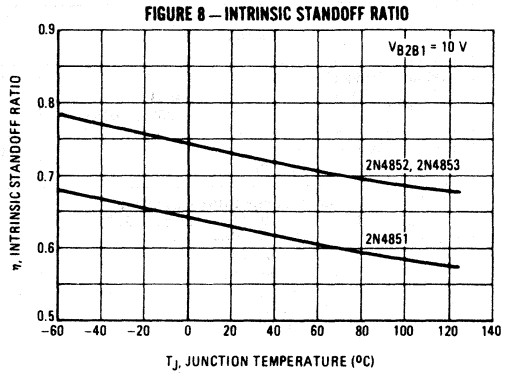
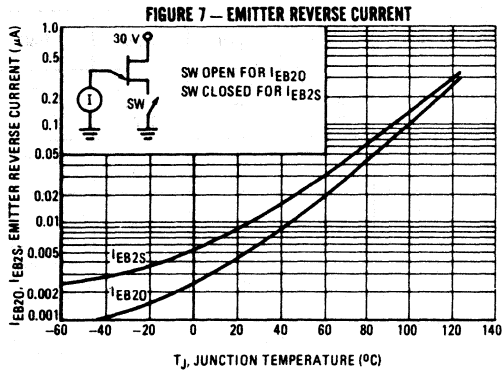


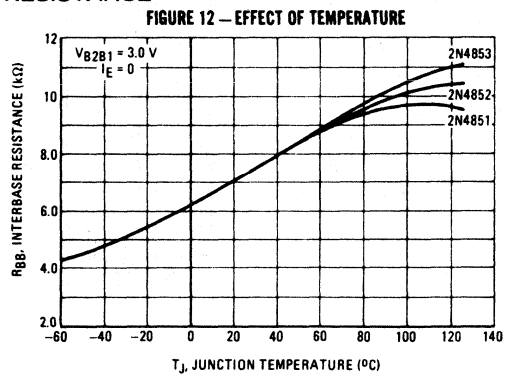
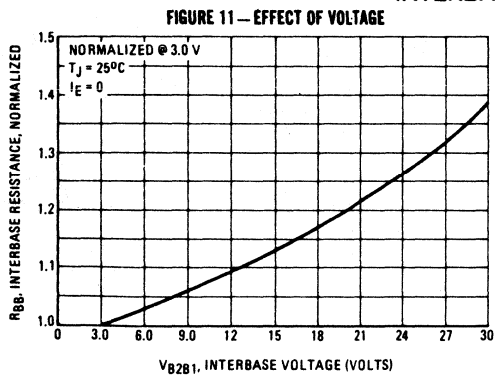
FIGURE 6 — PRR TEST CIRCUIT AND WAVEFORM



TYPICAL CHARACTERISTICS

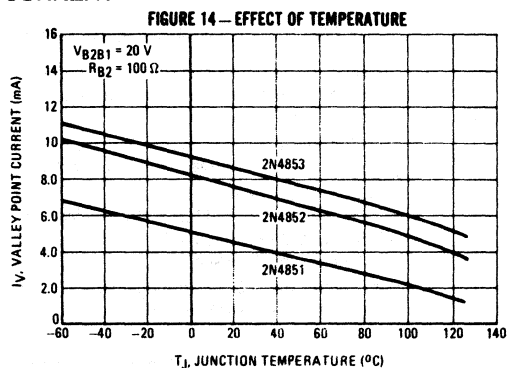
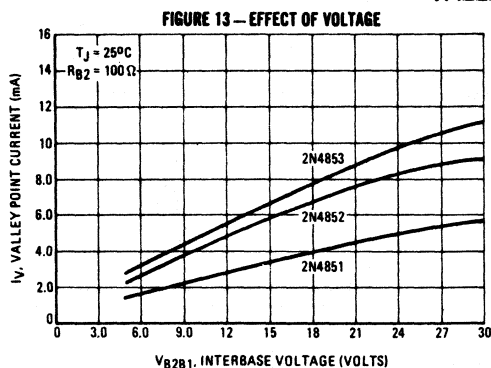


INTERBASE RESISTANCE

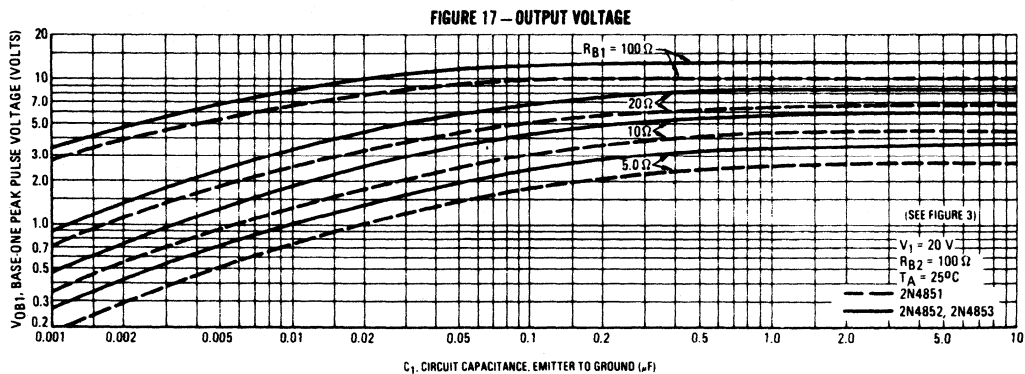
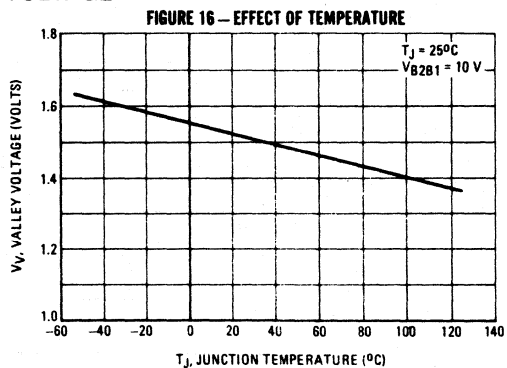
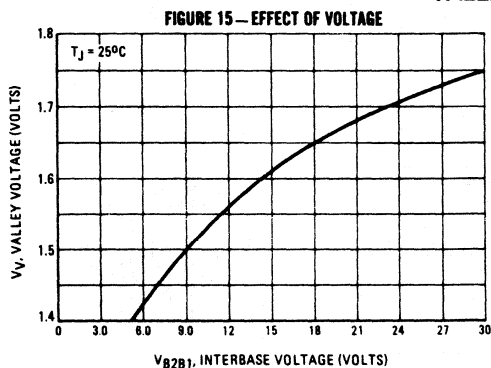


TYPICAL CHARACTERISTICS

VALLEY CURRENT



VALLEY VOLTAGE



2N4854 (SILICON)

2N4855

2N4854JAN,JTX,JTXV Available

MULTIPLE SILICON ANNULAR TRANSISTORS

... designed for use as differential amplifiers, dual general-purpose switches and amplifiers, front end detectors, and temperature compensation amplifiers.

- Low Collector-Emitter Saturation Voltage –
 $V_{CE(sat)} = 0.4 \text{ Vdc (Max) @ } I_C = 150 \text{ mAdc}$
- Fast Switching Times –
 $t_{on} = 60 \text{ ns (Max) and } t_{off} = 350 \text{ ns (Max)}$
- DC Current Gain Specified –
 $0.1 \text{ mAdc to } 300 \text{ mAdc}$
- High Current-Gain-Bandwidth Product –
 $f_T = 200 \text{ MHz (Typ) @ } I_C = 20 \text{ mAdc}$

*MAXIMUM RATINGS

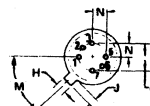
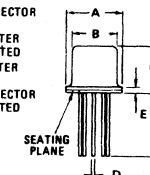
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector 1 to Collector 2 Voltage	V_{C1C2}	± 200	Vdc
Voltage Rating any Lead to Case		± 200	
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	600	mAdc
		One Die	Both Die
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 2.0	600 4.0 mW mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 6.67	2.0 13.33 Watts
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

*Indicates JEDEC Registered Data.

NPN/PNP SILICON MULTIPLE TRANSISTORS



STYLE 1:
 PIN 1. COLLECTOR
 2. BASE
 3. EMITTER
 4. OMITTED
 5. EMITTER
 6. BASE
 7. COLLECTOR
 8. OMITTED



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70		0.500	
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

FIGURE 1 – DELAY AND RISE TIMES

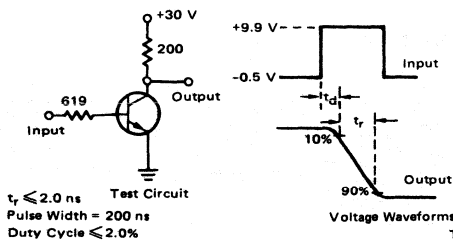
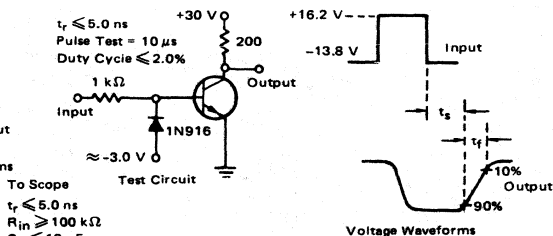


FIGURE 2 – STORAGE AND FALL TIMES



For PNP Test Circuit, Reverse diode and voltage polarities.

*** ELECTRICAL CHARACTERISTICS (Each Side)** ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) ($I_C = 10\text{ mAdc}$, $I_B = 0$)	BV_{CEO}	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 50\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$)	I_{CBO}	—	10	μAdc
Emitter Cutoff Current ($V_{EB} = 3.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	10	nAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 0.1\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$)	2N4854 2N4855	h_{FE}	35 20	—	—
($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$)	2N4854 2N4855		50 25	—	—
($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$)	2N4854 2N4855		75 35	—	—
($I_C = 150\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) (1)	2N4854 2N4855		100 40	300 120	—
($I_C = 150\text{ mAdc}$, $V_{CE} = 1.0\text{ Vdc}$) (1)	2N4854 2N4855		50 20	—	—
($I_C = 300\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) (1)	2N4854 2N4855		35 20	—	—
Collector-Emitter Saturation Voltage (1) ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$)		$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage (1) ($I_C = 150\text{ mAdc}$, $I_B = 15\text{ mAdc}$)		$V_{BE(sat)}$	0.75	1.2	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain–Bandwidth Product ($I_C = 20\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)		f_T	200	—	MHz
Collector-Base Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)		C_{cb}	—	8.0	pF
Input Impedance ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N4854 2N4855	h_{ie}	1.5 0.75	9.0 4.5	k ohms
Small-Signal Current Gain ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N4854 2N4855	h_{fe}	60 30	300 150	—
Output Admittance ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	2N4854 2N4855	h_{oe}	— —	50 25	μmhos
Noise Figure ($I_C = 100\text{ }\mu\text{Adc}$, $V_{CE} = 10\text{ Vdc}$, $R_S = 1.0\text{ k ohm}$, $f = 1.0\text{ kHz}$)		NF	—	8.0	dB

SWITCHING CHARACTERISTICS

Delay Time	(V _{CC} = 30 Vdc, V _{BE(off)} = 0.5 Vdc, I _C = 150 mAdc, I _{B1} = 15 mAdc)	t _d	—	20	ns
Rise Time		t _r	—	40	ns
Storage Time	(V _{CC} = 30 Vdc, I _C = 150 mAdc, I _{B1} = I _{B2} = 15 mAdc)	t _s	—	280	ns
Fall Time		t _f	—	70	ns

* Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.

2N4856, A

thru

2N4861, A

N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode symmetrical Field-Effect transistors designed for low-power switching and chopper applications.

- Low Drain-Source "ON" Resistance –
 $r_{ds(on)} = 25 \text{ Ohms (Max) @ } f = 1.0 \text{ kHz} - 2N4856,A, 2N4859,A$
- Low Drain Cutoff Current –
 $I_{D(off)} = 250 \text{ pAdc (Max) @ } V_{DS} = 15 \text{ Vdc}$

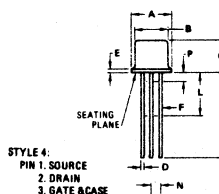
N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS



*MAXIMUM RATINGS

Rating	Symbol	2N4856,A 2N4857,A 2N4858,A	2N4859,A 2N4860,A 2N4861,A	Unit
Drain-Gate Voltage	V_{DG}	+40	+30	Vdc
Drain-Source Voltage	V_{DS}	+40	+30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	-40	-30	Vdc
Forward Gate Current	I_{GF}	50		mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	360 2.4		mW mW/ $^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200		$^\circ\text{C}$

*Indicates JEDEC Registered Data.

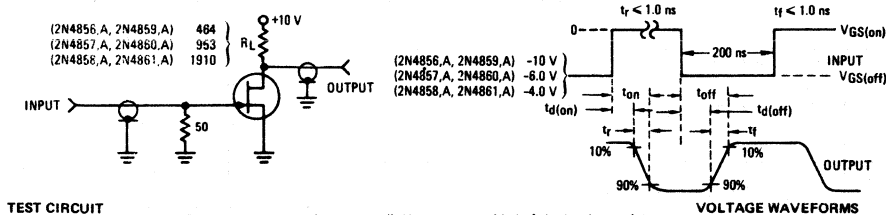


DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	3.31	3.84	0.209	0.230
B	4.82	4.86	0.178	0.190
C	4.32	5.33	0.170	0.210
D	1.28	1.52	0.011	0.021
E	0.762	—	0.030	—
F	0.408	0.482	0.016	0.019
G	2.14	2.14	0.085	0.085
H	0.814	1.17	0.032	0.046
J	0.711	1.22	0.028	0.048
K	13.70	—	0.540	—
L	0.76	—	0.030	—
M	0.76	—	0.030	—
N	1.27	1.27	0.050	0.050
P	—	17.27	—	0.680

All JEDEC notes and dimensions apply.

CASE 22-03
(TO-18)

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



TEST CIRCUIT

- NOTES: a. The input waveforms are supplied by a generator with the following characteristics:
 $Z_{out} = 50 \text{ ohms}$, Duty Cycle $\approx 2.0\%$.
- b. Waveforms are monitored on an oscilloscope with the following characteristics:
 $t_r < 0.75 \text{ ns}$, $R_{in} \geq 1.0 \text{ megohm}$, $C_{in} < 2.5 \text{ pF}$.

VOLTAGE WAVEFORMS

2N4856,A thru 2N4861,A (continued)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^{\circ}\text{C}$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit	
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage ($I_G = 1.0 \mu\text{Adc}$, $V_{DS} = 0$)	2N4856,A,2N4857,A,2N4858,A 2N4859,A,2N4860,A,2N4861,A	$V_{(BR)GSS}$	-40 -30	— —	Vdc	
Gate-Source Cutoff Voltage ($V_{DS} = 15 \text{ Vdc}$, $I_D = 0.5 \text{ nAdc}$)	2N4856,A,2N4859,A 2N4857,A,2N4860,A 2N4858,A,2N4861,A	$V_{GS(off)}$	-4.0 -2.0 -0.8	-10 -6.0 -4.0	Vdc	
Gate Reverse Current ($V_{GS} = -20 \text{ Vdc}$, $V_{DS} = 0$) ($V_{GS} = -15 \text{ Vdc}$, $V_{DS} = 0$) ($V_{GS} = -20 \text{ Vdc}$, $V_{DS} = 0$, $T_A = 150^\circ\text{C}$) ($V_{GS} = -15 \text{ Vdc}$, $V_{DS} = 0$, $T_A = 150^\circ\text{C}$)	2N4856,A,2N4857,A,2N4858,A 2N4859,A,2N4860,A,2N4861,A 2N4856,A,2N4857,A,2N4858,A 2N4859,A,2N4860,A,2N4861,A	I_{GSS}	— — — —	0.25 0.25 0.5 0.5	nAdc μAdc	
Drain Cutoff Current ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = -10 \text{ Vdc}$) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = -10 \text{ Vdc}$, $T_A = 150^\circ\text{C}$)		$I_{D(off)}$	— —	0.25 0.5	nAdc μAdc	
ON CHARACTERISTICS						
Zero-Gate Voltage Drain Current (1) ($V_{DS} = 15 \text{ Vdc}$, $V_{GS} = 0$)	2N4856,A,2N4859,A 2N4857,A,2N4860,A 2N4858,A,2N4861,A	I_{DSS}	50 20 8.0	— 100 80	mAdc	
Drain-Source "ON" Voltage ($I_D = 20 \text{ mAdc}$, $V_{GS} = 0$) ($I_D = 10 \text{ mAdc}$, $V_{GS} = 0$) ($I_D = 5.0 \text{ mAdc}$, $V_{GS} = 0$)	2N4856,A,2N4859,A 2N4857,A,2N4860,A 2N4858,A,2N4861,A	$V_{DS(on)}$	— — —	0.75 0.5 0.5	Vdc	
SMALL-SIGNAL CHARACTERISTICS						
Drain-Source "ON" Resistance ($V_{GS} = 0$, $I_D = 0$, $f = 1.0 \text{ kHz}$)	2N4856,A,2N4859,A 2N4857,A,2N4860,A 2N4858,A,2N4861,A	$r_{ds(on)}$	— — —	25 40 60	Ohms	
Input Capacitance ($V_{DS} = 0$, $V_{GS} = -10 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)	2N4856 thru 2N4861 2N4856 A thru 2N4861 A	C_{iss}	—	18 10	pF	
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = -10 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)	2N4856 thru 2N4861 2N4856 A,2N4859 A 2N4857 A,2N4858 A,2N4860 A,2N4861 A	C_{rss}	— — —	8.0 4.0 3.5	pF	
SWITCHING CHARACTERISTICS (See Figure 1) (2)						
Turn-On Delay Time	Conditions for 2N4856,A, 2N4859,A: ($V_{DD} = 10 \text{ Vdc}$, $I_{D(on)} = 20 \text{ mAdc}$, $V_{GS(on)} = 0$, $V_{GS(off)} = -10 \text{ Vdc}$)	2N4856, 2N4859 2N4856A, 2N4859A 2N4857, 2N4860 2N4857A, 2N4860A 2N4858, 2N4861 2N4858A, 2N4861A	$t_{d(on)}$	— — — — — —	6.0 5.0 6.0 6.0 10 8.0	ns
Rise Time	Conditions for 2N4857,A, 2N4860,A: ($V_{DD} = 10 \text{ Vdc}$, $I_{D(on)} = 10 \text{ mAdc}$, $V_{GS(on)} = 0$, $V_{GS(off)} = -6.0 \text{ Vdc}$)	2N4856,A, 2N4859,A 2N4857,A, 2N4860,A 2N4858, 2N4861 2N4858A, 2N4861A	t_r	— — — —	3.0 4.0 10 8.0	ns
Turn-Off Time	Conditions for 2N4858,A, 2N4861,A: ($V_{DD} = 10 \text{ Vdc}$, $I_{D(on)} = 5.0 \text{ mAdc}$, $V_{GS(on)} = 0$, $V_{GS(off)} = -4.0 \text{ Vdc}$)	2N4856, 2N4859 2N4856A, 2N4859A 2N4857, 2N4860 2N4857A, 2N4860A 2N4858, 2N4861 2N4858A, 2N4861A	t_{off}	— — — — — —	25 20 50 40 100 80	ns

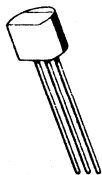
* Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width = 100 ms, Duty Cycle $\leq 10\%$.

(2) The $I_{D(on)}$ values are nominal; exact values vary slightly with transistor parameters.

2N4870 (SILICON)

2N4871



PN unijunction transistors designed for use in pulse and timing circuits, sensing circuits and thyristor trigger circuits.

CASE 29
(TO-92)



MAXIMUM RATINGS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Rating	Symbol	Value	Unit
RMS Power Dissipation*	P_D^*	300	mW
RMS Emitter Current	I_e	50	mA
Peak-Pulse Emitter Current**	i_e^{**}	1.5	Amp
Emitter Reverse Voltage	V_{B2E}	30	Volts
Interbase Voltage†	$V_{B2B1}^\dagger$	35	Volts
Operating Junction Temperature Range	T_J	-65 to +125	$^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +150	$^\circ\text{C}$

*Derate 3.0 mW/ $^\circ\text{C}$ increase in ambient temperature.

**Duty cycle $\leq 1\%$, PRR = 10 PPS (see Figure 5).

†Based upon power dissipation at $T_A = 25^\circ\text{C}$.

FIGURE 1 — UNIJUNCTION TRANSISTOR SYMBOL AND NOMENCLATURE

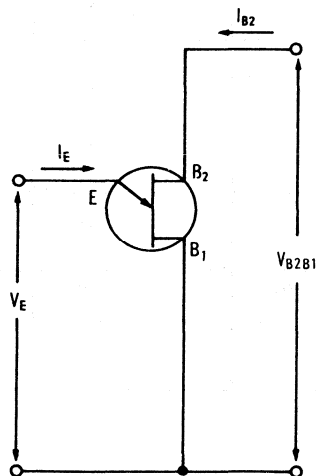
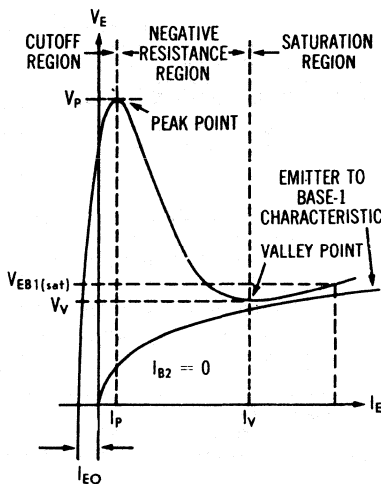


FIGURE 2 — STATIC EMITTER CHARACTERISTICS CURVES



2N4870, 2N4871 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Intrinsic Standoff Ratio* ($V_{B2B1} = 10\text{ V}$) 2N4870 2N4871	4, 7	η^*	0.56 0.70	- -	0.75 0.85	-
Interbase Resistance ($V_{B2B1} = 3.0\text{ V}$, $I_E = 0$)	10, 11	R_{BB}	4.0	6.0	9.1	k ohms
Interbase Resistance Temperature Coefficient ($V_{B2B1} = 3.0\text{ V}$, $I_E = 0$, $T_A = -65$ to $+125^\circ\text{C}$)	11	αR_{BB}	0.10	-	0.90	%/ $^\circ\text{C}$
Emitter Saturation Voltage** ($V_{B2B1} = 10\text{ V}$, $I_E = 50\text{ mA}$)		$V_{EB1(\text{sat})}^{**}$	-	2.5	-	Volts
Modulated Interbase Current ($V_{B2B1} = 10\text{ V}$, $I_E = 50\text{ mA}$)		$I_{B2(\text{mod})}$	-	15	-	mA
Emitter Reverse Current ($V_{B2E} = 30\text{ V}$, $I_{B1} = 0$)	6	I_{EB2O}	-	0.005	1.0	μA
Peak-Point Emitter Current ($V_{B2B1} = 25\text{ V}$)	8, 9	I_P	-	1.0	5.0	μA
Valley-Point Current** ($V_{B2B1} = 20\text{ V}$, $R_{B2} = 100\text{ ohms}$) 2N4870 2N4871	12, 13	I_V^{**}	2.0 4.0	5.0 7.0	- -	mA
Base-One Peak Pulse Voltage 2N4870 2N4871	3, 16	V_{OB1}	3.0 5.0	6.0 8.0	- -	Volts

* η Intrinsic standoff ratio, is defined in terms of peak-point voltage, V_P , by means of the equation: $V_P = \eta V_{B2B1} + V_F$, where V_F is approximately 0.49 volt at 25°C @ $I_E = 10 \mu\text{A}$ and decreases with temperature at approximately $2.5 \text{ mV}/^\circ\text{C}$. The test circuit is shown in Figure 4. Components R_1 , C_1 , and the UJT form a relaxation oscillator, the remaining circuitry serves as a peak-voltage detector. The forward drop of Diode D_1 compensates for V_F . To use, the "cal" button is pushed, and R_3 is adjusted to make the current meter, M_1 , read full scale. When the "cal" button is released, the value of η is read directly from the meter, if full scale on the meter reads 1.0.

** Use pulse techniques: $PW \approx 300 \mu s$, duty cycle $\leq 2.0\%$ to avoid internal heating, which may result in erroneous readings.

FIGURE 3— V_{DB1} TEST CIRCUIT

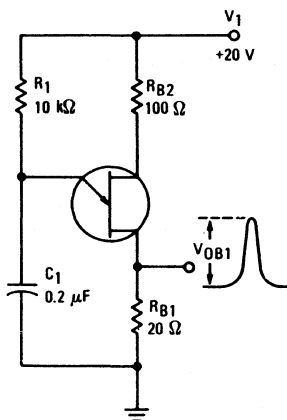


FIGURE 4 — η TEST CIRCUIT

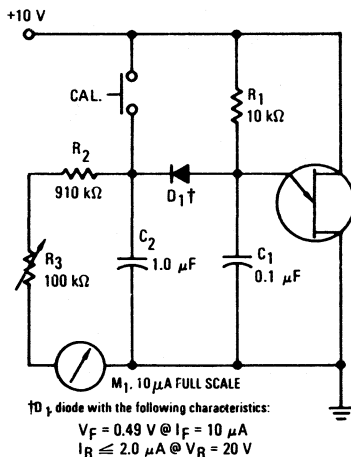
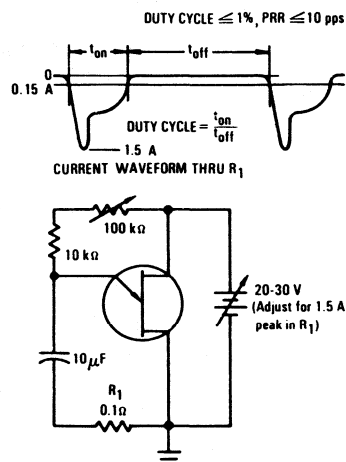
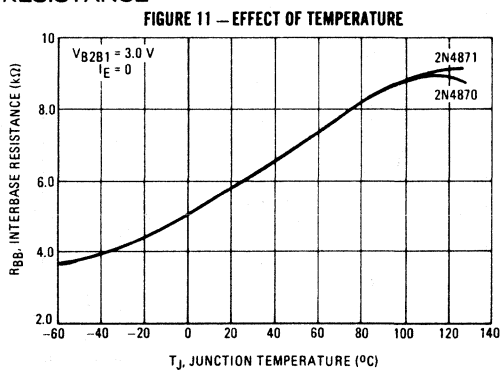
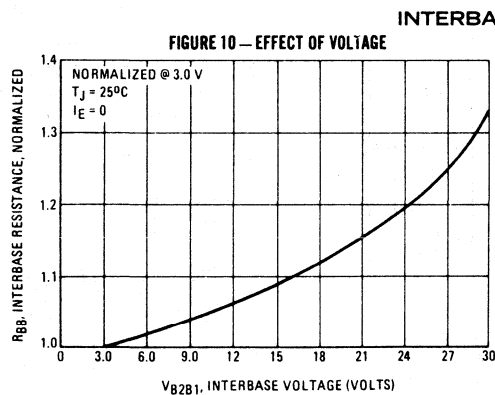
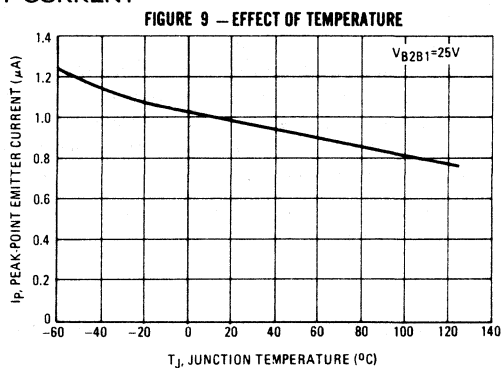
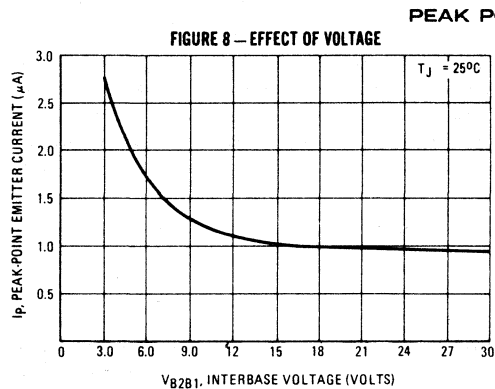
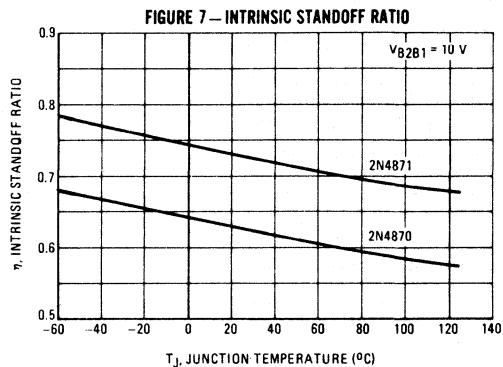
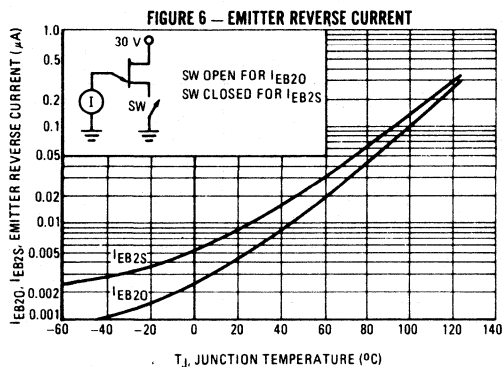


FIGURE 5 — PRR TEST CIRCUIT AND WAVEFORM

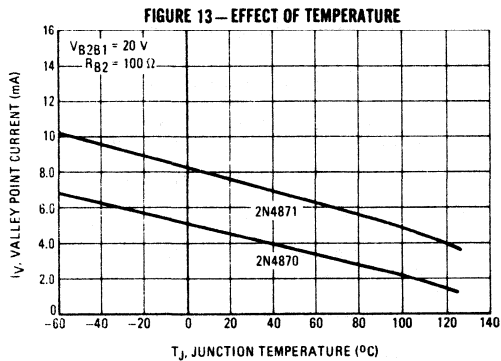
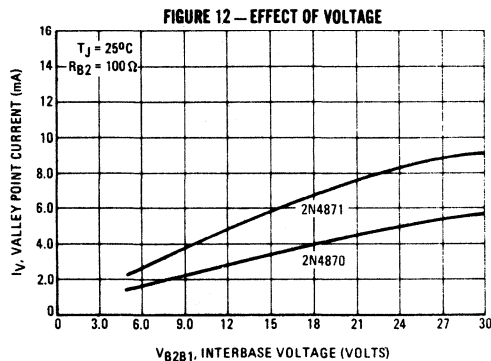


TYPICAL CHARACTERISTICS

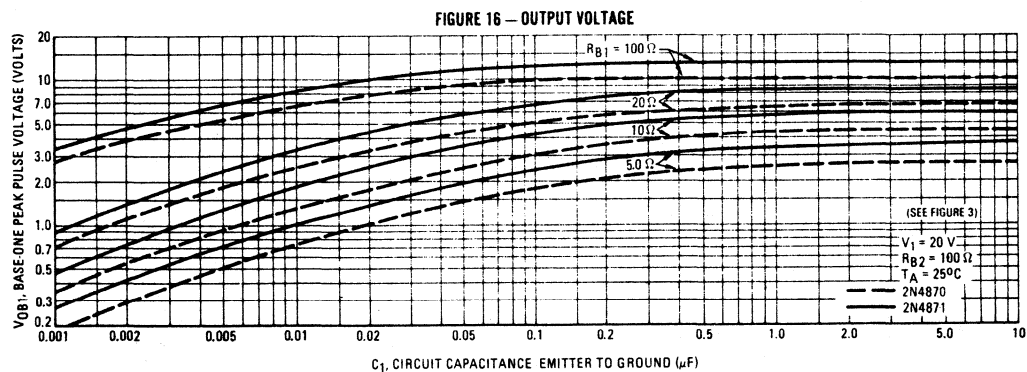
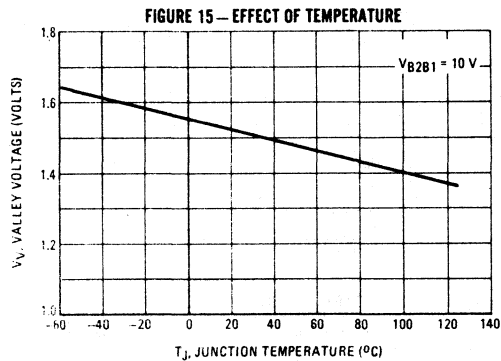
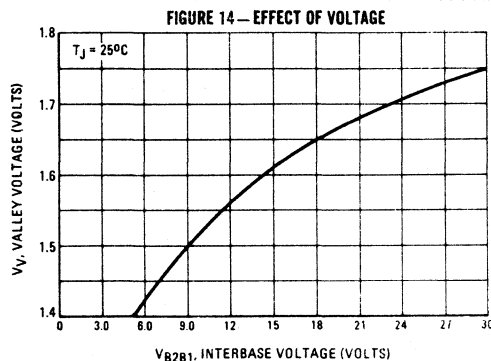


TYPICAL CHARACTERISTICS

VALLEY CURRENT



VALLEY VOLTAGE



2N4877 (SILICON)

MEDIUM-POWER NPN SILICON TRANSISTOR

- ... designed for switching and wide band amplifier applications.
- Low Collector-Emitter Saturation Voltage – $V_{CE(sat)} = 1.0 \text{ Vdc (Max) @ } I_C = 4.0 \text{ Amp}$
 - DC Current Gain Specified to 4 Amperes
 - Excellent Safe Operating Area
 - Packaged in the Compact TO-39 Case for Critical Space-Limited Applications.

* MAXIMUM RATINGS

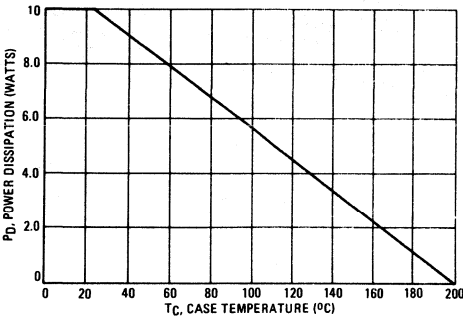
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CB}	70	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	4.0	Adc
Base Current	I_B	1.0	Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	10 57.2	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

*Indicates JEDEC Registered Data

THERMAL CHARACTERISTICS

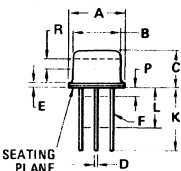
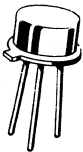
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	17.5	$^\circ\text{C/W}$

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE

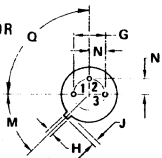


4 AMPERE
POWER TRANSISTOR

NPN SILICON
60 VOLTS
10 WATTS



- STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45°	NOM	45°	NOM
P	—	1.27	—	0.050
Q	90°	NOM	90°	NOM
R	2.54	—	0.100	—

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

*ELECTRICAL CHARACTERISTICS ($T_C = 25^{\circ}\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage (1) ($I_C = 200\text{ mAdc}$, $I_B = 0$)	$V_{CEO(sus)}$	60	—	Vdc
Collector Cutoff Current ($V_{CE} = 70\text{ Vdc}$, $V_{EB(off)} = 1.5\text{ Vdc}$) ($V_{CE} = 70\text{ Vdc}$, $V_{EB(off)} = 1.5\text{ Vdc}$, $T_C = 100^{\circ}\text{C}$)	I_{CEX}	— —	100 1.0	μAdc mAdc
Collector Cutoff Current ($V_{CB} = 70\text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	100	μAdc
Emitter Cutoff Current ($V_{BE} = 5.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	100	μAdc

ON CHARACTERISTICS(1)

DC Current Gain ($I_C = 1.0\text{ Adc}$, $V_{CE} = 2.0\text{ Vdc}$) ($I_C = 4.0\text{ Adc}$, $V_{CE} = 2.0\text{ Vdc}$)	h_{FE}	30 20	— 100	—
Collector-Emitter Saturation Voltage ($I_C = 4.0\text{ Adc}$, $I_B = 0.4\text{ Adc}$)	$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 4.0\text{ Adc}$, $I_B = 0.4\text{ Adc}$)	$V_{BE(sat)}$	—	1.8	Vdc

DYNAMIC CHARACTERISTICS

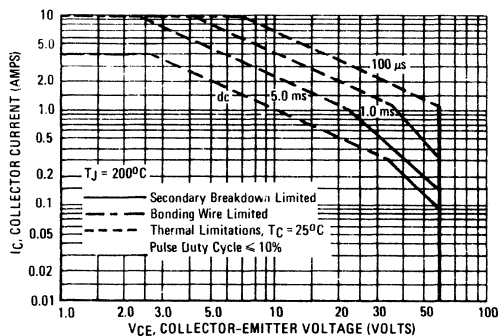
Current-Gain-Bandwidth Product ($I_C = 0.25\text{ Adc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ MHz}$) ($I_C = 0.25\text{ Adc}$, $V_{CE} = 10\text{ Vdc}$, $f = 10\text{ MHz}$)**	f_T	4.0 30	— —	MHz
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SWITCHING CHARACTERISTICS

Rise Time ($V_{CC} = 25\text{ Vdc}$, $I_C = 4.0\text{ Adc}$, $I_{B1} = 0.4\text{ Adc}$)	t_r	—	100	ns
Storage Time	t_s	—	1.5	μs
Fall Time ($I_{B2} = 0.4\text{ Adc}$)	t_f	—	500	ns

*Indicates JEDEC Registered Data.
**Motorola guarantees this value in addition to JEDEC Registered Data.
Note 1: Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.

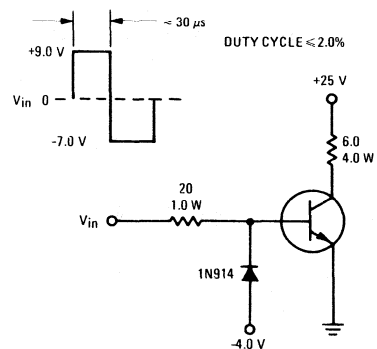
FIGURE 2 — ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 2 is based on $T_{J(pk)} = 200^{\circ}\text{C}$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200^{\circ}\text{C}$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 3 — SWITCHING TIME TEST CIRCUIT



PNP SILICON ANNULAR TRANSISTOR

... designed for applications in audio-output feedback control, and general, medium-current switching and amplifier circuits.

- Direct Complement to NPN 2N3053
- Low Collector-Emitter Saturation Voltage –
 $V_{CE(sat)} = 0.12 \text{ Vdc (Typ) @ } I_C = 150 \text{ mAdc}$
- High Current-Gain-Bandwidth Product –
 $f_T = 280 \text{ (Typ) @ } I_C = 50 \text{ mAdc}$

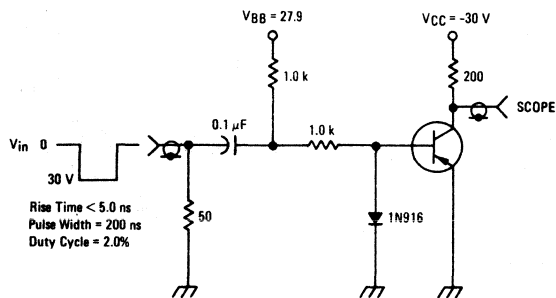
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	500 700**	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0 5.7	Watt mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	5.0 28.6	Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

* Indicates JEDEC Registered Data.

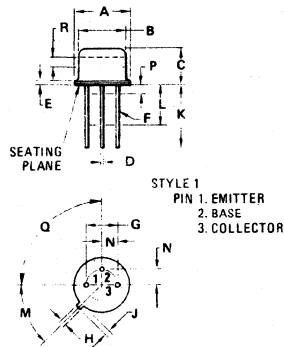
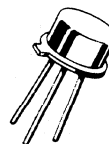
** Motorola Guarantees this Data in Addition to JEDEC Registered Data.

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



SCOPE CHARACTERISTICS
IMPEDANCE 10 MEG MIN
CAPACITANCE 7.0 pF MAX

PNP SILICON SWITCHING AND AMPLIFIER TRANSISTOR



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° NOM	45° NOM	—	—
P	—	1.27	—	0.050
Q	90° NOM	90° NOM	—	—
R	2.54	—	0.100	—

All JEDEC dimensions and notes apply.

CASE 79-02
TO 39

2N4890S (continued)

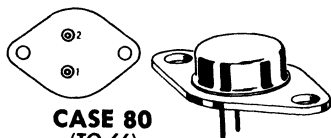
*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit	
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (Note 1) ($I_C = 100\ \mu\text{A}$, $I_B = 0$)	BV_{CEO}	40	—	—	Vdc	
Collector-Emitter Breakdown Voltage ($I_C = 10\ \text{mA}$, $R_{BE} = 10\ \text{ohms}$)	BV_{CER}	50	—	—	Vdc	
Collector-Base Breakdown Voltage ($I_C = 100\ \mu\text{A}$, $I_E = 0$)	BV_{CBO}	60	—	—	Vdc	
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu\text{A}$, $I_C = 0$)	BV_{EBO}	5.0	—	—	Vdc	
Collector Cutoff Current ($V_{CE} = 60\ \text{Vdc}$, $V_{BE(\text{off})} = 1.5\ \text{Vdc}$)	I_{CEX}	—	—	0.25	μA	
Base Cutoff Current ($V_{CE} = 60\ \text{Vdc}$, $V_{BE(\text{off})} = 1.5\ \text{Vdc}$)	I_{BL}	—	—	0.25	μA	
ON CHARACTERISTICS						
DC Current Gain (Note 1) ($I_C = 150\ \text{mA}$, $V_{CE} = 2.5\ \text{Vdc}$) ($I_C = 150\ \text{mA}$, $V_{CE} = 10\ \text{Vdc}$)	h_{FE}	25 50	130 140	— 250	—	
Collector-Emitter Saturation Voltage ($I_C = 150\ \text{mA}$, $I_B = 15\ \text{mA}$)	$V_{CE(\text{sat})}$	—	0.12	1.4	Vdc	
Base-Emitter Saturation Voltage ($I_C = 150\ \text{mA}$, $I_B = 15\ \text{mA}$)	$V_{BE(\text{sat})}$	—	0.82	1.7	Vdc	
Base-Emitter On Voltage ($I_C = 150\ \text{mA}$, $V_{CE} = 2.5\ \text{Vdc}$)	$V_{BE(\text{on})}$	—	0.74	1.7	Vdc	
DYNAMIC CHARACTERISTICS						
Current-Gain Bandwidth Product ($I_C = 50\ \text{mA}$, $V_{CE} = 10\ \text{Vdc}$, $f = 20\ \text{MHz}$)	f_T	100	280	—	MHz	
Output Capacitance ($V_{CB} = 10\ \text{Vdc}$, $I_E = 0$, $f = 140\ \text{kHz}$)	C_{ob}	—	9.0	15	pF	
Input Capacitance ($V_{BE} = 0.5\ \text{Vdc}$, $I_C = 0$, $f = 140\ \text{kHz}$)	C_{ib}	—	60	80	pF	
SWITCHING CHARACTERISTICS						
Delay Time	($V_{CC} = 30\ \text{Vdc}$, $V_{BE(\text{off})} = 0.8\ \text{Vdc}$, $I_C = 150\ \text{mA}$, $I_{B1} = 15\ \text{mA}$) (Figure 1)	t_d	—	15	50	ns
Rise Time		t_r	—	20	50	ns
Storage Time	($V_{CC} = 30\ \text{Vdc}$, $I_C = 150\ \text{mA}$, $I_{B1} = I_{B2} = 15\ \text{mA}$) (Figure 1)	t_s	—	110	200	ns
Fall Time		t_f	—	20	70	ns

*Indicates JEDEC Registered Data

Note 1: Pulse Test: Pulse Width = 300 μs , Duty Cycle $\leq 2.0\%$.

2N4898 thru 2N4900 (SILICON)



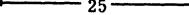
CASE 80
(TO-66)

STYLE 1:
PIN 1. BASE
2. EMITTER
CASE COLLECTOR

Medium-power PNP silicon transistors designed for driver circuits, switching, and amplifier applications. Complement to NPN 2N4910 thru 2N4912.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	2N4898	2N4899	2N4900	Unit
Collector-Emitter Voltage	V _{CEO}	40	60	80	Vdc
Collector-Base Voltage	V _{CB}	40	60	80	Vdc
Emitter-Base Voltage	V _{EB}				Vdc
Collector Current — Continuous *	I _C [*]				Adc
					
Base Current	I _B				Adc
Total Device Dissipation T _C = 25° C	P _D				Watts
Derate above 25° C					W/° C
Operating & Storage Junction Temperature Range	T _J , T _{stg}				° C

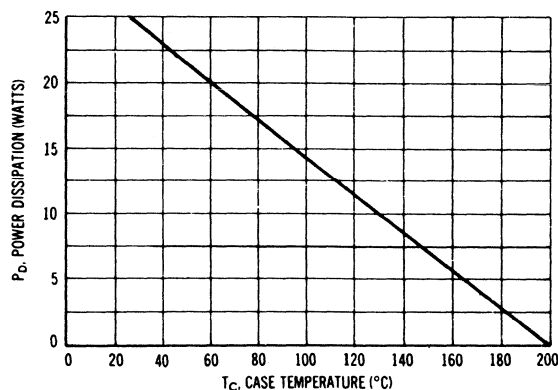
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	7.0	$^\circ\text{C/W}$

* The 1.0 Amp maximum I_C value is based upon JEDEC current gain requirements.

The 4.0 Amp maximum value is based upon actual current-handling capability of the device (see Figure 5).

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE



ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage ⁽¹⁾ ($I_C = 0.1 \text{ A dc}$, $I_B = 0$)	-	$V_{CEO(sus)}$	40 60 80	- - -	Vdc
Collector Cutoff Current ($V_{CE} = 20 \text{ Vdc}$, $I_B = 0$)	-	I_{CEO}	-	0.5	mA dc
($V_{CE} = 30 \text{ Vdc}$, $I_B = 0$)	-		-	0.5	
($V_{CE} = 40 \text{ Vdc}$, $I_B = 0$)	-		-	0.5	
Collector Cutoff Current ($V_{CE} = \text{Rated } V_{CEO}$, $V_{BE(off)} = 1.5 \text{ Vdc}$)	12	I_{CEX}	-	0.1	mA dc
($V_{CE} = \text{Rated } V_{CEO}$, $V_{BE(off)} = 1.5 \text{ Vdc}$, $T_C = 150^\circ\text{C}$)			-	1.0	
Collector Cutoff Current ($V_{CB} = \text{Rated } V_{CB}$, $I_E = 0$)	-	I_{CBO}	-	0.1	mA dc
Emitter Cutoff Current ($V_{BE} = 5.0 \text{ Vdc}$, $I_C = 0$)	-	I_{EBO}	-	1.0	mA dc

ON CHARACTERISTICS ⁽¹⁾

DC Current Gain ($I_C = 50 \text{ mA dc}$, $V_{CE} = 1.0 \text{ Vdc}$)	8	h_{FE}	40	-	-
($I_C = 500 \text{ mA dc}$, $V_{CE} = 1.0 \text{ Vdc}$)			20	100	
($I_C = 1.0 \text{ A dc}$, $V_{CE} = 1.0 \text{ Vdc}$)			10	-	
Collector-Emitter Saturation Voltage ($I_C = 1.0 \text{ A dc}$, $I_B = 0.1 \text{ A dc}$)	9 11 13	$V_{CE(sat)}$	-	0.6	Vdc
Base-Emitter Saturation Voltage ($I_C = 1.0 \text{ A dc}$, $I_B = 0.1 \text{ A dc}$)	11 13	$V_{BE(sat)}$	-	1.3	Vdc
Base-Emitter On Voltage ($I_C = 1.0 \text{ A dc}$, $V_{CE} = 1.0 \text{ Vdc}$)	11 13	$V_{BE(on)}$	-	1.3	Vdc

SMALL SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 250 \text{ mA dc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)	-	f_T	3.0	-	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)	-	C_{ob}	-	100	pF
Small-Signal Current Gain ($I_C = 250 \text{ mA dc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	-	h_{fe}	25	-	-

⁽¹⁾ Pulse Test: PW $\approx 300 \mu\text{s}$, Duty Cycle $\approx 2.0\%$

FIGURE 2 — SWITCHING TIME EQUIVALENT CIRCUIT

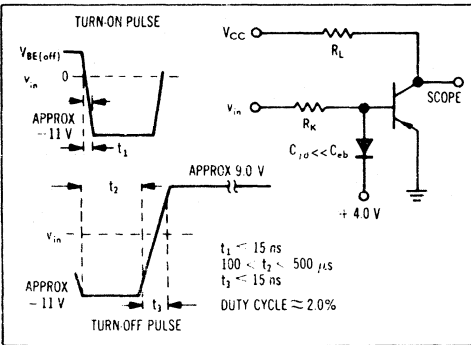


FIGURE 3 — TURN-ON TIME

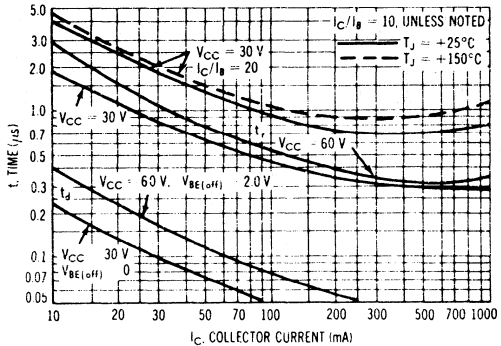


FIGURE 4 — THERMAL RESPONSE

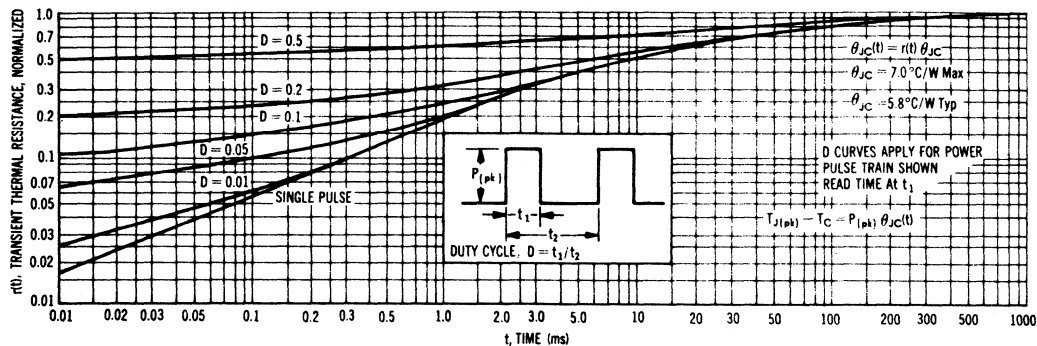
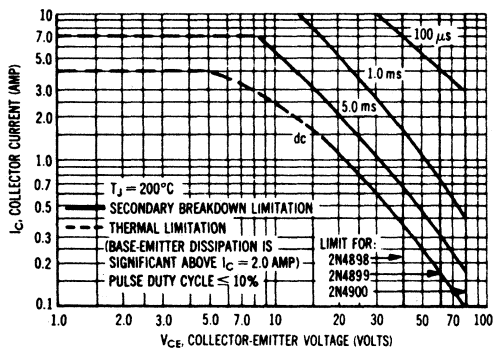


FIGURE 5 — ACTIVE-REGION SAFE OPERATING AREA



The safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor which must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 5 is based upon $T_{J(pk)} = 200^{\circ}\text{C}$; T_C is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200^{\circ}\text{C}$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power which can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 6 — STORAGE TIME

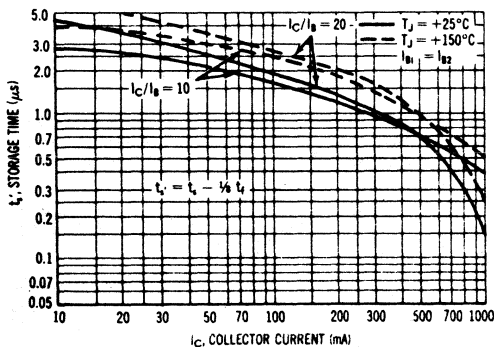


FIGURE 7 — FALL TIME

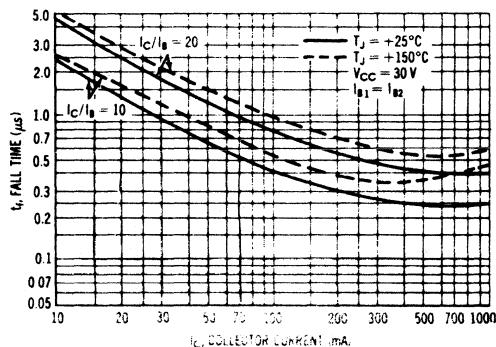


FIGURE 8 — CURRENT GAIN

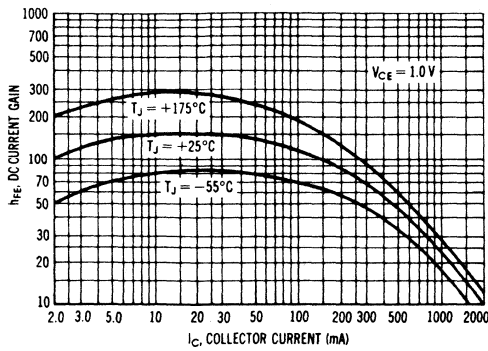


FIGURE 9 — COLLECTOR SATURATION REGION

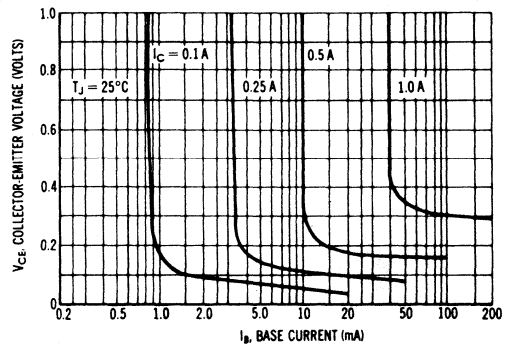


FIGURE 10 — EFFECTS OF BASE-EMITTER RESISTANCE

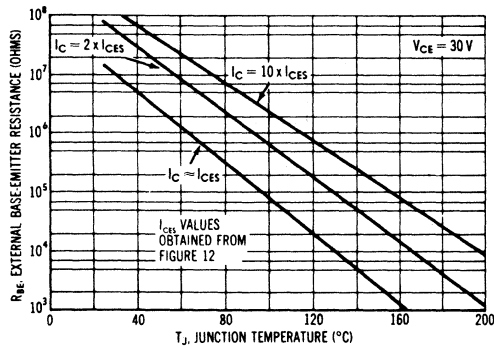


FIGURE 11 — "ON" VOLTAGE

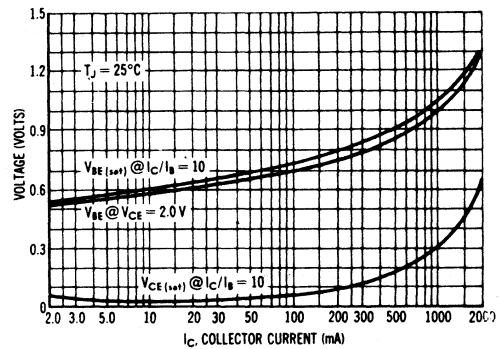


FIGURE 12 — COLLECTOR CUTOFF REGION

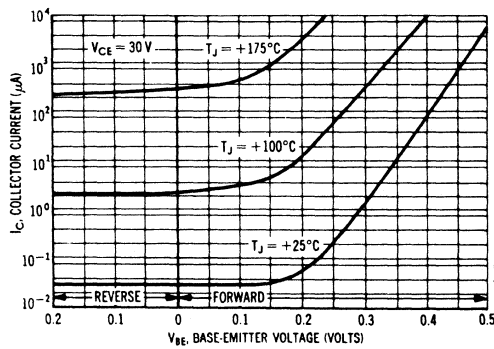
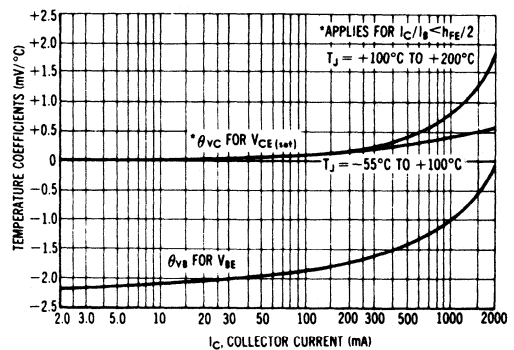


FIGURE 13 — TEMPERATURE COEFFICIENTS

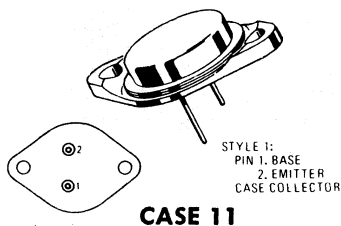


2N4901 (SILICON)**2N4902****2N4903**

PNP power transistors for use in power amplifier and switching circuits. Complement to NPN 2N5067, 2N5068, 2N5069.

MAXIMUM RATINGS

Rating	Symbol	2N4901	2N4902	2N4903	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current — Continuous	I_C	5.0			Adc
Base Current	I_B	1.0			Adc
Total Device Dissipation $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	87.5 0.5			Watts W/ $^\circ\text{C}$
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			$^\circ\text{C}$

**THERMAL CHARACTERISTICS**

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.0	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage* ($I_C = 0.2 \text{ Adc}$, $I_B = 0$)	2N4901 2N4902 2N4903	11	$V_{CEO(sus)}$	40 60 80	- - -	Vdc
Collector Cutoff Current ($V_{CE} = \text{Rated } V_{CEO}$, $I_B = 0$)			I_{CEO}	-	1.0	mAdc
Collector Cutoff Current ($V_{CE} = \text{Rated } V_{CEO}$, $V_{BE(off)} = 1.5 \text{ Vdc}$) ($V_{CE} = \text{Rated } V_{CEO}$, $V_{BE(off)} = 1.5 \text{ Vdc}$, $T_C = 150^\circ\text{C}$)		5, 6	I_{CEX}	- -	0.1 2.0	mAdc
Collector Cutoff Current ($V_{CB} = \text{Rated } V_{CB}$, $I_E = 0$)			I_{CBO}	-	0.1	mAdc
Emitter Cutoff Current ($V_{BE} = 5.0 \text{ Vdc}$, $I_C = 0$)			I_{EBO}	-	1.0	mAdc

ON CHARACTERISTICS

DC Current Gain* ($I_C = 1.0 \text{ Adc}$, $V_{CE} = 2.0 \text{ Vdc}$) ($I_C = 5.0 \text{ Adc}$, $V_{CE} = 2.0 \text{ Vdc}$)		1	h_{FE}	20 7.0	80 -	-
Collector-Emitter Saturation Voltage* ($I_C = 1.0 \text{ Adc}$, $I_B = 0.1 \text{ Adc}$) ($I_C = 5.0 \text{ Adc}$, $I_B = 1.0 \text{ Adc}$)		2, 3, 4	$V_{CE(sat)}$	- -	0.4 1.5	Vdc
Base-Emitter On Voltage* ($I_C = 1.0 \text{ Adc}$, $V_{CE} = 2.0 \text{ Vdc}$)		3, 4	$V_{BE(on)}$	-	1.2	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 1.0 \text{ Adc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)			f_T	4.0	-	MHz
Small-Signal Current Gain ($I_C = 0.5 \text{ Adc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)			h_{fe}	20	-	-

* Pulse Test: PW = 300 μs , Duty Cycle = 2.0%

2N4901, 2N4902, 2N4903 (continued)

FIGURE 1 — NORMALIZED DC CURRENT GAIN

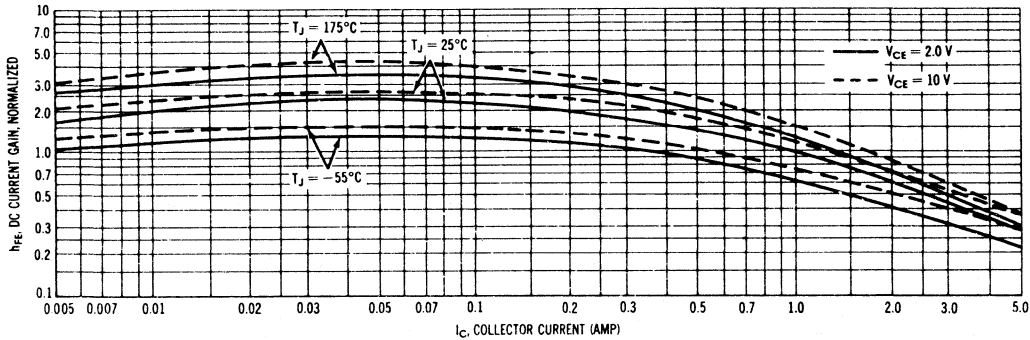


FIGURE 2 — COLLECTOR SATURATION REGION

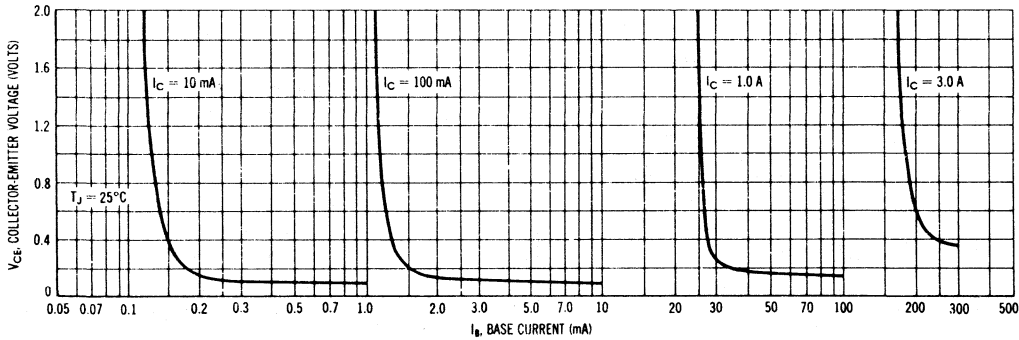


FIGURE 3 — "ON" VOLTAGE

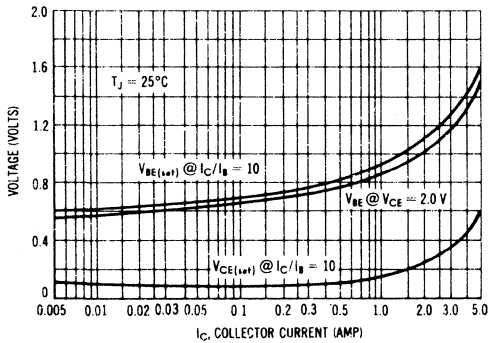
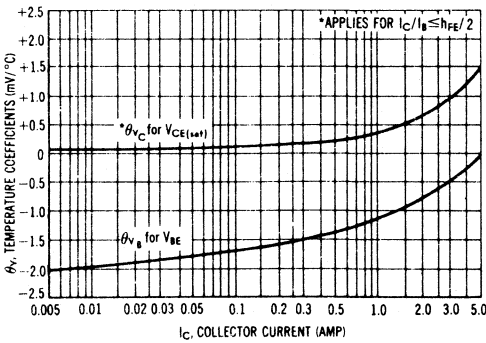


FIGURE 4 — TEMPERATURE COEFFICIENTS



TYPICAL "OFF" REGION CHARACTERISTICS

FIGURE 5 — CUT-OFF REGION

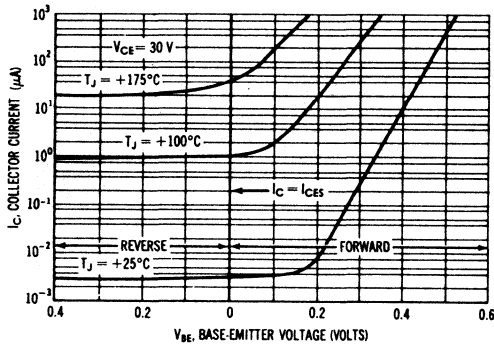


FIGURE 6 — EFFECTS OF BASE-EMITTER RESISTANCE

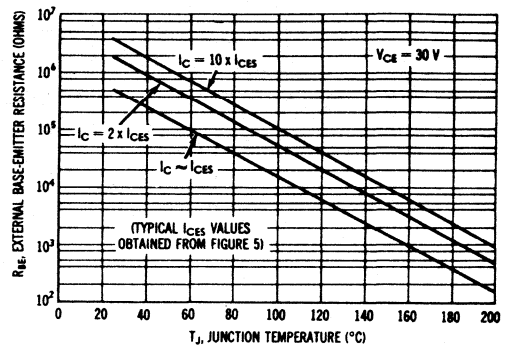


FIGURE 7 — SWITCHING TIME EQUIVALENT CIRCUIT

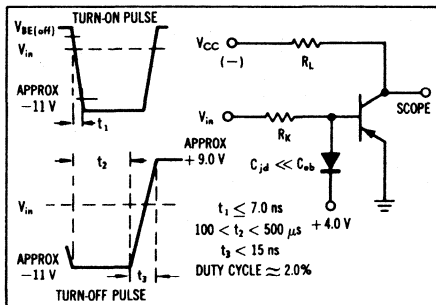


FIGURE 8 — CAPACITANCE

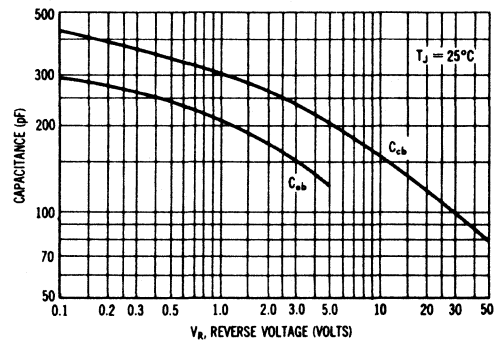


FIGURE 9 — TURN-ON TIME

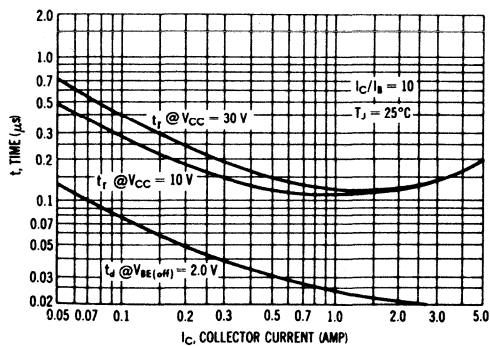
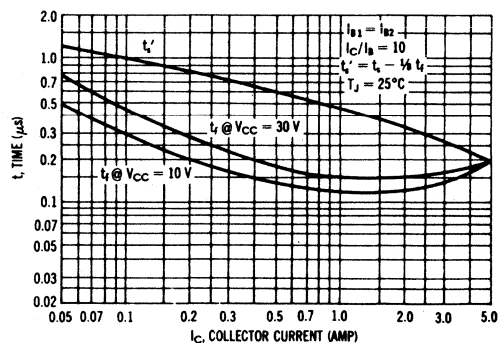
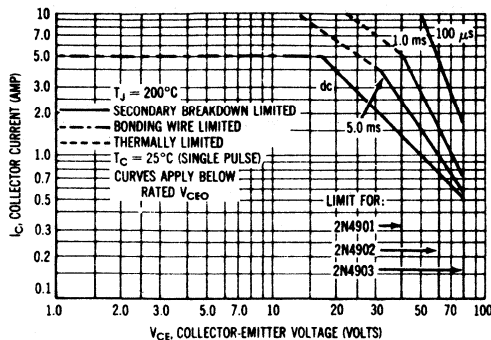


FIGURE 10 — TURN-OFF TIME



RATING AND THERMAL DATA

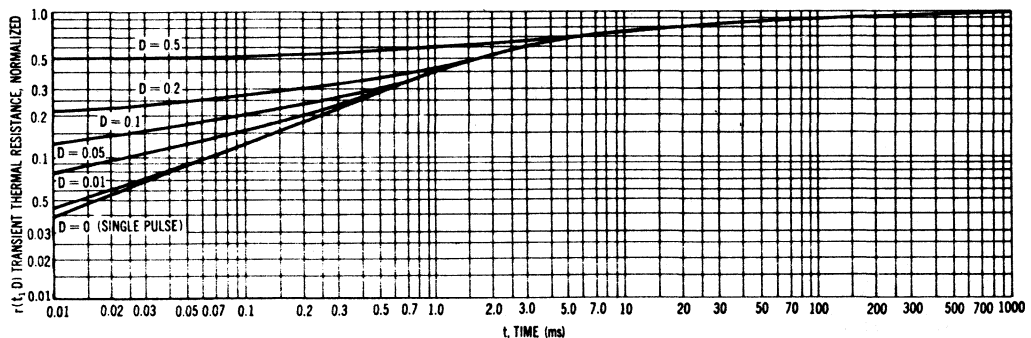
FIGURE 11 — ACTIVE-REGION SAFE OPERATING AREAS



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

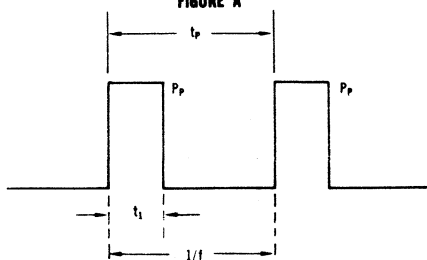
The data of Figure 11 is based on $T_{j(pk)} = 200^\circ\text{C}$; T_C is variable depending on conditions. Pulse curves are valid for duty cycles to 10% provided $T_{j(pk)} < 200^\circ\text{C}$. $T_{j(pk)}$ may be calculated from the data in Figure 12. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 12 — TRANSIENT THERMAL RESISTANCE



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA

FIGURE A



DUTY CYCLE $D = t_1 \cdot f = \frac{t_1}{t_p}$
PEAK PULSE POWER = P_p

A train of periodical power pulses can be represented by the model shown in Figure A. Using the model and the device thermal response, the normalized effective transient thermal resistance of Figure 12 was calculated for various duty cycles.

To find $\theta_{JC}(t)$, multiply the value obtained from Figure 12 by the steady state value θ_{JC} .

Example:

Example.
The 2N4901 is dissipating 100 watts under the following conditions:
 $t_1 = 0.1$ ms, $t_r = 0.5$ ms. ($D = 0.2$)

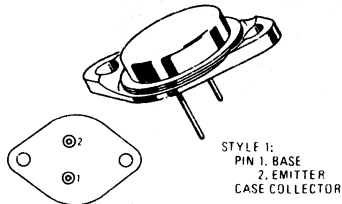
Using Figure 12, at a pulse width of 0.1 ms and $D = 0.2$, the reading of $r(t, D)$ is 0.27.

The peak rise in junction temperature is therefore

$$\Delta T = r(t) \times P_p \times \theta_{JC} = 0.27 \times 100 \times 2.0 = 54^\circ\text{C}$$

2N4904 (SILICON)**2N4905****2N4906**

PNP power transistors for use in power amplifier and switching circuits. Complement to NPN 2N4913 thru 2N4915.

**CASE 11****MAXIMUM RATINGS**

Rating	Symbol	2N4904	2N4905	2N4906	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current — Continuous	I_C	5.0			Adc
Base Current	I_B	1.0			Adc
Total Device Dissipation $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	87.5			Watts
		0.5			W/ $^\circ\text{C}$
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			$^\circ\text{C}$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.0	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage (1) ($I_C = 0.2 \text{ Adc}, I_B = 0$)	2N4904 2N4905 2N4906	11	$V_{CEO(sus)}$	40 60 80	- - -	Vdc
Collector Cutoff Current ($V_{CE} = \text{Rated } V_{CEO}, I_B = 0$)			I_{CEO}	-	1.0	mAdc
Collector Cutoff Current ($V_{CE} = \text{Rated } V_{CEO}, V_{BE(off)} = 1.5 \text{ Vdc}$) ($V_{CE} = \text{Rated } V_{CEO}, V_{BE(off)} = 1.5 \text{ Vdc}, T_C = 150^\circ\text{C}$)		5, 6	I_{CEX}	- -	0.1 2.0	mAdc
Collector Cutoff Current ($V_{CB} = \text{Rated } V_{CB}, I_E = 0$)			I_{CBO}	-	0.1	mAdc
Emitter Cutoff Current ($V_{BE} = 5.0 \text{ Vdc}, I_C = 0$)			I_{EBO}	-	1.0	mAdc

ON CHARACTERISTICS (1)

DC Current Gain ($I_C = 2.5 \text{ Adc}, V_{CE} = 2.0 \text{ Vdc}$) ($I_C = 5.0 \text{ Adc}, V_{CE} = 2.0 \text{ Vdc}$)		1	h_{FE}	25 7.0	100 -	-
Collector-Emitter Saturation Voltage ($I_C = 2.5 \text{ Adc}, I_B = 0.25 \text{ Adc}$) ($I_C = 5.0 \text{ Adc}, I_B = 1.0 \text{ Adc}$)		2, 3, 4	$V_{CE(sat)}$	- -	1.0 1.5	Vdc
Base-Emitter On Voltage ($I_C = 2.5 \text{ Adc}, V_{CE} = 2.0 \text{ Vdc}$)		3, 4	$V_{BE(on)}$	-	1.4	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 1.0 \text{ Adc}, V_{CE} = 10 \text{ Vdc}, f = 1.0 \text{ MHz}$)			f_T	4.0	-	MHz
Small-Signal Current Gain ($I_C = 0.5 \text{ Adc}, V_{CE} = 10 \text{ Vdc}, f = 1.0 \text{ kHz}$)			h_{fe}	40	-	

(1) Pulse Test: PW = 300 μs , Duty Cycle $\leq 2.0\%$

FIGURE 1 — NORMALIZED DC CURRENT GAIN

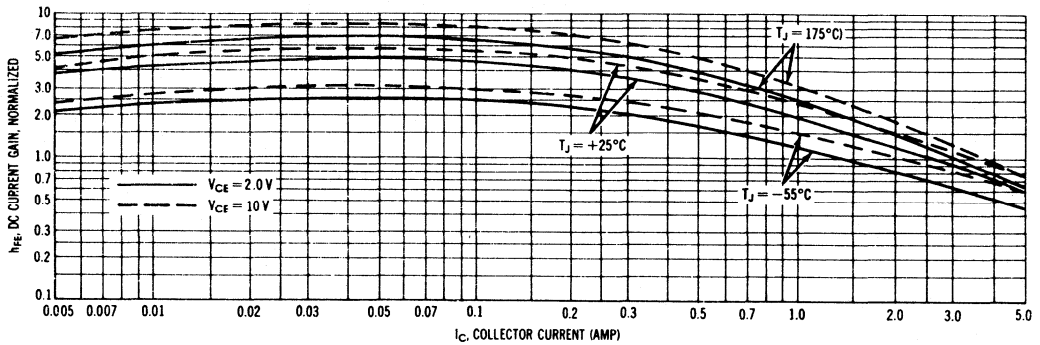


FIGURE 2 — COLLECTOR SATURATION REGION

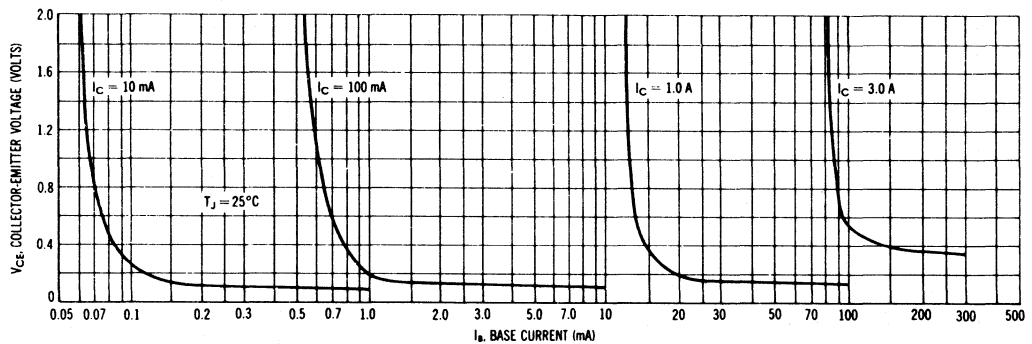


FIGURE 3 — "ON" VOLTAGE

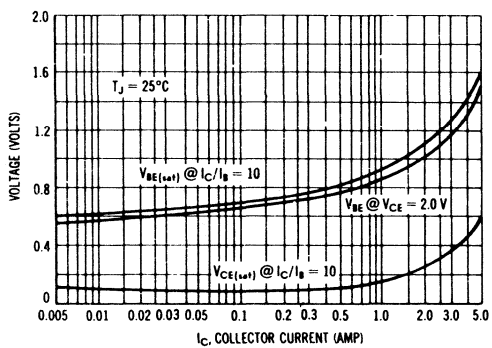
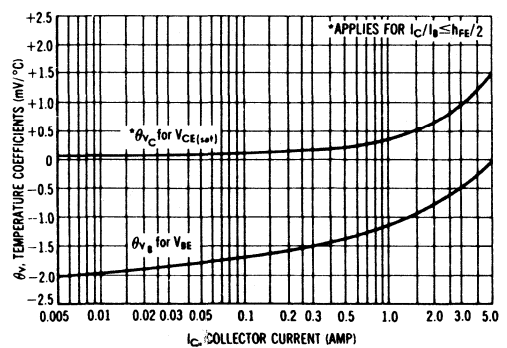


FIGURE 4 — TEMPERATURE COEFFICIENTS



TYPICAL "OFF" REGION CHARACTERISTICS

FIGURE 5 — CUT-OFF REGION

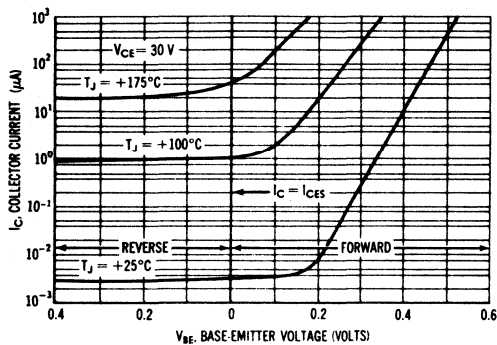


FIGURE 6 — EFFECTS OF BASE-EMITTER RESISTANCE

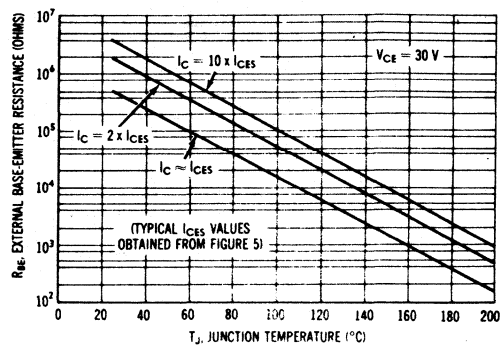


FIGURE 7 — SWITCHING TIME EQUIVALENT CIRCUIT

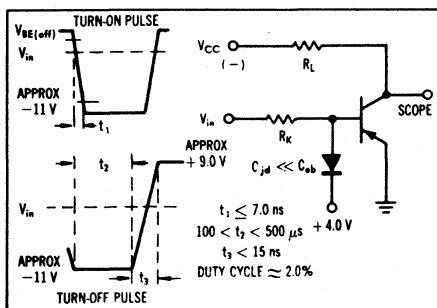


FIGURE 8 — CAPACITANCE

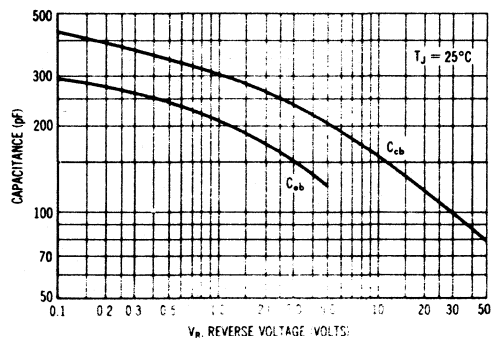


FIGURE 9 — TURN-ON TIME

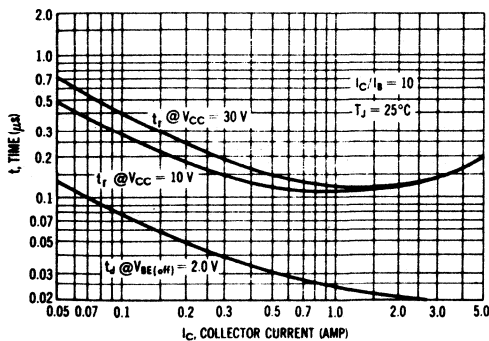
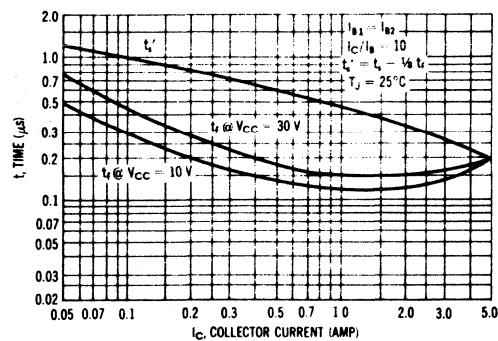
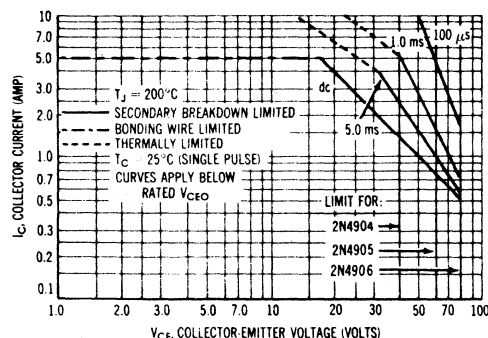


FIGURE 10 — TURN-OFF TIME



RATING AND THERMAL DATA

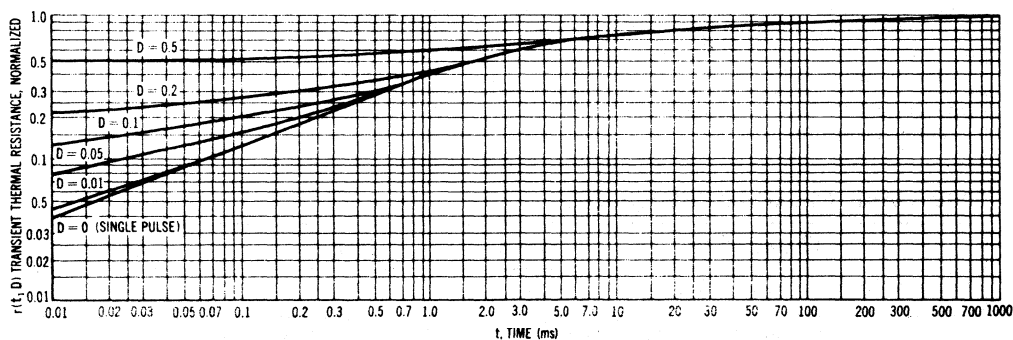
FIGURE 11 — ACTIVE-REGION SAFE OPERATING AREAS



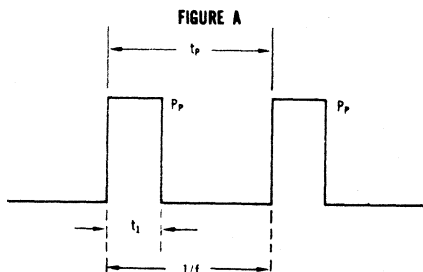
There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C — V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 11 is based on $T_{J(pk)} = 200^\circ\text{C}$. T_C is variable depending on conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} < 200^\circ\text{C}$. $T_{J(pk)}$ may be calculated from the data in Figure 12. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 12 — TRANSIENT THERMAL RESISTANCE



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA



$$\text{DUTY CYCLE } D = t_i \cdot f = \frac{t_i}{T}$$

$$\text{PEAK PULSE POWER} = P_p$$

A train of periodical power pulses can be represented by the model shown in Figure A. Using the model and the device thermal response, the normalized effective transient thermal resistance of Figure 12 was calculated for various duty cycles.

To find $\theta_{JC}(t)$, multiply the value obtained from Figure 12 by the steady state value θ_{JC} .

Example:

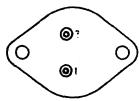
The 2N4904 is dissipating 100 watts under the following conditions: $t_i = 0.1$ ms, $t_p = 0.5$ ms. ($D = 0.2$)

Using Figure 12, at a pulse width of 0.1 ms and $D = 0.2$, the reading of $r(t_i, D)$ is 0.27.

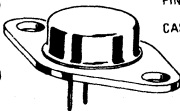
The peak rise in junction temperature is therefore

$$\Delta T = r(t) \times P_p \times \theta_{JC} = 0.27 \times 100 \times 2.0 = 54^\circ\text{C}$$

2N4910 thru 2N4912 (SILICON)



CASE 80
(TO-66)



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE COLLECTOR

Medium-power NPN silicon transistors designed for driver circuits, switching, and amplifier applications. Complement to PNP 2N4898 thru 2N4900.

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	2N4910	2N4911	2N4912	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	← 5.0 →			Vdc
Collector Current — Continuous*	I_C^*	← 1.0 → ← 4.0 →			Adc
Base Current — Continuous	I_B	← 1.0 →			Adc
Total Device Dissipation $T_C = 25^\circ\text{C}$	P_D	← 25 →			Watts
Derate above 25°C		← 0.143 →			mW/ $^\circ\text{C}$
Operating & Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →			$^\circ\text{C}$

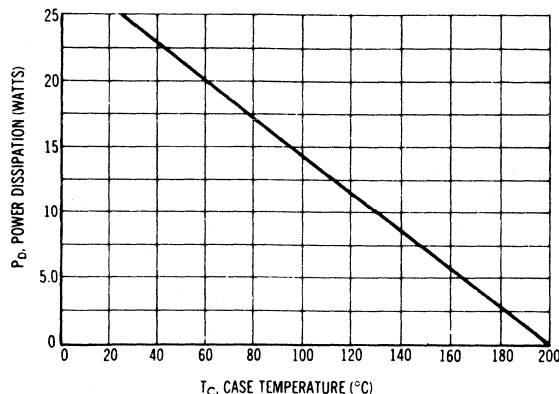
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	7.0	$^\circ\text{C/W}$

* The 1.0 Amp maximum I_C value is based upon JEDEC current gain requirements.

The 4.0 Amp maximum value is based upon actual current-handling capability of the device (see Figure 5).

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 5. All limits are applicable and must be observed.

2N4910 thru 2N4912 (continued)

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage (1) ($I_C = 0.1 \text{ A dc}$, $I_B = 0$)	-	$BV_{CEO(sus)}$	40 60 80	- - -	Vdc
Collector Cutoff Current ($V_{CE} = 20 \text{ Vdc}$, $I_B = 0$)	-	I_{CEO}	-	0.5	mA dc
($V_{CE} = 30 \text{ Vdc}$, $I_B = 0$)	-		-	0.5	
($V_{CE} = 40 \text{ Vdc}$, $I_B = 0$)	-		-	0.5	
Collector Cutoff Current ($V_{CE} = \text{Rated } V_{CEO}$, $V_{EB(off)} = 1.5 \text{ Vdc}$)	12	I_{CEX}	-	0.1	mA dc
($V_{CE} = \text{Rated } V_{CEO}$, $V_{EB(off)} = 1.5 \text{ Vdc}$, $T_C = 150^\circ\text{C}$)			-	1.0	
Collector Cutoff Current ($V_{CB} = \text{Rated } V_{CB}$, $I_E = 0$)	-	I_{CBO}	-	0.1	mA dc
Emitter Cutoff Current ($V_{EB} = 5.0 \text{ Vdc}$, $I_C = 0$)	-	I_{EBO}	-	1.0	mA dc

ON CHARACTERISTICS (1)

DC Current Gain ($I_C = 50 \text{ mA dc}$, $V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 500 \text{ mA dc}$, $V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 1.0 \text{ A dc}$, $V_{CE} = 1.0 \text{ Vdc}$)	8	h_{FE}	40 20 10	- 100 -	-
Collector-Emitter Saturation Voltage ($I_C = 1.0 \text{ A dc}$, $I_B = 0.1 \text{ A dc}$)	9 11 13	$V_{CE(sat)}$	-	0.6	Vdc
Base-Emitter Saturation Voltage ($I_C = 1.0 \text{ A dc}$, $I_B = 0.1 \text{ A dc}$)	11 13	$V_{BE(sat)}$	-	1.3	Vdc
Base-Emitter On Voltage ($I_C = 1.0 \text{ A dc}$, $V_{CE} = 1.0 \text{ Vdc}$)	11 13	$V_{BE(on)}$	-	1.3	Vdc

SMALL SIGNAL CHARACTERISTICS

Current-Gain — Bandwidth Product ($I_C = 250 \text{ mA dc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)	-	f_T	3.0	-	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)	-	C_{ob}	-	100	pF
Small-Signal Current Gain ($I_C = 250 \text{ mA dc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	-	h_{fe}	25	-	

(1) Pulse Test: $PW = 300 \mu\text{s}$, Duty Cycle $\approx 2.0\%$

FIGURE 2 — SWITCHING TIME EQUIVALENT CIRCUIT

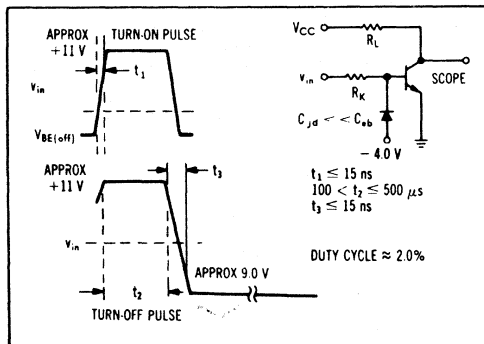


FIGURE 3 — TURN-ON TIME

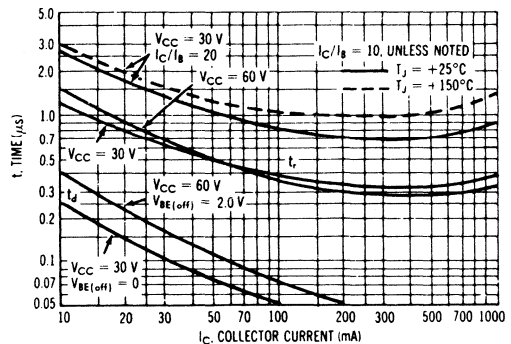


FIGURE 4 — THERMAL RESPONSE

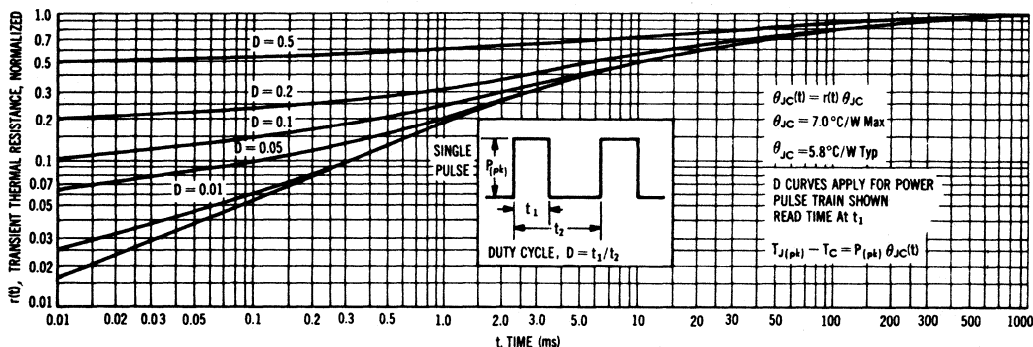
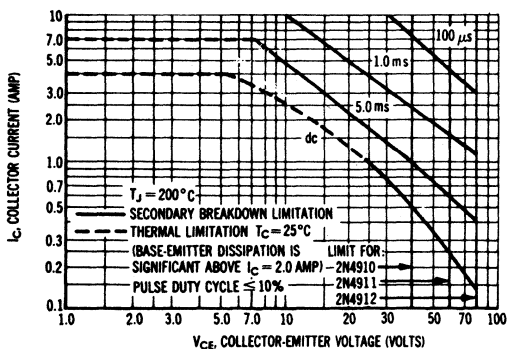


FIGURE 5 — ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200^\circ\text{C}$; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 200^\circ\text{C}$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 6 — STORAGE TIME

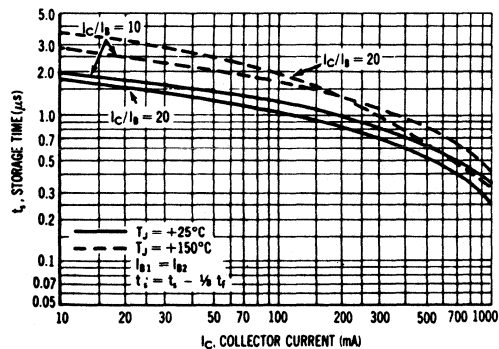
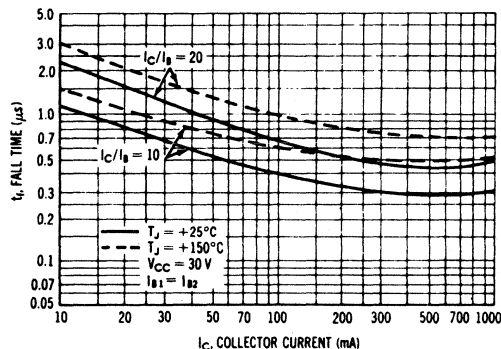


FIGURE 7 — FALL TIME



TYPICAL DC CHARACTERISTICS

FIGURE 8 — CURRENT GAIN

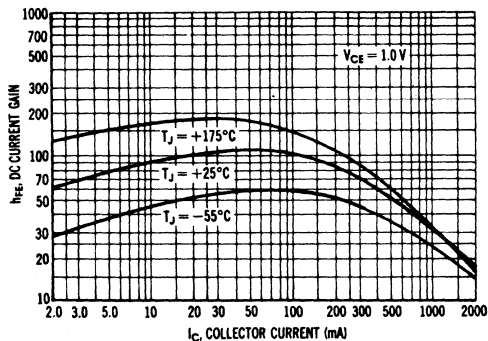


FIGURE 9 — COLLECTOR SATURATION REGION

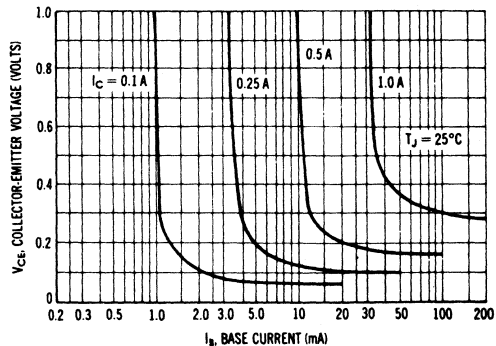


FIGURE 10 — EFFECTS OF BASE-EMITTER RESISTANCE

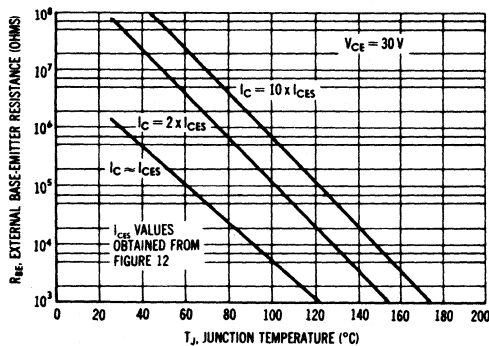


FIGURE 11 — "ON" VOLTAGE

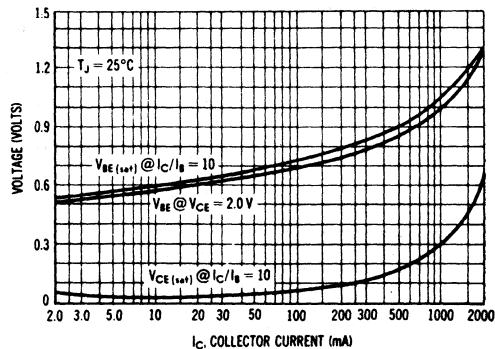


FIGURE 12 — COLLECTOR CUTOFF REGION

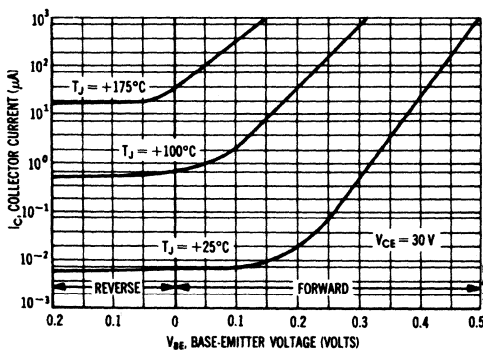
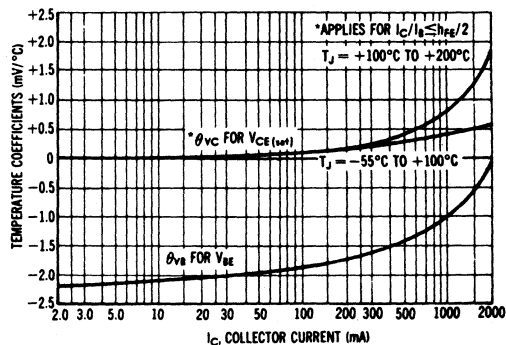


FIGURE 13 — TEMPERATURE COEFFICIENTS

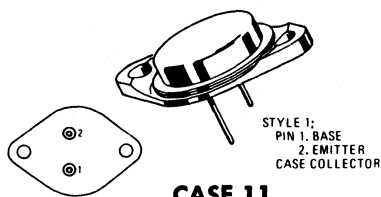


2N4913 (SILICON)**2N4914****2N4915**

NPN power transistors for use in power amplifier and switching circuits. Complement to PNP 2N4904 thru 2N4906.

MAXIMUM RATINGS

Rating	Symbol	2N4913	2N4914	2N4915	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current - Continuous	I_C	5.0			Adc
Base Current - Continuous	I_B	1.0			Adc
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	87.5 0.5			Watts W/ $^\circ\text{C}$
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			$^\circ\text{C}$

**CASE 11**

Collector connected to case

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.0	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Sustaining Voltage ⁽¹⁾ ($I_C = 0.2\text{ Adc}$, $I_B = 0$)	2N4913 2N2914 2N4915	11	$BV_{CEO(sus)}$	40 60 80	- - -	Vdc
Collector Cutoff Current ($V_{CE} = \text{Rated } V_{CEO}$, $I_B = 0$)			I_{CEO}	-	1.0	mAdc
Collector Cutoff Current ($V_{CE} = \text{Rated } V_{CEO}$, $V_{EB(off)} = 1.5\text{ Vdc}$) ($V_{CE} = \text{Rated } V_{CEO}$, $V_{EB(off)} = 1.5\text{ Vdc}$, $T_C = 150^\circ\text{C}$)		5, 6	I_{CEX}	- -	1.0 2.0	mAdc
Collector Cutoff Current ($V_{CB} = \text{Rated } V_{CB}$, $I_E = 0$)		5, 6	I_{CBO}	-	1.0	mAdc
Emitter Cutoff Current ($V_{EB} = 5.0\text{ Vdc}$, $I_C = 0$)			I_{EBO}	-	1.0	mAdc

ON CHARACTERISTICS ⁽¹⁾

DC Current Gain ($I_C = 2.5\text{ Adc}$, $V_{CE} = 2.0\text{ Vdc}$) ($I_C = 5.0\text{ Adc}$, $V_{CE} = 2.0\text{ Vdc}$)	1	h_{FE}	25 7.0	100 -	-	
Collector-Emitter Saturation Voltage ($I_C = 2.5\text{ Adc}$, $I_B = 250\text{ mAdc}$) ($I_C = 5.0\text{ Adc}$, $I_B = 1.0\text{ Adc}$)	2, 3, 4	$V_{CE(sat)}$	- -	1.0 1.5		Vdc
Base-Emitter On Voltage ($I_C = 2.5\text{ Adc}$, $V_{CE} = 2.0\text{ Vdc}$)	3, 4	$V_{BE(on)}$	-	1.4		Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 1.0\text{ Adc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ MHz}$)		f_T	4.0	-		MHz
Small-Signal Current Gain ($I_C = 500\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)		h_{fe}	20	-		

⁽¹⁾ Pulse Test, PW $\approx 300\text{ }\mu\text{s}$, Duty Cycle $\approx 2.0\%$

2N4913, 2N4914, 2N4915 (continued)

FIGURE 1 — NORMALIZED DC CURRENT GAIN

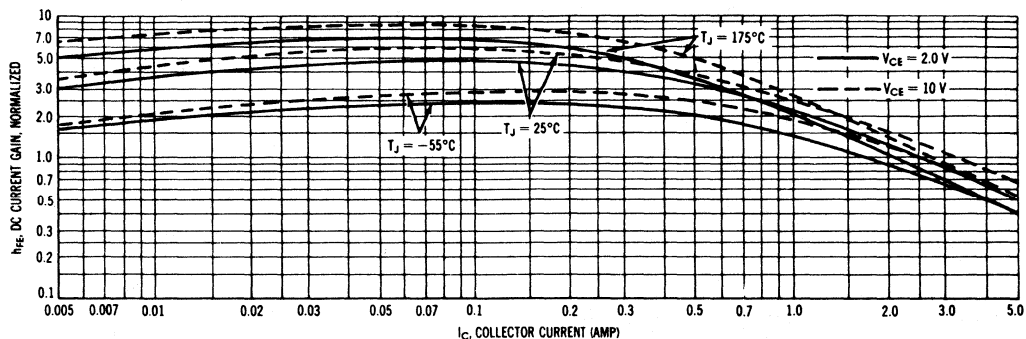


FIGURE 2 — COLLECTOR SATURATION REGION

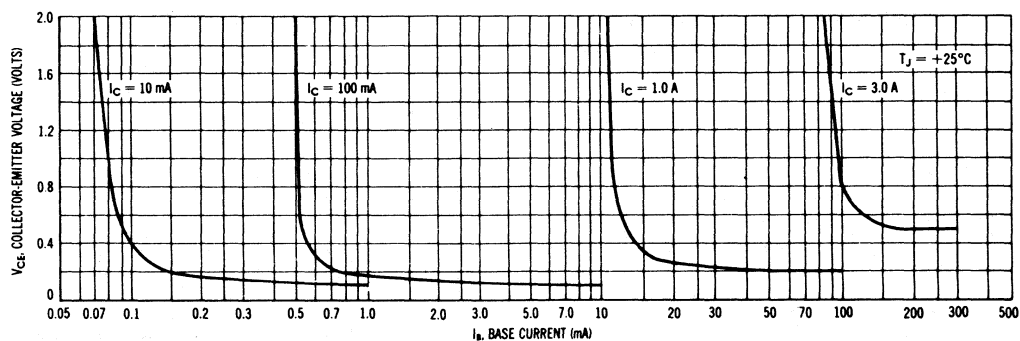


FIGURE 3 — "ON" VOLTAGES

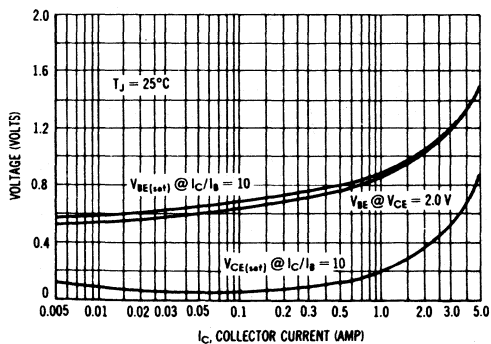
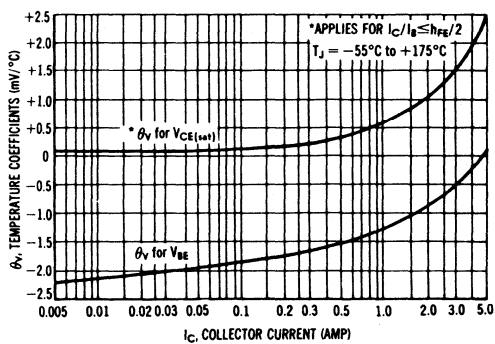


FIGURE 4 — TEMPERATURE COEFFICIENTS



TYPICAL "OFF" REGION CHARACTERISTICS

FIGURE 5 — CUT-OFF REGION

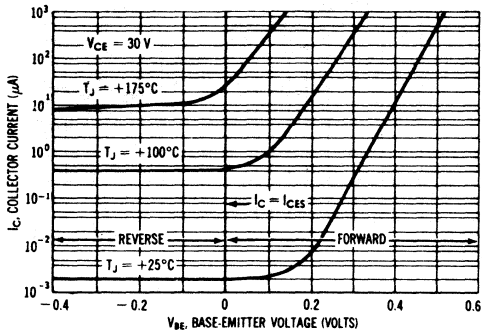


FIGURE 6 — EFFECTS OF BASE-EMITTER RESISTANCE

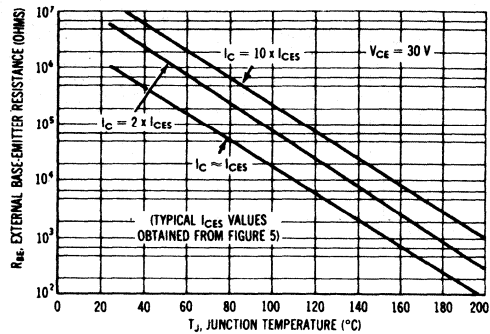


FIGURE 7 — SWITCHING TIME EQUIVALENT CIRCUIT

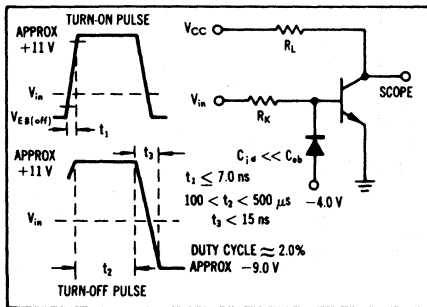


FIGURE 8 — CAPACITANCE

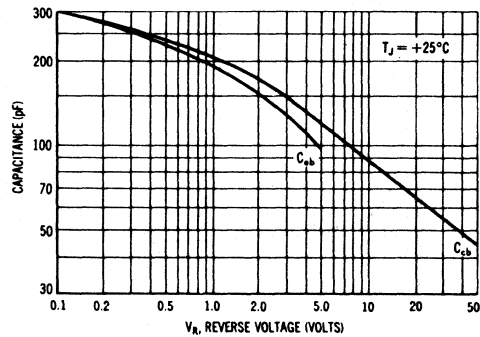


FIGURE 9 — TURN-ON TIME

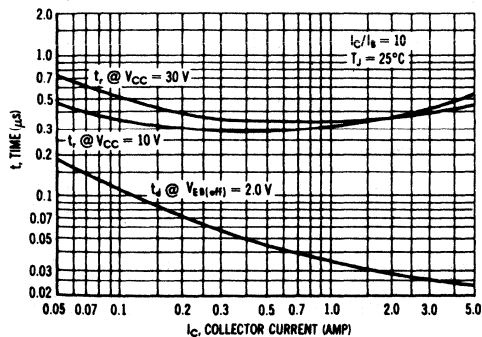
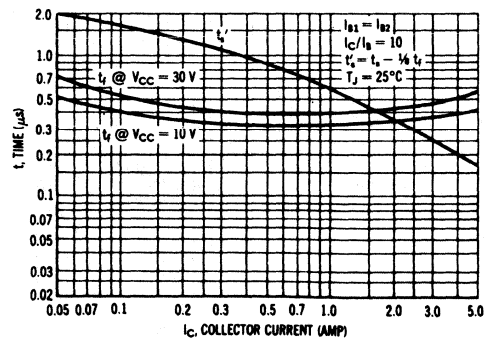
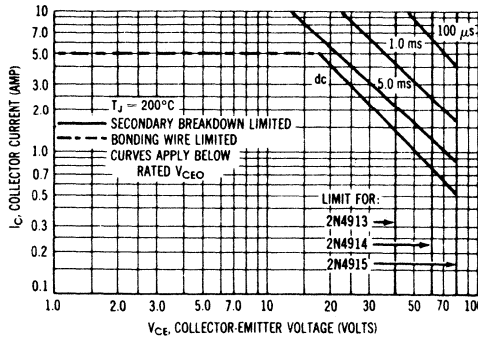


FIGURE 10 — TURN-OFF TIME



RATING AND THERMAL DATA

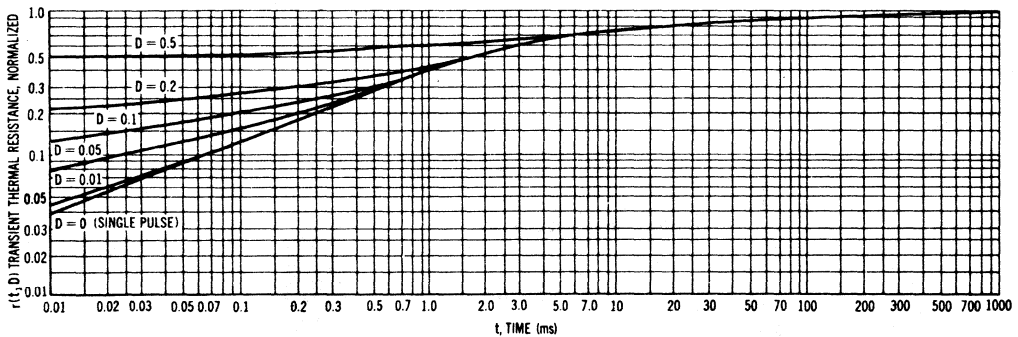
FIGURE 11 — ACTIVE-REGION SAFE OPERATING AREAS



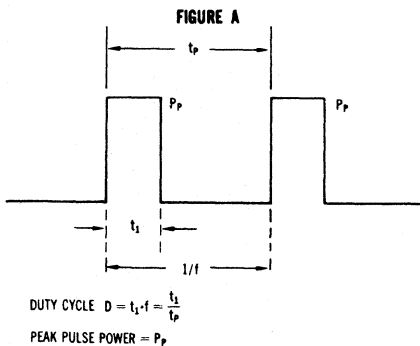
There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 11 is based on $T_{J(pk)} = 200^\circ\text{C}$; T_C is variable depending on conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} < 200^\circ\text{C}$. $T_{J(pk)}$ may be calculated from the data in Figure 12. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 12 — TRANSIENT THERMAL RESISTANCE



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA



A train of periodical power pulses can be represented by the model as shown in Figure A. Using the model and the device thermal response, the normalized effective transient thermal resistance of Figure 12 was calculated for various duty cycles.

To find $\theta_{JC}(t)$, multiply the value obtained from Figure 12 by the steady state value θ_{JC} .

Example:

The 2N4913 is dissipating 100 watts under the following conditions: $t_1 = 0.1$ ms, $t_p = 0.5$ ms. ($D = 0.2$)

Using Figure 12, at a pulse width of 0.1 ms and $D = 0.2$, the reading of $r(t_1, D)$ is 0.28.

The peak rise in junction temperature is therefore

$$\Delta T = r(t) \times P_p \times \theta_{JC} = 0.28 \times 100 \times 2.0 = 56^\circ\text{C}$$

2N4918 thru 2N4920 (SILICON)

MJE4918 thru MJE4920

MEDIUM-POWER PLASTIC PNP SILICON TRANSISTORS

... designed for driver circuits, switching, and amplifier applications. These high-performance plastic devices feature:

- Low Saturation Voltage — $V_{CE(sat)} = 0.6 \text{ Vdc (Max) @ } I_C = 1.0 \text{ Amp}$
- Excellent Power Dissipation Due to Thermopad Construction — $P_D = 30 \text{ and } 40 \text{ W @ } T_C = 25^\circ\text{C}$
- Excellent Safe Operating Area
- Gain Specified to $I_C = 1.0 \text{ Amp}$
- Complement to NPN 2N4921, 2N4922, 2N4923 and MJE4921, MJE4922, MJE4923
- Choice of Packages — 2N4918 thru 2N4920, 30 Watts, Case 77
MJE4918 thru MJE4920, 40 Watts, Case 199

*MAXIMUM RATINGS

Ratings	Symbol	2N4918 MJE4918	2N4919 MJE4919	2N4920 MJE4920	Unit
Collector-Emitter Voltage	V_{CE0}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current — Continuous (1)	I_C^*	1.0			Adc
		3.0			Adc
Base Current	I_B	1.0			Adc
		2N4918 series			MJE4918 series
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	30	40	40	Watts W/ $^\circ\text{C}$
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150			$^\circ\text{C}$

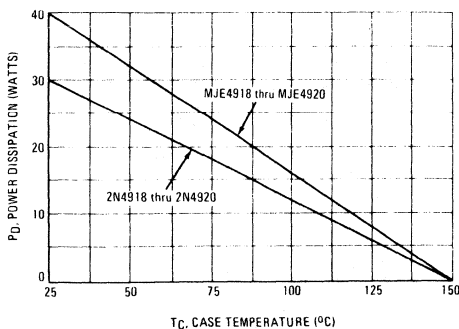
THERMAL CHARACTERISTICS (2)

Characteristic	Symbol	2N4918/20	MJE4918/20	Unit
Thermal Resistance, Junction to Case	θ_{JC}	4.16	3.125	$^\circ\text{C/W}$

*Indicates JEDEC Registered Data for 2N4918 Series

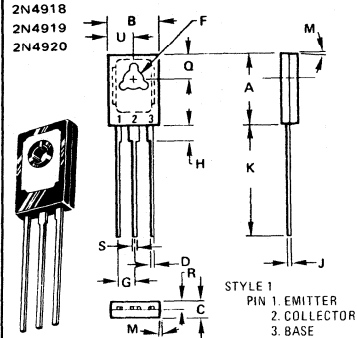
- (1) The 1.0 Amp maximum I_C value is based upon JEDEC current gain requirements. The 3.0 Amp maximum value is based upon actual current-handling capability of the device (See Figure 5).
- (2) Recommend use of thermal compound for lowest thermal resistance.

FIGURE 1 — POWER DERATING



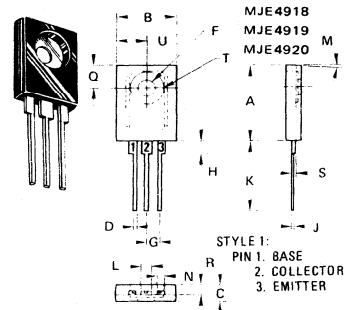
3 AMPERE GENERAL-PURPOSE POWER TRANSISTORS

40-80 VOLTS
30 and 40 WATTS



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.80	11.05	0.425	0.435
B	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.00	0.115	0.118
G	2.36 BSC		0.093 BSC	
H	2.16	2.41	0.085	0.095
J	0.38	0.64	0.015	0.025
K	15.38	16.64	0.605	0.655
M	30 TYP		30 TYP	
Q	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155

CASE 77-03



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.08	16.33	0.633	0.643
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	0.51	0.76	0.020	0.030
F	3.61	3.86	0.142	0.152
G	2.54 BSC		0.100 BSC	
H	2.67	2.92	0.105	0.115
J	0.43	0.69	0.017	0.027
K	14.73	14.99	0.580	0.590
L	2.16	2.41	0.085	0.095
M	30 TYP		30 TYP	
N	1.47	1.73	0.058	0.068
Q	4.78	5.03	0.188	0.198
R	1.91	2.16	0.075	0.085
S	0.81	0.86	0.032	0.034
T	6.99	7.24	0.275	0.285
U	6.22	6.48	0.245	0.255

1. DIM "G" IS TO CENTER LINE OF LEADS.
CASE 199-04

ELECTRICAL CHARACTERISTICS ($T_C = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) ($I_C = 0.1 \text{ Adc}$, $I_B = 0$)	—	$V_{CE(sus)}$	40 60 80	— — —	Vdc
Collector Cutoff Current ($V_{CE} = 20 \text{ Vdc}$, $I_B = 0$) ($V_{CE} = 30 \text{ Vdc}$, $I_B = 0$) ($V_{CE} = 40 \text{ Vdc}$, $I_B = 0$)	—	I_{CEO}	— — —	0.5 0.5 0.5	mAdc
Collector Cutoff Current ($V_{CE} = \text{Rated } V_{CEO}$, $V_{BE(off)} = 1.5 \text{ Vdc}$) ($V_{CE} = \text{Rated } V_{CEO}$, $V_{BE(off)} = 1.5 \text{ Vdc}$, $T_C = 125^\circ\text{C}$)	13	I_{CEX}	— —	0.1 0.5	mAdc
Collector Cutoff Current ($V_{CB} = \text{Rated } V_{CB}$, $I_E = 0$)	—	I_{CBO}	—	0.1	mAdc
Emitter Cutoff Current ($V_{BE} = 5.0 \text{ Vdc}$, $I_C = 0$)	—	I_{EBO}	—	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (1) ($I_C = 50 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 500 \text{ mAdc}$, $V_{CE} = 1.0 \text{ Vdc}$) ($I_C = 1.0 \text{ Adc}$, $V_{CE} = 1.0 \text{ Vdc}$)	9	h_{FE}	40 20 10	— 100 —	—
Collector-Emitter Saturation Voltage (1) ($I_C = 1.0 \text{ Adc}$, $I_B = 0.1 \text{ Adc}$)	10 12 14	$V_{CE(sat)}$	—	0.6	Vdc
Base-Emitter Saturation Voltage (1) ($I_C = 1.0 \text{ Adc}$, $I_B = 0.1 \text{ Adc}$)	12 14	$V_{BE(sat)}$	—	1.3	Vdc
Base-Emitter On Voltage (1) ($I_C = 1.0 \text{ Adc}$, $V_{CE} = 1.0 \text{ Vdc}$)	12 14	$V_{BE(on)}$	—	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain – Bandwidth Product ($I_C = 250 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)	—	f_T	3.0	—	MHz
Output Capacitance ($V_{CB} = 10 \text{ Vdc}$, $I_E = 0$, $f = 100 \text{ kHz}$)	—	C_{ob}	—	100	pF
Small-Signal Current Gain ($I_C = 250 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$, $f = 1.0 \text{ kHz}$)	—	h_{fe}	25	—	—

*Indicates JEDEC Registered Data for 2N4918 Series.

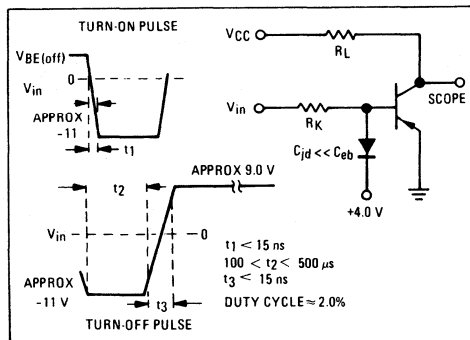
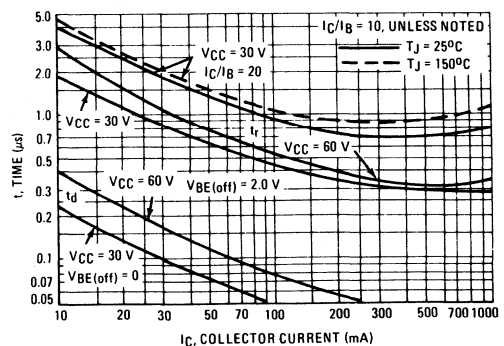
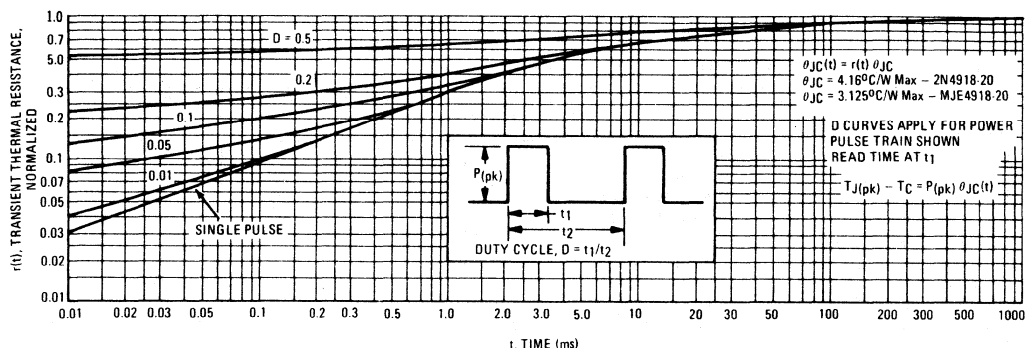
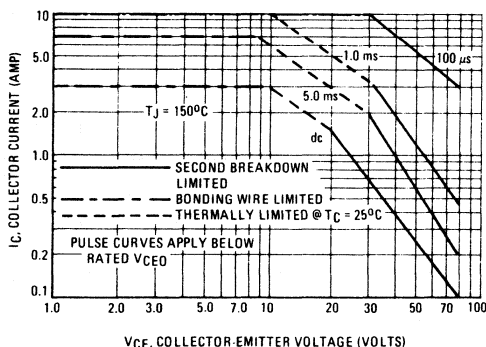
(1) Pulse Test: $PW \approx 300 \mu\text{s}$, Duty Cycle $\approx 2.0\%$ **FIGURE 2 – SWITCHING TIME EQUIVALENT CIRCUIT****FIGURE 3 – TURN-ON TIME**

FIGURE 4 – THERMAL RESPONSE



ACTIVE-REGION SAFE OPERATING AREA

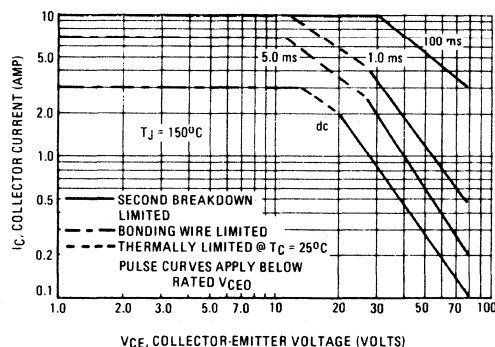
FIGURE 5 – 2N4918 thru 2N4920



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ operation i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 5 and 6 is based on $T_{J(pk)} = 150^\circ\text{C}$.

FIGURE 6 – MJE4918 thru MJE4920



T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150^\circ\text{C}$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 7 – STORAGE TIME

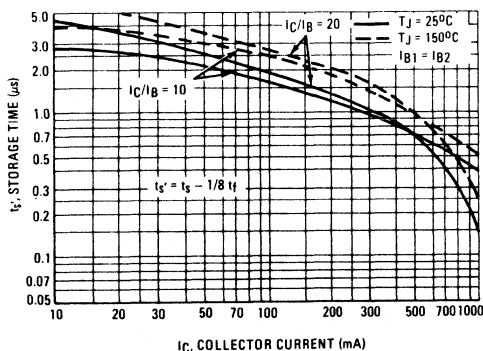
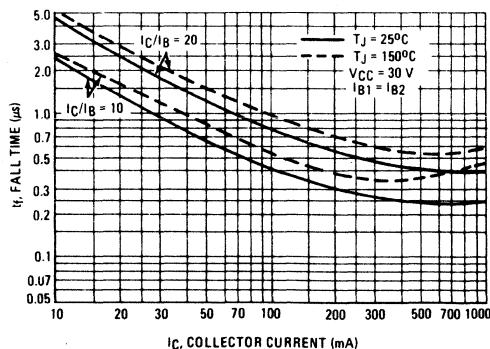


FIGURE 8 – FALL TIME



TYPICAL DC CHARACTERISTICS

FIGURE 9 – CURRENT GAIN

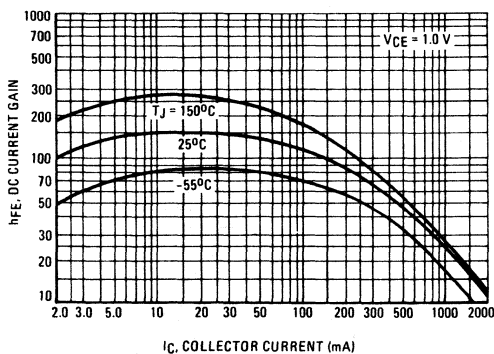


FIGURE 10 – COLLECTOR SATURATION REGION

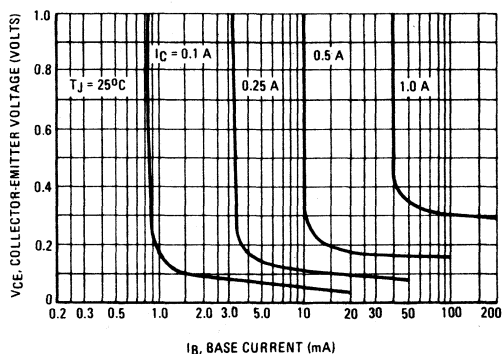


FIGURE 11 – EFFECTS OF BASE-EMITTER RESISTANCE

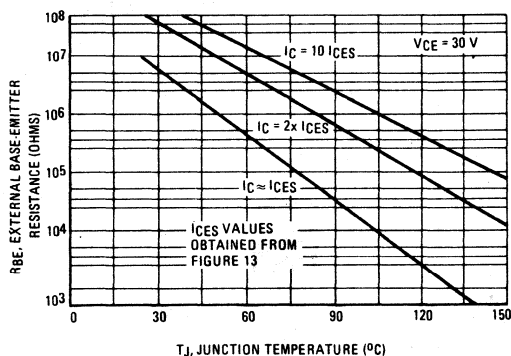


FIGURE 12 – "ON" VOLTAGE

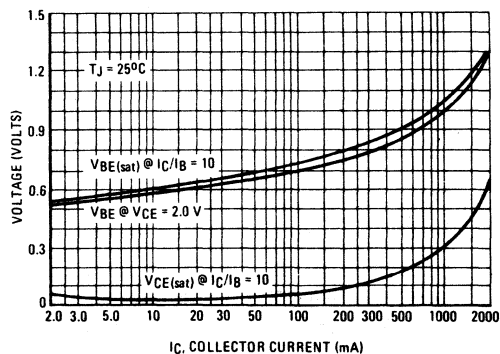


FIGURE 13 – COLLECTOR CUTOFF REGION

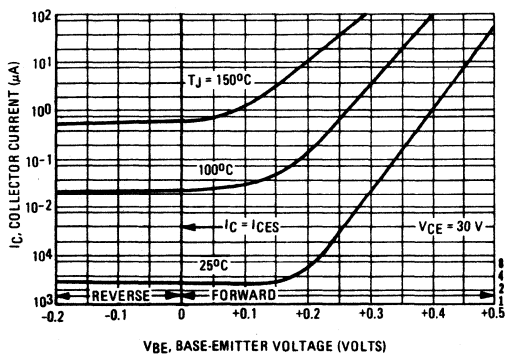
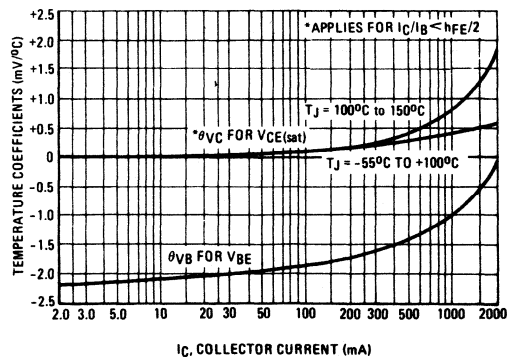


FIGURE 14 – TEMPERATURE COEFFICIENTS



2N4921 thru 2N4923 (SILICON)

MJE4921 thru MJE4923

MEDIUM-POWER PLASTIC NPN SILICON TRANSISTORS

... designed for driver circuits, switching, and amplifier applications. These high-performance plastic devices feature:

- Low Saturation Voltage — $V_{CE(sat)} = 0.6 \text{ Vdc (Max) @ } I_C = 1.0 \text{ Amp}$
- Excellent Power Dissipation Due to Thermopad Construction — $P_D = 30 \text{ and } 40 \text{ W @ } T_C = 25^\circ\text{C}$
- Excellent Safe Operating Area
- Gain Specified to $I_C = 1.0 \text{ Amp}$
- Complement to PNP 2N4918, 2N4919, 2N4920 and MJE4918, MJE4919, MJE4920
- Choice of Packages — 2N4921 thru 2N4923, 30 Watts — Case 77

MJE4921 thru MJE4923, 40 Watts — Case 199

*MAXIMUM RATINGS

Rating	Symbol	2N4921 MJE4921	2N4922 MJE4922	2N4923 MJE4923	Unit
Collector-Emitter Voltage	V_{CE0}	40	60	80	V/dc
Collector-Base Voltage	V_{CB}	40	60	80	V/dc
Emitter-Base Voltage	V_{EB}	5.0			V/dc
Collector Current - Continuous (1)	I_C	1.0			A/dc
		3.0			
Base Current - Continuous	I_B	1.0			A/dc
		2N4921 Series		MJE4921 Series	
Total Device Dissipation @ $T_C = 25^{\circ}\text{C}$	P_D	30		40	Watts
Derate above 25°C		0.24		0.32	W/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150			°C

THERMAL CHARACTERISTICS (2)

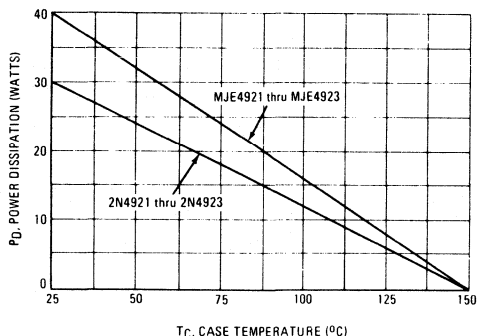
Characteristic	Symbol	2N4921/4923	MJE4921/4923	Unit
Thermal Resistance, Junction to Case	θ_{JC}	4.16	3.125	°C/W

(1) The 1.0 Amp maximum I_C value is based upon JEDEC current gain requirements. The 3.0 Amp maximum value is based upon actual current handling capability of the device (see Figures 5 and 6).

(2) Recommend use of thermal compound for lowest thermal resistance.

*Indicates JEDEC Registered Data for 2N4921 Series.

FIGURE 1 — POWER DERATING

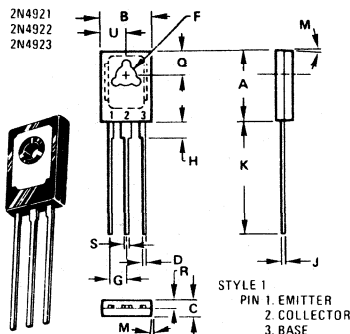


Safe Area Curves are indicated by Figures 5 and 6. All limits are applicable and must be observed.

3 AMPERE GENERAL-PURPOSE POWER TRANSISTORS

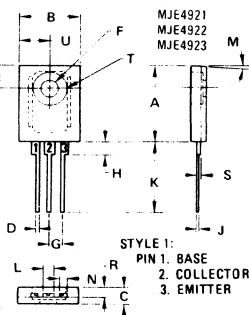
40-80 VOLTS
30 and 40 WATTS

2N4921
2N4922
2N4923



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.80	11.05	0.425	0.435
B	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.00	0.115	0.118
G	2.36 BSC		0.093 BSC	
H	2.16	2.41	0.085	0.095
J	0.38	0.64	0.015	0.025
K	15.38	16.64	0.605	0.655
M	30 TYP		30 TYP	
Q	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155

CASE 77-03



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.08	16.33	0.633	0.643
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	0.51	0.76	0.020	0.030
F	3.61	3.86	0.142	0.152
G	2.54 BSC		0.100 BSC	
H	2.67	2.92	0.105	0.115
J	0.43	0.69	0.017	0.027
K	14.73	14.99	0.580	0.590
L	2.16	2.41	0.085	0.095
M	30 TYP		30 TYP	
N	1.47	1.73	0.058	0.068
Q	4.78	5.03	0.189	0.198
R	1.91	2.16	0.075	0.085
S	0.81	0.86	0.032	0.034
T	6.99	7.24	0.275	0.285
U	6.22	6.48	0.245	0.255

1. DIM "G" IS TO CENTERLINE OF LEADS.

CASE 199-04

*ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Figure No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I _C = 0.1 Adc, I _B = 0)	—	V _{CEO(sus)}	40 60 80	—	Vdc
Collector Cutoff Current (V _{CE} = 20 Vdc, I _B = 0)	—	I _{CEO}	—	0.5	mAdc
(V _{CE} = 30 Vdc, I _B = 0)	—		—	0.5	
(V _{CE} = 40 Vdc, I _B = 0)	—		—	0.5	
Collector Cutoff Current (V _{CE} = Rated V _{CEO} , V _{EB(off)} = 1.5 Vdc)	13	I _{CEX}	—	0.1	mAdc
(V _{CE} = Rated V _{CEO} , V _{EB(off)} = 1.5 Vdc, T _C = 125°C)			—	0.5	
Collector Cutoff Current (V _{CB} = Rated V _{CB} , I _E = 0)	—	I _{CBO}	—	0.1	mAdc
Emitter Cutoff Current (V _{EB} = 5.0 Vdc, I _C = 0)	—	I _{EBO}	—	1.0	mAdc

ON CHARACTERISTICS

DC Current Gain (1) (I _C = 50 mAdc, V _{CE} = 1.0 Vdc) (I _C = 500 mAdc, V _{CE} = 1.0 Vdc) (I _C = 1.0 Adc, V _{CE} = 1.0 Vdc)	9	h _{FE}	40 20 10	— 100 —	—
Collector-Emitter Saturation Voltage (1) (I _C = 1.0 Adc, I _B = 0.1 Adc)	10 12 14	V _{CE(sat)}	—	0.6	Vdc
Base-Emitter Saturation Voltage (1) (I _C = 1.0 Adc, I _B = 0.1 Adc)	12 14	V _{BE(sat)}	—	1.3	Vdc
Base-Emitter On Voltage (1) (I _C = 1.0 Adc, V _{CE} = 1.0 Vdc)	12 14	V _{BE(on)}	—	1.3	Vdc

SMALL SIGNAL CHARACTERISTICS

Current-Gain – Bandwidth Product (I _C = 250 mAdc, V _{CE} = 10 Vdc, f = 1.0 MHz)	—	f _T	3.0	—	MHz
Output Capacitance (V _{CB} = 10 Vdc, I _E = 0, f = 100 kHz)	—	C _{ob}	—	100	pF
Small-Signal Current Gain (I _C = 250 mAdc, V _{CE} = 10 Vdc, f = 1.0 kHz)	—	h _{fe}	25	—	—

(1) Pulse Test: PW ≈ 300 μs, Duty Cycle ≈ 2.0%.
 *Indicates JEDEC Registered Data for 2N4921 Series.

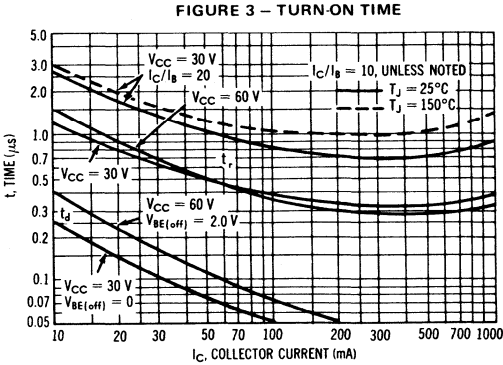
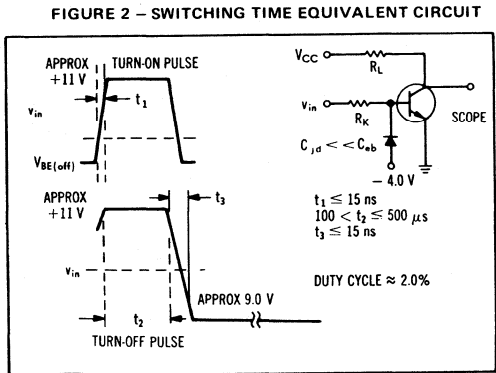
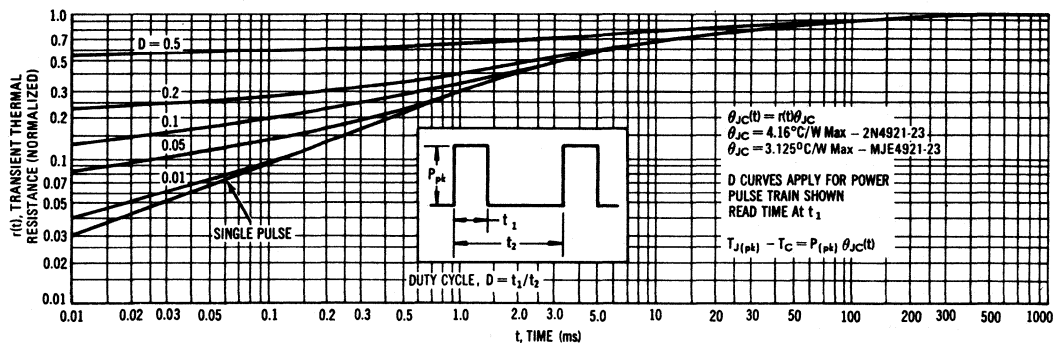


FIGURE 4 – THERMAL RESPONSE



ACTIVE – REGION SAFE OPERATING AREA

FIGURE 5 – 2N4921 thru 2N4923

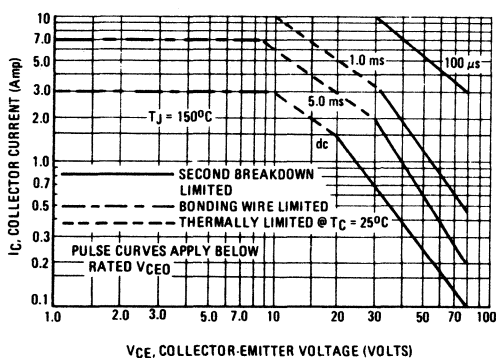
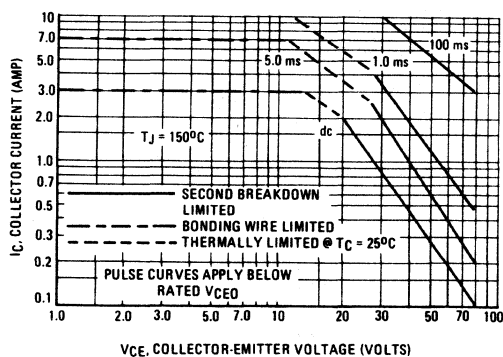


FIGURE 6 – MJE4921 thru MJE4923



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 5 and 6 is based on $T_{J(pk)} = 150^\circ\text{C}$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150^\circ\text{C}$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 7 – STORAGE TIME

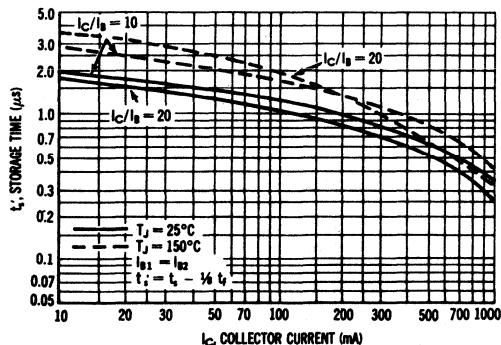


FIGURE 8 – FALL TIME

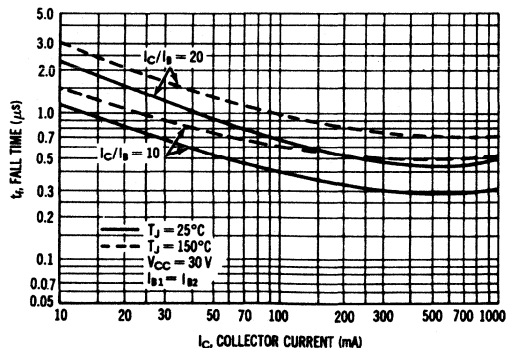


FIGURE 9 – CURRENT GAIN

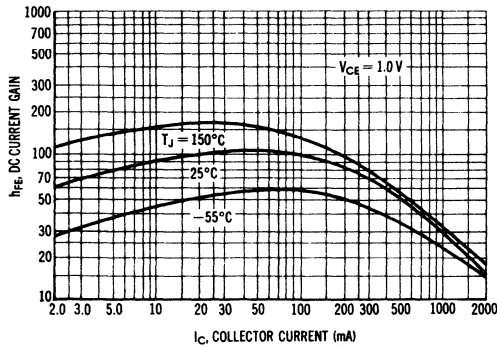


FIGURE 10 – COLLECTOR SATURATION REGION

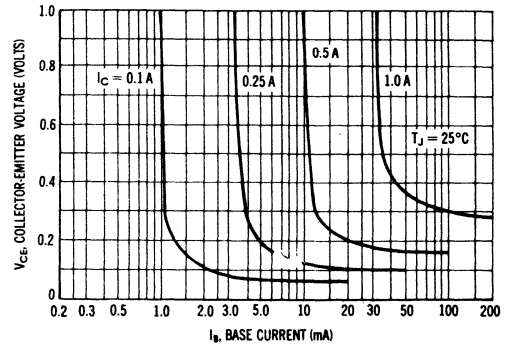


FIGURE 11 – EFFECTS OF BASE-EMITTER RESISTANCE

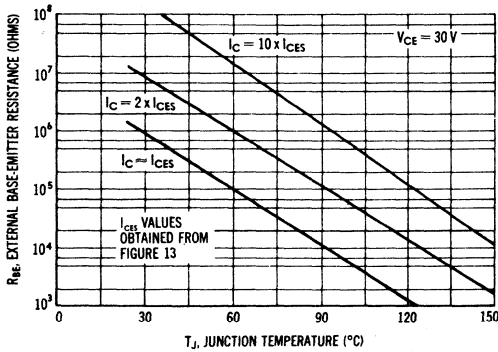


FIGURE 12 – "ON" VOLTAGE

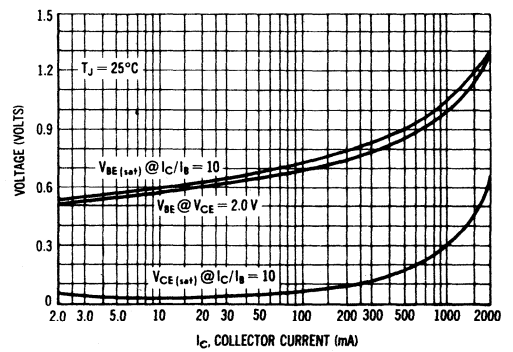


FIGURE 13 – COLLECTOR CUTOFF REGION

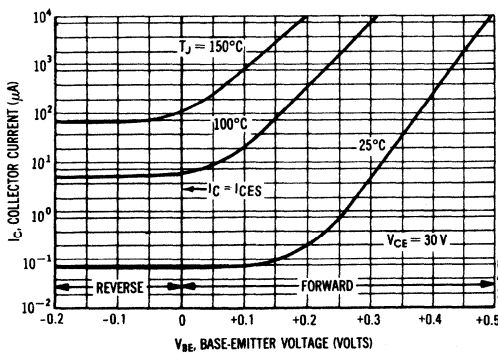
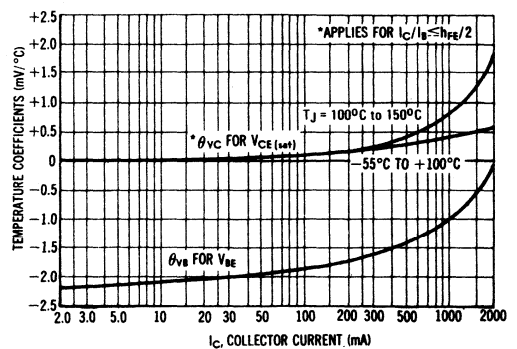


FIGURE 14 – TEMPERATURE COEFFICIENTS



2N4924S(SILICON)

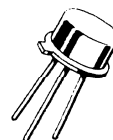
2N4925

NPN SILICON ANNULAR TRANSISTORS

...designed for high-voltage high-frequency amplifier applications

- High Collector-Emitter Breakdown Voltage
 $V_{CE0} = 100 \text{ Vdc (Min) @ } I_C = 10 \text{ mAdc} - 2N4924$
 $150 \text{ Vdc (Min) @ } I_C = 10 \text{ mAdc} - 2N4925$

NPN SILICON AMPLIFIER TRANSISTORS



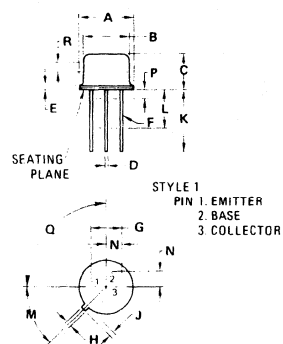
*MAXIMUM RATING

Rating	Symbol	2N4924	2N4925	Unit
Collector-Emitter Voltage	V_{CE0}	100	150	Vdc
Collector-Base Voltage	V_{CB}	100	150	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
Total Power Dissipation @ $T_A = 25^\circ\text{C}$	P_D	1.0		Watt
Derate above 25°C		5.71		mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$	P_D	5.0		Watts
Derate above 25°C		28.6		mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

*Indicates JEDEC Registered Data.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	$^\circ\text{C/W}$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	$^\circ\text{C/W}$



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45°	NOM	45°	NOM
P	—	1.27	—	0.050
Q	90°	NOM	90°	NOM
R	2.54	—	0.100	—

All JEDEC notes and dimensions apply.

CASE 79-02
TO-39

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
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OFF CHARACTERISTICS

Collector-Emitter Breakdown Voltage (1) ($I_C = 10 \text{ mAdc}$, $I_B = 0$)	2N4924 2N4925	BV_{CEO}	100 150	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 10 \text{ } \mu\text{Adc}$, $I_E = 0$)	2N4924 2N4925	BV_{CBO}	100 150	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10 \text{ } \mu\text{Adc}$, $I_C = 0$)		BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 50 \text{ Vdc}$, $I_E = 0$) ($V_{CB} = 75 \text{ Vdc}$, $I_E = 0$)		I_{CBO}	— —	0.1 0.1	μAdc
Emitter Cutoff Current ($V_{BE} = 3.0 \text{ Vdc}$)		I_{ERO}	—	0.1	μAdc

ON CHARACTERISTICS (1)

DC Current Gain ($I_C = 1.0 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$) ($I_C = 10 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$) ($I_C = 150 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$)	h_{FE}	25 35 40	— — 200	—
Collector-Emitter Saturation Voltage ($I_C = 10 \text{ mAdc}$, $I_B = 1.0 \text{ mAdc}$) ($I_C = 50 \text{ mAdc}$, $I_B = 5.0 \text{ mAdc}$)	$V_{CE(sat)}$	— —	0.25 0.4	Vdc
Base-Emitter On Voltage ($I_C = 50 \text{ mAdc}$, $V_{CE} = 10 \text{ Vdc}$)	$V_{BE(on)}$	—	0.95	Vdc

SMALL-SIGNAL CHARACTERISTICS

Current-Gain-Bandwidth Product (2) ($I_C = 20 \text{ mAdc}$, $V_{CE} = 20 \text{ Vdc}$, $f = 100 \text{ MHz}$)	f_T	100	500	MHz
Collector-Base Capacitance ($V_{CB} = 20 \text{ Vdc}$, $I_E = 0$, $f = 140 \text{ kHz}$)	C_{cb}	—	10	pF
Emitter-Base Capacitance ($V_{EB} = 1.0 \text{ Vdc}$, $I_C = 0$, $f = 140 \text{ kHz}$)	C_{eb}	—	80	pF

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width $\leq 300 \text{ } \mu\text{s}$, Duty Cycle $\leq 2.0\%$.(2) $f_T = |h_{fe}| \cdot f_{test}$.

2N4926 (SILICON)

2N4927

NPN SILICON ANNULAR TRANSISTORS

... designed for high-voltage amplifier applications.

- High Collector-Emitter Breakdown Voltage –
 $BV_{CEO} = 200 \text{ Vdc (Min) @ } I_C = 10 \text{ mAdc} - 2N4926$
 $250 \text{ Vdc (Min) @ } I_C = 10 \text{ mAdc} - 2N4927$

MAXIMUM RATINGS

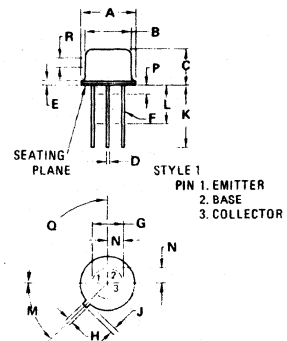
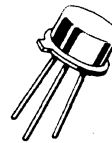
Rating	Symbol	2N4926	2N4927	Unit
*Collector-Emitter Voltage	V_{CEO}	200	250	Vdc
*Collector-Base Voltage	V_{CB}	200	250	Vdc
*Emitter-Base Voltage	V_{EB}	7.0		Vdc
*Collector Current – Continuous	I_C	50		mAdc
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	1.0	5.71	Watt mW/ $^\circ\text{C}$
*Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	5.0	28.6	Watts mW/ $^\circ\text{C}$
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		$^\circ\text{C}$

*Indicates JEDEC Registered Data.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	$^\circ\text{C/W}$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	$^\circ\text{C/W}$

NPN SILICON AMPLIFIER TRANSISTORS



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45°	NOM	45°	NOM
P	—	1.27	—	0.050
Q	90°	NOM	90°	NOM
R	2.54	—	0.100	—

All JEDEC notes and dimensions apply.

CASE 79
TO-39

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
*OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) ($I_C = 10\text{ mAdc}$, $I_B = 0$)	BV_{CEO}	200 250	— —	Vdc
Collector-Base Breakdown Voltage ($I_C = 0.1\text{ mAdc}$, $I_E = 0$)	BV_{CBO}	200 250	— —	Vdc
Emitter-Base Breakdown Voltage ($I_E = 0.1\text{ mAdc}$, $I_C = 0$)	BV_{EBO}	7.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 100\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 100\text{ Vdc}$, $I_E = 0$, $T_A = 100^\circ\text{C}$) ($V_{CB} = 150\text{ Vdc}$, $I_E = 0$) ($V_{CB} = 150\text{ Vdc}$, $I_E = 0$, $T_A = 100^\circ\text{C}$)	I_{CBO}	— — — —	0.1 10 0.1 10	$\mu\text{A dc}$
Emitter Cutoff Current ($V_{BE} = 5.0\text{ Vdc}$)	I_{EBO}	—	0.1	$\mu\text{A dc}$

ON CHARACTERISTICS (1)

*DC Current Gain ($I_C = 3.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 30\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 50\text{ mAdc}$, $V_{CE} = 20\text{ Vdc}$)	h_{FE}	10 15 20 20	— — 200 —	—
Collector-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$) ($I_C = 30\text{ mAdc}$, $I_B = 3.0\text{ mAdc}$)	$V_{CE(sat)}$	— —	1.0 2.0	Vdc
Base-Emitter Saturation Voltage ($I_C = 10\text{ mAdc}$, $I_B = 1.0\text{ mAdc}$) ($I_C = 50\text{ mAdc}$, $I_B = 3.0\text{ mAdc}$)	$V_{BE(sat)}$	— —	1.2 1.5	Vdc
Base-Emitter On Voltage ($I_C = 30\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$)	$V_{BE(on)}$	—	1.5	Vdc

***SMALL-SIGNAL CHARACTERISTICS**

Current-Gain-Bandwidth Product ($I_C = 10\text{ mAdc}$, $V_{CE} = 20\text{ Vdc}$, $f = 20\text{ MHz}$)	f_T	30	300	MHz
Output Capacitance ($V_{CB} = 20\text{ Vdc}$, $I_E = 0$, $f = 140\text{ kHz}$)	C_{cb}	—	6.0	pF
Input Impedance ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ie}	75	2000	ohm
Voltage Feedback Ratio ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{re}	0.1	2.0	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	25	250	—
Output Admittance ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{oe}	—	50	μmhos
Real Part of Input Impedance ($I_C = 10\text{ mAdc}$, $V_{CE} = 20\text{ Vdc}$, $f = 5.0\text{ MHz}$)	$\text{Re}(h_{ie})$	4.0	200	ohms

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width $\leq 300\text{ }\mu\text{s}$, Duty Cycle $\leq 2.0\%$.

2N4928S thru 2N4931S (SILICON)

2N4930S JAN & JTX
2N4931S JAN & JTX AVAILABLE



High-voltage PNP silicon annular transistors for use in general-purpose high-voltage applications.

CASE 79
(TO-39)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

Collector connected to case

* MAXIMUM RATINGS

Rating	Symbol	2N4928	2N4929	2N4930	2N4931	Unit
Collector-Emitter Voltage	V_{CEO}	100	150	200	250	Vdc
Collector-Base Voltage	V_{CB}	100	150	200	250	Vdc
Emitter-Base Voltage	V_{EB}	4.0	4.0	4.0	4.0	Vdc
Collector Current — Continuous	I_C	100	500	500	500	mA _{dc}
Total Device Dissipation @ $T_A = 25^\circ\text{C}$	P_D	0.6	1.0	1.0	1.0	Watt
Derate above 25°C		3.4	5.71	5.71	5.71	mW/ $^\circ\text{C}$
Total Device Dissipation @ $T_C = 25^\circ\text{C}$	P_D	3.0	5.0	5.0	5.0	Watt
Derate above 25°C		17.2	28.6	28.6	28.6	mW/ $^\circ\text{C}$
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200				$^\circ\text{C}$

* Indicates JEDEC Registered Data

2N4928S thru 2N4931S (continued)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ⁽¹⁾ ($I_C = 10 \text{ mA}_{dc}$, $I_B = 0$)	BV_{CEO}	100 150 200 250	- - - -	Vdc
Collector-Base Breakdown Voltage ($I_E = 0$, $I_C = 100 \mu\text{A}_{dc}$)	BV_{CBO}	100 150 200 250	- - - -	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{A}_{dc}$, $I_C = 0$)	BV_{EBO}	4.0	-	Vdc
Collector Cutoff Current ($V_{CB} = 50 \text{ Vdc}$, $I_E = 0$)	I_{CBO}	-	0.5	μA_{dc}
($V_{CB} = 75 \text{ Vdc}$, $I_E = 0$)		-	0.5	
($V_{CB} = 150 \text{ Vdc}$, $I_E = 0$)		-	1.0	
Emitter Cutoff Current ($V_{BE} = 3.0 \text{ Vdc}$, $I_C = 0$)	I_{EBO}	-	0.5	μA_{dc}
($V_{BE} = 3.0 \text{ Vdc}$, $I_C = 0$)		-	1.0	

ON CHARACTERISTICS

DC Current Gain ($I_C = 1.0 \text{ mA}_{dc}$, $V_{CE} = 10 \text{ Vdc}$)	All Types	h_{FE}	20	-	-
($I_C = 10 \text{ mA}_{dc}$, $V_{CE} = 10 \text{ Vdc}$) ⁽¹⁾	2N4928, 2N4929		25	200	
($I_C = 10 \text{ mA}_{dc}$, $V_{CE} = 10 \text{ Vdc}$) ⁽¹⁾	2N4930, 2N4931		20	200	
($I_C = 50 \text{ mA}_{dc}$, $V_{CE} = 10 \text{ Vdc}$) ⁽¹⁾	2N4928, 2N4929		20	-	
($I_C = 30 \text{ mA}_{dc}$, $V_{CE} = 10 \text{ Vdc}$) ⁽¹⁾	2N4930, 2N4931		20	-	
Collector-Emitter Saturation Voltage ⁽¹⁾ ($I_C = 10 \text{ mA}_{dc}$, $I_B = 1.0 \text{ mA}_{dc}$)	2N4928, 2N4929 2N4930, 2N4931	$V_{CE(sat)}$	- -	0.5 5.0	Vdc
Base-Emitter On Voltage ($I_C = 10 \text{ mA}_{dc}$, $V_{CE} = 10 \text{ Vdc}$)		$V_{BE(on)}$	-	1.0	Vdc

DYNAMIC CHARACTERISTICS

Current-Gain-Bandwidth Product ($I_C = 20 \text{ mA}_{dc}$, $V_{CE} = 20 \text{ Vdc}$, $f = 100 \text{ MHz}$)	2N4928, 2N4929	f_T	100	1,000	MHz
($I_C = 20 \text{ mA}_{dc}$, $V_{CE} = 20 \text{ Vdc}$, $f = 20 \text{ MHz}$)	2N4930, 2N4931		20	200	
Collector-Base Capacitance ($V_{CB} = 20 \text{ Vdc}$, $I_E = 0$, $f = 140 \text{ kHz}$)	2N4928	C_{cb}	-	6.0	pF
($V_{CB} = 20 \text{ Vdc}$, $I_E = 0$, $f = 140 \text{ kHz}$)	2N4929		-	10	
($V_{CB} = 20 \text{ Vdc}$, $I_E = 0$, $f = 140 \text{ kHz}$)	2N4930, 2N4931		-	20	
Emitter-Base Capacitance ($V_{BE} = 2.0 \text{ Vdc}$, $I_C = 0$, $f = 140 \text{ kHz}$)	2N4928	C_{eb}	-	40	pF
($V_{BE} = 1.0 \text{ Vdc}$, $I_C = 0$, $f = 140 \text{ kHz}$)	2N4929		-	80	
($V_{BE} = 0.5 \text{ Vdc}$, $I_C = 0$, $f = 140 \text{ kHz}$)	2N4930, 2N4931		-	400	

* Indicates JEDEC Registered Data

⁽¹⁾ Pulse Width $\leq 300 \mu\text{s}$; Duty Cycle $\leq 2.0\%$

MULTIPLE SILICON ANNULAR TRANSISTORS

... designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

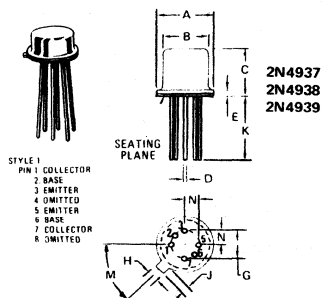
- Excellent Temperature Tracking – Dual Devices –
2N4938, 2N4930
 $\Delta|V_{BE1} - V_{BE2}| = 1.6 \text{ mVdc (Max) @ } -55 \text{ to } +25^\circ\text{C}$
 $= 2.0 \text{ mVdc (Max) @ } +25 \text{ to } +125^\circ\text{C}$
- DC Current Gain Specified – 100 μAdc to 1.0 mAdc
- High Current-Gain-Bandwidth Product –
 $f_T = 300 \text{ MHz @ } I_C = 10 \text{ mAdc}$

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector 1 to Collector 2 Voltage	V_{C1C2}	± 200	Vdc
Voltage Rating and Lead to Case		± 200	
Collector-Base Voltage	V_{CB}	50	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	50	mAdc
		One Die	Both Die
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Metal Can Derate above 25°C	P_D	500 2.9	600 3.4 mW/ $^\circ\text{C}$
Total Power Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D	1.2 6.85	2.0 11.42 Watts mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

*Indicates JEDEC Registered Data.

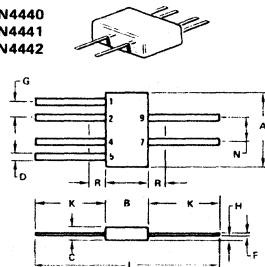
PNP SILICON MULTIPLE TRANSISTORS



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC	0.200 BSC		
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	—	0.500	—
M	45° BSC	45° BSC		
N	2.54 BSC	0.100 BSC		

CASE 654-07

2N4440
2N4441
2N4442



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.06	0.15	0.003	0.006
G	1.27 BSC	0.050 BSC		
H	—	0.89	—	0.035
K	3.81	—	0.150	—
N	2.54 BSC	0.100 BSC		
R	—	1.27	—	0.050

CASE 610A-03

2N4937 thru 2N4942 (continued)

*ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 10\text{ mAdc}$, $I_B = 0$)	BV_{CEO}	40	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\text{ }\mu\text{Adc}$, $I_E = 0$)	BV_{CBO}	50	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\text{ }\mu\text{Adc}$, $I_C = 0$)	BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current ($V_{CB} = 40\text{ Vdc}$, $I_E = 0$)	I_{CBO}	—	20	nAdc
Emitter Cutoff Current ($V_{BE} = 3.0\text{ Vdc}$, $I_C = 0$)	I_{EBO}	—	20	nAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 100\text{ }\mu\text{Adc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$) ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$)	h_{FE}	40 50 50	200 250 250	—
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain-Bandwidth Product ($I_C = 10\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$)	f_T	300	900	MHz
Output Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 140\text{ kHz}$) Emitter Guarded	C_{cb}	—	5.0	pF
Input Capacitance ($V_{BE} = 0.5\text{ Vdc}$, $I_C = 0$, $f = 140\text{ kHz}$) Collector Guarded	C_{eb}	—	10	pF
Input Impedance ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{ie}	1.0	10	k Ω
Voltage Feedback Ratio ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{re}	—	10	$\times 10^{-4}$
Small-Signal Current Gain ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{fe}	50	—	—
Output Admittance ($I_C = 1.0\text{ mAdc}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$)	h_{oe}	5.0	50	μmhos
Noise Figure ($I_C = 100\text{ }\mu\text{Adc}$, $V_{CE} = 10\text{ Vdc}$, $R_S = 3.0\text{ k}\Omega$, $f = 10\text{ Hz}$ to 15.7 kHz)	NF	—	4.0	dB
MATCHING CHARACTERISTICS				
DC Current Gain Ratio (1) ($I_C = 100\text{ }\mu\text{Adc}$ to 1.0 mAdc , $V_{CE} = 10\text{ Vdc}$) ($I_C = 100\text{ }\mu\text{Adc}$ to 1.0 mAdc , $V_{CE} = 10\text{ Vdc}$, $T_A = -55^\circ\text{C}$ to 125°C)	2N4937, 2N4941 2N4938, 2N4940 2N4937, 2N4941 2N4938, 2N4940	h_{FE1}/h_{FE2}	0.9 0.8 0.85 0.7	1.0 1.0 1.0 1.0
Base-Emitter Voltage Differential ($I_C = 100\text{ }\mu\text{Adc}$ to 1.0 mAdc , $V_{CE} = 10\text{ Vdc}$)	2N4937, 2N4941 2N4938, 2N4940	$ V_{BE1} - V_{BE2} $	— —	3.0 5.0
Base-Emitter Voltage Differential Gradient ($I_C = 100\text{ }\mu\text{Adc}$ to 1.0 mAdc , $V_{CE} = 10\text{ Vdc}$, $T_A = 25^\circ\text{C}$ to $+125^\circ\text{C}$) ($I_C = 100\text{ }\mu\text{Adc}$ to 1.0 mAdc , $V_{CE} = 10\text{ Vdc}$, $T_A = -55^\circ\text{C}$ to 25°C)	2N4937, 2N4941 2N4938, 2N4940 2N4937, 2N4941 2N4938, 2N4940	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	— — — —	1.0 2.0 0.8 1.6

*Indicates JEDEC Registered Data.

(1) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

2N4948 (SILICON)

2N4949



CASE 22A
(TO-18 Modified)
(Lead 3 connected to case)



STYLE 1:
PIN 1. EMITTER
2. BASE 1
3. BASE 2

Silicon annular unijunction transistors designed for military and industrial use in pulse, timing, triggering, sensing, and oscillator circuits. The annular process provides low leakage current, fast switching and low peak-point currents as well as outstanding reliability and uniformity.

MAXIMUM RATINGS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Rating	Symbol	Value	Unit
RMS Power Dissipation*	P_D	360*	mW
RMS Emitter Current	I_e	50	mA
Peak Pulse Emitter Current**	i_e	1.0**	Amp
Emitter Reverse Voltage	V_{B2E}	30	Volts
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

- * Derate 2.4 mW/ $^\circ\text{C}$ increase in ambient temperature. Total power dissipation (available power to Emitter and Base-Two) must be limited by external circuitry. Interbase voltage (V_{B2B1}) limited by power dissipation,

$$V_{B2B1} = \sqrt{R_{BB} \cdot P_D}$$

- ** Capacitance discharge current must fall to 0.37 Amp within 3.0 ms and PRR ≤ 10 PPS.

2N4948, 2N4949 (continued)

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Intrinsic Standoff Ratio ($V_{B2B1} = 10\text{ V}$) Note 1	η	0.55 0.74	- -	0.82 0.86	-
Interbase Resistance ($V_{B2B1} = 3.0\text{ V}$, $I_E = 0$)	R_{BB}	4.0	7.0	12.0	k ohms
Interbase Resistance Temperature Coefficient ($V_{B2B1} = 3.0\text{ V}$, $I_E = 0$, $T_A = -65^\circ\text{C}$ to $+100^\circ\text{C}$)	αR_{BB}	0.1	-	0.9	%/ $^\circ\text{C}$
Emitter Saturation Voltage ($V_{B2B1} = 10\text{ V}$, $I_E = 50\text{ mA}$) Note 2	$V_{EB1(\text{sat})}$	-	2.5	3.0	Volts
Modulated Interbase Current ($V_{B2B1} = 10\text{ V}$, $I_E = 50\text{ mA}$)	$I_{B2(\text{mod})}$	12	15	-	mA
Emitter Reverse Current ($V_{B2E} = 30\text{ V}$, $I_{B1} = 0$) ($V_{B2E} = 30\text{ V}$, $I_{B1} = 0$, $T_A = 125^\circ\text{C}$)	I_{EB2O}	- -	5.0 -	10 1.0	nA μA
Peak Point Emitter Current ($V_{B2B1} = 25\text{ V}$)	I_P	- -	0.6 0.6	2.0 1.0	μA
Valley Point Current ($V_{B2B1} = 20\text{ V}$, $R_{B2} = 100\text{ ohms}$) Note 2	I_V	2.0	4.0	- -	mA
Base-One Peak Pulse Voltage (Note 3, Figure 3)	V_{OB1}	3.0 6.0	5.0 8.0	- -	Volts
Maximum Oscillation Frequency (Figure 4)	$f_{(\text{max})}$	-	1.25	-	MHz

NOTES

1. Intrinsic standoff ratio.

η is defined by equation:

$$\eta = \frac{V_P - V_{(EB1)}}{V_{B2B1}}$$

Where V_P = Peak Point Emitter Voltage

V_{B2B1} = Interbase Voltage

$V_{(EB1)}$ = Emitter to Base-One Junction Diode Drop
($\sim 0.5\text{ V}$ @ $10\text{ }\mu\text{A}$)

2. Use pulse techniques: PW $\sim 300\text{ }\mu\text{s}$ duty cycle $\sim 2\%$ to avoid internal heating due to interbase modulation which may result in erroneous readings.

3. Base-One Peak Pulse Voltage is measured in circuit of Figure 3. This specification is used to ensure minimum pulse amplitude for applications in SCR firing circuits and other types of pulse circuits.

FIGURE 1 — UNIJUNCTION TRANSISTOR SYMBOL AND NOMENCLATURE

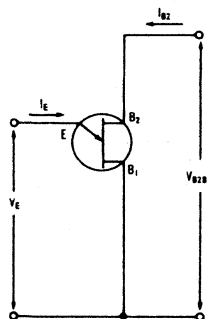


FIGURE 2 — STATIC EMITTER CHARACTERISTICS CURVES
(Exaggerated to Show Details)

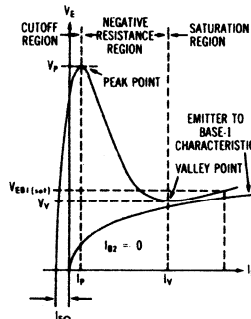


FIGURE 3 — V_{OB1} TEST CIRCUIT
(Typical Relaxation Oscillator)

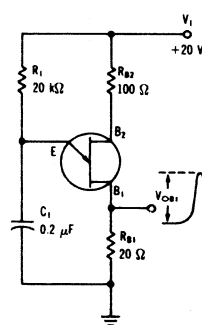
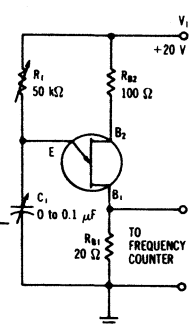


FIGURE 4 — $f_{(\text{max})}$ MAXIMUM FREQUENCY TEST CIRCUIT



2N4957, 2N4958 (SILICON)

2N4959, 2N5829

The RF Line

PNP SILICON SMALL-SIGNAL TRANSISTORS

... designed for high-gain, low-noise amplifier, oscillator and mixer applications.

- Specified 2.0 mAdc, 10 Vdc Characteristics –
Noise Figure = 2.5 dB – 2N5829
(@ 450 MHz) = 3.0 dB – 2N4957
= 3.3 dB – 2N4958
= 3.8 dB – 2N4959
Minimum Gain = 17 dB – 2N4957, 2N5829
(@ 450 MHz) = 16 dB – 2N4958
= 15 dB – 2N4959
Current-Gain-Bandwidth Product –
= 1.2 GHz – 2N4957, 2N5829
= 1.0 GHz – 2N4958, 2N4959

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current – Continuous	I_C	30	mAdc
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	200 1.14	mW mW/ $^\circ\text{C}$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	$^\circ\text{C}$

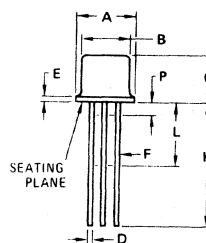
*Indicates JEDEC Registered Data.

1.2 GHz – 2.0 mAdc – 2N4957, 2N5829

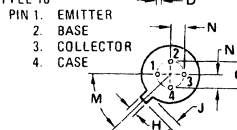
1.0 GHz – 2.0 mAdc – 2N4958, 2N4959

HIGH FREQUENCY TRANSISTORS

PNP SILICON



STYLE 10



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	—	0.76	—	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	—	1.27	—	0.050

ALL JEDEC dimensions and notes apply

CASE 20-03
TO-72

***ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 1.0\text{ mA}$, $I_E = 0$)	BV_{CEO}	30	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\text{ }\mu\text{A}$, $I_E = 0$)	BV_{CBO}	30	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\text{ }\mu\text{A}$, $I_C = 0$)	BV_{EBO}	3.0	—	—	Vdc
Collector Cutoff Current ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$) All Types ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $T_A = 150^\circ\text{C}$) 2N4957,8,9	I_{CBO}	—	—	0.1 100	μAdc

ON CHARACTERISTICS

DC Current Gain ($I_C = 2.0\text{ mA}$, $V_{CE} = 10\text{ Vdc}$) 2N4957,8,9 2N5829	h_{FE}	20 20	40 40	— 150	—
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DYNAMIC CHARACTERISTICS

Current-Gain—Bandwidth Product (1) ($I_E = 2.0\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 100\text{ MHz}$) 2N4957 2N5829 2N4958, 2N4959	f_T	1200 1200 1000	1600 — 1500	— 2500 2500	MHz
Collector-Base Capacitance ($V_{CB} = 10\text{ Vdc}$, $I_E = 0$, $f = 1.0\text{ MHz}$)	C_{cb}	—	0.4	0.8	pF
Small-Signal Current Gain ($I_C = 2.0\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 1.0\text{ kHz}$) 2N5829	h_{fe}	20	—	200	—
Collector-Base Time Constant ($I_E = 2.0\text{ mA}$, $V_{CB} = 10\text{ Vdc}$, $f = 63.6\text{ MHz}$) 2N4957,8,9 2N5829	$r_b'C_c$	— 1.0	— —	8.0 8.0	ps
Noise Figure ($I_C = 2.0\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $f = 450\text{ MHz}$) 2N4957 2N4958 2N4959 2N5829 ($I_C = 2.0\text{ mA}$, $V_{CE} = 10\text{ Vdc}$, $R_G = 50\text{ ohms}$, $f = 1.0\text{ GHz}$) 2N4957	NF	— — — — —	2.6 2.9 3.2 2.3 5.0	3.0 3.3 3.8 2.5 —	dB

FUNCTIONAL TESTS

Common-Emitter Amplifier Power Gain ($V_{CE} = 10\text{ Vdc}$, $I_C = 2.0\text{ mA}$, $f = 450\text{ MHz}$) 2N5829 2N4957 2N4958 2N4959 ($V_{CE} = 10\text{ Vdc}$, $I_C = 2.0\text{ mA}$, $R_G = 50\text{ ohms}$, $f = 1.0\text{ GHz}$) 2N4957	G_{pe}	17 17 16 15 —	— — — — 13	— 25 25 25 —	dB
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*Indicates JEDEC Registered Data.

(1) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

RF PERFORMANCE DATA

FIGURE 1 – NOISE FIGURE AND POWER GAIN TEST CIRCUIT

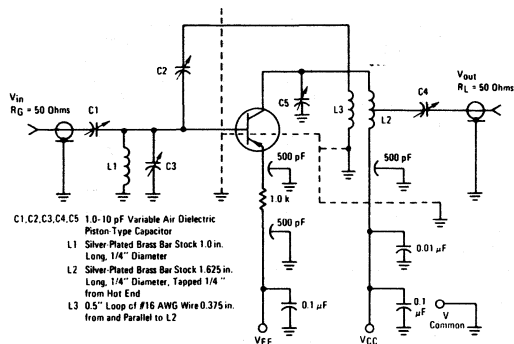


FIGURE 3 – NOISE FIGURE versus FREQUENCY

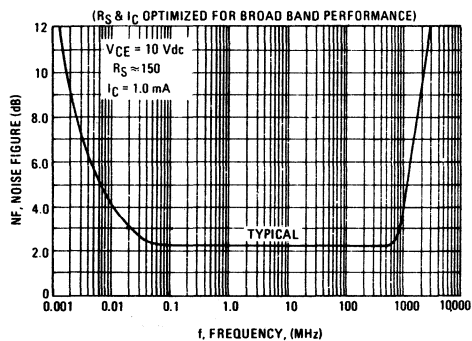


FIGURE 2 – UNILATERALIZED POWER GAIN versus FREQUENCY

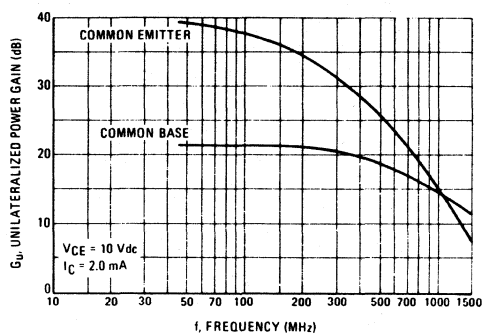


FIGURE 4 – NOISE FIGURE AND POWER GAIN versus COLLECTOR CURRENT

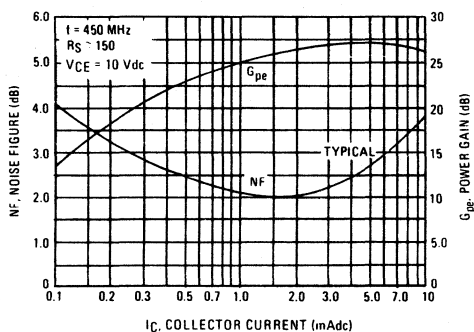


FIGURE 5 – CONTOURS OF NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT

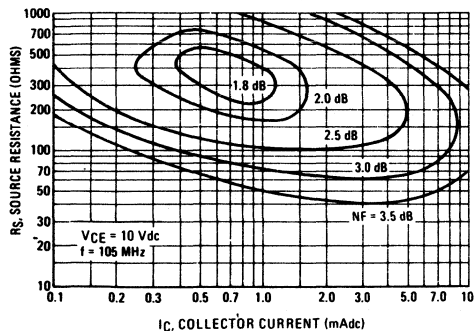
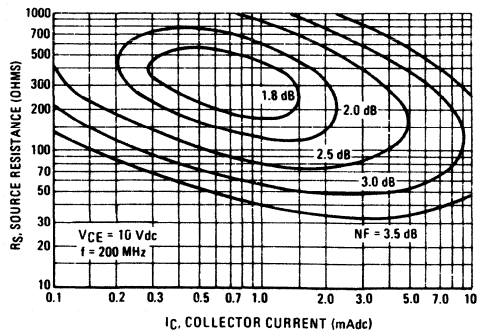


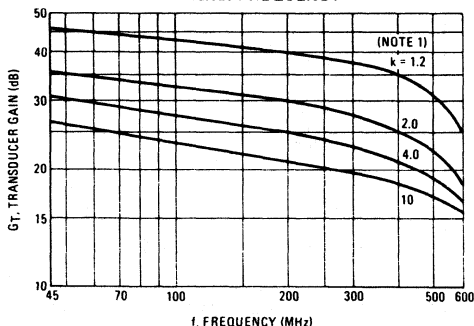
FIGURE 6 – CONTOURS OF NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT



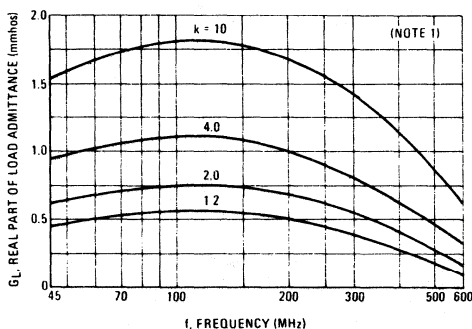
COMMON EMITTER CIRCUIT DESIGN DATA

($V_{CE} = 10 \text{ Vdc}$, $I_C = 2.0 \text{ mAdc}$)

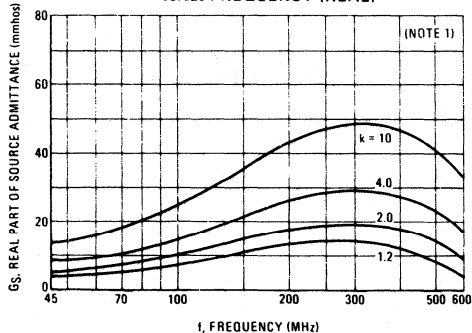
**FIGURE 7 – TRANSDUCER GAIN
versus FREQUENCY**



**FIGURE 9 – LOAD ADMITTANCE
versus FREQUENCY (REAL)**



**FIGURE 11 – SOURCE ADMITTANCE
versus FREQUENCY (REAL)**



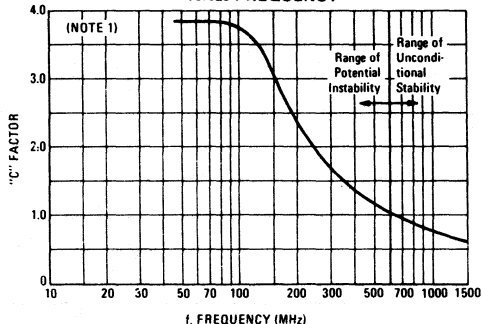
NOTE 1

Figures 7 through 18 are included to assist the circuit designer in determining the stability of his particular circuit. Two stability criteria are given in these figures.

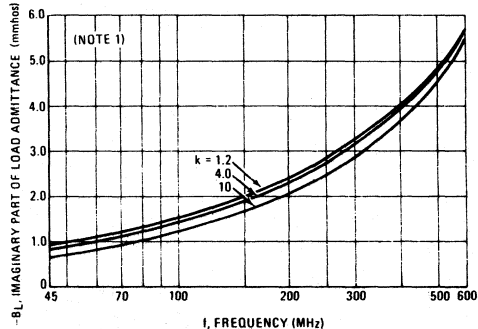
The Linvill "C" factor* is a measure of transistor stability when the input and output are terminated in the worst-case (open circuit) condition. When

* "Transistors and Active Circuits," Linvill and Gibbons, McGraw-Hill, 1961

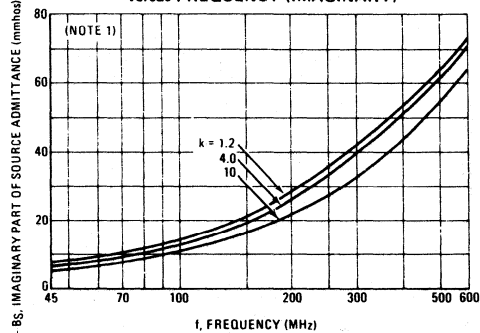
**FIGURE 8 – LINVILL STABILITY FACTOR
versus FREQUENCY**



**FIGURE 10 – LOAD ADMITTANCE
versus FREQUENCY (IMAGINARY)**



**FIGURE 12 – SOURCE ADMITTANCE
versus FREQUENCY (IMAGINARY)**



"C" is less than 1.0, the circuit is unconditionally stable. When "C" is greater than 1.0, the circuit is potentially unstable.

The Stern "K" factor† has been defined to determine the stability of a practical amplifier terminated in finite load and source admittances. If "K" is greater than 1.0, the circuit will be stable. If less than 1.0, the circuit will be unstable. For further details, see Application Note AN-215.

† "Stability and Power Gain of Tuned Transistor Amplifiers," Arthur P. Stern, Proc. I.R.E., March 1967.

COMMON BASE CIRCUIT DESIGN DATA

($V_{CB} = 10 \text{ Vdc}$, $I_C = 2.0 \text{ mAdc}$)

FIGURE 13 – TRANSDUCER GAIN
versus FREQUENCY

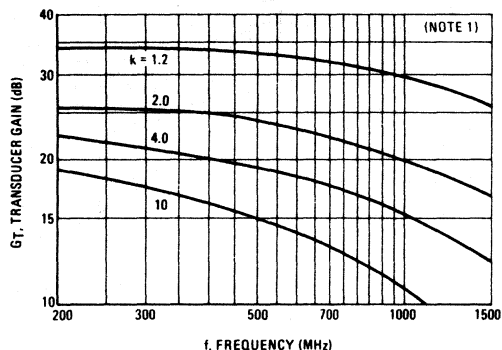


FIGURE 14 – LINVILL STABILITY FACTOR
versus FREQUENCY

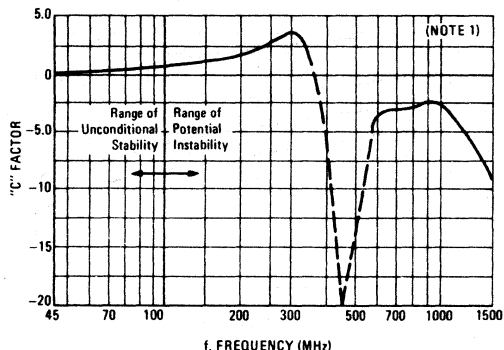


FIGURE 15 – LOAD ADMITTANCE
versus FREQUENCY (REAL)

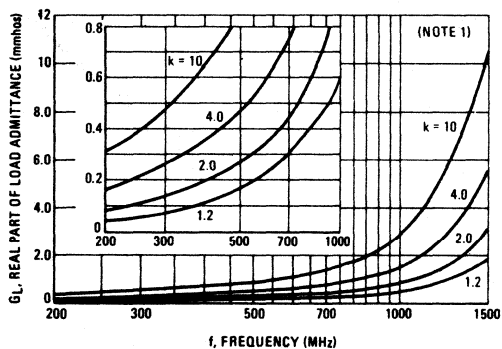


FIGURE 16 – LOAD ADMITTANCE
versus FREQUENCY (IMAGINARY)

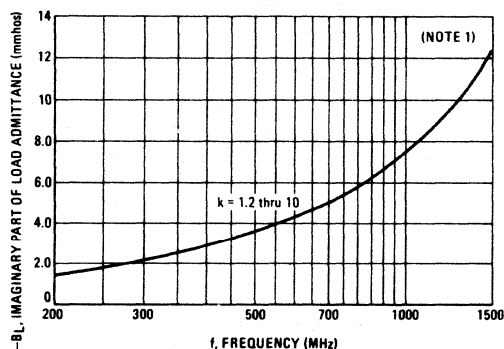


FIGURE 17 – SOURCE ADMITTANCE
versus FREQUENCY (REAL)

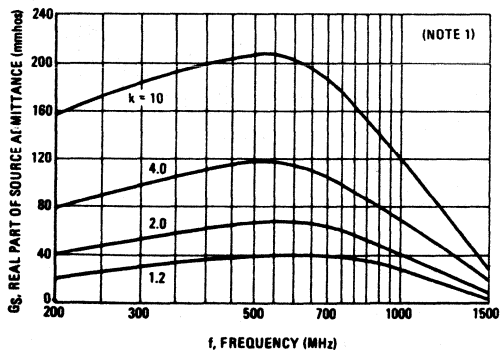


FIGURE 18 – SOURCE ADMITTANCE
versus FREQUENCY (IMAGINARY)

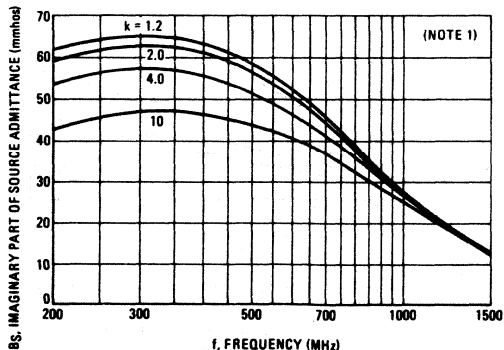


FIGURE 19 — SMALL-SIGNAL CURRENT GAIN
versus FREQUENCY

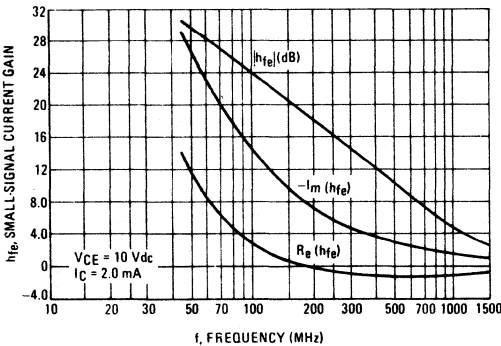


FIGURE 20 — POLAR h_{fe}

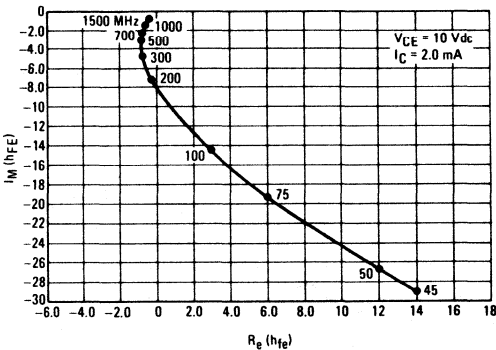


FIGURE 21 — f_T versus COLLECTOR CURRENT

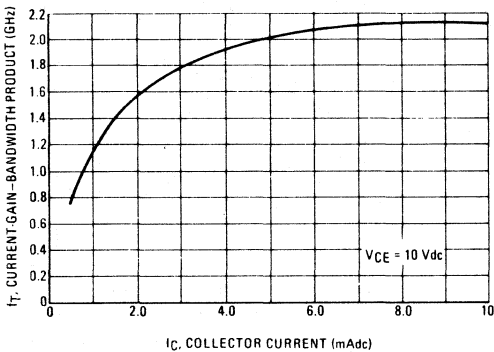


FIGURE 22 — DC CURRENT GAIN

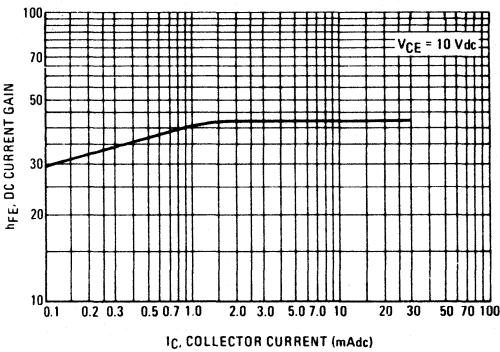


FIGURE 23 — CAPACITANCE

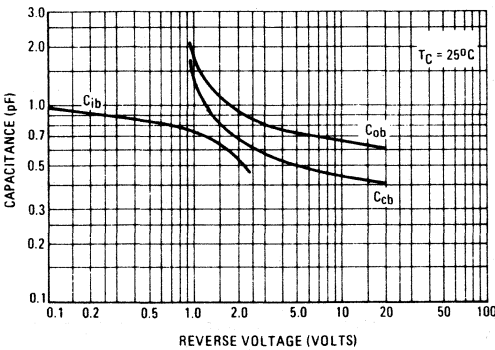
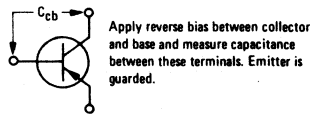
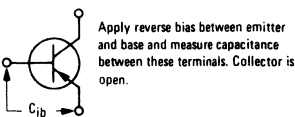
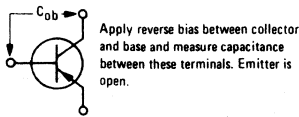
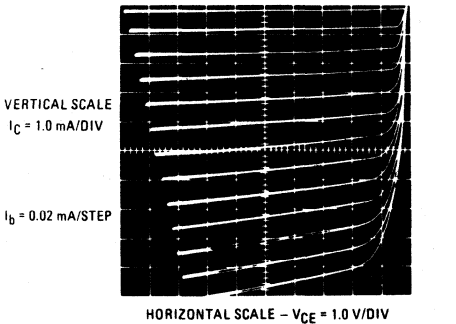


FIGURE 24 — COLLECTOR CHARACTERISTICS



Y PARAMETERS versus CURRENT

(f = 450 MHz)

COMMON BASE

$V_{CB} = 10 \text{ Vdc}$ ——— $V_{CB} = 15 \text{ Vdc}$ - - -

FIGURE 25 – INPUT ADMITTANCE

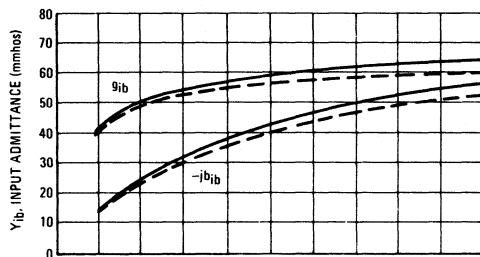


FIGURE 27 – FORWARD TRANSFER ADMITTANCE

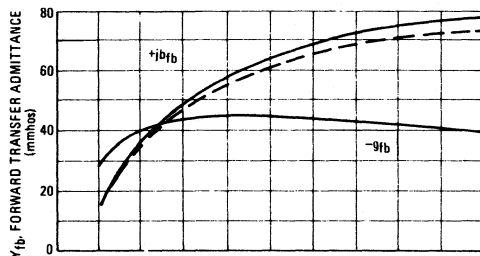


FIGURE 29 – OUTPUT ADMITTANCE

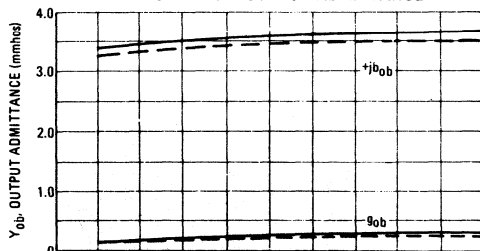
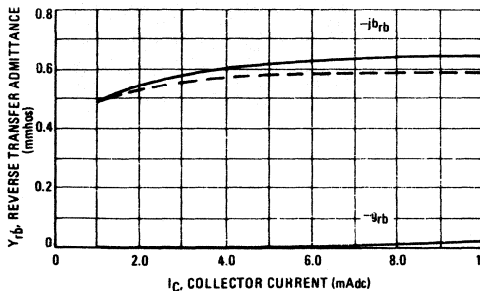


FIGURE 31 – REVERSE TRANSFER ADMITTANCE



COMMON EMITTER

$V_{CE} = 10 \text{ Vdc}$ ——— $V_{CE} = 15 \text{ Vdc}$ - - -

FIGURE 26 – INPUT ADMITTANCE

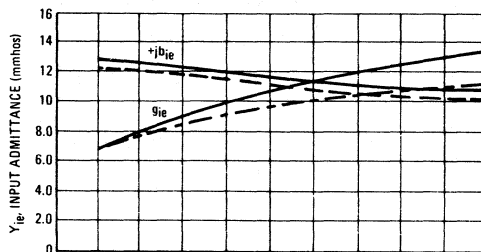


FIGURE 28 – FORWARD TRANSFER ADMITTANCE

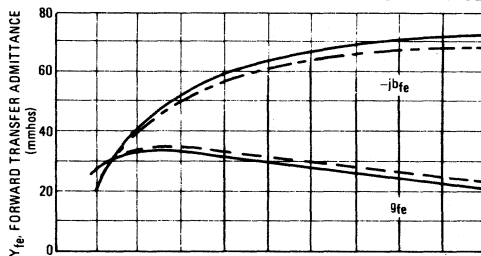


FIGURE 30 – OUTPUT ADMITTANCE

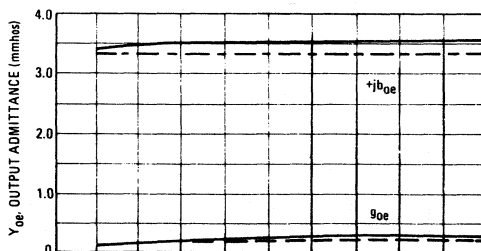
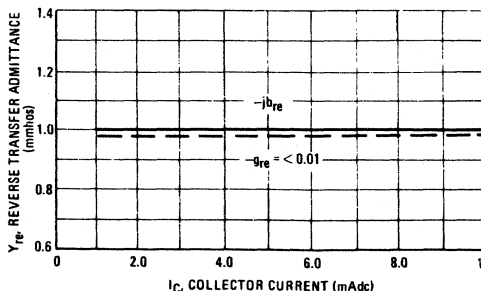


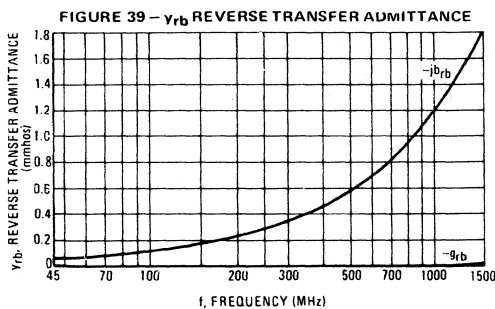
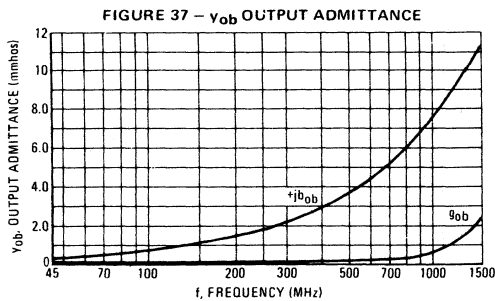
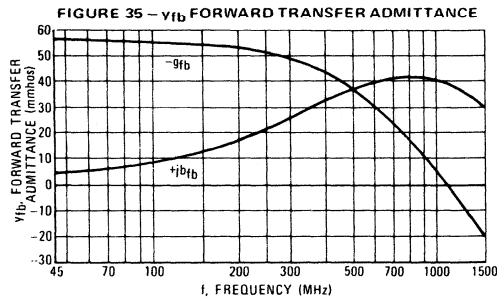
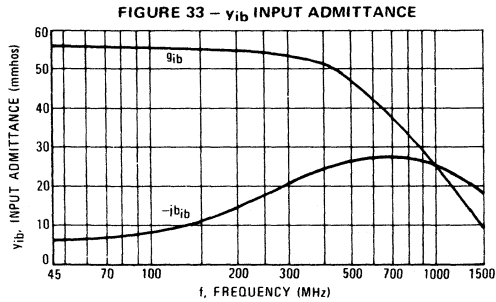
FIGURE 32 – REVERSE TRANSFER ADMITTANCE



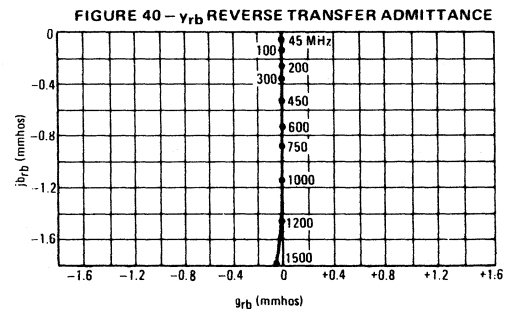
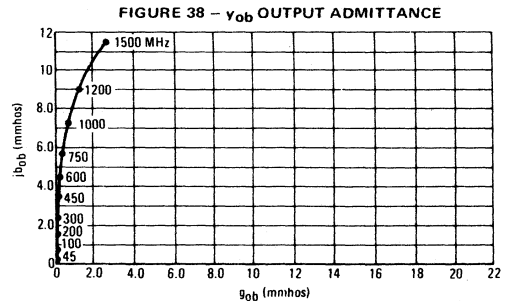
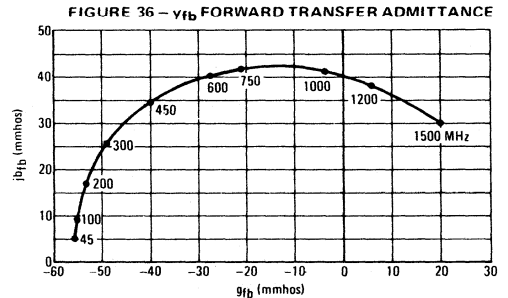
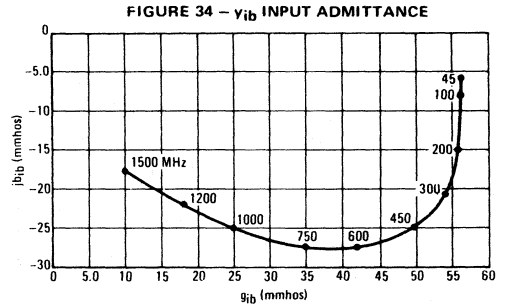
COMMON BASE Y PARAMETER VARIATIONS

($V_{CB} = 10 \text{ Vdc}$, $I_C = 2.0 \text{ mAdc}$)

Y PARAMETERS versus FREQUENCY



POLAR Y PARAMETERS versus FREQUENCY



COMMON EMITTER Y PARAMETER VARIATIONS

($V_{CE} = 10 \text{ Vdc}$, $I_C = 2.0 \text{ mAdc}$)

Y PARAMETERS versus FREQUENCY

FIGURE 41 - y_{ie} INPUT ADMITTANCE

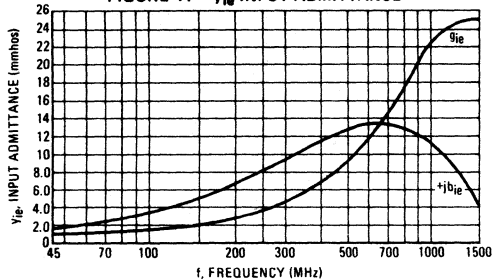


FIGURE 43 - y_{fe} FORWARD TRANSFER ADMITTANCE

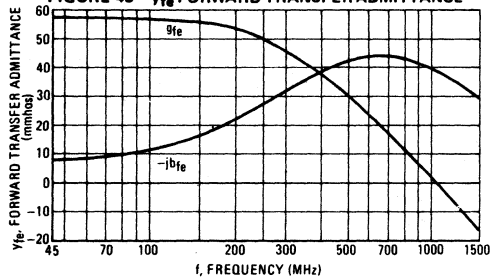


FIGURE 45 - y_{oe} OUTPUT ADMITTANCE

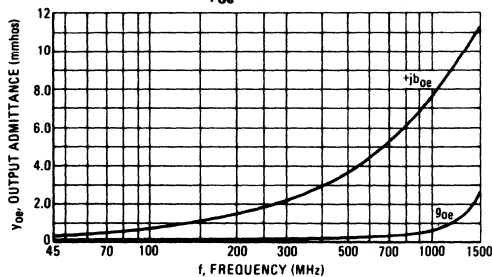
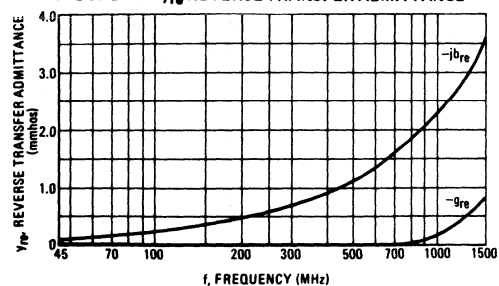


FIGURE 47 - y_{re} REVERSE TRANSFER ADMITTANCE



POLAR Y PARAMETERS versus FREQUENCY

FIGURE 42 - y_{ie} INPUT ADMITTANCE

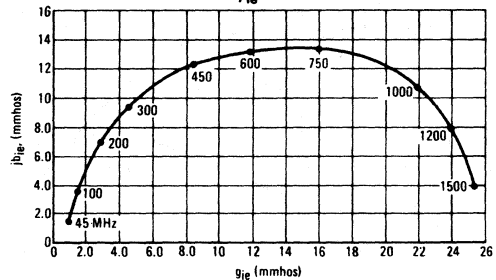


FIGURE 44 - y_{fe} FORWARD TRANSFER ADMITTANCE

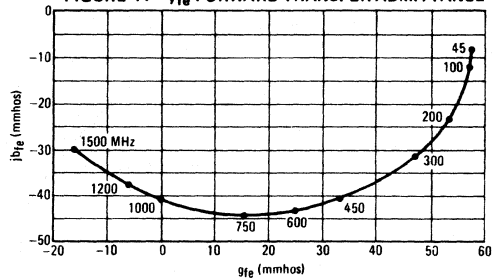


FIGURE 46 - y_{oe} OUTPUT ADMITTANCE

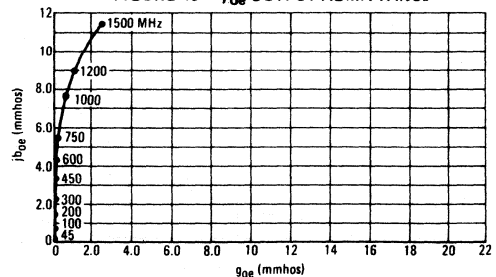
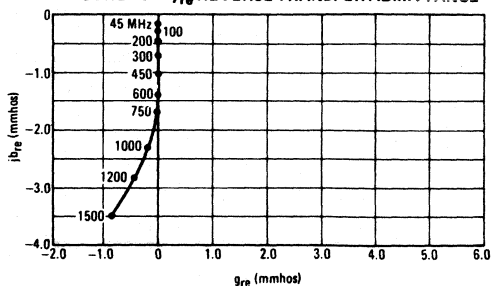


FIGURE 48 - y_{re} REVERSE TRANSFER ADMITTANCE



2N4993 (SILICON)



SILICON BIDIRECTIONAL SWITCH

... designed for full-wave triggering in Triac phase control circuits, half-wave SCR triggering applications and as voltage level detectors.

- Low Switching Voltage — 8.0 Volts Typical
- Uniform Characteristics in Each Direction
- Low On-State Voltage — 1.7 Volts Maximum
- Low Off-State Current — 1.0 μ A Maximum
- Low Temperature Coefficient — 0.02 %/°C Typical

*MAXIMUM RATINGS

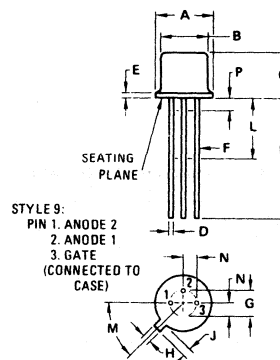
Rating	Symbol	Value	Unit
Power Dissipation	P_D	350	mW
DC Forward Anode Current	I_F	200	mA
DC Gate Current (off-state only)	$I_{G(off)}$	5.0	mA
Repetitive Peak Forward Current (1.0% Duty Cycle, 10 μ s Pulse Width)	$I_{FM(rep)}$	1.0	Amp
Non-Repetitive Forward Current 10 μ s Pulse Width	$I_{FM(nonrep)}$	5.0	Amp
Operating Junction Temperature Range	T_J	-55 to +150	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

* Indicates JEDEC Registered Data

SILICON BIDIRECTIONAL SWITCH

6.0-10 VOLTS
350 mW

DS 2519



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	—	0.762	—	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC	—	0.100 BSC	—
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45° BSC	—	45° BSC	—
N	1.27 BSC	—	0.050 BSC	—
P	—	1.27	—	0.050

All JEDEC notes and dimensions apply.
CASE 22-03
(TO-18)

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
*Switching Voltage	V_S	6.0	8.0	10	Vdc
*Switching Current	I_S	—	175	500	μAdc
*Switching Voltage Differential	$ V_{S1} - V_{S2} $	—	0.3	0.5	Vdc
Holding Current	I_H	—	0.7	1.5	mAdc
*Off-State Blocking Current ($V_F = 5.0\text{ Vdc}$, $T_A = 25^\circ\text{C}$) ($V_F = 5.0\text{ Vdc}$, $T_A = 100^\circ\text{C}$)	I_B	— —	0.08 6.0	1.0 10	μAdc
*Forward On-State Voltage ($I_F = 200\text{ mAdc}$)	V_F	—	1.4	1.7	Vdc
Peak Output Voltage ($C_C = 0.1\text{ }\mu\text{F}$, $R_L = 20\text{ ohms}$, (Figure 7))	V_O	3.5	4.8	—	Vdc
Turn-On Time (Figure 8)	t_{on}	—	1.0	—	μs
Turn-Off Time (Figure 9)	t_{off}	—	30	—	μs
Temperature Coefficient of Switching Voltage	T_C	—	+0.02	—	%/ $^\circ\text{C}$
*Switching Current Differential	$ I_{S2} - I_{S1} $	—	—	100	μAdc

*Indicates JEDEC Registered Data

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 – SWITCHING VOLTAGE versus TEMPERATURE

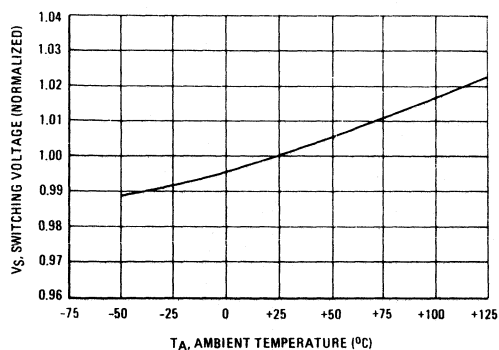


FIGURE 2 – SWITCHING CURRENT versus TEMPERATURE

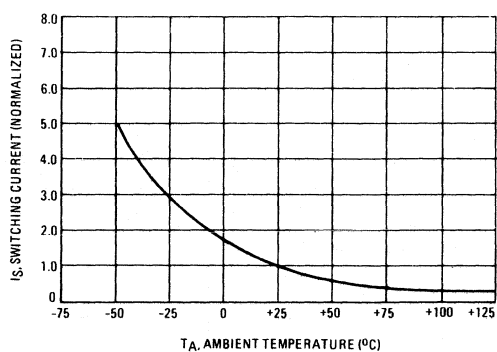


FIGURE 3 – HOLDING CURRENT versus TEMPERATURE

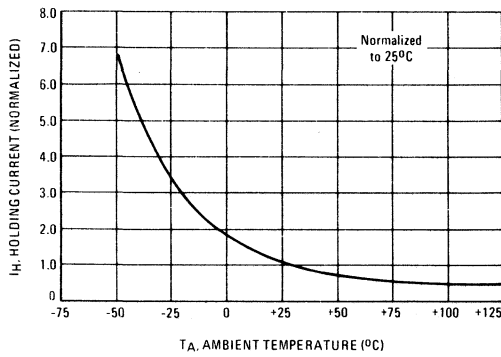


FIGURE 4 – OFF-STATE BLOCKING CURRENT versus TEMPERATURE

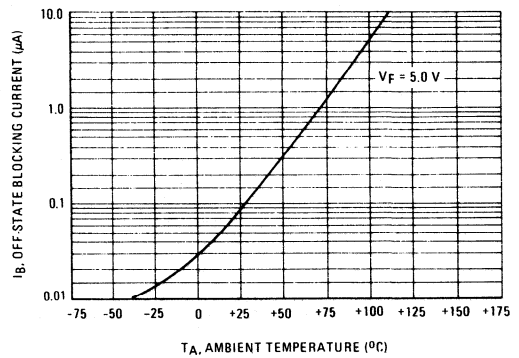


FIGURE 5 – ON-STATE VOLTAGE versus FORWARD CURRENT

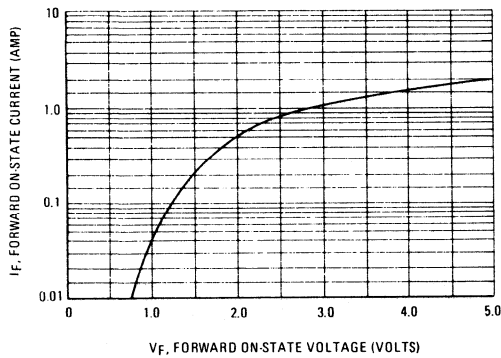


FIGURE 6 – PEAK OUTPUT VOLTAGE (FUNCTION OF R_L AND C_c)

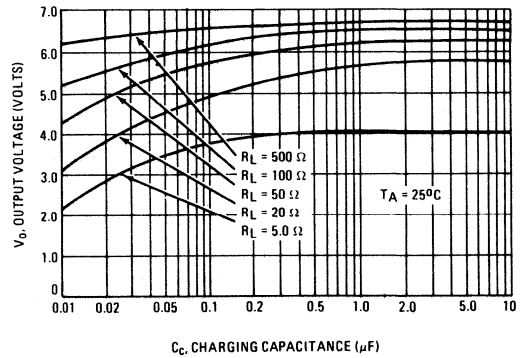


FIGURE 7 – PEAK OUTPUT VOLTAGE TEST CIRCUIT

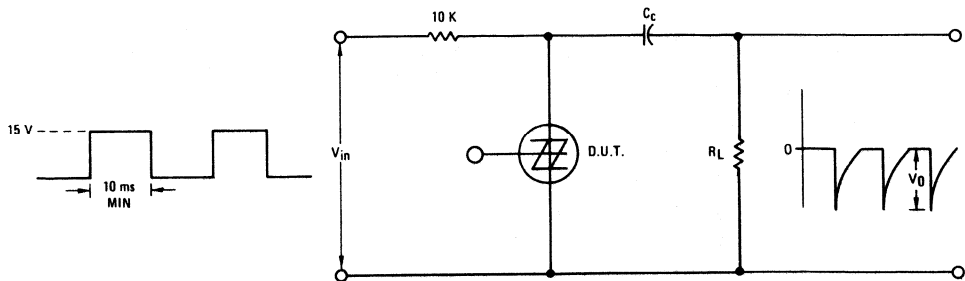
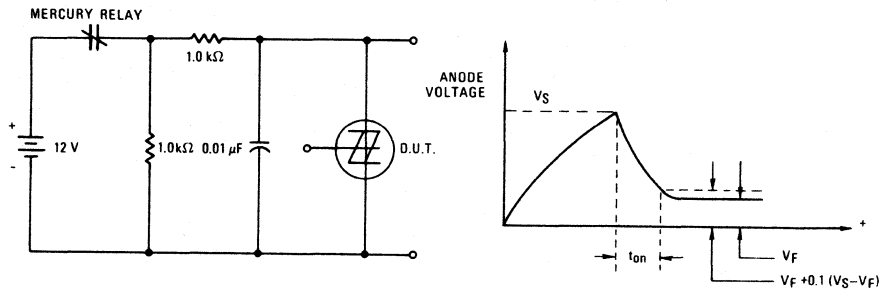
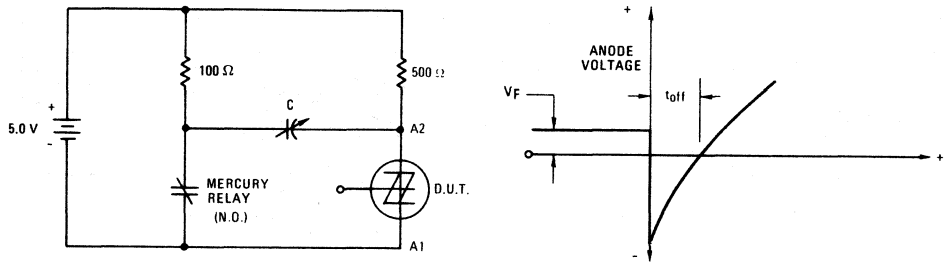


FIGURE 8 – TURN-ON TIME TEST CIRCUIT



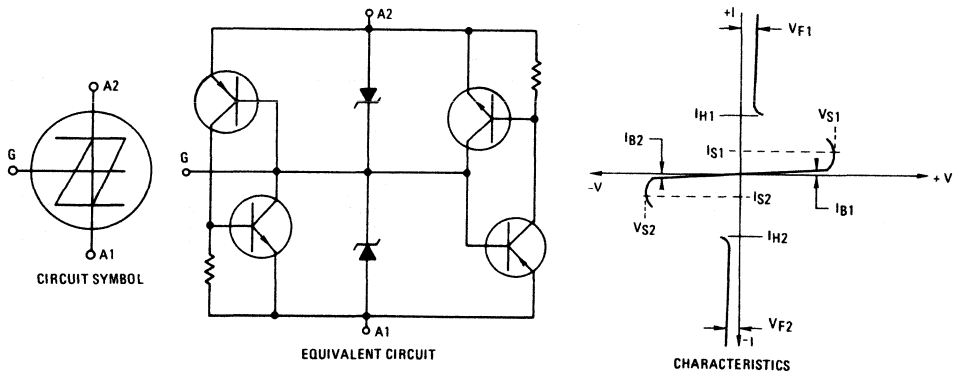
Turn-on time is measured from the time V_S is achieved to the time when the anode voltage drops to within 90% of the difference between V_S and V_F .

FIGURE 9 – TURN-OFF TIME TEST CIRCUIT



With the SBS in conduction and the relay contacts open, close the contacts to cause anode A2 to be driven negative. Decrease C until the SBS just remains off when anode A2 becomes positive. The turn-off time, t_{off} , is the time from initial contact closure and until anode A2 voltage reaches zero volts.

FIGURE 10 – DEVICE EQUIVALENT CIRCUIT, CHARACTERISTICS AND SYMBOLS



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