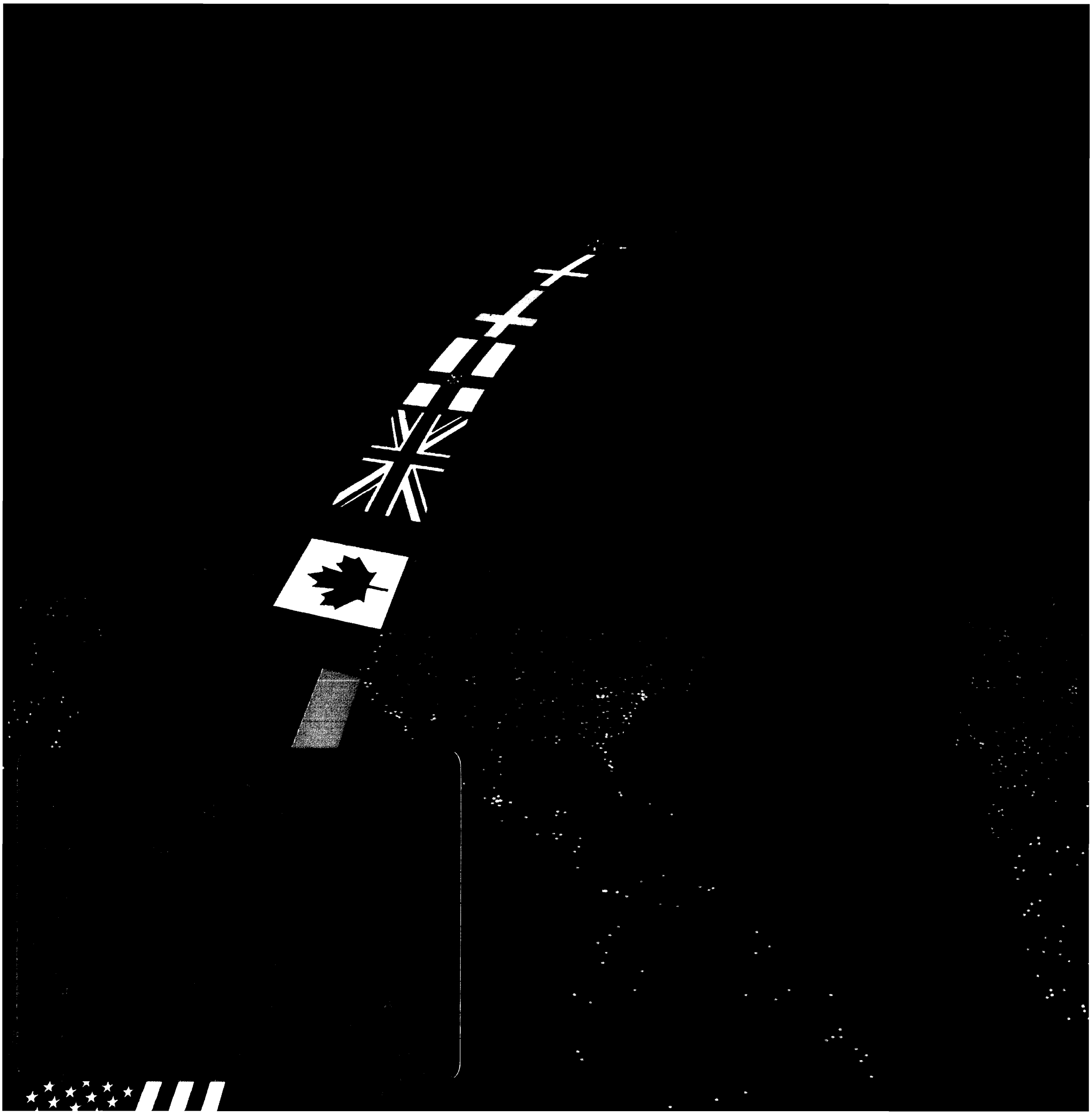
MOTOROLA

DL118/D
REV 5

Optoelectronics

Device Data



MOTOROLA

OPTOELECTRONICS DEVICE DATA

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Alphanumeric Index

Bold, italic denotes preferred devices.

▶Devices new to Opto Data Book, Rev 5.

Available Opto Sample Kits

The following Optoisolator sample kits are available from the Motorola Literature Distribution Center.

Sample Kit Number	Description
KITMOC2A60/D	• 600 V Power Opto™ Isolator
KIT600VOPTO/D	• Sample kit showcasing 600 Vac optoisolators. Included are: * MOC3163 (600 V/Zero Cross/Triac Drivers) * MOC3052 (600 V/Random Phase/Triac Drivers) * MOC2A60 (Power Opto™ Isolator)
KITMOC3050/D	• MOC3050 Series (600 V/Random Phase/Triac Drivers)
KITMOC3160/D	• MOC3160 Series (600 V/Zero Cross/Triac Drivers)
KITMOC256/D	• MOC256 (AC Input/SOIC–8 Optoisolator)
KITMOCD200SERI/D	• MOCD200 Series (Dual Channel/SOIC–8 Optoisolators)

Data Sheet Fax via Touch–Tone Phone

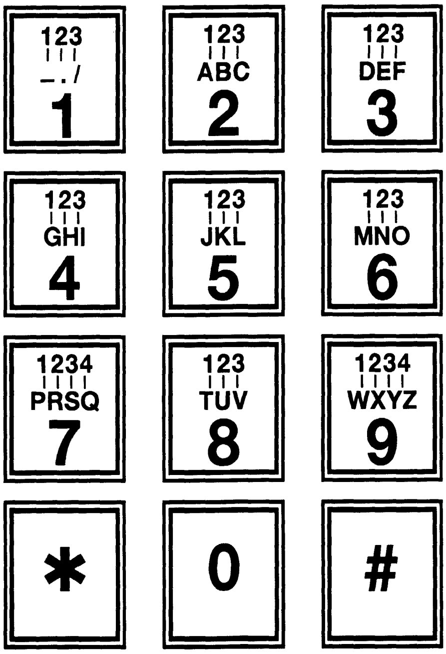
Motorola's **M*fax***SM system is as easy to use as dialing your touch–tone telephone. Your touch–tone phone becomes your link to ordering over 30,000 documents available for faxing. A fax of complete, easy–to–use instructions can be obtained with a first–time phone call into the system.

The combination of letters and numbers on the keypad will deliver faxes to your machine.

Number or letter strings entered for requests are ended with the use of the # sign.

Use 2–digit combinations when numbers entered are part of a part number.
EXAMPLE:
981 is entered:
09 08 01#
9 = 09
8 = 08
1 = 01

While keying 2–digit strings, the system will repeat back the entered letter or number.



Letters are entered with 2–digit combinations.
EXAMPLE:
DBL is entered:
31 22 53#
D = 31
B = 22
L = 53

The position of the letters on the keys determines the numbers entered. For instance MNO would be:
61 62 63#
M = 61 – key 6 position 1
N = 62 – key 6 position 2
O = 63 – key 6 position 3

EXAMPLE:
A requested document, MC6530 is entered:
61 23 06 05 03 00#
M = 61
C = 23
6 = 06
5 = 05
3 = 03
0 = 00

Motorola's **M*fax*** system repeats letter and number combinations as they are entered so changes for keys touched in error can be corrected. Complete help is available throughout the instructions when you dial into the system at **602–244–6609**. A Personal Identification Number (PIN) is assigned to you to speed up ordering of faxes.

Section 1

Introduction

General Product Information

The Motorola Optoelectronic Division produces optoisolators and power optoisolators.

Technology leadership in optoelectronic products is demonstrated by state-of-the-art 600 volt, zero-crossing triac drivers (MOC3163); the industry's only standard high temperature Darlington isolator (MOC8080) and the industry's only supplier of standard products with 7500 Vac peak isolation voltage.

The broad optoisolator line includes nearly all the transistor, Darlington, triac driver and Schmitt trigger devices now available in the industry. Motorola optoisolators come in the standard 6-pin DIP package, and the new small outline SOIC-8 style, surface mount package. Each device is listed in the easy-to-use Selector Guide (Section 3) and a detailed data sheet is presented in a succeeding chapter.

The Motorola Spectrum of OPTOISOLATORS

Optoelectronics is a special branch of semiconductor technology which has come into prominence during the last fifteen to twenty years. Solid state optoelectronic components have proven to be versatile design tools, offering the engineer inexpensive, reliable alternatives to their bulky predecessors.

Solid state light emitting diodes (LEDs) in the visible portion of the electromagnetic spectrum have virtually eliminated the usage of incandescent lamps as panel indicators. Infrared emitters and silicon photodetectors find application in optoisolators. Optoisolators are being designed into circuits previously using small mechanical relays and pulse transformers.

Over the years, solid state optoelectronic technology has advanced dramatically. Research into new and improved materials and processing techniques have led to devices having higher efficiencies, improved reliability, and lower cost.

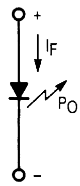


Figure 1. The LED

Emitters

Early emitters, both visible and infrared, suffered from low power output and rapid power output deterioration (degradation) when compared to present day devices. Emitter chip materials, commonly referred to as III-V compounds, are combinations of elements from the III and V columns of the periodic chart. The P-N junction is formed by either diffusing or by epitaxially growing the junction. Typical materials used for emitters include gallium arsenide (GaAs) and gallium aluminum arsenide (GaAlAs), among others.

When a forward bias current (I_F) flows through the emitter's P-N junction, photons are emitted. This is shown schematically in Figure 1. The total output power (P_O) is a function of the forward current (I_F), and is measured in milliwatts.

Motorola's optoisolator emitters operate at a wavelength of 940 nanometers (nm). See Figure 2. This encompasses the infrared portion of the electromagnetic frequency spectrum. The 940 nm emitters are the most cost effective. Most all optoisolators, for example, use the 940 nm emitter.

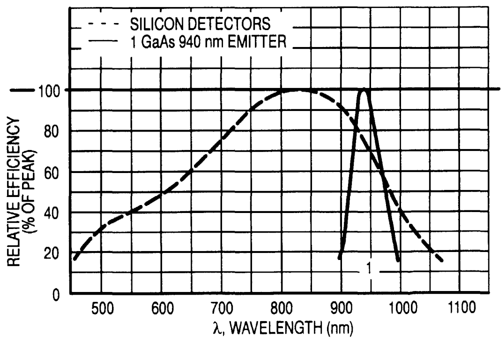


Figure 2. Emissivity versus Wavelength

Newly developed materials and refinements in chip processing and handling have led to more efficient and more reliable emitters. New packaging techniques have made low–cost plastic optoisolators possible.

Advances made in LED technology over the years have eliminated many of the problems of early-day devices. Even the problem of degradation of emitter power output over time has been brought to a level which is tolerable and predictable. When coupled to a silicon detector, today's devices can be expected to lead a long and useful life.

Detectors

As emitters have developed over the years, photodetectors have also advanced dramatically. Early phototransistors and photodiodes were soon joined by photodarlington detectors, and then by light-activated triacs. Innovations in design have created devices having higher sensitivity, speed and voltage capabilities. A variety of detectors is shown in Figure 3.

Recent developments in detector technology have led to larger and more complex circuit integration. Photodetectors incorporating Schmitt trigger logic outputs are becoming increasingly popular in applications requiring very fast speed, hysteresis for noise immunity, and logic level outputs.

Future trends point to even higher performance characteristics and higher levels of circuit integration.

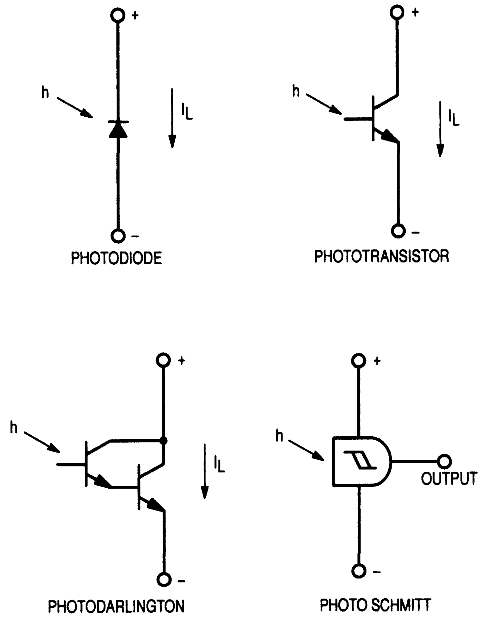


Figure 3. Light Sensitive Detectors

Optoisolators

Optoisolators, a block diagram of which is shown in Figure 4, are devices which contain at least one emitter, which is optically coupled to a photodetector through some sort of an insulating medium. This arrangement permits the passage of information from one circuit, which contains the emitter, to the other circuit containing the detector.

Because this information is passed optically across an insulating gap, the transfer is one-way; that is, the detector cannot affect the input circuit. This is important because the emitter may be driven by a low voltage circuit utilizing an MPU or logic gates, while the output photodetector may be part of a high voltage DC or even an ac load circuit. The optical isolation prevents interaction or even damage to the input circuit to be caused by the relatively hostile output circuit.

The most popular isolator package is the general purpose six-pin DIP, or dual in-line, package. Motorola also offers a small outline surface mountable SOIC-8 package along with 6-pin surface mount leadform options. This offers answers to many problems that have been created in the use of insertion technology. Printed circuit costs are lowered with the reduction of the number of board layers required and eliminates or reduces the number of plated through-holes in the board, contributing significantly to lower PC board prices.

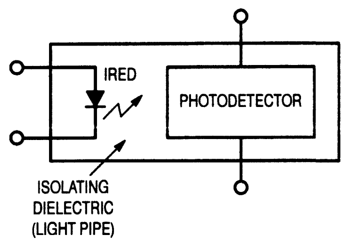


Figure 4. Block Diagram of Optoisolator

Various geometric designs have been used over the years for the internal light cavity between the emitter and detector. Motorola is the industry leader in isolation technology. All 6-pin optoisolators are guaranteed to meet or exceed 7500 Vac (pk) input-to-output isolation. See Figure 5.

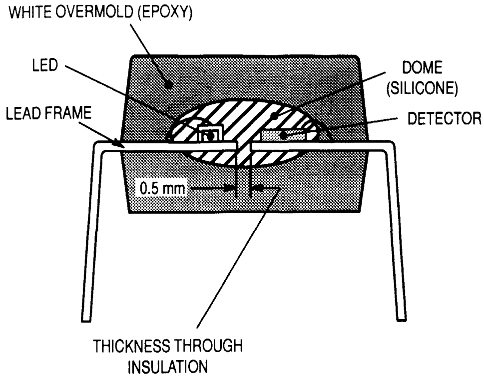


Figure 5. Geometric Design for Optoisolators

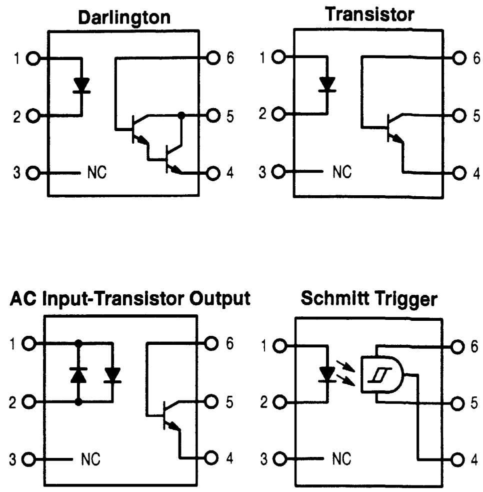


Figure 6. Various Optoisolator Configurations

The wide selection of photodetectors mentioned earlier is also available in the isolator packages. A variety of optoisolators is shown in Figure 6. With the emitters and detectors both sealed inside an ambient-protected package, the user need not be concerned with any of the optical considerations necessary with separate packages. An important operating parameter of the isolator is efficiency. This parameter defines the amount of input (emitter) current that is required to obtain a desired detector output. In the case of transistor or darlington output isolators, this efficiency is referred to as "current transfer ratio," or CTR. This is simply the guaranteed output current divided by the required input current. In the case of trigger-type isolators, such as one having Schmitt trigger (logic) or triac driver output, efficiency is defined by the amount of emitter current required to trigger the output. This is known as "forward trigger current," or I_{FT}.

Efficiency and isolation voltage are two of the most important operating parameters of the optoisolator.

All Motorola six-pin DIP optoisolators are recognized by the Underwriters' Laboratories Component Recognition Program. It should be noted that this recognition extends up to operating voltages of 240 volts ac(rms). Under UL criteria, these devices must have passed isolation voltage tests at approximately 5000 volts ac peak for one second. In addition, Motorola tests every six-pin DIP optoisolator to 7500 vac peak for a period of 1 second. Also, Motorola's six-pin DIP optoisolators are offered in a variety of optional lead form/trim options. See the section on Package Dimensions for more detailed information.

All Motorola 6-pin optoisolators are approved by VDE, the optoisolator standard which is accepted in most European countries. Check the Motorola data sheet section for specific information on approvals to various VDE norms.

Section 2

Quality and Reliability

Optocoupler Reliability and Quality

Reliability Considerations

Emitter Life

The area of optocoupler reliability that is of most concern to users is the life of the IRED (Infrared Emitting Diode). Anything which alters the carrier-recombination process (the light-emitting mechanism) will cause a decrease in coupling efficiency with time. There are several possible ways this can happen, depending upon the device and process design:

1. Propagation of initial crystal stress or damage through the device in the vicinity of the junction can cause an increase in non-radiative recombination, since carrier lifetimes are poor in such regions. Motorola now uses exclusively a Liquid Phase Epitaxial (LPE) process which allows a stress-free growth and minimizes the effect of substrate integrity, since the junction is formed some distance from the substrate.
2. Damage caused by assembly of the IRED chip into a package can also cause degradation, usually observable in less than a few hundred hours of operation. Motorola uses automatic die attach and wire attach equipment, so that operator control of pressure is eliminated. In addition, the application of a die passivation during assembly insures that the IRED chip is protected from external mechanical stress.
3. Impurities which exist in the chip as a result of process contamination can be detrimental if they are mobile in gallium arsenide. Forward current bias will energize these impurities and the current drift will draw them toward the junction where they can affect recombination to a greater degree. Proper process design and control of equipment is necessary to minimize this effect. Motorola continually audits its process to provide the necessary monitor on LED life characteristics.
4. Impurities external to the chip can be drawn into the device and affect recombination under certain conditions.

Detector Stability

While the detector has a lesser overall influence on the reliability of an optocoupler than the IRED (due to the difference between gallium arsenide and silicon characteristics), there still remain important considerations here as well. These primarily are measures of its ability to remain reliably "off" when the IRED is not energized, requiring that breakdown voltages and leakage be stable.

Efficient optically sensitive semiconductors place an extra burden on the manufacturer to produce stable devices. Large surface areas are needed to capture large amounts of light, but also give higher junction leakage. Low doping concentrations are necessary for long carrier lifetimes, but also create more chance for surface inversion which leads to leakage instability. High electrical gains magnify currents due to captured photons but do the same to junction leakage currents.

Package Integrity

There are several packaging considerations which are unique to an optocoupler. It is necessary, of course, that light be efficiently coupled from input to output. As a result, most optocouplers have internal constructions that are radically different than other semiconductor devices and use materials that are dictated by that construction. Just as parametric stability of the IRED and detector chips used in an optocoupler is important, so also is it important that package parameters be stable. Areas of concern are:

1. **Isolation Voltage** — Together with the transmission of a signal from input to output, the ability of an optocoupler to isolate its input from high voltage at its output is probably its most important feature. Human safety and equipment protection are often critically dependent upon dielectric stability under severe field conditions. Industry leading isolation voltage capability, both in terms of voltage level and stability, is the result. Motorola specifies all of its optocouplers at 7500 Vac peak isolation. Surface mount is 2500 rms.
2. **Mechanical Integrity** — It is also important that the package be capable of withstanding vibration and temperature stresses that may be found in the field environment. Motorola's solid package construction and the use of repeatable automatic ball bond wire attach equipment provide this performance at rated conditions.
3. **Moisture Protection** — Relatively high humidity is characteristic of many field environments, although usually not on a continuous basis. Motorola's chip design minimizes the effect of moisture internal to the package, usually by covering the aluminum metallizations with protective passivations. The package materials typically provide stable isolation voltage after well over 1000 hours of continuous exposure to a high temperature, high humidity environment and will provide very long term service under intermittently humid conditions.

Design Driven LED Degradation Model for Optoisolators

Results from a matrix of temperature and current stress testing of optoisolator LEDs are presented. Extensive statistical analysis of this large data base is shown, along with the method used to define the shape of the LED degradation curves. A basic equation was developed based on the Arrhenius model for temperature dependent effects and the author's experience with the physics of LED degradation. Also shown are the results of multiple regression analysis of the plotted points and how they were used to resolve the constants associated with this equation. In addition, explanations are presented of unusual findings and their causes. This equation can be used by circuit designers to predict LED degradation for any time, operating current and ambient temperature (an industry first). A graph of percent degradation versus time is shown, and was derived by plugging into the equation typical use currents and temperatures. A further refinement is presented that describes degradation in terms of a "Six Sigma" distribution, giving the ability to encompass variations encountered during production.

Background

Light Emitting Diodes (LEDs) are devices which use PN junctions to convert electrical current to light. This emitted light can be of the visible or infrared wave length. In the case of the LEDs in Motorola's optocouplers, this light is in the infrared (~940 nm) wave length. The externally applied current injects minority carriers which recombine with majority carriers in such a way as to give off light (or photons). This process is called "radiative recombination."[1] Figure 1 depicts the overall construction of Motorola's 940 nm LED die.

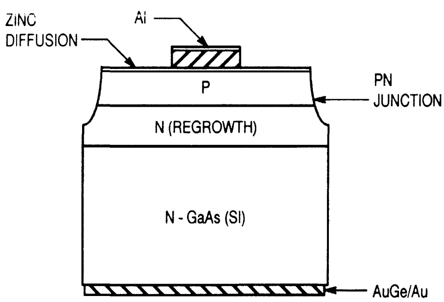


Figure 1. Amphoterically Doped LPE Grown Junction

The junction is an amphoterically doped liquid phase epitaxial (LPE) grown junction on a Gallium Arsenide (GaAs) substrate. The back side of the die uses AuGe metal to form an eutectic attach to the lead frame. A very thin Zn diffused layer is used to spread current across the junction. The top Al metal is used to provide ohmic contact for a wire bond connection.

LED Degradation

LED degradation occurs when the efficiency of radiative recombination of minority carriers is decreased with time.[2] At Motorola the following processing/assembly steps have been found to affect LED performance as it relates to LED degradation (Figure 2).

1. Wafer related defects
   a. Zn diffusion defects
   b. Substrate dislocations
   c. Surface polishing
   d. EPI defects
   e. Doping concentration
   f. Junction heating
   g. Ohmic contact stress
2. Assembly related defects
   a. Die attach stress
   b. Wire bond damage
   c. Molding stress

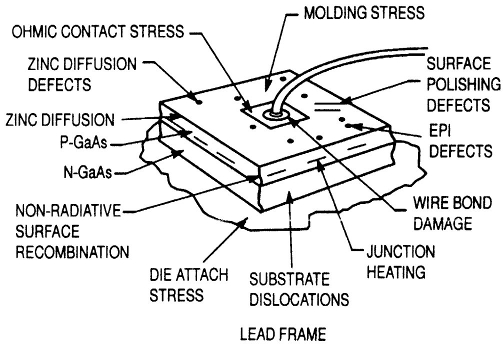


Figure 2. LED Degradation Sources

Approaches

In the past, a circuit designer needing information about LED degradation in optoisolators (couplers) would only receive curves that depicted LED degradation over time for a specific drive current, measurement current and ambient temperature. This forced the designer to assume a very worst case degradation and excluded the use of couplers in circuits requiring tighter limits on the amount of allowable degradation. No one in the Optoisolator industry supplied data about their LED performance to allow the designer to predict the amount of LED degradation for his specific application.

Solutions

Over the past three years Motorola's Optoelectronics Operation has invested significant resources to improve LED degradation performance. More than thirty experiments were designed and performed generating some 30 megabytes of computer data in an effort to identify and prove out the LED wafer processing improvements. These improvements include a number of critical wafer processing steps that required change and exact control.

Initial Room Temperature Testing

Transistor optocouplers (see Figure 3) samples were assembled using the above improvements and placed on LED burn-in.

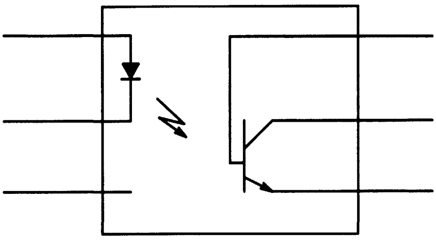


Figure 3. Transistor Optocoupler

The conditions were room temperature at a forward current (I_F) stress of 50 mAdc. The transistor was not biased. The ratio of the transistor collector current (I_C) to the I_F current is the measurement used to gauge LED light output. This ratio is known as Current Transfer Ratio (CTR). LED light output was measured at specified intervals during testing. The conditions for measurement were:

I_F = 10 mA; V_{CE} = 10 V.

Figure 4 is a graph of the average percentage degradation over 10,000 hours. The dotted lines represent the capabilities of the measurement system. As can be seen, little degradation occurred. Data generated from samples provided to one of our customers confirmed these results.

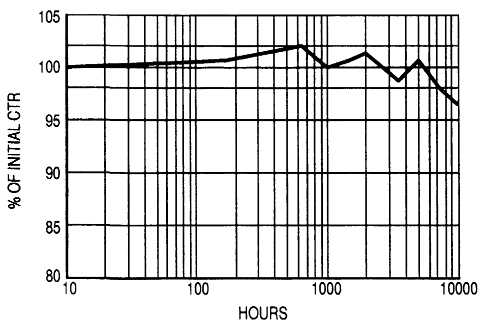


Figure 4. Plot of Average LED Degradation @ $I_{F(stress)}$ = 50 mA; $I_{F(meas)}$ = 10 mA @ 25°C

Accelerated Testing

In an effort to provide customers with information that would help them predict CTR degradation at any current and ambient, a temperature and stress current matrix evaluation was designed (see Table 1).

LED Stress Current	Ambient Stress Temperature 85°C	105°C	125°C
0.5 mA	**Group A** 30 Devices	**Group B** 30 Devices	**Group C** 30 Devices
3 mA	**Group D** 30 Devices	**Group E** 30 Devices	**Group F** 30 Devices
50 mA	**Group G** 30 Devices	**Group H** 30 Devices	**Group I** 30 Devices

Table 1

This testing led to results on a total of 270 devices with measurements taken at 6 times (0, 71, 168, 250, 500 and 1000 hours). The measurements were taken on I_B and I_C at 4 current levels (0.5, 3, 10 and 50 mA). This produced a total of or 12,960 data points.

The following (Table 2) is a summary of the results of the testing expressed in average percent degradation of I_C and I_B from 0 to 1000 hours. I_B is the transistor base photo current generated by the LED light output. I_C is the collector current of the phototransistor and is related to the LED light output multiplied by the h_{FE} of the transistor. Note that the 0.5 mA measurement results are not included. This was because the detector current generated at 0.5 mA LED drive current was very low (nA range). It was determined that measurement error was significant at this very low current.

LED Stress Current	Measurement Current	85°C I_C	85°C I_B	105°C I_C	105°C I_B	125°C I_C	125°C I_B
0.5 mA	3 mA	4.0	2.9	11.7	8.1	24.2	17.3
	10 mA	3.6	4.7	6.3	8.4	21.7	17.4
	50 mA	1.0	6.8	0.7	8.2	2.4	18.3
0.3 mA	3 mA	5.5	4.2	13.3	9.0	23.5	16.7
	10 mA	4.9	4.8	7.6	9.3	21.0	16.9
	50 mA	1.2	7.7	0.8	10.6	2.1	18.2
50 mA	3 mA	11.1	8.1	23.0	17.2	27.1	20.3
	10 mA	8.0	8.1	17.2	15.5	21.6	19.1
	50 mA	1.4	10.6	2.3	12.3	3.3	17.6

Table 2

Analysis of Results

A review of the above results reveals an unusual response for I_C degradation for the 50 mA measurement current. The percent degradation is much less when compared to the

10 mA I_B measurement. This apparent improvement in CTR is actually a function of the phototransistor's h_{FE} changing. To explain, the following graph (Figure 5) represents the h_{FE} of the transistor versus drive current (I_B).

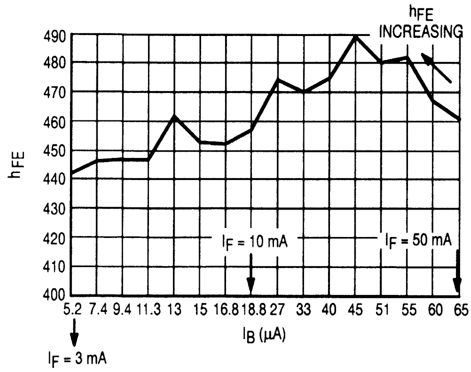


Figure 5. h_{FE} versus Photo Generated Current (I_B)

What this means is that as I_B decreases during stress testing (as would be the case with LED light output decreasing) in the area of 65 to 55 µA, the h_{FE} rises. Therefore as the LED degrades at high I_F currents (50 mA) the h_{FE} actually increases, compensating for the decrease in LED light output degradation. The overall result is that the CTR degradation appears to be less at the higher measurement currents.

This problem shows the need to express LED degradation more clearly. By using a term called Differential Quantum Efficiency (DQE) a truer picture of LED degradation can be obtained. DQE can be graphically pictured (see Figure 6).

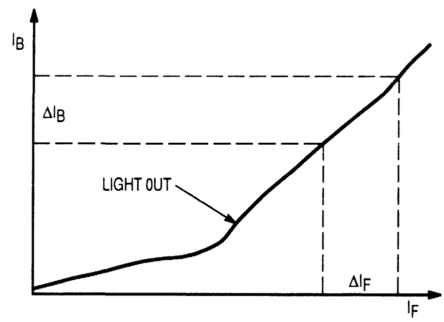


Figure 6. DQE Is Expressed as ΔI_B Divided by ΔI_F

In the case of this evaluation, DQE was derived by measuring I_B at the I_F delta of 3 to 10 mA. A summary table of the average DQE degradation percent from 0 to 1000 hours is shown below (Table 3). The calculated junction temperatures in degrees K are in parenthesis.

LED Stress Current	Ambient Stress Temperature 85°C	105°C	125°C
	Group A	Group B	Group C
0.5 mA	5.4 (358)	8.5 (378)	17.4 (398)
	Group D	Group E	Group F
3 mA	5.0 (359)	9.4 (379)	17.0 (399)
	Group G	Group H	Group I
50 mA	8.1 (371.5)	14.8 (391.5)	18.6 (411.1)

Table 3. Average DQE Degradation (%) 0 to 1000 Hours

A plot of these values on a graph (Figure 7) compares the DQE degradation at 1000 hours to LED junction temperature. The junction temperature was calculated based on a Theta J of 180°C/W. Note that the percent degradation appears to be affected only by overall junction temperature. That is, only the junction heating due to the surrounding ambient and the heating effects of LED current cause degradation, and not the effects due to current density (Group G ~ Group B).

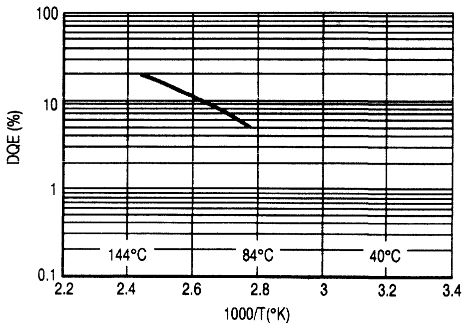


Figure 7. DQE Degradation (%)

A best fit straight line can be drawn through these points and its slope can be used to calculate the activation energy. A plot of the relative DQE versus time for all the groups are similar to B, E and H as shown in Figure 8.

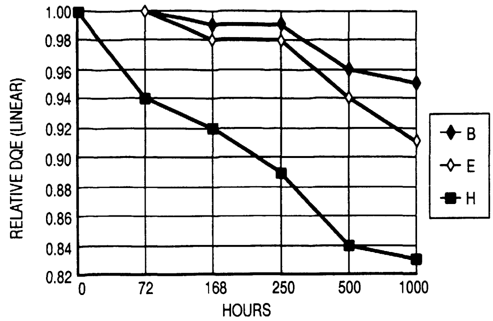


Figure 8. Relative DQE Degradation (%)

These curves can be fit to a polynomial of the kind that relates temperature to DQE degradation over time. This relationship can be expressed as:

Relative DQE (1)

$$= 1 \div (1 + e^{(A - Ea/T_jK)} \times \ln(1 + t^2 \times e^{(Ea/T_jK - B)}))$$

Where:

A & B = Constant

Ea = Activation Energy

$T_J = T_A + (V_F \times I_F \times \text{Theta J}) + 273$

K = Boltzmann's Constant (8.617×10^{-5} eV/°K)3

t = Time under stress testing

Theta J = 180°C/Watt

A = 16.85, B = 29.68, Ea = 0.61

Conclusions

By plugging in applicable junction temperatures and I_F drive currents, a prediction of degradation at any time can be made. A few representative curves of temperature and drive current are shown in Figure 9. By using this relationship, LED drive currents can now be much more accurately chosen at circuit design and can assure long operating life.

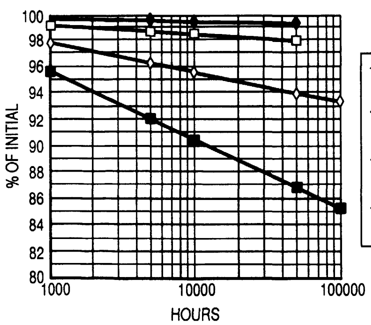


Figure 9. Average Degradation

A further refinement to the above expression was made to encompass the lot to lot variations that would be typically seen in a large volume production mode. This was accomplished by adjusting the constant "A" based on the Table 2 sample distributions. The six sigma points of each group in the sample were calculated and used to adjust their averages downward (X bar + 6 sigma). Replotting the curves in Figure 9 would look like those below in Figure 10. This predictability is made possible through the LED wafer processing improvements implemented, and the data analysis presented here.

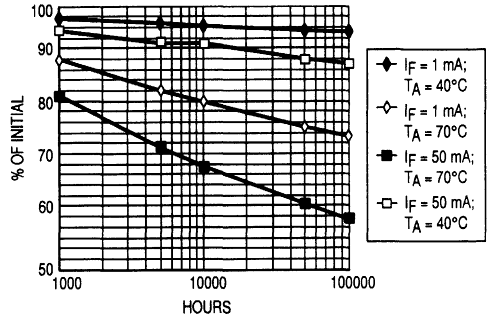


Figure 10. Six Sigma Degradation

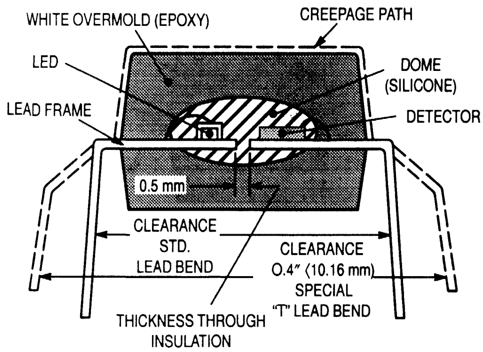
References

1. Motorola Applications Note AN440, *Motorola Optoelectronics Device Data Book,* Q2/89 DL118, REV 3.
2. J.R. Biard, G.E. Pittman, and T.F. Leezer. "Degradation of Quantum Efficiency in Gallium Arsenide Light Emitters," Proceedings of International Symposium on GaAs, Sept. 1966.
3. Wayne Nelson, *Accelerated Testing,* 1991, John Wiley and Sons.

Acknowledgements

The author wishes to thank Dr. Daniel L. Rode for his valuable assistance in the physical modeling of GaAs LED degradation.

Optocoupler Dome Package



The DOME package is a manufacturing/quality improvement in that it represents a significant reduction in the complexity of the assembly steps. This is consistent with Motorola's goal of continual quality improvement by reduction in process variations (in this case through assembly simplification).

The following reliability testing summary confirms the quality of design and material selection.

Dome Package Evaluation

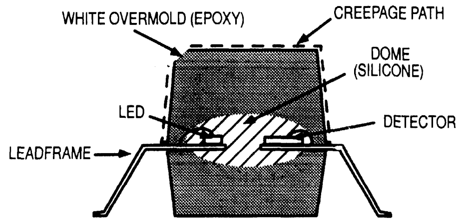
Package: 6-Pin DIP, Case 730A-04 (WHITE)

Parameters Monitored

Parameter	Conditions	Limits			
		Initial		End Points	
		Min	Max	Min	Max
I_R	$V_R = 3$ V		100 μA		100 μA
V_F	$I_F = 10$ mA		1.5 V		1.5 V
I_{CEO}	$V_{CE} = 10$ V		50 nA		50 nA
I_{CBO}	$V_{CB} = 10$ V		20 nA		20 nA
$V_{(BR)CEO}$	$I_C = 1$ mA	30 V		30 V	
$V_{(BR)CBO}$	$I_C = 100$ μA	70 V		70 V	
$V_{(BR)ECO}$	$I_E = 100$ μA	7 V		7 V	
I_C	$V_{CE} = 120$ V $I_F = 10$ mA	2 mA		2 mA	
$V_{CE(sat)}$	$I_C = 2$ mA $I_F = 50$ mA		0.5 V		0.5 V
V_{ISO}	f = 60 Hz t = 1 Sec.	5.35 k		—	

Life and Environmental Testing Results

Test	Conditions	Sample Size	Rejects	
			Limit	Catastrophic
IRED Burn-In	$I_F = 50$ mA t = 1000 Hrs.	100	0	0
H^3TRB	$T_A = 85°C$ RH = 85% $V_{CB} = 50$ V, t = 1000 Hrs.	71	0	0
HTRB	$T_A = 100°C$ $V_{CB} = 50$ V t = 1000 Hrs.	80	0	0
Intermittent Operating Life	$I_F = 50$ mA $I_C = 10$ mA $V_{CE} = 10$ V $T_{on} = T_{off} = 1$ Min t = 1000 Hrs.	100	0	0
High Temperature Storage	$T_A = 125°C$ t = 1000 Hrs.	99	0	0
Temperature Cycle	–40°C to +125°C Air-To-Air 15 Min at Extremes 1200 Cycles	58	0	0
Thermal Shock	Liquid-To-Liquid 0°C to +100°C 500 Cycles	100	0	0
Resistance to Solder Heat	MIL-Std-750, Method 2031 260°C for 10 sec Followed by V_{ISO}	50	0	0
Lead Pull	MIL-Std-750, Method 2036 Cond A, 2 Lbs. 1 Min	5	0	0



Dome Package Evaluation

Package: SOIC–8 8-Pin DIP, Case 846–01 (WHITE)

Parameters Monitored

Parameter	Conditions	Limits			
		Initial		End Points	
		Min	Max	Min	Max
I_R	$V_R = 6$ V		100 μA		100 μA
V_F	$I_F = 1$ mA		1.3 V		1.3 V
I_{CEO}	$V_{CE} = 5$ V		50 nA		50 nA
$V_{(BR)CEO}$	$I_C = 100$ mA	30 V		30 V	
$V_{(BR)ECO}$	$I_E = 100$ μA	5 V		5 V	
I_C	$V_{CE} = 5$ V $I_F = 1$ mA	5 mA		5 mA	
$V_{CE(sat)}$	$I_C = 0.5$ mA $I_F = 1$ mA		1 V		1 V

Life and Environmental Testing Results

Test	Conditions	Sample Size	Rejects	
			Limit	Catastrophic
IRED Burn-In	$I_F = 50$ mA t = 1000 Hrs.	100	0	0
H^3TRB	$T_A = 85°C$ RH = 85% $V_{CB} = 30$ V, t = 500 Hrs.	84	0	0
HTRB	$T_A = 100°C$ $V_{CB} = 30$ V t = 1000 Hrs.	84	0	0
Operating Life	$I_F = 1$ mA $I_C = 5$ mA $V_{CE} = 20$ V t = 1000 Hrs.	84	0	0
High Temperature Storage	$T_A = 100°C$ t = 1000 Hrs.	84	0	0
Temperature Cycle	–40°C to +125°C Air-To-Air 15 Min at Extremes 1000 Cycles	116	0	0
Autoclave	$T_A = 121°C$ Pressure = 15 psig	84	0	0
Solderability	MIL-Std-750, Method 2026 Steam Age = 8 Hrs.	7	0	0

Optocoupler Process Flow and QA Inspections (Dome Package)

1 PRE PROBE INSPECTION: A sampled microscopic inspection of class probed wafers for die related defects on the detector and emitter.

2 POST PROBE INSPECTION: Each lot of wafers is sampled and inspected microscopically and electrically to insure quality before shipping to the die cage. This includes both detector and emitter.

3 POST SAW INSPECTION: A sample of die is monitored by microscopic inspection for correct saw cut, and checks for cracks, chips, foreign material and missing metal are made. This includes both the detector and emitter.

4 DIE BOND INSPECTION: This microscopic inspection checks both die for die placement and orientation, cracks, chips and die attachment. In addition, a random sample of both bonded die are pushed off and the percent of remaining material evaluated.

5 WIRE BOND INSPECTION: Wire bonds are checked microscopically for placement, bond formation, damaged wire, lifted bonds and missing wire. In addition, a random sample of wire from the emitter and detector are subjected to a destructive wire pull test.

6 QA INTERNAL VISUAL GATE: This is a sampled QA gate to microscopically inspect for all of the defects described in numbers 4 and 5 above. All lots rejected are 100% rescreened before resubmitting.

7 QA VISUAL GATE: This is a sampled gate for the quality and dimensions of the dome coating operation.

8 MOLD INSPECTION: This is monitor inspection of a sample of molded units for defects such as voids, incomplete fills, etc.

9 LEAD TRIM AND FORM INSPECTION: The final trimmed and formed units are monitored through a visual inspection.

10 QA VISO GATE: This is a sampled electrical high voltage test of the capabilities of the device and assures the 100% Viso testing performed just prior is without error.

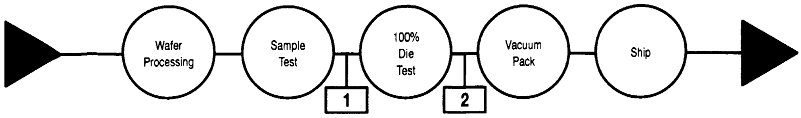
11 QA FINAL VISUAL INSPECTION: This is a final external microscopic inspection for physical defects or damage, plating defects and lead configuration.

12 WEEKLY LED BURN-IN AND TEMPERATURE CYCLING AUDIT: Current transfer ratio (CTR) is measured on a sample prior to and after the application of 72 hours of a high forward LED stress current and the percentage change is calculated. Also a sample of completed units is subjected to 300 cycles of air to air temperature cycling. This information provides trend data which is fed back to direct assembly/processing improvements.

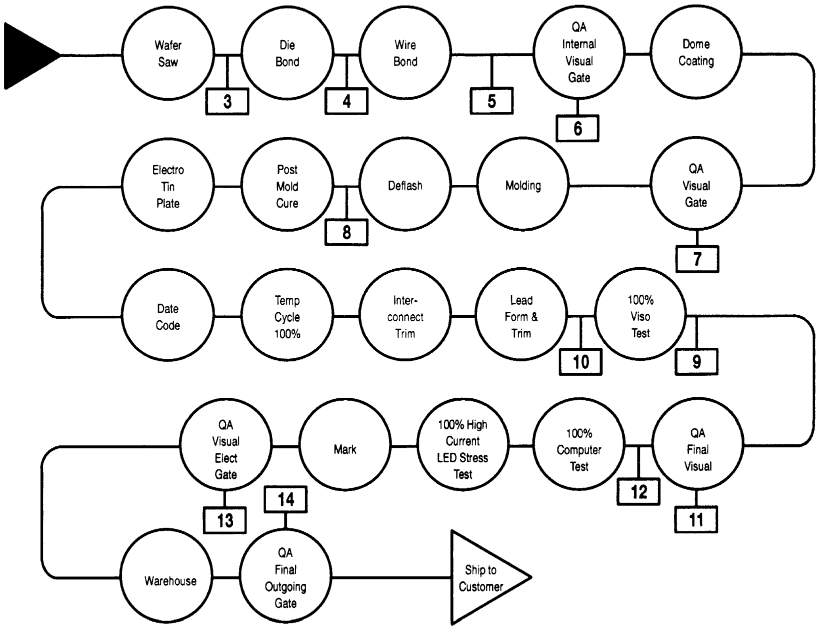
13 QA VISUAL/MECHANICAL AND ELECTRICAL GATE: A random sample from each final test lot is electrically tested to documented limits. In addition, marking and mechanical defects are gated.

14 OUTGOING FINAL INSPECTION: Outgoing lots are sample inspected for correct packing, part type, part count and documentation requirements.

Wafer Processing



Coupler Assembly, Test and Mark



Section 3

Optoelectronic Devices Selector Guide

In Brief . . .

Motorola's families of optoelectronic components encompass red and infrared GaAs emitters and silicon detectors that are well matched for a variety of applications.

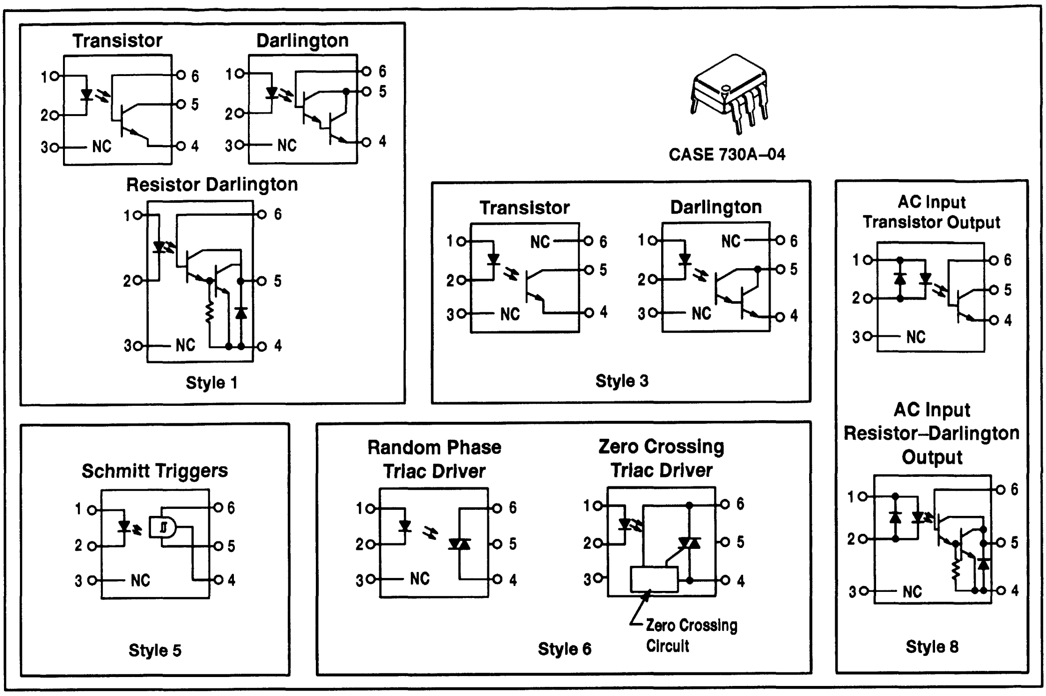
Optoisolators

Motorola's "Global" 6–Pin Dual In–line Package (DIP) devices use infrared emitting diodes that are optically coupled to a wide selection of output (Transistor, Darlington, Triac, and Schmitt trigger) silicon detectors. These devices are guaranteed to provide at least 7500 volts of isolation between the input and output and are 100% VISO tested. The entire line of Motorola 6–pin DIP packages are recognized by all major safety regulatories including UL and VDE. This extensive line of regulatory approvals attest to their suitability for use under the most stringent conditions. Motorola also offers a line of SOIC–8 small outline, surface mount devices that are UL approved and ideally suited for high density applications.

POWER OPTO™ Isolators

The MOC2A40 and MOC2A60 series are the first members of the POWER OPTO™ Isolator family from Motorola. The MOC2A40/60 are 2 Amp @ 40°C/400 or 600 Vac[pk]/Zero–Crossing/Optically Coupled Triacs. These isolated AC output devices are ruggedized to survive the harsh operating environments inherent in Industrial Controller applications. Additionally, their thermally optimized SIP package profile allows for high density stacking on 0.200″ centers and can handle 2 Amps @ 40°C (Free–Air Rating) *without the need for heatsinks, thermal grease, etc.*

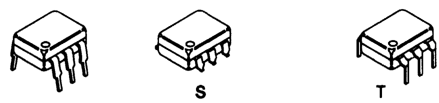
Optoisolators 6–Pin DIP Varieties and Lead Form Options



An optoisolator consists of a gallium arsenide infrared emitting diode, IRED, optically coupled to a monolithic silicon photodetector in a wide array of standard devices and encourages the use of special designs and selections for special applications. All Motorola optoisolators have V_{ISO} rating of 7500 Vac(pk), exceeding all other industry standard ratings.

Motorola offers global regulatory approvals, including UL, CSA, AUSTEL, NEMKO, BABT, SETI, SEMKO, and DEMKO. VDE(1) approved per standard 0884/8.87, with additional approvals to DIN IEC950 and IEC380/VDE 0806, IEC435/VDE 0805, IEC65/VDE 0860, VDE 110b, also covering all other standards with equal or less stringent requirements, including IEC204/VDE 0113, VDE 0160, VDE 0832, VDE 0833.

(1) VDE 0884/8.87 testing is an option; the suffix "V" must be added to the standard part number (see VDE Approved Optoisolators in Section 3).



CASE 730A–04 | (S) CASE 730C–04 Surface–mountable gull–wing option | (T) CASE 730D Wide–spaced (0.400) lead form option

Optoisolator
Lead Form Options:

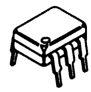
Motorola's 6–pin, dual in–line optoisolators can be ordered in either a surface–mountable, gull–wing lead form or a wide–spaced 0.400″ through–hole lead form, which is used to satisfy 8 mm PC board spacing requirements. ***Please first consult factory regarding availability for your lead form option, prior to ordering!***

- Attach "S" to any Motorola 6–pin, dual in–line part number for surface–mountable, gull–wing lead form.
- Attach "T" to any Motorola 6–pin, dual in–line part number for wide–spaced 0.400" through–hole lead form.

Tape and Reel Options:

- Attach "SR2" suffix to any Motorola 6–pin, dual in–line part number for tape and reeled, surface–mountable, gull–wing lead form.

6–Pin Dual In–Line Package



CASE 730A–04

Table 1. Transistor Output
Pinout: 1–Anode, 2–Cathode, 3–N.C., 4–Emitter, 5–Collector, 6–Base (Style 1)

Device	Current Transfer Ratio (CTR)			$V_{CE(sat)}$			t_r/t_f or t_{on}*/t_{off}* Typ					$V_{(BR)CEO}$	V_F	
	% Min	@ I_F mA	V_{CE} Volts	Volts Max	@ I_F mA	I_C mA	µs	@ I_C mA	V_{CC} Volts	R_L Ω	I_F mA	Volts Min	Volts Max	@ I_F mA
TIL111	8	16	0.4	0.4	16	2	5/5	2	10	100		30	1.4	16
4N27	10	10	10	0.5	50	2	1.2/1.3	10	10	100		30	1.5	10
4N28	10	10	10	0.5	50	2	1.2/1.3	10	10	100		30	1.5	10
4N38,A	20	20	1	1	20	4	1.6/2.2	10	10	100		80	1.5	10
4N25,A	20	10	10	0.5	50	2	1.2/1.3	10	10	100		30	1.5	10
4N26	20	10	10	0.5	50	2	1.2/1.3	10	10	100		30	1.5	10
MCT2	20	10	10	0.4	16	2	1.2/1.3		5	2k	15	30	1.5	20
MCT2E	20	10	10	0.4	16	2	1.2/1.3	2	10	100		30	1.5	20
CNY17–1	40–80	10	5	0.4	10	2.5	1.6/2.3"		5	75	10	70	1.65	60
MCT271	45–90	10	10	0.4	16	2	4.9*/4.5*	2	5	100		30	1.5	20
MOC8100	50	1	5	0.5	1	0.1	3.8/5.6	2	10	100		30	1.4	1
H11A1	50	10	10	0.4	10	0.5	1.2/1.3	2	10	100		30	1.5	10
H11A550	50	10	10	0.4	20	2	5*/5*	2	10	100		30	1.5	10
TIL117	50	10	10	0.4	10	0.5	5/5	2	10	100		30	1.4	16
TIL126	50	10	10	0.4	10	1	2/2	2	10	100		30	1.4	10
SL5501	45–250	10	0.4	0.4	20	2	20*/50*		5	1k	16	30	1.3	20
CNY17–2	63–125	10	5	0.4	10	2.5	1.6/2.3		5	75	10	70	1.65	60
MCT275	70–210	10	10	0.4	16	2	4.5*/3.5*	2	5	100		80	1.5	20
MCT272	75–150	10	10	0.4	16	2	6*/5.5*	2	5	100		30	1.5	20
4N35	100	10	10	0.3	10	0.5	3.2/4.7	2	10	100		30	1.5	10
4N36	100	10	10	0.3	10	0.5	3.2/4.7	2	10	100		30	1.5	10
4N37	100	10	10	0.3	10	0.5	3.2/4.7	2	10	100		30	1.5	10
CNY17–3	100–200	10	5	0.4	10	2.5	1.6/2.3		5	75	10	70	1.65	60
H11AV1	100–300	10	10	0.4	20	2	5*/4*	2	10	100		70	1.5	10
H11AV2	50	10	10	0.4	20	2	5*/4*	2	10	100		70	1.5	10
MCT273	125–250	10	10	0.4	16	2	7.6*/6.6*	2	5	100		30	1.5	20

Table 2. Transistor Output with No Base Connection
Pinout: 1–Anode, 2–Cathode, 3–N.C., 4–Emitter, 5–Collector, 6–Base (Style 3)

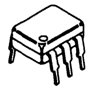
MOC8101	50–80	10	10	0.4	5	0.5	3.2/4.7	2	10	100		30	1.5	10
MOC8102	73–117	10	10	0.4	5	0.5	3.2/4.7	2	10	100		30	1.5	10
MOC8103	108–173	10	10	0.4	5	0.5	3.2/4.7	2	10	100		30	1.5	10
MOC8104	160–256	10	10	0.4	5	0.5	3.2/4.7	2	10	100		30	1.5	10
MOC8105	65–133	10	10	0.4	5	0.5	3.2/4.7	2	10	100		30	1.5	10
MOC8111	20	10	10	0.4	10	0.5	3.2/4.7	2	10	100		30	1.5	10
MOC8112	50	10	10	0.4	10	0.5	3.2/4.7	2	10	100		30	1.5	10
MOC8113	100	10	10	0.4	10	0.5	3.2/4.7	2	10	100		30	1.5	10

Table 3. AC Input – Transistor Output
Pinout: 1–LED 1 Anode/LED 2 Cathode, 2–LED 1 Cathode/LED 2 Anode, 3–N.C., 4–Emitter, 5–Collector, 6–Base (Style 8)

Device	Current Transfer Ratio (CTR)			$V_{CE(sat)}$			t_r/t_f or t_{on}*/t_{off}* Typ					$V_{(BR)CEO}$	V_F	
	% Min	@ I_F mA	V_{CE} Volts	Volts Max	@ I_F mA	I_C mA	µs	@ I_C mA	V_{CC} Volts	R_L Ω	I_F mA	Volts Min	Volts Max	@ I_F mA
H11AA1	20	±10	10	0.4	±10	0.5						30	1.5	±10
H11AA2	10	±10	10	0.4	±10	0.5						30	1.8	±10
H11AA3	50	±10	10	0.4	±10	0.5						30	1.5	±10
H11AA4	100	±10	10	0.4	±10	0.5						30	1.5	±10

Devices listed in bold, italic are Motorola preferred devices.

6–Pin Dual In–Line Package (continued)



CASE 730A–04

Table 4. Darlington Output
Pinout: 1–Anode, 2–Cathode, 3–N.C., 4–Emitter, 5–Collector, 6–Base (Style 1)

Device	Current Transfer Ratio (CTR) % Min	@ I_F mA	V_{CE} Volts	$V_{CE(sat)}$ Volts Max	@ I_F mA	I_C mA	t_r/t_f or t_{on}*/t_{off}* Typ µs	@ I_C mA	V_{CC} Volts	R_L Ω	I_F mA	$V_{(BR)CEO}$ Volts Min	V_F Volts Max	@ I_F mA
4N31	50	10	10	1.2	8	2	0.6*/17*	50	10		200	30	1.5	10
4N29,A	100	10	10	1	8	2	0.6*/17*	50	10		200	30	1.5	10
4N30	100	10	10	1	8	2	0.6*/17*	50	10		200	30	1.5	10
MCA231	200	1	1	1.2	10	50	80	10	10	100		30	1.5	20
TIL113	300	10	1.25	1	50	125	300	125	15	100		30	1.5	10
4N32	500	10	10	1	8	2	0.6*/45*	50	10		200	30	1.5	10
4N33	500	10	10	1	8	2	0.6*/45*	50	10		200	30	1.5	10
H11B1	500	1	5	1	1	1	1/2	10	10	100		25	1.5	10
MOC8080	500	10	5	1	1	1	1/2		10	100	5	55	1.5	10

Table 5. Darlington Output with No Base Connection
Pinout: 1–Anode, 2–Cathode, 3–N.C., 4–Emitter, 5–Collector, 6–N.C. (Style 3)

MOC119	300	10	2	1	10	10	1/2	2.5	10	100		30	1.5	10
MOC8030	300	10	1.5				1/2		50	100	10	80	2	10
MOC8020	500	10	5				1/2		50	100	10	50	2	10
MOC8050	500	10	1.5				1/2		50	100	10	80	2	10
MOC8021	1000	10	5				1/2		50	100	10	50	2	10

Table 6. Resistor Darlington Output
Pinout: 1–Anode, 2–Cathode, 3–N.C., 4–Emitter, 5–Collector, 6–Base (Style 1)

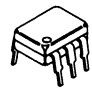
H11G1	1000	10	1	1	1	1	5*/100*		5	100	10	100	1.5	10
H11G2	1000	10	1	1	1	1	5*/100*		5	100	10	80	1.5	10
H11G3	200	1	5	1.2	50	20	5*/100*		5	100	10	55	1.5	10

Table 7. High Voltage Transistor Output
Pinout: 1–Anode, 2–Cathode, 3–N.C., 4–Emitter, 5–Collector, 6–Base (Style 1)

MOC8204	20	10	10	0.4	10	0.5	5*/5*	2	10	100		400	1.5	10
H11D1	20	10	10	0.4	10	0.5	5*/5*	2	10	100		300	1.5	10
H11D2	20	10	10	0.4	10	0.5	5*/5*	2	10	100		300	1.5	10

Devices listed in bold, italic are Motorola preferred devices.

6–Pin Dual In–Line Package (continued)



CASE 730A–04

Table 8. Triac Driver Output
Pinout: 1–Anode, 2–Cathode, 3–N.C., 4–Main Terminal, 5–Substrate, 6–Main Terminal (Style 6)

Device	Peak Blocking Voltage Min	LED Trigger Current–I_{FT} (V_{TM} = 3 V) mA Max	Zero Crossing Inhibit Voltage (at rated I_{FT}) Volts Max	Operating Voltage Vac	dv/dt V/µs Typ
MOC3010	250	15	—	125	10
MOC3011	250	10	—	125	10
MOC3012	250	5	—	125	10
MOC3021	400	15	—	125/280	10
MOC3022	400	10	—	125/280	10
MOC3023	400	5	—	125/280	10
MOC3051*	600	15	—	125/280	2000
MOC3052*	600	10	—	125/280	2000
MOC3031	250	15	20	125	2000
MOC3032	250	10	20	125	2000
MOC3033	250	5	20	125	2000
MOC3041	400	15	20	125/280	2000
MOC3042	400	10	20	125/280	2000
MOC3043	400	5	20	125/280	2000
MOC3061	600	15	20	125/280	1500
MOC3062	600	10	20	125/280	1500
MOC3063	600	5	20	125/280	1500
MOC3162*	600	10	15	125/280	1000
MOC3163*	600	5	15	125/280	1000
MOC3081	800	15	20	125/280/320	1500
MOC3082	800	10	20	125/280/320	1500
MOC3083	800	5	20	125/280/320	1500

* New Device Offering

Table 9. Schmitt Trigger Output
Pinout: 1–Anode, 2–Cathode, 3–N.C., 4–Output, 5–Ground, 6–V_{CC} (Style 5)

Device	Threshold Current On mA Max	Threshold Current Off mA Min	$I_{F(off)}/I_{F(on)}$		V_{CC}		t_r, t_f µs Typ
			Min	Max	Min	Max	
H11L1	1.6	0.3	0.5	0.9	3	16	0.1
H11L2	10	0.3	0.5	0.9	3	16	0.1
MOC5007	1.6	0.3	0.5	0.9	3	16	0.1
MOC5008	4	0.3	0.5	0.9	3	16	0.1
MOC5009	10	0.3	0.5	0.9	3	16	0.1

Devices listed in bold, italic are Motorola preferred devices.

Small Outline — Surface Mount

CASE 846–01
SO–8 DEVICES

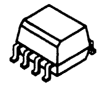


Table 10. Transistor Output
Pinout: 1–Anode, 2–Cathode, 3–N.C., 4–N.C., 5–Emitter, 6–Collector, 7–Base, 8–N.C. (Style 1)

		Current Transfer Ratio (CTR)			$V_{CE(sat)}$			t_r/t_f Typ					V_F	
Device	Marking	% Min	@ I_F mA	V_{CE} Volts	Volts Max	@ I_F mA	I_C mA	µs	@ I_C mA	V_{CC} Volts	R_L Ω	$V_{(BR)CEO}$ Volts Min	Volts Max	@ I_F mA
MOC205,R2	205	40–80	10	10	0.4	10	2	1.6	2	10	100	70	1.5	10
MOC206,R2	206	63–125	10	10	0.4	10	2	1.6	2	10	100	70	1.5	10
MOC207,R2	207	100–200	10	10	0.4	10	2	1.6	2	10	100	70	1.5	10
MOC211,R2	211	20	10	10	0.4	10	2	3.2	2	10	100	30	1.5	10
MOC212,R2	212	50	10	10	0.4	10	2	3.2	2	10	100	30	1.5	10
MOC213,R2	213	100	10	10	0.4	10	2	3.2	2	10	100	30	1.5	10
MOC215,R2	215	20	1	5	0.4	1	0.1	3.2	2	10	100	30	1.3	1
MOC216,R2	216	50	1	5	0.4	1	0.1	3.2	2	10	100	30	1.3	1
MOC217,R2	217	100	1	5	0.4	1	0.1	3.2	2	10	100	30	1.3	1

Table 11. Darlington Output
Pinout: 1–Anode, 2–Cathode, 3–N.C., 4–N.C., 5–Emitter, 6–Collector, 7–Base, 8–N.C. (Style 1)

MOC223,R2	223	500	1	5	1	1	0.5	2	5	10	100	30	1.3	1
MOC263,R2*	263	500	1	5	1	1	0.5	2	5	10	100	30	1.3	1

All devices are shipped in tape and reel format. (See Tape and Reel Specifications Section for more information.)
*No Base Connection to Pin 7

Table 12. AC Input – Transistor Output (Single Channel) (Style 2)

MOC256,R2	256	20	±10	10	0.4	±10	0.5					30	1.5	±10

Table 13. Transistor Output (Dual Channel) (Style 3)

MOCD207,R2	D207	100–200	10	10	0.4	10	2	1.6	2	10	100	70	1.5	10
MOCD208,R2	D208	45–125	10	10	0.4	10	2	1.6	2	10	100	70	1.5	10
MOCD211,R2	D211	20	10	10	0.4	10	2	3.2	2	10	100	30	1.5	10
MOCD213,R2	D213	100	10	10	0.4	10	2	3.2	2	10	100	70	1.5	10
MOCD217,R2	D217	100	1	5	0.4	1	0.1	3.2	2	10	100	30	1.5	1

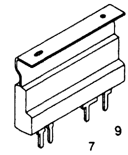
Table 14. Darlington Output (Dual Channel) (Style 3)

MOCD223,R2	D223	500	1	5	1	1	0.5	2	5	10	100	30	1.3	1

R2 devices are shipped in tape and reel format. (See Tape and Reel Specifications Section for more information.)

Devices listed in bold, italic are Motorola preferred devices.

POWER OPTO™ Isolators



CASE 417–02
PLASTIC PACKAGE

Table 15. POWER OPTO Isolator 2 Amp Zero–Cross Triac Output
Pinout: (1,4,5,6,8 No Pin), 2 – LED Cathode, 3– LED Anode, 7–Main Terminal, 9–Main Terminal

Device	Peak Blocking Voltage (Volts) Min	Led Trigger Current If T (V_{TM} = 2 V) mA Max	On State Voltage V_{TM} (Rated I_{FT} I_{TM} = 2 A) (Volts) Max	Zero Crossing Inhibit Voltage (I_F = Rated I_{FT}) (Volts) Max	Operating Voltage Vac rms (Volts)	dv/dt (static) (V_{IN} = 200 V) (V/µs) Min
MOC2A40–5	400	5	1.3	10	125	400
MOC2A40–10	400	10	1.3	10	125	400
MOC2A60–5	600	5	1.3	10	125/280	400
MOC2A60–10	600	10	1.3	10	125/280	400

No suffix = Style 2 (Standard Heat Tab), "F" suffix = Style 1 (Flush Mount Heat Tab), "C" suffix = Style 1 (Cuf–off Heat Tab)

Devices listed in bold, italic are Motorola preferred devices.

Devices listed in bold, italic are Motorola preferred devices.

Section 4

Safety Regulatory Information

Safety Regulatory Approvals for Motorola's "Global" Optoisolators

Motorola's entire line of 6–pin optoisolators are approved by all major safety regulatories.

Safety Standard Approvals for 6–Pin Optoisolators

GlobalOptoisolator™	VDE	UL	CSA	SETI	SEMKO	DEMKO	NEMKO	BABT
MOCXXXX	* (1)	*	*	*	*	*	*	*
SOCXXXX	* (1)	*	*	*	*	*	*	*
4NXXXXXX	* (1)	*	*	*	*	*	*	*
H1XXXXXX	* (1)	*	*	*	*	*	*	*
MCXXXXXX	* (1)	*	*	*	*	*	*	*
TIXXXXXX	* (1)	*	*	*	*	*	*	*
CNXXXXXX	* (1)	*	*	*	*	*	*	*

* = Approved

Regulatory Approval Certification Index

Regulatory Agency	Certificate File Number
VDE(0883)	41853 (expired 12/31/91)
VDE(0884)(1)	62054 (replaces VDE0883)
UL (isolation)	E54915
UL (flammability)	E–8436
CSA	CA93952
FIMKO	41990
SEMKO	9313138
DEMKO	Approved per SEMKO
NEMKO	A99177
BABT	CR/0117
AUSTEL	03 887 0711

Note: Motorola's 8–pin surface mount optocouplers are approved by UL only and have a guaranteed isolation voltage of 3000 Vac(rms).

All Motorola 6–pin optocouplers are 100% tested for isolation voltage and are guaranteed to 7500 Vac(peak).

UL Flammability Rating = 94VO (File number E–8436) for all optocouplers.

(1) VDE 0884 testing is an option; the suffix letter "V" must be added to the standard part number.

SAFETY REGULATORY APPROVAL DOCUMENTATIONS

DEMKO

Danmarks Elektriske Materielkontrol

Lyskær 8 . Postboks 514

DK-2730 Herlev . Danmark

Telephone: +45 42 94 72 66
Telefax: +45 42 94 72 61
Telex: 35125 demko dk

Motorola Semiconducteurs S.A.
Avenue General Eisenhower B P 1029
31023 Toulouse Cedex
Frankrig
(France)

Examiner:

J. Frederiksen

Your reference	Your letter	Our letter	Our reference	Ext.	Herlev
	91-02-14		101133 JF	210	1991-04-24

Approval (translation)

DEMKO hereby grants approval of the below-mentioned devices:

Optocouplers
marked.:"Motorola"
input max. 60mA, output max. 150 mW
01) type: CNY17-2V
02) type: MOC.....V
03) type: SOC.....V
04) type: 4N......V
05) type: MCX.....V
06) type: TIX.....V
07) type: CNX.....V
08) type: H7X.....V
09) type: ILX.....V
manufacturer: Motorola Inc., USA
for building-in.

The type designation consists of max. 9 characters.
The points consists of max. 5 characters.
"V" indicates carrying out with so-called "DOME-package".

The approval is granted on the basis of EMKO-TUE (12B/74)DK 002/87 for use across double or reinforced insulation in plug-connected protable apparatus with ordinary degree of protection against moisture, for use in IEC 335 and IEC 950 based apparatus.

The approval is granted according to the agreement on Nordic testing and based on tests carried out by SEMKO, cf. letter of approval No. 9014099 dated 1990-05-11 and No. 9020023 dated 1991-05-17.

The approval covers only equipment identical to that approved by SEMKO.

LO/10051

49.41 SE

The equipment may be provided with the registered mark of approval Ⓓ.

./. We enclose our invoice No. 62076.

For DEMKO

E.H. Overballe
Afdelingsleder

N NEMKO

NOTICE OF RESULT Ref.No. A 99177

Applicant:
Motorola Inc.
Optoelectronic Department
5005 E. McDowell Rd.
Phoenix, AZ 85008, USA

Responsible manufacturer:
Motorola Inc.,
Phoenix, AZ/USA

Oslo:
1993-08-17

Group: Optocouplers

A 99177 01	Type:	MOC.....
A 99177 02	Type:	3OC.....
A 99177 03	Type:	4N.....
A 99177 04	Type:	H1.....
A 99177 05	Type:	MC.....
A 99177 06	Type:	TI.....
A 99177 07	Type:	CN.....
A 99177 08	Type:	H7.....
A 99177 09	Type:	IL.....

Please, find enclosed Statement of Conformity according to your application.

This NOTICE OF RESULT replaces previous NOTICE OF RESULT (with same ref.no.) issued 1993-04-05.

Please, send the last original of the Statement of Conformity (issued 1993-03-31) to NEMKO as this also have been corrected.

Yours faithfully
NEMKO

for B. Myrvallen
M. Andersen
Office- and data section

M. Krohn
M. Krohn

NEMKO

STATEMENT OF CONFORMITY

Ref.No. **A99177**

Product	**Opto coupler**
Name and address of the applicant	**Motorola Inc.** **Optoelectronic Department** **5005 E. MacDowell Rd.** **Phoenix, AZ 85008, USA**
Name and address of the manufacturer	**Motorola Inc.,** **Phonix, AZ/USA**
Name and address of the factory	
Rating and principal characteristics	
Trade mark (if any).	**MOTOROLA**
Model/Type Ref.	**MOC....., 3OC....., 4N....., H1....., MC.....,** **TI....., CN....., H7....., IL..... .**
Additional information (if necessary)	**Our statement of conformity are based upon SETI report 130757-01...09 of 1990-05-03, and a letter from Motorola Inc.**
A sample of the product has been tested and found to be in conformity with the current HD/EN and equivalent standard, (number and edition).	**IEC 950-86, EMKO-TUE (74-SEC) 203/90,** **IEC 65 AND EMKO-TUE (12B-SEC) 205/90.** **The opto couplers fulfils the requirement to reinforced insulation, for working voltages until 250V.**

Oslo, date **1993-08-16**

Michael Krohn

Internal ref. **MICHAEL KROHN**
(No., Name or initials of contact persons)

Issued by

NEMKO

for B. Myrvollen

J.I. Tidemann
Head of electronics and appliances department

SEMKO

CERTIFICATE

Page	Reference No.
1	9313138

Applicant	Applicant or representative
MOTOROLA INC. 5005 EAST MC DOWELL ROAD PHOENIX, ARIZONA 85008 U.S.A	MOTOROLA AB SEMICONDUCTOR PROD SECTOR DALVÄGEN 2 171 36 SOLNA

1151G Optoinsulator for bridging of reinforced insulat.

01 TYPE DESIGNATION: MOC.....
Input: max 60 mA. Output: max 150 mW.

02 TYPE DESIGNATION: SOC.....
Input: max 60 mA. Output: max 150 mW.

03 TYPE DESIGNATION: 4N.....
Input: max 60 mA. Output: max 150 mW.

04 TYPE DESIGNATION: MC.....
Input: max 60 mA. Output: max 150 mW.

05 TYPE DESIGNATION: TI.....
Input: max 60 mA. Output: max 150 mW.

06 TYPE DESIGNATION: CN.....
Input: max 60 mA. Output: max 150 mW.

07 TYPE DESIGNATION: H11.....
Input: max 60 mA. Output: max 150 mW.

08 TYPE DESIGNATION: IL.....
Input: max 60 mA. Output: max 150 mW.

The product defined above is hereby certified for S-marking according to SS-433 07 84 (SEMKO 9335-2-304, bil. BB) EMKO-TUE(12B/74)DK 002/87.

The products or the packaging shall be provided with SEMKOs registered S-mark, durably designed and according to standard sheet 44.

The certificate is valid up to and including 2000-12-31.

A licence fee will be charged for the products according to the valid list of fees.

Ref and date of application			Ref No. (please quote in correspondence)
000000			9313138
Internal ref	Sign P	Sign AO	Our ref and date of issue
PAK/MMB			KLEMETS PAUL 930407

S 70 E

Postal address SEMKO AB | Visiting address | Telephone | Telex | Teletex | Telefax

SEMKO **CERTIFICATE**

Page	Reference No.
2	9313138

Applicant	Applicant or representative
MOTOROLA INC. 5005 EAST MC DOWELL ROAD PHOENIX, ARIZONA 85008 U.S.A	MOTOROLA AB SEMICONDUCTOR PROD SECTOR DALVÄGEN 2 171 36 SOLNA

The testing has been carried out according to the agreement on Nordic testing for the purpose of certification/approval also in the other Nordic countries.

The national deviations of the other Nordic countries have been covered.

When an application for certificate/approval is made in another Nordic country, you shall submit, via your representative, a copy of this approval, necessary documentation and a set of enclosed copies of photographs.

After judgement from case to case, the optocoupler can bridge basic insulation, supplementary insulation, double insulation or reinforced insulation, provided that the test data stated above are not exceeded in normal operation or under fault conditions in the appliance.

This certificate/approval replaces our certificate issued earlier, with reference No. 9020023/1-8 dated 1990-05-17. New certificate/approval has been issued on account of change type designation.

SEMKO AB

Ref and date of application			Ref No. (please quote in correspondence)
000000			9313138
Internal ref	Sign P	Sign AC	Our ref and date of issue
PAK/MMB			KLEMETS PAUL 930407

S 70 E

Postal address SEMKO AB | Visiting address | Telephone | Telex | Telefax | Telefax

PROFILE OF CERTIFICATION REPORTS

178 Rexdale Blvd., Rexdale (Toronto), Ontario M9W 1R3

NUMBR P93592X0000 FILE NO: CA 93592

SUBMITTOR

Motorola Inc.
Optoelectronic Products, Signal Products Div.
Motorola Semiconductor Products Sector Mail Drop Z200
5005 E. McDowell Rd.
Phoenix, AZ 85008

Page No: CRP 1 of 1
Date: August 24, 1994
Replaces: January 27, 1994

FACTORY	INSPECTION OFFICE	FILE NO
F1 Carsem (M) SND BHD Jalan Lapagan Terbang 30720 Ipoh P.O. Box 204 Perak Darual Ridzuan, Malaysia	SISIR	CA 93592
F2 Motorola Korea Ltd. 445 Kwang-Jang-Dong Sung-Dong-Gu Seoul, Korea	Kaitech	CA 93592

REPORT NO-APPL. NO	FACTORY NOS	SUBJECT
-1		May 22, 1991 - Series of optoisolators.
-2		January 27, 1994 - Update to -1 for series with variable suffix.
-3		August 24, 1994 - Addition of F2 (Korea).

* * * * * * * * * * *

Canadian Standards Association
Association canadienne de normalisation

CERTIFICATION RECORD

The company named below has been authorized by Canadian Standards Association to represent the products listed in this record as "CSA Certified" or "CSA Accepted", as applicable, and to affix the CSA Mark to these products according to the terms and conditions of the CSA Service Agreement and applicable CSA program requirements (including additional Markings).

NUMBR 093592X0000 August 24, 1994(Replaces:January 27, 1994)

CLASS 9073 30 (Component Acceptance Service)

MOTOROLA INC. 93592
Optoelectronic Products, Signal Products Div.
Motorola Semiconductor Products Sector
5005 E. McDowell Rd.
Phoenix, AZ 85008
FACTORY
F1 CARSEM (M) SND BHD
Jalan Lapagan Terbang
30720 Ipoh
P.O. Box 204
Perak Darual Ridzuan, Malaysia
F2 Motorola Korea Ltd.
445 Kwang-Jang-Dong
Sung-Dong-Gu
Seoul, Korea

OPTO - ISOLATORS - Component

- Opto-isolators: rated 7500V ac dielectric strength and a minimum package dissipation of 400mW; Series;

MOC XXXXX	CNX XXXXX	H1X XXXXX
SOC XXXXX	ILX XXXXX	MCX XXXXX
4NX XXXXX	SLX XXXXX	TIX XXXXX

Where XXXXX are digits, numbers, characters, letters or spaces which specifiy various parametric selections.
Notes:
1. Tests performed: (a) Dielectric; (b) Maximum dissipation; (c) Operating ambient.
2. The CSA Component Acceptance Mark may appear on the device or shipping tube.
3. The dielectric stated refers to the rated peak ac voltage for one minute, unless otherwise indicated.

* * * * * * * * * *

Underwriters Laboratories Inc.®

FPQU2 April 5, 1994
Component – Optical Isolators

MOTOROLA INC OPTO SENSOR & COMMODITY DIV **E54915 (S)**
(B–cont. from A card)

Optical isolated switches.
Type Dome coplanar; Types 4N, CNX, CNY, H11, IL, MC, MOC, OPI, SCS, SOC, TIL, followed by up to five letters or numbers; Types 200-299.
Provides 2500 V ac isolation.
Types 8521-1, 521-2, 521-3, 521-4 with or without prefix MO.
Type 8560, followed by GIFT or JIFT, followed by 5 or 7 with prefix MO.
Provides 4000 V ac isolation.
Type 8634 may be prefixed with MO.
Type 8634, followed by GB with prefix MO.
Provides 5000 V ac isolation.
Types 8321, 8821+ may be followed by -1 through -4 may be prefixed by MO.
Provides 2500 V ac isolation.
Types 8560 followed by A through L, may be prefixed with MO.
Type 8521, followed by -1X, -1GR, -1BL, -1YG, -1GB, -2GB, -3GB, -4BG with prefix MO.

Reports: June 17, 1985; December 10, 1992; April 29, 1993; December 10, 1992; April 29, 1993; December 10, 1992; December 10, 1992; April 29, 1993.

Replaces E54915B dated April 30, 1993. (Cont. on C card)
644714001 **Underwriters Laboratories Inc.®** DII/0115208
10

333 Pfingsten Road
Northbrook, Illinois 60062–2096, USA
708/272–8800
Telex: 6502543343
FAX No. (708) 272–8129

1285 Walt Whitman Road
Melville, L.I., New York 11747–3081, USA
516/271–6200
Telex No. 6852015
FAX No. (516) 271–8259

1655 Scott Blvd.
Santa Clara, California 95050–4169, USA
408/985–2400
FAX No. (408) 296–3256

12 Laboratory Drive
P.O. Box 13995
Research Triangle Park,
North Carolina 27709–3995, USA
919/549–1400
Telex No. 4937928
FAX No. (919) 549–1842

Zeichengenehmigungs-Ausweis der VDE-Prüfstelle Nr. 62054 Blatt 1

VDE-Prüfstelle, Merianstraße 28, D-6050 Offenbach

Nur gültig mit umseitigen Bedingungen

Name und Sitz des Zeichengenehmigungs-Inhabers

Motorola Inc., High Frequency and Optical Product Div., 5005 East McDowell Road USA Phoenix, AZ 85008

Fertigungsstätte

-AC- A. L. Khor, Prod. MGR., Carsem (M) Sdn. Bhd., Jalan Lapangan Terbang, MAL Ipoh,

Zeichen des Antragstellers	Antragsdatum	Aktenzeichen		Ausstellungsda
H. Gempe	18.07.89	12605-4880-1005/A1G	Be/gö/ba	25.04.19

VDE-Zeichen: Statistik

Beschreibung: Jah gebü Einh

Geprüft nach DIN VDE 0884/08.87

Opto-Elektronisches Koppelelement

Typenbezeichnung: MOC XXXXX, SOC XXXXX, 4NX XXXXX, H1X XXXXX, MCX XXXXX, TIX XXXXX, CNX XXXXX, H7X XXXXX, ILX XXXXX 66

X are digits, numbers, characters, letters or spaces which specify chips and the various parametric selections.

Klimatische Prüfklasse: (DIN IEC 68 Teil 1)	55/100/21
Isolationsspannung U_{IORM}:	800 V (Scheitelwert)
Höchste zulässige Überspannung: (Transiente Überspannung) U_{TR}	6000 V (Scheitelwert)
Verschmutzungsgrad: (DIN VDE 0109/12.83)	2
Kriechstrecke zwischen Sende- und Empfangsteil:	> 7,5 mm
Luftstrecke zwischen Sende- und Empfangsteil:	> 7,5 mm
Kriechstromfestigkeit:	CTI 175 (Isolierstoffgruppe IIIa nach DIN VDE 0109)
Betriebstemperaturbereich:	-55 Cel ... +100 Cel
Lagertemperaturbereich:	-55 Cel ... +150 Cel

Zeichengenehmigungs-Ausweis der VDE-Prüfstelle Nr. 62054 Blatt 2

VDE-Prüfstelle, Merianstraße 28, D-6050 Offenbach

Nur gültig mit Blatt 1 und etwaigen Folgeblättern

Name und Sitz des Zeichengenehmigungsinhabers

Motorola Inc., High Frequency and Optical Product Div., 5005 East McDowell Road USA Phoenix, AZ 85008

Fertigungsstätte

-AC- A. L. Khor, Prod. MGR., Carsem (M) Sdn. Bhd., Jalan Lapangan Terbang, MAL Ipoh,

Zeichen des Antragstellers	Antragsdatum	Aktenzeichen		Ausstellungsdatum
H. Gempe	18.07.89	12605-4880-1005/A1G	Be/gö/ba	25.04.1990

Beschreibung: Statistik 1 — Jahresgebühre Einheit

Fortsetzung von Blatt 1 — Übertrag 66

Sicherheitsgrenzwerte: (unter Zugrundelegung der Derating Kurve)	Eingang	Ausgang
Strom I_{si}	350 mA	---
Leistung P_{si}	---	800 mW
Temperatur T_{si}	175 Cel	

Weitere Einzelheiten: Anlage Nr. 1

66
====

VDE-Prüfstelle
Abt. TB

i. A.

Willy Bergmann

Verband Deutscher Elektrotechniker (VDE) e.V.
VDE-Prüfstelle

Genehmigung

zum Benutzen der umseitig abgebildeten, gesetzlich geschützten Verbandszeichen.

Die Zeichengenehmigung gilt nur für die umseitig bezeichnete Firma und die angegebenen Fertigungsstätten. Sie kann allein von der VDE-Prüfstelle auf Dritte übertragen werden.

Das Recht zum Benutzen der umseitig abgebildeten Verbandszeichen erstreckt sich nur auf solche Erzeugnisse, die den umseitig aufgeführten — von der VDE-Prüfstelle untersuchten und anerkannten — entsprechen.

Die Zeichengenehmigung gilt nur für vollständige, gebrauchsfertige Erzeugnisse, sofern nicht von der VDE-Prüfstelle Abweichungen hiervon ausdrücklich gestattet sind.

Alle Erzeugnisse, für die das Verbandszeichen benutzt wird, müssen mit dem der VDE-Prüfstelle gemeldeten und von dieser anerkannten Firmenzeichen (Ursprungszeichen) versehen sein. Verbandszeichen und Firmenzeichen sind stets gemeinsam auf oder in den gleichen Teilen — möglichst in der gleichen Weise — haltbar und deutlich sichtbar anzubringen.

Der Inhaber der Zeichengenehmigung ist verpflichtet, die Fertigung der mit dem Verbandszeichen versehenen Erzeugnisse laufend auf Übereinstimmung mit den VDE-Bestimmungen zu überwachen und insbesondere die in den VDE-Bestimmungen festgelegten oder von der VDE-Prüfstelle geforderten Kontrollprüfungen ordnungsgemäß durchzuführen.

Für die Zeichengenehmigung gelten außer den vorgenannten Bedingungen auch alle übrigen Bestimmungen des Allgemeinen Vertrages. Sie hat solange Gültigkeit, wie die VDE-Bestimmungen gelten, die der Prüfung zugrunde gelegt worden sind, sofern sie nicht auf Grund der Bedingungen des Allgemeinen Vertrages früher zurückgezogen werden muß.

Dieser Zeichengenehmigungs-Ausweis muß der VDE-Prüfstelle zurückgegeben werden, wenn er für ungültig erklärt worden ist.

Verband Deutscher Elektrotechniker (VDE) e.V.
VDE-Prüfstelle

i. V. [signature] i. V. [signature]

BRITISH APPROVALS BOARD FOR TELECOMMUNICATIONS
Claremont House
34 Molesey Road
Hersham
Walton on Thames
Surrey, KT12 4RQ

Certificate of Recognition

No. CR/ 0117

This is to certify

MOTOROLA INCORPORATED

of 5005 EAST MCDOWELL ROAD, PHOENIX, ARIZONA, 85008, USA

is authorised to use this Certificate of Recognition in relation to the type of Device set out in the first section of the Schedule hereto produced in accordance with the standard set out in the third section of the said Schedule and bearing the unique number set out in the second section of the said Schedule. This Certificate is issued subject to and in accordance with the Certificate of Recognition Regulations. The purpose of this certificate is the avoidance of duplicate testing of Devices used with a variety of types of apparatus submitted for approval under the Telecommunications Act 1984 and does not imply compliance with any other legal requirements to which the type of Device may be subject.

Dated this 9th **day** July **19** 93 (Replacement)

Director
British Approvals Board for Telecommunications

SCHEDULE	
1st Section Designated Type of Device	
RANGE OF OPTOISOLATORS	
2nd Section Device Unique Recognition Number with Details of Identification	3rd Section
Packaging marked with device identity codes as detailed overleaf (10/08/93).	Clauses of BS6301:1989 and BS EN41003:1991 as endorsed overleaf.

THIS CERTIFICATE IS NOT TRANSFERABLE AND REMAINS THE PROPERTY OF THE BRITISH APPROVALS BOARD FOR TELECOMMUNICATIONS

This Certificate covers the following Part Numbers: (10/08/93)

MOCxxxxx	MCx xxxxx	CNx xxxx	H1x xxxxx
4Nxxxxxx	TIx xxxxx	SOCxxxxx	TLPxxxxx

This Certificate does not certify the following Part Numbers: (10/08/93)

H11G1xxxx	H11G2xxxx	H11G3xxxx	H11G4xxxx
SOC1022	SOC2700S		
SOC1023	SOC2700SR2		
SOC2700	SOC2700T		
SOC2700F	SOC381		
SOC2700L	SOC857		

Tests have been carried out against the following standards:

BS6301:1989 Clauses:

3.2.1.2; 3.2.1.3(b); 3.2.3.2; 3.5.2.

BS EN41003:1991:Clauses:

4.2.1; 4.2.3(a); 4.4.2; 4.5.1.

Notes Relating To Use

1) Tests against any of the above clauses may be repeated on any host apparatus containing the components where, in the opinion of BABT, the implementation could affect the results obtained.

2) When used as described in the application notes, the component may be used to provide a reinforced barrier as defined in BS6301:1989 and indicated by the above clauses, for a barrier voltage of 250 Volts a.c. r.m.s. at 50Hz.

3) Products incorporating the component will require assessment against the requirements of the relevant product standards except insofar as the means of application of the component confers compliance with the clauses listed above.

4) This certificate applies to devices manufactured subsequent to the 1st July 1993. All devices bear a Motorola date code "XXYY" where "XX" is the year and "YY" is the week of manufacture e.g. 9326 is week ending 2nd July 1993.

FIMKO(FI)

Lehti / Blad / Leaf 1 (2)

Viitteenne - Er ref. - Your ref.	Kirjeenne - Ert brev - Your letter	Käsittely - Handläggning - Handling	Luettelointinumero - Reg. nummer - Reg.nr
	1995-01-20	AE laboratory	757-180470-09

Tehtävänantaja - Uppdragsgivare - Applicant	Valmistaja/Valmistuttaja - Tillverkare/Tillverkad för - Manufacturer/manufactured for
045829 Motorola Inc. M/D Z200 5005 E McDowell Road PHOENIX, AZ 85008,USA	016010 Motorola Korea Ltd 445 Kwang-Jang-Dong Sung-Dong-Gu SEOUL, KOREA

CERTIFICATE

41990	**OPTOCOUPLER**	
01	Type MOC.....	"MOTOROLA"
02	Type SOC.....	"MOTOROLA"
03	Type 4N.....	"MOTOROLA"
04	Type H1.....	"MOTOROLA"
05	Type MC.....	"MOTOROLA"
06	Type TI.....	"MOTOROLA"
07	Type CN.....	"MOTOROLA"
08	Type H7.....	"MOTOROLA"
09	Type IL.....	"MOTOROLA"

Other information: The component fulfils the requirement of reinforced insulation.

The component has been tested with relevant parts of standard EN 60950 (1992), Am. 1 (1993), Am. 2 (1993) and EMKO-TSE(74-SEC)207/94.

Thermal cycling test according to clause 2.9.5 has been carried out ten times for the component at 100°C/25°C/0°C/25°C. Humidity treatment of 48 h as well as electric strength tests at 3 000 V/1 minute and 10 000 V/1 minute were carried out to the component after thermal cycling tests.

* Distance through insulation between input and output is more than 0.4 mm; measured a minimum of 0.5 mm.

* External creepage distances and clearances between input and output are more than 5 mm/4 mm.

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Fax -358-0-6925474

Erityistunnusten merkitykset kääntöpuolella.
Specialkodernas betydelser på omstående sida.
Meanings of special codes on the backside.

FIMKO(FI)

Lehti Blad Leaf 2(2)

Viitteenne - Er ref. - Your ref.	Kirjeenne - Ert brev - Your letter	Käsittely - Handläggning - Handling	Luettelointinumero - Reg. nummer - Reg.nr
	1995-01-20	AE laboratory	757-180470-09

Tehtävänantaja - Uppdragsgivare - Applicant
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Motorola Inc.
M/D Z200
5005 E McDowell Road
PHOENIX, AZ 85008,USA

Valmistaja/Valmistuttaja - Tillverkare/Tillverkad för - Manufacturer/manufactured for
016010
Motorola Korea Ltd
445 Kwang-Jang-Dong
Sung-Dong-Gu
SEOUL, KOREA

- There is not internal creepage distance between input and output.
- Insulation between the input and output withstands electric strength test of 3 000 V/1 minute; it withstands even electric strength test of 10 000 kV/ 1 minute.
- Enclosure of the component withstands electric strength test of 1 500 V/ 1 minute and it fulfils the requirement of basic insulation.

Further information regarding this test result is given by Soili Martikainen and Timo Siionsaari.

Helsinki, January 20, 1995.

ELECTRICAL INSPECTORATE
FIMKO

Soili Martikainen

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Erityistunnusten merkitykset kääntöpuolella.
Specialkodernas betydelser på omstående sida.
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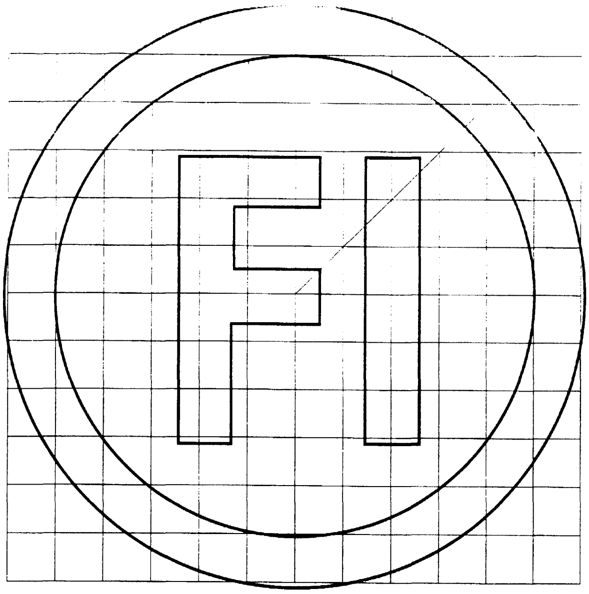
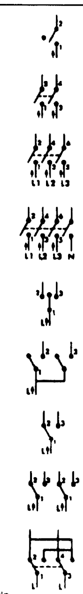


ERITYISTUNNUSTEN MERKITYKSET – SPECIALKODERNAS BETYDELSER – MEANINGS OF SPECIAL CODES

Kytkentä-Koppling-Connection (SFS 4598)



1.	
2.	
3.	
03.	
4.	
5.	
6.	
6.2	
7.	
8.	säätökytkin
9.	reglerström-
10.	ställare
11.	regulating
12.	switch
___ Y	Ryhmäjohdon jatkamiseen Med över-kopplings-klämmor Terminals for looping in

Väri-Färg-Colour (IEC 757)

TT	väritön transparent
WH	valkoinen vit white
GY	harmaa grå grey
BK	musta svart black
RD	punainen röd red
GN	vihreä grön green
GNY	= vihreä/keltainen grön/gul green and yellow
YE	keltainen gul yellow
BU	sininen blå blue
BUL	vaaleansininen ljusblå lightblue
BN	ruskea brun brown
OG	oranssi orange
VT	violetti violett
PK	vaaleanpun. ljusröd pink
GD	kulta guld gold
TQ	turkoosi turkos turquoise
SR	hopea silver
ALL	kaikki värit alla färger all colours

Aine-Material

NK	kumi gummi rubber
SIR	silikonikumi silikongummi silicon rubber
PTS	kertamuovi härdplast plastic, thermosetting
PF	fenolimuovi fenolplast
PTP	kestomuovi termoplast plastic, thermoplastic
PE	polyeteeni polyethylene
PVC	polyvinylchloride
PA	nylon
PP	polypropen
PC	polykarbonate
CM	keraaminen keramisk ceramic
Fe	teräs stål steel
Cu	kupari koppar copper
Al	alumiini aluminium
X	ruostumaton teräs rostfritt stål stainless steel
G	valuteräs gjutjärn cast iron
Ms	messinki mässing brass
Sn	tina tenn tin
Cr	kromi krom chrome
Zn	sinkki zink
Ag	hopea silver
Pb	lyijy bly lead

Aukot-Införingsöppningarna-Openings

N	aihio utbrytningsöppning pre-pressed
P	kierteitetty gängad threaded
R	kalvotiiviste membrantätning membran
T	putkimuhvi rörmuff conduit entry
V	holkkitiiviste hylsakruvtätning cable gland
F	laippa fläns flange

Koteloinitiluokka-Kapslingsklass-Protection provided by enclosure

IP..	SFS 2972/IEC 529 mukaisesti SFS 2972/IEC 529 according to IEC 529/SFS 2972
ORDIN	kosketussuojainen beröringsskyddad ordinary
UNPRO	suojattava för inbyggnad unenclosed
DRIP	tippuvedenpitävä droppskyddad drip-proof
RAIN	sateenpitävä regnskyddad rain-proof
SPLAS	roiskevedenpitävä sköljtät splash-proof
JET	suihkuvedenpitävä spolsäker jet-proof
DUSTP	pölynsuojainen dammskyddad dust-protected
DUSTT	pölynpitävä dammtät dust-tight
IMMER	vedenpitävä vattentät watertight
SUBME	painevedenpitävä tryckvattentät pressurewater-tight

VDE Approved Optoisolators

VDE has approved Motorola's entire portfolio of 6–pin DIP optoisolators against their new components standard VDE 0884 which replaces VDE 0883. The VDE 0884 components standard requires additional electrical testing to a stringent isolation partial discharge test.

The VDE 0883 specification expired 12/31/91. Motorola optoisolators can now be ordered to comply with the VDE 0884 specification.

VDE approval is based on mechanical and electrical performance of the Motorola package, shown in Figure 3. This 6–Pin DIP package incorporates specially developed materials and assembly processes optimizing thermal and moisture stability while maintaining the high level of LED life and isolation voltage. All Motorola 6–pin DIP optoisolators are made in this package, and have these approvals.

VDE 0884 Component Standard (replaces VDE 0883)

Electrical ratings in this standard are:
Input–to–Output Voltage, 1 second
V_{Pr1} = 1.6 V_{IDRM}, Partial Discharge < 5 picocouloumbs, V_{Pr1} = 1280 V(pk)
Maximum operating peak voltage, V_{IDRM} = 800 V(pk)
Isolation resistance: $V_{I–O}$ = 500 Vdc, 10^{11} Ω, T_A = 100°C.
Note: The isolation partial discharge test V_{Pr1}, is performed after the completion of the high voltage withstand (hipot) tests.

VDE 0883 Component Standard (expired 12/31/91)

Electrical ratings in this standard were:
Isolation withstand voltages:
3750 V_{RMS}, 1 min, T_A = 100°C
5300 Vdc, 1 min, T_A = 100°C
Isolation surge withstand voltage:
10 kV per IEC 65, 50 discharges
Isolation resistance:
10^{11} Ω, 500 Vdc, T_A = 100°C

NOTE: **VDE 0884/8.87 testing is an option**; the suffix letter "V" must be added to the standard part number. (See below.)
Standard thru hole — MOC3063V
0.4″ wide spaced leadform — MOC3063TV (to satisfy 8 mm spacing requirement)
Standard–profile surface mount — MOC3063SV
Tape and Reel for surface mount — MOC3063S/SR2V

Optoisolators, a block diagram of which is shown in Figure 1, are devices which contain at least one emitter, which is optically coupled to a photo–detector through some sort of an insulating medium. This arrangement permits the passage of information from one circuit, which contains the emitter, to the other circuit containing the detector.

Because this information is passed optically across an insulating gap, the transfer is one–way; that is, the detector cannot affect the input circuit. This is important because the emitter may be driven by a low voltage circuit utilizing an MPU or logic gates, while the output photo–detector may be part of a high voltage dc or even an ac load circuit. The optical isolation prevents interaction or even damage to the input circuit to be caused by the relatively hostile output circuit.

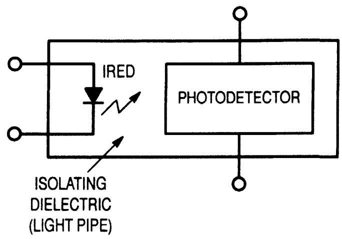


Figure 1. Block Diagram of Optoisolator

Various geometric designs have been used over the years for the internal light cavity between the emitter and detector. Motorola is the industry leader in isolation technology. All 6–pin optoisolators are guaranteed to meet or exceed 7500 Vac (pk) input–to–output isolation. See Figure 2.

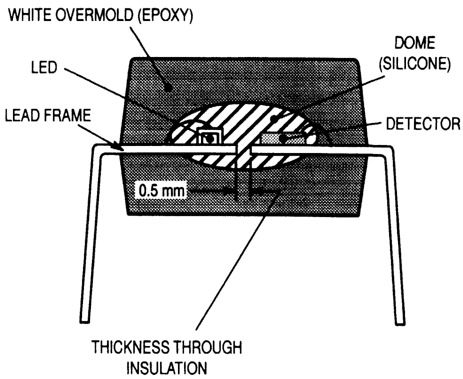


Figure 2. Geometric Design for Optoisolators

VDE Approved Optoisolators (continued)

Equipment Standards Compliance

With the approval of the Motorola package to these component standards, combined with its VDE approval ratings, a wide range of Equipment Standards are covered. The table below summarizes these Equipment Standard coverages.

Two levels of electrical interface, or insulation, are used: 1. Reinforced, or safe, insulation; 2. Basic insulation.

Reinforced Insulation (sometimes referred to as "safe" electrical isolation) is required in an optoisolator interfacing between a hazardous voltage circuit, like an ac line, and a **touchable s**afe **e**xtra **l**ow **v**oltage (SELV) circuit.

Basic Insulation is required in an optoisolator which interfaces between a hazardous voltage circuit and a **non–touchable, e**xtra **l**ow **v**oltage (ELV) circuit.

The 6–pin DIP optoisolators are suitable for both levels of electrical interface. The smaller SOIC–8 optoisolators comply with basic Insulation standards only.

Mechanical ratings are shown in the table below.

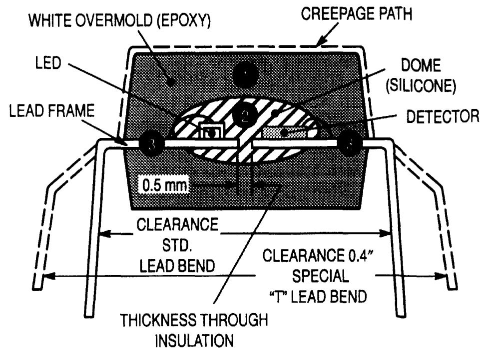


Figure 3. "DOME" Package

Examples for Safety Applications for Motorola VDE Approved Optoisolators

Standard (2)			Requirements for reinforced (double) or safe insulation for equipment with an operating voltage up to 250 Vrms (line voltage to ELV or SELV interfaces)				
VDE (5)	DIN IEC	Equipment	Creepage	Clearance (1)	Isolation Barrier	Dielectric Strength	Isolation Resistance
			[mm]	[mm]	[mm]	[kV RMS]	[Ω]
0806	950	Office Machines	8.0	8.0	0.4	3.75	7 x 10^6
0805	950	Data Processing	8.0	8.0	0.4	3.75	7 x 10^6
0804	—	Telecommunication	8.0	8.0	—	2.5	2 x 10^6
0860	65	Electrical Household	6.0	6.0	0.4	3.0 (10)*	4 x 10^6
0113	204	Industrial Controls	8.0	8.0	—	2.5	1 x 10^6
0160	—	Power Installations with Electronic Equipment	8.0	8.0	—	2.7	1 x 10^6
0832	—	Traffic Light Controls	8.0	8.0	—	2.5	4 x 10^6
0883	—	Alarm Systems	8.0	8.0	—	2.5	2 x 10^6
0831	—	Electrical Signal System for Railroads	8.0	8.0	—	2.0	2 x 10^6
0110	—	General Std. for Electrical Equipment	8.0	8.0	—	2.0	—
0883	—	Optoisolator Component Standard (obsolete 12/31/91)	8.5	8.3 (10) (1)	0.5	3.75 (10)*	10 x 10^{11}
0884(4)	—	Optoisolator Component Standard (replaces VDE0883)	>7.5	>7.5	0.5	—	10 x 10^{12}
			VDE Rating for Motorola 6–pin DIP Optoisolators				

All Motorola 6–pin DIP Optoisolators meet or exceed the requirements of above listed VDE and DIN IEC Standards.

* Impulse discharge withstand voltage.

(1) To satisfy 8.0 mm creepage path on a PC board Motorola offers a special lead bend of 0.4 inch on all 6–pin dual in–line optoisolators. Order by attaching "T" to the end of the Motorola part number.

(2) VDE standards (translated into English language) and IEC standards can be ordered from the American National Standard Institute ANSI, 1430 Broadway, N.Y., N. Y. 10018, Sales Department, 212–642–4900.

(3) Creepage path distances are measured from lead to lead across the top, bottom and ends of the package body.

(4) VDE 0884 testing is an option; the suffix letter "V" must be added to the standard number.

(5) For more information regarding the use of VDE approved devices, refer to "VDE Circuit Board Layout Design Rules" in the Applications Information section.

VDE 0884 Approved Optocouplers

Prepared by: Horst Gempe
Discrete Applications Engineering

INTRODUCTION

In mid–1990 Motorola received VDE 0884 approval for all optocouplers in a dome package. This opens an even wider range of safe isolation applications than with the former approval against VDE 0883. For example, optocouplers which have VDE 0884 approval are now accepted in appliances, and it is expected that many other equipment standards will follow.

VDE 0884 is a new optocoupler standard for safe isolation. In many parts it has the same tests as the older VDE 0883 optocoupler standard, but there are two significant additions in safety philosophy which make this standard unique against all others. These additions are the introduction of the partial discharge test and the specification of the safety temperature, current and power dissipation ratings. Both contribute to an even safer isolation and avoid confusion of worst case conditions in order to still guarantee the safe isolation of optocouplers over the lifetime of the equipment.

Many parameters and classifications of this new optoisolator standard are harmonized with the newest basic safety standards such as isolation coordination standards VDE 0109, IEC664, and IEC664A, as well as equipment standards such as those for office machines and data processing equipment DIN/IEC950.

These new standards define and classify the environment to which the insulation system is exposed. The major new variables are the installation category and the pollution degree. Optocouplers are now rated to these new criteria. VDE plans to incorporate the partial discharge criterion into the basic standards, as well as into the individual equipment standards in the near future.

While the new standards are much better defined than the older ones, they demand intimate knowledge from the equipment designer about all conditions to which the equipment is exposed and detailed information about the safety parameters and ratings of the optoisolator.

This application note informs the user of Motorola optoisolators about the VDE safety ratings, classification and performance, and gives guidance in applying these ratings to the requirements of the individual equipment standards.

VDE Data Sheet

Table 1 shows the Motorola Dome Optocouplers for safe electrical isolation in accordance with VDE 0884.

Table 1. VDE 0884 Ratings for Motorola Dome Optocouplers – VDE Approval Document No. 62054

Description	Symbol	Rating	Unit
Installation category (DIN VDE 0109, 12/83, Table 1)			
Rated line voltage < 600 V_{rms}	—	I to III	—
Rated line voltage < 300 V_{rms}	—	I to IV	—
Climatic category (DIN IEC 68 part 1/09.80)	—	55/100/21	—
Pollution degree (DIN VDE 0109, 12 /83)	—	2	—
Creepage path between input and output	—	> 7.5	mm
Clearance between input and output	—		
Standard leadform 0.3″	—	> 7.5	mm
Special leadform 0.4″	—	> 10	mm
Thickness through insulation (insulation barrier)	—	0.5	mm
Comparative tracking index (DIN IEC 112/VDE 303 part 1/ 06.84)	CTI	175	—
Isolation group per VDE 0109	—	IIIa	—

Table 1. VDE 0884 Ratings for Motorola Dome Optocouplers – VDE Approval Document No. 62054 (cont)

Description	Symbol	Rating	Unit
Isolation resistance at VI/O = 500 Vdc			
T_A = 25°C	R_{iso}	10^{12}	Ω
T_A = 100°C	R_{iso}	10^{11}	Ω
T_A = 175°C	R_{iso}	10^{9}	Ω
Maximum operating peak voltage	V_{IORM}	800	Vpk
Production input to output test voltage, 1 second V_{pr1} = 1.6 x V_{IORM}, Partial discharge < 5 pC	V_{pr1}(1)	1280	Vpk
Qualification input to ouptut test voltage, 1 minute V_{pr2} = 1.2 V_{IORM}, Partial discharge < 5 pC	V_{pr2}(1)	960	Vpk
Maximum transient overvoltage V_{tr} = 10 seconds Qualification Test	V_{tr}	6000	Vpk
Operating Temperature	T_A	–55 to +100	°C
Storage Temperature	T_{stg}	–55 to +150	°C

Maximum Safety Temperature, Power and Current Ratings In Case of a Single Fault Condition

Description	Symbol	Rating	Unit
Maximum package safety temperature	T_{si}	175	°C
Maximum LED safety input current, P_{si} = 0, T_A = 25°C (Linear derate from 25°C to zero at T_A = T_{si} = 175°C)	I_{si}	400	mA
Maximum detector safety power dissipation, T_A = 25°C (Linear derate from 25°C to zero at T_A = T_{si} = 175°C)	P_{si}	800	mW

1. The isolation partial discharge tests V_{pr1}, V_{pr2} in accordance with VDE 0884 are performed after high voltage withstand (hipot) tests.

Explanation of VDE 0884 ratings

Installation Category

The four installation categories are based on the principles of insulation coordination as found in VDE 0109 and IEC 664. These standards categorize and specify the expected line transients to earth ground within an ac line installation and distribution system.

The highest transients are expected at installation category four, which is the primary supply level from overhead lines or underground cable systems and its associated spark gap and over-current protection equipment. The locations are the main fuse and the service entrance. For a 380 V ac rms system, the peak transient voltage may be up to 6000 V_{pk}.

Installation category three follows installation category four and is the fixed electrical installation with its individual circuit breakers for each branch within a building. For a 380/220 V_{rms} installation peak, transients of 4000 V are expected.

Installation category two is portable equipment such as appliances which use the outlets of the fixed electrical installation. Transients of up to 2500 Vpk are expected.

Installation category one is special equipment or individual circuits within portable equipment which operate on the secondary voltage of a power supply or transformer with max 60 V ac or dc peak. Examples are telecommunication, data processing and other electronic equipment. Even in these cases, transients of up to 500 Vpk in respect to earth ground are possible, unless transient suppression is provided.

Climatic Category 55/100/21

These numbers specify the environmental condition for the approval test. The temperature range is –55 to +100°C with a 21–day humidity soak.

Pollution Degree

There are four pollution degrees. Pollution degree one specifies non-conductive or only dry non-conductive pollution which is found inside most electronic equipment in a controlled environment such as an office.

Pollution degree 2 assumes normally dry, non-conductive pollution with occasional temporary conductivity caused by condensation. Examples are appliances like washers, dishwashers and equipment in non-temperature controlled environments.

Pollution degree three has expected conductive pollution, and pollution degree four assumes persistent conductive pollution as found in an outside environment such as rain or snow.

Creepage and Clearance

The creepage path is the shortest distance on the surface of the optocoupler package between input and output leads. The clearance is the shortest distance between input and output leads through air. A special lead bend is available which increases this distance and guarantees an adequate creepage part on the circuit board.

Comparative Tracking Index

This index indicates a insulator's withstand capability to surface deterioration caused by sparks or leakage currents over the creepage path. This may be the case when conductive pollution occurs. CTI is a relative number and is used to compare insulation materials. The higher the number, the better the resistance to deterioration. Glass and ceramics are very resistant and have a CTI of >600. Some circuit board materials are <100.

Isolation Group

The isolation group characterizes insulators to their resistance to tracking. Insulators which remain unaffected by the CTI test belong to isolation group I; insulators which erode or decompose with carbon residues are found in isolation group III.

- CTI –rating   Isolation group
- ≥600   I
- 100–600   II
- 175–400   IIIa
- 100–175   IIIb

Isolation Resistance

In the qualification test this parameter is measured after the environment's 21-day humidity soak and a short surface dry at ambient temperature at 500 Vdc, and at the maximum safety temperature T_{si} = 175°C. Motorola tests this parameter in production during the transient withstand test (hipot test).

Maximum Operating Peak Voltage V_{IORM}

This is the maximum repetitive peak voltage for safe isolation. In some equipment, it is not necessarily the peak line voltage. Switching power supplies, for example, may develop repetitive peak voltages between primary and secondary circuits exceeding the ac peak voltage by superimposing inductive voltage transients of the flyback transformer onto the line voltage.

Safe isolation of the insulation material is guaranteed when the optocoupler is operated within this rating, since partial discharge which might destroy the insulation barrier is guaranteed not to be present.

Partial Discharge Test Voltage V_{pr1} and V_{pr2}

Partial discharge is a corona discharge in a part of the insulation barrier caused by voids or locally high electrical field gradients. Partial discharge may decompose or erode the insulation material over time and lead to a permanent insulation failure. The VDE 0884 safety philosophy demands that the peak repetitive operating voltage is lower than the partial discharge initiation and extinction voltage of the optocoupler, thus avoiding the cause of an isolation degradation or breakdown over time. All optocouplers have to pass a partial discharge test at 1280 V ac peak for one second. During this time the device is monitored for partial discharge by a highly sensitive narrow band RF circuit and the device is rejected when a partial discharge activity of 5 pico couloumbs or larger is recorded.

Maximum Transient Overvoltage, V_{tr}

This is the classical hipot test which may lead to erosion, decomposition and consequent breakdown of the insulation barrier when the device is exposed over a long period of time. The qualification test is 10 seconds and must be considered to weaken the insulation barrier.

Many standards still demand the hipot test. To comply with these standards, Motorola tests 100 percent of all optocouplers for one second to a minimum of 6000 V ac peak (4200 V ac rms), while monitoring the leakage current. After this test, the devices have to pass the 1 second partial discharge test.

Maximum Safety Temperature, Power and Safety Ratings

The user of the optocoupler has to take care that the device is never operated above the specified maximum safety values. These ratings exceed the maximum ratings for proper electrical function of the part. The safety ratings only guarantee safe isolation under a single failure mode; they do not mean normal operating conditions.

Partial Discharge Theory and Test

The partial discharge only bridges a part of the insulation barrier between two conductors. These discharges may be adjacent to one of the conductors or within the insulation barrier. They may occur in cavities within the insulation or in layers with different dielectric properties. Sharp edges on conductors, cavities in solid insulation, or air gaps between a conductor and the insulation material, and layers with different dielectric materials do create highly localized electrical fields which lead to discharges. The energies of these discharges are very small, but over time they may lead to progressive deterioration of the dielectric properties of the insulation barrier until breakdown occurs. The length of time to destruction of the insulation barrier depends on the discharge energies involved and the insulation materials withstand capability to the discharges.

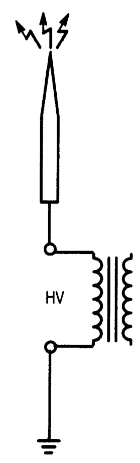


Figure 1a. Corona Discharge on a Needle Point

Figure 1a shows that corona discharge is induced into the air by a sharp needlepoint electrode which creates a high field gradient very close to the point. The voltage necessary to initiate corona discharge depends on the radius of the needle point, the polarity, the properties of the surrounding gas and its pressure. In this example, corona discharges start at 2700 V with positive charge and 2000 V with negative charge into the air at sea level atmospheric pressure and a needlepoint with a curvature radius of ~1 mil. Very sharp needlepoints show discharges already at ~500 V.

Figure 1b shows corona, or partial discharge between two glass plates. Since this discharge finds place only within a part of the insulation barrier, it is defined as partial discharge. The electrical field gradient in the air between the glass plates is much higher than within the glass plates because of the difference of the dielectric constant between glass and air. This arrangement is used to produce ozone, which demonstrates the resistance of glass to corona discharge.

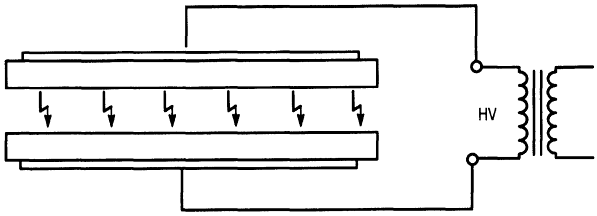


Figure 1b. Corona Discharge Between Two Glass Plates

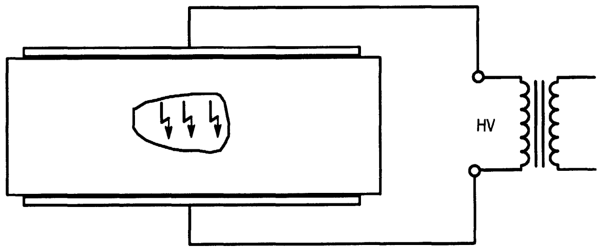


Figure 1c. Corona Discharge in the Void of an Insulator

Figure 1c shows a solid insulator with an enclosed void. Corona discharge is initiated in this void by the same mechanism as seen in Figure 1b.

Partial discharge in any test object has measurable quantities such as a charge (q) which is expressed in pico coulombs and a repetition rate (n.) per time unit which could be 1/2 cycle or one second.

Wideband Test Method

Figure 2 shows a simple detection method which consists of a variable partial discharge free high voltage transformer, a current limiting resistor, R1, a coupling capacitor, C1 and a load resistor R2. The partial discharge can be observed directly with an oscilloscope which should have a 100 MHz bandwidth and a sensitivity of 1 mv/div. Partial discharges generate short current pulses with a fast rise time in the ns region which generates a signal on the load resistor. Coupling capacitor C1 is so dimensioned that it appears as a very low impedance to the fast rising discharge pulses. For short discharge pulses, the signal amplitude on the load resistor is proportional to the discharge energy within the device under test.

Narrowband Test Method

In Figure 3, R2 is replaced by an LC resonance tank circuit. The partial discharge pulses generate a dampened oscillatory waveform at the resonance frequency of the tank circuit. The capacitive leakage current of the device under test is now depressed due to the low impedance of the tank circuit at line frequency. Narrowband test methods are used because of their lower noise levels.

Calibration of the Detection Circuit

Discharges within the DUT cannot be directly measured, but they produce a signal on the terminal of the load resistor or LC tank circuit with an amplitude proportional to the discharge energy within the insulation. This energy or charge is defined as the apparent charge q. Apparent charge q can be simulated by charges instantaneously injected into the test circuit. It is now possible to correlate the response of the detection circuit to known charges and calibrate the output response signal amplitude to pico coulombs.

The energy q stored in a capacitor C at a voltage V is:

$$q = V \times C.$$

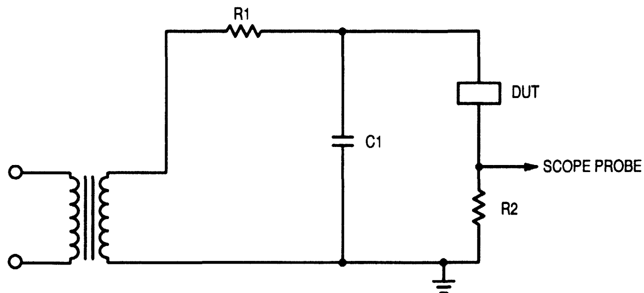


Figure 2. Wideband Partial Discharge Test Circuit

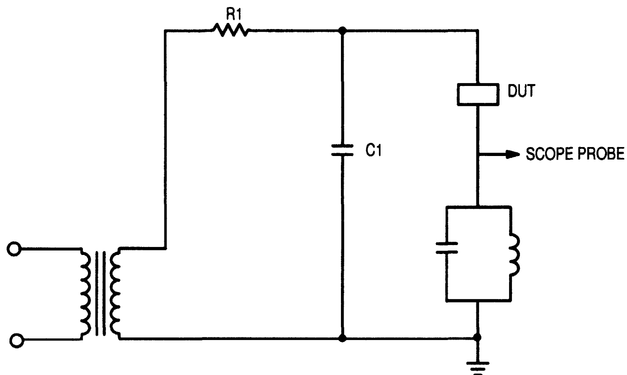


Figure 3. Narrowband Partial Discharge Test Circuit

Figure 4 shows a calibration generator consisting of a known capacitance Cc and a square wave generator with fast rise time (100 ns or less) and a known amplitude Vp and a repetition rate of 120 Hz. Calibration of the entire detection circuit is performed with the high voltage switched off. By choosing Cc = 10 pf and a square generator with an adjustable peak voltage of 0.1 – 10 V, a partial discharge detection systems response can be calibrated from 1 pC to 100 pC.

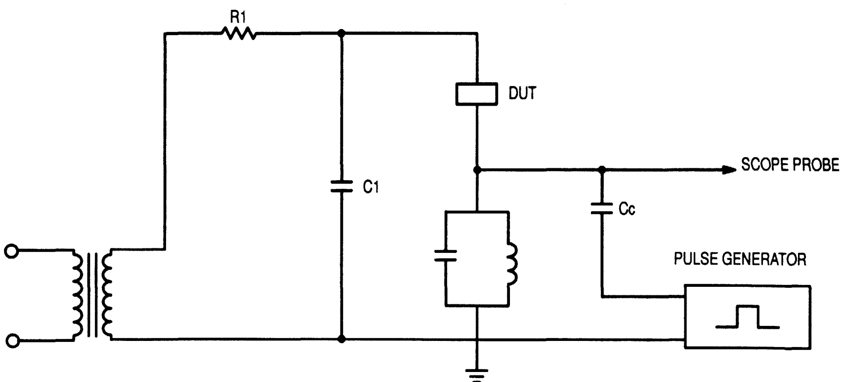


Figure 4. Narrowband Partial Discharge Test Circuit with Calibrator

Partial Discharge Measurement

A very important parameter of partial discharge besides its apparent charge q is the voltage at which it occurs, which is called initiation voltage, and the voltage at which it disappears, which is called extinction voltage. In most cases the extinction voltage is found to be about 10 – 20% lower than the initiation voltage. For measurement of the initiation voltage, the ac voltage of the device under test is slowly raised until partial discharge is observed. When the voltage is raised further, more discharges per half cycle may be observed. Also an increase of the energy of each individual discharge may be noted. By lowering the ac voltage, the discharges will subside and the extinction voltage is found.

Great care must be taken that all high voltage conductors are smooth and without sharp edges. This avoids corona discharge into the surrounding air. Also incomplete galvanic contact to the device under test might lead to micro arcs which falsify the test results. The high voltage transformer must be absolutely free of partial discharge and protected from line transients and noise.

It is important to note that all partial discharge measurements for optocouplers are performed with an ac sinusoidal voltage of 50 or 60 Hz. Measurements of partial discharge with dc voltage show different results in initiation, extinction and repetition rates of the discharges.

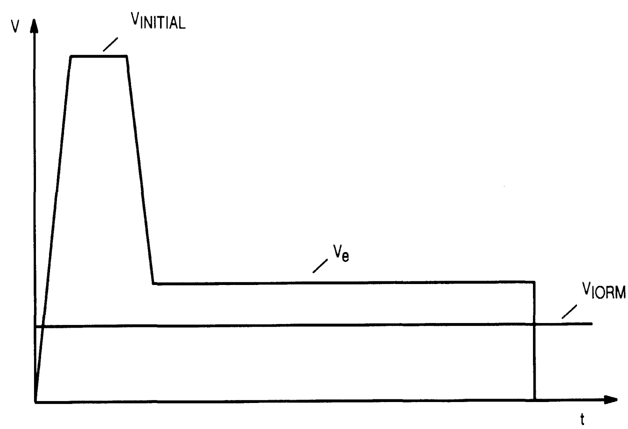
VDE Standard Test Circuit

VDE uses the narrowband test method as shown in Figure 3 and a calibration circuit as shown in Figure 4. The center frequency of the tank circuit may be any value from 150 kHz up to 5 MHz, but the 3 dB bandwidth must be 15 kHz. Tank circuits with the center frequency of the AM IF of 455 kHz are commonly used in combination with a parallel resistor to set the bandwidth. Calibrator rise time is 50 ns max and fall time between 100 – 1000 µs. Coupling capacitor C must be 1 nF or greater. Partial discharge pulses of 1 pC must still be detectable.

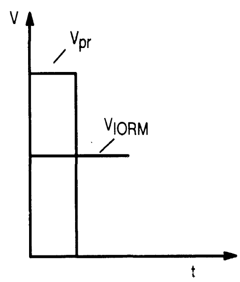
VDE Partial Discharge Qualification Test

This test is performed after the environmental stress as described in Chapter 5 VDE qualification, test lot 1. The ac voltage is raised with 100 V/sec. to $V_{initial}$, which is the maximum transient withstand voltage V_{tr} specified by the manufacturer, and applied for 10 seconds. Partial discharge may occur under this condition. The voltage is then lowered to the manufacturer's specified voltage V_{pr2}, (which is 20% higher than the specified operating voltage) and maintained for 62 seconds. Partial discharge is monitored after a settling time of one second. No discharges above 5 pC may occur. See Figure 5.

Voltage curve in the partial discharge voltage measurement.



Voltage curve (ac) for type testing using environmental tests.



Test voltage curve (ac) for routine tests.

Figure 5. Voltage Curve in the Partial Discharge Voltage Measurement

Manufacturer Production Test

The test voltage is suddenly raised to V_{pr1} which is 1.6 times the operating voltage V_{IORM}; partial discharge is monitored for one second. Devices with a partial discharge above 5 pC are rejected.

Explanation of the Comparative Tracking Index (CTI) Test

This test classifies insulation materials to their resistance to deterioration caused by surface leakage currents in the presence of conductive pollutants.

Platinum electrodes are placed onto samples of the mold compound material used for the optocoupler's package. A conductive pollutant consisting of a solution of NH4 Cl and DI water is dropped between two platinum electrodes which are connected to an ac power source and a 0.5 A current circuit breaker. The number of drops which can be applied until the material under test decomposes and forms a conductive creepage path depends on the electrode voltage and the material itself. CTI is the voltage a test specimen can withstand without tracking, which means without tripping the circuit breaker when 50 drops are applied. CTI is found statistically by conducting many tests with different voltages where the amount of drops until the circuit breaker opens are recorded. Short tests for verification of a CTI rating keep the electrode voltage constant. Several samples have to pass 50 drops without signs of tracking.

VDE 0884 Qualification Test

Manufacturers of optocouplers must supply samples to VDE and pass all tests as shown below.

Sample size 80 units

- Visual inspection
- Isolation voltage (@ V_{pr1} = 1.6 V_{IORM})
- Functional test
- Creepage and clearance measurements
- Isolation resistance (@500 Vdc)
- Resistance to solder heat (260°C, 5 sec.)

Lot 1, 20 units

- 5 temperature cycles, dwell 3 hrs. at specified min., max. storage temperature
- Vibration, 10 to 2000 Hz, 0.75 mm, 10 g
- Shock, 100 g, 6 ms
- Dry heat, 16 Hr, T_A = 100°C, V_{iso} = V_{IORM} or min 700 V_{pk}
- 1 humid cycle @ T_A = 55°C
- Cold storage, 2 Hr., @ min. storage temperature
- Humid heat, 21 days, 40°C, RH 93%
- End test after room temp. dry of 6 Hrs. for partial discharge @ V_{IORM} x 1.2, 5 pC max., Isolation resistance 1012 Ω @ 500 Vdc max 25°C
- Isolation surge voltage 10 KV 50 discharges 1 nF
- Isolation resistance min.109 Ω

Lot 2, 30 units

- Input overload safety test, t = 72 hrs., T_A = T_{si}, I = I_{si}
- End test for partial discharge @ V_{IORM}, 5 pC max

Lot 3, 30 units

- Output overload safety test, t = 72 Hrs., T_A = Tsi, P = P_{si}
- End test for partial discharge @ V_{IORM}, 5 pC max

VDE Circuit Board Layout Design Rules

The most demanding and stringent safety requirements are on interfaces between a safety low–voltage circuit [SELV] and a hazardous voltage (240 V power line). The requirements for creepage path and clearance dimensioning are different for each individual equipment norm and also depend on the isolation group and safety class of the equipment and the circuit board's resistance to tracking. Isolation materials are classified for their resistance to tracking creepage current stability from KB 100 to KB $\leq$600 (see VDE 303). On circuit board materials with a low KB value, the creepage path distance requirements are higher than for materials with a high KB value. In the following examples we therefore show creepage path dimensions for KB 100, the lowest value which is easily met by most circuit board materials.

The least stringent requirements on optocouplers, as well as printboard layouts, are within and in between SELV or ELV loops or circuits. (ELV = Electrical Low Voltage which does not meet the safety low voltage requirements.)

In studying the individual equipment norms, the designer will discover that optocouplers are not mentioned in most of the norms. He has to use the requirements for transformers or potted components instead.

Spacing requirements between two live tracks on a PC board within a low or high voltage loop (circuit) should generally meet the VDE requirements for minimum clearance and creepage path dimensions. If they do not, the circuit has to show some sort of current limiting (fuse, high–impedance, etc.) which prevents fire hazard due to an eventual short or sparkover between the two tracks. The VDE testing institute will conduct, in this case, a shorting test and a tracking test (arcing). See VDE 804. Classical cases are rectifiers, thyristors and high–voltage transistors which, sometimes due to their close pinout, might not meet the VDE equipment requirements at a certain voltage.

PRINTED CIRCUIT BOARD LAYOUT FOR SELV–POWER INTERFACES

The circuit board layout examples shown here are dimensioned so that they provide a safe electrical isolation between metal parts carrying line voltage (called Power Interface) and conductors connected to a SELV circuit.

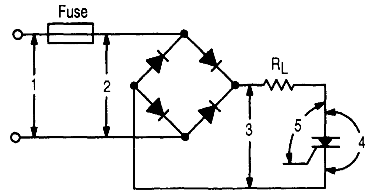
The required thickness through insulation for the optocoupler can be found in the individual VDE equipment norms. (See examples for safety applications, Table 1.)

Many Class I equipment norms permit the use of parts (modules, PC boards) which meet the Safety Class II dimension and isolation requirements. This enables the designer to take advantage of the less complex and space demanding design of the Class II PC board layout also in Class I classified equipment.

Optocoupler Mounting on PC Boards for Safety Class I

SELV transformers for Class I equipment have a Faraday shield which is connected to earth ground between primary and secondary windings. This is **not** applicable to optocouplers, but creepage path and clearance requirements from safety Class II can be applied. Class I also demands an earth ground track on the circuit board between SELV — and power circuit. Applying the Class I rules, this earth ground track should be between the coupler input and output. However, this cannot be done without violating the minimum creepage path and clearance requirements. A possible solution is shown on Figure 9 and Figure 10.

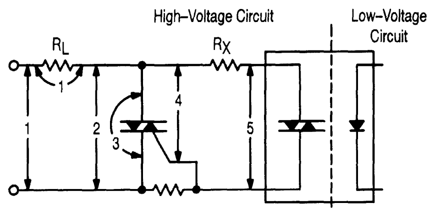
Figure 1.



1 — Clearance and creepage path **must** meet min requirements*
2 — Current limited due to fuse
3, 4 — Current limited due to R_L and fuse
5 — Current limited due to I_{GT}, R_L and fuse

2, 3, 4, 5 — Clearance and creepage path may be smaller than VDE min requirements but **must** meet fire hazard requirements due to short and arcing between the tracks. There shall be no flames or explosion during the test.

Figure 2.



1 Clearance and creepage path **must** meet min requirements*
2 Current limited due to R_L
3 Current limited due to R_L
4 Current limited due to I_{GT}
5 Current limited due to I_{GT} and R_X

* See Table 1 and Appendix Table 2 and 3 for minimum spacings and voltage requirements.

The earth ground track itself has to show a minimum distance to the equipment body (i.e., frame, circuit board enclosure) or to any inactive, active or hazardous track on the circuit board. According to many VDE equipment norms, this creepage path distance for 250 V Max is 4 mm. A mechanically unsecured circuit board which can be plugged in and out without a tool and is electrically connected through a standard PC board connector, has to show an isolation of the earth ground track to Class II, which is 8 mm. This is because a standard PC connector, as shown in Figure 9, does not guarantee earthing contact **before** there is termination of the life 220 V tracks on the circuit board when plugged in. Another reason for increased spacing is when the circuit board metal enclosure is not securely earth grounded. This is the case when the connection is done with the PC module mounting screws through lacquer or oxide layers to a grounded rack or frame. (See Figure 10.) PC board designs per Figures 9 and 10 account for these possibilities and, therefore, show dimensions M, N and A, B and D as 8 mm instead of 4 mm.

Table 1. Examples for Safety Applications for Motorola VDE Approved Optoisolators

Standard (2)			Requirements for reinforced (double) or safe insulation for equipment with an operating voltage up to 250 Vrms (line voltage to ELV or SELV interfaces)				
VDE	DIN IEC	Equipment	Creepage	Clearance (1)	Isolation Barrier	Dielectric Strength	Isolation Resistance
			[mm]	[mm]	[mm]	[kV RMS]	[Ω]
0806	950	Office Machines	8.0	8.0	0.5	3.75	7×10^6
0805	950	Data Processing	8.0	8.0	—	3.75	7×10^6
0804	—	Telecommunication	8.0	8.0	—	2.5	2×10^6
0860	65	Electrical Household	6.0	6.0	0.4	3.0 (10)*	4×10^6
0113	204	Industrial Controls	8.0	8.0	—	2.5	1×10^6
0160	—	Power Installations with Electronic Equipment	8.0	8.0	—	2.7	1×10^6
0832	—	Traffic Light Controls	8.0	8.0	—	2.5	4×10^6
0883	—	Alarm Systems	8.0	8.0	—	2.5	2×10^6
0831	—	Electrical Signal System for Railroads	8.0	8.0	—	2.0	2×10^6
0110	—	General Std. for Electrical Equipment	8.0	8.0	—	2.0	—
0883	—	Optoisolator Component Standard (obsolete 12/31/91)	8.5	8.3 (10) (1)	0.5	3.75 (10)*	10×10^{11}
0884(4)	—	Optoisolator Component Standard (replaces VDE0883)	>7.5	>7.5	0.5	—	10×10^{12}
			VDE Rating for Motorola 6–pin DIP Optoisolators				

All Motorola 6–pin DIP Optoisolators meet or exceed the requirements of above listed VDE and DIN IEC Standards.
* Impulse discharge withstand voltage.

1. To satisfy 8.0 mm creepage path on a PC board Motorola offers a special lead bend of 0.4 inch on all 6–pin dual–in–line optoisolators. Order by attaching "T" to the end of the Motorola part number.
2. VDE standards (translated into English language) and IEC standards can be ordered from the American National Standard Institute ANSI 1430 Broadway, N. Y., N. Y. 10018, Sales Department 212–642–4900.
3. Creepage path distances are measured from lead to lead across the top, bottom and ends of the package body.
4. VDE 0884 testing is an option; the suffix letter "V" must be added to the standard number.

Figure 3. Optocoupler Mounting on PC Boards for Safety Class II with Creepage Path and Clearance

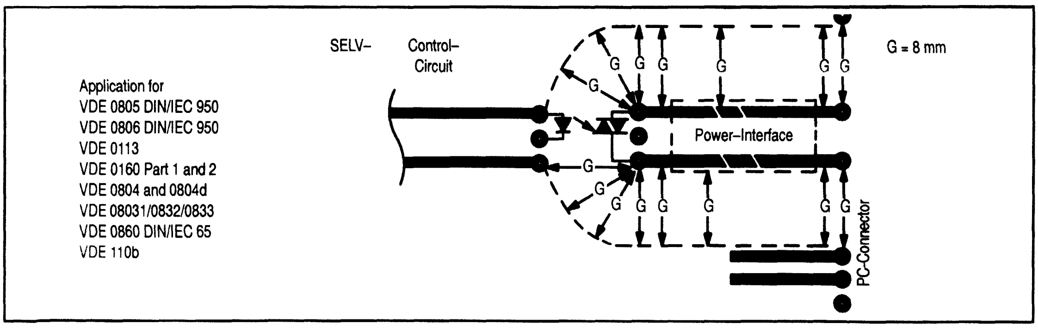
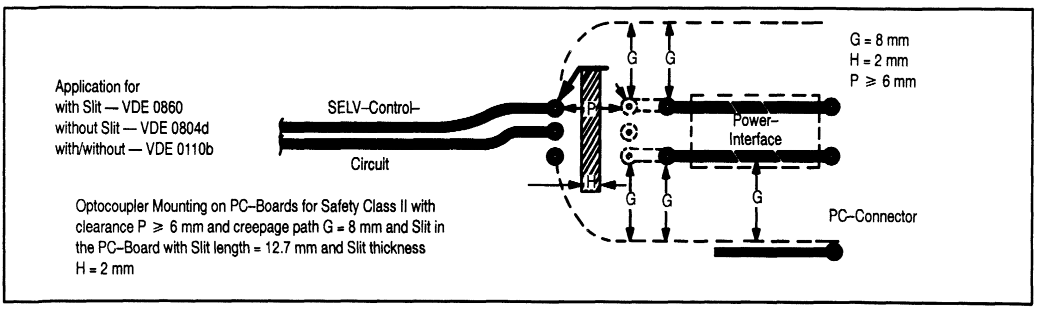
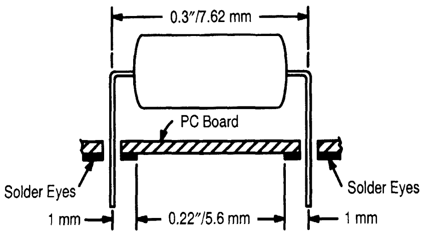


Figure 4. Optocoupler Mounting on PC Boards for Safety Class II with Clearance



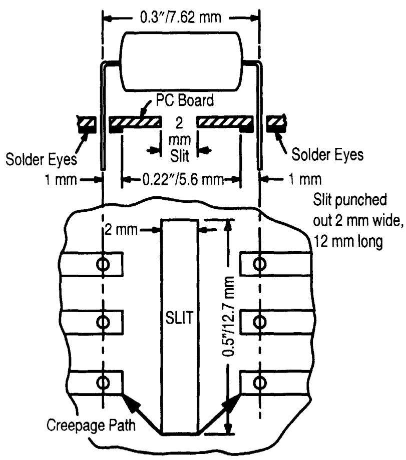
COUPLER MOUNTING ON A CIRCUIT BOARD
Clearance and Creepage Path Between Input and Output for Optocouplers on a PC Board

Figure 5.



Input/Output Leads — L = 0.3″/7.62 mm
Clearance Limited Due to PC Board
Solder Eyes — 0.22″/5.6 mm
Creepage Path on PC Board — 0.22″/5.6 mm

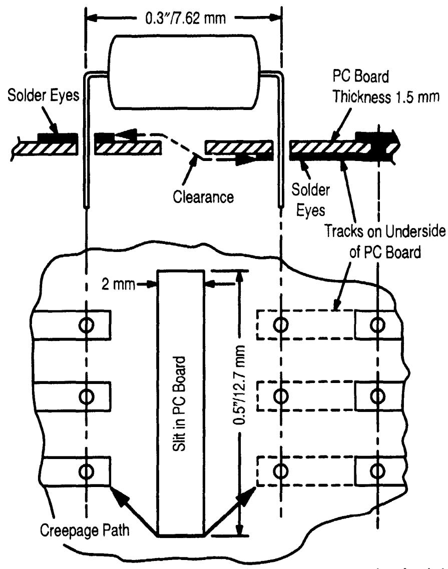
Figure 6.



VDE equipment norms demanding longer creepage path than 0.22″/5.6 mm can be accomplished by a slit in the PC board between the coupler input and output solder eyes of 2 mm width.

Input/Output Leads — L = 0.3″/7.62 mm
Clearance on PC Boards — 0.22″/5.6 mm Min
Creepage Path on PC Board — 0.31/8 mm Min

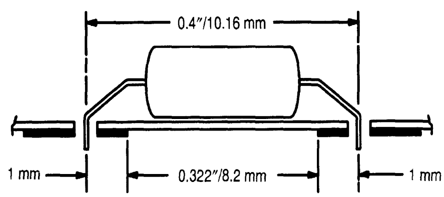
Figure 7.



If a clearance of 0.23″/6 mm and a creepage path of minimum 8 mm is required, this is a possible solution.

Slit — 0.5″/12.7 mm long, 2 mm wide
PC Board Thickness — 1.5 mm
Clearance — 6 mm Min
Creepage Path — 8 mm Min

Figure 8.



Where the equipment norms demand a clearance and creepage path of 8 mm Min, the coupler input and output leads should be bent to 0.4″/10.16 mm and the printboard layout should be as shown.

Safety Coupler Mounting with Spacing — L = 0.4″/10.16 mm
Clearance on PC Boards — 0.322″/8.2 mm
Creepage Path on PC Board — 0.322″/8.2 mm

All Motorola 6–pin dual–in–line optoisolators are available in 0.400″ lead form. Attach "T" to any Motorola 6–pin dual–in–line part number, for wide–spaced 0.400″ lead form.

Figure 9. Optocoupler Mounting on PC Board According to Safety Class I with Only One PC Board Plug Connection

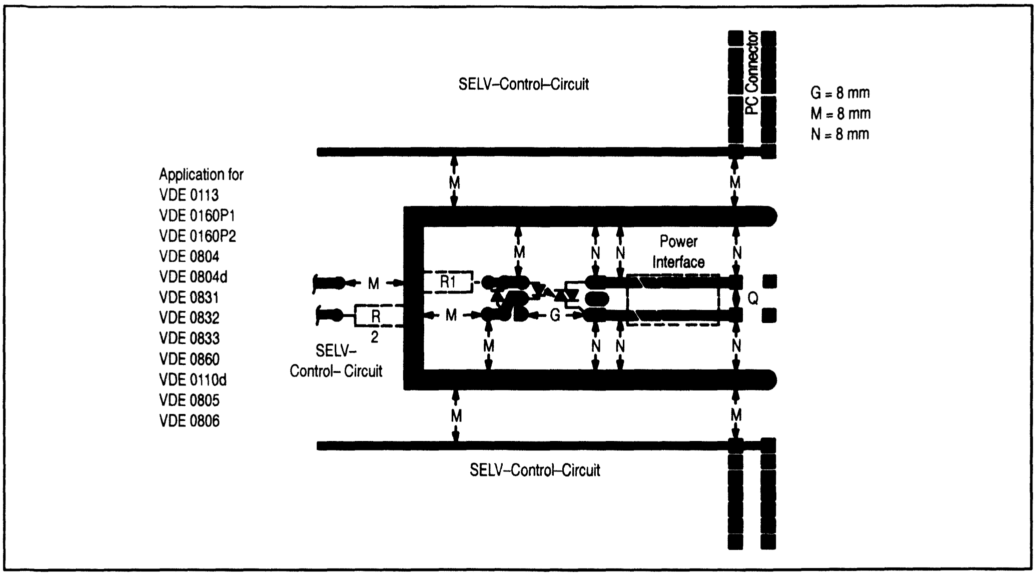
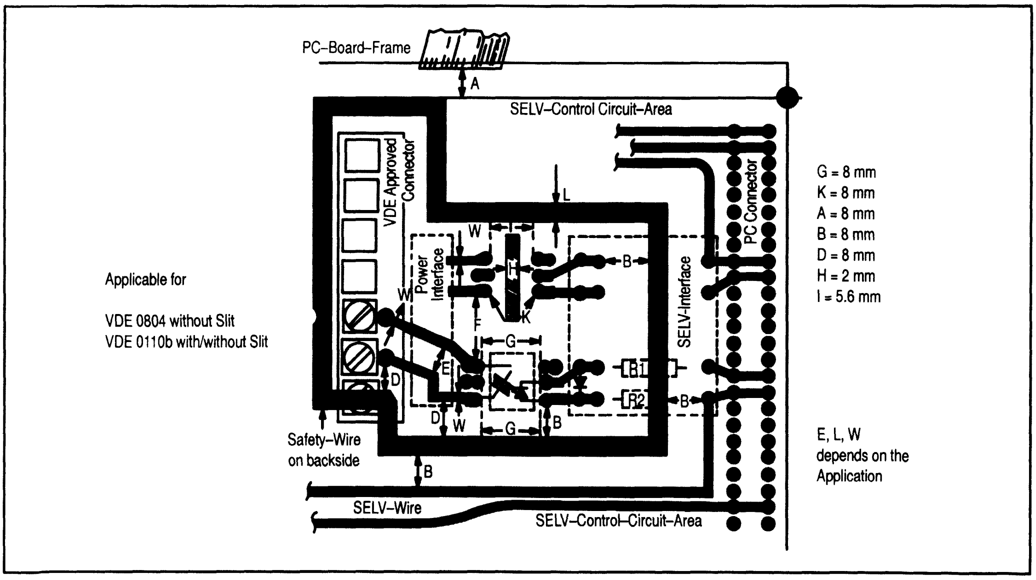


Figure 10. Optocoupler Mounting on PC Board According to Safety Class I with One Plug–Connection for the SELV–Control Circuit and One Screw–Connection for the Power–Interface



DEFINITION OF TERMS

The following paragraphs define terms used by the regulatories and international standard initiators. A separate discussion is given for:

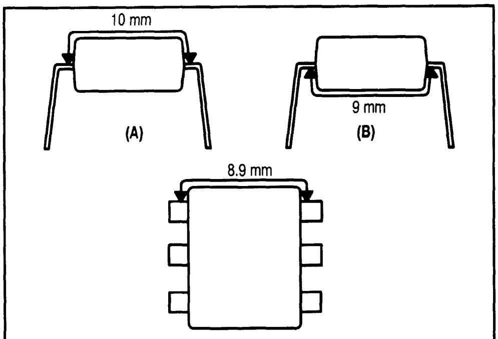
1. Creepage and Clearance
2. Voltage
3. Insulations
4. Circuits
5. Equipment

1. CREEPAGE AND CLEARANCE

ISOLATION CREEPAGE PATH

Denotes the shortest path between two conductive parts measured along the surface of the insulation, i.e., on the optocouplers, it is the shortest distance on the surface of the package between the input and output leads. On the circuit board in which the coupler is mounted, it is the shortest distance across the surface on the board between the solder eyes of the coupler input/output leads. Coupler and circuit board creepage path have to meet the minimum specified distances for the individual VDE equipment norms.

Figure 11.

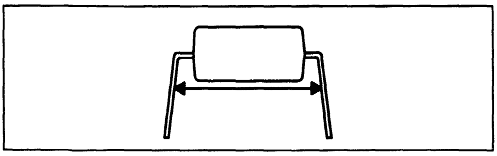


*Approximate measurements. For minimum measurements required, see Table 1.

CLEARANCE

Denotes the shortest distance between two conductive parts or between a conductive part and the bonding surface of the equipment, measured through air.

Figure 12.



2. VOLTAGES

HAZARDOUS VOLTAGE: A voltage exceeding 42.4 V peak or dc, existing in a circuit which does not meet the requirements for a limited current circuit.

WORKING VOLTAGE shall be the voltage which exists across the insulation under normal working conditions. Where the rms value is used, a sinusoidal ac waveform shall be assumed. Where the dc value is used, the peak value of any superimposed ripple shall be considered.

EXTRA–LOW VOLTAGE (ELV): A voltage between conductors or between a conductor and earth not exceeding 42.4 V peak or dc, existing in a secondary circuit which is separated from hazardous voltages by at least basic insulation, but which does not meet the requirements for a SELV circuit nor those for a limited current circuit.

ISOLATION WITHSTAND VOLTAGE: An ac or dc test voltage insulation has to withstand without breakdown or damage. It should not be confused with working or operating voltage.

ISOLATION SURGE VOLTAGE: A positive or negative transient voltage of defined energy and rise and fall times which the insulation has to withstand without breakdown or damage.

3. INSULATIONS

INSULATION, OPERATIONAL (functional): Insulation which is necessary for the correct operation of the equipment.
- Between parts of different potential.
- Between ELV or SELV circuits and earthed conductive parts.

INSULATION, BASIC: Insulation to provide basic protection against electric shock.
- Between a part at hazardous voltage and an earthed conductive part.
- Between a part at hazardous voltage and a SELV circuit which relies on being earthed for its integrity.
- Between a primary power conductor and the earthed screen or core for a primary power transformer.
- As an element of double insulation.

INSULATION, SUPPLEMENTARY: Independent insulation applied in addition to basic insulation in order to ensure protection against electric shock in the event of a failure of the basic insulation.
- Between an accessible conductive part and a part which could assume a hazardous voltage in the event of a failure of basic insulation.
- Between the outer surface of handles, knobs, grips and the like, and their shafts unless earthed.
- Between a floating non–SELV secondary circuit and an unearthed conductive part of the body.

INSULATION, DOUBLE: Insulation comprising both basic insulation and supplementary insulation.

INSULATION, REINFORCED: A single insulation system which provides a degree of protection against electric shock equivalent to double insulation under the conditions specified in the standard.

SAFE ELECTRICAL ISOLATION: Denotes an insulation system isolating a hazardous voltage circuit from a SELV circuit such that an insulation breakdown either is unlikely or does not cause a hazardous condition on the SELV circuit.
- Between an unearthed accessible conductive part or a floating SELV circuit, and a primary circuit.

4. CIRCUITS

PRIMARY CIRCUIT: An internal circuit which is directly connected to the external supply mains or other equivalent source (such as motor–alternator set) which supplies the electric power. It includes the primary windings of transformers, motors, other loading devices and the means of connection to the supply mains.

SECONDARY CIRCUIT: A circuit which has no direct connection to primary power and derives its power from a transformer, converter or equivalent isolation device situated within the equipment.

SAFETY EXTRA–LOW VOLTAGE (SELV) CIRCUIT: A circuit which is so designed and protected that under normal and single fault conditions the voltage between any two accessible parts, one of which may be the body or earth, does not exceed a safe value.

5. EQUIPMENTS

CLASS I EQUIPMENT: denotes equipment in which protection against electric shock does not rely on basic insulation only, but which includes an additional safety precaution in that operator–accessible conductive parts are connected to the protective earthing conductor in the fixed wiring of the installation in such a way that the operator–accessible conductive parts cannot become hazardous in the event of a failure of the basic insulation.

Class I equipment may have parts with double insulation or reinforced insulation, or parts operating at safety extra–low voltage.

CLASS II EQUIPMENT denotes equipment in which protection against electric shock does not rely on basic insulation only, but in which additional safety precautions, such as double insulation or reinforced insulation, are provided, there being no provision for protective earthing or reliance upon installation conditions.

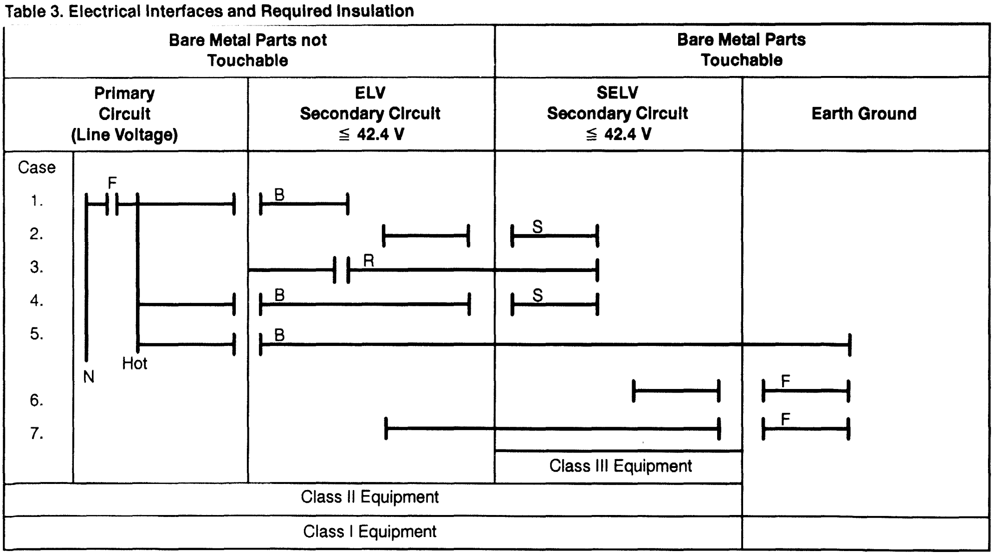
CLASS III EQUIPMENT: Equipment in which protection against electric shock relies upon supply from SELV circuits and in which hazardous voltages are not generated.

Table 2. Minimum Rating Requirements for a Working Voltage up to 250 Vrms

Insulation	Creepage [mm]	Clearance [mm]	Isolation Barrier [mm]	Diel. Strength [kV ac rms]	Isolation Resistance Ω
Operational	2.5	3	—	0.5	—
Basic	3	4	—	1.5	$2\ 10^6$
Supplementary	4	4	– to 2	2.5	$5\ 10^6$
Reinforced	8	8	– to 2*	2.5 to 3.75*	$7\ 10^6$

* See Table 1 for details.

Table 3. Electrical Interfaces and Required Insulation

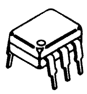


B = Basic Insulation F = Functional (Operation Insulation)

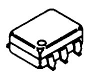
R = Reinforced or Safe Insulation S = Supplementary Insulation

Section 5

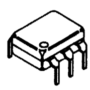
Optoisolators/Optocouplers



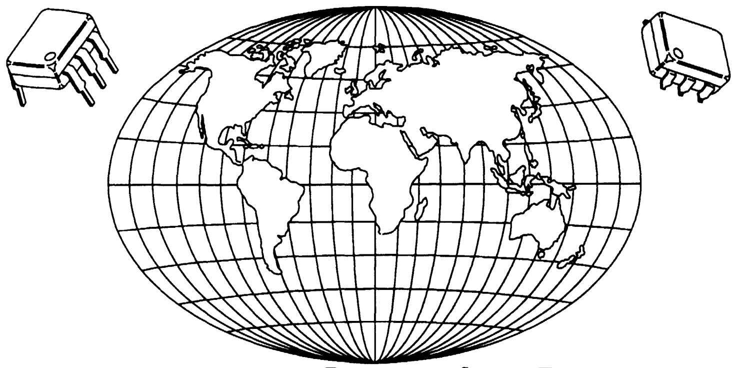
CASE 730A–04



CASE 730C–04



CASE 730D–05



GlobalOptoisolator™

Motorola's optoisolators satisfy the broad range of regulatory requirements imposed throughout the world. "Global" optoisolators are your "passport" to the world marketplace.

Motorola 6-PIN DIP Optoisolators Feature:

- "Global" Safety Regulatory Approvals: **VDE(1), UL, CSA, SETI, SEMKO, DEMKO, NEMKO, AUSTEL and BABT**
- The Industry's Highest Input-Output Voltage Isolation, Guaranteed and 100% tested — 7500 Vac Peak.
- VDE approved per standard 0884/8.87(1) (Certificate number 62054), with additional approval to DIN IEC950/VDE0806 & VDFE0805, IEC65/VDE0860, VDE110b, covering all other standards with equal or less stringent requirements, including IEC204/VDE0113, VDE0160, VDE0832, VDE0833.
- Special leadform available to satisfy VDE0884/8.87 requirement for 8 mm minimum creepage distance between input and output solder pads (add suffix "T" to part number). VDE 0884 testing is an option.
- Surface mount leadforming is available for all 6-PIN DIP devices. To obtain the Surface Mount leadform option (0.020–0.025 inches stand off height), simply add the suffix "S" to the end of the part number (i.e., MOC8104S). *Note:* Consult factory to determine device availability prior to ordering .
- Tape and Reel (1,000 pieces per reel) is available for "S" (Surface Mount leadform option) by adding the suffix "R2" (i.e., MOC8104SR2).
- Available in a wide variety of output types — Transistor, Darlington, Schmitt Trigger, and Zero Cross/Random Phase Triac Drivers.

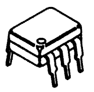
(1) VDE 0884 testing is an option; the suffix letter "V" must be added to the part number.

Leadform and Test Options for DIP–6 Optoisolators

Leadform Option(s):

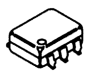
Motorola OPTO offers a variety of leadform options for their DIP–6 Optoisolators. Add the following suffix(s) to the standard device type to specify leadform option. ***Please consult factory prior to ordering for availability!***

Standard Leadform



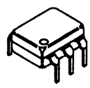
CASE 730A–04

"S" suffix = gull–winged, surface mountable



S
(S) CASE 730C–04
Surface–mountable gull–wing option

"T" suffix = wide spaced leadform (0.400″)



T
(T) CASE 730D–03
Wide–spaced (0.400″) leadform option

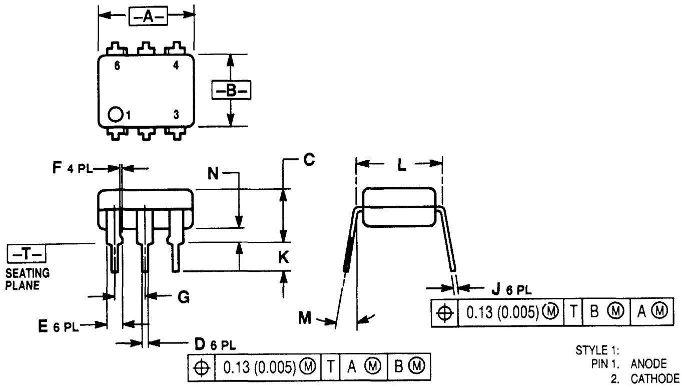
"SR2" suffix = gull–winged, surface mountable, in 13″ tape and reel.

VDE 0884/8.87 Test Option:

To specify VDE 0884/8.87 testing, add the suffix letter "V" to the standard part number. *Example:*

Standard through hole	MOC3163V
0.400" wide spaced leadform	MOC3163TV (satisfies 8mm spacing)
Surface mount	MOC3163SV
Surface mount (tape and reeled)	MOC3163SR2V

PACKAGE DIMENSIONS



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION L TO CENTER OF LEAD WHEN FORMED PARALLEL.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.320	0.350	8.13	8.89
B	0.240	0.260	6.10	6.60
C	0.115	0.200	2.93	5.08
D	0.016	0.020	0.41	0.50
E	0.040	0.070	1.02	1.77
F	0.010	0.014	0.25	0.36
G	0.100 BSC		2.54 BSC	
J	0.008	0.012	0.21	0.30
K	0.100	0.150	2.54	3.81
L	0.300 BSC		7.62 BSC	
M	0°	15°	0°	15°
N	0.015	0.100	0.38	2.54

STYLE 1:
PIN 1. ANODE
2. CATHODE
3. NC
4. EMITTER
5. COLLECTOR
6. BASE

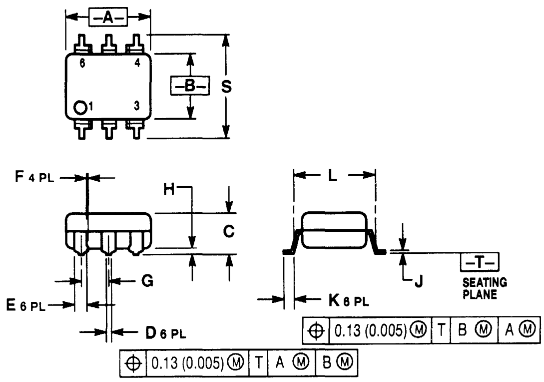
STYLE 3:
PIN 1. ANODE
2. CATHODE
3. NC
4. EMITTER
5. COLLECTOR
6. NC

STYLE 5:
PIN 1. ANODE
2. CATHODE
3. NC
4. OUTPUT
5. GROUND
6. V_{CC}

STYLE 6:
PIN 1. ANODE
2. CATHODE
3. NC
4. MAIN TERMINAL
5. SUBSTRATE
6. MAIN TERMINAL

STYLE 8:
PIN 1. LED 1 ANODE/LED 2 CATHODE
2. LED 1 CATHODE/LED 2 ANODE
3. NC
4. EMITTER
5. COLLECTOR
6. BASE

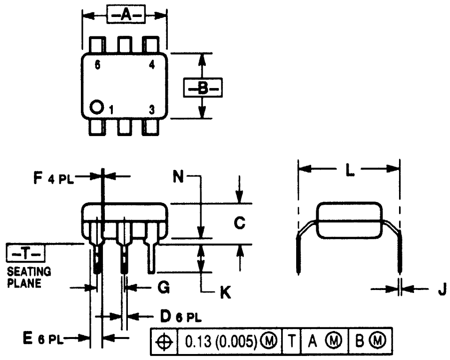
CASE 730A–04
ISSUE G



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.320	0.350	8.13	8.89
B	0.240	0.260	6.10	6.60
C	0.115	0.200	2.93	5.08
D	0.016	0.020	0.41	0.50
E	0.040	0.070	1.02	1.77
F	0.010	0.014	0.25	0.36
G	0.100 BSC		2.54 BSC	
H	0.020	0.025	0.51	0.63
J	0.008	0.012	0.20	0.30
K	0.006	0.035	0.16	0.88
L	0.320 BSC		8.13 BSC	
S	0.332	0.390	8.43	9.90

CASE 730C–04
ISSUE D



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION L TO CENTER OF LEAD WHEN FORMED PARALLEL.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.320	0.350	8.13	8.89
B	0.240	0.260	6.10	6.60
C	0.115	0.200	2.93	5.08
D	0.016	0.020	0.41	0.50
E	0.040	0.070	1.02	1.77
F	0.010	0.014	0.25	0.36
G	0.100 BSC		2.54 BSC	
J	0.008	0.012	0.21	0.30
K	0.100	0.150	2.54	3.81
L	0.400	0.425	10.16	10.80
N	0.015	0.040	0.38	1.02

CASE 730D–05
ISSUE D

GlobalOptoisolator™

VDE	UL	CSA	SETI	SEMKO	DEMKO	NEMKO	BABT

6-Pin DIP Optoisolators Transistor Output

4N25*
4N25A*
4N26*
[CTR = 20% Min]
4N27
4N28
[CTR = 10% Min]
***Motorola Preferred Devices**

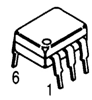
The 4N25/A, 4N26, 4N27 and 4N28 devices consist of a gallium arsenide infrared emitting diode optically coupled to a monolithic silicon phototransistor detector.

- Most Economical Optoisolator Choice for Medium Speed, Switching Applications
- Meets or Exceeds All JEDEC Registered Specifications
- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

Applications

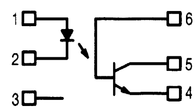
- General Purpose Switching Circuits
- Interfacing and coupling systems of different potentials and impedances
- I/O Interfacing
- Solid State Relays

STYLE 1 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

SCHEMATIC



PIN 1. LED ANODE
2. LED CATHODE
3. N.C.
4. EMITTER
5. COLLECTOR
6. BASE

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Reverse Voltage	V_R	3	Volts
Forward Current — Continuous	I_F	60	mA
LED Power Dissipation @ T_A = 25°C with Negligible Power in Output Detector Derate above 25°C	P_D	120 1.41	mW mW/°C
OUTPUT TRANSISTOR			
Collector–Emitter Voltage	V_{CEO}	30	Volts
Emitter–Collector Voltage	V_{ECO}	7	Volts
Collector–Base Voltage	V_{CBO}	70	Volts
Collector Current — Continuous	I_C	150	mA
Detector Power Dissipation @ T_A = 25°C with Negligible Power in Input LED Derate above 25°C	P_D	150 1.76	mW mW/°C
TOTAL DEVICE			
Isolation Surge Voltage(1) (Peak ac Voltage, 60 Hz, 1 sec Duration)	V_{ISO}	7500	Vac(pk)
Total Device Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Ambient Operating Temperature Range(2)	T_A	–55 to +100	°C
Storage Temperature Range(2)	T_{stg}	–55 to +150	°C
Soldering Temperature (10 sec, 1/16″ from case)	T_L	260	°C

1. Isolation surge voltage is an internal device dielectric breakdown rating. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.
2. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 5

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)(1)

Characteristic		Symbol	Min	Typ(1)	Max	Unit
INPUT LED						
Forward Voltage (I_F = 10 mA)	T_A = 25°C T_A = –55°C T_A = 100°C	V_F	— — —	1.15 1.3 1.05	1.5 — —	Volts
Reverse Leakage Current (V_R = 3 V)		I_R	—	—	100	µA
Capacitance (V = 0 V, f = 1 MHz)		C_J	—	18	—	pF
OUTPUT TRANSISTOR						
Collector–Emitter Dark Current (V_{CE} = 10 V, T_A = 25°C	4N25,25A,26,27 4N28	I_{CEO}	— —	1 1	50 100	nA
(V_{CE} = 10 V, T_A = 100°C)	All Devices	I_{CEO}	—	1	—	µA
Collector–Base Dark Current (V_{CB} = 10 V)		I_{CBO}	—	0.2	—	nA
Collector–Emitter Breakdown Voltage (I_C = 1 mA)		$V_{(BR)CEO}$	30	45	—	Volts
Collector–Base Breakdown Voltage (I_C = 100 µA)		$V_{(BR)CBO}$	70	100	—	Volts
Emitter–Collector Breakdown Voltage (I_E = 100 µA)		$V_{(BR)ECO}$	7	7.8	—	Volts
DC Current Gain (I_C = 2 mA, V_{CE} = 5 V)		h_{FE}	—	500	—	—
Collector–Emitter Capacitance (f = 1 MHz, V_{CE} = 0)		C_{CE}	—	7	—	pF
Collector–Base Capacitance (f = 1 MHz, V_{CB} = 0)		C_{CB}	—	19	—	pF
Emitter–Base Capacitance (f = 1 MHz, V_{EB} = 0)		C_{EB}	—	9	—	pF
COUPLED						
Output Collector Current (I_F = 10 mA, V_{CE} = 10 V)	4N25,25A,26 4N27,28	I_C (CTR)(2)	2 (20) 1 (10)	7 (70) 5 (50)	— —	mA (%)
Collector–Emitter Saturation Voltage (I_C = 2 mA, I_F = 50 mA)		$V_{CE(sat)}$	—	0.15	0.5	Volts
Turn–On Time (I_F = 10 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)		t_{on}	—	2.8	—	µs
Turn–Off Time (I_F = 10 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)		t_{off}	—	4.5	—	µs
Rise Time (I_F = 10 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)		t_r	—	1.2	—	µs
Fall Time (I_F = 10 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)		t_f	—	1.3	—	µs
Isolation Voltage (f = 60 Hz, t = 1 sec)(4)		V_{ISO}	7500	—	—	Vac(pk)
Isolation Resistance (V = 500 V)(4)		R_{ISO}	10^{11}	—	—	Ω
Isolation Capacitance (V = 0 V, f = 1 MHz)(4)		C_{ISO}	—	0.2	—	pF

1. Always design to the specified minimum/maximum electrical limits (where applicable).
2. Current Transfer Ratio (CTR) = I_C/I_F x 100%.
3. For test circuit setup and waveforms, refer to Figure 11.
4. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.

TYPICAL CHARACTERISTICS

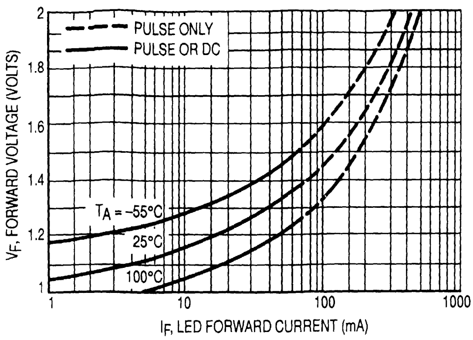


Figure 1. LED Forward Voltage versus Forward Current

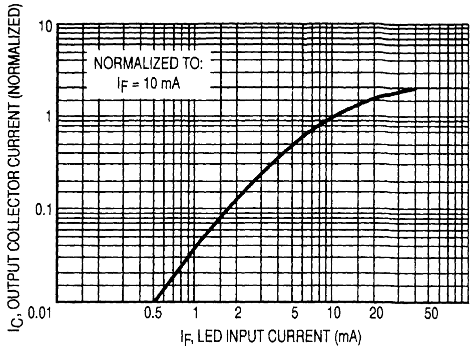


Figure 2. Output Current versus Input Current

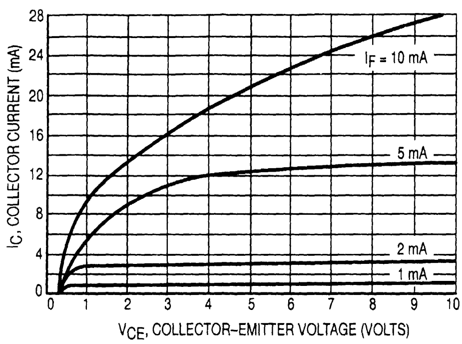


Figure 3. Collector Current versus Collector-Emitter Voltage

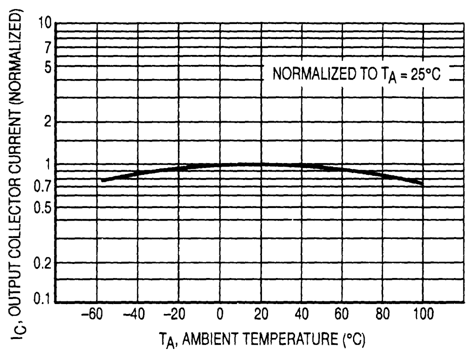


Figure 4. Output Current versus Ambient Temperature

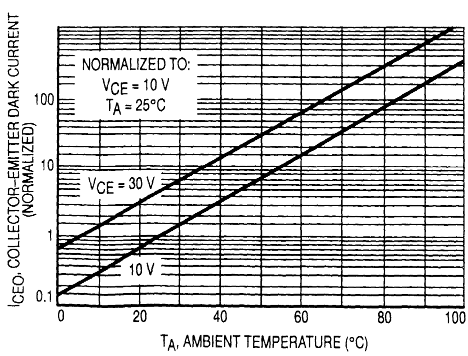


Figure 5. Dark Current versus Ambient Temperature

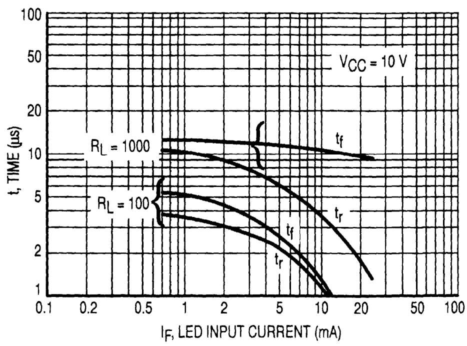


Figure 6. Rise and Fall Times (Typical Values)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)(1)

Characteristic		Symbol	Min	Typ(1)	Max	Unit
INPUT LED						
Forward Voltage (I_F = 10 mA)	T_A = 25°C T_A = –55°C T_A = 100°C	V_F	— — —	1.15 1.3 1.05	1.5 — —	Volts
Reverse Leakage Current (V_R = 3 V)		I_R	—	—	100	μA
Capacitance (V = 0 V, f = 1 MHz)		C_J	—	18	—	pF
OUTPUT TRANSISTOR						
Collector–Emitter Dark Current (V_{CE} = 10 V, T_A = 25°C	4N25,25A,26,27 4N28	I_{CEO}	— —	1 1	50 100	nA
(V_{CE} = 10 V, T_A = 100°C)	All Devices	I_{CEO}	—	1	—	μA
Collector–Base Dark Current (V_{CB} = 10 V)		I_{CBO}	—	0.2	—	nA
Collector–Emitter Breakdown Voltage (I_C = 1 mA)		$V_{(BR)CEO}$	30	45	—	Volts
Collector–Base Breakdown Voltage (I_C = 100 μA)		$V_{(BR)CBO}$	70	100	—	Volts
Emitter–Collector Breakdown Voltage (I_E = 100 μA)		$V_{(BR)ECO}$	7	7.8	—	Volts
DC Current Gain (I_C = 2 mA, V_{CE} = 5 V)		h_{FE}	—	500	—	—
Collector–Emitter Capacitance (f = 1 MHz, V_{CE} = 0)		C_{CE}	—	7	—	pF
Collector–Base Capacitance (f = 1 MHz, V_{CB} = 0)		C_{CB}	—	19	—	pF
Emitter–Base Capacitance (f = 1 MHz, V_{EB} = 0)		C_{EB}	—	9	—	pF
COUPLED						
Output Collector Current (I_F = 10 mA, V_{CE} = 10 V)	4N25,25A,26 4N27,28	I_C (CTR)(2)	2 (20) 1 (10)	7 (70) 5 (50)	— —	mA (%)
Collector–Emitter Saturation Voltage (I_C = 2 mA, I_F = 50 mA)		$V_{CE(sat)}$	—	0.15	0.5	Volts
Turn–On Time (I_F = 10 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)		t_{on}	—	2.8	—	μs
Turn–Off Time (I_F = 10 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)		t_{off}	—	4.5	—	μs
Rise Time (I_F = 10 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)		t_r	—	1.2	—	μs
Fall Time (I_F = 10 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)		t_f	—	1.3	—	μs
Isolation Voltage (f = 60 Hz, t = 1 sec)(4)		V_{ISO}	7500	—	—	Vac(pk)
Isolation Resistance (V = 500 V)(4)		R_{ISO}	10^{11}	—	—	Ω
Isolation Capacitance (V = 0 V, f = 1 MHz)(4)		C_{ISO}	—	0.2	—	pF

1. Always design to the specified minimum/maximum electrical limits (where applicable).
2. Current Transfer Ratio (CTR) = I_C/I_F x 100%.
3. For test circuit setup and waveforms, refer to Figure 11.
4. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.

TYPICAL CHARACTERISTICS

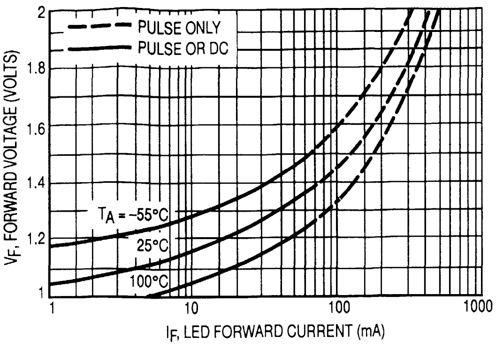


Figure 1. LED Forward Voltage versus Forward Current

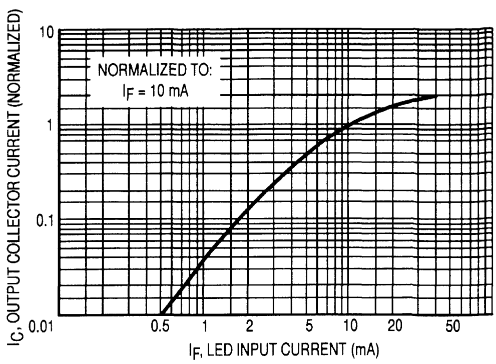


Figure 2. Output Current versus Input Current

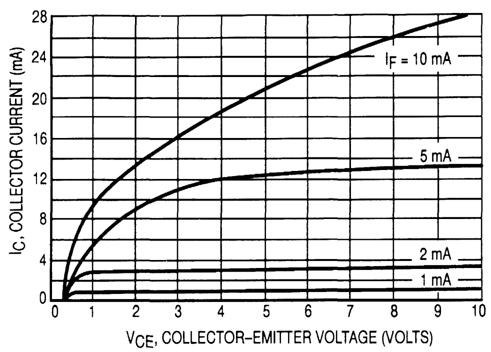


Figure 3. Collector Current versus Collector–Emitter Voltage

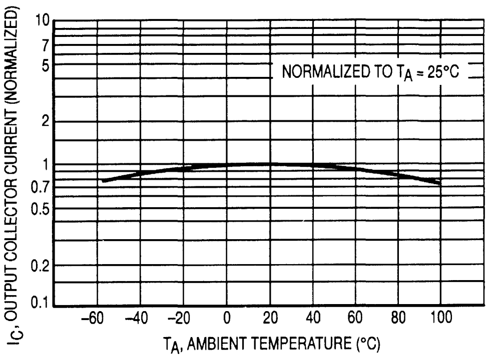


Figure 4. Output Current versus Ambient Temperature

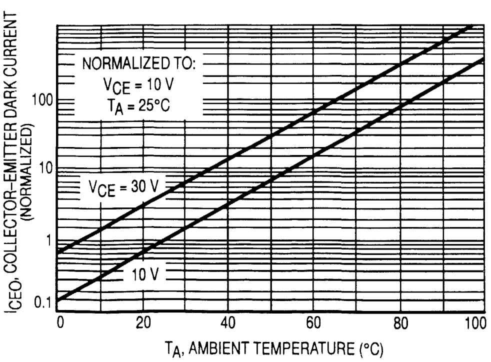


Figure 5. Dark Current versus Ambient Temperature

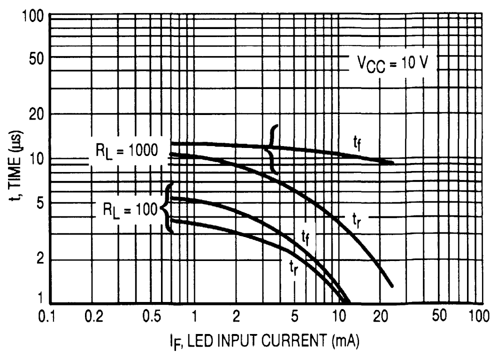


Figure 6. Rise and Fall Times (Typical Values)

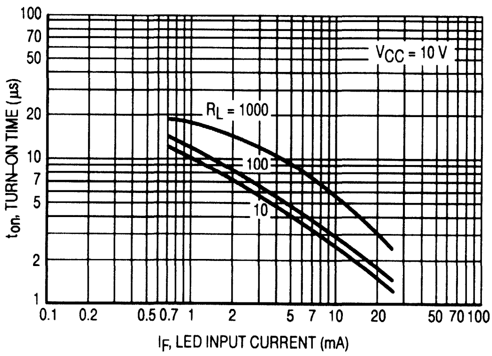


Figure 7. Turn–On Switching Times (Typical Values)

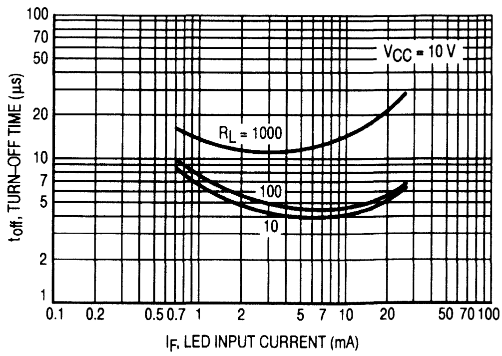


Figure 8. Turn–Off Switching Times (Typical Values)

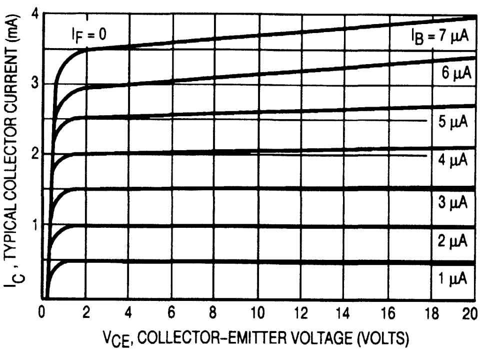


Figure 9. DC Current Gain (Detector Only)

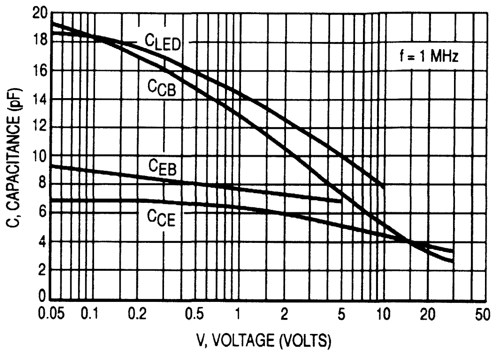


Figure 10. Capacitances versus Voltage

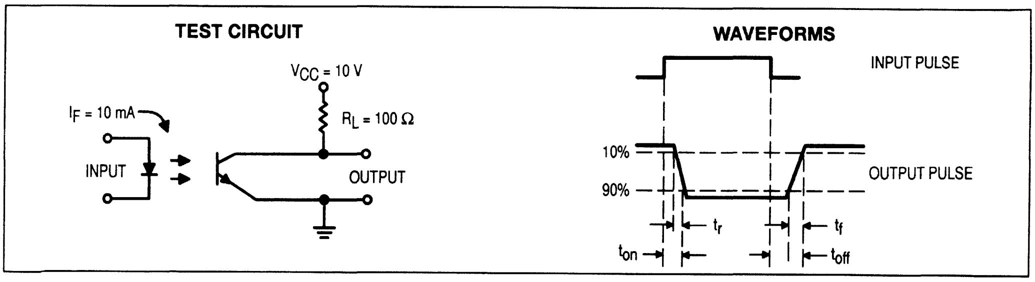


Figure 11. Switching Time Test Circuit and Waveforms

GlobalOptoisolator™

VDE	UL	CSA	SETI	SEMKO	DEMKO	NEMKO	BABT

6-Pin DIP Optoisolators Darlington Output

4N29

4N29A

4N30*
[CTR = 100% Min]

4N31
[CTR = 50% Min]

4N32*

4N33 *
[CTR = 500% Min]

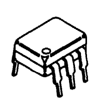
*Motorola Preferred Devices

The 4N29/A, 4N30, 4N31, 4N32(1) and 4N33(1) devices consist of a gallium arsenide infrared emitting diode optically coupled to a monolithic silicon photodarlington detector.

This series is designed for use in applications requiring high collector output currents at lower input currents.

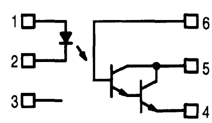
- Higher Sensitivity to Low Input Drive Current
- Meets or Exceeds All JEDEC Registered Specifications
- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

STYLE 1 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

SCHEMATIC



PIN 1. LED ANODE
2. LED CATHODE
3. N.C.
4. EMITTER
5. COLLECTOR
6. BASE

Applications

- Low Power Logic Circuits
- Interfacing and coupling systems of different potentials and impedances
- Telecommunications Equipment
- Portable Electronics
- Solid State Relays

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Reverse Voltage	V_R	3	Volts
Forward Current — Continuous	I_F	60	mA
LED Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	120 1.41	mW mW/°C
OUTPUT DETECTOR			
Collector–Emitter Voltage	V_{CEO}	30	Volts
Emitter–Collector Voltage	V_{ECO}	5	Volts
Collector–Base Voltage	V_{CBO}	30	Volts
Collector Current — Continuous	I_C	150	mA
Detector Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 1.76	mW mW/°C
TOTAL DEVICE			
Isolation Surge Voltage(2) (Peak ac Voltage, 60 Hz, 1 sec Duration)	V_{ISO}	7500	Vac(pk)
Total Device Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Ambient Operating Temperature Range(3)	T_A	–55 to +100	°C
Storage Temperature Range(3)	T_{stg}	–55 to +150	°C
Soldering Temperature (10 sec, 1/16″ from case)	T_L	260	°C

1. Difference in 4N32 and 4N33 is JEDEC Registration for VISO only. All Motorola 6–Pin devices exceed JEDEC specification and are 7500 Vac(pk). The same applies for 4N29 and 4N30.
2. Isolation surge voltage is an internal device dielectric breakdown rating. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.
3. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 4

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)(1)

Characteristic		Symbol	Min	Typ(1)	Max	Unit
INPUT LED						
*Reverse Leakage Current (V_R = 3 V, R_L = 1 M ohms)		I_R	—	0.05	100	μA
*Forward Voltage (I_F = 10 mA)		V_F	—	1.34	1.5	Volts
Capacitance (V_R = 0 V, f = 1 MHz)		C	—	1.8	—	pF
OUTPUT DETECTOR (T_A = 25°C and I_F = 0, unless otherwise noted)						
*Collector–Emitter Dark Current (V_{CE} = 10 V, Base Open)		I_{CEO}	—	—	100	nA
*Collector–Base Breakdown Voltage (I_C = 100 μA, I_E = 0)		$V_{(BR)CBO}$	30	—	—	Volts
*Collector–Emitter Breakdown Voltage (I_C = 100 μA, I_B = 0)		$V_{(BR)CEO}$	30	—	—	Volts
*Emitter–Collector Breakdown Voltage (I_E = 100 μA, I_B = 0)		$V_{(BR)ECO}$	5	—	—	Volts
DC Current Gain (V_{CE} = 5 V, I_C = 500 μA)		h_{FE}	—	16K	—	—
COUPLED (T_A = 25°C unless otherwise noted)						
*Collector Output Current (3) (V_{CE} = 10 V, I_F = 10 mA)	4N32, 4N33 4N29, 4N30 4N31	I_C (CTR)(2)	50 (500) 10 (100) 5 (50)	— — —	— — —	mA (%)
Isolation Surge Voltage(4,5) (60 Hz ac Peak, 1 Second)	4N29/A, 4N30, 31, 32, 33 *4N29, 4N32 *4N30, 4N31, 4N33	V_{ISO}	7500 2500 1500	— — —	— — —	Vac(pk)
Isolation Resistance(4) (V = 500 V)		R_{ISO}	—	10^{11}	—	Ohms
*Collector–Emitter Saturation Voltage(3) (I_C = 2 mA, I_F = 8 mA)	4N31 4N29, 4N30, 4N32, 4N33	$V_{CE(sat)}$	— —	— —	1.2 1	Volts
Isolation Capacitance(4) (V = 0 V, f = 1 MHz)		C_{ISO}	—	0.2	—	pF
Turn–On Time(6) (I_C = 50 mA, I_F = 200 mA, V_{CC} = 10 V)		t_{on}	—	0.6	5	μs
Turn–Off Time(6) (I_C = 50 mA, I_F = 200 mA, V_{CC} = 10 V)	4N29, 30, 31 4N32, 33	t_{off}	— —	17 45	40 100	μs

* Indicates JEDEC Registered Data. All Motorola 6–pin devices have V_{ISO} rating of 7500 Vac(pk).

1. Always design to the specified minimum/maximum electrical limits (where applicable).
2. Current Transfer Ratio (CTR) = I_C/I_F x 100%.
3. Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2%.
4. For this test, Pins 1 and 2 are common and Pins 4, 5 and 6 are common.
5. Isolation Surge Voltage, V_{ISO}, is an internal device dielectric breakdown rating.
6. For test circuit setup and waveforms, refer to Figure 11.

TYPICAL CHARACTERISTICS

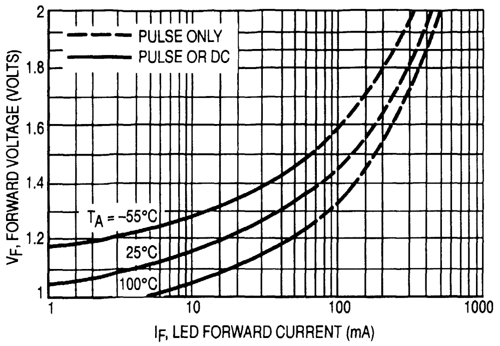


Figure 1. LED Forward Voltage versus Forward Current

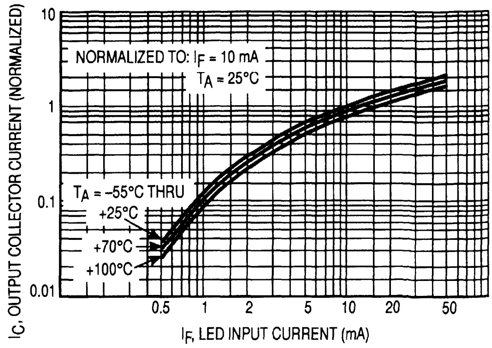


Figure 2. Output Current versus Input Current

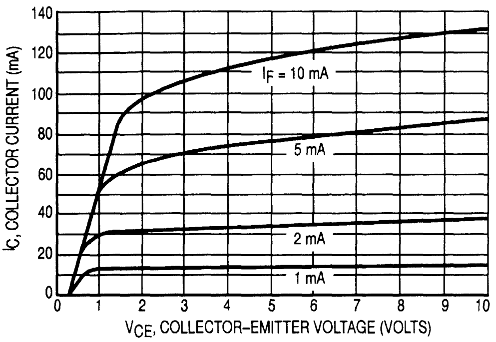


Figure 3. Collector Current versus Collector–Emitter Voltage

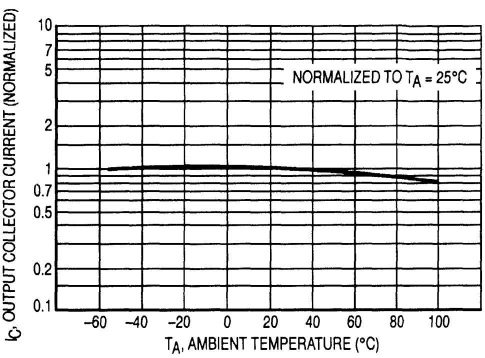


Figure 4. Output Current versus Ambient Temperature

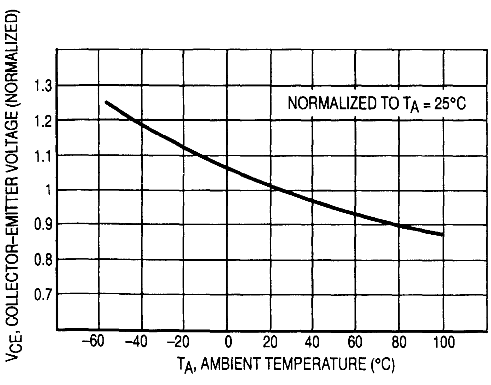


Figure 5. Collector–Emitter Voltage versus Ambient Temperature

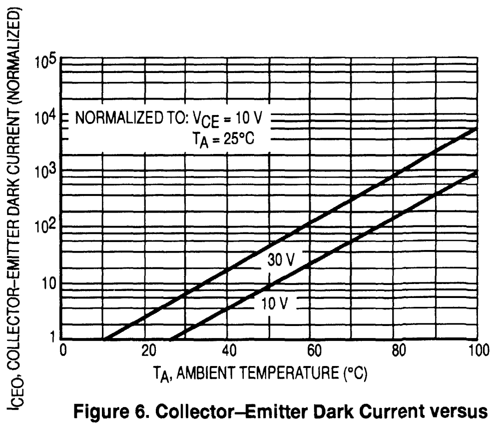


Figure 6. Collector–Emitter Dark Current versus Ambient Temperature

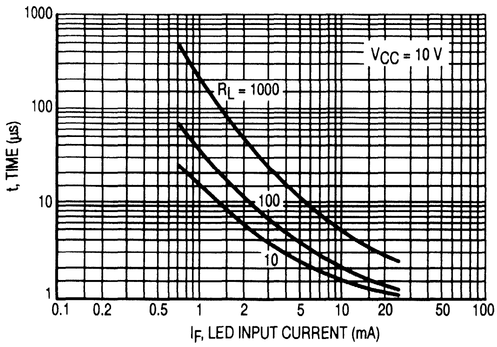


Figure 7. Turn–On Switching Times

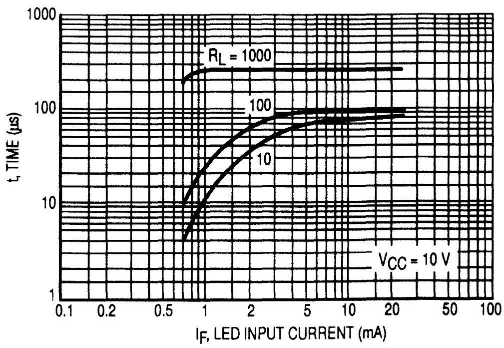


Figure 8. Turn–Off Switching Times

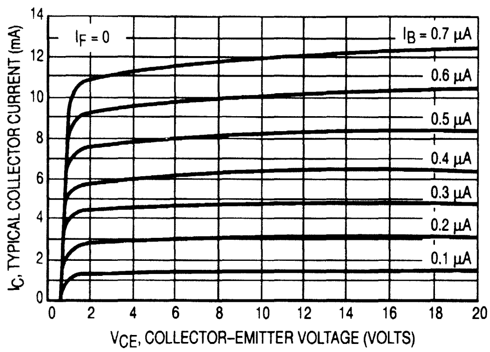


Figure 9. DC Current Gain (Detector Only)

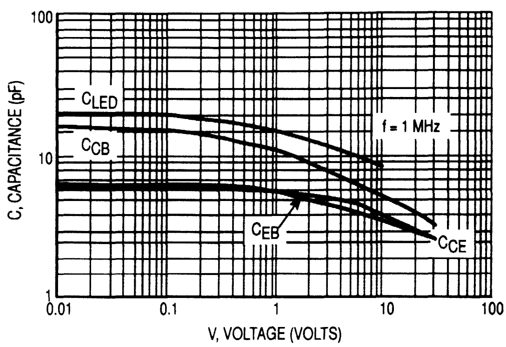


Figure 10. Capacitances versus Voltage

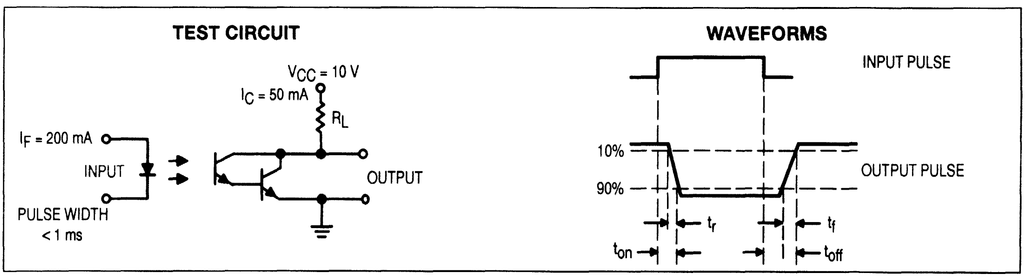


Figure 11. Switching Time Test Circuit and Waveforms

GlobalOptoisolator™

VDE	UL	CSA	SETI	SEMKO	DEMKO	NEMKO	BABT

6-Pin DIP Optoisolators Transistor Output

4N35*
4N36
4N37
[CTR = 100% Min]

***Motorola Preferred Device**

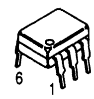
The 4N35, 4N36 and 4N37 devices consist of a gallium arsenide infrared emitting diode optically coupled to a monolithic silicon phototransistor detector.

- Current Transfer Ratio — 100% Minimum @ Specified Conditions
- Guaranteed Switching Speeds
- Meets or Exceeds all JEDEC Registered Specifications
- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

Applications

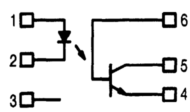
- General Purpose Switching Circuits
- Interfacing and coupling systems of different potentials and impedances
- Regulation Feedback Circuits
- Monitor & Detection Circuits
- Solid State Relays

STYLE 1 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

SCHEMATIC



PIN 1. LED ANODE
2. LED CATHODE
3. N.C.
4. EMITTER
5. COLLECTOR
6. BASE

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Reverse Voltage	V_R	6	Volts
Forward Current — Continuous	I_F	60	mA
LED Power Dissipation @ T_A = 25°C with Negligible Power in Output Detector Derate above 25°C	P_D	120 1.41	mW mW/°C
OUTPUT TRANSISTOR			
Collector–Emitter Voltage	V_{CEO}	30	Volts
Emitter–Base Voltage	V_{EBO}	7	Volts
Collector–Base Voltage	V_{CBO}	70	Volts
Collector Current — Continuous	I_C	150	mA
Detector Power Dissipation @ T_A = 25°C with Negligible Power in Input LED Derate above 25°C	P_D	150 1.76	mW mW/°C
TOTAL DEVICE			
Isolation Source Voltage(1) (Peak ac Voltage, 60 Hz, 1 sec Duration)	V_{ISO}	7500	Vac(pk)
Total Device Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Ambient Operating Temperature Range(2)	T_A	–55 to +100	°C
Storage Temperature Range(2)	T_{stg}	–55 to +150	°C
Soldering Temperature (10 sec, 1/16″ from case)	T_L	260	°C

1. Isolation surge voltage is an internal device dielectric breakdown rating. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.
2. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 2

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)(1)

Characteristic		Symbol	Min	Typ(1)	Max	Unit
INPUT LED						
Forward Voltage (I_F = 10 mA)	T_A = 25°C T_A = –55°C T_A = 100°C	V_F	0.8 0.9 0.7	1.15 1.3 1.05	1.5 1.7 1.4	V
Reverse Leakage Current (V_R = 6 V)		I_R	—	—	10	µA
Capacitance (V = 0 V, f = 1 MHz)		C_J	—	18	—	pF
OUTPUT TRANSISTOR						
Collector–Emitter Dark Current (V_{CE} = 10 V, T_A = 25°C) (V_{CE} = 30 V, T_A = 100°C)		I_{CEO}	— —	1 —	50 500	nA µA
Collector–Base Dark Current (V_{CB} = 10 V)	T_A = 25°C T_A = 100°C	I_{CBO}	—	0.2 100	20 —	nA
Collector–Emitter Breakdown Voltage (I_C = 1 mA)		$V_{(BR)CEO}$	30	45	—	V
Collector–Base Breakdown Voltage (I_C = 100 µA)		$V_{(BR)CBO}$	70	100	—	V
Emitter–Base Breakdown Voltage (I_E = 100 µA)		$V_{(BR)EBO}$	7	7.8	—	V
DC Current Gain (I_C = 2 mA, V_{CE} = 5 V)		h_{FE}	—	400	—	—
Collector–Emitter Capacitance (f = 1 MHz, V_{CE} = 0)		C_{CE}	—	7	—	pF
Collector–Base Capacitance (f = 1 MHz, V_{CB} = 0)		C_{CB}	—	19	—	pF
Emitter–Base Capacitance (f = 1 MHz, V_{EB} = 0)		C_{EB}	—	9	—	pF
COUPLED						
Output Collector Current (I_F = 10 mA, V_{CE} = 10 V)	T_A = 25°C T_A = –55°C T_A = 100°C	I_C (CTR)(2)	10 (100) 4 (40) 4 (40)	30 (300) — —	— — —	mA (%)
Collector–Emitter Saturation Voltage (I_C = 0.5 mA, I_F = 10 mA)		$V_{CE(sat)}$	—	0.14	0.3	V
Turn–On Time	(I_C = 2 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)	t_{on}	—	7.5	10	µs
Turn–Off Time		t_{off}	—	5.7	10	
Rise Time		t_r	—	3.2	—	
Fall Time		t_f	—	4.7	—	
Isolation Voltage (f = 60 Hz, t = 1 sec)		V_{ISO}	7500	—	—	Vac(pk)
Isolation Current(4) ($V_{I–O}$ = 3550 Vpk) ($V_{I–O}$ = 2500 Vpk) ($V_{I–O}$ = 1500 Vpk)	4N35 4N36 4N37	I_{ISO}	— — —	— — 8	100 100 100	µA
Isolation Resistance (V = 500 V)(4)		R_{ISO}	10^{11}	—	—	Ω
Isolation Capacitance (V = 0 V, f = 1 MHz)(4)		C_{ISO}	—	0.2	2	pF

1. Always design to the specified minimum/maximum electrical limits (where applicable).
2. Current Transfer Ratio (CTR) = I_C/I_F x 100%.
3. For test circuit setup and waveforms, refer to Figure 11.
4. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.

TYPICAL CHARACTERISTICS

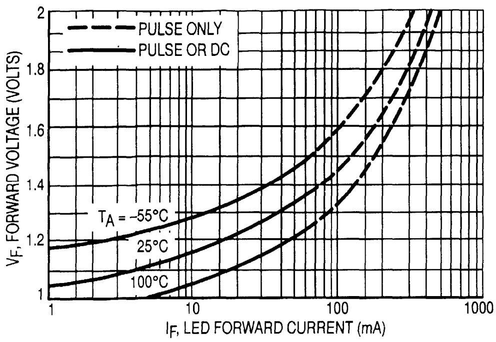


Figure 1. LED Forward Voltage versus Forward Current

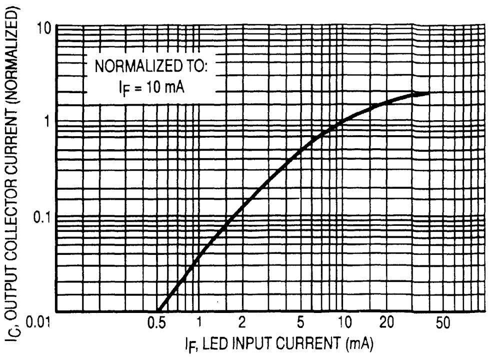


Figure 2. Output Current versus Input Current

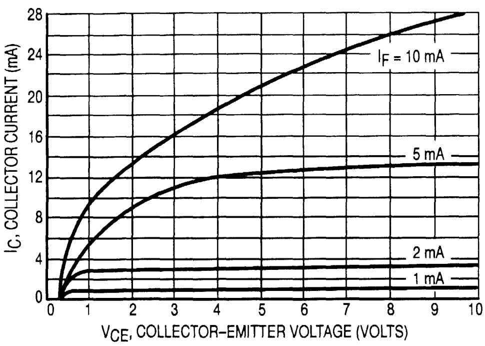


Figure 3. Collector Current versus Collector–Emitter Voltage

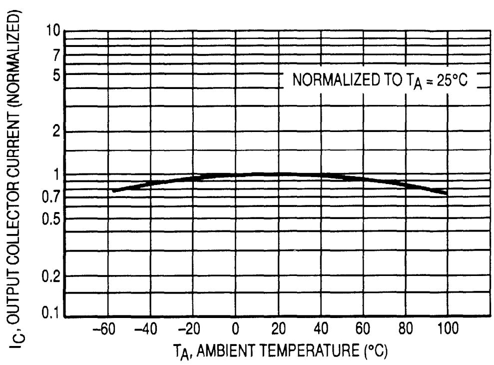


Figure 4. Output Current versus Ambient Temperature

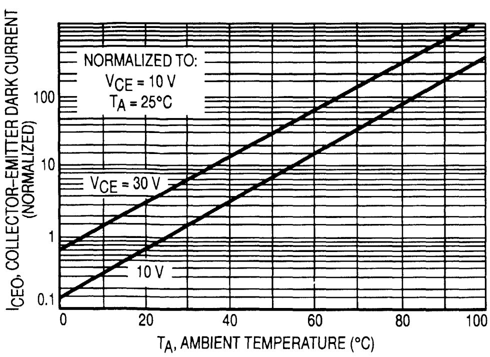


Figure 5. Dark Current versus Ambient Temperature

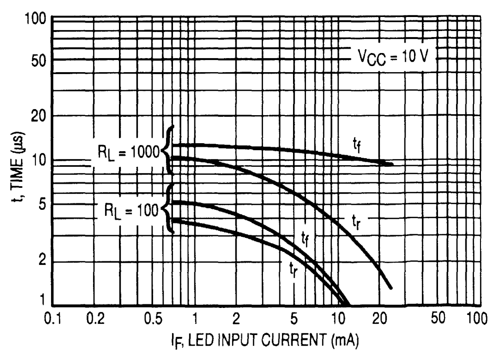


Figure 6. Rise and Fall Times (Typical Values)

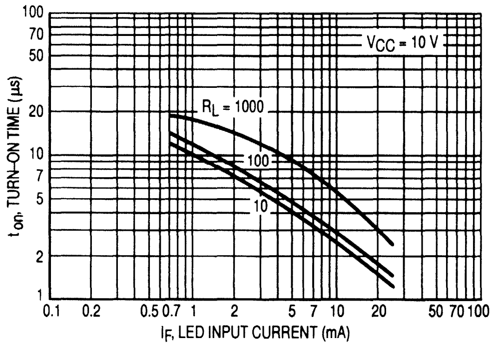


Figure 7. Turn–On Switching Times

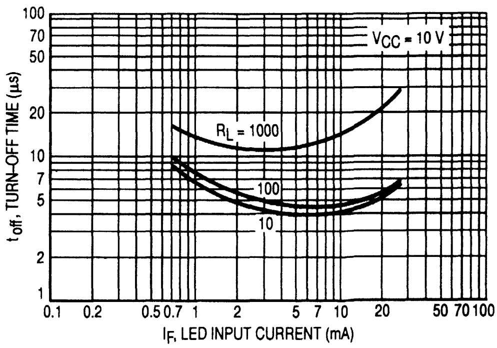


Figure 8. Turn–Off Switching Times

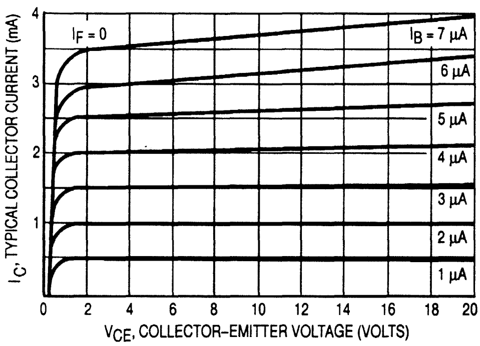


Figure 9. DC Current Gain (Detector Only)

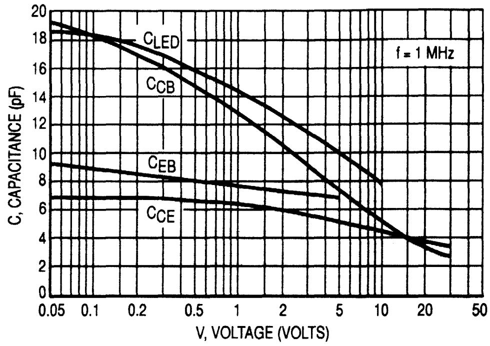


Figure 10. Capacitances versus Voltage

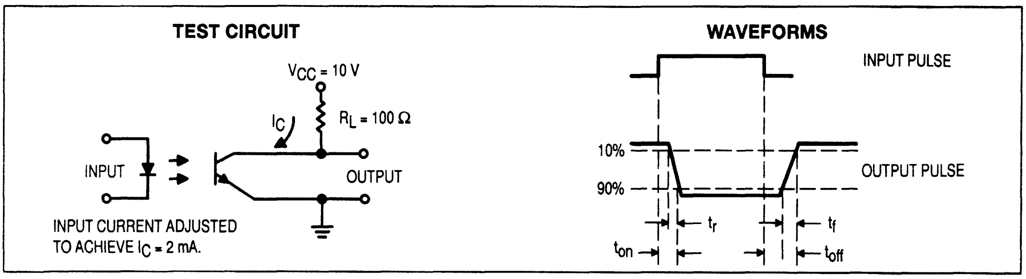


Figure 11. Switching Time Test Circuit and Waveforms

GlobalOptoisolator™

VDE	UL	CSA	SETI	SEMKO	DEMKO	NEMKO	BABT

6-Pin DIP Optoisolators Transistor Output

The 4N38 and 4N38A(1) devices consist of a gallium arsenide infrared emitting diode optically coupled to a monolithic silicon phototransistor detector.

- Guaranteed 80 Volt Collector–to–Emitter Breakdown ($(BR)CEO$) Minimum
- Meets or Exceeds All JEDEC Registered Specifications
- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

Applications

- General Purpose Switching Circuits
- Interfacing and coupling systems of different potentials and impedances
- Monitor and Detection Circuits

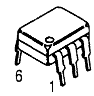
4N38

4N38A*

[CTR = 20% Min]

***Motorola Preferred Device**

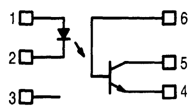
STYLE 1 PLASTIC



6 1

STANDARD THRU HOLE
CASE 730A–04

SCHEMATIC



PIN 1. LED ANODE
2. LED CATHODE
3. N.C.
4. EMITTER
5. COLLECTOR
6. BASE

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Reverse Voltage	V_R	3	Volts
Forward Current — Continuous	I_F	80	mA
Forward Current — Pk (PW = 300 μs, 2% duty cycle)	$I_{F(pk)}$	3	A
LED Power Dissipation @ T_A = 25°C with Negligible Power in Output Detector Derate above 25°C	P_D	150 1.41	mW mW/°C
OUTPUT TRANSISTOR			
Collector–Emitter Voltage	V_{CEO}	80	Volts
Emitter–Collector Voltage	V_{ECO}	7	Volts
Collector–Base Voltage	V_{CBO}	80	Volts
Collector Current — Continuous	I_C	100	mA
Detector Power Dissipation @ T_A = 25°C with Negligible Power in Input LED Derate above 25°C	P_D	150 1.76	mW mW/°C
TOTAL DEVICE			
Isolation Surge Voltage(2) (Peak ac Voltage, 60 Hz, 1 sec Duration)	V_{ISO}	7500	Vac(pk)
Total Device Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Ambient Operating Temperature Range(3)	T_A	–55 to +100	°C
Storage Temperature Range(3)	T_{stg}	–55 to +150	°C
Soldering Temperature (10 sec, 1/16″ from case)	T_L	260	°C

1. 4N38 does not require UL approval; 4N38A does. Otherwise both parts are identical. Both parts built by Motorola have UL approval.
2. Isolation surge voltage is an internal device dielectric breakdown rating. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.
3. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 2

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)(1)

Characteristic	Symbol	Min	Typ	Max	Unit
INPUT LED					
Forward Voltage (I_F = 10 mA) T_A = 25°C T_A = –55°C T_A = 100°C	V_F	— — —	1.15 1.3 1.05	1.5 — —	Volts
Reverse Leakage Current (V_R = 3 V)	I_R	—	—	100	μA
Capacitance (V = 0 V, f = 1 MHz)	C_J	—	18	—	pF
OUTPUT TRANSISTOR					
Collector–Emitter Dark Current (V_{CE} = 60 V, T_A = 25°C) (V_{CE} = 60 V, T_A = 100°C)	I_{CEO}	— —	20 6	50 —	nA μA
Collector–Base Dark Current (V_{CB} = 60 V)	I_{CBO}	—	2	20	nA
Collector–Emitter Breakdown Voltage (I_C = 1 mA)	$V_{(BR)CEO}$	80	120	—	Volts
Collector–Base Breakdown Voltage (I_C = 1 μA)	$V_{(BR)CBO}$	80	120	—	Volts
Emitter–Collector Breakdown Voltage (I_E = 100 μA)	$V_{(BR)ECO}$	7	7.8	—	Volts
DC Current Gain (I_C = 2 mA, V_{CE} = 5 V)	h_{FE}	—	400	—	—
Collector–Emitter Capacitance (f = 1 MHz, V_{CE} = 0)	C_{CE}	—	8	—	pF
Collector–Base Capacitance (f = 1 MHz, V_{CB} = 0)	C_{CB}	—	21	—	pF
Emitter–Base Capacitance (f = 1 MHz, V_{EB} = 0)	C_{EB}	—	8	—	pF
COUPLED					
Output Collector Current (I_F = 20 mA, V_{CE} = 1 V)	I_C (CTR)(2)	4 (20)	7 (35)	—	mA (%)
Collector–Emitter Saturation Voltage (I_C = 4 mA, I_F = 20 mA)	$V_{CE(sat)}$	—	—	1	Volts
Turn–On Time (I_C = 2 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)	t_{on}	—	5	—	μs
Turn–Off Time (I_C = 2 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)	t_{off}	—	4	—	μs
Rise Time (I_C = 2 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)	t_r	—	2	—	μs
Fall Time (I_C = 2 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)	t_f	—	3	—	μs
Isolation Voltage (f = 60 Hz, t = 1 sec)(4)	V_{ISO}	7500	—	—	Vac(pk)
Isolation Resistance (V = 500 V)(4)	R_{ISO}	10^{11}	—	—	Ω
Isolation Capacitance (V = 0 V, f = 1 MHz)(4)	C_{ISO}	—	0.2	—	pF

1. Always design to the specified minimum/maximum electrical limits (where applicable).
2. Current Transfer Ratio (CTR) = I_C/I_F x 100%.
3. For test circuit setup and waveforms, refer to Figure 11.
4. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.

TYPICAL CHARACTERISTICS

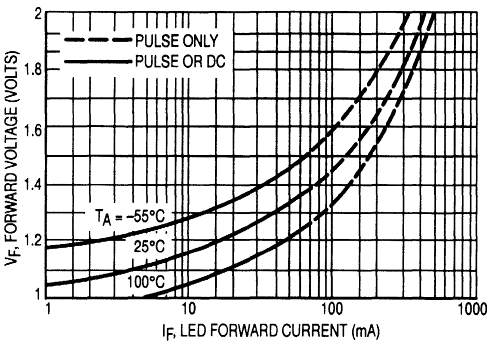


Figure 1. LED Forward Voltage versus Forward Current

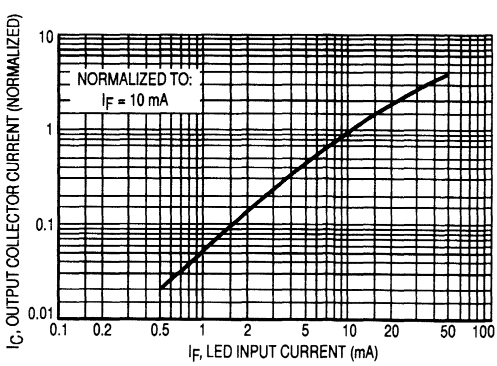


Figure 2. Output Current versus Input Current

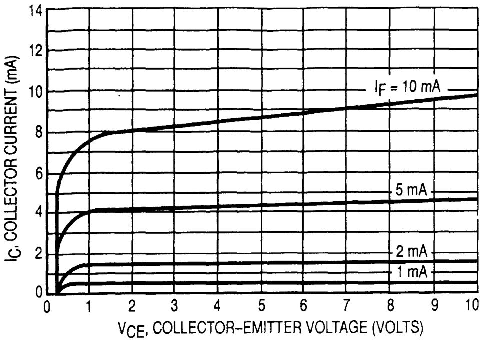


Figure 3. Collector Current versus Collector–Emitter Voltage

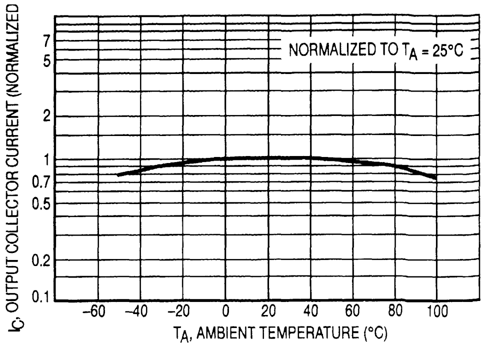


Figure 4. Output Current versus Ambient Temperature

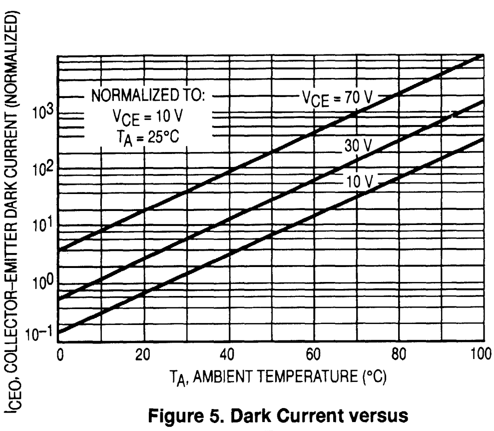


Figure 5. Dark Current versus Ambient Temperature

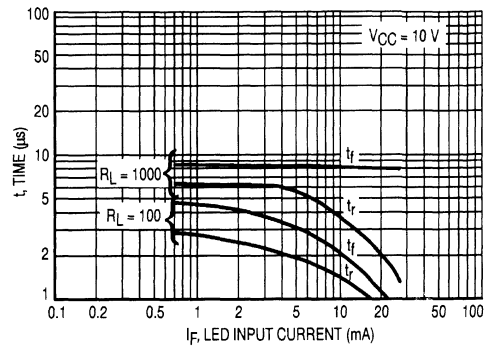


Figure 6. Rise and Fall Times (Typical Values)

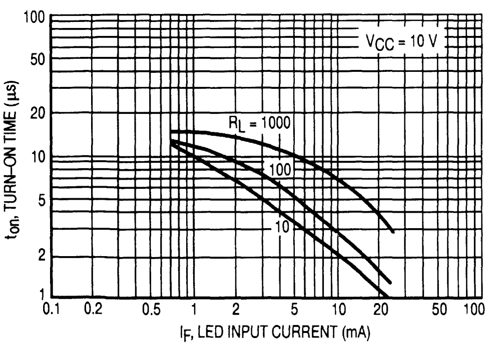


Figure 7. Turn–On Switching Times (Typical Values)

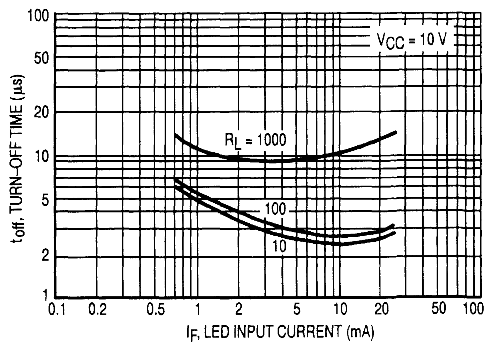


Figure 8. Turn–Off Switching Times (Typical Values)

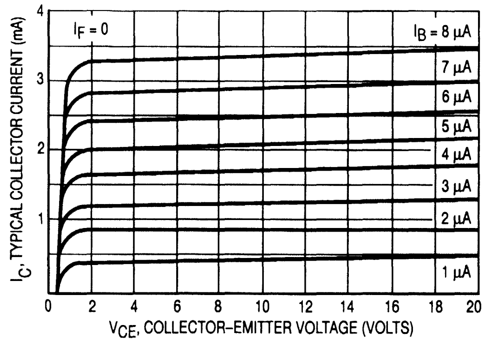


Figure 9. DC Current Gain (Detector Only)

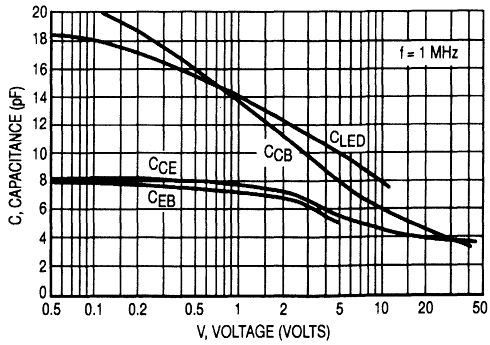


Figure 10. Capacitances versus Voltage

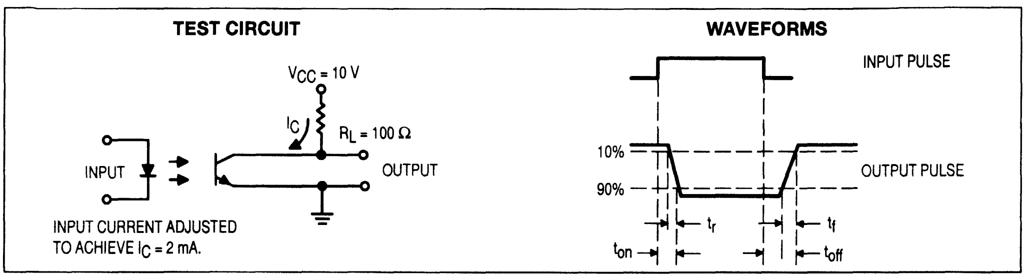


Figure 11. Switching Time Test Circuit and Waveforms

GlobalOptoisolator™

VDE	UL	CSA	SETI	SEMKO	DEMKO	NEMKO	BABT

6-Pin DIP Optoisolators Transistor Output

CNY17-1
[CTR = 40–80%]
CNY17-2*
[CTR = 63–125%]
CNY17-3*
[CTR = 100–200%]

*Motorola Preferred Devices

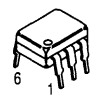
The CNY17–1, CNY17–2 and CNY17–3 devices consist of a gallium arsenide infrared emitting diode optically coupled to a monolithic silicon phototransistor detector.

- Closely Matched Current Transfer Ratio (CTR) to Minimize Unit–to–Unit Variation
- Guaranteed 70 Volt $V_{(BR)CEO}$ Minimum
- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

Applications

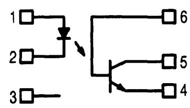
- Feedback Control Circuits, Open Loop Gain Control in Power Supplies
- Interfacing and coupling systems of different potentials and impedances
- General Purpose Switching Circuits
- Monitor and Detection Circuits

STYLE 1 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

SCHEMATIC



PIN 1. LED ANODE
2. LED CATHODE
3. N.C.
4. EMITTER
5. COLLECTOR
6. BASE

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Reverse Voltage	V_R	6	Volts
Forward Current — Continuous	I_F	60	mA
Forward Current — Pk (PW = 1 μs, 330 pps)	$I_{F(pk)}$	1.5	A
LED Power Dissipation @ T_A = 25°C with Negligible Power in Output Detector Derate above 25°C	P_D	120 1.41	mW mW/°C
OUTPUT TRANSISTOR			
Collector–Emitter Voltage	V_{CEO}	70	Volts
Emitter–Base Voltage	V_{EBO}	7	Volts
Collector–Base Voltage	V_{CBO}	70	Volts
Collector Current — Continuous	I_C	100	mA
Detector Power Dissipation @ T_A = 25°C with Negligible Power in Input LED Derate above 25°C	P_D	150 1.76	mW mW/°C
TOTAL DEVICE			
Isolation Surge Voltage(1) (Peak ac Voltage, 60 Hz, 1 sec Duration)	V_{ISO}	7500	Vac(pk)
Total Device Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Ambient Operating Temperature Range(2)	T_A	–55 to +100	°C
Storage Temperature Range(2)	T_{stg}	–55 to +150	°C
Soldering Temperature (10 sec, 1/16″ from case)	T_L	260	°C

1. Isolation surge voltage is an internal device dielectric breakdown rating. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.
2. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 1

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)(1)

Characteristic		Symbol	Min	Typ	Max	Unit
INPUT LED						
Forward Voltage (I_F = 60 mA)	T_A = 25°C T_A = –55°C T_A = 100°C	V_F	— — —	1.35 1.5 1.25	1.65 — —	Volts
Reverse Leakage Current (V_R = 6 V)		I_R	—	—	10	μA
Capacitance (V = 0, f = 1 MHz)		C_J	—	18	—	pF
OUTPUT TRANSISTOR						
Collector–Emitter Dark Current (V_{CE} = 10 V, T_A = 25°C)	CNY17–1,2 CNY17–3	I_{CEO}	— —	5 5	50 100	nA
(V_{CE} = 10 V, T_A = 100°C)	All devices	I_{CEO}	—	1.6	—	μA
Collector–Base Dark Current (V_{CB} = 10 V)		I_{CBO}	—	0.5	—	nA
Collector–Emitter Breakdown Voltage (I_C = 1 mA)		$V_{(BR)CEO}$	70	120	—	Volts
Collector–Base Breakdown Voltage (I_C = 100 μA)		$V_{(BR)CBO}$	70	120	—	Volts
Emitter–Base Breakdown Voltage (I_E = 100 μA)		$V_{(BR)EBO}$	7	7.8	—	Volts
DC Current Gain (I_C = 2 mA, V_{CE} = 5 V) (Typical Value)		hFE	—	400	—	—
Collector–Emitter Capacitance (f = 1 MHz, V_{CE} = 0)		C_{CE}	—	8	—	pF
Collector–Base Capacitance (f = 1 MHz, V_{CB} = 0)		C_{CB}	—	21	—	pF
Emitter–Base Capacitance (f = 1 MHz, V_{EB} = 0)		C_{EB}	—	8	—	pF
COUPLED						
Output Collector Current (I_F = 10 mA, V_{CE} = 5 V)	CNY17–1 CNY17–2 CNY17–3	I_C (CTR)(2)	4 (40) 6.3 (63) 10 (100)	6 (60) 10 (100) 15 (150)	8 (80) 12.5 (125) 20 (200)	mA (%)
Collector–Emitter Saturation Voltage (I_C = 2.5 mA, I_F = 10 mA)		$V_{CE(sat)}$	—	0.18	0.4	Volts
Delay Time (I_F = 10 mA, V_{CC} = 5 V, R_L = 75 Ω, Figure 11)		t_d	—	1.6	5.6	μs
Rise Time (I_F = 10 mA, V_{CC} = 5 V, R_L = 75 Ω, Figure 11)		t_r	—	1.6	4	μs
Storage Time (I_F = 10 mA, V_{CC} = 5 V, R_L = 75 Ω, Figure 11)		t_s	—	0.7	4.1	μs
Fall Time (I_F = 10 mA, V_{CC} = 5 V, R_L = 75 Ω, Figure 11)		t_f	—	2.3	3.5	μs
Delay Time (I_F = 20 mA, V_{CC} = 5 V, R_L = 1 kΩ)(3) (I_F = 10 mA, V_{CC} = 5 V, R_L = 1 kΩ)(3)	 CNY17–1 CNY17–2,3	t_d	 — —	 1.2 1.8	 5.5 8	μs
Rise Time (I_F = 20 mA, V_{CC} = 5 V, R_L = 1 kΩ)(3) (I_F = 10 mA, V_{CC} = 5 V, R_L = 1 kΩ)(3)	 CNY17–1 CNY17–2,3	t_r	 — —	 3.3 5	 4 6	μs
Storage Time (I_F = 20 mA, V_{CC} = 5 V, R_L = 1 kΩ)(3) (I_F = 10 mA, V_{CC} = 5 V, R_L = 1 kΩ)(3)	 CNY17–1 CNY17–2,3	t_s	 — —	 4.4 2, 7	 34 39	μs
Fall Time (I_F = 20 mA, V_{CC} = 5 V, R_L = 1 kΩ)(3) (I_F = 10 mA, V_{CC} = 5 V, R_L = 1 kΩ)(3)	 CNY17–1 CNY17–2,3	t_f	 — —	 9.7 9.4, 20	 20 24	μs
Isolation Voltage (f = 60 Hz, t = 1 sec)(4)		V_{ISO}	7500	—	—	Vac(pk)
Isolation Resistance (V = 500 V)(4)		R_{ISO}	10^{11}	—	—	Ω
Isolation Capacitance (V = 0, f = 1 MHz)(4)		C_{ISO}	—	0.2	0.5	pF

1. Always design to the specified minimum/maximum electrical limits (where applicable).
2. Current Transfer Ratio (CTR) = I_C/I_F x 100%.
3. For test circuit setup and waveforms, refer to Figure 11.
4. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.

TYPICAL CHARACTERISTICS

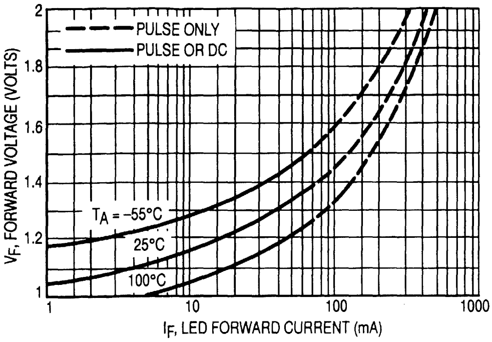


Figure 1. LED Forward Voltage versus Forward Current

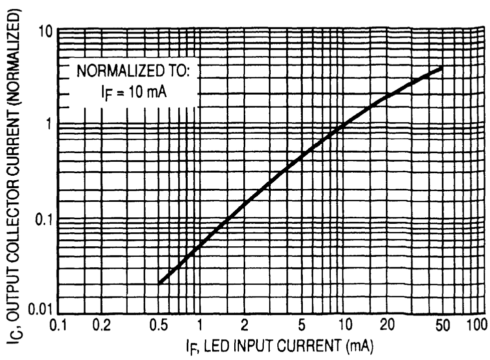


Figure 2. Output Current versus Input Current

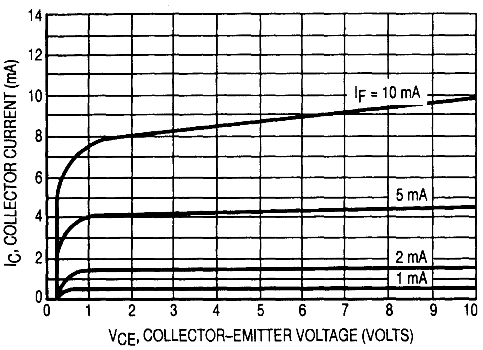


Figure 3. Collector Current versus Collector–Emitter Voltage

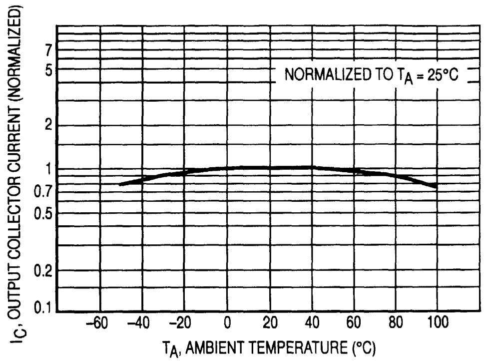


Figure 4. Output Current versus Ambient Temperature

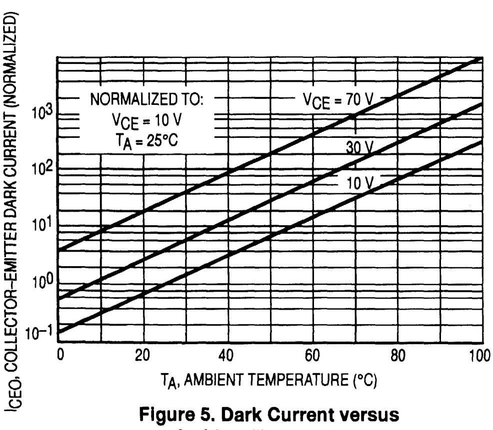


Figure 5. Dark Current versus Ambient Temperature

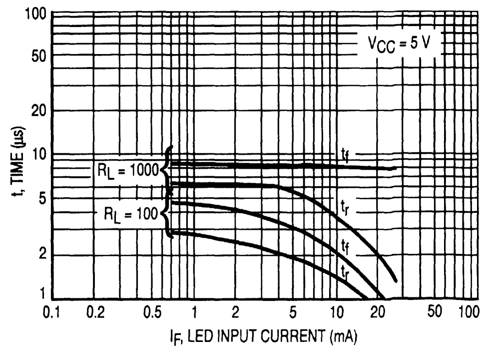


Figure 6. Rise and Fall Times CNY17–1 and CNY17–2

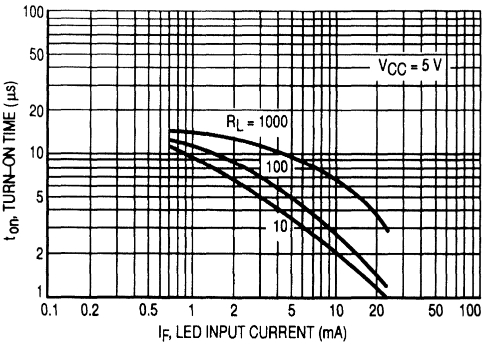


Figure 7. Turn–On Switching Times

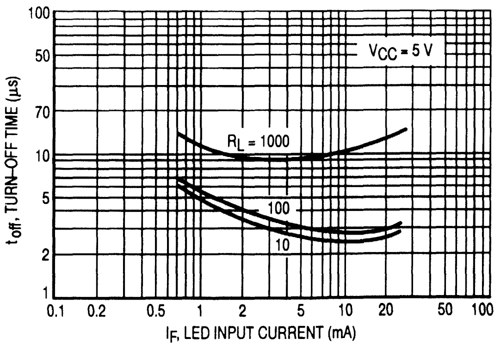


Figure 8. Turn–Off Switching Times CNY17–1 and CNY17–2

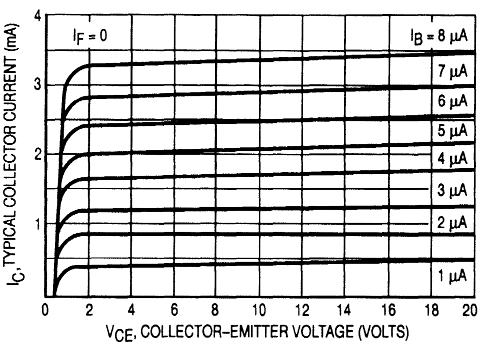


Figure 9. DC Current Gain (Detector Only)

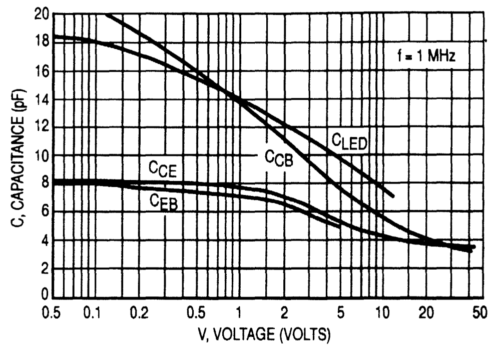


Figure 10. Capacitances versus Voltage

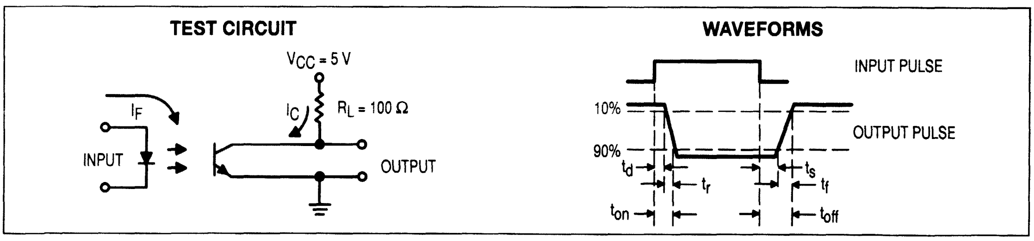


Figure 11. Switching Time Test Circuit and Waveforms

GlobalOptoisolator™

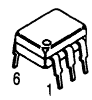
VDE | UL | CSA | SETI | SEMKO | DEMKO | NEMKO | BABT

6-Pin DIP Optoisolators Transistor Output

H11A1*
[CTR = 50% Min]

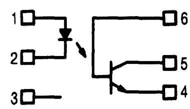
*Motorola Preferred Device

STYLE 1 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

SCHEMATIC



PIN 1. LED ANODE
2. LED CATHODE
3. N.C.
4. EMITTER
5. COLLECTOR
6. BASE

The H11A1 device consists of a gallium arsenide infrared emitting diode optically coupled to a monolithic silicon phototransistor detector.

- Current Transfer Ratios (CTR) 30% and 50%
- Economical Optoisolators for General Purpose/High Volume Applications
- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

Applications

- General Purpose Switching Circuits
- Interfacing and coupling systems of different potentials and impedances
- Monitor and Detection Circuits

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Reverse Voltage	V_R	3	Volts
Forward Current — Continuous	I_F	60	mA
LED Power Dissipation @ T_A = 25°C with Negligible Power in Output Detector Derate above 25°C	P_D	120 1.41	mW mW/°C
OUTPUT TRANSISTOR			
Collector–Emitter Voltage	V_{CEO}	30	Volts
Emitter–Collector Voltage	V_{ECO}	7	Volts
Collector–Base Voltage	V_{CBO}	70	Volts
Collector Current — Continuous	I_C	150	mA
Detector Power Dissipation @ T_A = 25°C with Negligible Power in Input LED Derate above 25°C	P_D	150 1.76	mW mW/°C
TOTAL DEVICE			
Isolation Surge Voltage(1) (Peak ac Voltage, 60 Hz, 1 sec Duration)	V_{ISO}	7500	Vac(pk)
Total Device Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Ambient Operating Temperature Range(2)	T_A	−55 to +100	°C
Storage Temperature Range(2)	T_{stg}	−55 to +150	°C
Soldering Temperature (10 sec, 1/16″ from case)	T_L	260	°C

1. Isolation surge voltage is an internal device dielectric breakdown rating. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.
2. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 1

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)(1)

Characteristic		Symbol	Min	Typ(1)	Max	Unit
INPUT LED						
Forward Voltage (I_F = 10 mA,	T_A = 25°C)	V_F	—	1.15	1.5	Volts
	T_A = −55°C		—	1.3	—	
	T_A = 100°C		—	1.05	—	
Reverse Leakage Current (V_R = 3 V)		I_R	—	0.01	10	μA
Capacitance (V = 0 V, f = 1 MHz)		C_J	—	18	—	pF
OUTPUT TRANSISTOR						
Collector–Emitter Dark Current (V_{CE} = 10 V)	T_A = 25°C	I_{CEO}	—	1	50	nA
	T_A = 100°C		—	1	—	μA
Collector–Base Dark Current (V_{CB} = 10 V)	T_A = 25°C	I_{CBO}	—	0.2	20	nA
	T_A = 100°C		—	100	—	
Collector–Emitter Breakdown Voltage (I_C = 10 mA)		$V_{(BR)CEO}$	30	45	—	Volts
Collector–Base Breakdown Voltage (I_C = 100 μA)		$V_{(BR)CBO}$	70	100	—	Volts
Emitter–Collector Breakdown Voltage (I_E = 100 μA)		$V_{(BR)ECO}$	7	7.8	—	Volts
DC Current Gain (I_C = 5 mA, V_{CE} = 5 V) (Typical Value)		h_{FE}	—	500	—	—
Collector–Emitter Capacitance (f = 1 MHz, V_{CE} = 0 V)		C_{CE}	—	7	—	pF
Collector–Base Capacitance (f = 1 MHz, V_{CB} = 0 V)		C_{CB}	—	19	—	pF
Emitter–Base Capacitance (f = 1 MHz, V_{EB} = 0 V)		C_{EB}	—	9	—	pF
COUPLED						
Output Collector Current (I_F = 10 mA, V_{CE} = 10 V)	H11A1	I_C (CTR)(2)	5 (50)	12 (120)	—	mA (%)
Collector–Emitter Saturation Voltage (I_C = 0.5 mA, I_F = 10 mA)		$V_{CE(sat)}$	—	0.1	0.4	Volts
Turn–On Time (I_F = 10 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)		t_{on}	—	2.8	—	μs
Turn–Off Time (I_F = 10 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)		t_{off}	—	4.5	—	μs
Rise Time (I_F = 10 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)		t_r	—	1.2	—	μs
Fall Time (I_F = 10 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)		t_f	—	1.3	—	μs
Isolation Voltage (f = 60 Hz, t = 1 sec)(4)		V_{ISO}	7500	—	—	Vac(pk)
Isolation Resistance (V = 500 V)(4)		R_{ISO}	10^{11}	—	—	Ω
Isolation Capacitance (V = 0 V, f = 1 MHz)(4)		C_{ISO}	—	0.2	—	pF

1. Always design to the specified minimum/maximum electrical limits (where applicable).
2. Current Transfer Ratio (CTR) = I_C/I_F x 100%.
3. For test circuit setup and waveforms, refer to Figure 11.
4. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.

TYPICAL CHARACTERISTICS

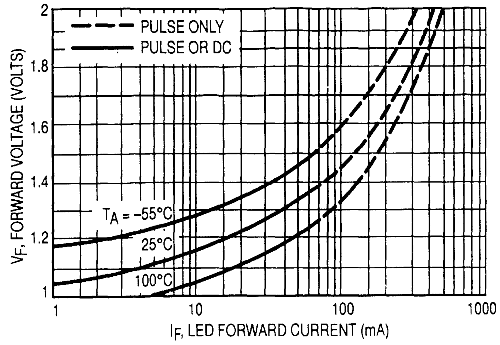


Figure 1. LED Forward Voltage versus Forward Current

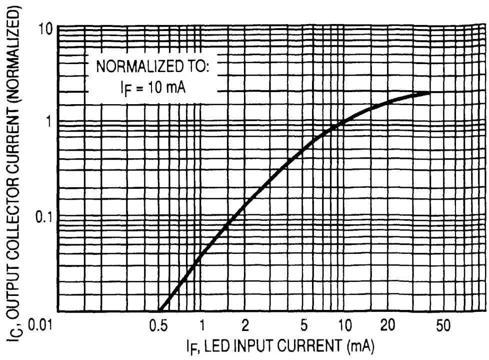


Figure 2. Output Current versus Input Current

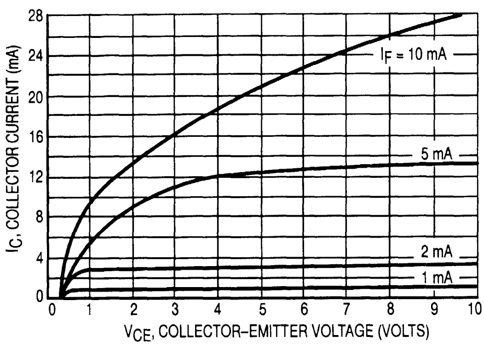


Figure 3. Collector Current versus Collector–Emitter Voltage

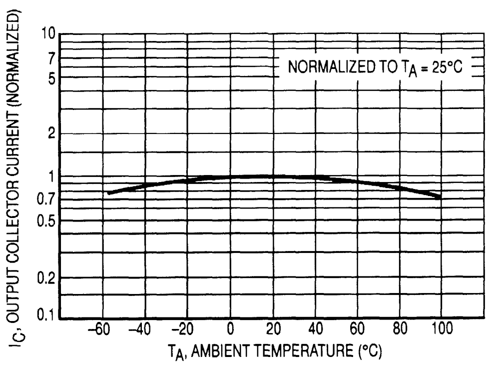


Figure 4. Output Current versus Ambient Temperature

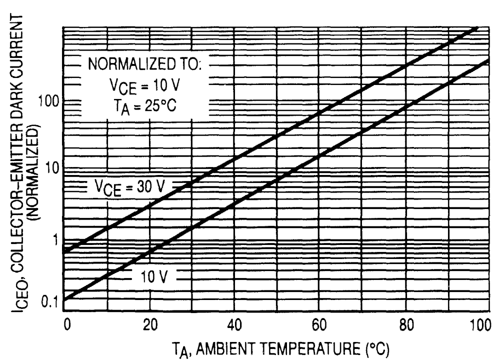


Figure 5. Dark Current versus Ambient Temperature

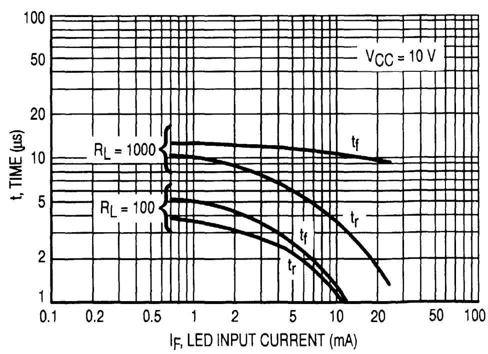


Figure 6. Rise and Fall Times (Typical Values)

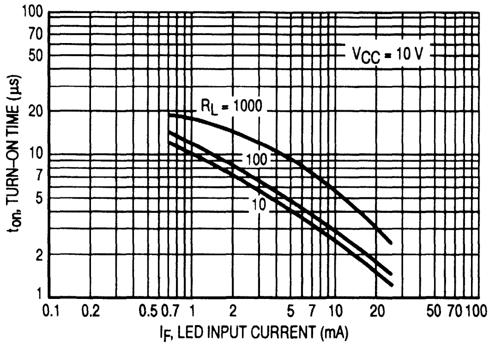


Figure 7. Turn–On Switching Times (Typical Values)

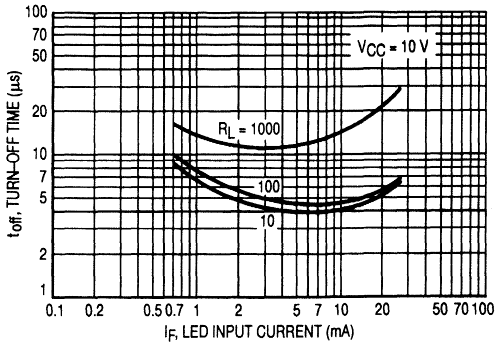


Figure 8. Turn–Off Switching Times (TypicalValues)

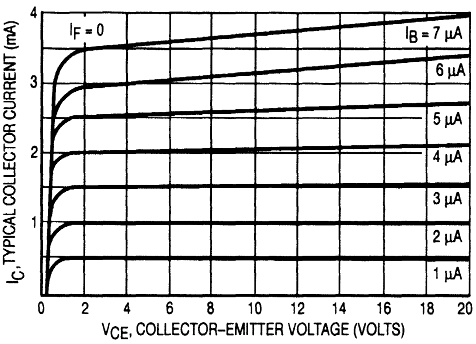


Figure 9. DC Current Gain (Detector Only)

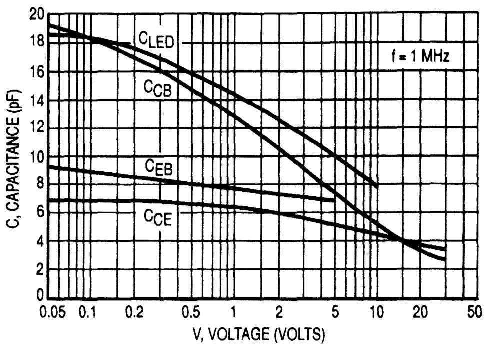


Figure 10. Capacitances versus Voltage

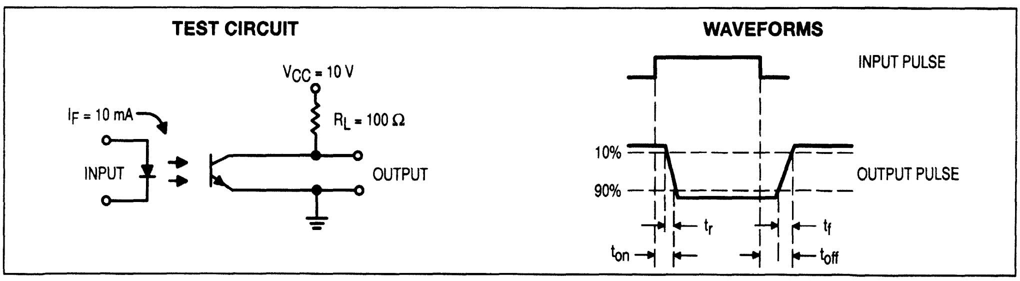


Figure 11. Switching Time Test Circuit and Waveforms

GlobalOptoisolator™

VDE | UL | CSA | SETI | SEMKO | DEMKO | NEMKO | BABT

6-Pin DIP Optoisolators AC Input/Transistor Output

H11AA1*
[CTR = 20% Min]

H11AA2
[CTR = 10% Min]

H11AA3
[CTR = 50% Min]

H11AA4*
[CTR = 100% Min]

*Motorola Preferred Devices

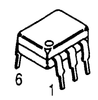
The H11AA1, H11AA2, H11AA3, H11AA4 devices consist of two gallium–arsenide infrared emitting diodes connected in inverse parallel, optically coupled to a monolithic silicon phototransistor detector.

- Built–In Protection for Reverse Polarity
- Guaranteed CTR Minimum Values as High as 100%
- Guaranteed Minimum/Maximum Symmetry Limits
- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

Applications

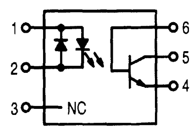
- Detecting or Monitoring ac Signals
- AC Line/Digital Logic Isolation
- Programmable Controllers
- Interfacing and coupling systems of different potentials and impedances
- AC/DC — Input Modules

STYLE 8 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

SCHEMATIC



PIN 1. INPUT LED
2. INPUT LED
3. NO CONNECTION
4. EMITTER
5. COLLECTOR
6. BASE

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Forward Current — Continuous (RMS)	I_F	60	mA
LED Power Dissipation @ T_A = 25°C with Negligible Power in Output Detector Derate above 25°C	P_D	120 1.41	mW mW/°C
OUTPUT TRANSISTOR			
Collector–Emitter Voltage	V_{CEO}	30	Volts
Emitter–Base Voltage	V_{EBO}	5	Volts
Collector–Base Voltage	V_{CBO}	70	Volts
Collector Current — Continuous	I_C	150	mA
Detector Power Dissipation @ T_A = 25°C with Negligible Power in Input LEDs Derate above 25°C	P_D	150 1.76	mW mW/°C
TOTAL DEVICE			
Isolation Surge Voltage(1) (Peak ac Voltage, 60 Hz, 1 sec Duration)	V_{ISO}	7500	Vac(pk)
Total Device Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Ambient Operating Temperature Range(2)	T_A	–55 to +100	°C
Storage Temperature Range(2)	T_{stg}	–55 to +150	°C
Soldering Temperature (10 sec, 1/16″ from case)	T_L	260	°C

1. Isolation surge voltage is an internal device dielectric breakdown rating. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.
2. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 1

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)(1)

Characteristic		Symbol	Min	Typ(1)	Max	Unit
INPUT LED						
Forward Voltage	H11AA1,3,4	V_F	—	1.15	1.5	Volts
(I_F = 10 mA, either direction)	H11AA2		—	1.15	1.8	
T_A = −55°C	All devices		—	1.3	—	
T_A = 100°C	All devices		—	1.05	—	
Capacitance (V = 0 V, f = 1 MHz)		C_J	—	20	—	pF
OUTPUT TRANSISTOR						
Collector–Emitter Dark Current	H11AA1,3,4	I_{CEO}	—	1	100	nA
(V_{CE} = 10 V)	H11AA2		—	1	200	nA
T_A = 100°C	All devices		—	1	—	μA
Collector–Base Dark Current (V_{CB} = 10 V)		I_{CBO}	—	0.2	—	nA
Collector–Emitter Breakdown Voltage (I_C = 10 mA)		$V_{(BR)CEO}$	30	45	—	Volts
Collector–Base Breakdown Voltage (I_C = 100 μA)		$V_{(BR)CBO}$	70	100	—	Volts
Emitter–Collector Breakdown Voltage (I_E = 100 μA)		$V_{(BR)ECO}$	5	7.8	—	Volts
DC Current Gain (I_C = 2 mA, V_{CE} = 5 V) (Typical Value)		h_{FE}	—	500	—	—
Collector–Emitter Capacitance (f = 1 MHz, V_{CE} = 0 V)		C_{CE}	—	1.7	—	pF
Collector–Base Capacitance (f = 1 MHz, V_{CB} = 0 V)		C_{CB}	—	20	—	pF
Emitter–Base Capacitance (f = 1 MHz, V_{EB} = 0 V)		C_{EB}	—	10	—	pF
COUPLED						
Output Collector Current	H11AA1	I_C (CTR)(2)	2 (20)	5 (50)	—	mA (%)
(I_F = ±10 mA, V_{CE} = 10 V)	H11AA2		1 (10)	2 (20)	—	
	H11AA3		5 (50)	10 (100)	—	
	H11AA4		10 (100)	15 (150)	—	
Output Collector Current Symmetry(3) $\left(\frac{I_C \text{ at } I_F = +10 \text{ mA}, V_{CE} = 10 \text{ V}}{I_C \text{ at } I_F = -10 \text{ mA}, V_{CE} = 10 \text{ V}}\right)$	H11AA1,3,4	—	0.33	—	3	—
Collector–Emitter Saturation Voltage (I_C = 0.5 mA, I_F = ±10 mA)		$V_{CE(sat)}$	—	0.1	0.4	Volts
Isolation Voltage (f = 60 Hz, t = 1 sec)(4)		V_{ISO}	7500	—	—	Vac(pk)
Isolation Resistance (V = 500 V)(4)		R_{ISO}	10^{11}	—	—	Ω
Isolation Capacitance (V = 0 V, f = 1 MHz)(4)		C_{ISO}	—	0.2	—	pF

1. Always design to the specified minimum/maximum electrical limits (where applicable).
2. Current Transfer Ratio (CTR) = I_C/I_F x 100%.
3. This specification guarantees that the higher of the two I_C readings will be no more than 3 times the lower at I_F = 10 mA.
4. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.

TYPICAL CHARACTERISTICS

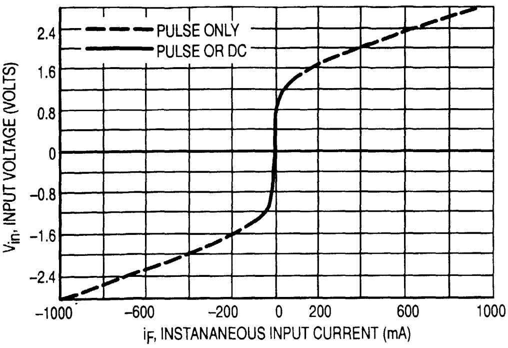


Figure 1. Input Voltage versus Input Current

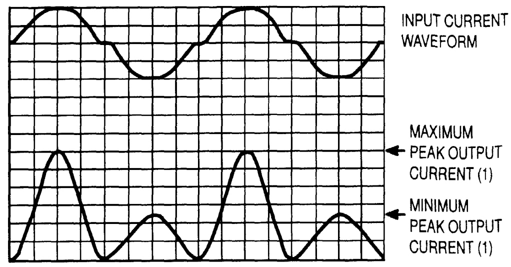


Figure 2. Output Characteristics

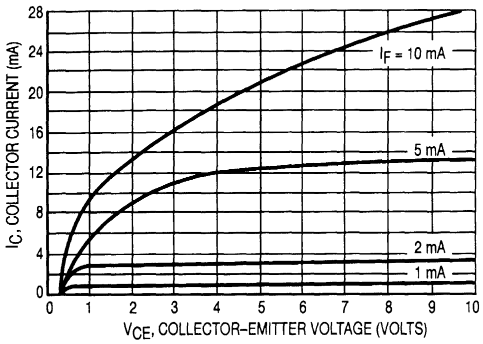


Figure 3. Collector Current versus Collector–Emitter Voltage

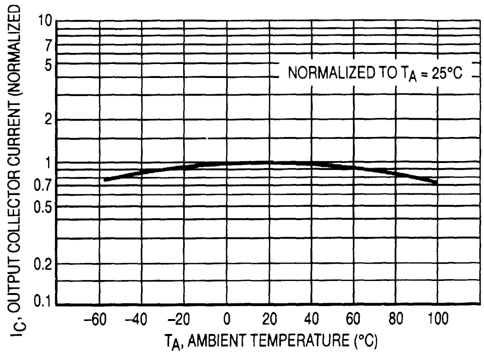


Figure 4. Output Current versus Ambient Temperature

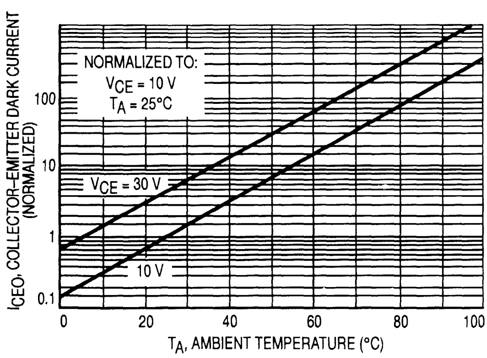


Figure 5. Dark Current versus Ambient Temperature

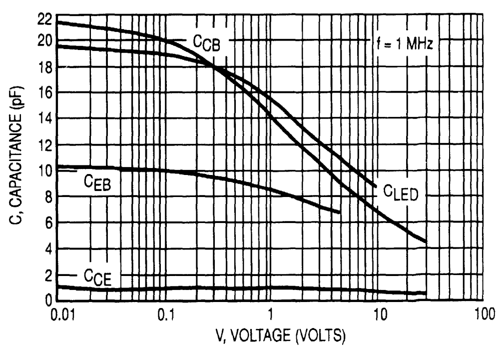


Figure 6. Capacitances versus Voltage

GlobalOptoisolator™

VDE	UL	CSA	SETI	SEMKO	DEMKO	NEMKO	BABT

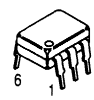
6-Pin DIP Optoisolators Transistor Output

H11AV1,A*
[CTR = 100% Min]
H11AV2,A
[CTR = 50% Min]
***Motorola Preferred Devices**

The H11AV1,A and H11AV2,A devices consist of a gallium arsenide infrared emitting diode optically coupled to a monolithic silicon phototransistor detector.

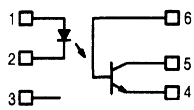
- Guaranteed 70 Volt $V_{(BR)CEO}$ Minimum
- **'A' Suffix = 0.400″ Wide Spaced Leadform (Same as 'T' Suffix. Refer to Leadform Options Section in Opto Data Book.)**
- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

STYLE 1 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

SCHEMATIC



PIN 1. LED ANODE
2. LED CATHODE
3. N.C.
4. EMITTER
5. COLLECTOR
6. BASE

Applications

- General Purpose Switching Circuits
- Interfacing and coupling systems of different potentials and impedances
- Monitor and Detection Circuits
- Regulation and Feedback Circuits
- Solid State Relays

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Reverse Voltage	V_R	6	Volts
Forward Current — Continuous	I_F	60	mA
LED Power Dissipation @ T_A = 25°C with Negligible Power in Output Detector Derate above 25°C	P_D	120 1.41	mW mW/°C
OUTPUT TRANSISTOR			
Collector–Emitter Voltage	V_{CEO}	70	Volts
Emitter–Base Voltage	V_{EBO}	7	Volts
Collector–Base Voltage	V_{CBO}	70	Volts
Collector Current — Continuous	I_C	150	mA
Detector Power Dissipation @ T_A = 25°C with Negligible Power in Input LED Derate above 25°C	P_D	150 1.76	mW mW/°C
TOTAL DEVICE			
Isolation Surge Voltage(1) (Peak ac Voltage, 60 Hz, 1 sec Duration)	V_{ISO}	7500	Vac(pk)
Total Device Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Ambient Operating Temperature Range(2)	T_A	−55 to +100	°C
Storage Temperature Range(2)	T_{stg}	−55 to +150	°C
Soldering Temperature (10 sec, 1/16″ from case)	T_L	260	°C

1. Isolation surge voltage is an internal device dielectric breakdown rating. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.
2. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 1

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)(1)

Characteristic	Symbol	Min	Typ(1)	Max	Unit
INPUT LED					
Forward Voltage (I_F = 10 mA) T_A = 25°C T_A = –55°C T_A = 100°C	V_F	0.8 0.9 0.7	1.15 1.3 1.05	1.5 1.7 1.4	Volts
Reverse Leakage Current (V_R = 6 V)	I_R	—	—	10	μA
Capacitance (V = 0 V, f = 1 MHz)	C_J	—	18	—	pF
OUTPUT TRANSISTOR					
Collector–Emitter Dark Current (V_{CE} = 10 V)	I_{CEO}	—	5	50	nA
Collector–Base Dark Current (V_{CB} = 10 V)	I_{CBO}	—	0.5	—	nA
Collector–Emitter Breakdown Voltage (I_C = 1 mA)	$V_{(BR)CEO}$	70	100	—	Volts
Collector–Base Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CBO}$	70	100	—	Volts
Emitter–Collector Breakdown Voltage (I_E = 100 μA)	$V_{(BR)ECO}$	7	8	—	Volts
DC Current Gain (I_C = 2 mA, V_{CE} = 10 V) (Typical Value)	h_{FE}	—	500	—	—
Collector–Emitter Capacitance (f = 1 MHz, V_{CE} = 10 V)	C_{CE}	—	4.5	—	pF
COUPLED					
Output Collector Current (I_F = 10 mA, V_{CE} = 10 V) H11AV1, H11AV1A H11AV2, H11AV2A	I_C (CTR)(2)	 10 (100) 5 (50)	 15 (150) 10 (100)	 30 (300) —	mA (%)
Collector–Emitter Saturation Voltage (I_C = 2 mA, I_F = 20 mA)	$V_{CE(sat)}$	—	0.15	0.4	Volts
Turn–On Time (I_C = 2 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)	t_{on}	—	5	15	μs
Turn–Off Time (I_C = 2 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)	t_{off}	—	4	15	μs
Isolation Voltage (f = 60 Hz, t = 1 sec)(4)	V_{ISO}	7500	—	—	Vac(pk)
Isolation Resistance (V = 500 V)(4)	R_{ISO}	10^{11}	—	—	Ω
Isolation Capacitance (V = 0 V, f = 1 MHz)(4)	C_{ISO}	—	0.2	0.5	pF

1. Always design to the specified minimum/maximum electrical limits (where applicable).
2. Current Transfer Ratio (CTR) = I_C/I_F x 100%.
3. For test circuit setup and waveforms, refer to Figure 11.
4. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.

TYPICAL CHARACTERISTICS

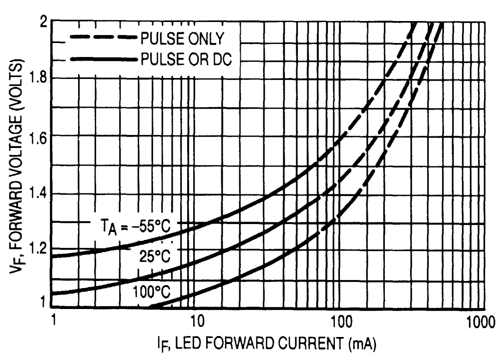


Figure 1. LED Forward Voltage versus Forward Current

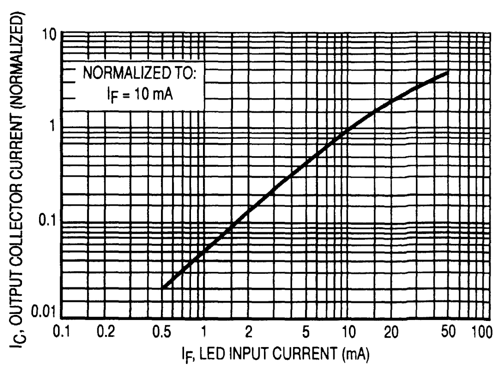


Figure 2. Output Current versus Input Current

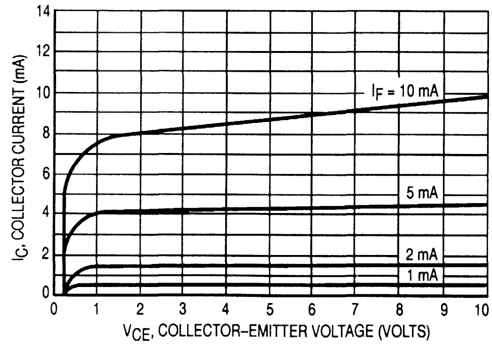


Figure 3. Collector Current versus Collector–Emitter Voltage

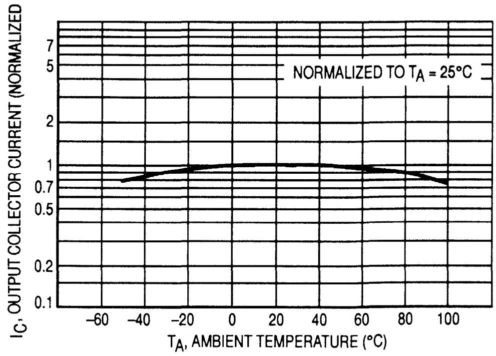


Figure 4. Output Current versus Ambient Temperature

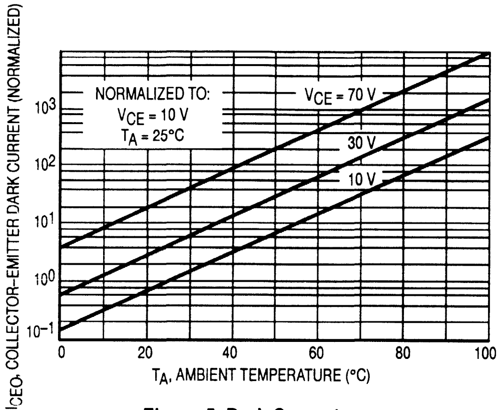


Figure 5. Dark Current versus Ambient Temperature

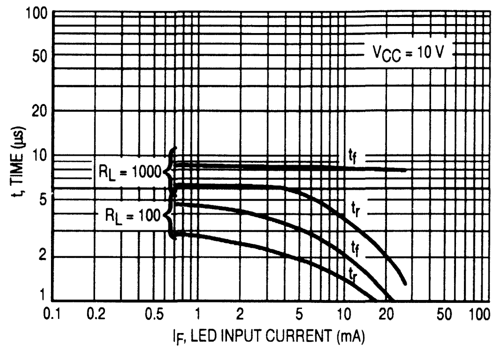


Figure 6. Rise and Fall Times (Typical Values)

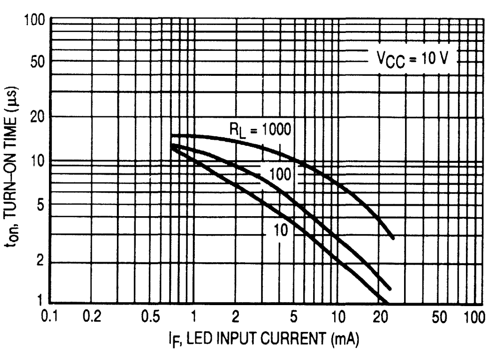


Figure 7. Turn–On Switching Times

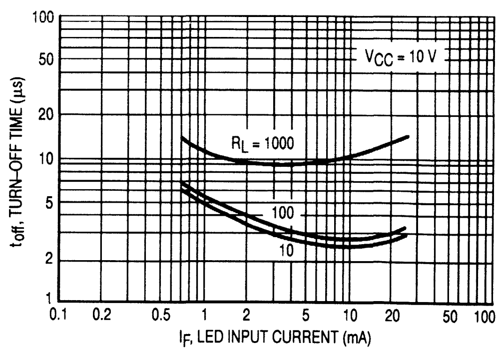


Figure 8. Turn–Off Switching Times

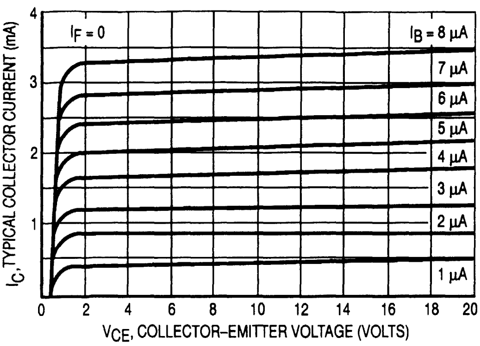


Figure 9. DC Current Gain (Detector Only)

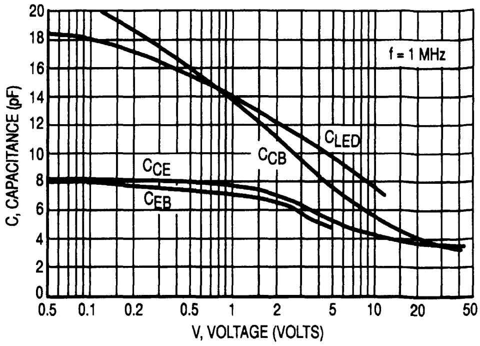


Figure 10. Capacitances versus Voltage

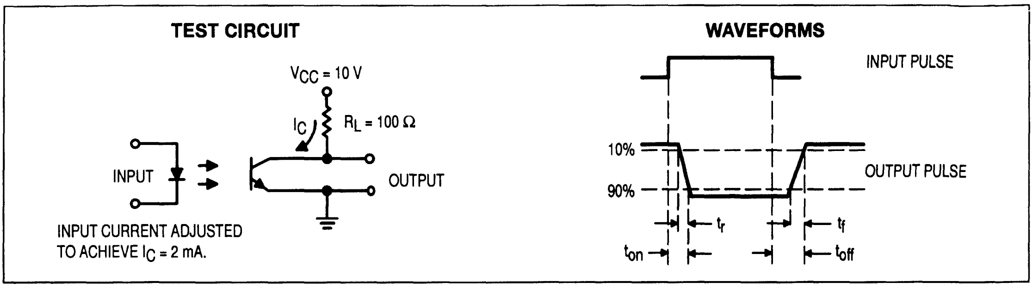


Figure 11. Switching Time Test Circuit and Waveforms

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

GlobalOptoisolator™

VDE	UL	CSA	SETI	SEMKO	DEMKO	NEMKO	BABT

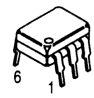
6-Pin DIP Optoisolators Darlington Output (Low Input Current)

H11B1*
[CTR = 500% Min]
H11B3
[CTR = 100% Min]
***Motorola Preferred Device**

The H11B1 and H11B3 devices consist of a gallium arsenide infrared emitting diode optically coupled to a monolithic silicon photodarlington detector. They are designed for use in applications requiring high output current (I_C) at low LED input currents (I_F).

- High Sensitivity to Low Input Drive Current (I_F = 1 mA)
- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

STYLE 1 PLASTIC

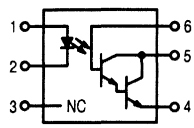


STANDARD THRU HOLE
CASE 730A–04

Applications

- Appliances, Measuring Instruments
- I/O Interfaces for Computers
- Programmable Controllers
- Interfacing and coupling systems of different potentials and impedances
- Solid State Relays
- Portable Electronics

SCHEMATIC



PIN 1. LED ANODE
2. LED CATHODE
3. N.C.
4. EMITTER
5. COLLECTOR
6. BASE

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Reverse Voltage	V_R	3	Volts
Forward Current — Continuous	I_F	60	mA
LED Power Dissipation @ T_A = 25°C with Negligible Power in Output Detector	P_D	150	mW
Derate above 25°C		1.41	mW/°C
OUTPUT DETECTOR			
Collector–Emitter Voltage	V_{CEO}	25	Volts
Emitter–Base Voltage	V_{EBO}	7	Volts
Collector–Base Voltage	V_{CBO}	30	Volts
Collector Current — Continuous	I_C	100	mA
Detector Power Dissipation @ T_A = 25°C with Negligible Power in Input LED	P_D	150	mW
Derate above 25°C		1.76	mW/°C
TOTAL DEVICE			
Isolation Surge Voltage(1) (Peak ac Voltage, 60 Hz, 1 sec Duration)	V_{ISO}	7500	Vac(pk)
Total Device Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Ambient Operating Temperature Range(2)	T_A	−55 to +100	°C
Storage Temperature Range(2)	T_{stg}	−55 to +150	°C
Soldering Temperature (10 sec, 1/16″ from case)	T_L	260	°C

1. Isolation surge voltage is an internal device dielectric breakdown rating.
For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.
2. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 1

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)(1)

Characteristic		Symbol	Min	Typ(1)	Max	Unit
INPUT LED						
Forward Voltage (I_F = 10 mA)	H11B1	V_F	—	1.15	1.5	Volts
Forward Voltage (I_F = 50 mA)	H11B3	V_F	—	1.34	1.5	Volts
Reverse Leakage Current (V_R = 3 V)		I_R	—	—	10	μA
Capacitance (V = 0 V, f = 1 MHz)		C_J	—	18	—	pF
OUTPUT DETECTOR						
Collector–Emitter Dark Current (V_{CE} = 10 V)		I_{CEO}	—	5	100	nA
Collector–Emitter Breakdown Voltage (I_C = 10 mA)		$V_{(BR)CEO}$	25	80	—	Volts
Collector–Base Breakdown Voltage (I_C = 100 μA)		$V_{(BR)CBO}$	30	100	—	Volts
Emitter–Collector Breakdown Voltage (I_E = 100 μA)		$V_{(BR)ECO}$	7	—	—	Volts
DC Current Gain (I_C = 5 mA, V_{CE} = 5 V) (Typical Value)		h_{FE}	—	16K	—	—
Collector–Emitter Capacitance (f = 1 MHz, V_{CE} = 5 V)		C_{CE}	—	4.9	—	pF
Collector–Base Capacitance (f = 1 MHz, V_{CB} = 5 V)		C_{CB}	—	6.3	—	pF
Emitter–Base Capacitance (f = 1 MHz, V_{EB} = 5 V)		C_{EB}	—	3.8	—	pF
COUPLED						
Output Collector Current (I_F = 1 mA, V_{CE} = 5 V)	H11B1 H11B3	I_C (CTR)(2)	5 (500) 1 (100)	— —	— —	mA (%)
Collector–Emitter Saturation Voltage (I_C = 1 mA, I_F = 1 mA)		$V_{CE(sat)}$	—	0.7	1	Volts
Turn–On Time (I_F = 5 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)		t_{on}	—	3.5	—	μs
Turn–Off Time (I_F = 5 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)		t_{off}	—	95	—	μs
Rise Time (I_F = 5 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)		t_r	—	1	—	μs
Fall Time (I_F = 5 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)		t_f	—	2	—	μs
Isolation Voltage (f = 60 Hz, t = 1 sec)(4)		V_{ISO}	7500	—	—	Vac(pk)
Isolation Resistance (V = 500 V)(4)		R_{ISO}	10^{11}	—	—	Ω
Isolation Capacitance (V = 0 V, f = 1 MHz)(4)		C_{ISO}	—	0.2	—	pF

1. Always design to the specified minimum/maximum electrical limits (where applicable).
2. Current Transfer Ratio (CTR) = I_C/I_F x 100%.
3. For test circuit setup and waveforms, refer to Figure 11.
4. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.

TYPICAL CHARACTERISTICS

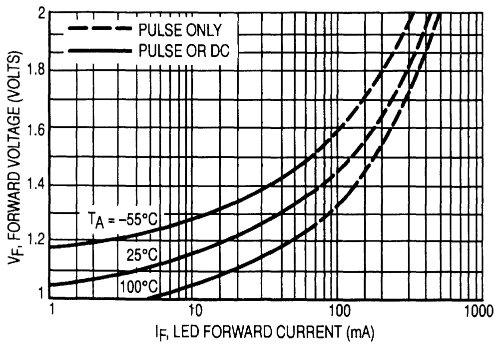


Figure 1. LED Forward Voltage versus Forward Current

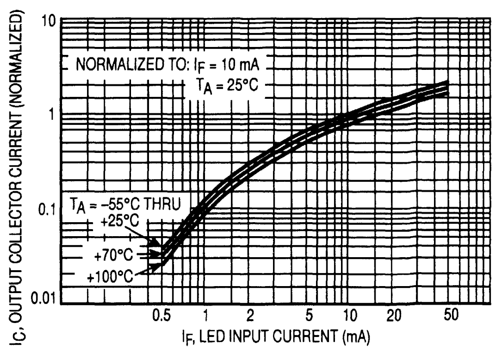


Figure 2. Output Current versus Input Current

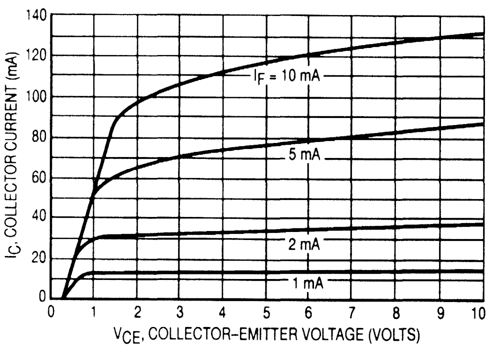


Figure 3. Collector Current versus Collector–Emitter Voltage

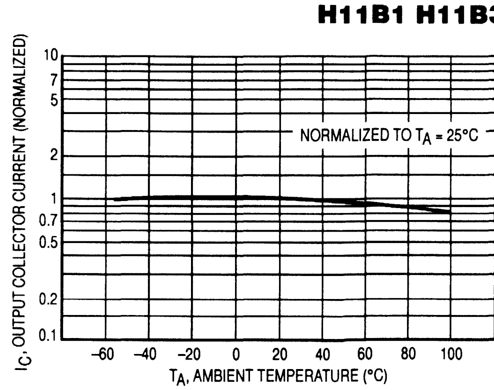


Figure 4. Output Current versus Ambient Temperature

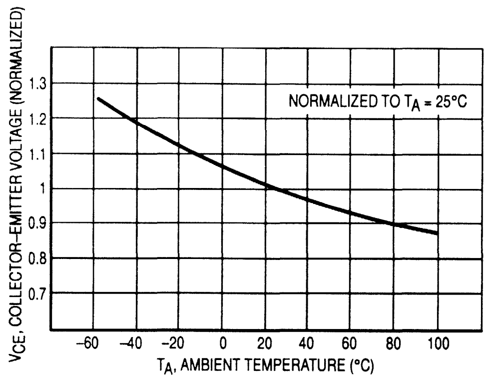


Figure 5. Collector–Emitter Voltage versus Ambient Temperature

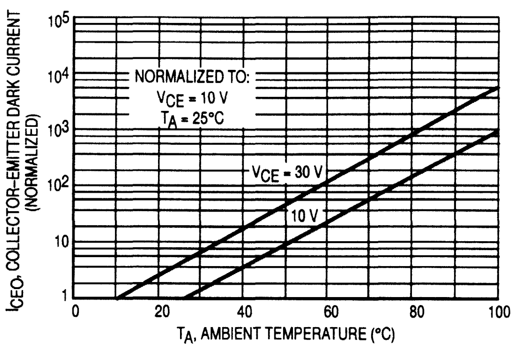


Figure 6. Collector–Emitter Dark Current versus Ambient Temperature

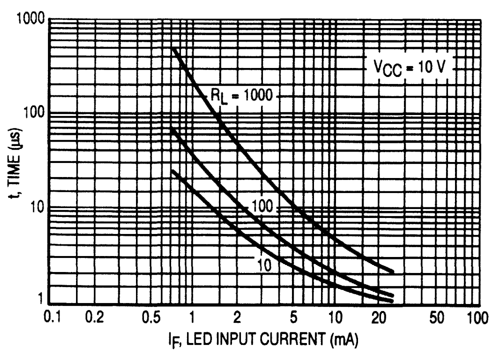


Figure 7. Turn–On Switching Times (Typical Values)

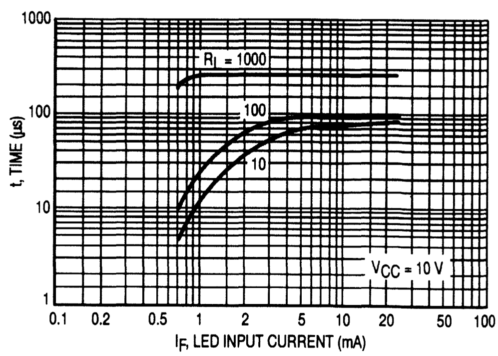


Figure 8. Turn–Off Switching Times (Typical Values)

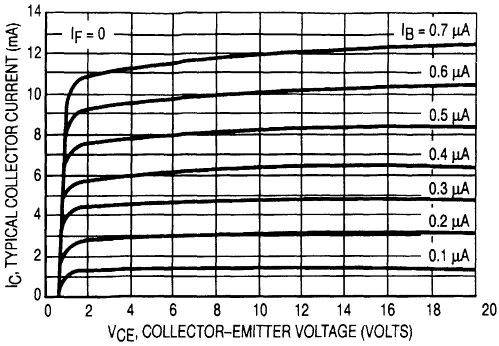


Figure 9. DC Current Gain (Detector Only)

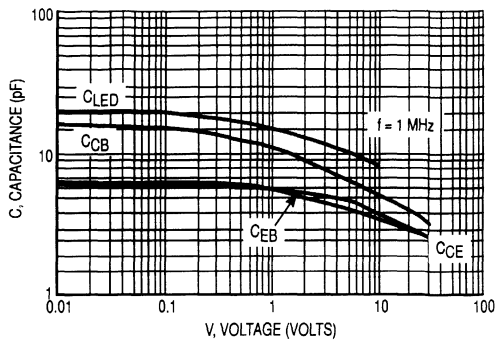


Figure 10. Capacitance versus Voltage

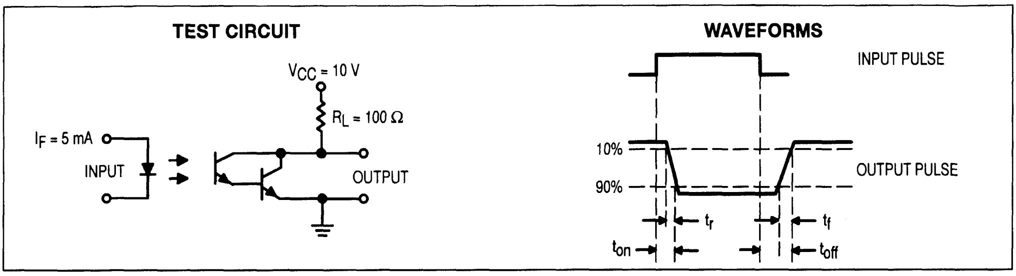


Figure 11. Switching Time Test Circuit and Waveforms

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

GlobalOptoisolator™

VDE | UL | CSA | SETI | SEMKO | DEMKO | NEMKO | BABT

6-Pin DIP Optoisolators High Voltage Transistor Output (300 Volts)

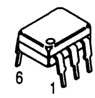
H11D1*

H11D2

[CTR = 20% Min]

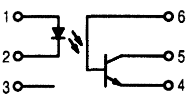
***Motorola Preferred Device**

STYLE 1 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

SCHEMATIC



PIN 1. ANODE
2. CATHODE
3. N.C.
4 EMITTER
5. COLLECTOR
6. BASE

The H11D1 and H11D2 consist of gallium arsenide infrared emitting diodes optically coupled to high voltage, silicon, phototransistor detectors in a standard 6–pin DIP package. They are designed for high voltage applications and are particularly useful in copy machines and solid state relays.

- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

Applications

- Copy Machines
- Interfacing and coupling systems of different potentials and impedances
- Monitor and Detection Circuits
- Solid State Relays

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Forward Current — Continuous	I_F	60	mA
Forward Current — Peak Pulse Width = 1 µs, 330 pps	I_F	1.2	Amps
LED Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	120 1.41	mW mW/°C
OUTPUT TRANSISTOR			
Collector–Emitter Voltage	V_{CER}	300	Volts
Emitter–Collector Voltage	V_{ECO}	7	Volts
Collector–Base Voltage	V_{CBO}	300	Volts
Collector Current — Continuous	I_C	100	mA
Detector Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 1.76	mW mW/°C
TOTAL DEVICE			
Total Device Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Operating Temperature Range(3)	T_J	–55 to +100	°C
Storage Temperature Range(3)	T_{stg}	–55 to +150	°C
Soldering Temperature (10 s)	T_L	260	°C
Isolation Surge Voltage Peak ac Voltage, 60 Hz, 1 Second Duration(1)	V_{ISO}	7500	Vac(pk)

1. Isolation surge voltage is an internal device dielectric breakdown rating. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.
2. H11D1 is rated @ 5656 Volts peak (V_{ISO}). H11D2 is rated @ 3535 Volts peak (V_{ISO}) Otherwise they are identical, both parts built by Motorola are rated @ 7500 Volts peak (V_{ISO})
3. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 1

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)(1)

Characteristic		Symbol	Min	Typ(1)	Max	Unit
INPUT LED (T_A = 25°C unless otherwise noted)						
Reverse Leakage Current (V_R = 6 V)		I_R	—	—	10	μA
Forward Voltage (I_F = 10 mA)		V_F	—	1.2	1.5	Volts
Capacitance (V = 0 V, f = 1 MHz)		C	—	18	—	pF
OUTPUT TRANSISTOR (T_A = 25°C and I_F = 0 unless otherwise noted)						
Collector–Emitter Dark Current (R_{BE} = 1 MΩ) (V_{CE} = 200 V, T_A = 25°C)	H11D1,2	I_{CER}	—	—	100	nA
(T_A = 100°C)	H11D1,2		—	—	250	μA
Collector–Base Breakdown Voltage (I_C = 100 μA)	H11D1,2	$V_{(BR)CBO}$	—	—	300	Volts
Collector–Emitter Breakdown Voltage (I_C = 1 mA, R_{BE} = 1 MΩ)	H11D1,2	$V_{(BR)CER}$	—	—	300	Volts
Emitter–Base Breakdown Voltage (I_E = 100 μA)		$V_{(BR)EBO}$	7	—	—	Volts
COUPLED (T_A = 25°C unless otherwise noted)						
Output Collector Current (V_{CE} = 10 V, I_F = 10 mA, R_{BE} = 1 MΩ)	H11D1,2	I_C (CTR)(2)	2 (20)	—	—	mA (%)
Surge Isolation Voltage (Input to Output)(3) Peak ac Voltage, 60 Hz, 1 sec		V_{ISO}	7500	—	—	Vac(pk)
Isolation Resistance(3) (V = 500 V)		R_{ISO}	—	10^{11}	—	Ohms
Collector–Emitter Saturation Voltage (I_C = 0.5 mA, I_F = 10 mA, R_{BE} = 1 MΩ)		$V_{CE(sat)}$	—	—	0.4	Volts
Isolation Capacitance(3) (V = 0, f = 1 MHz)		C_{ISO}	—	0.2	—	pF
Turn–On Time	V_{CC} = 10 V, I_C = 2 mA, R_L = 100 Ω	t_{on}	—	5	—	μs
Turn–Off Time	V_{CC} = 10 V, I_C = 2 mA, R_L = 100 Ω	t_{off}	—	5	—	μs

1. Always design to the specified minimum/maximum electrical limits (where applicable).
2. Current Transfer Ratio (CTR) = I_C/I_F x 100%.
3. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.

TYPICAL CHARACTERISTICS

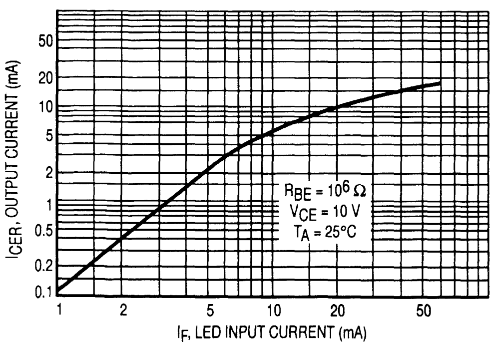


Figure 1. Output Current versus LED Input Current

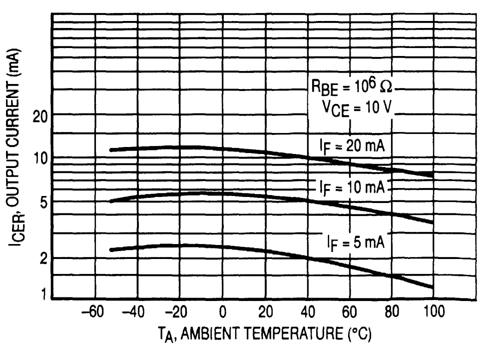


Figure 2. Output Current versus Temperature

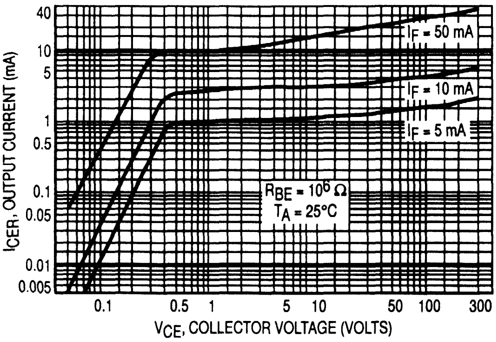


Figure 3. Output Characteristics

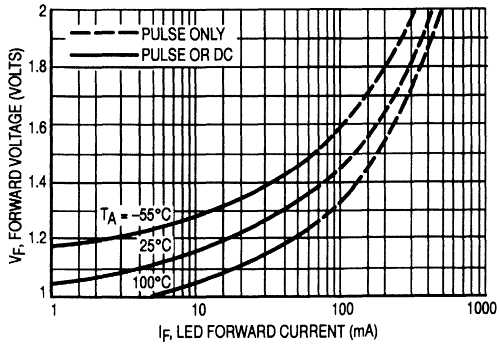


Figure 4. Forward Characteristics

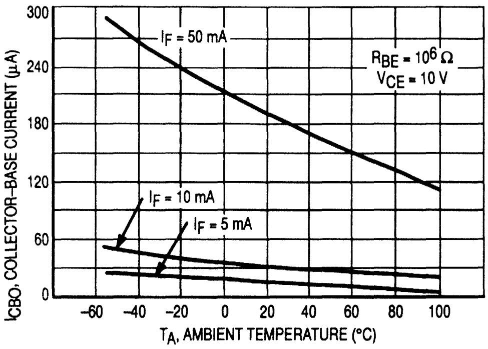


Figure 5. Collector–Base Current versus Temperature

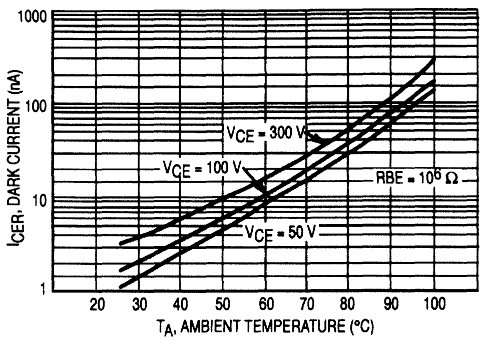


Figure 6. Dark Current versus Temperature

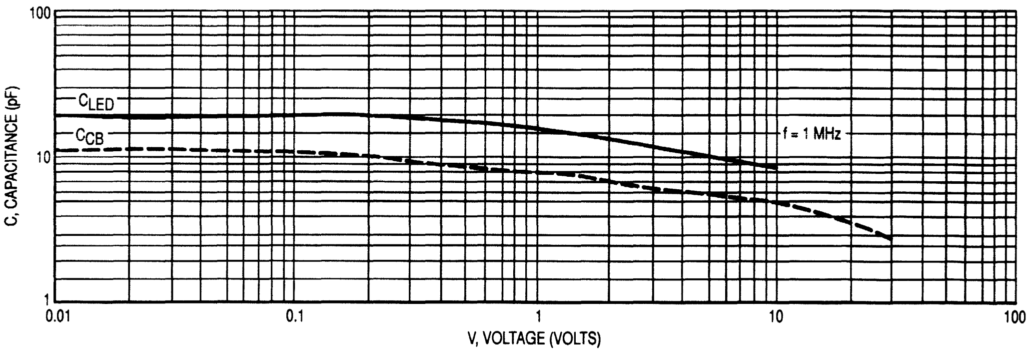


Figure 7. Capacitance versus Voltage

GlobalOptoisolator™

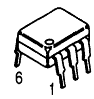
VDE	UL	CSA	SETI	SEMKO	DEMKO	NEMKO

6-Pin DIP Optoisolators Darlington Output (On-Chip Resistors)

H11G1*
[CTR = 1000% Min]
H11G2*
[CTR = 1000% Min]
H11G3
[CTR = 200% Min]

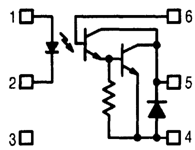
*Motorola Preferred Devices

STYLE 1 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

SCHEMATIC



PIN 1. ANODE
2. CATHODE
3. N.C.
4. EMITTER
5. COLLECTOR
6. BASE

The H11G1, H11G2 and H11G3 devices consist of gallium arsenide IREDs optically coupled to silicon photodarlington detectors which have integral base–emitter resistors. The on–chip resistors improve higher temperature leakage characteristics. Designed with high isolation, high CTR, high voltage and low leakage, they provide excellent performance.

- High CTR, H11G1 & H11G2 — 1000% (@ I_F = 10 mA), 500% (@ I_F = 1 mA)
- High $V_{(BR)CEO}$, H11G1 — 100 Volts, H11G2 — 80 Volts
- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

Applications

- Interfacing and coupling systems of different potentials and impedances
- Phase and Feedback Controls
- General Purpose Switching Circuits
- Solid State Relays

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Reverse Voltage	V_R	6	Volts
Forward Current — Continuous	I_F	60	mA
Forward Current — Peak Pulse Width = 300 μs, 2% Duty Cycle	I_F	3	Amps
LED Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	120 1.41	mW mW/°C
OUTPUT DETECTOR			
Collector–Emitter Voltage H11G1 H11G2 H11G3	V_{CEO}	100 80 55	Volts
Emitter–Base Voltage	V_{EBO}	7	Volts
Collector Current — Continuous	I_C	150	mA
Detector Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 1.76	mW mW/°C
TOTAL DEVICE			
Total Device Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Operating Junction Temperature Range(2)	T_A	–55 to +100	°C
Storage Temperature Range(2)	T_{stg}	–55 to +150	°C
Soldering Temperature (10 s)	T_L	260	°C
Isolation Surge Voltage(1) (Peak ac Voltage, 60 Hz, 1 sec Duration)	V_{ISO}	7500	Vac(pk)

1. Isolation surge voltage is an internal device dielectric breakdown rating. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.
2. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 1

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)[1]

Characteristic		Symbol	Min	Typ[1]	Max	Unit
INPUT LED						
Reverse Leakage Current (V_R = 3 V)		I_R	—	0.05	10	μA
Forward Voltage I_F = 10 mA)		V_F	—	1.1	1.5	Volts
Capacitance (V = 0 V, f = 1 MHz)		C_J	—	18	—	pF
DARLINGTON OUTPUT (T_A = 25°C and I_F = 0 unless otherwise noted)						
Collector–Emitter Breakdown Current		$V_{(BR)CEO}$				Volts
(I_C = 1 mA, I_F = 0)	H11G1		100	—	—	
	H11G2		80	—	—	
	H11G3		55	—	—	
Collector–Base Breakdown Voltage		$V_{(BR)CBO}$				Volts
(I_C = 100 μA, I_F = 0)	H11G1		100	—	—	
	H11G2		80	—	—	
	H11G3		55	—	—	
Emitter–Base Breakdown Voltage (I_E = 100 μA, I_F = 0)		$V_{(BR)EBO}$	7	—	—	Volts
Collector–Emitter Dark Current		I_{CEO}				
(V_{CE} = 80 V)	H11G1		—	—	100	nA
(V_{CE} = 80 V, T_A = 80°C)	H11G1		—	—	100	μA
(V_{CE} = 60 V)	H11G2		—	—	100	nA
(V_{CE} = 60 V, T_A = 80°C)	H11G2		—	—	100	μA
(V_{CE} = 30 V)	H11G3		—	—	100	nA
Capacitance (V_{CB} = 10 V, f = 1 MHz)		C_{CB}	—	6	—	pF
COUPLED (T_A = 25°C unless otherwise noted)						
Collector Output Current		I_C (CTR)[2]				mA (%)
(V_{CE} = 1 V, I_F = 10 mA)	H11G1, 2		100 (1000)	—	—	
(V_{CE} = 5 V, I_F = 1 mA)	H11G1, 2		5 (500)	—	—	
(V_{CE} = 5 V, I_F = 1 mA)	H11G3		2 (200)	—	—	
Collector–Emitter Saturation Voltage		$V_{CE(sat)}$				Volts
(I_F = 1 mA, I_C = 1 mA)	H11G1, 2		—	0.75	1	
(I_F = 16 mA, I_C = 50 mA)	H11G1, 2		—	0.85	1	
(I_F = 20 mA, I_C = 50 mA)	H11G3		—	0.85	1.2	
Isolation Surge Voltage[3,4] (60 Hz ac Peak, 1 Second)		V_{ISO}	7500	—	—	Vac(pk)
Isolation Resistance[3] (V = 500 Vdc)			—	10^{11}	—	Ohms
Isolation Capacitance[3] (V = 0 V, f = 1 MHz)		C_{IO}	—	2	—	pF
SWITCHING (T_A = 25°C)						
Turn–On Time	(I_F = 10 mA, V_{CC} = 5 V, R_L = 100 Ω, Pulse Width ≤ 300 μs, f = 30 Hz)	t_{on}	—	5	—	μs
Turn–Off Time		t_{off}	—	100	—	

1. Always design to the specified minimum/maximum electrical limits (where applicable).
2. Current Transfer Ratio (CTR) = I_C/I_F x 100%.
3. For this test, Pins 1 and 2 are common, and Photodarlington Pins 4 and 5 are common.
4. Isolation Surge Voltage, V_{ISO}, is an internal device dielectric breakdown rating.

TYPICAL CHARACTERISTICS

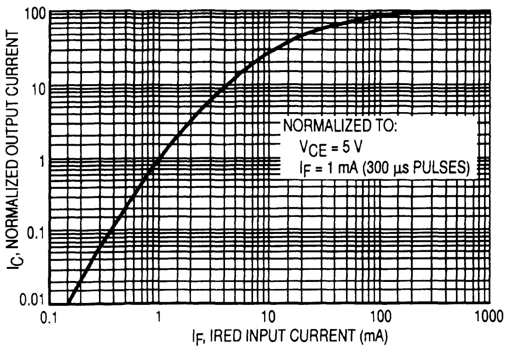


Figure 1. Output Current versus Input Current

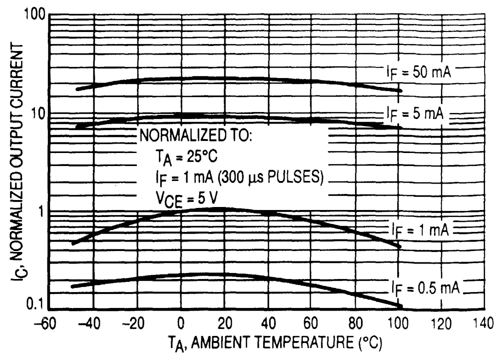


Figure 2. Output Current versus Temperature

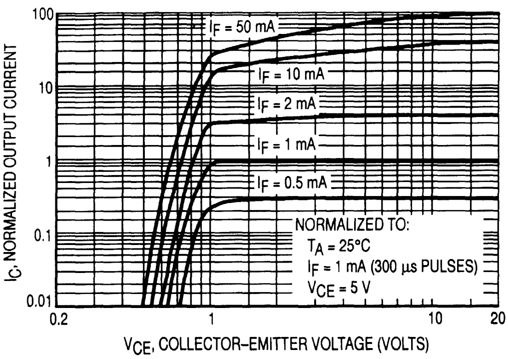


Figure 3. Output Current versus Collector–Emitter Voltage

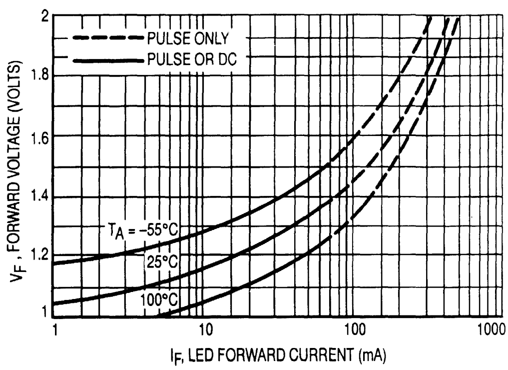


Figure 4. LED Forward Characteristics

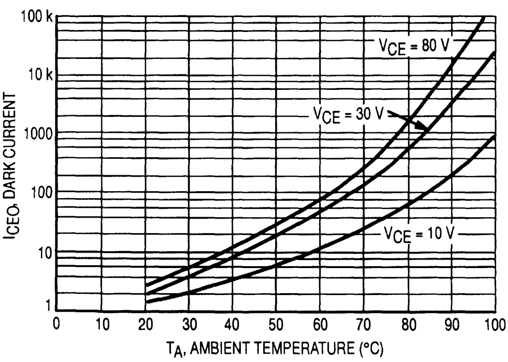


Figure 5. Collector–Emitter Dark Current versus Temperature

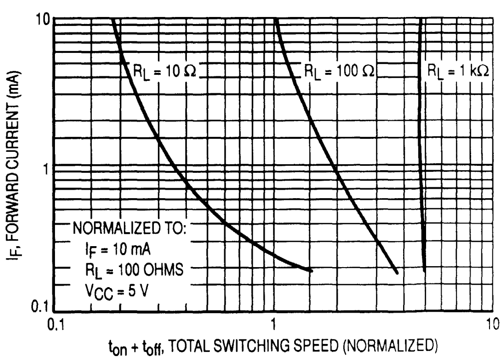
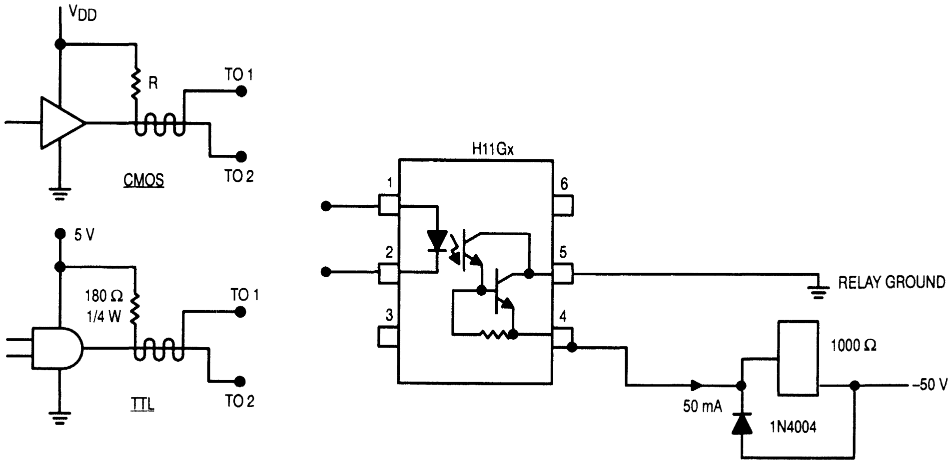


Figure 6. Input Current versus Total Switching Speed (Typical Values)

INTERFACING TTL OR CMOS LOGIC TO 50–VOLT, 1000–OHMS RELAY FOR TELEPHONY APPLICATIONS

In order to interface positive logic to negative–powered electromechanical relays, a change in voltage level and polarity plus electrical isolation are required. The H11Gx can provide this interface and eliminate the external amplifiers and voltage divider networks previously required. The circuit below shows a typical approach for the interface.



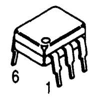
GlobalOptoisolator™

VDE | UL | CSA | SETI | SEMKO | DEMKO | NEMKO | BABT

6-Pin DIP Optoisolators Logic Output

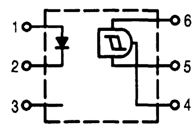
H11L1*
[IF(on) = 1.6 mA Max]
H11L2
[IF(on) = 10 mA Max]
***Motorola Preferred Device**

STYLE 5 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

SCHEMATIC



PIN 1. ANODE
2. CATHODE
3. NC
4. OPEN COLLECTOR OUTPUT
5. GND
6. V_{CC}

The H11L1 and H11L2 have a gallium arsenide IRED optically coupled to a high–speed integrated detector with Schmitt trigger output. Designed for applications requiring electrical isolation, fast response time, noise immunity and digital logic compatibility.

- Guaranteed Switching Times — t_{on}, t_{off} < 4 µs
- Built–In On/Off Threshold Hysteresis
- High Data Rate, 1 MHz Typical (NRZ)
- Wide Supply Voltage Capability
- Microprocessor Compatible Drive
- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

Applications

- Interfacing Computer Terminals to Peripheral Equipment
- Digital Control of Power Supplies
- Line Receiver — Eliminates Noise
- Digital Control of Motors and Other Servo Machine Applications
- Logic to Logic Isolator
- Logic Level Shifter — Couples TTL to CMOS

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Reverse Voltage	V_R	6	Volts
Forward Current — Continuous — Peak Pulse Width = 300 µs, 2% Duty Cycle	I_F	60 1.2	mA Amp
LED Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	120 1.41	mW mW/°C
OUTPUT DETECTOR			
Output Voltage Range	V_o	0–16	Volts
Supply Voltage Range	V_{CC}	3–16	Volts
Output Current	I_O	50	mA
Detector Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 1.76	mW mW/°C
TOTAL DEVICE			
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Maximum Operating Temperature(2)	T_A	–40 to +85	°C
Storage Temperature Range(2)	T_{stg}	–55 to +150	°C
Soldering Temperature (10 s)	T_L	260	°C
Isolation Surge Voltage (Pk ac Voltage, 60 Hz, 1 Second Duration)(1)	V_{ISO}	7500	Vac(pk)

1. Isolation surge voltage is an internal device dielectric breakdown rating. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.
2. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 1

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)(1)

Characteristic		Symbol	Min	Typ(1)	Max	Unit
INPUT LED						
Reverse Leakage Current (V_R = 3 V, R_L = 1 MΩ)		I_R	—	0.05	10	μA
Forward Voltage (I_F = 10 mA) (I_F = 0.3 mA)		V_F	— 0.75	1.2 0.95	1.5 —	Volts
Capacitance (V_R = 0 V, f = 1 MHz)		C	—	18	—	pF
OUTPUT DETECTOR						
Operating Voltage		V_{CC}	3	—	15	Volts
Supply Current (I_F = 0, V_{CC} = 5 V)		$I_{CC(off)}$	—	1	5	mA
Output Current, High (I_F = 0, V_{CC} = V_o = 15 V)		I_{OH}	—	—	100	μA
COUPLED						
Supply Current (I_F = $I_{F(on)}$, V_{CC} = 5 V)		$I_{CC(on)}$	—	1.6	5	mA
Output Voltage, Low (R_L = 270 Ω, V_{CC} = 5 V, I_F = $I_{F(on)}$)		V_{OL}	—	0.2	0.4	Volts
Threshold Current, ON (R_L = 270 Ω, V_{CC} = 5 V)	H11L1 H11L2	$I_{F(on)}$	— —	1.2 —	1.6 10	mA
Threshold Current, OFF (R_L = 270 Ω, V_{CC} = 5 V)	H11L1 H11L2	$I_{F(off)}$	0.3 0.3	0.75 —	— —	mA
Hysteresis Ratio (R_L = 270 Ω, V_{CC} = 5 V)		$\frac{I_{F(off)}}{I_{F(on)}}$	0.5	0.75	0.9	
Isolation Voltage(2) 60 Hz, AC Peak, 1 second, T_A = 25°C		V_{ISO}	7500	—	—	Vac(pk)
Turn–On Time	R_L = 270 Ω(3) V_{CC} = 5 V, I_F = $I_{F(on)}$ T_A = 25°C	t_{on}	—	1.2	4	μs
Fall Time		t_f	—	0.1	—	
Turn–Off Time		t_{off}	—	1.2	4	
Rise Time		t_r	—	0.1	—	

1. Always design to the specified minimum/maximum electrical limits (where applicable).
2. For this test, IRED Pins 1 and 2 are common and Output Gate Pins 4, 5, 6 are common.
3. R_L value effect on switching time is negligible.

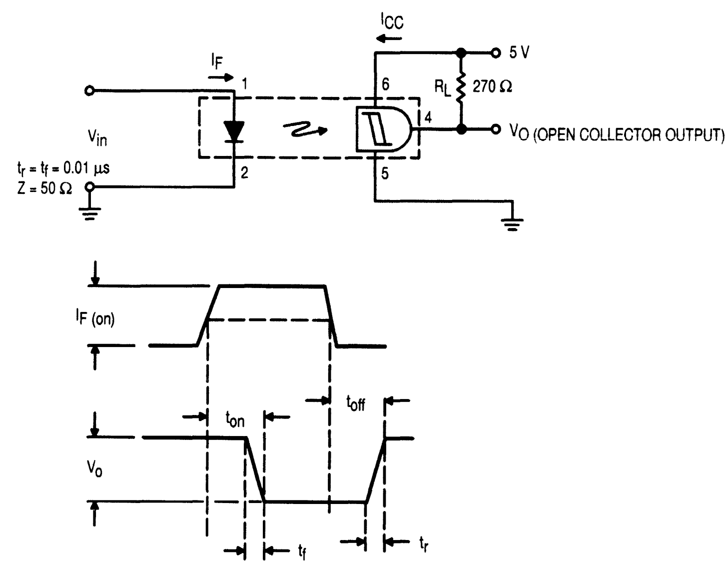


Figure 1. Switching Test Circuit

TYPICAL CHARACTERISTICS

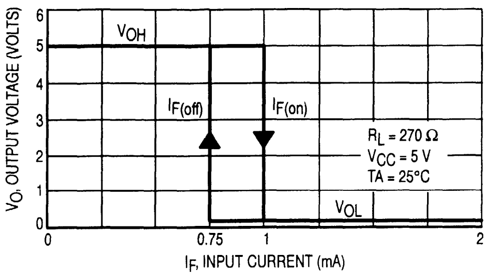


Figure 2. Transfer Characteristics for H11L1

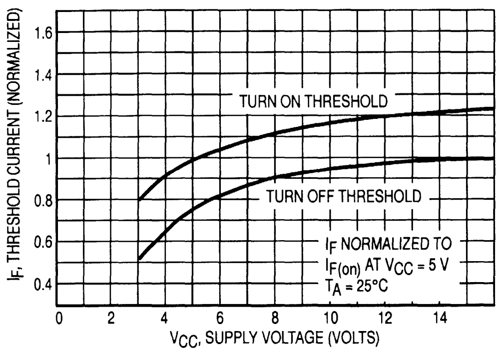


Figure 3. Threshold Current versus Supply Voltage

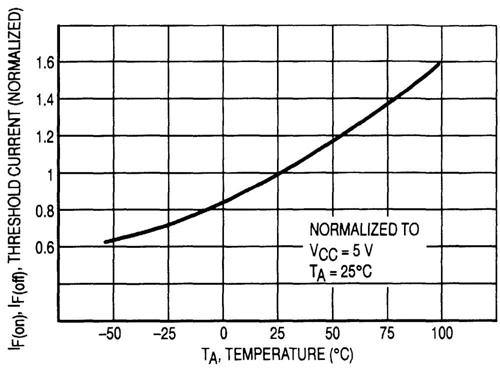


Figure 4. Threshold Current versus Temperature

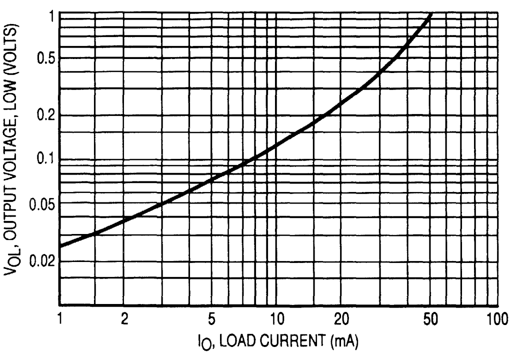


Figure 5. Output Voltage, Low versus Load Current

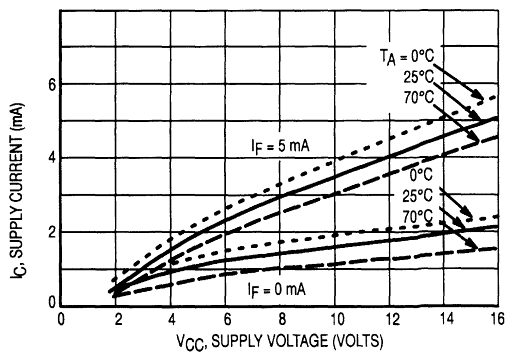


Figure 6. Supply Current versus Supply Voltage

GlobalOptoisolator™

VDE | UL | CSA | SETI | SEMKO | DEMKO | NEMKO | BABT

6-Pin DIP Optoisolators Transistor Output

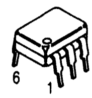
MCT2
MCT2E
[CTR = 20% Min]

The MCT and MCT2E devices consist of a gallium arsenide infrared emitting diode optically coupled to a monolithic silicon phototransistor detector.

Applications

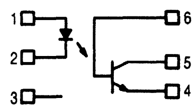
- General Purpose Switching Circuits
- Interfacing and coupling systems of different potentials and impedances
- I/O Interfacing
- Solid State Relays
- Monitor and Detection Circuits
- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

STYLE 1 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

SCHEMATIC



PIN 1. LED ANODE
2. LED CATHODE
3. N.C.
4. EMITTER
5. COLLECTOR
6. BASE

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Reverse Voltage	V_R	3	Volts
Forward Current — Continuous	I_F	60	mA
LED Power Dissipation @ T_A = 25°C with Negligible Power in Output Detector	P_D	120	mW
Derate above 25°C		1.41	mW/°C
OUTPUT TRANSISTOR			
Collector–Emitter Voltage	V_{CEO}	30	Volts
Emitter–Collector Voltage	V_{ECO}	7	Volts
Collector–Base Voltage	V_{CBO}	70	Volts
Collector Current — Continuous	I_C	150	mA
Detector Power Dissipation @ T_A = 25°C with Negligible Power in Input LED	P_D	150	mW
Derate above 25°C		1.76	mW/°C
TOTAL DEVICE			
Isolation Surge Voltage(1) (Peak ac Voltage, 60 Hz, 1 sec Duration)	V_{ISO}	7500	Vac(pk)
Total Device Power Dissipation @ T_A = 25°C	P_D	250	mW
Derate above 25°C		2.94	mW/°C
Ambient Operating Temperature Range(2)	T_A	−55 to +100	°C
Storage Temperature Range(2)	T_{stg}	−55 to +150	°C
Soldering Temperature (10 sec, 1/16″ from case)	T_L	260	°C

1. Isolation surge voltage is an internal device dielectric breakdown rating. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.
2. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

REV 1

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)(1)

Characteristic		Symbol	Min	Typ(1)	Max	Unit
INPUT LED						
Forward Voltage (I_F = 20 mA)	T_A = 25°C T_A = –55°C T_A = 100°C	V_F	— — —	1.23 1.35 1.15	1.5 — —	Volts
Reverse Leakage Current (V_R = 3 V)		I_R	—	0.01	10	µA
Capacitance (V = 0 V, f = 1 MHz)		C_J	—	18	—	pF
OUTPUT TRANSISTOR						
Collector–Emitter Dark Current (V_{CE} = 10 V)	T_A = 25°C T_A = 100°C	I_{CEO}	— —	1 1	50 —	nA µA
Collector–Base Dark Current (V_{CB} = 10 V)	T_A = 25°C T_A = 100°C	I_{CBO}	— —	0.2 100	20 —	nA
Collector–Emitter Breakdown Voltage (I_C = 1 mA)		$V_{(BR)CEO}$	30	45	—	Volts
Collector–Base Breakdown Voltage (I_C = 10 µA)		$V_{(BR)CBO}$	70	100	—	Volts
Emitter–Collector Breakdown Voltage (I_E = 100 µA)		$V_{(BR)ECO}$	7	7.8	—	Volts
DC Current Gain (I_C = 5 mA, V_{CE} = 5 V)		h_{FE}	—	500	—	—
Collector–Emitter Capacitance (f = 1 MHz, V_{CE} = 0 V)		C_{CE}	—	7	—	pF
Collector–Base Capacitance (f = 1 MHz, V_{CB} = 0 V)		C_{CB}	—	19	—	pF
Emitter–Base Capacitance (f = 1 MHz, V_{EB} = 0 V)		C_{EB}	—	9	—	pF
COUPLED						
Output Collector Current (I_F = 10 mA, V_{CE} = 10 V)		I_C (CTR)(2)	2 (20)	7 (70)	—	mA (%)
Collector–Emitter Saturation Voltage (I_C = 2 mA, I_F = 16 mA)		$V_{CE(sat)}$	—	0.19	0.4	Volts
Turn–On Time (I_F = 10 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)		t_{on}	—	2.8	—	µs
Turn–Off Time (I_F = 10 mA, V_{CC} = 10 V, R_L = 100 Ω,)(3)		t_{off}	—	4.5	—	µs
Rise Time (I_F = 10 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)		t_r	—	1.2	—	µs
Fall Time (I_F = 10 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)		t_f	—	1.3	—	µs
Isolation Voltage (f = 60 Hz, t = 1 sec)(4)		V_{ISO}	7500	—	—	Vac(pk)
Isolation Resistance (V = 500 V)(4)		R_{ISO}	10^{11}	—	—	Ω
Isolation Capacitance (V = 0 V, f = 1 MHz)(4)		C_{ISO}	—	0.2	—	pF

1. Always design to the specified minimum/maximum electrical limits (where applicable).
2. Current Transfer Ratio (CTR) = I_C/I_F x 100%.
3. For test circuit setup and waveforms, refer to Figure 11.
4. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.

TYPICAL CHARACTERISTICS

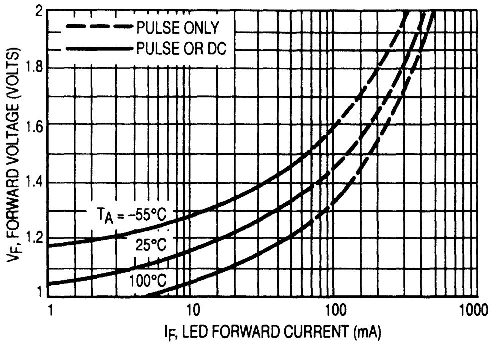


Figure 1. LED Forward Voltage versus Forward Current

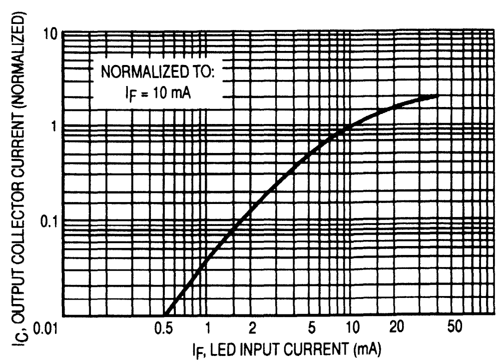


Figure 2. Output Current versus Input Current

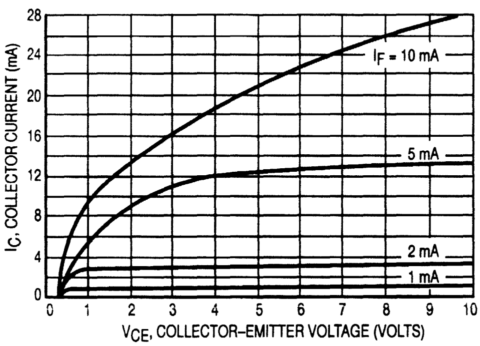


Figure 3. Collector Current versus Collector–Emitter Voltage

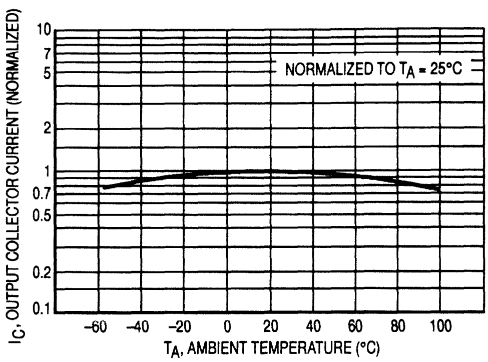


Figure 4. Output Current versus Ambient Temperature

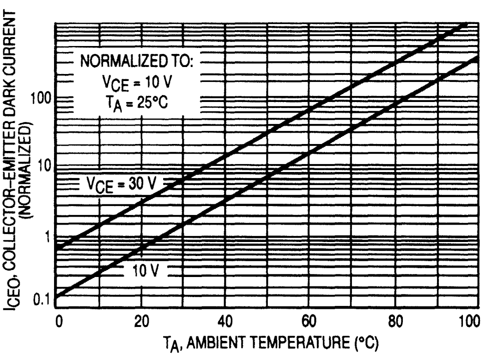


Figure 5. Dark Current versus Ambient Temperature

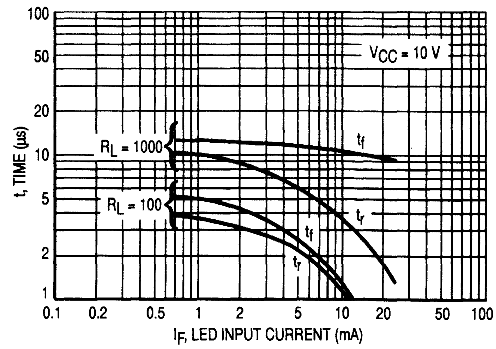


Figure 6. Rise and Fall Times (Typical Values)

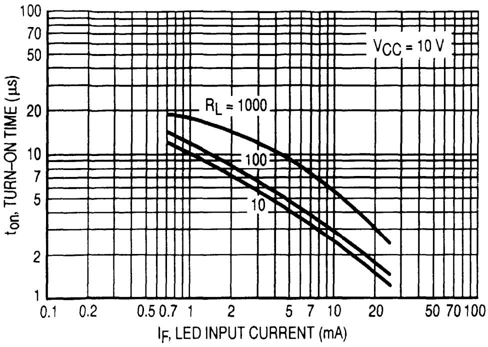


Figure 7. Turn–On Switching Times (Typical Values)

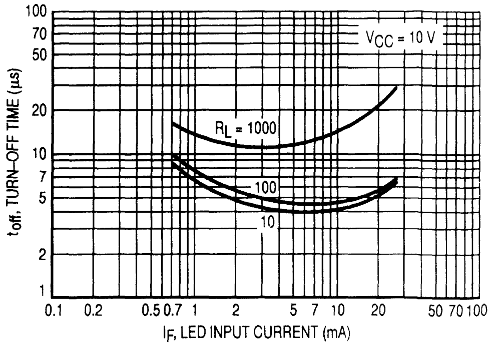


Figure 8. Turn–Off Switching Times (Typical Values)

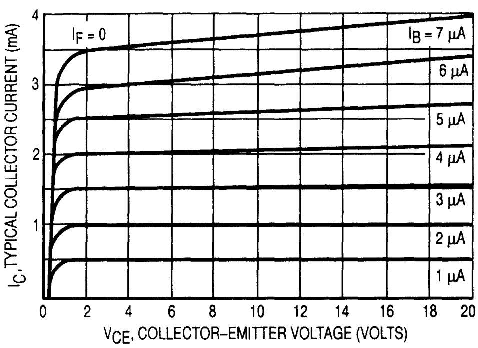


Figure 9. DC Current Gain (Detector Only)

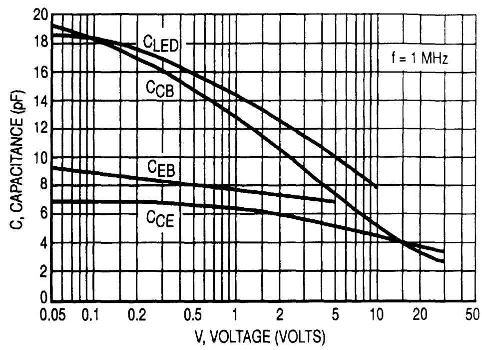


Figure 10. Capacitances versus Voltage

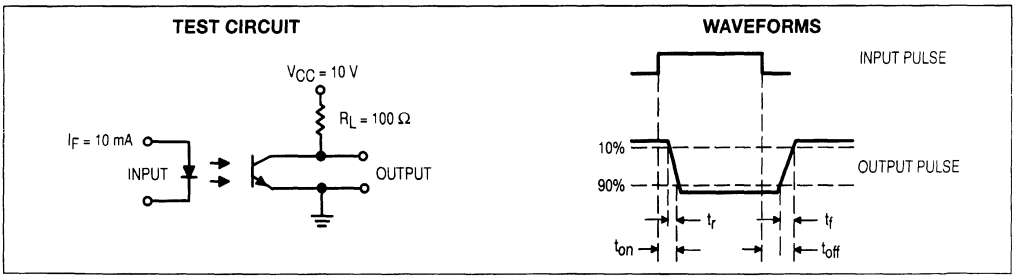


Figure 11. Switching Time Test Circuit and Waveforms

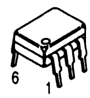
GlobalOptoisolator™

VDE	UL	CSA	SETI	SEMKO	DEMKO	NEMKO	BABT

6-Pin DIP Optoisolator Darlington Output (No Base Connection)

MOC119
[CTR = 300% Min]

STYLE 3 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

The MOC119 device consists of a gallium arsenide infrared emitting diode optically coupled to a monolithic silicon photodarlington detector. The chip to Pin 6 connection has been eliminated for better performance when used in high noise environments.

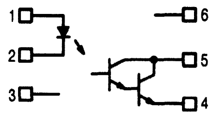
It is designed for use in applications requiring high improved noise immunity.

- Provides Higher Output Collector Current (I_C) with Lower Values of Input Drive Current (I_F)
- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

Applications

- Appliance, Measuring Instruments
- Interfacing and coupling systems of different potentials and impedances
- Monitor and Detection Circuits
- I/O Interfaces for Computers
- Solid State Relays
- Portable Electronics
- Programmable Controllers

SCHEMATIC



PIN 1. LED ANODE
2. LED CATHODE
3. N.C.
4. EMITTER
5. COLLECTOR
6. N.C.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Reverse Voltage	V_R	3	Volts
Forward Current — Continuous	I_F	60	mA
LED Power Dissipation @ T_A = 25°C with Negligible Power in Output Detector	P_D	120	mW
Derate above 25°C		1.41	mW/°C
OUTPUT DETECTOR			
Collector–Emitter Voltage	V_{CEO}	30	Volts
Emitter–Collector Voltage	V_{ECO}	7	Volts
Detector Power Dissipation @ T_A = 25°C with Negligible Power in Input LED	P_D	150	mW
Derate above 25°C		1.76	mW/°C
TOTAL DEVICE			
Isolation Surge Voltage(1) (Peak ac Voltage, 60 Hz, 1 sec Duration)	V_{ISO}	7500	Vac(pk)
Total Device Power Dissipation @ T_A = 25°C	P_D	250	mW
Derate above 25°C		2.94	mW/°C
Ambient Operating Temperature Range(2)	T_A	−55 to +100	°C
Storage Temperature Range(2)	T_{stg}	−55 to +150	°C
Soldering Temperature (10 sec, 1/16″ from case)	T_L	260	°C

1. Isolation surge voltage is an internal device dielectric breakdown rating. For this test, Pins 1 and 2 are common, and Pins 4 and 5 are common.
2. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

REV 2

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)(1)

Characteristic	Symbol	Min	Typ(1)	Max	Unit
INPUT LED					
Reverse Leakage Current (V_R = 3 V)	I_R	—	0.05	100	μA
Forward Voltage (I_F = 10 mA)	V_F	—	1.15	1.5	Volts
Capacitance (V_R = 0 V, f = 1 MHz)	C	—	18	—	pF
PHOTOTRANSISTOR (T_A = 25°C and I_F = 0 unless otherwise noted)					
Collector–Emitter Dark Current (V_{CE} = 10 V)	I_{CEO}	—	—	100	nA
Collector–Emitter Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CEO}$	30	—	—	Volts
Emitter–Collector Breakdown Voltage (I_E = 10 μA)	$V_{(BR)ECO}$	7	—	—	Volts
COUPLED (T_A = 25°C unless otherwise noted)					
Collector Output Current(3) (V_{CE} = 2 V, I_F = 10 mA)	I_C (CTR)(2)	30 (300)	45 (450)	—	mA (%)
Isolation Surge Voltage(4,5), 60 Hz ac Peak, 1 Second	V_{ISO}	7500	—	—	Vac(pk)
Isolation Resistance(4) (V = 500 V)	R_{ISO}	—	10^{11}	—	Ohms
Collector–Emitter Saturation Voltage(3) (I_C = 10 mA, I_F = 10 mA)	$V_{CE(sat)}$	—	—	1	Volt
Isolation Capacitance(4) (V = 0 V, f = 1 MHz)	C_{ISO}	—	0.2	—	pF

SWITCHING (Figures 4, 5)

Characteristic	Conditions	Symbol	Min	Typ	Max	Unit
Turn–On Time	V_{CE} = 10 V, R_L = 100 Ω, I_F = 5 mA(6)	t_{on}	—	3.5	—	μs
Turn–Off Time		t_{off}	—	95	—	
Rise Time		t_r	—	1	—	
Fall Time		t_f	—	2	—	

1. Always design to the specified minimum/maximum electrical limits (where applicable).
2. Current Transfer Ratio (CTR) = I_C/I_F x 100%.
3. Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤2%.
4. For this test, LED Pins 1 and 2 are common and Phototransistor Pins 4 and 5 are common.
5. Isolation Surge Voltage, V_{ISO}, is an internal device dielectric breakdown rating.
6. For test circuit setup and waveforms, refer to Figure 9.

TYPICAL CHARACTERISTICS

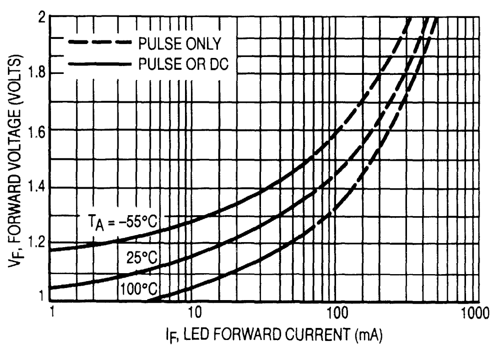


Figure 1. LED Forward Voltage versus Forward Current

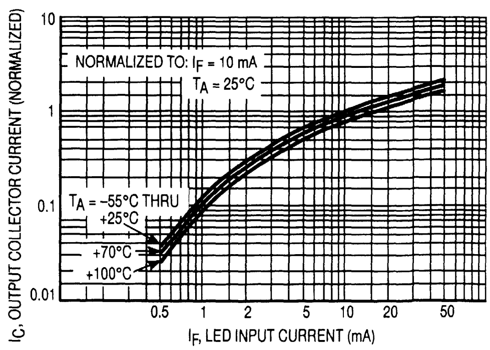


Figure 2. Output Current versus Input Current

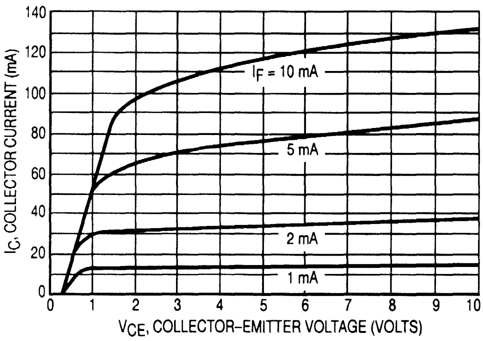


Figure 3. Collector Current versus Collector–Emitter Voltage

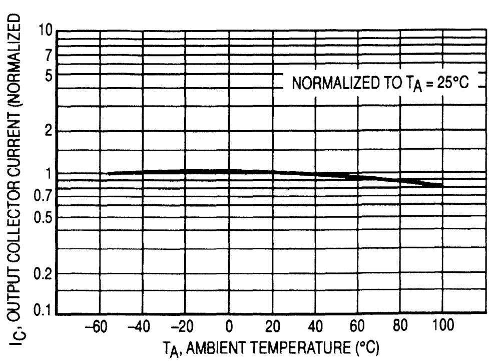


Figure 4. Output Current versus Ambient Temperature

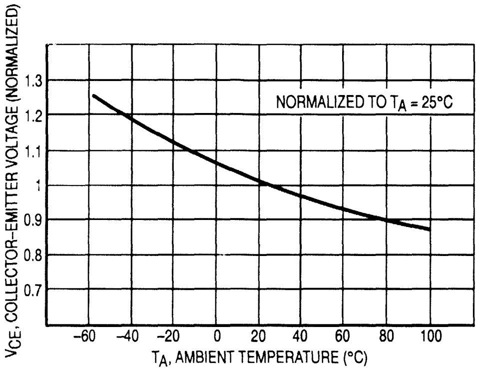


Figure 5. Collector–Emitter Voltage versus Ambient Temperature

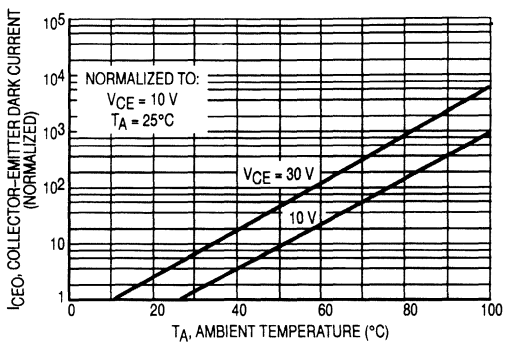


Figure 6. Collector–Emitter Dark Current versus Ambient Temperature

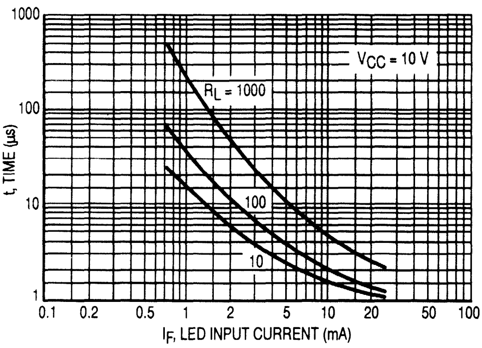


Figure 7. Turn–On Switching Times

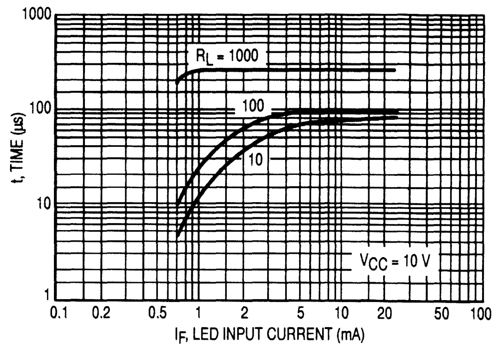


Figure 8. Turn–Off Switching Times

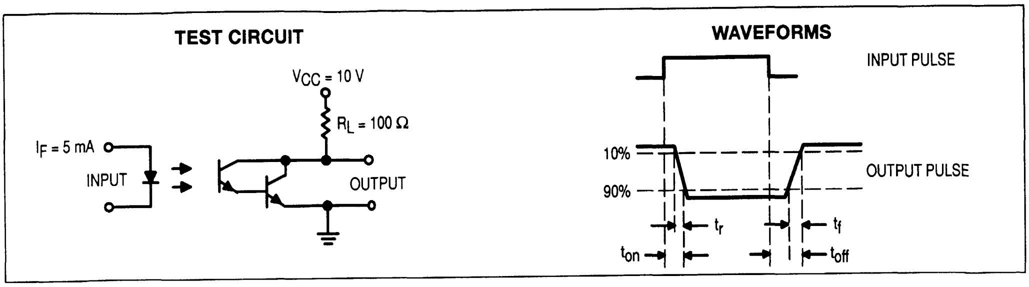


Figure 9. Switching Time Test Circuit and Waveforms

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

GlobalOptoisolator™

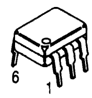
VDE	UL	CSA	SETI	SEMKO	DEMKO	NEMKO	BABT

6-Pin DIP Random-Phase Optoisolators Triac Driver Output
(250 Volts Peak)

MOC3010
[IFT = 15 mA Max]
MOC3011
[IFT = 10 mA Max]
MOC3012*
[IFT = 5 mA Max]

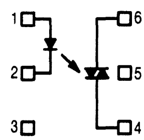
***Motorola Preferred Device**

STYLE 6 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

COUPLER SCHEMATIC



1. ANODE
2. CATHODE
3. NC
4. MAIN TERMINAL
5. SUBSTRATE
   DO NOT CONNECT
6. MAIN TERMINAL

The MOC3010 Series consists of gallium arsenide infrared emitting diodes, optically coupled to silicon bilateral switch and are designed for applications requiring isolated triac triggering, low–current isolated ac switching, high electrical isolation (to 7500 Vac peak), high detector standoff voltage, small size, and low cost.

- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

Recommended for 115 Vac(rms) Applications:

- Solenoid/Valve Controls
- Lamp Ballasts
- Interfacing Microprocessors to 115 Vac Peripherals
- Motor Controls
- Static ac Power Switch
- Solid State Relays
- Incandescent Lamp Dimmers

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INFRARED EMITTING DIODE			
Reverse Voltage	V_R	3	Volts
Forward Current — Continuous	I_F	60	mA
Total Power Dissipation @ T_A = 25°C Negligible Power in Transistor Derate above 25°C	P_D	100 1.33	mW mW/°C
OUTPUT DRIVER			
Off–State Output Terminal Voltage	V_{DRM}	250	Volts
Peak Repetitive Surge Current (PW = 1 ms, 120 pps)	I_{TSM}	1	A
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 4	mW mW/°C
TOTAL DEVICE			
Isolation Surge Voltage(1) (Peak ac Voltage, 60 Hz, 1 Second Duration)	V_{ISO}	7500	Vac(pk)
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	330 4.4	mW mW/°C
Junction Temperature Range	T_J	–40 to +100	°C
Ambient Operating Temperature Range(2)	T_A	–40 to +85	°C
Storage Temperature Range(2)	T_{stg}	–40 to +150	°C
Soldering Temperature (10 s)	T_L	260	°C

1. Isolation surge voltage, V_{ISO}, is an internal device dielectric breakdown rating.
   For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.
2. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

Preferred devices are Motorola recommended choices for future use and best overall value.

(Replaces MOC3009/D)

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

Characteristic	Symbol	Min	Typ	Max	Unit
INPUT LED					
Reverse Leakage Current (V_R = 3 V)	I_R	—	0.05	100	μA
Forward Voltage (I_F = 10 mA)	V_F	—	1.15	1.5	Volts
OUTPUT DETECTOR (I_F = 0 unless otherwise noted)					
Peak Blocking Current, Either Direction (Rated V_{DRM}(1))	I_{DRM}	—	10	100	nA
Peak On–State Voltage, Either Direction (I_{TM} = 100 mA Peak)	V_{TM}	—	1.8	3	Volts
Critical Rate of Rise of Off–State Voltage (Figure 7, Note 2)	dv/dt	—	10	—	V/μs
COUPLED					
LED Trigger Current, Current Required to Latch Output (Main Terminal Voltage = 3 V(3))	I_{FT}				mA
MOC3010		—	8	15	
MOC3011		—	5	10	
MOC3012		—	3	5	
Holding Current, Either Direction	I_H	—	100	—	μA

1. Test voltage must be applied within dv/dt rating.
2. This is static dv/dt. See Figure 7 for test circuit. Commutating dv/dt is a function of the load–driving thyristor(s) only.
3. All devices are guaranteed to trigger at an I_F value less than or equal to max I_{FT}. Therefore, recommended operating I_F lies between max I_{FT} (15 mA for MOC3010, 10 mA for MOC3011, 5 mA for MOC3012) and absolute max I_F (60 mA).

TYPICAL ELECTRICAL CHARACTERISTICS
T_A = 25°C

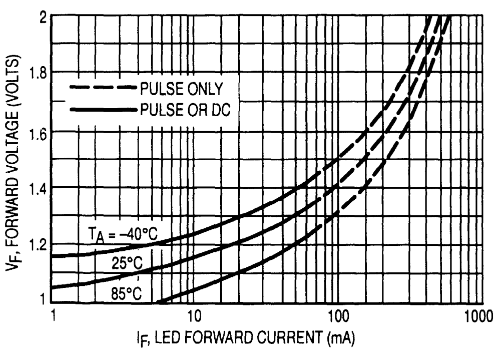


Figure 1. LED Forward Voltage versus Forward Current

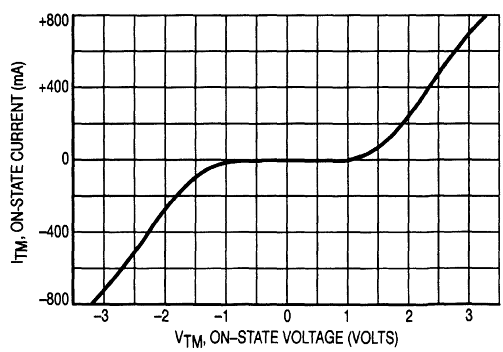


Figure 2. On–State Characteristics

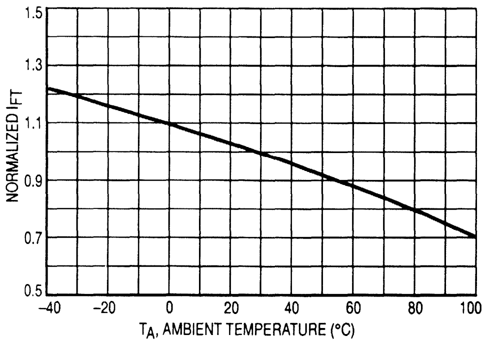


Figure 3. Trigger Current versus Temperature

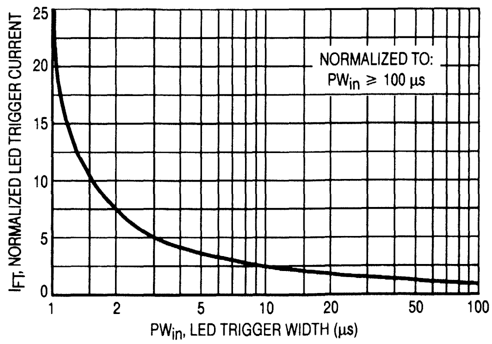


Figure 4. LED Current Required to Trigger versus LED Pulse Width

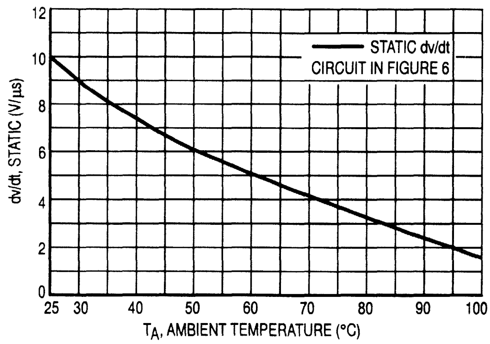
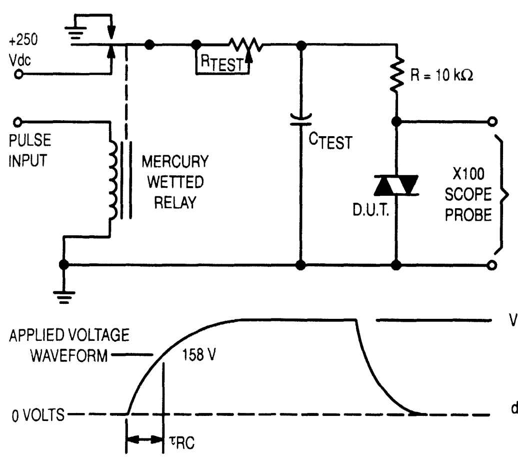


Figure 5. dv/dt versus Temperature



1. The mercury wetted relay provides a high speed repeated pulse to the D.U.T.
2. 100x scope probes are used, to allow high speeds and voltages.
3. The worst–case condition for static dv/dt is established by triggering the D.U.T. with a normal LED input current, then removing the current. The variable R_{TEST} allows the dv/dt to be gradually increased until the D.U.T. continues to trigger in response to the applied voltage pulse, even after the LED current has been removed. The dv/dt is then decreased until the D.U.T. stops triggering. τ_{RC} is measured at this point and recorded.

$$dv/dt = \frac{0.63\ V_{max}}{\tau_{RC}} = \frac{158}{\tau_{RC}}$$

Figure 6. Static dv/dt Test Circuit

TYPICAL APPLICATION CIRCUITS

NOTE: This optoisolator should not be used to drive a load directly. It is intended to be a trigger device only. Additional information on the use of the MOC3010/3011/3012 is available in Application Note AN–780A.

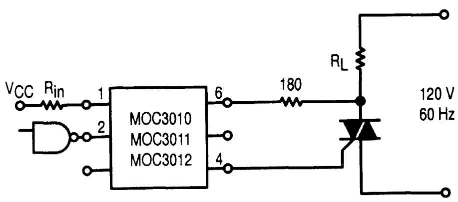


Figure 7. Resistive Load

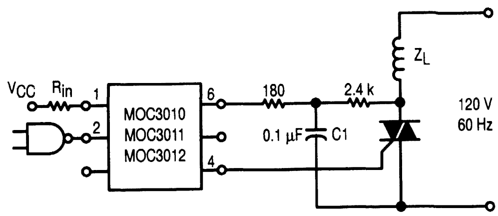


Figure 8. Inductive Load with Sensitive Gate Triac ($I_{GT} \leq 15$ mA)

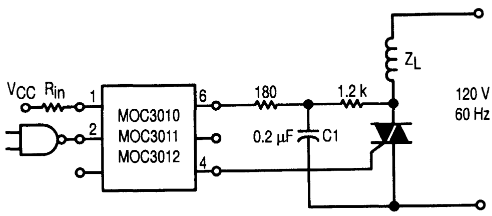


Figure 9. Inductive Load with Non–Sensitive Gate Triac (15 mA $< I_{GT} <$ 50 mA)

GlobalOptoisolator™

VDE | UL | CSA | SETI | SEMKO | DEMKO | NEMKO | BABT

6-Pin DIP Random-Phase Optoisolators Triac Driver Output
(400 Volts Peak)

MOC3021
[IFT = 15 mA Max]
MOC3022
[IFT = 10 mA Max]
MOC3023*
[IFT = 5 mA Max]

*Motorola Preferred Device

The MOC3020 Series consists of gallium arsenide infrared emitting diodes, optically coupled to a silicon bilateral switch.

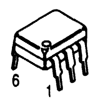
- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

They are designed for applications requiring isolated triac triggering.

Recommended for 115/240 Vac(rms) Applications:

- Solenoid/Valve Controls
- Lamp Ballasts
- Interfacing Microprocessors to 115 Vac Peripherals
- Motor Controls
- Static ac Power Switch
- Solid State Relays
- Incandescent Lamp Dimmers

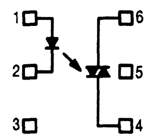
STYLE 6 PLASTIC



6 1

STANDARD THRU HOLE
CASE 730A–04

SCHEMATIC



1. ANODE
2. CATHODE
3. NC
4. MAIN TERMINAL
5. SUBSTRATE DO NOT CONNECT
6. MAIN TERMINAL

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INFRARED EMITTING DIODE			
Reverse Voltage	V_R	3	Volts
Forward Current — Continuous	I_F	60	mA
Total Power Dissipation @ T_A = 25°C Negligible Power in Triac Driver Derate above 25°C	P_D	100 1.33	mW mW/°C
OUTPUT DRIVER			
Off–State Output Terminal Voltage	V_{DRM}	400	Volts
Peak Repetitive Surge Current (PW = 1 ms, 120 pps)	I_{TSM}	1	A
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 4	mW mW/°C
TOTAL DEVICE			
Isolation Surge Voltage(1) (Peak ac Voltage, 60 Hz, 1 Second Duration)	V_{ISO}	7500	Vac(pk)
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	330 4.4	mW mW/°C
Junction Temperature Range	T_J	–40 to +100	°C
Ambient Operating Temperature Range(2)	T_A	–40 to +85	°C
Storage Temperature Range(2)	T_{stg}	–40 to +150	°C
Soldering Temperature (10 s)	T_L	260	°C

1. Isolation surge voltage, V_{ISO}, is an internal device dielectric breakdown rating. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.
2. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 1

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

Characteristic	Symbol	Min	Typ	Max	Unit
INPUT LED					
Reverse Leakage Current (V_R = 3 V)	I_R	—	0.05	100	μA
Forward Voltage (I_F = 10 mA)	V_F	—	1.15	1.5	Volts
OUTPUT DETECTOR (I_F = 0 unless otherwise noted)					
Peak Blocking Current, Either Direction (Rated V_{DRM}(1))	I_{DRM}	—	10	100	nA
Peak On–State Voltage, Either Direction (I_{TM} = 100 mA Peak)	V_{TM}	—	1.8	3	Volts
Critical Rate of Rise of Off–State Voltage (Figure 7, Note 2)	dv/dt	—	10	—	V/μs
COUPLED					
LED Trigger Current, Current Required to Latch Output (Main Terminal Voltage = 3 V(3))	I_{FT}				mA
MOC3021		—	8	15	
MOC3022		—	—	10	
MOC3023		—	—	5	
Holding Current, Either Direction	I_H	—	100	—	μA

1. Test voltage must be applied within dv/dt rating.
2. This is static dv/dt. See Figure 7 for test circuit. Commutating dv/dt is a function of the load–driving thyristor(s) only.
3. All devices are guaranteed to trigger at an I_F value less than or equal to max I_{FT}. Therefore, recommended operating I_F lies between max I_{FT} (15 mA for MOC3021, 10 mA for MOC3022, 5 mA for MOC3023) and absolute max I_F (60 mA).

TYPICAL ELECTRICAL CHARACTERISTICS

T_A = 25°C

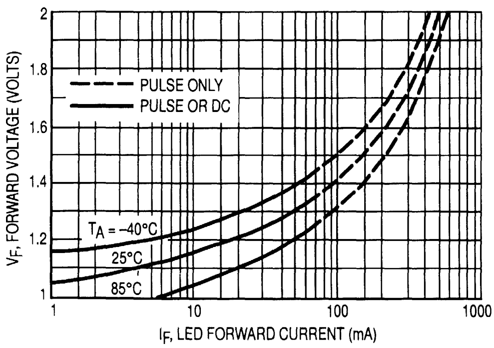


Figure 1. LED Forward Voltage versus Forward Current

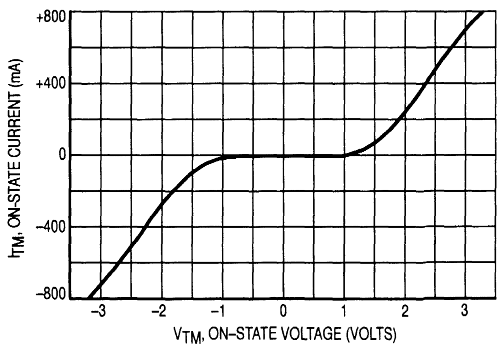


Figure 2. On–State Characteristics

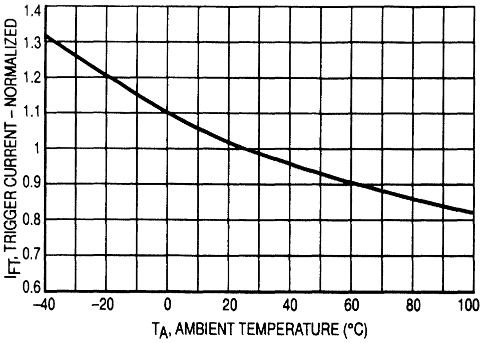


Figure 3. Trigger Current versus Temperature

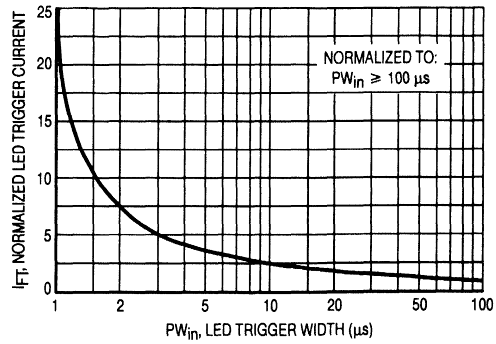


Figure 4. LED Current Required to Trigger versus LED Pulse Width

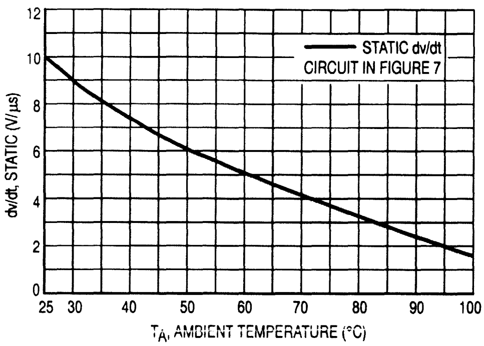


Figure 5. dv/dt versus Temperature

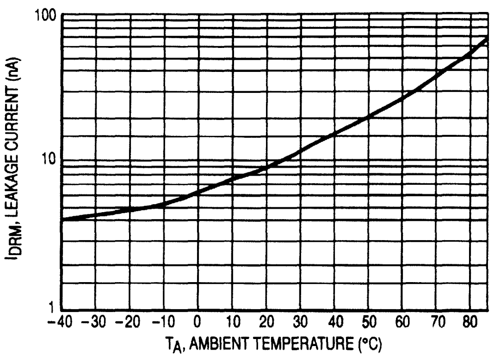
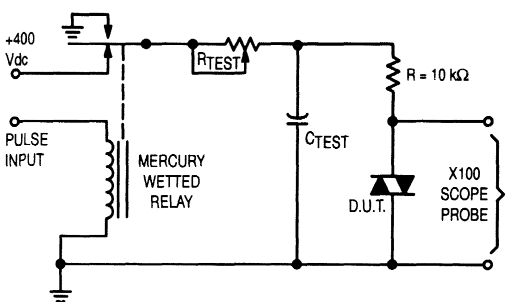
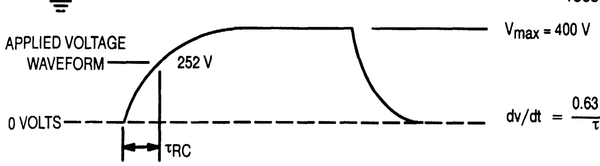


Figure 6. Leakage Current, I_{DRM} versus Temperature

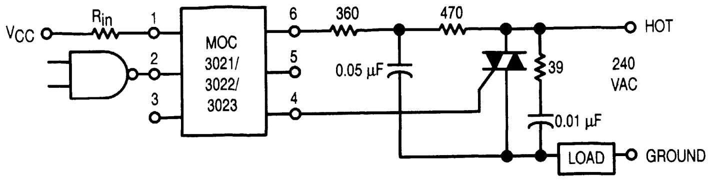


1. The mercury wetted relay provides a high speed repeated pulse to the D.U.T.
2. 100x scope probes are used, to allow high speeds and voltages.
3. The worst–case condition for static dv/dt is established by triggering the D.U.T. with a normal LED input current, then removing the current. The variable R_{TEST} allows the dv/dt to be gradually increased until the D.U.T. continues to trigger in response to the applied voltage pulse, even after the LED current has been removed. The dv/dt is then decreased until the D.U.T. stops triggering. τ_{RC} is measured at this point and recorded.



$$dv/dt = \frac{0.63\ V_{max}}{\tau_{RC}} = \frac{252}{\tau_{RC}}$$

Figure 7. Static dv/dt Test Circuit



* This optoisolator should not be used to drive a load directly. It is intended to be a trigger device only.

Additional information on the use of optically coupled triac drivers is available in Application Note AN–780A.

In this circuit the "hot" side of the line is switched and the load connected to the cold or ground side.

The 39 ohm resistor and 0.01 µF capacitor are for snubbing of the triac, and the 470 ohm resistor and 0.05 µF capacitor are for snubbing the coupler. These components may or may not be necessary depending upon the particular triac and load used.

Figure 8. Typical Application Circuit

GlobalOptoisolator™

VDE	UL	CSA	SETI	SEMKO	DEMKO	NEMKO	BABT

# MOC3051
[IFT = 15 mA Max]
# MOC3052*
[IFT = 10 mA Max]

*Motorola Preferred Device

6-Pin DIP Random-Phase Optoisolators Triac Drivers
(600 Volts Peak)

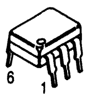
The MOC3051 Series consists of a GaAs infrared LED optically coupled to a non–Zero–crossing silicon bilateral AC switch (triac). The MOC3051 Series isolates low voltage logic from 115 and 240 Vac lines to provide random phase control of high current triacs or thyristors. The MOC3051 Series features greatly enhanced static dv/dt capability to ensure stable switching performance of inductive loads.

- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

Recommended for 115/240 Vac(rms) Applications:

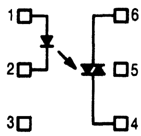
- Solenoid/Valve Controls
- Lamp Ballasts
- Static AC Power Switch
- Interfacing Microprocessors to 115 and 240 Vac Peripherals
- Solid State Relays
- Incandescent Lamp Dimmers
- Temperature Controls
- Motor Controls

STYLE 6 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

COUPLER SCHEMATIC



1. ANODE
2. CATHODE
3. NC
4. MAIN TERMINAL
5. SUBSTRATE DO NOT CONNECT
6. MAIN TERMINAL

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INFRARED EMITTING DIODE			
Reverse Voltage	V_R	3	Volts
Forward Current — Continuous	I_F	60	mA
Total Power Dissipation @ T_A = 25°C Negligible Power in Triac Driver Derate above 25°C	P_D	100 1.33	mW mW/°C
OUTPUT DRIVER			
Off-State Output Terminal Voltage	V_{DRM}	600	Volts
Peak Repetitive Surge Current (PW = 100 μs, 120 pps)	I_{TSM}	1	A
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 4	mW mW/°C
TOTAL DEVICE			
Isolation Surge Voltage (1) (Peak ac Voltage, 60 Hz, 1 Second Duration)	V_{ISO}	7500	Vac(pk)
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	330 4.4	mW mW/°C
Junction Temperature Range	T_J	–40 to +100	°C
Ambient Operating Temperature Range (2)	T_A	–40 to +85	°C
Storage Temperature Range(2)	T_{stg}	–40 to +150	°C
Soldering Temperature (10 s)	T_L	260	°C

1. Isolation surge voltage, V_{ISO}, is an internal device dielectric breakdown rating. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.
2. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

Preferred devices are Motorola recommended choices for future use and best overall value.

(Replaces MOC3050/D)

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

Characteristic	Symbol	Min	Typ	Max	Unit
INPUT LED					
Reverse Leakage Current (V_R = 3 V)	I_R	—	0.05	100	μA
Forward Voltage (I_F = 10 mA)	V_F	—	1.15	1.5	Volts
OUTPUT DETECTOR (I_F = 0 unless otherwise noted)					
Peak Blocking Current, Either Direction (Rated V_{DRM}, Note 1) @ I_{FT} per device	I_{DRM}	—	10	100	nA
Peak On–State Voltage, Either Direction (I_{TM} = 100 mA Peak)	V_{TM}	—	1.7	2.5	Volts
Critical Rate of Rise of Off–State Voltage @ 400 V (Refer to test circuit, Figure 10)	dv/dt static	1000	—	—	V/μs
COUPLED					
LED Trigger Current, Either Direction, Current Required to Latch Output (Main Terminal Voltage = 3 V, Note 2)	I_{FT}				mA
MOC3051		—	—	15	
MOC3052		—	—	10	
Holding Current, Either Direction	I_H	—	280	—	μA

1. Test voltage must be applied within dv/dt rating.
2. All devices are guaranteed to trigger at an I_F value less than or equal to max I_{FT}. Therefore, recommended operating I_F lies between max 15 mA for MOC3051, 10 mA for 3052 and absolute max I_F (60 mA).

TYPICAL ELECTRICAL CHARACTERISTICS
T_A = 25°C

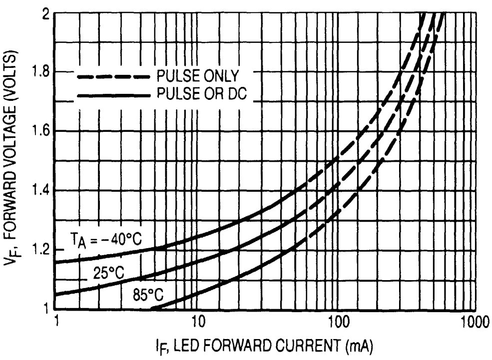


Figure 1. LED Forward Voltage versus Forward Current

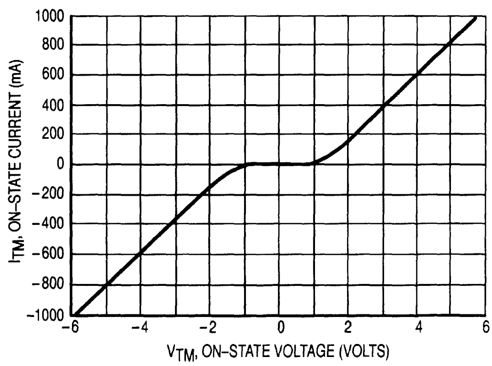


Figure 2. On–State Characteristics

TYPICAL ELECTRICAL CHARACTERISTICS

T_A = 25°C

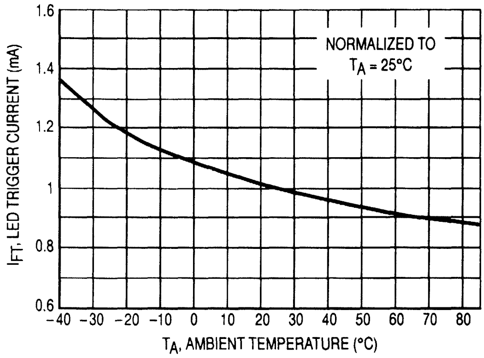


Figure 3. Trigger Current versus Temperature

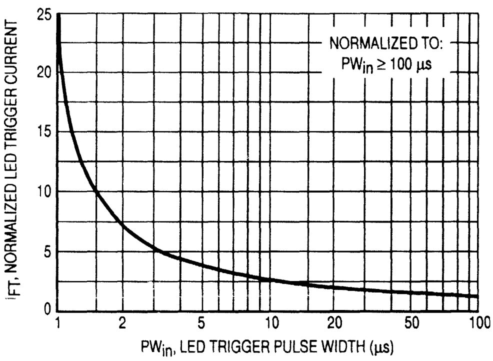


Figure 4. LED Current Required to Trigger versus LED Pulse Width

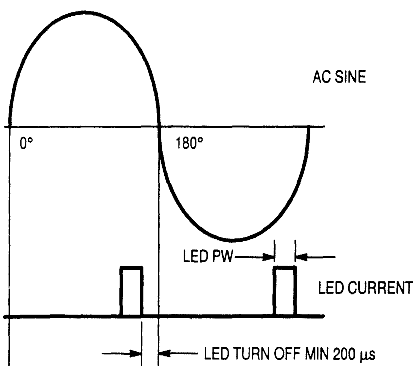


Figure 5. Minimum Time for LED Turn–Off to Zero Cross of AC Trailing Edge

I_{FT} versus Temperature (normalized)

This graph shows the increase of the trigger current when the device is expected to operate at an ambient temperature below 25°C. Multiply the normalized I_{FT} shown on this graph with the data sheet guaranteed I_{FT}.

Example:
T_A = −40°C, I_{FT} = 10 mA
I_{FT} @ −40°C = 10 mA x 1.4 = 14 mA

Phase Control Considerations

LED Trigger Current versus PW (normalized)

Random Phase Triac drivers are designed to be phase controllable. They may be triggered at any phase angle within the AC sine wave. Phase control may be accomplished by an AC line zero cross detector and a variable pulse delay generator which is synchronized to the zero cross detector. The same task can be accomplished by a microprocessor which is synchronized to the AC zero crossing. The phase controlled trigger current may be a very short pulse which saves energy delivered to the input LED. LED trigger pulse currents shorter than 100 µs must have an increased amplitude as shown on Figure 4. This graph shows the dependency of the trigger current I_{FT} versus the pulse width t (PW). The reason for the I_{FT} dependency on the pulse width can be seen on the chart delay t(d) versus the LED trigger current.

I_{FT} in the graph I_{FT} versus (PW) is normalized in respect to the minimum specified I_{FT} for static condition, which is specified in the device characteristic. The normalized I_{FT} has to be multiplied with the devices guaranteed static trigger current.

Example:
Guaranteed I_{FT} = 10 mA, Trigger pulse width PW = 3 µs
I_{FT} (pulsed) = 10 mA x 5 = 50 mA

Minimum LED Off Time in Phase Control Applications

In Phase control applications one intends to be able to control each AC sine half wave from 0 to 180 degrees. Turn on at zero degrees means full power and turn on at 180 degree means zero power. This is not quite possible in reality because triac driver and triac have a fixed turn on time when activated at zero degrees. At a phase control angle close to 180 degrees the driver's turn on pulse at the trailing edge of the AC sine wave must be limited to end 200 µs before AC zero cross as shown in Figure 5. This assures that the triac driver has time to switch off. Shorter times may cause loss of control at the following half cycle.

TYPICAL ELECTRICAL CHARACTERISTICS

$T_A = 25°C$

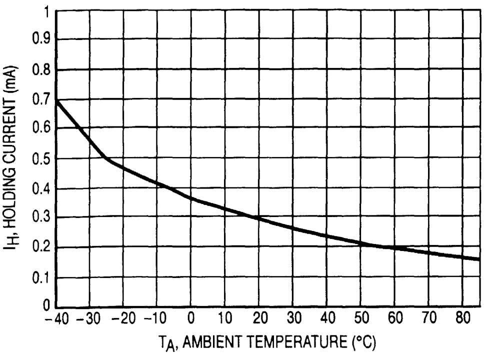


Figure 6. Holding Current, I_H versus Temperature

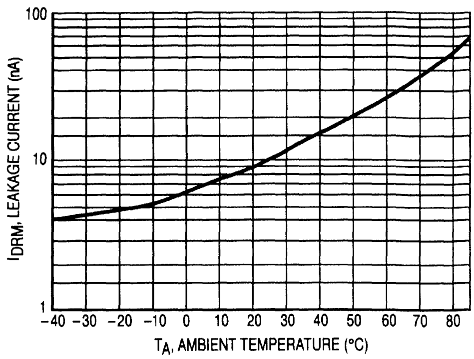


Figure 7. Leakage Current, I_{DRM} versus Temperature

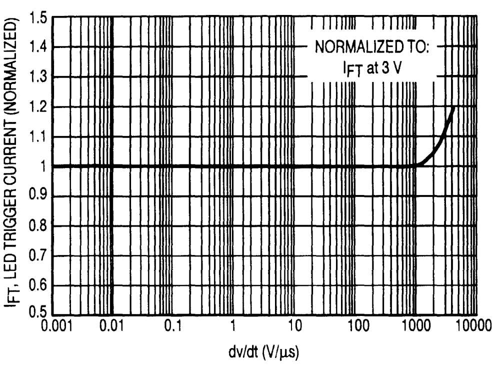


Figure 8. ED Trigger Current, I_{FT}, versus dv/dt

I_{FT} versus dv/dt

Triac drivers with good noise immunity (dv/dt static) have internal noise rejection circuits which prevent false triggering of the device in the event of fast raising line voltage transients. Inductive loads generate a commutating dv/dt that may activate the triac drivers noise suppression circuits. This prevents the device from turning on at its specified trigger current. It will in this case go into the mode of "half waving" of the load. Half waving of the load may destroy the power triac and the load.

Figure 8 shows the dependency of the triac drivers I_{FT} versus the reapplied voltage rise with a Vp of 400 V. This dv/dt condition simulates a worst case commutating dv/dt amplitude.

It can be seen that the I_{FT} does not change until a commutating dv/dt reaches 1000 V/µs. Practical loads generate a commutating dv/dt of less than 50 V/µs. The data sheet specified I_{FT} is therefore applicable for all practical inductive loads and load factors.

TYPICAL ELECTRICAL CHARACTERISTICS

$T_A = 25°C$

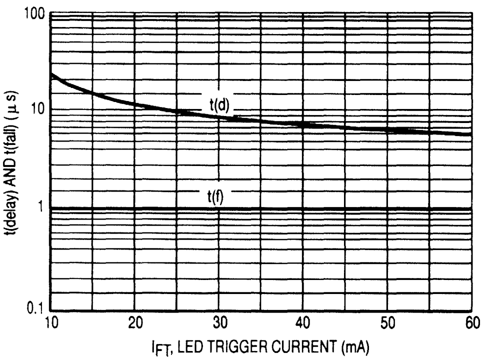


Figure 9. Delay Time, t(d), and Fall Time, t(f), versus LED Trigger Current

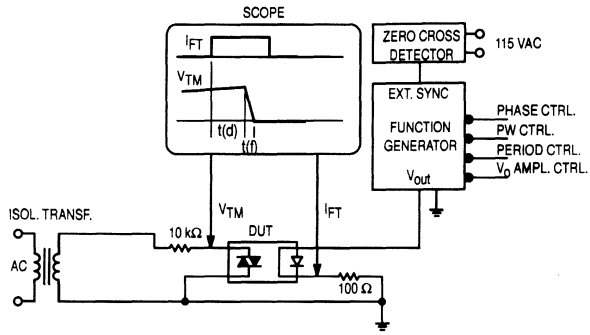
t(delay), t(f) versus I_{FT}

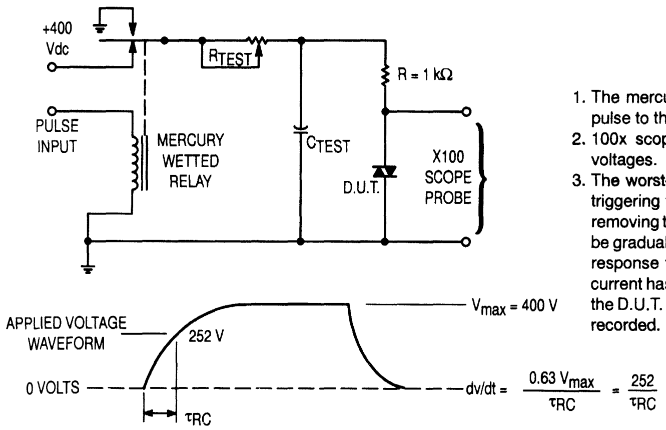
The triac driver's turn on switching speed consists of a turn on delay time t(d) and a fall time t(f). Figure 9 shows that the delay time depends on the LED trigger current, while the actual trigger transition time t(f) stays constant with about one micro second.

The delay time is important in very short pulsed operation because it demands a higher trigger current at very short trigger pulses. This dependency is shown in the graph I_{FT} versus LED PW.

The turn on transition time t(f) combined with the power triac's turn on time is important to the power dissipation of this device.

Switching Time Test Circuit





1. The mercury wetted relay provides a high speed repeated pulse to the D.U.T.
2. 100x scope probes are used, to allow high speeds and voltages.
3. The worst–case condition for static dv/dt is established by triggering the D.U.T. with a normal LED input current, then removing the current. The variable R_{TEST} allows the dv/dt to be gradually increased until the D.U.T. continues to trigger in response to the applied voltage pulse, even after the LED current has been removed. The dv/dt is then decreased until the D.U.T. stops triggering. τ_{RC} is measured at this point and recorded.

Figure 10. Static dv/dt Test Circuit

APPLICATIONS GUIDE

Basic Triac Driver Circuit

The new random phase triac driver family MOC3052 and MOC3051 are very immune to static dv/dt which allows snubberless operations in all applications where external generated noise in the AC line is below its guaranteed dv/dt withstand capability. For these applications a snubber circuit is not necessary when a noise insensitive power triac is used. Figure 11 shows the circuit diagram. The triac driver is directly connected to the triac main terminal 2 and a series Resistor R which limits the current to the triac driver. Current limiting resistor R must have a minimum value which restricts the current into the driver to maximum 1A.

$R = Vp\ AC/I_{TM}$ max rep. $= Vp\ AC/1A$

The power dissipation of this current limiting resistor and the triac driver is very small because the power triac carries the load current as soon as the current through driver and current limiting resistor reaches the trigger current of the power triac. The switching transition times for the driver is only one micro second and for power triacs typical four micro seconds.

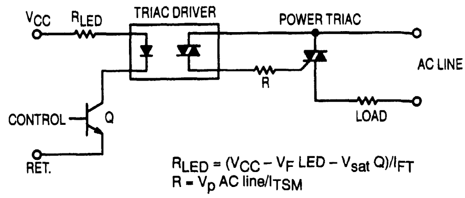


Figure 11. Basic Driver Circuit

Triac Driver Circuit for Noisy Environments

When the transient rate of rise and amplitude are expected to exceed the power triacs and triac drivers maximum ratings a snubber circuit as shown in Figure 12 is recommended. Fast transients are slowed by the R–C snubber and excessive amplitudes are clipped by the Metal Oxide Varistor MOV.

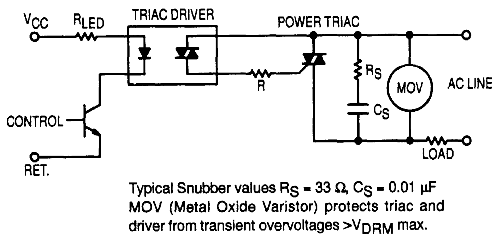


Figure 12. Triac Driver Circuit for Noisy Environments

Triac Driver Circuit for Extremely Noisy Environments, as specified in the noise standards IEEE472 and IEC255–4.

Industrial control applications do specify a maximum transient noise dv/dt and peak voltage which is superimposed onto the AC line voltage. In order to pass this environment noise test a modified snubber network as shown in Figure 13 is recommended.

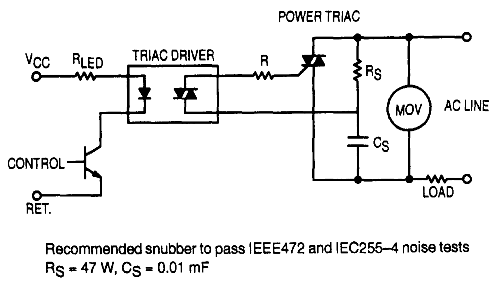


Figure 13. Triac Driver Circuit for Extremely Noisy Environments

GlobalOptoisolator™

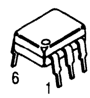
VDE	UL	CSA	SETI	SEMKO	DEMKO	NEMKO	BABT

6-Pin DIP Zero-Cross Optoisolators Triac Driver Output
(250 Volts Peak)

MOC3031
[IFT = 15 mA Max]
MOC3032
[IFT = 10 mA Max]
MOC3033*
[IFT = 5 mA Max]

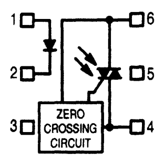
*Motorola Preferred Device

STYLE 6 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

COUPLER SCHEMATIC



1. ANODE
2. CATHODE
3. NC
4. MAIN TERMINAL
5. SUBSTRATE
   DO NOT CONNECT
6. MAIN TERMINAL

The MOC3031, MOC3032 and MOC3033 devices consist of gallium arsenide infrared emitting diodes optically coupled to a monolithic silicon detector performing the function of a Zero Voltage crossing bilateral triac driver.

They are designed for use with a triac in the interface of logic systems to equipment powered from 115 Vac lines, such as teletypewriters, CRTs, printers, motors, solenoids and consumer appliances, etc.

- Simplifies Logic Control of 115 Vac Power
- Zero Voltage Crossing
- dv/dt of 2000 V/µs Typical, 1000 V/µs Guaranteed
- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

Recommended for 115 Vac(rms) Applications:

- Solenoid/Valve Controls
- Lighting Controls
- Static Power Switches
- AC Motor Drives
- Temperature Controls
- E.M. Contactors
- AC Motor Starters
- Solid State Relays

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INFRARED LED			
Reverse Voltage	V_R	3	Volts
Forward Current — Continuous	I_F	60	mA
Total Power Dissipation @ T_A = 25°C Negligible Power in Output Driver Derate above 25°C	P_D	120 1.41	mW mW/°C
OUTPUT DRIVER			
Off–State Output Terminal Voltage	V_{DRM}	250	Volts
Peak Repetitive Surge Current (PW = 100 µs, 120 pps)	I_{TSM}	1	A
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 1.76	mW mW/°C
TOTAL DEVICE			
Isolation Surge Voltage(1) (Peak ac Voltage, 60 Hz, 1 Second Duration)	V_{ISO}	7500	Vac(pk)
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Junction Temperature Range	T_J	–40 to +100	°C
Ambient Operating Temperature Range(2)	T_A	–40 to +85	°C
Storage Temperature Range(2)	T_{stg}	–40 to +150	°C
Soldering Temperature (10 s)	T_L	260	°C

1. Isolation surge voltage, V_{ISO}, is an internal device dielectric breakdown rating. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.
2. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

Preferred devices are Motorola recommended choices for future use and best overall value.

(Replaces MOC3030/D)

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

Characteristic	Symbol	Min	Typ	Max	Unit
INPUT LED					
Reverse Leakage Current (V_R = 3 V)	I_R	—	0.05	100	μA
Forward Voltage (I_F = 30 mA)	V_F	—	1.3	1.5	Volts
OUTPUT DETECTOR (I_F = 0 unless otherwise noted)					
Leakage with LED Off, Either Direction (Rated V_{DRM}(1))	I_{DRM1}	—	10	100	nA
Peak On–State Voltage, Either Direction (I_{TM} = 100 mA Peak)	V_{TM}	—	1.8	3	Volts
Critical Rate of Rise of Off–State Voltage	dv/dt	1000	2000	—	V/μs
COUPLED					
LED Trigger Current, Current Required to Latch Output (Main Terminal Voltage = 3 V(2))	I_{FT}				mA
MOC3031		—	—	15	
MOC3032		—	—	10	
MOC3033		—	—	5	
Holding Current, Either Direction	I_H	—	250	—	μA
Isolation Voltage (f = 60 Hz, t = 1 sec)	V_{ISO}	7500	—	—	Vac(pk)
ZERO CROSSING					
Inhibit Voltage (I_F = Rated I_{FT}, MT1–MT2 Voltage above which device will not trigger.)	V_{IH}	—	5	20	Volts
Leakage in Inhibited State (I_F = Rated I_{FT}, Rated V_{DRM}, Off State)	I_{DRM2}	—	—	500	μA

1. Test voltage must be applied within dv/dt rating.
2. All devices are guaranteed to trigger at an I_F value less than or equal to max I_{FT}. Therefore, recommended operating I_F lies between max I_{FT} (15 mA for MOC3031, 10 mA for MOC3032, 5 mA for MOC3033) and absolute max I_F (60 mA).

TYPICAL ELECTRICAL CHARACTERISTICS
T_A = 25°C

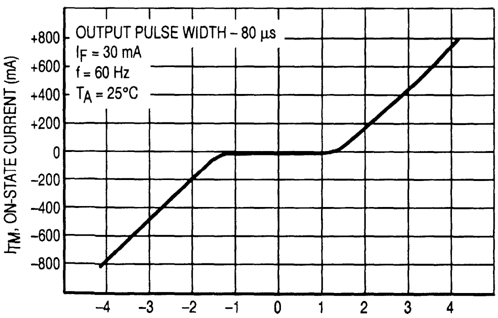


Figure 1. On–State Characteristics

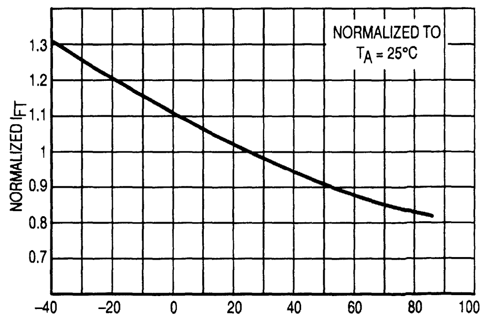


Figure 2. Trigger Current versus Temperature

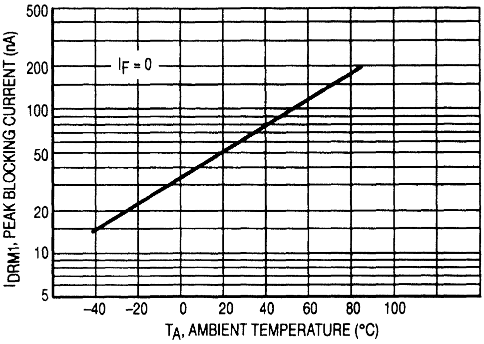


Figure 3. I_{DRM1}, Peak Blocking Current versus Temperature

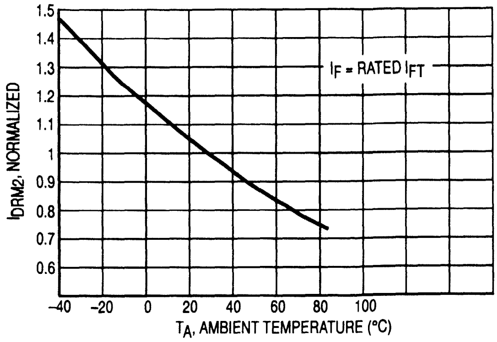


Figure 4. I_{DRM2}, Leakage in Inhibit State versus Temperature

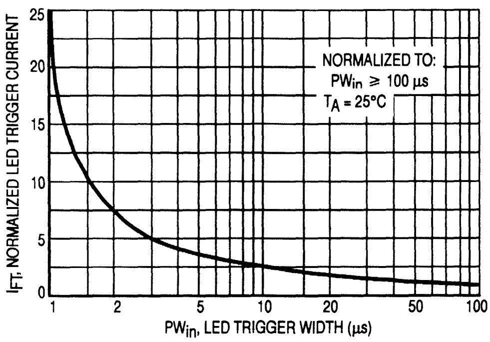
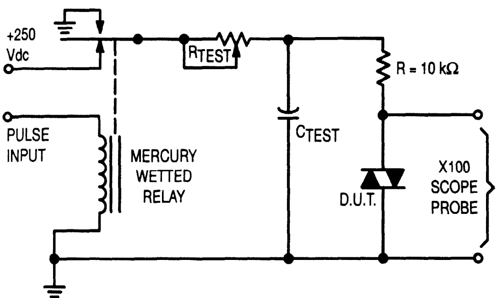
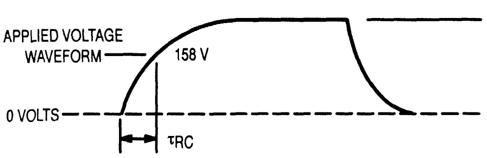


Figure 5. LED Current Required to Trigger versus LED Pulse Width

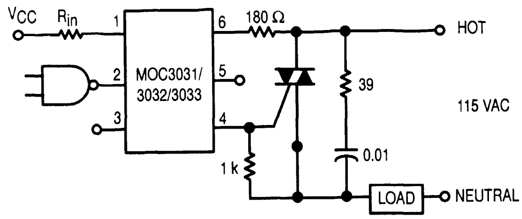


1. The mercury wetted relay provides a high speed repeated pulse to the D.U.T.
2. 100x scope probes are used, to allow high speeds and voltages.
3. The worst–case condition for static dv/dt is established by triggering the D.U.T. with a normal LED input current, then removing the current. The variable R_{TEST} allows the dv/dt to be gradually increased until the D.U.T. continues to trigger in response to the applied voltage pulse, even after the LED current has been removed. The dv/dt is then decreased until the D.U.T. stops triggering. τ_{RC} is measured at this point and recorded.



$$dv/dt = \frac{0.63\ V_{max}}{\tau_{RC}} = \frac{158}{\tau_{RC}}$$

Figure 6. Static dv/dt Test Circuit

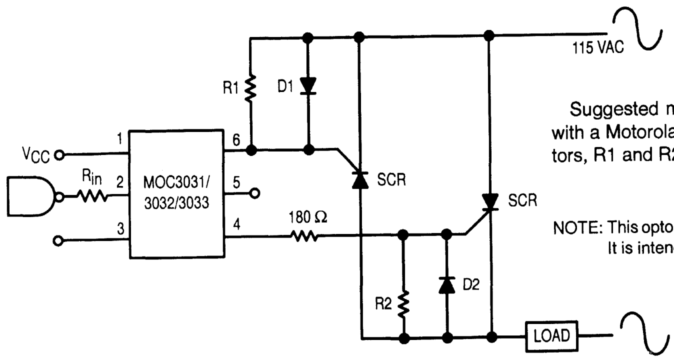


Typical circuit for use when hot line switching is required. In this circuit the "hot" side of the line is switched and the load connected to the cold or neutral side. The load may be connected to either the neutral or hot line.

R_{in} is calculated so that I_F is equal to the rated I_{FT} of the part, 5 mA for the MOC3033, 10 mA for the MOC3032, or 15 mA for the MOC3031. The 39 ohm resistor and 0.01 μF capacitor are for snubbing of the triac and may or may not be necessary depending upon the particular triac and load used.

* For highly inductive loads (power factor < 0.5), change this value to 360 ohms.

Figure 7. Hot–Line Switching Application Circuit



Suggested method of firing two, back–to–back SCR's, with a Motorola triac driver. Diodes can be 1N4001; resistors, R1 and R2, are optional 1 k ohm.

NOTE: This optoisolator should not be used to drive a load directly. It is intended to be a trigger device only.

Figure 8. Inverse–Parallel SCR Driver Circuit

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

GlobalOptoisolator™

VDE	UL	CSA	SETI	SEMKO	DEMKO	NEMKO	BABT

6-Pin DIP Zero-Cross Optoisolators Triac Driver Output
(400 Volts Peak)

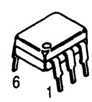
MOC3041
[IFT = 15 mA Max]

MOC3042
[IFT = 10 mA Max]

MOC3043*
[IFT = 5 mA Max]

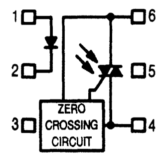
*Motorola Preferred Device

STYLE 6 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

COUPLER SCHEMATIC



1. ANODE
2. CATHODE
3. NC
4. MAIN TERMINAL
5. SUBSTRATE DO NOT CONNECT
6. MAIN TERMINAL

The MOC3041, MOC3042 and MOC3043 devices consist of gallium arsenide infrared emitting diodes optically coupled to a monolithic silicon detector performing the function of a Zero Voltage Crossing bilateral triac driver.

They are designed for use with a triac in the interface of logic systems to equipment powered from 115 Vac lines, such as solid–state relays, industrial controls, motors, solenoids and consumer appliances, etc.

- Simplifies Logic Control of 115 Vac Power
- Zero Voltage Crossing
- dv/dt of 2000 V/μs Typical, 1000 V/μs Guaranteed
- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

Recommended for 115/240 Vac(rms) Applications:

- Solenoid/Valve Controls
- Lighting Controls
- Static Power Switches
- AC Motor Drives
- Temperature Controls
- E.M. Contactors
- AC Motor Starters
- Solid State Relays

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INFRARED EMITTING DIODE			
Reverse Voltage	V_R	6	Volts
Forward Current — Continuous	I_F	60	mA
Total Power Dissipation @ T_A = 25°C Negligible Power in Output Driver Derate above 25°C	P_D	120 1.41	mW mW/°C
OUTPUT DRIVER			
Off–State Output Terminal Voltage	V_{DRM}	400	Volts
Peak Repetitive Surge Current (PW = 100 μs, 120 pps)	I_{TSM}	1	A
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 1.76	mW mW/°C
TOTAL DEVICE			
Isolation Surge Voltage(1) (Peak ac Voltage, 60 Hz, 1 Second Duration)	V_{ISO}	7500	Vac(pk)
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Junction Temperature Range	T_J	−40 to +100	°C
Ambient Operating Temperature Range(2)	T_A	−40 to +85	°C
Storage Temperature Range(2)	T_{stg}	−40 to +150	°C
Soldering Temperature (10 s)	T_L	260	°C

1. Isolation surge voltage, V_{ISO}, is an internal device dielectric breakdown rating.
   For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.
2. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

Preferred devices are Motorola recommended choices for future use and best overall value.

(Replaces MOC3040/D)

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

Characteristic	Symbol	Min	Typ	Max	Unit
INPUT LED					
Reverse Leakage Current (V_R = 6 V)	I_R	—	0.05	100	μA
Forward Voltage (I_F = 30 mA)	V_F	—	1.3	1.5	Volts
OUTPUT DETECTOR (I_F = 0 unless otherwise noted)					
Leakage with LED Off, Either Direction (Rated V_{DRM}(1))	I_{DRM1}	—	2	100	nA
Peak On–State Voltage, Either Direction (I_{TM} = 100 mA Peak)	V_{TM}	—	1.8	3	Volts
Critical Rate of Rise of Off–State Voltage(3)	dv/dt	1000	2000	—	V/μs
COUPLED					
LED Trigger Current, Current Required to Latch Output (Main Terminal Voltage = 3 V(2))	I_{FT}				mA
MOC3041		—	—	15	
MOC3042		—	—	10	
MOC3043		—	—	5	
Holding Current, Either Direction	I_H	—	250	—	μA
Isolation Voltage (f = 60 Hz, t = 1 sec)	V_{ISO}	7500	—	—	Vac(pk)
ZERO CROSSING					
Inhibit Voltage (I_F = Rated I_{FT}, MT1–MT2 Voltage above which device will not trigger.)	V_{IH}	—	5	20	Volts
Leakage in Inhibited State (I_F = Rated I_{FT}, Rated V_{DRM}, Off State)	I_{DRM2}	—	—	500	μA

1. Test voltage must be applied within dv/dt rating.
2. All devices are guaranteed to trigger at an I_F value less than or equal to max I_{FT}. Therefore, recommended operating I_F lies between I_{FT} (15 mA for MOC3041, 10 mA for MOC3042, 5 mA for MOC3043) and absolute max I_F (60 mA).
3. This is static dv/dt. See Figure 7 for test circuit. Commutating dv/dt is a function of the load–driving thyristor(s) only.

TYPICAL ELECTRICAL CHARACTERISTICS
T_A = 25°C

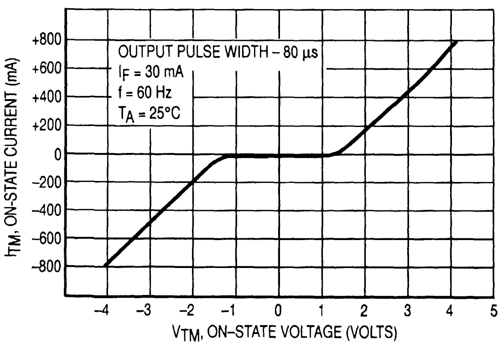


Figure 1. On–State Characteristics

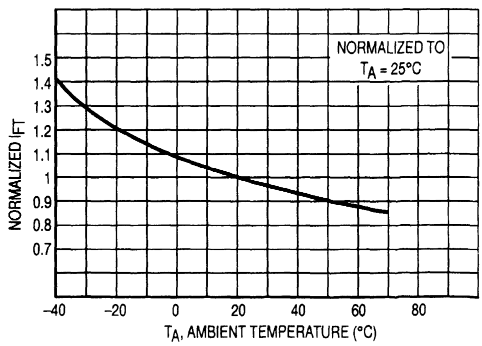


Figure 2. Trigger Current versus Temperature

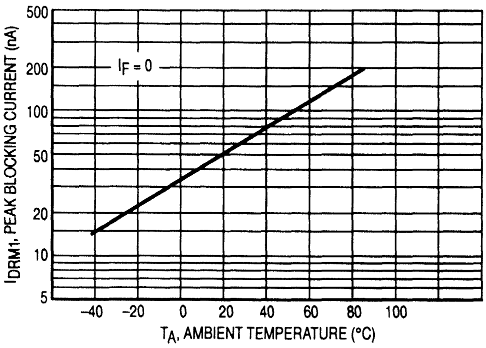


Figure 3. I_{DRM1}, Peak Blocking Current versus Temperature

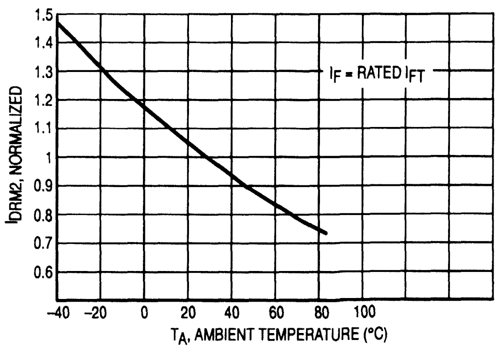


Figure 4. I_{DRM2}, Leakage in Inhibit State versus Temperature

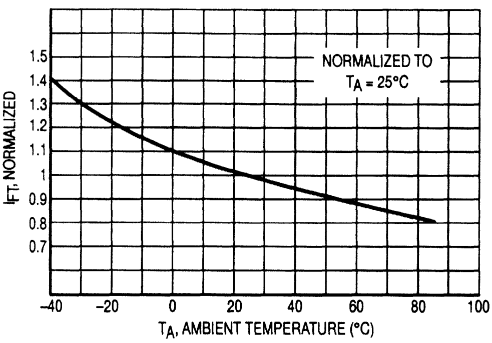


Figure 5. Trigger Current versus Temperature

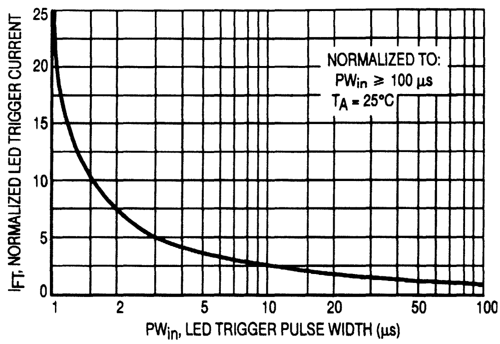
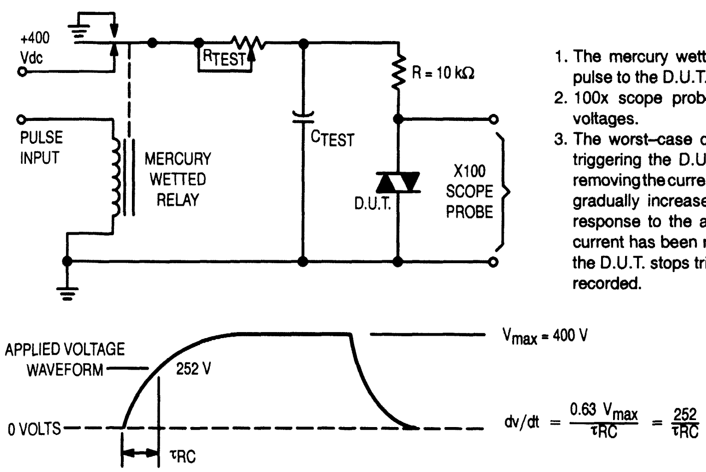


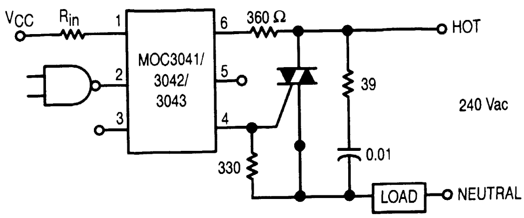
Figure 6. LED Current Required to Trigger versus LED Pulse Width



1. The mercury wetted relay provides a high speed repeated pulse to the D.U.T.
2. 100x scope probes are used, to allow high speeds and voltages.
3. The worst-case condition for static dv/dt is established by triggering the D.U.T. with a normal LED input current, then removing the current. The variable R_{TEST} allows the dv/dt to be gradually increased until the D.U.T. continues to trigger in response to the applied voltage pulse, even after the LED current has been removed. The dv/dt is then decreased until the D.U.T. stops triggering. τ_{RC} is measured at this point and recorded.

$$dv/dt = \frac{0.63\ V_{max}}{\tau_{RC}} = \frac{252}{\tau_{RC}}$$

Figure 7. Static dv/dt Test Circuit

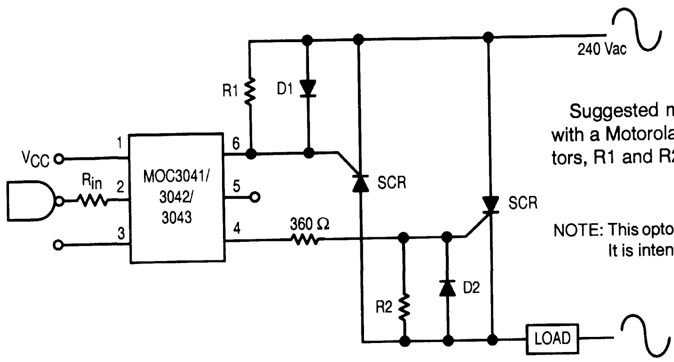


Typical circuit for use when hot line switching is required. In this circuit the "hot" side of the line is switched and the load connected to the cold or neutral side. The load may be connected to either the neutral or hot line.

R_{in} is calculated so that I_F is equal to the rated I_{FT} of the part, 5 mA for the MOC3043, 10 mA for the MOC3042, or 15 mA for the MOC3041. The 39 ohm resistor and 0.01 μF capacitor are for snubbing of the triac and may or may not be necessary depending upon the particular triac and load used.

* For highly inductive loads (power factor < 0.5), change this value to 360 ohms.

Figure 8. Hot–Line Switching Application Circuit



Suggested method of firing two, back–to–back SCR's, with a Motorola triac driver. Diodes can be 1N4001; resistors, R1 and R2, are optional 330 ohms.

NOTE: This optoisolator should not be used to drive a load directly. It is intended to be a trigger device only.

Figure 9. Inverse–Parallel SCR Driver Circuit

GlobalOptoisolator™

VDE | UL | CSA | SETI | SEMKO | DEMKO | NEMKO | BABT

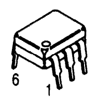
6-Pin DIP Zero-Cross Optoisolators Triac Driver Output

(600 Volts Peak)

MOC3061
[IFT = 15 mA Max]
MOC3062
[IFT = 10 mA Max]
MOC3063*
[IFT = 5 mA Max]

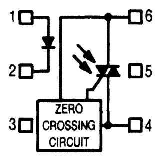
***Motorola Preferred Device**

STYLE 6 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

COUPLER SCHEMATIC



1. ANODE
2. CATHODE
3. NC
4. MAIN TERMINAL
5. SUBSTRATE
   DO NOT CONNECT
6. MAIN TERMINAL

The MOC3061, MOC3062 and MOC3063 devices consist of gallium arsenide infrared emitting diodes optically coupled to monolithic silicon detectors performing the functions of Zero Voltage Crossing bilateral triac drivers.

They are designed for use with a triac in the interface of logic systems to equipment powered from 115/240 Vac lines, such as solid–state relays, industrial controls, motors, solenoids and consumer appliances, etc.

- Simplifies Logic Control of 115/240 Vac Power
- Zero Voltage Crossing
- dv/dt of 1500 V/μs Typical, 600 V/μs Guaranteed
- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

Recommended for 115/240 Vac(rms) Applications:

- Solenoid/Valve Controls
- Lighting Controls
- Static Power Switches
- AC Motor Drives
- Temperature Controls
- E.M. Contactors
- AC Motor Starters
- Solid State Relays

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
INFRARED EMITTING DIODE			
Reverse Voltage	V_R	6	Volts
Forward Current — Continuous	I_F	60	mA
Total Power Dissipation @ T_A = 25°C Negligible Power in Output Driver Derate above 25°C	P_D	120 1.41	mW mW/°C
OUTPUT DRIVER			
Off–State Output Terminal Voltage	V_{DRM}	600	Volts
Peak Repetitive Surge Current (PW = 100 μs, 120 pps)	I_{TSM}	1	A
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 1.76	mW mW/°C
TOTAL DEVICE			
Isolation Surge Voltage(1) (Peak ac Voltage, 60 Hz, 1 Second Duration)	V_{ISO}	7500	Vac(pk)
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Junction Temperature Range	T_J	–40 to +100	°C
Ambient Operating Temperature Range(2)	T_A	–40 to +85	°C
Storage Temperature Range(2)	T_{stg}	–40 to +150	°C
Soldering Temperature (10 s)	T_L	260	°C

1. Isolation surge voltage, V_{ISO}, is an internal device dielectric breakdown rating.
   For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.
2. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

Preferred devices are Motorola recommended choices for future use and best overall value.

(Replaces MOC3060/D)

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

Characteristic	Symbol	Min	Typ	Max	Unit
INPUT LED					
Reverse Leakage Current (V_R = 6 V)	I_R	—	0.05	100	μA
Forward Voltage (I_F = 30 mA)	V_F	—	1.3	1.5	Volts
OUTPUT DETECTOR (I_F = 0)					
Leakage with LED Off, Either Direction (Rated V_{DRM}(1))	I_{DRM1}	—	60	500	nA
Critical Rate of Rise of Off–State Voltage(3)	dv/dt	600	1500	—	V/μs
COUPLED					
LED Trigger Current, Current Required to Latch Output (Main Terminal Voltage = 3 V(2))	I_{FT}				mA
MOC3061		—	—	15	
MOC3062		—	—	10	
MOC3063		—	—	5	
Peak On–State Voltage, Either Direction (I_{TM} = 100 mA, I_F = Rated I_{FT})	V_{TM}	—	1.8	3	Volts
Holding Current, Either Direction	I_H	—	250	—	μA
Inhibit Voltage (MT1–MT2 Voltage above which device will not trigger.) (I_F = Rated I_{FT})	V_{INH}	—	5	20	Volts
Leakage in Inhibited State (I_F = Rated I_{FT}, Rated V_{DRM}, Off State)	I_{DRM2}	—	—	500	μA
Isolation Voltage (f = 60 Hz, t = 1 sec)	V_{ISO}	7500	—	—	Vac(pk)

1. Test voltage must be applied within dv/dt rating.
2. All devices are guaranteed to trigger at an I_F value less than or equal to max I_{FT}. Therefore, recommended operating I_F lies between max I_{FT} (15 mA for MOC3061, 10 mA for MOC3062, 5 mA for MOC3063) and absolute max I_F (60 mA).
3. This is static dv/dt. See Figure 7 for test circuit. Commutating dv/dt is a function of the load–driving thyristor(s) only.

TYPICAL CHARACTERISTICS
T_A = 25°C

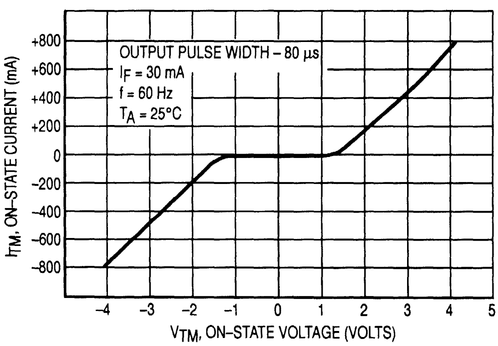


Figure 1. On–State Characteristics

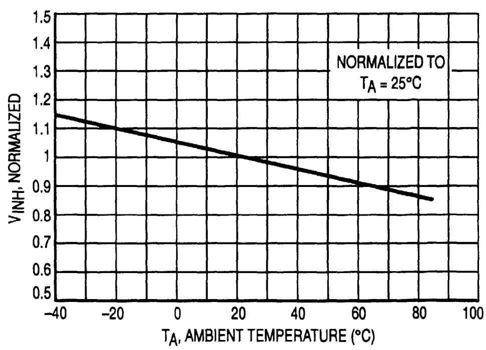


Figure 2. Inhibit Voltage versus Temperature

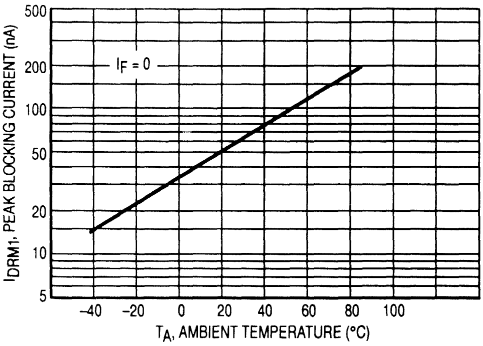


Figure 3. Leakage with LED Off versus Temperature

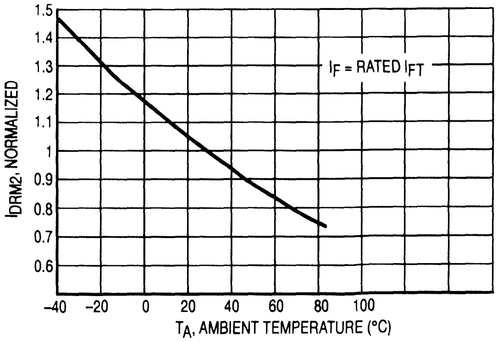


Figure 4. I_{DRM2}, Leakage in Inhibit State versus Temperature

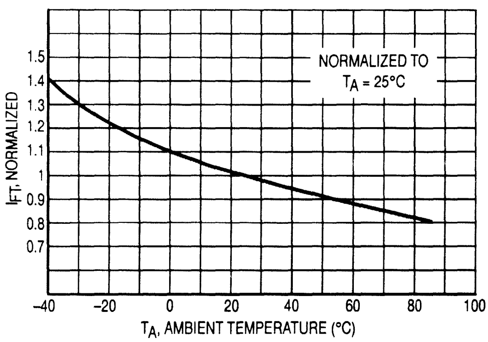


Figure 5. Trigger Current versus Temperature

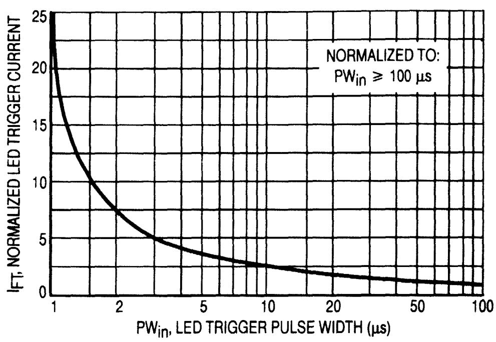
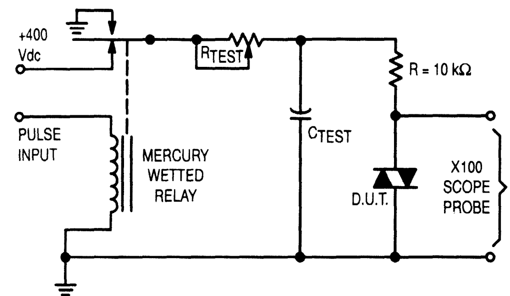
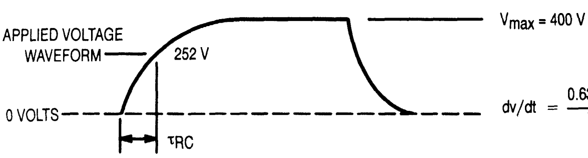


Figure 6. LED Current Required to Trigger versus LED Pulse Width

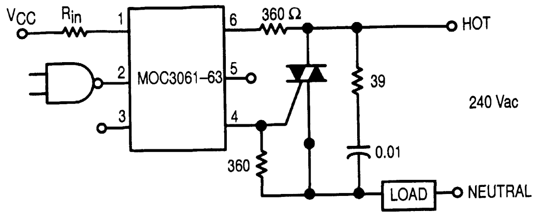


1. The mercury wetted relay provides a high speed repeated pulse to the D.U.T.
2. 100x scope probes are used, to allow high speeds and voltages.
3. The worst–case condition for static dv/dt is established by triggering the D.U.T. with a normal LED input current, then removing the current. The variable R_{TEST} allows the dv/dt to be gradually increased until the D.U.T. continues to trigger in response to the applied voltage pulse, even after the LED current has been removed. The dv/dt is then decreased until the D.U.T. stops triggering. τ_{RC} is measured at this point and recorded.



$$dv/dt = \frac{0.63\ V_{max}}{\tau_{RC}} = \frac{378}{\tau_{RC}}$$

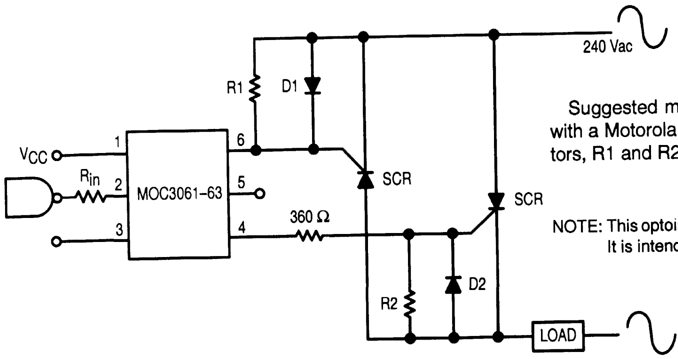
Figure 7. Static dv/dt Test Circuit



Typical circuit for use when hot line switching is required. In this circuit the "hot" side of the line is switched and the load connected to the cold or neutral side. The load may be connected to either the neutral or hot line.

R_{in} is calculated so that I_F is equal to the rated I_{FT} of the part, 15 mA for the MOC3061, 10 mA for the MOC3062, and 5 mA for the MOC3063. The 39 ohm resistor and 0.01 µF capacitor are for snubbing of the triac and may or may not be necessary depending upon the particular triac and load used.

Figure 8. Hot–Line Switching Application Circuit



Suggested method of firing two, back–to–back SCR's, with a Motorola triac driver. Diodes can be 1N4001; resistors, R1 and R2, are optional 330 ohms.

NOTE: This optoisolator should not be used to drive a load directly. It is intended to be a trigger device only.

Figure 9. Inverse–Parallel SCR Driver Circuit

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

GlobalOptoisolator™

VDE	UL	CSA	SETI	SEMKO	DEMKO	NEMKO	BABT

# MOC3162
[IFT = 10 mA Max]
# MOC3163*
[IFT = 5 mA Max]

*Motorola Preferred Device

6-Pin DIP Zero-Cross Optoisolators Triac Driver Output
(600 Volts Peak)

The MOC3162 and MOC3163 devices consist of gallium arsenide infrared emitting diodes optically coupled to monolithic silicon detectors performing the functions of Zero Voltage Crossing bilateral triac drivers.

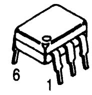
They are designed for use with a triac in the interface of logic systems to equipment powered from 115/240 Vac lines, such as solid–state relays, industrial controls, motors, solenoids and consumer appliances, etc.

- Simplifies Logic Control of 115/240 Vac Power
- Zero Voltage Turn–On
- dv/dt of 1000 V/µs Guaranteed Minimum @ 600 V Peak
- I_{FT} Insensitive to Static dv/dt (Within Rated V_{DRM})
- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

Recommended for 115/240 Vac(rms) Applications:

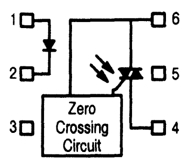
- Solenoid/Valve Controls
- Lighting Controls
- Static Power Switches
- AC Motor Drives
- Static AC Power Switch
- Temperature Controls
- E.M. Contactors
- AC Motor Starters
- Solid State Relays

STYLE 6 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

COUPLER SCHEMATIC



1. ANODE
2. CATHODE
3. NC
4. MAIN TERMINAL
5. SUBSTRATE
   DO NOT CONNECT
6. MAIN TERMINAL

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INFRARED EMITTING DIODE			
Reverse Voltage	V_R	6.0	Volts
Forward Current — Continuous	I_F	60	mA
Total Power Dissipation @ T_A = 25°C Negligible Power in Output Driver Derate above 25°C	P_D	120 1.60	mW mW/°C
OUTPUT DRIVER			
Off–State Output Terminal Voltage	V_{DRM}	600	Volts
Peak Repetitive Surge Current (PW = 100 µs, 120 pps)	I_{TSM}	1.0	A
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 2.0	mW mW/°C
TOTAL DEVICE			
Isolation Surge Voltage (1) (Peak ac Voltage, 60 Hz, 1 Second Duration)	V_{ISO}	7500	Vac(pk)
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 3.3	mW mW/°C
Junction Temperature Range	T_J	–40 to +100	°C
Ambient Operating Temperature Range (2)	T_A	–40 to +35	°C
Storage Temperature Range(2)	T_{stg}	–40 to +150	°C
Soldering Temperature (10 s)	T_L	260	°C

1. Isolation surge voltage, V_{ISO}, is an internal device dielectric breakdown rating. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.
2. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

Preferred devices are Motorola recommended choices for future use and best overall value.

(Replaces MOC3160/D)

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

Characteristic		Symbol	Min	Typ	Max	Unit
INPUT LED						
Reverse Leakage Current (V_R = 6.0 V)		I_R	—	0.05	100	μA
Forward Voltage (I_F = 30 mA)		V_F	—	1.15	1.5	Volts
OUTPUT DETECTOR (I_F = 0)						
Leakage with LED Off, Either Direction (Rated V_{DRM}, Note 1)		I_{DRM}	—	10	100	nA
Critical Rate of Rise of Off–State Voltage (Note 3) @ 600 V Peak		dv/dt	1000	—	—	V/μs
COUPLED						
LED Trigger Current, Current Required to Latch Output (Main Terminal Voltage = 3.0 V, Note 2)		I_{FT}				mA
	MOC3162		—	—	10	
	MOC3163		—	—	5.0	
Peak On–State Voltage, Either Direction (I_{TM} = 100 mA Peak, I_F = Rated I_{FT})		V_{TM}	—	1.7	3.0	Volts
Holding Current, Either Direction		I_H	—	200	—	μA
Inhibit Voltage (MT1–MT2 Voltage Above Which Device Will Not Trigger) (I_F = Rated I_{FT})		V_{INH}	—	8.0	15	Volts
Leakage in Inhibited State (I_F = 10 mA Maximum, at Rated V_{DRM}, Off State)		I_{DRM2}	—	250	500	μA

1. Test voltage must be applied within dv/dt rating.
2. All devices are guaranteed to trigger at an I_F value less than or equal to max I_{FT}. Therefore, recommended operating I_F lies between max I_{FT} (10 mA for MOC3162, 5.0 mA for MOC3163) and absolute max I_F (60 mA).
3. This is static dv/dt. See Figure 9 for test circuit. Commutating dv/dt is a function of the load–driving thyristor(s) only.

TYPICAL ELECTRICAL CHARACTERISTICS

T_A = 25°C

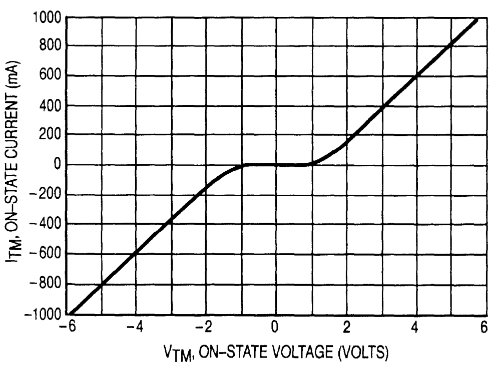


Figure 1. On–State Characteristics

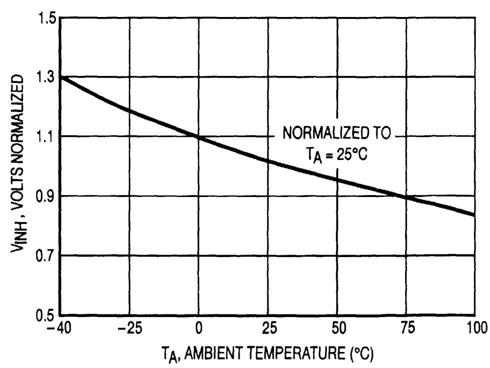


Figure 2. Inhibit Voltage versus Temperature

TYPICAL ELECTRICAL CHARACTERISTICS

$T_A = 25°C$

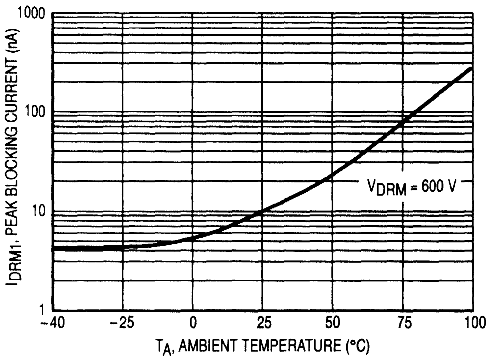


Figure 3. Leakage with LED Off versus Temperature

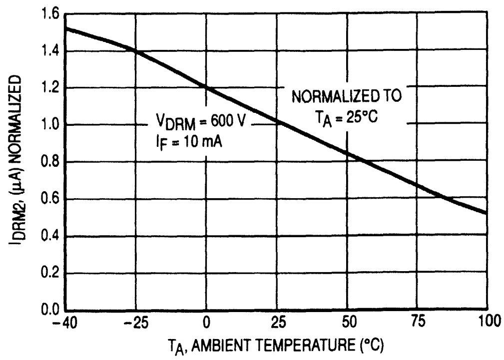


Figure 4. I_{DRM2}, Leakage in Inhibit State versus Temperature

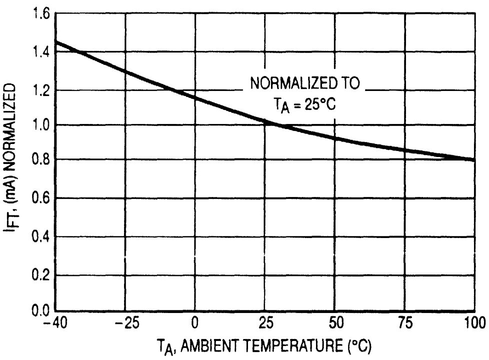


Figure 5. Trigger Current versus Temperature

I_{FT} versus Temperature (Normalized)

This graph shows the increase of the trigger current when the device is expected to operate at an ambient temperature below 25°C. Multiply the normalized I_{FT} shown on this graph with the data sheet guaranteed I_{FT}.

Example:
$T_A = -40°C$, $I_{FT} = 10$ mA
I_{FT} @ − 40°C = 10 mA x 1.4 = 14 mA

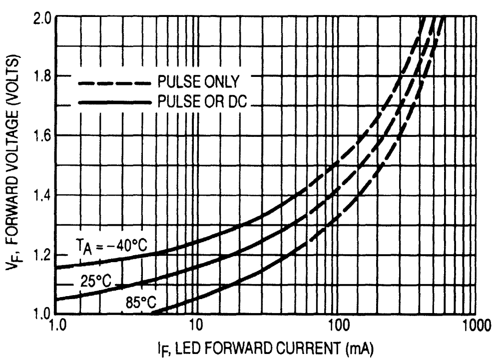


Figure 6. LED Forward Voltage versus Forward Current

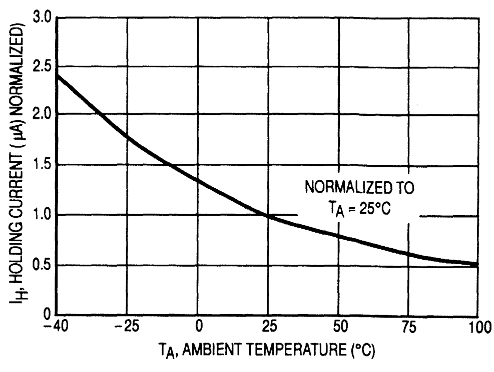


Figure 7. Holding Current, I_H versus Temperature

TYPICAL ELECTRICAL CHARACTERISTICS

$T_A = 25°C$

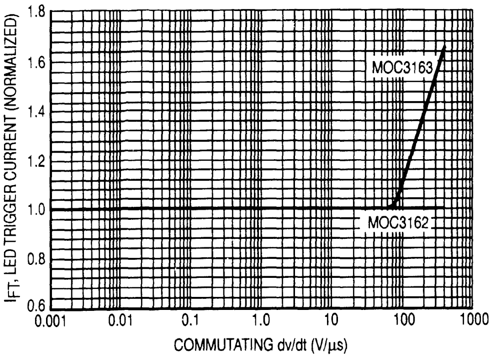


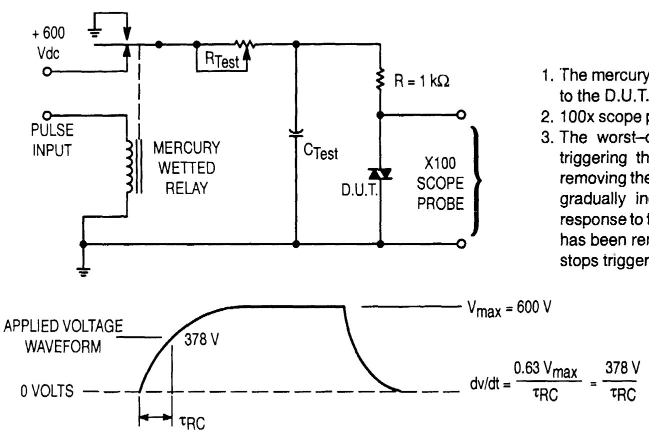
Figure 8. LED Trigger Current, I_{FT}, versus dv/dt

I_{FT} versus dv/dt

Triac drivers with good noise immunity (dv/dt stat.) have internal noise rejection circuits which prevent false triggering of the device in the event of fast raising line voltage transients. Inductive loads generate a commutating dv/dt that may activate the triac driver's noise suppression circuits. This prevents the device from turning on at its specified trigger current. It will in this case go into the mode of "half–waving" of the load. Half–waving of the load may destroy the power triac and the load.

Figure 8 shows the dependency of the triac drivers I_{FT} versus the reapplied voltage rise with a V_p of 600 V. This dv/dt condition simulates a worst case commutating dv/dt amplitude.

It can be seen that the required trigger current I_{FT} changes with increased dv/dt. Practical loads generate a commutating dv/dt of less than 50 V/μs. The rate of rise of the commutating dv/dt is effectively slowed by the use of snubber networks across the main triac. This snubber is also needed to keep the commutating dv/dt generated by inductive loads within the commutating dv/dt ratings of the power triac.



1. The mercury wetted relay provides a high speed repeated pulse to the D.U.T.
2. 100x scope probes are used, to allow high speeds and voltages.
3. The worst–case condition for static dv/dt is established by triggering the D.U.T. with a normal LED input current, then removing the current. The variable R_{TEST} allows the dv/dt to be gradually increased until the D.U.T. continues to trigger in response to the applied voltage pulse, even after the LED current has been removed. The dv/dt is then decreased until the D.U.T. stops triggering. τ_{RC} is measured at this point and recorded.

Figure 9. Static dv/dt Test Circuit

TYPICAL ELECTRICAL CHARACTERISTICS

T_A = 25°C

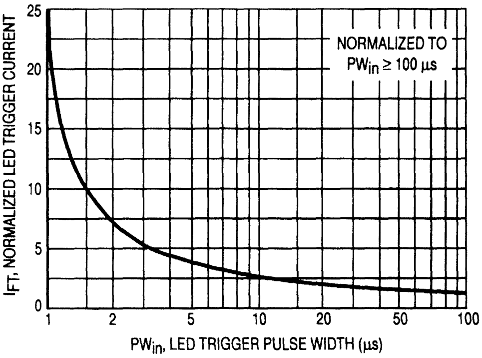


Figure 10. LED Current Required to Trigger versus LED Pulse Width

LED Trigger Current versus PW (Normalized)

For resistive loads the triac drivers may be controlled by short pulse into the input LED. This input pulse must be synchronized with the AC line voltage zero–crossing points. LED trigger pulse currents shorter than 100 µs must have an increased amplitude as shown on Figure 10. This graph shows the dependency of the trigger current I_{FT} versus the pulse width t(PW). I_{FT} in the graph, I_{FT} versus (PW), is normalized in respect to the minimum specified I_{FT} for static condition, which is specified in the device characteristic. The normalized I_{FT} has to be multiplied with the device's guaranteed static trigger current.

Example:
Guaranteed I_{FT} = 10 mA, Trigger pulse width PW = 3.0 µs
I_{FT}(pulsed) = 10 mA x 5.0 = 50 mA

APPLICATIONS GUIDE

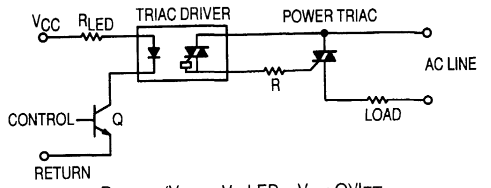
BASIC APPLICATIONS

Basic Triac Driver Circuit

Zero–cross triac drivers are very immune to static dv/dt. This allows snubberless operations in all applications where the external generated noise amplitude and rate of rise in the AC line is not exceeding the devices' guaranteed limits. For these applications a snubber circuit is not necessary when a noise insensitive power triac is used. Figure 11 shows the circuit diagram. The triac driver is directly connected to the triac main terminal 2 and a series Resistor R which limits the current to the triac driver. Current limiting resistor R could be very small for normal operation since the triac driver can be only switched on within the zero–cross window. Worst case consideration, however, considers accidental turn on at the peak of the line voltage due to a line transient exceeding the devices' maximum ratings. For this reason R should be calculated to limit the current to I_{drm} max at the peak of the line voltage.

$R = V_p\ AC/I_{TM}$ max rep. $= V_p\ AC/1A$

The power dissipation of this current limiting resistor and the triac driver is very small because the power triac carries the load current as soon as the current through driver and current limiting resistor reaches the trigger current of the power triac. The switching transition time for the driver is only one micro second and for power triacs typical four micro seconds.

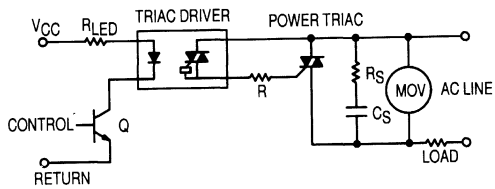


$R_{LED} = (V_{CC} - V_F\ LED - V_{sat}\ Q)/I_{FT}$
$R = V_p\ AC\ line/I_{TSM}$
The load may be placed on either side of the AC line.

Figure 11. Basic Driver Circuit

Triac Driver Circuit for Noisy Environments

When the transient rate of rise and amplitude are expected to exceed the power triacs and triac drivers maximum ratings a snubber circuit as shown in Figure 12 is recommended. Fast transients are slowed by the R–C snubber and excessive amplitudes are clipped by the Metal Oxide Varistor MOV.



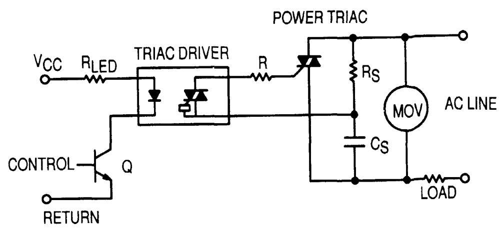
Traditional snubber configuration
Typical Snubber values $R_S = 33\ \Omega$, $C_S = 0.01\ \mu F$
MOV (Metal Oxide Varistor) protects triac and driver from transient overvoltages $>V_{DRM}$ max

Figure 12. Triac Driver Circuit for Noisy Environments

Triac Driver Circuit for Extremely Noisy Environments

Noisy environments for this circuit are defined in the noise standards IEEE472, IEC255–4 and IEC801–4.

Industrial control applications, for example, do specify a maximum expected transient noise dv/dt and peak voltage which is superimposed onto the AC line voltage. Figure 13 shows a split snubber network which enhances the circuits noise immunity by protecting the triac driver with optimized efficiency.



Recommended snubber values $R_S = 10\ W$, $C_S = 0.033\ mF$

Figure 13. Triac Driver Circuit for Extremely Noisy Environments

APPLICATIONS GUIDE

Hot–Line Switching Application Circuit

Typical circuit for use when hot–line switching is required. In this circuit the "hot" side of the line is switched and the load connected to the cold or neutral side. The load may be connected to either the neutral or hot–line.

R_{in} is calculated so that I_F is equal to the rated I_{FT} of the part, 10 mA for the MOC3162, and 5.0 mA for the MOC3163. The 39 ohm resistor and 0.01 µF capacitor are for snubbing of the triac and may or may not be necessary depending upon the particular triac and load used.

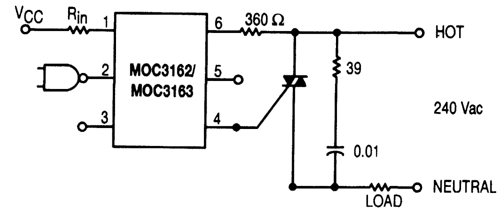


Figure 14. Hot–Line Switching Application Circuit

Inverse Parallel SCR Driver Circuit

Two inverse parallel SCR's are controlled by one triac driver with a minimum component count as shown in Figure 15. A snubber network and a MOV across the main terminals of the SCR's protects the semiconductors from transients on the AC line.

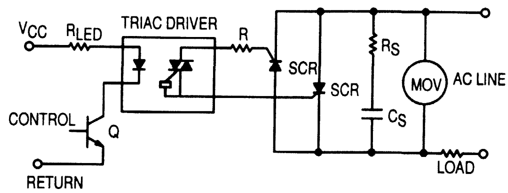


Figure 15. Inverse Parallel SCR Driver Circuit

GlobalOptoisolator™

VDE	UL	CSA	SETI	SEMKO	DEMKO	NEMKO	BABT

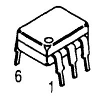
6-Pin DIP Zero-Cross Optoisolators Triac Driver Output

(800 Volts Peak)

MOC3081
[IFT = 15 mA Max]
MOC3082
[IFT = 10 mA Max]
MOC3083*
[IFT = 5 mA Max]

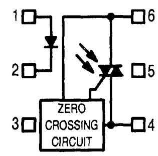
***Motorola Preferred Device**

STYLE 6 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

COUPLER SCHEMATIC



1. ANODE
2. CATHODE
3. NC
4. MAIN TERMINAL
5. SUBSTRATE
   DO NOT CONNECT
6. MAIN TERMINAL

The MOC3081, MOC3082 and MOC3083 devices consist of gallium arsenide infrared emitting diodes optically coupled to monolithic silicon detectors performing the function of Zero Voltage Crossing bilateral triac drivers.

They are designed for use with a triac in the interface of logic systems to equipment powered from 240 Vac lines, such as solid–state relays, industrial controls, motors, solenoids and consumer appliances, etc.

- Simplifies Logic Control of 240 Vac Power
- Zero Voltage Crossing
- dv/dt of 1500 V/μs Typical, 600 V/μs Guaranteed
- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

Recommended for 240 Vac(rms) Applications:

- Solenoid/Valve Controls
- Lighting Controls
- Static Power Switches
- AC Motor Drives
- Temperature Controls
- E.M. Contactors
- AC Motor Starters
- Solid State Relays

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
INPUT LED			
Reverse Voltage	V_R	6	Volts
Forward Current — Continuous	I_F	60	mA
Total Power Dissipation @ T_A = 25°C Negligible Power in Output Driver Derate above 25°C	P_D	120 1.41	mW mW/°C
OUTPUT DRIVER			
Off–State Output Terminal Voltage	V_{DRM}	800	Volts
Peak Repetitive Surge Current (PW = 100 μs, 120 pps)	I_{TSM}	1	A
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 1.76	mW mW/°C
TOTAL DEVICE			
Isolation Surge Voltage(1) (Peak ac Voltage, 60 Hz, 1 Second Duration)	V_{ISO}	7500	Vac(pk)
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Junction Temperature Range	T_J	–40 to +100	°C
Ambient Operating Temperature Range(2)	T_A	–40 to +85	°C
Storage Temperature Range(2)	T_{stg}	–40 to +150	°C
Soldering Temperature (10 s)	T_L	260	°C

1. Isolation surge voltage, V_{ISO}, is an internal device dielectric breakdown rating.
   For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.
2. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 1

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

Characteristic	Symbol	Min	Typ	Max	Unit
INPUT LED					
Reverse Leakage Current (V_R = 6 V)	I_R	—	0.05	100	μA
Forward Voltage (I_F = 30 mA)	V_F	—	1.3	1.5	Volts
OUTPUT DETECTOR (I_F = 0)					
Leakage with LED Off, Either Direction (V_{DRM} = 800 V(1))	I_{DRM1}	—	80	500	nA
Critical Rate of Rise of Off–State Voltage(3)	dv/dt	600	1500	—	V/μs
COUPLED					
LED Trigger Current, Current Required to Latch Output (Main Terminal Voltage = 3 V(2))	I_{FT}				mA
MOC3081		—	—	15	
MOC3082		—	—	10	
MOC3083		—	—	5	
Peak On–State Voltage, Either Direction (I_{TM} = 100 mA, I_F = Rated I_{FT})	V_{TM}	—	1.8	3	Volts
Holding Current, Either Direction	I_H	—	250	—	μA
Inhibit Voltage (MT1–MT2 Voltage above which device will not trigger) (I_F = Rated I_{FT})	V_{INH}	—	5	20	Volts
Leakage in Inhibited State (I_F = Rated I_{FT}, V_{DRM} = 800 V, Off State)	I_{DRM2}	—	300	500	μA

1. Test voltage must be applied within dv/dt rating.
2. All devices are guaranteed to trigger at an I_F value less than or equal to max I_{FT}. Therefore, recommended operating I_F lies between max I_{FT} (15 mA for MOC3081, 10 mA for MOC3082, 5 mA for MOC3083) and absolute max I_F (60 mA).
3. This is static dv/dt. See Figure 7 for test circuit. Commutating dv/dt is a function of the load–driving thyristor(s) only.

TYPICAL CHARACTERISTICS

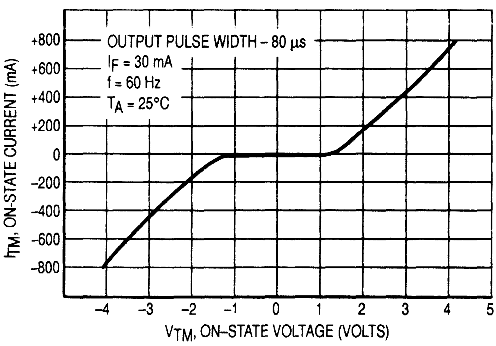


Figure 1. On–State Characteristics

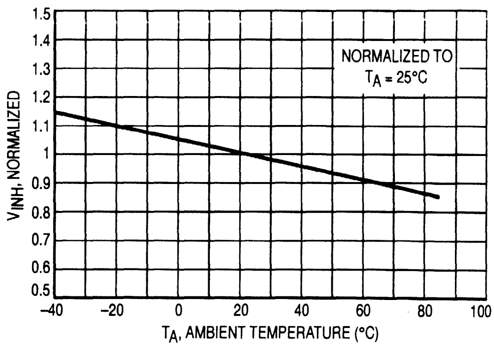


Figure 2. Inhibit Voltage versus Temperature

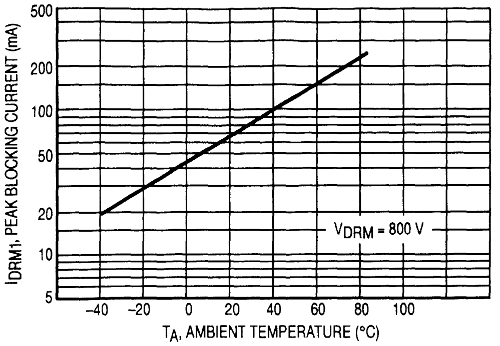


Figure 3. Leakage with LED Off versus Temperature

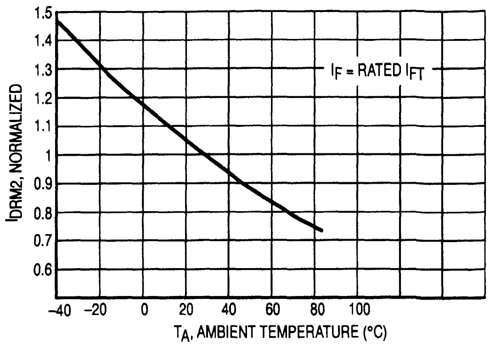


Figure 4. I_{DRM2}, Leakage in Inhibit State versus Temperature

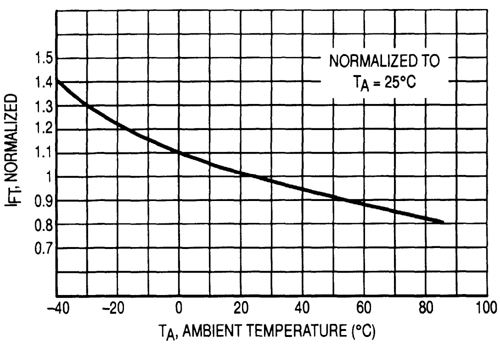


Figure 5. Trigger Current versus Temperature

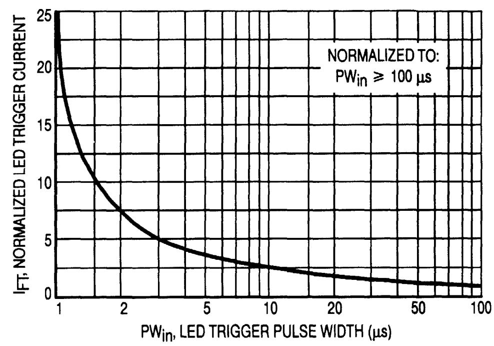
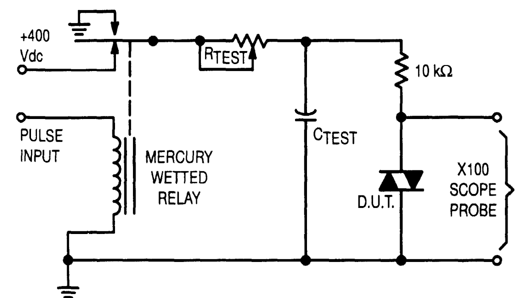
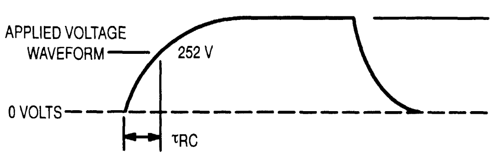


Figure 6. LED Current Required to Trigger versus LED Pulse Width

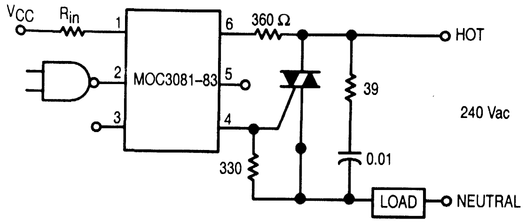


1. The mercury wetted relay provides a high speed repeated pulse to the D.U.T.
2. 100x scope probes are used, to allow high speeds and voltages.
3. The worst–case condition for static dv/dt is established by triggering the D.U.T. with a normal LED input current, then removing the current. The variable R_{TEST} allows the dv/dt to be gradually increased until the D.U.T. continues to trigger in response to the applied voltage pulse, even after the LED current has been removed. The dv/dt is then decreased until the D.U.T. stops triggering. τ_{RC} is measured at this point and recorded.



$$dv/dt = \frac{0.63\ V_{max}}{\tau_{RC}} = \frac{504}{\tau_{RC}}$$

Figure 7. Static dv/dt Test Circuit

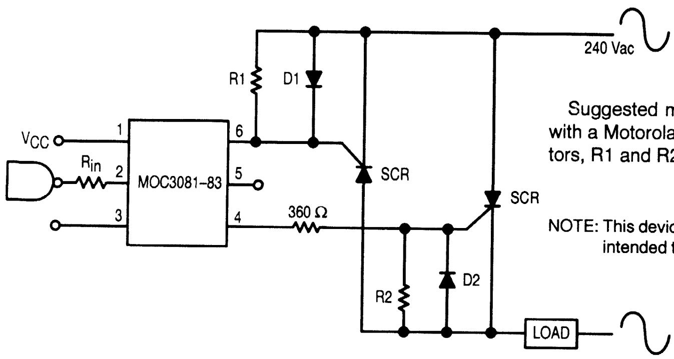


* For highly inductive loads (power factor < 0.5), change this value to 360 ohms.

Typical circuit for use when hot line switching is required. In this circuit the "hot" side of the line is switched and the load connected to the cold or neutral side. The load may be connected to either the neutral or hot line.

R_{in} is calculated so that I_F is equal to the rated I_{FT} of the part, 15 mA for the MOC3081, 10 mA for the MOC3082, and 5 mA for the MOC3083. The 39 ohm resistor and 0.01 µF capacitor are for snubbing of the triac and may or may not be necessary depending upon the particular triac and load used.

Figure 8. Hot–Line Switching Application Circuit



Suggested method of firing two, back–to–back SCR's, with a Motorola triac driver. Diodes can be 1N4001; resistors, R1 and R2, are optional 330 ohms.

NOTE: This device should not be used to drive a load directly. It is intended to be a trigger device only.

Figure 9. Inverse–Parallel SCR Driver Circuit

GlobalOptoisolator™

VDE | UL | CSA | SETI | SEMKO | DEMKO | NEMKO | BABT

MOC5007*
[IF(on) = 1.6 mA Max]
MOC5008
[IF(on) = 4 mA Max]
MOC5009
[IF(on) = 10 mA Max]

***Motorola Preferred Device**

6-Pin DIP Optoisolators Logic Output

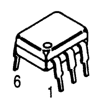
The MOC5007, MOC5008 and MOC5009 have a gallium arsenide IRED optically coupled to a high–speed integrated detector with Schmitt trigger output. Ideal for applications requiring electrical isolation, fast response time, noise immunity and digital logic compatibility.

- Guaranteed Switching Times — t_{on}, t_{off} 4 < µs
- Built–In ON/OFF Threshold Hysteresis
- High Data Rate, 1 MHz Typical (NRZ)
- Wide Supply Voltage Capability
- Microprocessor Compatible Drive
- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

Applications

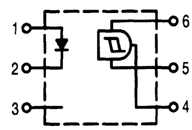
- Interfacing Computer Terminals to Peripheral Equipment
- Digital Control of Power Supplies
- Line Receiver — Eliminates Noise
- Digital Control of Motors and Other Servo Machine Applications
- Logic to Logic Isolator
- Logic Level Shifter — Couples TTL to CMOS

STYLE 5 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

SCHEMATIC



PIN 1. ANODE
2. CATHODE
3. NC
4. OPEN COLLECTOR OUTPUT
5. GROUND
6. V_{CC}

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Reverse Voltage	V_R	6	Volts
Forward Current — Continuous Peak Pulse Width = 300 µs, 2% Duty Cycle	I_F	60 1.2	mA Amp
LED Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	120 1.41	mW mW/°C
OUTPUT DETECTOR			
Output Voltage Range	V_o	0–16	Volts
Supply Voltage Range	V_{CC}	3–16	Volts
Output Current	I_O	50	mA
Detector Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 1.76	mW mW/°C
TOTAL DEVICE			
Total Device Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Maximum Operating Temperature(2)	T_A	–40 to +85	°C
Storage Temperature Range(2)	T_{stg}	–55 to +150	°C
Soldering Temperature (10 s)	T_L	260	°C
Isolation Surge Voltage(1) (Peak ac Voltage, 60 Hz, 1 Second Duration)	V_{ISO}	7500	Vac(pk)

1. Isolation surge voltage is an internal device dielectric breakdown rating. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.
2. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 1

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)(1)

Characteristic		Symbol	Min	Typ1)	Max	Unit
INPUT LED						
Reverse Leakage Current (V_R = 3 V, RL = 1 MΩ)		I_R	—	0.05	10	μA
Forward Voltage (I_F = 10 mA) (I_F = 0.3 mA)		V_F	— 0.75	1.2 0.95	1.5 —	Volts
Capacitance (V_R = 0 V, f = 1 MHz)		C	—	18	—	pF
OUTPUT DETECTOR						
Operating Voltage		V_{CC}	3	—	15	Volts
Supply Current (I_F = 0, V_{CC} = 5 V)		$I_{CC(off)}$	—	1	5	mA
Output Current, High (I_F = 0, V_{CC} = V_o = 15 V)		I_{OH}	—	—	100	μA
COUPLED						
Supply Current (I_F = $I_{F(on)}$, V_{CC} = 5 V)		$I_{CC(on)}$	—	1.6	5	mA
Output Voltage, Low (R_L = 270 Ω, V_{CC} = 5 V, I_F = $I_{F(on)}$)		V_{OL}	—	0.2	0.4	Volts
Threshold Current, ON (R_L = 270 Ω, V_{CC} = 5 V)	MOC5007 MOC5008 MOC5009	$I_{F(on)}$	— — —	1.2 — —	1.6 4 10	mA
Threshold Current, OFF (R_L = 270 Ω, V_{CC} = 5 V)	MOC5007 MOC5008, 5009	$I_{F(off)}$	0.3 0.3	0.75 —	— —	mA
Hysteresis Ratio (R_L = 270 Ω, V_{CC} = 5 V)		$\frac{I_{F(off)}}{I_{F(on)}}$	0.5	0.75	0.9	
Isolation Voltage(2) 60 Hz, AC Peak, 1 second, T_A = 25°C		V_{ISO}	7500	—	—	Vac(pk)
Turn–On Time	R_L = 270 Ω(3) V_{CC} = 5 V, I_F = $I_{F(on)}$ T_A = 25°C	t_{on}	—	1.2	4	μs
Fall Time		t_f	—	0.1	—	
Turn–Off Time		t_{off}	—	1.2	4	
Rise Time		t_r	—	0.1	—	

1. Always design to the specified minimum/maximum electrical limits (where applicable).
2. For this test, IRED Pins 1 and 2 are common and Output Gate Pins 4, 5, 6 are common.
3. R_L value effect on switching time is negligible.

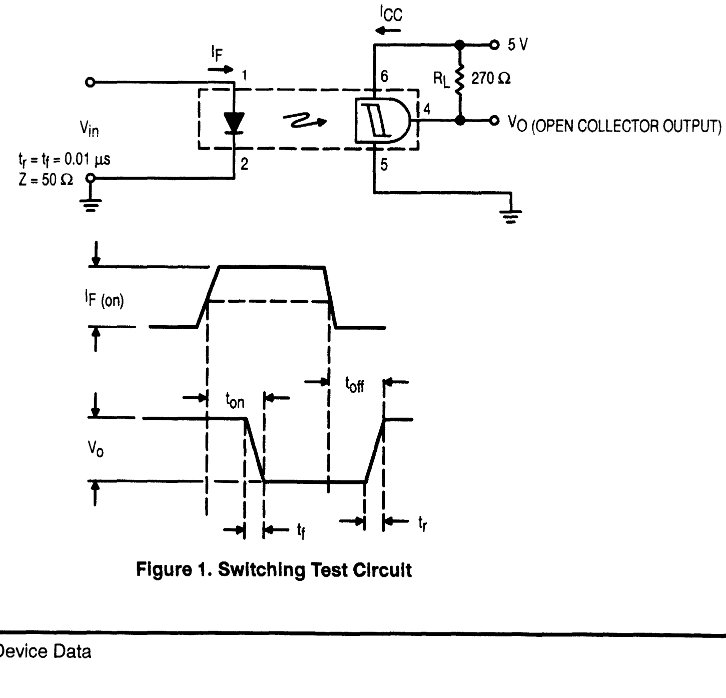


Figure 1. Switching Test Circuit

TYPICAL CHARACTERISTICS

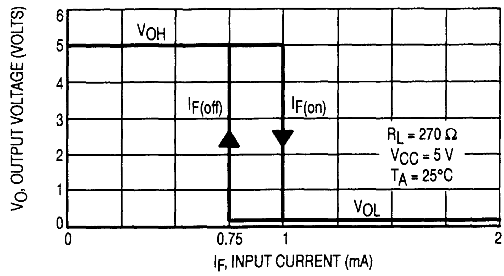


Figure 2. Transfer Characteristics for MOC5007

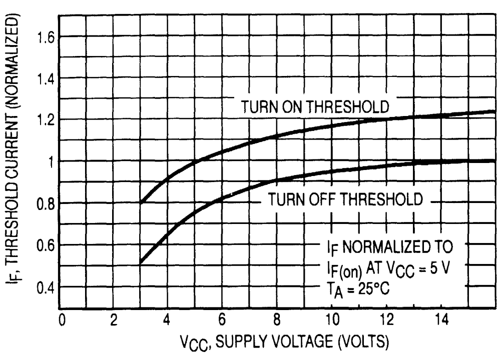


Figure 3. Threshold Current versus Supply Voltage

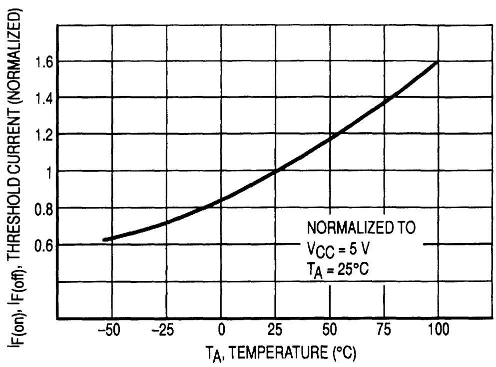


Figure 4. Threshold Current versus Temperature

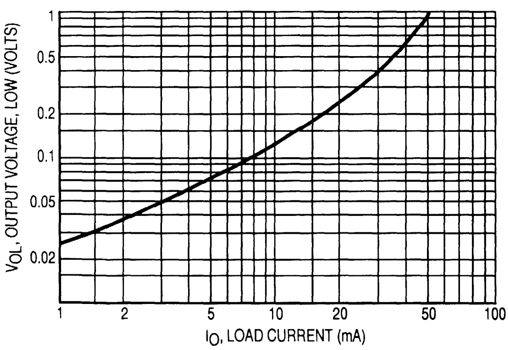


Figure 5. Output Voltage, Low versus Load Current

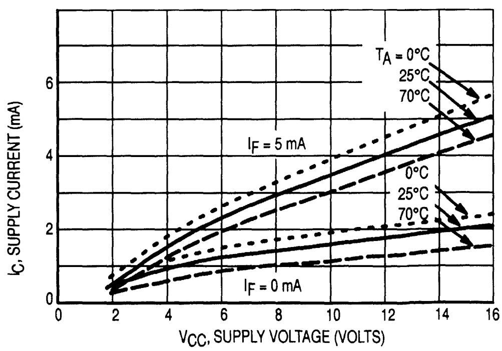


Figure 6. Supply Current versus Supply Voltage

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

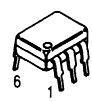
GlobalOptoisolator™

VDE	UL	CSA	SETI	SEMKO	DEMKO	NEMKO	BABT

6-Pin DIP Optoisolators Darlington Output (No Base Connection)

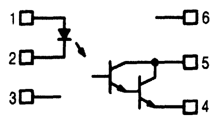
MOC8020
[CTR = 500% Min]
MOC8021
[CTR = 1000% Min]

STYLE 3 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

SCHEMATIC



PIN 1. LED ANODE
2. LED CATHODE
3. N.C.
4. EMITTER
5. COLLECTOR
6. N.C.

The MOC8020 and MOC8021 devices consist of a gallium arsenide infrared emitting diode optically coupled to a monolithic silicon photodarlington detector. The chip to Pin 6 base connection has been eliminated to improve the device's output performance in higher noise environments.

- No Base Connection for Improved Noise Immunity
- Higher Sensitivity to Low Input Drive Current
- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

Applications

- Appliances, Measuring Instruments
- I/O Interfaces for Computers
- Programmable Controllers
- Portable Electronics
- Interfacing and coupling systems of different potentials and impedances
- Solid State Relays
- Circuits Exposed to High Noise Environments

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Reverse Voltage	V_R	3	Volts
Forward Current — Continuous	I_F	60	mA
LED Power Dissipation @ T_A = 25°C with Negligible Power in Output Detector Derate above 25°C	P_D	120 1.41	mW mW/°C
OUTPUT DETECTOR			
Collector–Emitter Voltage	V_{CEO}	50	Volts
Collector Current Continuous	IC	150	mA
Emitter–Collector Voltage	V_{ECO}	5	Volts
Detector Power Dissipation @ T_A = 25°C with Negligible Power in Input LED Derate above 25°C	P_D	150 1.76	mW mW/°C
TOTAL DEVICE			
Isolation Surge Voltage(1) (Peak ac Voltage, 60 Hz, 1 sec Duration)	V_{ISO}	7500	Vac(pk)
Total Device Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Ambient Operating Temperature Range(2)	T_A	–55 to +100	°C
Storage Temperature Range(2)	T_{stg}	–55 to +150	°C
Soldering Temperature (10 sec, 1/16″ from case)	T_L	260	°C

1. Isolation surge voltage is an internal device dielectric breakdown rating. For this test, Pins 1 and 2 are common, and Pins 4 and 5 are common.
2. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

REV 1

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)(1)

Characteristic	Symbol	Min	Typ(1)	Max	Unit
INPUT LED					
Reverse Leakage Current (V_R = 3 V)	I_R	—	0.05	10	μA
Forward Voltage (I_F = 10 mA)	V_F	—	1.15	2	Volts
Capacitance (V = 0 V, f = 1 MHz)	C	—	18	—	pF
PHOTODARLINGTON (T_A = 25°C and I_F = 0, unless otherwise noted)					
Collector–Emitter Dark Current (V_{CE} = 10 V)	I_{CEO}	—	—	100	nA
Collector–Emitter Base Breakdown Voltage (I_C = 1 mA)	$V_{(BR)CEO}$	50	—	—	Volts
Emitter–Collector Breakdown Voltage (I_E = 100 μA)	$V_{(BR)ECO}$	5	—	—	Volts
COUPLED (T_A = 25°C unless otherwise noted)					
Collector Output Current (V_{CE} = 5 V, I_F = 10 mA) MOC8020	I_C (CTR)(2)	50 (500)	—	—	mA (%)
MOC8021		100 (1000)	—	—	
Isolation Surge Voltage(3,4), 60 Hz Peak ac, 1 Second	V_{ISO}	7500	—	—	Vac(pk)
Isolation Resistance(3) (V = 500 V)	R_{ISO}	—	10^{11}	—	Ohms
Isolation Capacitance(3) (V = 0, f = 1 MHz)	C_{ISO}	—	0.2	—	pF
SWITCHING					
Turn–On Time — V_{CC} = 10 V, R_L = 100 Ω, I_F = 5 mA(5)	t_{on}	—	3.5	—	μs
Turn–Off Time	t_{off}	—	95	—	
Rise Time	t_r	—	1	—	
Fall Time	t_f	—	2	—	

1. Always design to the specified minimum/maximum electrical limits (where applicable).
2. Current Transfer Ratio (CTR) = I_C/I_F x 100%.
3. For this test, LED Pins 1 and 2 are common and Phototransistor Pins 4 and 5 are common.
4. Isolation Surge Voltage, V_{ISO}, is an internal device dielectric breakdown rating.
5. For test circuit setup and waveforms, refer to Figure 9.

TYPICAL CHARACTERISTICS

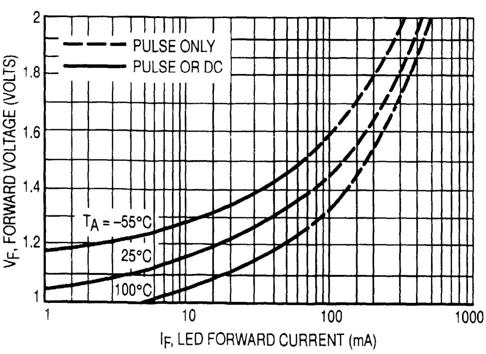


Figure 1. LED Forward Voltage versus Forward Current

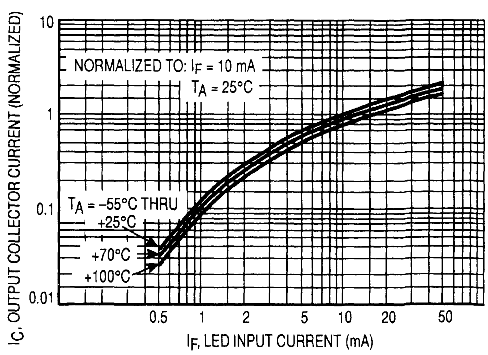


Figure 2. Output Current versus Input Current

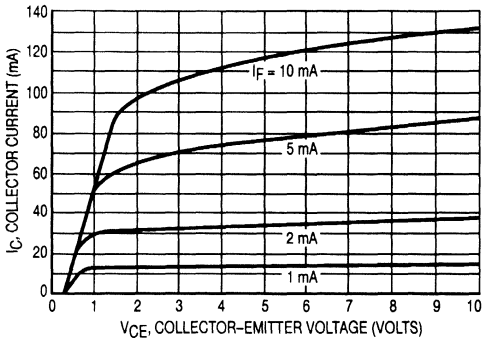


Figure 3. Collector Current versus Collector–Emitter Voltage

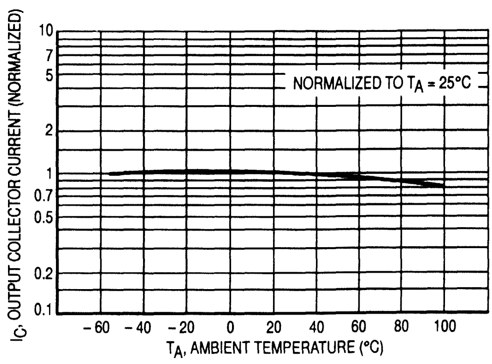


Figure 4. Output Current versus Ambient Temperature

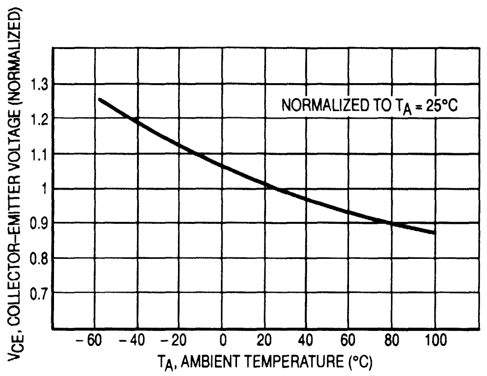


Figure 5. Collector–Emitter Voltage versus Ambient Temperature

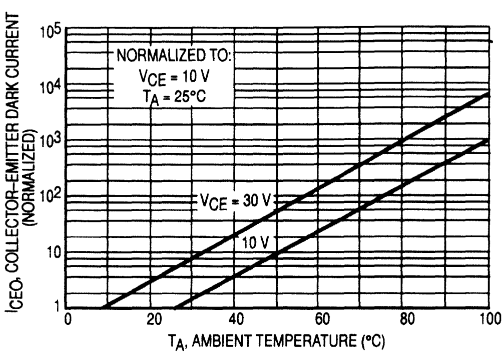


Figure 6. Collector–Emitter Dark Current versus Ambient Temperature

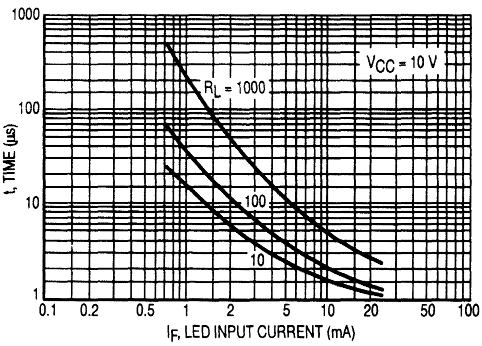


Figure 7. Turn–On Switching Times (Typical Value)

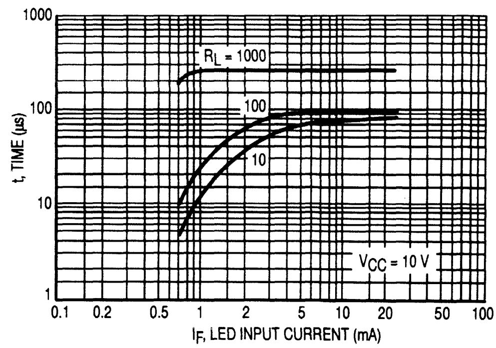


Figure 8. Turn–Off Switching Times (Typical Value)

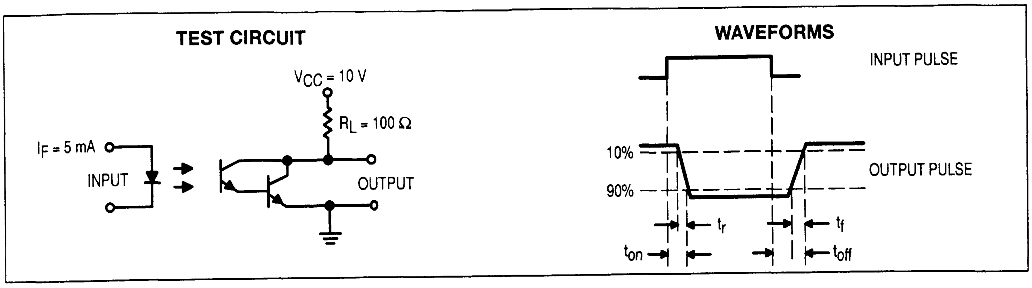


Figure 9. Switching Time Test Circuit and Waveforms

GlobalOptoisolator™

VDE | UL | CSA | SETI | SEMKO | DEMKO | NEMKO | BABT

MOC8030

[CTR = 300% Min]

MOC8050

[CTR = 500% Min]

Motorola Preferred Devices

6-Pin DIP Optoisolators Darlington Output (No Base Connection)

The MOC8030 and MOC8050 devices consist of gallium arsenide infrared emitting diodes optically coupled to monolithic silicon photodarlington detectors. The chip to Pin 6 base connection has been eliminated to improve output performance in high noise environments.

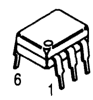
They are best suited for use in applications susceptible to high EMI levels.

- No Base Connection for Improved Noise Immunity
- High Collector–Emitter Breakdown Voltage — 80 Volts Minimum
- Higher Sensitivity to Low Input Drive Current
- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

Applications

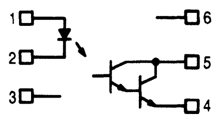
- Appliances, Measuring Instruments
- I/O Interfaces for Computers
- Programmable Controllers
- Portable Electronics
- Interfacing and coupling systems of different potentials and impedance
- Solid State Relays

STYLE 3 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

SCHEMATIC



PIN 1. LED ANODE
2. LED CATHODE
3. N.C.
4. EMITTER
5. COLLECTOR
6. N.C.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Reverse Voltage	V_R	3	Volts
Forward Current — Continuous	I_F	60	mA
LED Power Dissipation @ T_A = 25°C with Negligible Power in Output Detector Derate above 25°C	P_D	120 1.41	mW mW/°C
OUTPUT DETECTOR			
Collector–Emitter Voltage	V_{CEO}	80	Volts
Collector Current Continuous	IC	150	mA
Emitter–Collector Voltage	V_{ECO}	5	Volts
Detector Power Dissipation @ T_A = 25°C with Negligible Power in Input LED Derate above 25°C	P_D	150 1.76	mW mW/°C
TOTAL DEVICE			
Isolation Surge Voltage(1) (Peak ac Voltage, 60 Hz, 1 sec Duration)	V_{ISO}	7500	Vac(pk)
Total Device Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Ambient Operating Temperature Range(2)	T_A	−55 to +100	°C
Storage Temperature Range(2)	T_{stg}	−55 to +150	°C
Soldering Temperature (10 sec, 1/16″ from case)	T_L	260	°C

1. Isolation surge voltage is an internal device dielectric breakdown rating. For this test, Pins 1 and 2 are common, and Pins 4 and 5 are common.
2. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 2

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)(1)

Characteristic	Symbol	Min	Typ(1)	Max	Unit
INPUT LED					
Reverse Leakage Current (V_R = 3 V)	I_R	—	0.05	10	μA
Forward Voltage (I_F = 10 mA)	V_F	—	1.15	2	Volts
Capacitance (V_R = 0 V, f = 1 MHz)	C	—	18	—	pF
PHOTODARLINGTON (T_A = 25°C and I_F = 0, unless otherwise noted)					
Collector–Emitter Dark Current (V_{CE} = 60 V)	I_{CEO}	—	—	1	μA
Collector–Emitter Breakdown Voltage (I_C = 1 mA)	$V_{(BR)CEO}$	80	—	—	Volts
Emitter–Collector Breakdown Voltage (I_E = 100 μA)	$V_{(BR)ECO}$	5	—	—	Volts
COUPLED (T_A = 25°C unless otherwise noted)					
Collector Output Current (V_{CE} = 1.5 V, I_F = 10 mA) MOC8030	I_C (CTR)(2)	30 (300)	—	—	mA (%)
MOC8050		50 (500)	—	—	
Isolation Surge Voltage(3,4), 60 Hz Peak ac, 5 Second	V_{ISO}	7500	—	—	Vac(pk)
Isolation Resistance(3) (V = 500 V)	R_{ISO}	—	10^{11}	—	Ohms
Isolation Capacitance(3) (V = 0 V, f = 1 MHz)	C_{ISO}	—	0.2	—	pF

SWITCHING

Characteristic	Conditions	Symbol	Min	Typ	Max	Unit
Turn–On Time	V_{CC} = 10 V, R_L = 100 Ω, I_F = 5 mA(5)	t_{on}	—	3.5	—	μs
Turn–Off Time		t_{off}	—	95	—	
Rise Time		t_r	—	1	—	
Fall Time		t_f	—	2	—	

1. Always design to the specified minimum/maximum electrical limits (where applicable).
2. Current Transfer Ratio (CTR) = I_C/I_F x 100%.
3. For this test, LED Pins 1 and 2 are common and Phototransistor Pins 4 and 5 are common.
4. Isolation Surge Voltage, V_{ISO}, is an internal device dielectric breakdown rating.
5. For test circuit setup and waveforms, refer to Figure 9.

TYPICAL CHARACTERISTICS

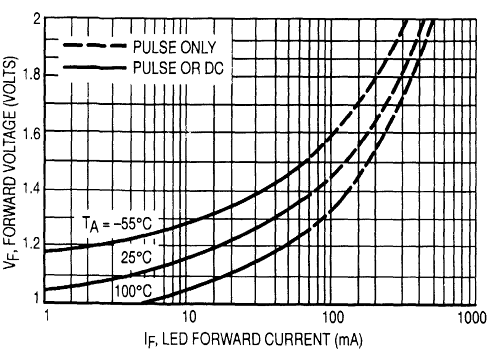


Figure 1. LED Forward Voltage versus Forward Current

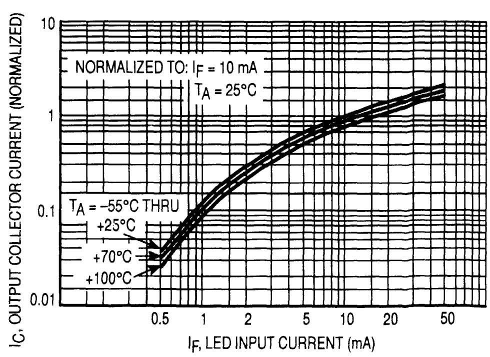


Figure 2. Output Current versus Input Current

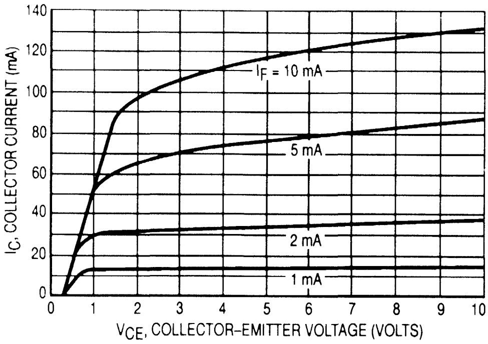


Figure 3. Collector Current versus Collector–Emitter Voltage

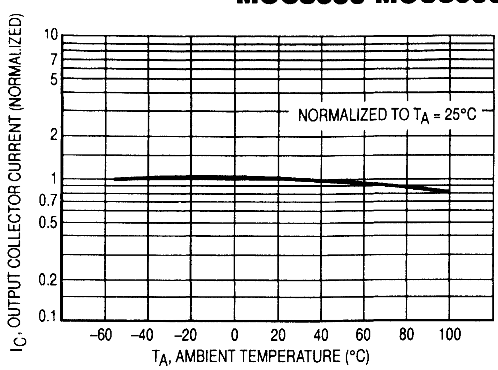


Figure 4. Output Current versus Ambient Temperature

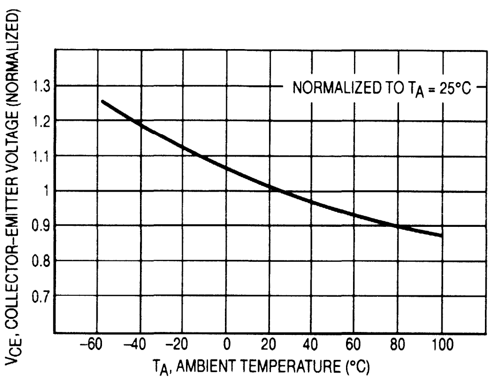


Figure 5. Collector–Emitter Voltage versus Ambient Temperature

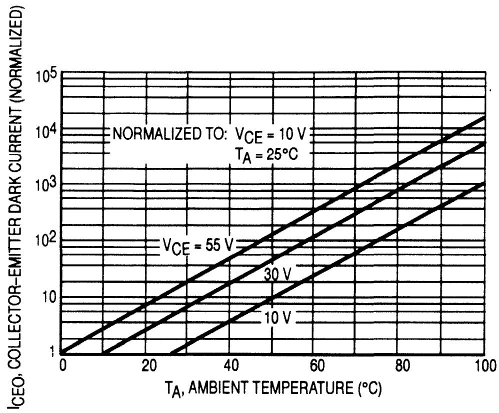


Figure 6. Collector–Emitter Dark Current versus Ambient Temperature

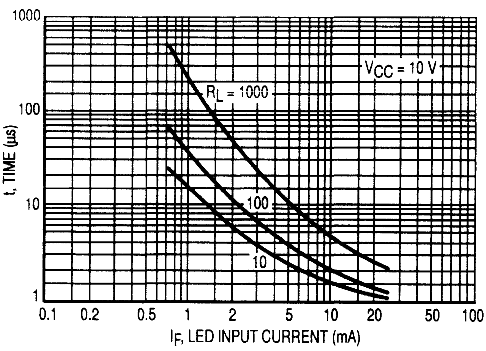


Figure 7. Turn–On Switching Times (Typical Values)

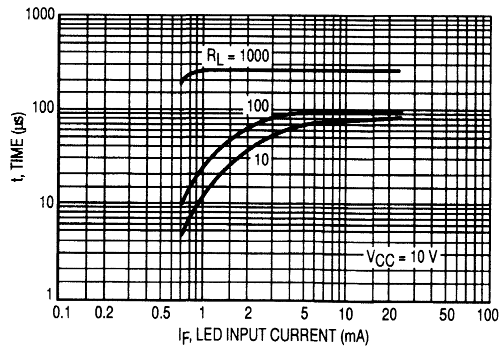


Figure 8. Turn–Off Switching Times (Typical Values)

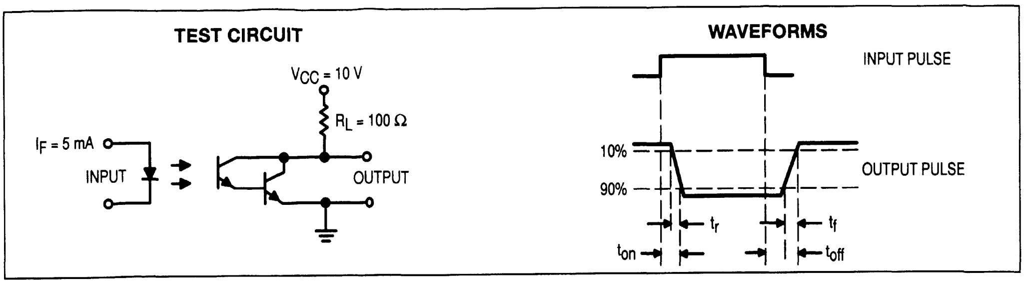


Figure 9. Switching Time Test Circuit and Waveforms

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

GlobalOptoisolator™

VDE | UL | CSA | SETI | SEMKO | DEMKO | NEMKO | BABT

MOC8080

[CTR = 500% Min]

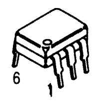
Motorola Preferred Device

6-Pin DIP Optoisolator Darlington Output

The MOC8080 device consists of a gallium arsenide infrared emitting diode optically coupled to a monolithic silicon photodarlington detector. They are designed for use in applications requiring high gain at specified input currents.

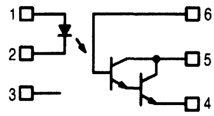
- High Output Collector Current (I_C)
- Low, Stable Leakage Current at Elevated Temperature
- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

STYLE 1 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

SCHEMATIC



PIN 1. LED ANODE
2. LED CATHODE
3. N.C.
4. EMITTER
5. COLLECTOR
6. BASE

Applications

- Appliances, Measuring Instruments
- General Purpose Switching Circuits
- Programmable Controllers
- Portable Electronics
- Interfacing and coupling systems of different potentials and impedances
- Solid State Relays

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Reverse Voltage	V_R	6	Volts
Forward Current — Continuous	I_F	60	mA
LED Power Dissipation @ T_A = 25°C with Negligible Power in Output Detector Derate above 25°C	P_D	120 1.41	mW mW/°C
OUTPUT DETECTOR			
Collector–Emitter Voltage	V_{CEO}	55	Volts
Emitter–Collector Voltage	V_{ECO}	5	Volts
Collector–Base Voltage	V_{CBO}	55	Volts
Collector Current — Continuous	I_C	150	mA
Detector Power Dissipation @ T_A = 25°C with Negligible Power in Input LED Derate above 25°C	P_D	150 1.76	mW mW/°C
TOTAL DEVICE			
Isolation Surge Voltage(1) (Peak ac Voltage, 60 Hz, 1 sec Duration)	V_{ISO}	7500	Vac(pk)
Total Device Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Ambient Operating Temperature Range(2)	T_A	–55 to +100	°C
Storage Temperature Range(2)	T_{stg}	–55 to +150	°C
Soldering Temperature (10 sec, 1/16″ from case)	T_L	260	°C

1. Isolation surge voltage is an internal device dielectric breakdown rating.
   For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.
2. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 1

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)(1)

Characteristic		Symbol	Min	Typ(1)	Max	Unit
INPUT LED						
Forward Voltage (I_F = 10 mA)	T_A = 25°C T_A = −55°C T_A = 100°C	V_F	0.8 0.9 0.7	1.15 1.3 1.05	1.5 1.7 1.4	V
Reverse Leakage Current (V_R = 3 V)		I_R	—	—	100	μA
Capacitance (V = 0 V, f = 1 MHz)		C	—	18	—	pF
OUTPUT DETECTOR						
Collector–Emitter Dark Current (V_{CE} = 10 V)	T_A = 25°C T_A = 100°C	I_{CEO}	— —	5 5	100 100	nA μA
Collector–Base Dark Current (V_{CB} = 10 V)	T_A = 25°C T_A = 100°C	I_{CBO}	— —	1 100	20 —	nA
Collector–Emitter Breakdown Voltage (I_C = 1 mA)		$V_{(BR)CEO}$	55	80	—	V
Collector–Base Breakdown Voltage (I_C = 100 μA)		$V_{(BR)CBO}$	55	100	—	V
Emitter–Collector Breakdown Voltage (I_E = 100 μA)		$V_{(BR)ECO}$	5	7	—	V
DC Current Gain (I_C = 5 mA, V_{CE} = 5 V) (Typical)		h_{FE}	—	16 k	—	—
Collector–Emitter Capacitance (f = 1 MHz, V_{CE} = 5 V)		C_{CE}	—	3.9	—	pF
Collector–Base Capacitance (f = 1 MHz, V_{CB} = 5 V)		C_{CB}	—	6.3	—	pF
Emitter–Base Capacitance (f = 1 MHz, V_{EB} = 5 V)		C_{EB}	—	3.8	—	pF
COUPLED						
Output Collector Current (I_F = 10 mA, V_{CE} = 5 V)		I_C (CTR)(2)	50 (500)	117 (1117)	—	mA (%)
Collector–Emitter Saturation Voltage (I_C = 1 mA, I_F = 1 mA)		$V_{CE(sat)}$	—	0.6	1	V
Turn–On Time	V_{CC} = 10 V, R_L = 100 Ω, I_F = 5 mA(3)	t_{on}	—	3.5	—	μs
Turn–Off Time		t_{off}	—	95	—	
Rise Time		t_r	—	1	—	
Fall Time		t_f	—	2	—	
Isolation Voltage (f = 60 Hz, t = 1 sec)(4)		V_{ISO}	7500	—	—	Vac(pk)
Isolation Resistance (V = 500 V)(4)		R_{ISO}	10^{11}	—	—	Ω
Isolation Capacitance (V = 0 V, f = 1 MHz)(4)		C_{ISO}	—	0.2	2	pF

1. Always design to the specified minimum/maximum electrical limits (where applicable).
2. Current Transfer Ratio (CTR) = I_C/I_F x 100%.
3. For test circuit setup and waveforms, refer to Figure 11.
4. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.

TYPICAL CHARACTERISTICS

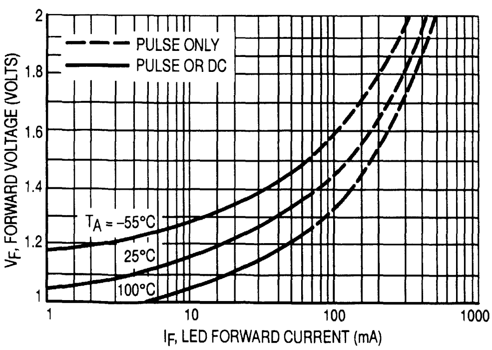


Figure 1. LED Forward Voltage versus Forward Current

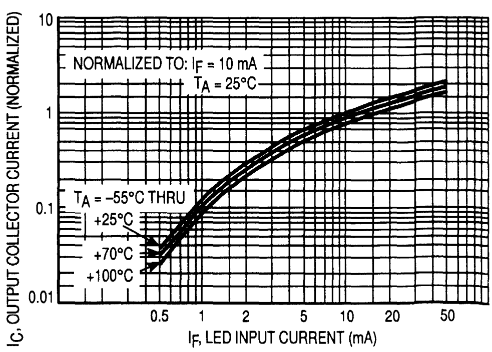


Figure 2. Output Current versus Input Current

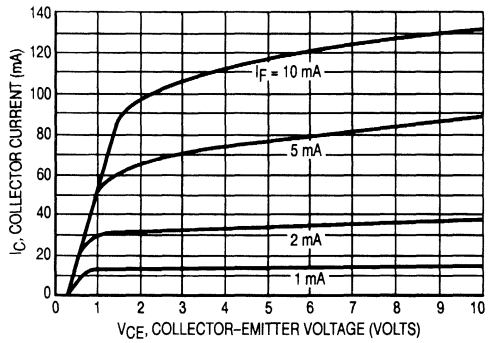


Figure 3. Collector Current versus Collector–Emitter Voltage

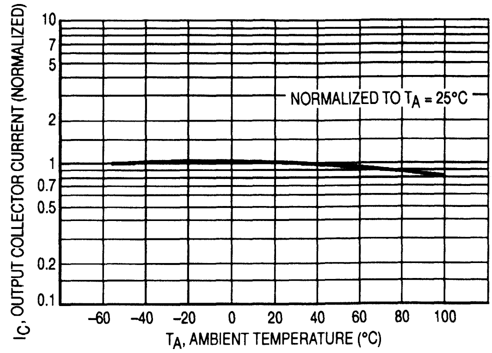


Figure 4. Output Current versus Ambient Temperature

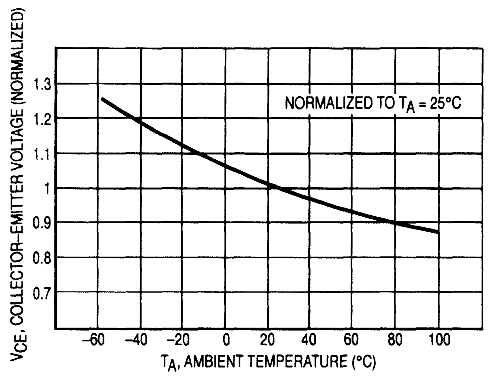


Figure 5. Collector–Emitter Voltage versus Ambient Temperature

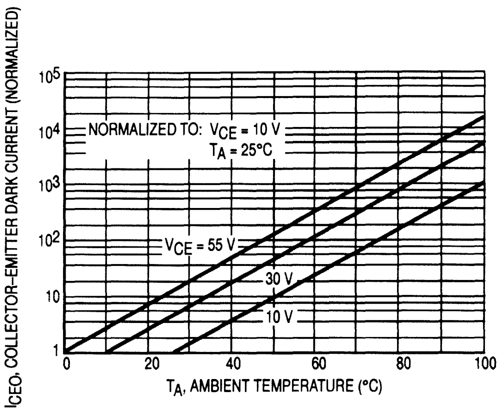


Figure 6. Collector–Emitter Dark Current versus Ambient Temperature

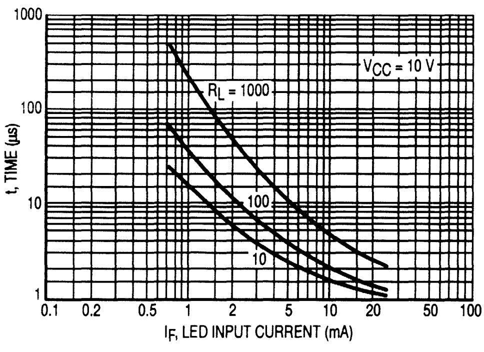


Figure 7. Turn–On Switching Times (Typical Values)

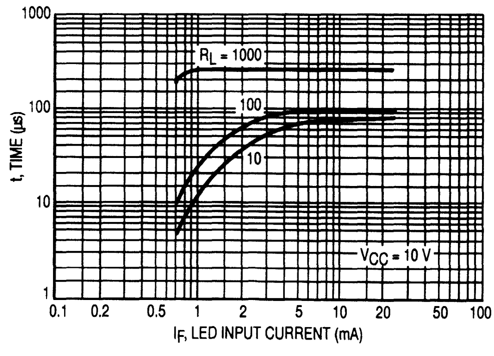


Figure 8. Turn–Off Switching Times (Typical Values)

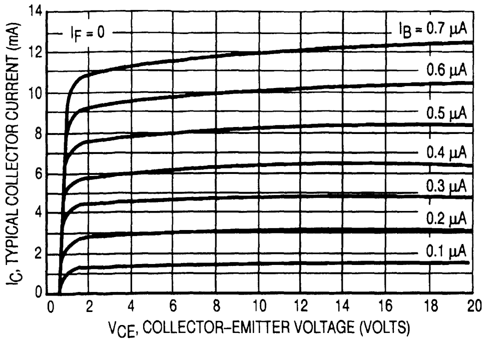


Figure 9. DC Current Gain (Detector Only)

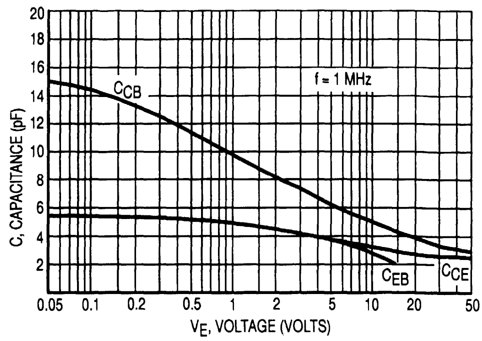


Figure 10. Detector Capacitances versus Voltage

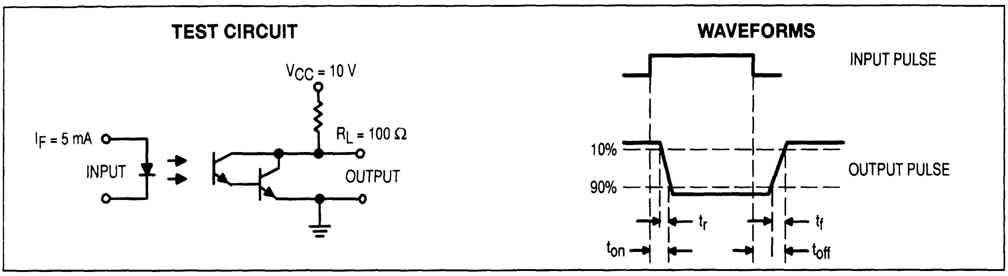


Figure 11. Switching Time Test Circuit and Waveforms

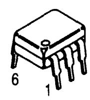
GlobalOptoisolator™

VDE	UL	CSA	SETI	SEMKO	DEMKO	NEMKO	BABT

6-Pin DIP Optoisolator Transistor Output

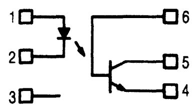
MOC8100
[CTR = 50% Min]

STYLE 1 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

SCHEMATIC



PIN 1. LED ANODE
2. LED CATHODE
3. N.C.
4. EMITTER
5. COLLECTOR
6. BASE

The MOC8100 device consists of a gallium arsenide infrared emitting diode optically coupled to a monolithic silicon phototransistor detector. It is designed for applications requiring higher output collector current (I_C) with lower input drive current (I_F).

- Current Transfer Ratio Guaranteed to be > 50% at 1 mA LED Drive Level
- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

Applications

- Appliances, Measuring Instruments
- General Purpose Switching Circuits
- Programmable Controllers
- Portable Electronics
- Interfacing and coupling systems of different potentials and impedances
- Low Power Logic Circuits
- Telecommunications Equipment

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Reverse Voltage	V_R	6	Volts
Forward Current — Continuous	I_F	60	mA
LED Power Dissipation @ T_A = 25°C with Negligible Power in Output Detector	P_D	120	mW
Derate above 25°C		1.41	mW/°C
OUTPUT TRANSISTOR			
Collector–Emitter Voltage	V_{CEO}	30	Volts
Emitter–Base Voltage	V_{EBO}	7	Volts
Collector–Base Voltage	V_{CBO}	70	Volts
Collector Current — Continuous	I_C	150	mA
Detector Power Dissipation @ T_A = 25°C with Negligible Power in Input LED	P_D	150	mW
Derate above 25°C		1.76	mW/°C
TOTAL DEVICE			
Isolation Surge Voltage(1) (Peak ac Voltage, 60 Hz, 1 sec Duration)	V_{ISO}	7500	Vac(pk)
Total Device Power Dissipation @ T_A = 25°C	P_D	250	mW
Derate above 25°C		2.94	mW/°C
Ambient Operating Temperature Range(2)	T_A	−55 to +100	°C
Storage Temperature Range(2)	T_{stg}	−55 to +150	°C
Soldering Temperature (10 sec, 1/16″ from case)	T_L	260	°C

1. Isolation surge voltage is an internal device dielectric breakdown rating. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.
2. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

REV 1

MOC8100

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)(1)

Characteristic	Symbol	Min	Typ(1)	Max	Unit
INPUT LED					
Forward Voltage (I_F = 10 mA) T_A = 0–70°C T_A = –55°C T_A = 100°C	V_F	— — —	1.15 1.3 1.05	1.4 — —	Volts
Reverse Leakage Current (V_R = 6 V)	I_R	—	0.05	10	μA
Capacitance (V = 0 V, f = 1 MHz)	C_J	—	18	—	pF
OUTPUT TRANSISTOR					
Collector–Emitter Dark Current (V_{CE} = 5 V, T_A = 25°C)	I_{CEO}	—	3	25	nA
(V_{CB} = 30 V, T_A = 70°C)	I_{CEO}	—	0.05	50	μA
Collector–Base Dark Current (V_{CB} = 5 V)	I_{CBO}	—	0.2	10	nA
Collector–Emitter Breakdown Voltage (I_C = 1 mA)	$V_{(BR)CEO}$	30	45	—	Volts
Collector–Base Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CBO}$	70	100	—	Volts
Emitter–Base Breakdown Voltage (I_E = 100 μA)	$V_{(BR)EBO}$	7	7.8	—	Volts
DC Current Gain (I_C = 1 mA, V_{CE} = 5 V) (Typical Value)	h_{FE}	—	600	—	—
Collector–Emitter Capacitance (f = 1 MHz, V_{CE} = 0)	C_{CE}	—	7	—	pF
Collector–Base Capacitance (f = 1 MHz, V_{CB} = 0)	C_{CB}	—	19	—	pF
Emitter–Base Capacitance (f = 1 MHz, V_{EB} = 0)	C_{EB}	—	9	—	pF
COUPLED					
Output Collector Current (I_F = 1 mA, V_{CE} = 5 V) (I_F = 1 mA, V_{CE} = 5 V, T_A = 0 to +70°C)	I_C (CTR)(2)	 0.5 (50) 0.3 (30)	 1 (100) 0.6 (60)	 — —	mA (%)
Collector–Emitter Saturation Voltage (I_C = 100 μA, I_F = 1 mA)	$V_{CE(sat)}$	—	0.22	0.5	Volts
Turn–On Time (I_C = 2 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)	t_{on}	—	9	20	μs
Turn–Off Time (I_C = 2 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)	t_{off}	—	7	20	μs
Rise Time (I_C = 2 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)	t_r	—	3.8	—	μs
Fall Time (I_C = 2 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)	t_f	—	5.6	—	μs
Isolation Voltage (f = 60 Hz, t = 1 sec)(4)	V_{ISO}	7500	—	—	Vac(pk)
Isolation Resistance (V = 500 V)(4)	R_{ISO}	10^{11}	—	—	Ω
Isolation Capacitance (V = 0 V, f = 1 MHz)(4)	C_{ISO}	—	0.2	2	pF

1. Always design to the specified minimum/maximum electrical limits (where applicable).
2. Current Transfer Ratio (CTR) = I_C/I_F x 100%.
3. For test circuit setup and waveforms, refer to Figure 11.
4. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.

TYPICAL CHARACTERISTICS

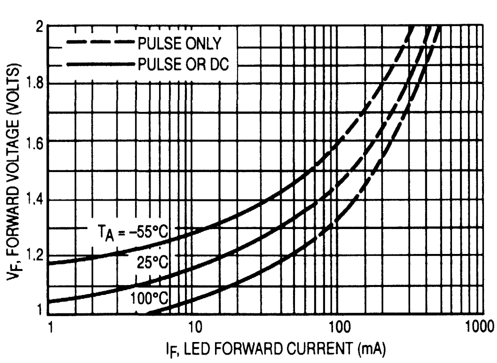


Figure 1. LED Forward Voltage versus Forward Current

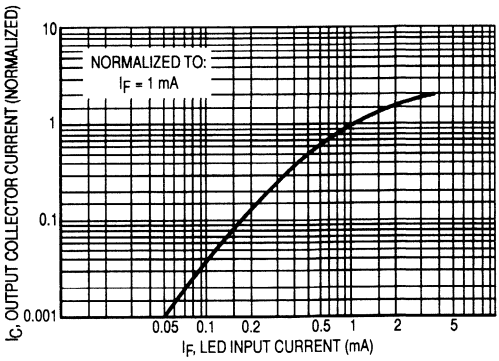


Figure 2. Output Current versus Input Current

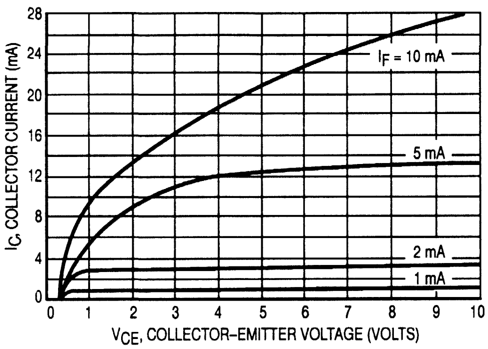


Figure 3. Collector Current versus Collector–Emitter Voltage

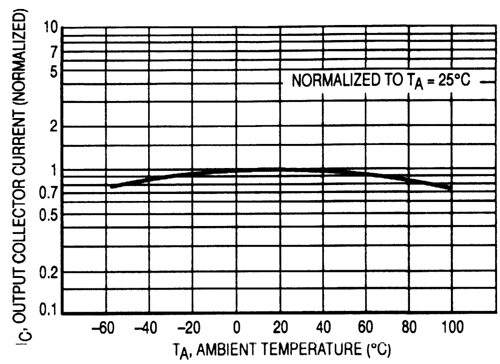


Figure 4. Output Current versus Ambient Temperature

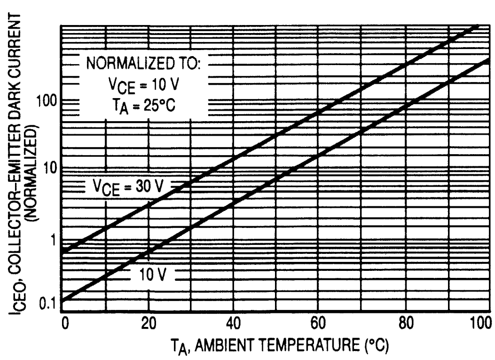


Figure 5. Dark Current versus Ambient Temperature

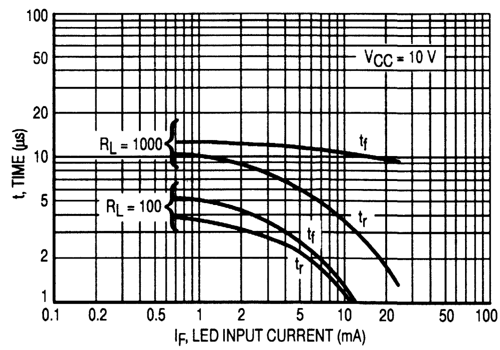


Figure 6. Rise and Fall Times (Typical Values)

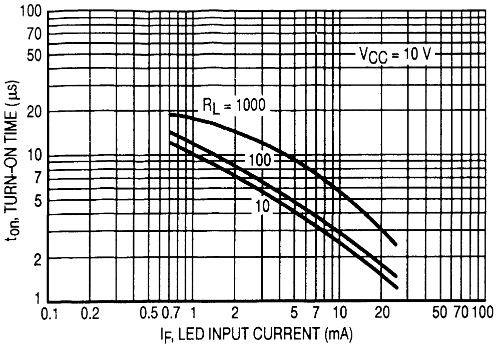


Figure 7. Turn–On Switching Times

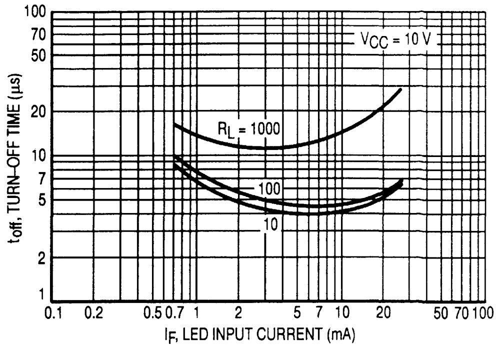


Figure 8. Turn–Off Switching Times

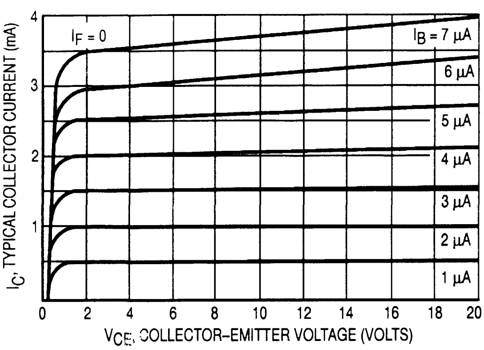


Figure 9. DC Current Gain (Detector Only)

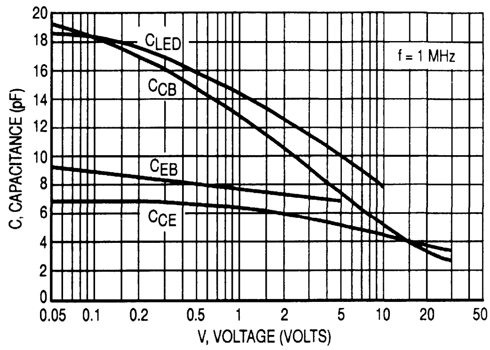


Figure 10. Capacitances versus Voltage

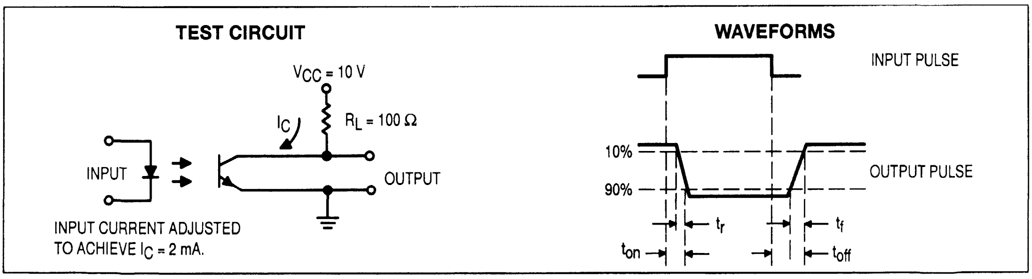


Figure 11. Switching Time Test Circuit and Waveforms

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

GlobalOptoisolator™

VDE	UL	CSA	SETI	SEMKO	DEMKO	NEMKO	BABT

6-Pin DIP Optoisolators for Power Supply Applications (No Base Connection)

MOC8101
[CTR = 50–80%]
MOC8102
[CTR = 73–117%]
MOC8103
[CTR = 108–173%]
MOC8104
[CTR = 160–256%]
MOC8105*
[CTR = 65–133%]

*Motorola Preferred Device

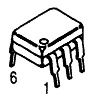
The MOC8101, MOC8102, MOC8103, MOC8104 and MOC8105 devices consist of a gallium arsenide LED optically coupled to a silicon phototransistor in a dual-in-line package.

- Closely Matched Current Transfer Ratio (CTR) Minimizes Unit-to-Unit Variation
- Narrow (CTR) Windows that translate to a Narrow and Predictable Open Loop Gain Window
- Very Low Coupled Capacitance along with No Chip to Pin 6 Base Connection for Minimum Noise Susceptibility
- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

Applications

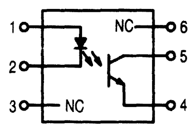
- Switchmode Power Supplies (Feedback Control)
- AC Line/Digital Logic Isolation
- Interfacing and coupling systems of different potentials and impedances

STYLE 3 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

SCHEMATIC



PIN 1. ANODE
2. CATHODE
3. NO CONNECTION
4. EMITTER
5. COLLECTOR
6. NO CONNECTION

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Forward Current — Continuous	I_F	60	mA
Forward Current — Peak (PW = 100 µs, 120 pps)	$I_F(pk)$	1	A
Reverse Voltage	V_R	6	Volts
LED Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	120 1.41	mW mW/°C
OUTPUT TRANSISTOR			
Collector–Emitter Voltage	V_{CEO}	30	Volts
Emitter–Collector Voltage	V_{ECO}	7	Volts
Collector Current — Continuous	I_C	150	mA
Detector Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 1.76	mW mW/°C
TOTAL DEVICE			
Input–Output Isolation Voltage(1) (f = 60 Hz, t = 1 sec.)	V_{ISO}	7500	Vac(pk)
Total Device Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Ambient Operating Temperature Range(2)	T_A	–55 to +100	°C
Storage Temperature Range(2)	T_{stg}	–55 to +150	°C
Lead Soldering Temperature (1/16″ from case, 10 sec. duration)	T_L	260	°C

1. Input–Output Isolation Voltage, V_{ISO}, is an internal device dielectric breakdown rating. For this test, Pins 1 and 2 are common, and Pins 4 and 5 are common.
2. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 1

MOC8101 MOC8102 MOC8103 MOC8104 MOC8105

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)(1)

Characteristic	Symbol	Min	Typ(1)	Max	Unit
INPUT LED					
Forward Voltage (I_F = 10 mA)	V_F	1.0	1.15	1.5	V
Reverse Leakage Current (V_R = 5.0 V)	I_R	—	0.05	10	µA
Capacitance	C	—	18	—	pF
OUTPUT TRANSISTOR					
Collector–Emitter Dark Current (V_{CE} = 10 V, T_A = 25°C)	I_{CEO1}	—	1.0	50	nA
(V_{CE} = 10 V, T_A = 100°C)	I_{CEO2}	—	1.0	—	µA
Collector–Emitter Breakdown Voltage (I_C = 1.0 mA)	$V_{(BR)CEO}$	30	45	—	V
Emitter–Collector Breakdown Voltage (I_E = 100 µA)	$V_{(BR)ECO}$	7.0	7.8	—	V
Collector–Emitter Capacitance (f = 1.0 MHz, V_{CE} = 0)	C_{CE}	—	7.0	—	pF
COUPLED					
Output Collector Current (I_F = 10 mA, V_{CE} = 10 V) MOC8101	I_C (CTR)(2)	5.0 (50)	6.5 (65)	8.0 (80)	mA (%)
MOC8102		7.3 (73)	9.0 (90)	11.7 (117)	
MOC8103		10.8 (108)	14 (140)	17.3 (173)	
MOC8104		16 (160)	20 (200)	25.6 (256)	
MOC8105		6.5 (65)	10 (100)	13.3 (133)	
Collector–Emitter Saturation Voltage (I_C = 500 µA, I_F = 5.0 mA)	$V_{CE(sat)}$	—	0.15	0.4	V
Turn–On Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)	t_{on}	—	7.5	20	µs
Turn–Off Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)	t_{off}	—	5.7	20	µs
Rise Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)	t_r	—	3.2	—	µs
Fall Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)	t_f	—	4.7	—	µs
Isolation Voltage (f = 60 Hz, t = 1.0 sec.)(4)	V_{ISO}	7500	—	—	Vac(pk)
Isolation Resistance (V_{I-O} = 500 V)(4)	R_{ISO}	10^{11}	—	—	Ω
Isolation Capacitance (V_{I-O} = 0, f = 1.0 MHz)(4)	C_{ISO}	—	0.2	—	pF

1. Always design to the specified minimum/maximum electrical limits (where applicable).
2. Current Transfer Ratio (CTR) = I_C/I_F x 100%.
3. For test circuit setup and waveforms, refer to Figure 7.
4. For this test, Pins 1 and 2 are common, and Pins 4 and 5 are common.

TYPICAL CHARACTERISTICS

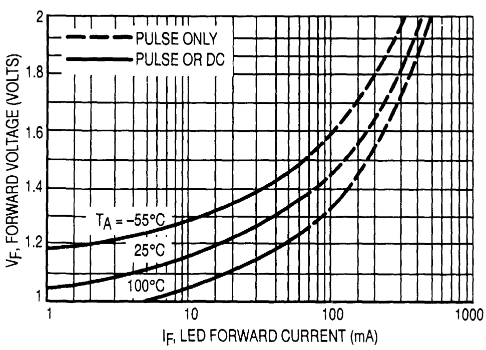


Figure 1. LED Forward Voltage versus Forward Current

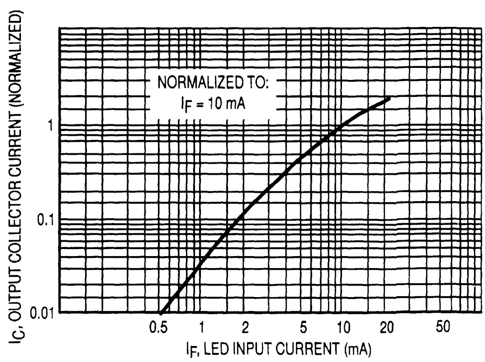


Figure 2. Output Current versus Input Current

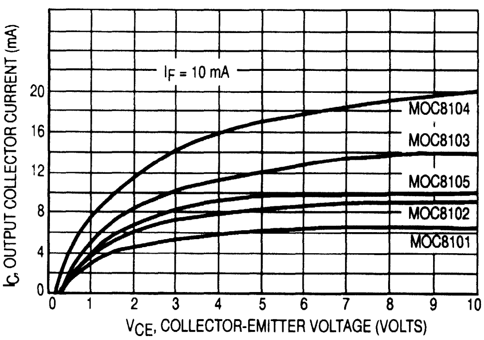


Figure 3. Collector Current versus Collector–Emitter Voltage

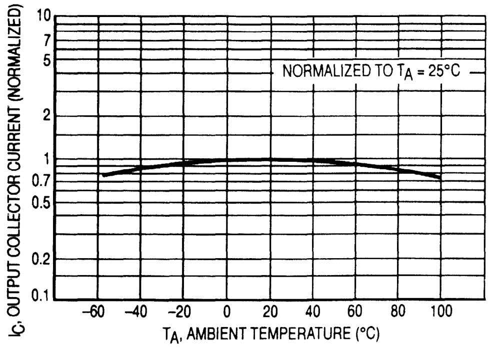


Figure 4. Output Current versus Ambient Temperature

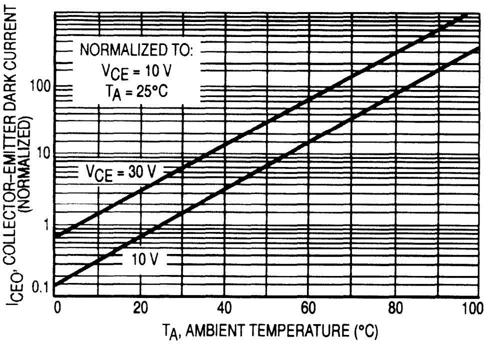


Figure 5. Dark Current versus Ambient Temperature

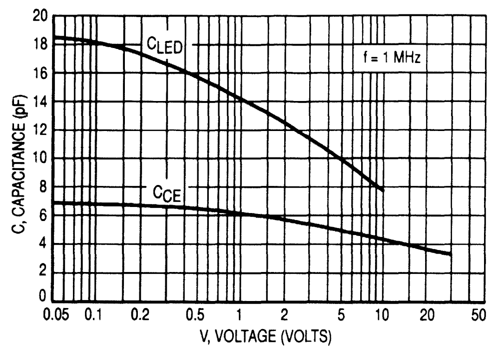


Figure 6. Capacitance versus Voltage

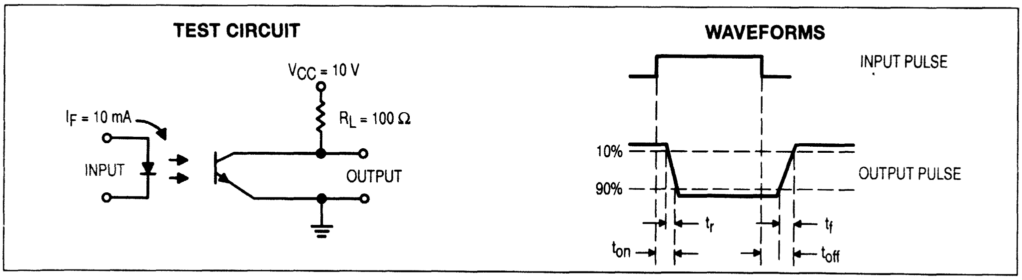


Figure 7. Switching Time Test Circuit and Waveforms

GlobalOptoisolator™

VDE	UL	CSA	SETI	SEMKO	DEMKO	NEMKO	BABT

MOC8111*
[CTR = 20% Min]
MOC8112*
[CTR = 50% Min]
MOC8113
[CTR = 100% Min]

*Motorola Preferred Devices

6-Pin DIP Optoisolators Transistor Output (No Base Connection)

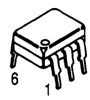
The MOC8111, MOC8112 and MOC8113 devices consist of a gallium arsenide infrared emitting diode optically coupled to a monolithic silicon phototransistor detector. The internal base–to–Pin 6 connection has been eliminated for improved noise immunity.

- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

Applications

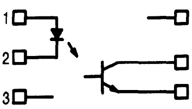
- Appliances, Measuring Instruments
- Regulation and Feedback Control
- Programmable Controllers
- Interfacing and coupling systems of different potentials and impedances
- General Purpose Switching Circuits
- High Noise Environments

STYLE 3 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

SCHEMATIC



PIN 1. LED ANODE
2. LED CATHODE
3. N.C.
4. EMITTER
5. COLLECTOR
6. N.C.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Reverse Voltage	V_R	6	Volts
Forward Current — Continuous	I_F	60	mA
LED Power Dissipation @ T_A = 25°C with Negligible Power in Output Detector Derate above 25°C	P_D	120 1.41	mW mW/°C
OUTPUT TRANSISTOR			
Collector–Emitter Voltage	V_{CEO}	30	Volts
Emitter–Collector Voltage	V_{ECO}	7	Volts
Collector Current — Continuous	I_C	150	mA
Detector Power Dissipation @ T_A = 25°C with Negligible Power in Input LED Derate above 25°C	P_D	150 1.76	mW mW/°C
TOTAL DEVICE			
Isolation Surge Voltage(1) (Peak ac Voltage, 60 Hz, 1 sec Duration)	V_{ISO}	7500	Vac(pk)
Total Device Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Ambient Operating Temperature Range(2)	T_A	–55 to +100	°C
Storage Temperature Range(2)	T_{stg}	–55 to +150	°C
Soldering Temperature (10 sec, 1/16″ from case)	T_L	260	°C

1. Isolation surge voltage is an internal device dielectric breakdown rating. For this test, Pins 1 and 2 are common, and Pins 4 and 5 are common.
2. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 1

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)(1)

Characteristic		Symbol	Min	Typ(1)	Max	Unit
INPUT LED						
Forward Voltage (I_F = 10 mA)	T_A = 25°C T_A = –55°C T_A = 100°C	V_F	—	1.15 1.3 1.05	1.5	Volts
Reverse Leakage Current (V_R = 6 V)		I_R	—	0.05	10	μA
Capacitance (V = 0, f = 1 MHz)		C_J	—	18	—	pF
OUTPUT TRANSISTOR						
Collector–Emitter Dark Current (V_{CE} = 10 V, T_A = 25°C)		I_{CEO}	—	1	50	nA
(V_{CE} = 10 V, T_A = 100°C)		I_{CEO}	—	1	—	μA
Collector–Emitter Breakdown Voltage (I_C = 1 mA)		$V_{(BR)CEO}$	30	45	—	Volts
Emitter–Collector Breakdown Voltage (I_E = 100 μA)		$V_{(BR)ECO}$	7	7.8	—	Volts
Collector–Emitter Capacitance (f = 1 MHz, V_{CE} = 0)		C_{CE}	—	7	—	pF
COUPLED						
Output Collector Current (I_F = 10 mA, V_{CE} = 10 V)	MOC8111 MOC8112 MOC8113	I_C (CTR)(2)	2 (20) 5 (50) 10 (100)	5 (50) 10 (100) 20 (200)	— — —	mA (%)
Collector–Emitter Saturation Voltage (I_C = 500 μA, I_F = 10 mA)		$V_{CE(sat)}$	—	0.15	0.4	Volts
Turn–On Time (I_C = 2 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)		t_{on}	—	7.5	20	μs
Turn–Off Time (I_C = 2 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)		t_{off}	—	5.7	20	μs
Rise Time (I_C = 2 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)		t_r	—	3.2	—	μs
Fall Time (I_C = 2 mA, V_{CC} = 10 V, R_L = 100 Ω)(3)		t_f	—	4.7	—	μs
Isolation Voltage (f = 60 Hz, t = 1 sec)(4)		V_{ISO}	7500	—	—	Vac(pk)
Isolation Resistance (V = 500 V)(4)		R_{ISO}	10^{11}	—	—	Ω
Isolation Capacitance (V = 0, f = 1 MHz)(4)		C_{ISO}	—	0.2	—	pF

1. Always design to the specified minimum/maximum electrical limits (where applicable).
2. Current Transfer Ratio (CTR) = I_C/I_F x 100%.
3. For test circuit setup and waveforms, refer to Figure 10.
4. For this test, Pins 1 and 2 are common, and Pins 4 and 5 are common.

TYPICAL CHARACTERISTICS

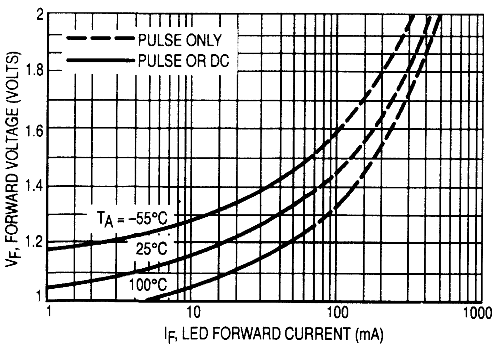


Figure 1. LED Forward Voltage versus Forward Current

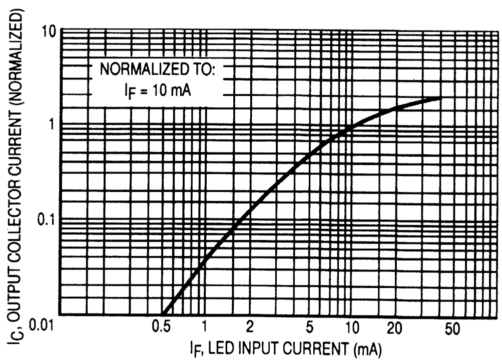


Figure 2. Output Current versus Input Current

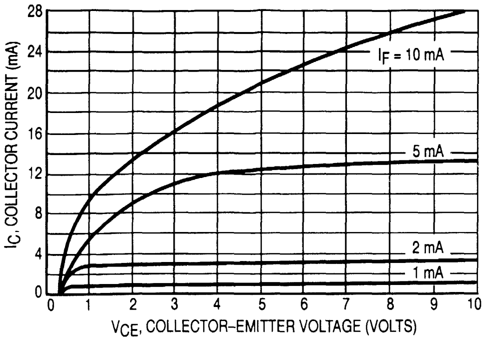


Figure 3. Collector Current versus Collector–Emitter Voltage

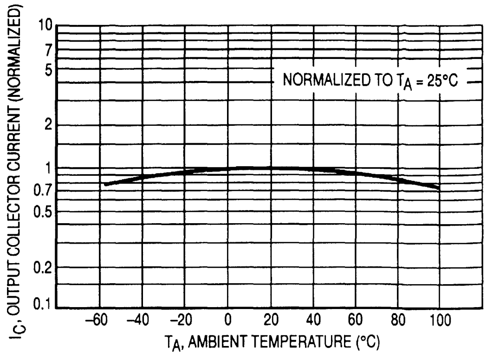


Figure 4. Output Current versus Ambient Temperature

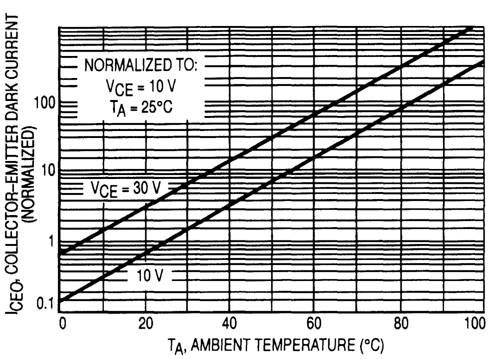


Figure 5. Dark Current versus Ambient Temperature

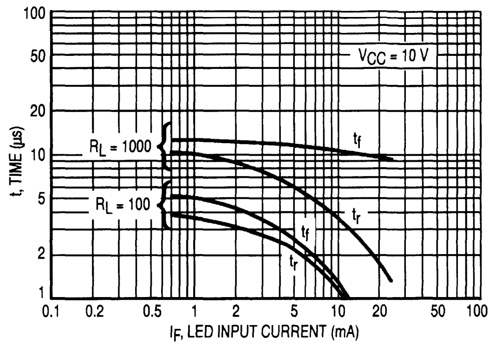


Figure 6. Rise and Fall Times (Typical Values)

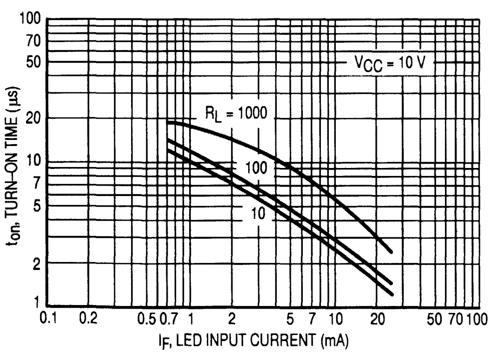


Figure 7. Turn–On Switching Times

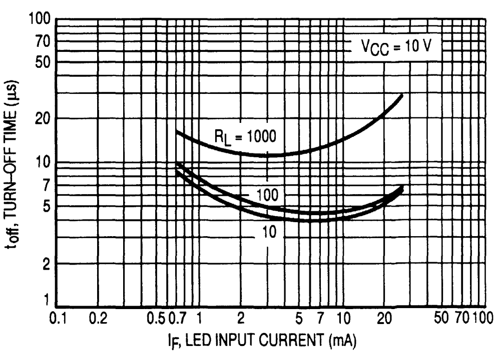


Figure 8. Turn–Off Switching Times

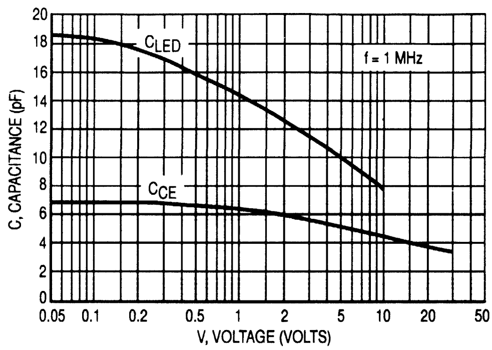


Figure 9. Capacitances versus Voltage

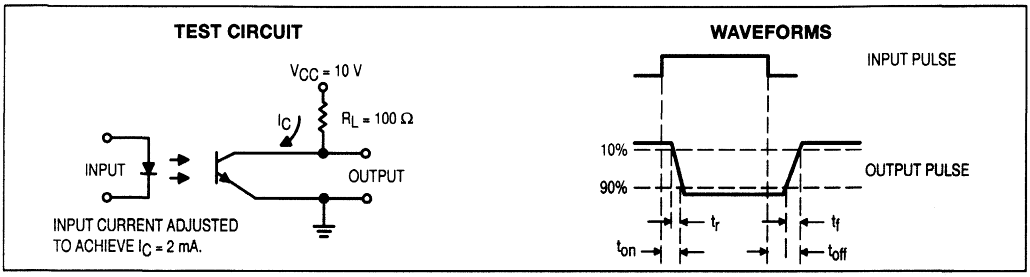


Figure 10. Switching Time Test Circuit and Waveforms

GlobalOptoisolator™

VDE	UL	CSA	SETI	SEMKO	DEMKO	NEMKO	BABT

# MOC8204*
[CTR = 20% Min]
# MOC8205
[CTR = 10% Min]
# MOC8206
[CTR = 5% Min]

*Motorola Preferred Device

6-Pin DIP Optoisolators High Voltage Transistor Output (400 Volts)

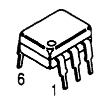
The MOC8204, MOC8205 and MOC8206 devices consist of gallium arsenide infrared emitting diodes optically coupled to high voltage, silicon, phototransistor detectors in a standard 6–pin DIP package. They are designed for high voltage applications and are particularly useful in copy machines and solid state relays.

- ***To order devices that are tested and marked per VDE 0884 requirements, the suffix "V" must be included at end of part number. VDE 0884 is a test option.***

Applications

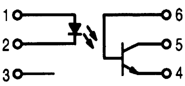
- Copy Machines
- Interfacing and coupling systems of different potentials and impedances
- Monitor and Detection Circuits
- Solid State Relays

STYLE 1 PLASTIC



STANDARD THRU HOLE
CASE 730A–04

SCHEMATIC



PIN 1. ANODE
2. CATHODE
3. N.C.
4. EMITTER
5. COLLECTOR
6. BASE

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Forward Current — Continuous	I_F	60	mA
Forward Current — Peak Pulse Width = 1 μs, 330 pps	I_F	1.2	Amp
LED Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	120 1.41	mW mW/°C
OUTPUT TRANSISTOR			
Collector–Emitter Voltage	V_{CER}	400	Volts
Emitter–Collector Voltage	V_{ECO}	7	Volts
Collector–Base Voltage	V_{CBO}	400	mA
Collector Current (Continuous)	I_C	100	mA
Detector Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 1.76	mW mW/°C
TOTAL DEVICE			
Total Device Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Operating Temperature Range(2)	T_J	−55 to +100	°C
Storage Temperature Range(2)	T_{stg}	−55 to +150	°C
Soldering Temperature (10 s)	T_L	260	°C
Isolation Surge Voltage Peak ac Voltage, 60 Hz, 1 Second Duration(1)	V_{ISO}	7500	Vac(pk)

1. Isolation surge voltage is an internal device dielectric breakdown rating. For this test, Pins 1 and 2 are common, and Pins 4, 5 and 6 are common.
2. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 1

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)(1)

Characteristic	Symbol	Min	Typ(1)	Max	Unit
INPUT LED (T_A = 25°C unless otherwise noted)					
Reverse Leakage Current (V_R = 6 V)	I_R	—	—	10	μA
Forward Voltage (I_F = 10 mA)	V_F	—	1.2	15	Volts
Capacitance (V = 0 V, f = 1 MHz)	C_J	—	18	—	pF
OUTPUT TRANSISTOR (T_A = 25°C and I_F = 0 unless otherwise noted)					
Collector–Emitter Dark Current (R_{BE} = 1 MΩ) (V_{CE} = 300 V) T_A = 25°C	I_{CER}	—	—	100	nA
T_A = 100°C		—	—	250	μA
Collector–Base Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CBO}$	400	—	—	Volts
Collector–Emitter Breakdown Voltage (I_C = 1 mA, R_{BE} = 1 MΩ)	$V_{(BR)CER}$	400	—	—	Volts
Emitter–Base Breakdown Voltage (I_E = 100 μA)	$V_{(BR)EBO}$	7	—	—	Volts
COUPLED (T_A = 25°C unless otherwise noted)					
Output Collector Current (V_{CE} = 10 V, I_F = 10 mA, R_{BE} = 1 MΩ) MOC8204	I_C (CTR)(2)	2 (20)	—	—	mA (%)
MOC8205		1 (10)	—	—	
MOC8206		0.5 (5)	—	—	
Collector–Emitter Saturation Voltage (I_C = 0.5 mA, I_F = 10 mA, R_{BE} = 1 MΩ)	$V_{CE(sat)}$	—	—	0.4	Volts
Surge Isolation Voltage (Input to Output)(3) Peak ac Voltage, 60 Hz, 1 sec	V_{ISO}	7500	—	—	Vac(pk)
Isolation Resistance(3) (V = 500 V)	R_{ISO}	—	10^{11}	—	Ohms
Isolation Capacitance(1) (V = 0 V, f = 1 MHz)	C_{ISO}	—	0.2	—	pF
Turn–On Time (V_{CC} = 10 V, I_C = 2 mA, R_L = 100 Ω)	t_{on}	—	5	—	μs
Turn–Off Time (V_{CC} = 10 V, I_C = 2 mA, R_L = 100 Ω)	t_{off}	—	5	—	

1. Always design to the specified minimum/maximum electrical limits (where applicable).
2. Current Transfer Ratio (CTR) = I_C/I_F x 100%.
3. For this test LED Pins 1 and 2 are common and phototransistor Pins 4, 5 and 6 are common.

TYPICAL CHARACTERISTICS

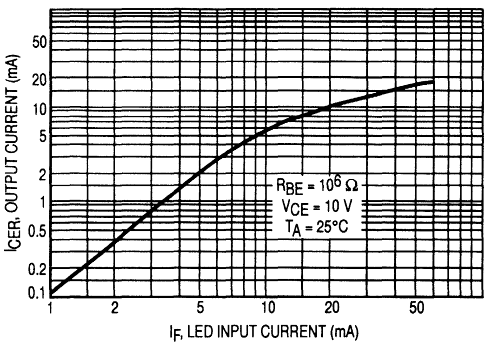


Figure 1. Output Current versus LED Input Current

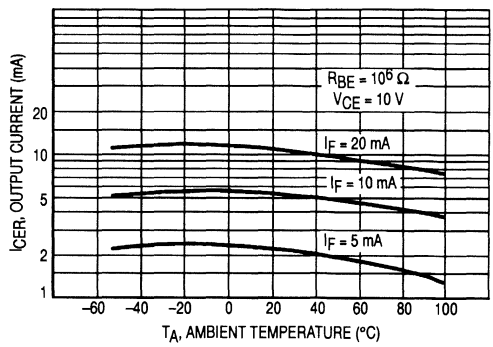


Figure 2. Output Current versus Temperature

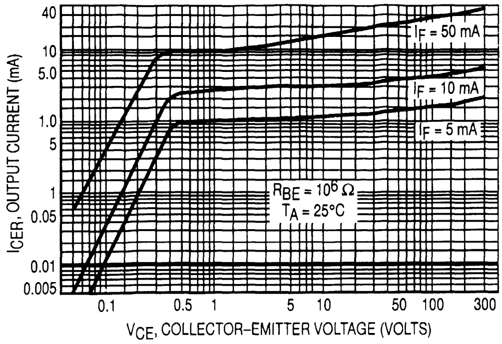


Figure 3. Output Characteristics

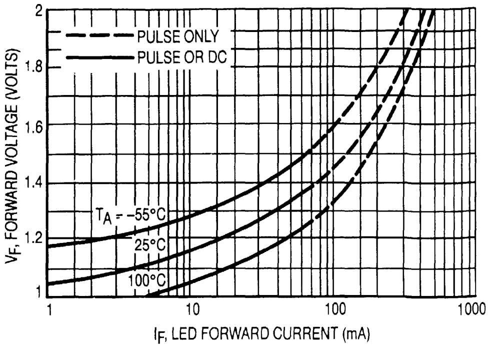


Figure 4. Forward Characteristics

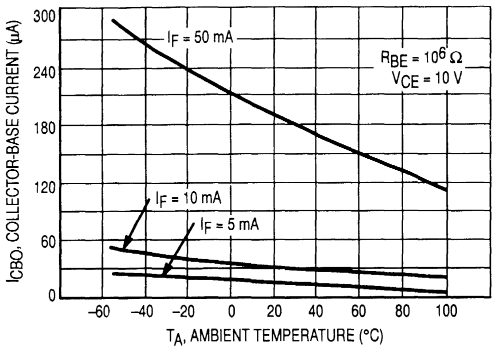


Figure 5. Collector–Base Current versus Temperature

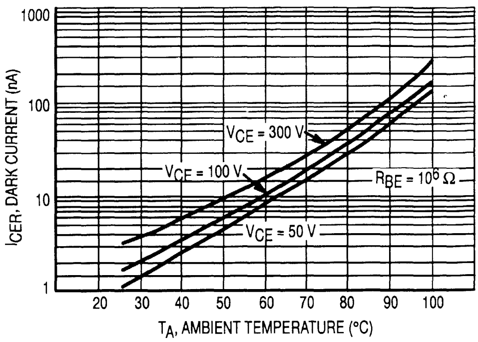
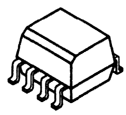


Figure 6. Dark Current versus Temperature

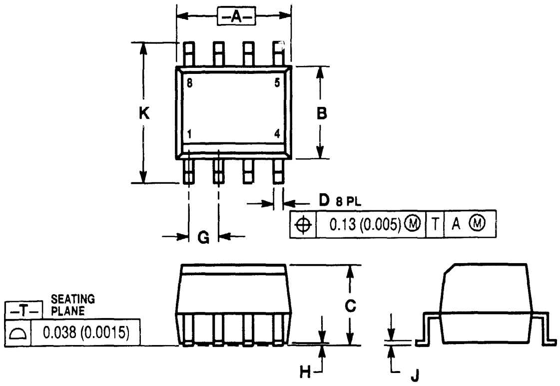
Section 6

SOIC–8 Small Outline Optoisolators



CASE 846–01

PACKAGE DIMENSIONS



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.182	0.202	4.63	5.13
B	0.144	0.164	3.66	4.16
C	0.123	0.143	3.13	3.63
D	0.011	0.021	0.28	0.53
G	0.050 BSC		1.27 BSC	
H	0.003	0.008	0.08	0.20
J	0.006	0.010	0.16	0.25
K	0.224	0.244	5.69	6.19

STYLE 1: (Single Channel)
PIN 1. ANODE
2. CATHODE
3. NC
4. NC
5. EMITTER
6. COLLECTOR
7. BASE
8. NC

STYLE 2: (AC Input)
PIN 1. INPUT
2. INPUT
3. NC
4. NC
5. EMITTER
6. COLLECTOR
7. BASE
8. NC

STYLE 3: (Dual Channel)
PIN 1. ANODE 1
2. CATHODE 1
3. ANODE 2
4. CATHODE 2
5. EMITTER 2
6. COLLECTOR 2
7. EMITTER 1
8. COLLECTOR 1

STYLE 4: Single Channel–Baseless)
PIN 1. ANODE
2. CATHODE
3. NC
4. NC
5. EMITTER
6. COLLECTOR
7. NC
8. NC

CASE 846–01
ISSUE B

Small Outline Optoisolators
Transistor Output

These devices consist of a gallium arsenide infrared emitting diode optically coupled to a monolithic silicon phototransistor detector, in a surface mountable, small outline, plastic package. They are ideally suited for high density applications, and eliminate the need for through–the–board mounting.

- Convenient Plastic SOIC–8 Surface Mountable Package Style
- Closely Matched Current Transfer Ratios
- Minimum $V_{(BR)CEO}$ of 70 Volts Guaranteed
- Standard SOIC–8 Footprint, with 0.050″ Lead Spacing
- Shipped in Tape and Reel, which Conforms to EIA Standard RS481A
- Compatible with Dual Wave, Vapor Phase and IR Reflow Soldering
- High Input–Output Isolation of 3000 Vac (rms) Guaranteed
- UL Recognized File #E54915

Ordering Information:

- To obtain MOC205, 206, 207, 208 in Tape and Reel, add R2 suffix to device numbers:
  R2 = 2500 units on 13″ reel
- To obtain MOC205, 206, 207, 208 in quantities of 50 (shipped in sleeves) — No Suffix

Marking Information:

- MOC205 = 205
- MOC206 = 206
- MOC207 = 207
- MOC208 = 208

Applications:

- Feedback Control Circuits
- Interfacing and coupling systems of different potentials and impedances
- General Purpose Switching Circuits
- Monitor and Detection Circuits

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Forward Current — Continuous	I_F	60	mA
Forward Current — Peak (PW = 100 μs, 120 pps)	$I_{F(pk)}$	1.0	A
Reverse Voltage	V_R	6.0	V
LED Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	90 0.8	mW mW/°C
OUTPUT TRANSISTOR			
Collector–Emitter Voltage	V_{CEO}	70	V
Collector–Base Voltage	V_{CBO}	70	V
Emitter–Collector Voltage	V_{ECO}	7.0	V
Collector Current — Continuous	I_C	150	mA
Detector Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 1.76	mW mW/°C

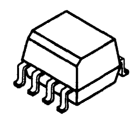
NOTE: Thickness through insulation between input and output ≥ 0.5 mm.

Preferred devices are Motorola recommended choices for future use and best overall value.

MOC205
[CTR = 40–80%]
MOC206*
[CTR = 63–125%]
MOC207*
[CTR = 100–200%]
MOC208*
[CTR = 40–125%]

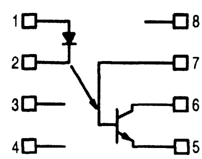
*Motorola Preferred Devices

SMALL OUTLINE OPTOISOLATORS TRANSISTOR OUTPUT



CASE 846–01, STYLE 1
PLASTIC

SCHEMATIC



1. LED ANODE
2. LED CATHODE
3. NO CONNECTION
4. NO CONNECTION
5. EMITTER
6. COLLECTOR
7. BASE
8. NO CONNECTION

REV 1

MAXIMUM RATINGS — continued (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
TOTAL DEVICE			
Input–Output Isolation Voltage[1,2] (60 Hz, 1.0 sec. duration)	V_{ISO}	3000	Vac(rms)
Total Device Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Ambient Operating Temperature Range[3]	T_A	–55 to +100	°C
Storage Temperature Range[3]	T_{stg}	–55 to +150	°C
Lead Soldering Temperature (1/16″ from case, 10 sec. duration)	—	260	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)[4]

Characteristic	Symbol	Min	Typ[4]	Max	Unit
INPUT LED					
Forward Voltage (I_F = 10 mA)	V_F	—	1.15	1.5	V
Reverse Leakage Current (V_R = 6.0 V)	I_R	—	0.1	100	μA
Capacitance	C	—	18	—	pF
OUTPUT TRANSISTOR					
Collector–Emitter Dark Current (V_{CE} = 10 V, T_A = 25°C)	I_{CEO1}	—	1.0	50	nA
(V_{CE} = 10 V, T_A = 100°C)	I_{CEO2}	—	1.0	—	μA
Collector–Emitter Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CEO}$	70	120	—	V
Emitter–Collector Breakdown Voltage (I_E = 100 μA)	$V_{(BR)ECO}$	7.0	7.8	—	V
Collector–Emitter Capacitance (f = 1.0 MHz, V_{CE} = 0)	C_{CE}	—	7.0	—	pF
COUPLED					
Output Collector Current (I_F = 10 mA, V_{CE} = 10 V) MOC205	I_C (CTR)[5]	4.0 (40)	6.0 (60)	8.0 (80)	mA (%)
MOC206		6.3 (63)	9.4 (94)	12.5 (125)	
MOC207		10 (100)	15 (150)	20 (200)	
MOC208		4.0 (40)	8.0 (80)	12.5 (125)	
Collector–Emitter Saturation Voltage (I_C = 2.0 mA, I_F = 10 mA)	$V_{CE(sat)}$	—	0.15	0.4	V
Turn–On Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_{on}	—	3.0	—	μs
Turn–Off Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_{off}	—	2.8	—	μs
Rise Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_r	—	1.6	—	μs
Fall Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_f	—	2.2	—	μs
Input–Output Isolation Voltage (f = 60 Hz, t = 1.0 sec.)[1,2]	V_{ISO}	3000	—	—	Vac(rms)
Isolation Resistance (V_{I-O} = 500 V)[2]	R_{ISO}	10^{11}	—	—	Ω
Isolation Capacitance (V_{I-O} = 0, f = 1.0 MHz)[2]	C_{ISO}	—	0.2	—	pF

1. Input–Output Isolation Voltage, V_{ISO}, is an internal device dielectric breakdown rating.
2. For this test, pins 1 and 2 are common, and pins 5, 6 and 7 are common.
3. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.
4. Always design to the specified minimum/maximum electrical limits (where applicable).
5. Current Transfer Ratio (CTR) = I_C/I_F x 100%.

TYPICAL CHARACTERISTICS

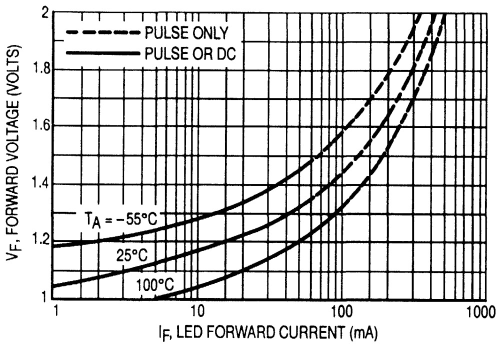


Figure 1. LED Forward Voltage versus Forward Current

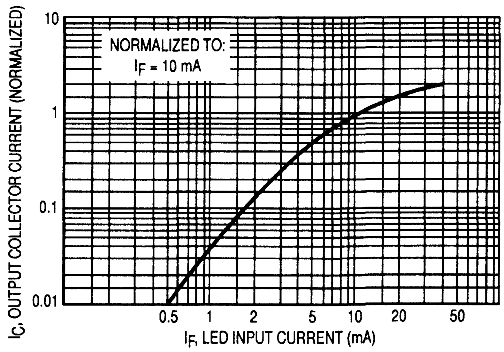


Figure 2. Output Current versus Input Current

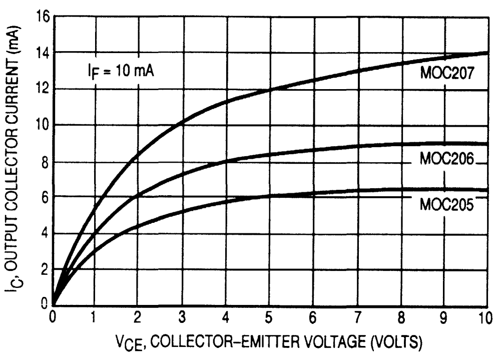


Figure 3. Output Current versus Collector–Emitter Voltage

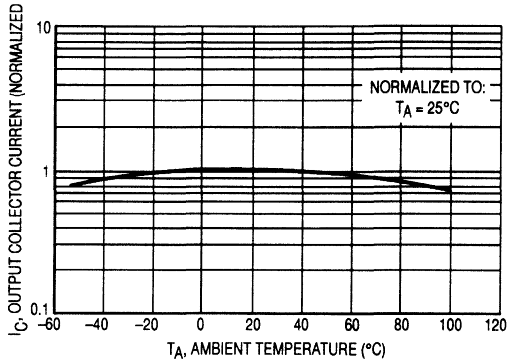


Figure 4. Output Current versus Ambient Temperature

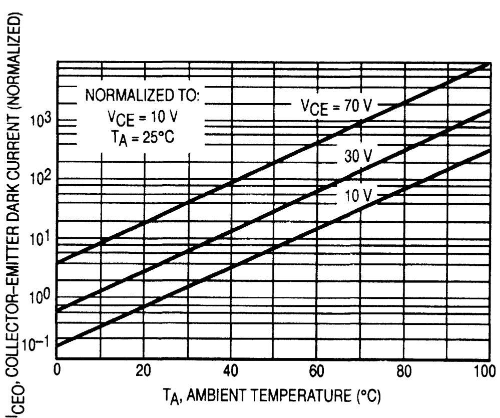


Figure 5. Dark Current versus Ambient Temperature

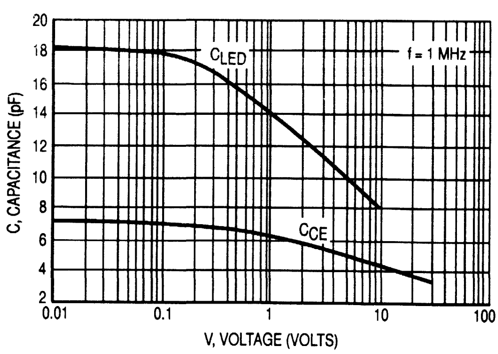


Figure 6. Capacitance versus Voltage

MOC211
[CTR = 20% Min]
MOC212
[CTR = 50% Min]
MOC213
[CTR = 100% Min]

Motorola Preferred Devices

Small Outline Optoisolators
Transistor Output

These devices consist of a gallium arsenide infrared emitting diode optically coupled to a monolithic silicon phototransistor detector, in a surface mountable, small outline, plastic package. They are ideally suited for high density applications, and eliminate the need for through–the–board mounting.

- Convenient Plastic SOIC–8 Surface Mountable Package Style
- Standard SOIC–8 Footprint, with 0.050″ Lead Spacing
- Shipped in Tape and Reel, which Conforms to EIA Standard RS481A
- Compatible with Dual Wave, Vapor Phase and IR Reflow Soldering
- High Input–Output Isolation of 3000 Vac (rms) Guaranteed
- UL Recognized File #E54915

Ordering Information:

- To obtain MOC211, 212 and 213 in Tape and Reel, add R2 suffix to device numbers: R2 = 2500 units on 13″ reel
- To obtain MOC211, 212 and 213 in quantities of 50 (shipped in sleeves) — No Suffix

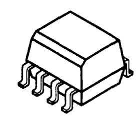
Marking Information:

- MOC211 = 211
- MOC212 = 212
- MOC213 = 213

Applications:

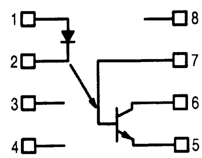
- General Purpose Switching Circuits
- Interfacing and coupling systems of different potentials and impedances
- Regulation Feedback Circuits
- Monitor and Detection Circuits

SMALL OUTLINE OPTOISOLATORS TRANSISTOR OUTPUT



CASE 846–01, STYLE 1
PLASTIC

SCHEMATIC



1. LED ANODE
2. LED CATHODE
3. NO CONNECTION
4. NO CONNECTION
5. EMITTER
6. COLLECTOR
7. BASE
8. NO CONNECTION

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Forward Current — Continuous	I_F	60	mA
Forward Current — Peak (PW = 100 µs, 120 pps)	$I_F(pk)$	1.0	A
Reverse Voltage	V_R	6.0	V
LED Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	90 0.8	mW mW/°C
OUTPUT TRANSISTOR			
Collector–Emitter Voltage	V_{CEO}	30	V
Collector–Base Voltage	V_{CBO}	70	V
Emitter–Collector Voltage	V_{ECO}	7.0	V
Collector Current — Continuous	I_C	150	mA
Detector Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 1.76	mW mW/°C

NOTE: Thickness through insulation between input and output is ≥ 0.5 mm.

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 1

MAXIMUM RATINGS — continued (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
TOTAL DEVICE			
Input–Output Isolation Voltage[1,2] (60 Hz, 1.0 sec. duration)	V_{ISO}	3000	Vac(rms)
Total Device Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Ambient Operating Temperature Range[3]	T_A	–55 to +100	°C
Storage Temperature Range[3]	T_{stg}	–55 to +150	°C
Lead Soldering Temperature (1/16″ from case, 10 sec. duration)	—	260	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)[4]

Characteristic	Symbol	Min	Typ[4]	Max	Unit
INPUT LED					
Forward Voltage (I_F = 10 mA)	V_F	—	1.15	1.5	V
Reverse Leakage Current (V_R = 6.0 V)	I_R	—	0.1	100	μA
Capacitance	C	—	18	—	pF
OUTPUT TRANSISTOR					
Collector–Emitter Dark Current (V_{CE} = 10 V, T_A = 25°C)	$I_{CEO}1$	—	1.0	50	nA
(V_{CE} = 10 V, T_A = 100°C)	$I_{CEO}2$	—	1.0	—	μA
Collector–Emitter Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CEO}$	30	90	—	V
Emitter–Collector Breakdown Voltage (I_E = 100 μA)	$V_{(BR)ECO}$	7.0	7.8	—	V
Collector–Emitter Capacitance (f = 1.0 MHz, V_{CE} = 0)	C_{CE}	—	7.0	—	pF
COUPLED					
Output Collector Current (I_F = 10 mA, V_{CE} = 10 V) MOC211	I_C (CTR)[5]	2.0 (20)	6.5 (65)	—	mA (%)
MOC212		5.0 (50)	9.0 (90)	—	
MOC213		10 (100)	14 (140)	—	
Collector–Emitter Saturation Voltage (I_C = 2.0 mA, I_F = 10 mA)	$V_{CE(sat)}$	—	0.15	0.4	V
Turn–On Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_{on}	—	7.5	—	μs
Turn–Off Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_{off}	—	5.7	—	μs
Rise Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_r	—	3.2	—	μs
Fall Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_f	—	4.7	—	μs
Input–Output Isolation Voltage (f = 60 Hz, t = 1.0 sec.)[1,2]	V_{ISO}	3000	—	—	Vac(rms)
Isolation Resistance ($V_{I–O}$ = 500 V)[2]	R_{ISO}	10^{11}	—	—	Ω
Isolation Capacitance ($V_{I–O}$ = 0, f = 1.0 MHz)[2]	C_{ISO}	—	0.2	—	pF

1. Input–Output Isolation Voltage, V_{ISO}, is an internal device dielectric breakdown rating.
2. For this test, pins 1 and 2 are common, and pins 5, 6 and 7 are common.
3. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.
4. Always design to the specified minimum/maximum electrical limits (where applicable).
5. Current Transfer Ratio (CTR) = I_C/I_F x 100%.

TYPICAL CHARACTERISTICS

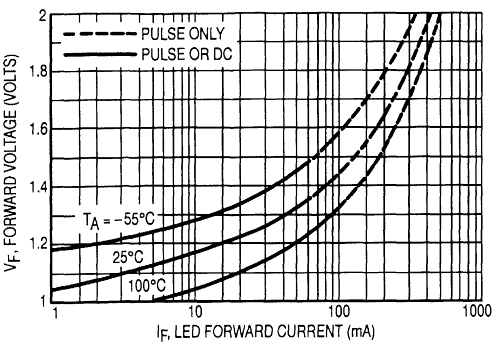


Figure 1. LED Forward Voltage versus Forward Current

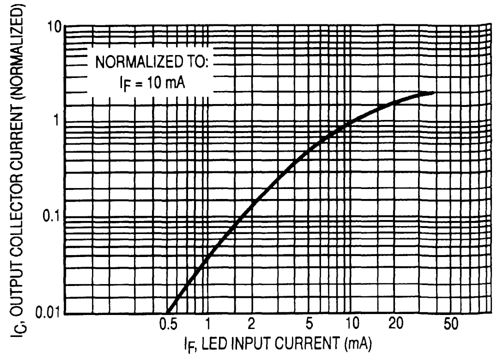


Figure 2. Output Current versus Input Current

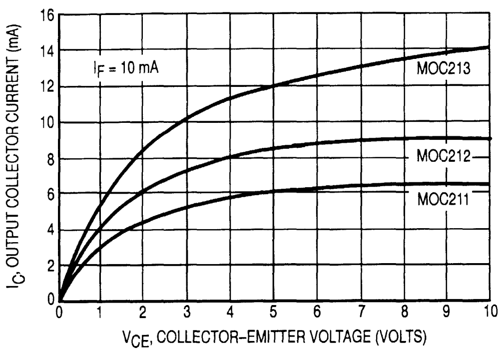


Figure 3. Output Current versus Collector–Emitter Voltage

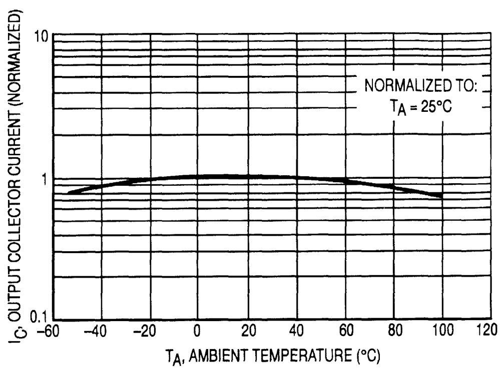


Figure 4. Output Current versus Ambient Temperature

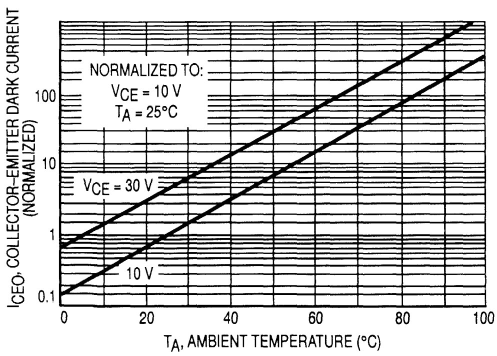


Figure 5. Dark Current versus Ambient Temperature

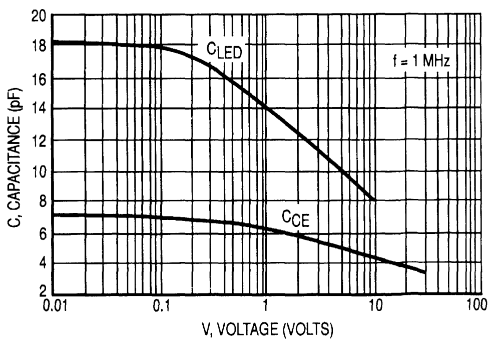


Figure 6. Capacitance versus Voltage

Small Outline Optoisolators

Transistor Output (Low Input Current)

MOC215
[CTR = 20% Min]
MOC216
[CTR = 50% Min]
MOC217
[CTR = 100% Min]

Motorola Preferred Devices

These devices consist of a gallium arsenide infrared emitting diode optically coupled to a monolithic silicon phototransistor detector, in a surface mountable, small outline, plastic package. They are ideally suited for high density applications, and eliminate the need for through–the–board mounting.

- Convenient Plastic SOIC–8 Surface Mountable Package Style
- Low LED Input Current Required, for Easier Logic Interfacing
- Standard SOIC–8 Footprint, with 0.050″ Lead Spacing
- Shipped in Tape and Reel, which Conforms to EIA Standard RS481A
- Compatible with Dual Wave, Vapor Phase and IR Reflow Soldering
- High Input–Output Isolation of 3000 Vac (rms) Guaranteed
- UL Recognized UL File #E54915

Ordering Information:

- To obtain MOC215, 216, 217 in Tape and Reel, add R2 suffix to device numbers:
  R2 = 2500 units on 13″ reel
- To obtain MOC215, 216, 217 in quantities of 50 (shipped in sleeves) — No Suffix

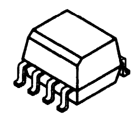
Marking Information:

- MOC215 = 215
- MOC216 = 216
- MOC217 = 217

Applications:

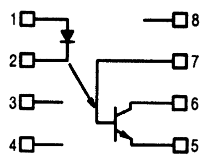
- Low power Logic Circuits
- Interfacing and coupling systems of different potentials and impedances
- Telecommunications equipment
- Portable electronics

SMALL OUTLINE OPTOISOLATORS TRANSISTOR OUTPUT



CASE 846–01, STYLE 1
PLASTIC

SCHEMATIC



1. LED ANODE
2. LED CATHODE
3. NO CONNECTION
4. NO CONNECTION
5. EMITTER
6. COLLECTOR
7. BASE
8. NO CONNECTION

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Forward Current — Continuous	I_F	60	mA
Forward Current — Peak (PW = 100 μs, 120 pps)	$I_F(pk)$	1.0	A
Reverse Voltage	V_R	6.0	V
LED Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	90 0.8	mW mW/°C
OUTPUT TRANSISTOR			
Collector–Emitter Voltage	V_{CEO}	30	V
Collector–Base Voltage	V_{CBO}	70	V
Emitter–Collector Voltage	V_{ECO}	7.0	V
Collector Current — Continuous	I_C	150	mA
Detector Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 1.76	mW mW/°C

NOTE: Thickness through insulation between input and output is ≥ 0.5 mm.

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 1

MAXIMUM RATINGS — continued (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
TOTAL DEVICE			
Input–Output Isolation Voltage(1,2) (60 Hz, 1.0 sec. duration)	V_{ISO}	3000	Vac(rms)
Total Device Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Ambient Operating Temperature Range(3)	T_A	–55 to +100	°C
Storage Temperature Range(3)	T_{stg}	–55 to +150	°C
Lead Soldering Temperature (1/16″ from case, 10 sec. duration)	—	260	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)(4)

Characteristic	Symbol	Min	Typ(4)	Max	Unit
INPUT LED					
Forward Voltage (I_F = 1.0 mA)	V_F	—	1.05	1.3	V
Reverse Leakage Current (V_R = 6.0 V)	I_R	—	0.1	100	μA
Capacitance	C	—	18	—	pF
OUTPUT TRANSISTOR					
Collector–Emitter Dark Current (V_{CE} = 5.0 V, T_A = 25°C)	I_{CEO1}	—	1.0	50	nA
(V_{CE} = 5.0 V, T_A = 100°C)	I_{CEO2}	—	1.0	—	μA
Collector–Emitter Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CEO}$	30	90	—	V
Emitter–Collector Breakdown Voltage (I_E = 100 μA)	$V_{(BR)ECO}$	7.0	7.8	—	V
Collector–Emitter Capacitance (f = 1.0 MHz, V_{CE} = 0)	C_{CE}	—	7.0	—	pF
COUPLED					
Output Collector Current (I_F = 1.0 mA, V_{CE} = 5.0 V) MOC215 MOC216 MOC217	I_C (CTR)(5)	200 (20) 500 (50) 1.0 (100)	500(50) 800 (80) 1.3 (130)	— — —	μA (%) μA (%) mA (%)
Collector–Emitter Saturation Voltage (I_C = 100 μA, I_F = 1.0 mA)	$V_{CE(sat)}$	—	0.35	0.4	V
Turn–On Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_{on}	—	7.5	—	μs
Turn–Off Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_{off}	—	5.7	—	μs
Rise Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_r	—	3.2	—	μs
Fall Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_f	—	4.7	—	μs
Input–Output Isolation Voltage (f = 60 Hz, t = 1.0 sec.)(1,2)	V_{ISO}	3000	—	—	Vac(rms)
Isolation Resistance ($V_{I–O}$ = 500 V)(2)	R_{ISO}	10^{11}	—	—	Ω
Isolation Capacitance ($V_{I–O}$ = 0, f = 1.0 MHz)(2)	C_{ISO}	—	0.2	—	pF

1. Input–Output Isolation Voltage, V_{ISO}, is an internal device dielectric breakdown rating.
2. For this test, pins 1 and 2 are common, and pins 5, 6 and 7 are common.
3. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.
4. Always design to the specified minimum/maximum electrical limits (where applicable).
5. Current Transfer Ratio (CTR) = I_C/I_F x 100%.

TYPICAL CHARACTERISTICS

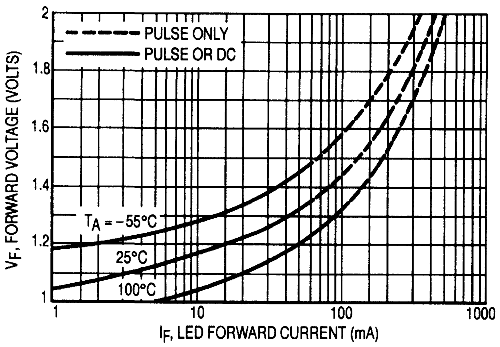


Figure 1. LED Forward Voltage versus Forward Current

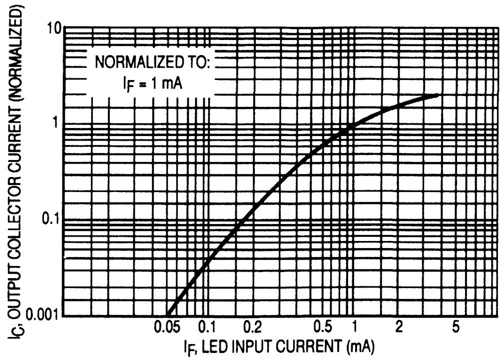


Figure 2. Output Current versus Input Current

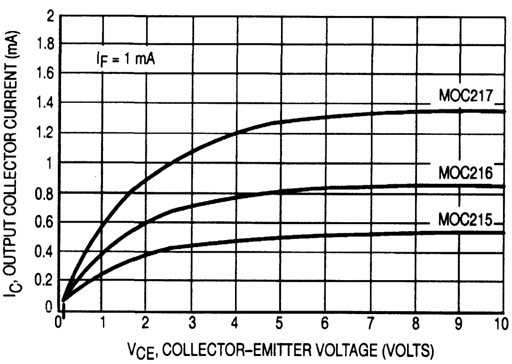


Figure 3. Output Current versus Collector–Emitter Voltage

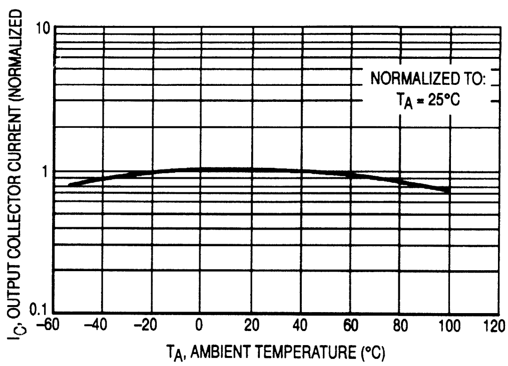


Figure 4. Output Current versus Ambient Temperature

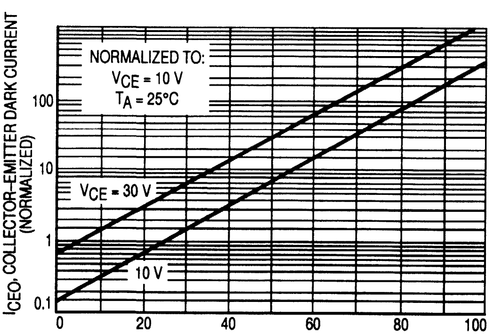


Figure 5. Dark Current versus Ambient Temperature

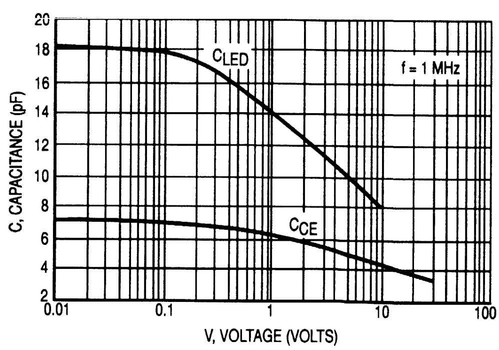


Figure 6. Capacitance versus Voltage

MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

Small Outline Optoisolators
Darlington Output

These devices consist of a gallium arsenide infrared emitting diode optically coupled to a monolithic silicon photodarlington detector, in a surface mountable, small outline, plastic package. They are ideally suited for high density applications, and eliminate the need for through–the–board mounting.

- Convenient Plastic SOIC–8 Surface Mountable Package Style
- High Current Transfer Ratio (CTR) at Low LED Input Current, for Easier Logic Interfacing
- Standard SOIC–8 Footprint, with 0.050″ Lead Spacing
- Shipped in Tape and Reel, which Conforms to EIA Standard RS481A
- Compatible with Dual Wave, Vapor Phase and IR Reflow Soldering
- High Input–Output Isolation of 3000 Vac (rms) Guaranteed
- UL Recognized File #E54915

Ordering Information:

- To obtain MOC223 in Tape and Reel, add R2 suffix to device numbers: R2 = 2500 units on 13″ reel
- To obtain MOC223 in quantities of 50 (shipped in sleeves) — No Suffix

Marking Information:

- MOC223 = 223

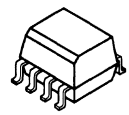
Applications:

- Low power Logic Circuits
- Interfacing and coupling systems of different potentials and impedances
- Telecommunications equipment
- Portable electronics

MOC223
[CTR = 500% Min]

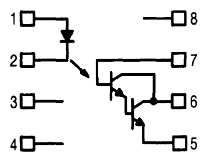
Motorola Preferred Device

SMALL OUTLINE OPTOISOLATORS DARLINGTON OUTPUT



CASE 846–01, STYLE 1
PLASTIC

SCHEMATIC



1. LED ANODE
2. LED CATHODE
3. NO CONNECTION
4. NO CONNECTION
5. EMITTER
6. COLLECTOR
7. BASE
8. NO CONNECTION

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Forward Current — Continuous	I_F	60	mA
Forward Current — Peak (PW = 100 µs, 120 pps)	$I_F(pk)$	1.0	A
Reverse Voltage	V_R	6.0	V
LED Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	90 0.8	mW mW/°C
OUTPUT DARLINGTON			
Collector–Emitter Voltage	V_{CEO}	30	V
Collector–Base Voltage	V_{CBO}	70	V
Emitter–Collector Voltage	V_{ECO}	7.0	V
Collector Current — Continuous	I_C	150	mA
Detector Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 1.76	mW mW/°C

NOTE: Thickness through insulation between input and output is ≥ 0.5 mm.

Preferred devices are Motorola recommended choices for future use and best overall value.

(Replaces MOC221/D)

MAXIMUM RATINGS — continued (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
TOTAL DEVICE			
Input–Output Isolation Voltage[1,2] (60 Hz, 1.0 sec. duration)	V_{ISO}	3000	Vac(rms)
Total Device Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Ambient Operating Temperature Range[3]	T_A	–55 to +100	°C
Storage Temperature Range[3]	T_{stg}	–55 to +150	°C
Lead Soldering Temperature (1/16″ from case, 10 sec. duration)	—	260	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)[4]

Characteristic	Symbol	Min	Typ[4]	Max	Unit
INPUT LED					
Forward Voltage (I_F = 1.0 mA)	V_F	—	1.05	1.3	V
Reverse Leakage Current (V_R = 6.0 V)	I_R	—	0.1	100	μA
Capacitance	C	—	18	—	pF
OUTPUT DARLINGTON					
Collector–Emitter Dark Current (V_{CE} = 5.0 V, T_A = 25°C)	$I_{CEO}1$	—	1.0	50	nA
(V_{CE} = 5.0 V, T_A = 100°C)	$I_{CEO}2$	—	1.0	—	μA
Collector–Emitter Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CEO}$	30	90	—	V
Emitter–Collector Breakdown Voltage (I_E = 100 μA)	$V_{(BR)ECO}$	7.0	7.8	—	V
Collector–Emitter Capacitance (f = 1.0 MHz, V_{CE} = 0)	C_{CE}	—	5.5	—	pF
COUPLED					
Output Collector Current (I_F = 1.0 mA, V_{CE} = 5.0 V)	I_C (CTR)[5]	5.0 (500)	10 (1000)	—	mA (%)
Collector–Emitter Saturation Voltage (I_C = 500 μA, I_F = 1.0 mA)	$V_{CE(sat)}$	—	—	1.0	V
Turn–On Time (I_F = 5.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_{on}	—	3.5	—	μs
Turn–Off Time (I_F = 5.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_{off}	—	95	—	μs
Rise Time (I_F = 5.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_r	—	1.0	—	μs
Fall Time (I_F = 5.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_f	—	2.0	—	μs
Input–Output Isolation Voltage (f = 60 Hz, t = 1.0 sec.)[1,2]	V_{ISO}	3000	—	—	Vac(rms)
Isolation Resistance ($V_{I–O}$ = 500 V)[2]	R_{ISO}	10^{11}	—	—	Ω
Isolation Capacitance ($V_{I–O}$ = 0, f = 1.0 MHz)[2]	C_{ISO}	—	0.2	—	pF

1. Input–Output Isolation Voltage, V_{ISO}, is an internal device dielectric breakdown rating.
2. For this test, pins 1 and 2 are common, and pins 5, 6 and 7 are common.
3. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.
4. Always design to the specified minimum/maximum electrical limits (where applicable).
5. Current Transfer Ratio (CTR) = I_C/I_F x 100%.

TYPICAL CHARACTERISTICS

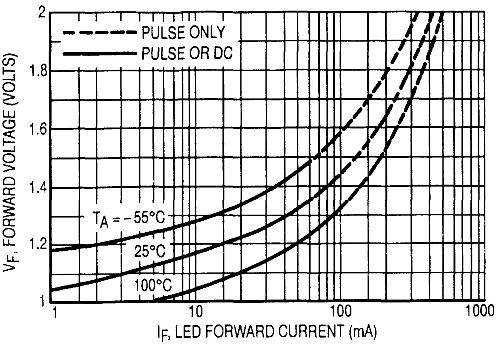


Figure 1. LED Forward Voltage versus Forward Current

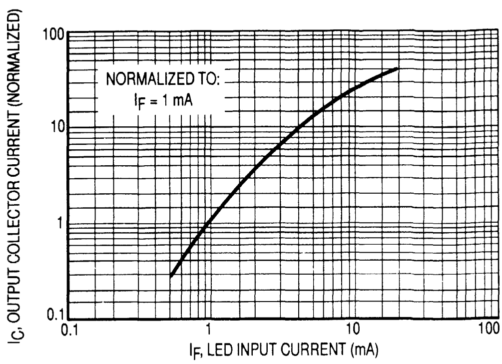


Figure 2. Output Current versus Input Current

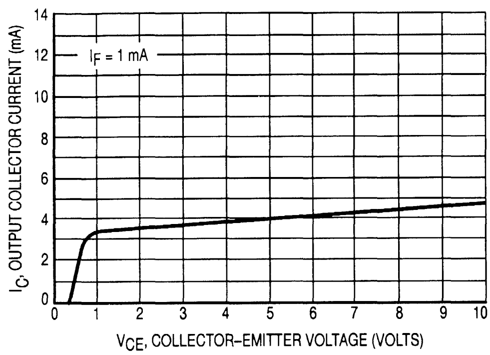


Figure 3. Output Current versus Collector–Emitter Voltage

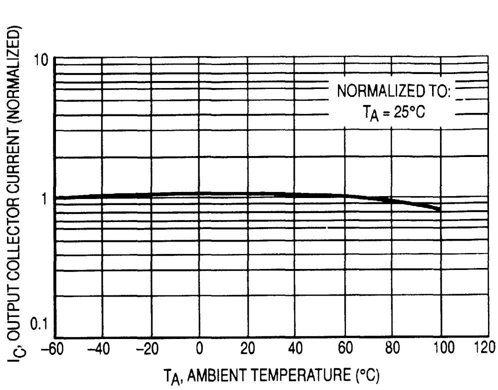


Figure 4. Output Current versus Ambient Temperature

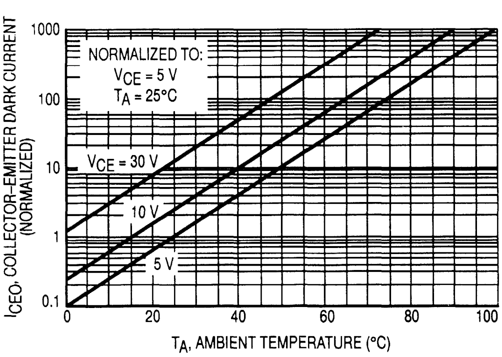


Figure 5. Dark Current versus Ambient Temperature

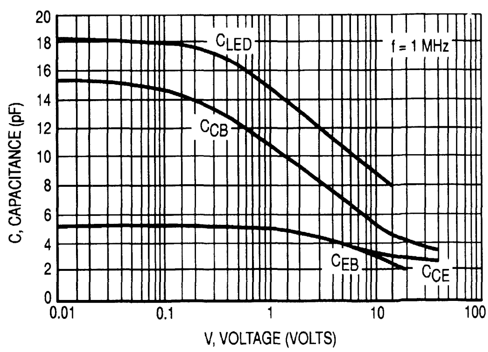


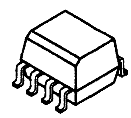
Figure 6. Capacitance versus Voltage

AC Input Phototransistor Small Outline Surface Mount Optocoupler

MOC256

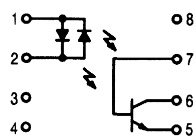
Motorola Preferred Device

SMALL OUTLINE OPTOISOLATORS AC INPUT TRANSISTOR OUTPUT



CASE 846–01, STYLE 2 PLASTIC

SCHEMATIC



PIN 1. AC IN
2. AC IN
3. N.C.
4. N.C.
5. EMITTER
6. COLLECTOR
7. BASE
8. N.C.

The MOC256 is an AC input phototransistor optocoupler. The device consists of two infrared emitters connected in anti–parallel and coupled to a silicon NPN phototransistor detector. They are designed for applications requiring the detection or monitoring of AC signals. These devices are constructed with a standard SOIC–8 footprint.

- Guaranteed Current Transfer Ratio CTR of 20% at I_F=10 mA
- UL Recognized. File Number E54915
- Industry Standard SOIC–8 Surface Mountable Package
- Standard Lead Spacing of 0.050 inches
- Available in Tape and Reel Option (Conforms to EIA Standard RS481A)
- Bidirectional AC Input (Protection Against Reversed DC Bias)
- Guaranteed CTR Symmetry of 2:1 Maximum
- High Input–Output Isolation of 3000 Vac (rms) Guaranteed

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Forward Current — Continuous	I_F	60	mA
Forward Current — Peak (PW = 100 µs, 120 pps)	$I_{F(pk)}$	1	A
Reverse Voltage	V_R	6	V
LED Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	90 0.8	mW mW/°C
OUTPUT TRANSISTOR			
Collector–Emitter Voltage	V_{CEO}	30	V
Emitter–Base Voltage	V_{ECO}	7	V
Collector Current — Continuous	I_C	150	mA
Detector Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 1.76	mW mW/°C
TOTAL DEVICE			
Input–Output Isolation Voltage(1) (60 Hz, 1 sec Duration)	V_{ISO}	3000	Vac(rms)
Total Device Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Ambient Operating Temperature Range(2)	T_A	−55 to +100	°C
Storage Temperature Range(2)	T_{stg}	−55 to +150	°C
Lead Soldering Temperature (10 sec, 1/16″ from case)	—	260	°C

1. Input–output isolation voltage is an internal device dielectric breakdown rating. For this test, Pins 1 and 2 are common, and Pins 5, 6 and 7 are common.
2. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.

NOTE: Thickness through insulation between input and output is ≥ 0.5 mm.

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 1

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)[1]

Characteristic	Symbol	Min	Typ[1]	Max	Unit
INPUT LED					
Forward Voltage (I_F = 10 mA, either direction)	V_F	—	1.15	1.5	Volts
Capacitance (V = 0 V, f = 1 MHz)	C_J	—	20	—	pF
OUTPUT TRANSISTOR					
Collector–Emitter Dark Current (V_{CE} = 10 V)	I_{CEO}	—	1	100	nA
T_A = 100°C		—	1	—	μA
Collector–Base Dark Current (V_{CB} = 10 V)	I_{CBO}	—	0.2	—	nA
Collector–Emitter Breakdown Voltage (I_C = 10 mA)	$V_{(BR)CEO}$	30	45	—	Volts
Collector–Base Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CBO}$	70	100	—	Volts
Emitter–Collector Breakdown Voltage (I_E = 100 μA)	$V_{(BR)ECO}$	5	7.8	—	Volts
DC Current Gain (I_C = 2 mA, V_{CE} = 5 V)	h_{FE}	—	500	—	—
Collector–Emitter Capacitance (f = 1 MHz, V_{CE} = 0 V)	C_{CE}	—	7	—	pF
Collector–Base Capacitance (f = 1 MHz, V_{CB} = 0 V)	C_{CB}	—	20	—	pF
Emitter–Base Capacitance (f = 1 MHz, V_{EB} = 0 V)	C_{EB}	—	10	—	pF
COUPLED					
Output Collector Current (I_F = ±10 mA, V_{CE} = 10 V)	I_C (CTR)[5]	2 (20)	15 (150)	—	mA (%)
Output Collector Current Symmetry[3] $\left(\frac{I_C \text{ at } I_F = +10 \text{ mA}, V_{CE} = 10 \text{ V}}{I_C \text{ at } I_F = -10 \text{ mA}, V_{CE} = 10 \text{ V}}\right)$	—	0.5	1.0	2.0	—
Collector–Emitter Saturation Voltage (I_C = 0.5 mA, I_F = ±10 mA)	$V_{CE(sat)}$	—	0.1	0.4	Volts
Input–Output Isolation Voltage (f = 60 Hz, t = 1 sec)[4,5]	V_{ISO}	3000	—	—	Vac(rms)
Isolation Resistance (V = 500 V)[5]	R_{ISO}	10^{11}	—	—	Ω
Isolation Capacitance (V = 0 V, f = 1 MHz)[5]	C_{ISO}	—	0.2	—	pF

1. Always design to the specified minimum/maximum electrical limits (where applicable).
2. Current Transfer Ratio (CTR) = I_C/I_F x 100%.
3. This specification guarantees that the higher of the two I_C readings will be no more than 3 times the lower at I_F = 10 mA.
4. Input–Output Isolation Voltage, V_{ISO}, is an internal device dielectric breakdown rating.
5. For this test, pins 1 and 2 are common, and pins 5, 6 and 7 are common.

TYPICAL CHARACTERISTICS

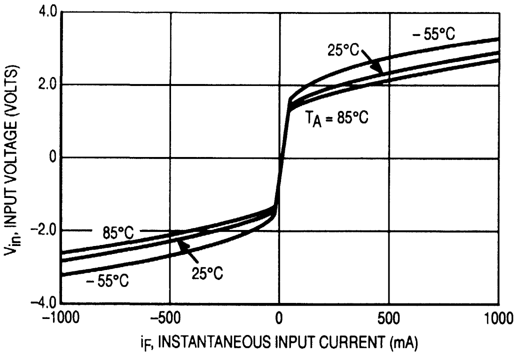


Figure 1. Input Voltage versus Input Current

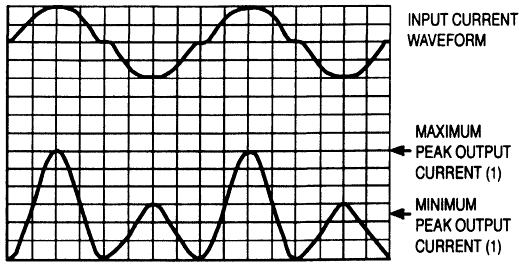


Figure 2. Output Characteristics

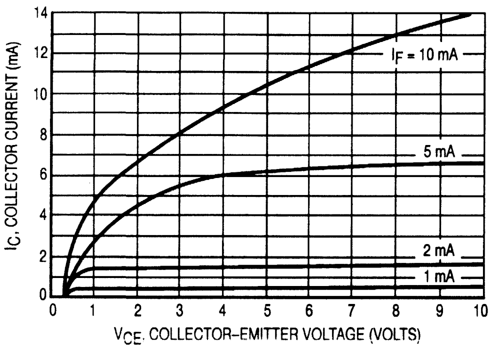


Figure 3. Collector Current versus Collector–Emitter Voltage

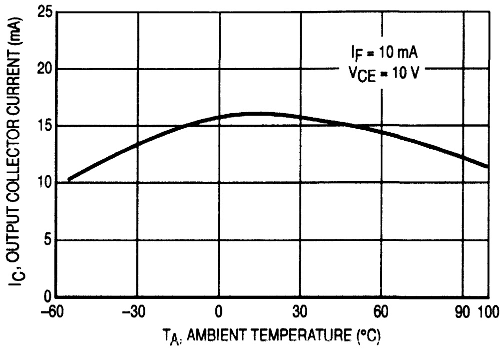


Figure 4. Output Current versus Ambient Temperature

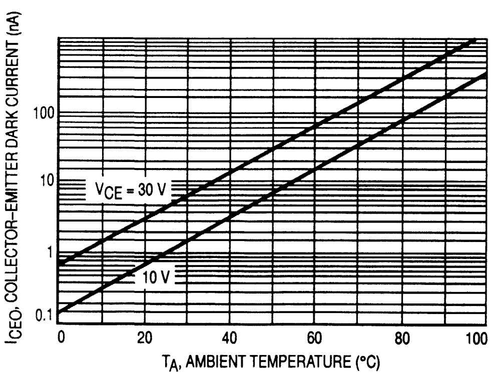


Figure 5. Dark Current versus Ambient Temperature

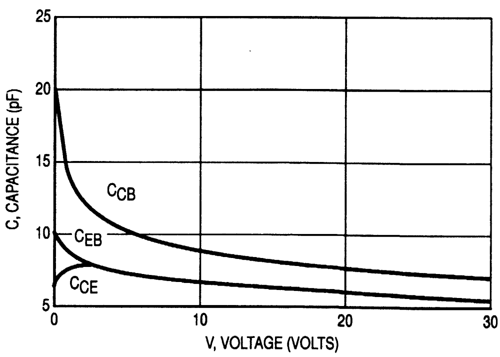


Figure 6. Capacitances versus Voltage

Small Outline Optoisolators
Darlington Output (No Base Connection)

These devices consist of a gallium arsenide infrared emitting diode optically coupled to a monolithic silicon photodarlington detector, in a surface mountable, small outline, plastic package. No base connection for improved noise immunity.

- Convenient Plastic SOIC–8 Surface Mountable Package Style
- High Current Transfer Ratio (CTR) at Low LED Input Current, for Easier Logic Interfacing
- Standard SOIC–8 Footprint, with 0.050″ Lead Spacing
- Shipped in Tape and Reel, which Conforms to EIA Standard RS481A
- Compatible with Dual Wave, Vapor Phase and IR Reflow Soldering
- High Input–Output Isolation of 3000 Vac (rms) Guaranteed
- UL Recognized File #E54915

Ordering Information:

- To obtain MOC263 in Tape and Reel, add R2 suffix to device numbers:
  R2 = 2500 units on 13″ reel
- To obtain MOC263 in quantities of 50 (shipped in sleeves) — No Suffix

Marking Information:

- MOC263 = 263

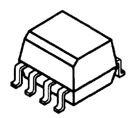
Applications:

- Low Power Logic Circuits
- Interfacing and coupling systems of different potentials and impedances
- Telecommunications equipment
- Portable electronics

MOC263
[CTR = 500% Min]

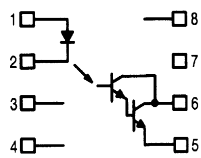
Motorola Preferred Device

SMALL OUTLINE OPTOISOLATORS DARLINGTON OUTPUT NO BASE CONNECTION



CASE 846–01, STYLE 1
PLASTIC

SCHEMATIC



1. LED ANODE
2. LED CATHODE
3. NO CONNECTION
4. NO CONNECTION
5. EMITTER
6. COLLECTOR
7. NO CONNECTION
8. NO CONNECTION

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Forward Current — Continuous	I_F	60	mA
Forward Current — Peak (PW = 100 μs, 120 pps)	$I_{F(pk)}$	1.0	A
Reverse Voltage	V_R	6.0	V
LED Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	90 0.8	mW mW/°C
OUTPUT DARLINGTON			
Collector–Emitter Voltage	V_{CEO}	30	V
Emitter–Collector Voltage	V_{ECO}	7.0	V
Collector Current — Continuous	I_C	150	mA
Detector Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 1.76	mW mW/°C

NOTE: Thickness through insulation between input and output is ≥ 0.5 mm.

Preferred devices are Motorola recommended choices for future use and best overall value.

MAXIMUM RATINGS — continued (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
TOTAL DEVICE			
Input–Output Isolation Voltage(1,2) (60 Hz, 1.0 sec. duration)	V_{ISO}	3000	Vac(rms)
Total Device Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Ambient Operating Temperature Range(3)	T_A	–55 to +100	°C
Storage Temperature Range(3)	T_{stg}	–55 to +150	°C
Lead Soldering Temperature (1/16″ from case, 10 sec. duration)	—	260	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)(4)

Characteristic	Symbol	Min	Typ(4)	Max	Unit
INPUT LED					
Forward Voltage (I_F = 1.0 mA)	V_F	—	1.05	1.3	V
Reverse Leakage Current (V_R = 6.0 V)	I_R	—	0.1	100	μA
Capacitance	C	—	18	—	pF
OUTPUT DARLINGTON					
Collector–Emitter Dark Current (V_{CE} = 5.0 V, T_A = 25°C)	$I_{CEO}1$	—	1.0	50	nA
(V_{CE} = 5.0 V, T_A = 100°C)	$I_{CEO}2$	—	1.0	—	μA
Collector–Emitter Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CEO}$	30	90	—	V
Emitter–Collector Breakdown Voltage (I_E = 100 μA)	$V_{(BR)ECO}$	7.0	7.8	—	V
Collector–Emitter Capacitance (f = 1.0 MHz, V_{CE} = 0)	C_{CE}	—	5.5	—	pF
COUPLED					
Output Collector Current (I_F = 1.0 mA, V_{CE} = 5.0 V)		5.0 (500)	10 (1000)	—	mA (%)
Collector–Emitter Saturation Voltage (I_C = 500 μA, I_F = 1.0 mA)	$V_{CE(sat)}$	—	—	1.0	V
Turn–On Time (I_F = 5.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_{on}	—	3.5	—	μs
Turn–Off Time (I_F = 5.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_{off}	—	95	—	μs
Rise Time (I_F = 5.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_r	—	1.0	—	μs
Fall Time (I_F = 5.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_f	—	2.0	—	μs
Input–Output Isolation Voltage (f = 60 Hz, t = 1.0 sec.)(1,2)	V_{ISO}	3000	—	—	Vac(rms)
Isolation Resistance (V_{I-O} = 500 V)(2)	R_{ISO}	10^{11}	—	—	Ω
Isolation Capacitance (V_{I-O} = 0, f = 1.0 MHz)(2)	C_{ISO}	—	0.2	—	pF

1. Input–Output Isolation Voltage, V_{ISO}, is an internal device dielectric breakdown rating.
2. For this test, pins 1 and 2 are common, and pins 5, 6 and 7 are common.
3. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.
4. Always design to the specified minimum/maximum electrical limits (where applicable).
5. Current Transfer Ratio (CTR) = I_C/I_F x 100%.

TYPICAL CHARACTERISTICS

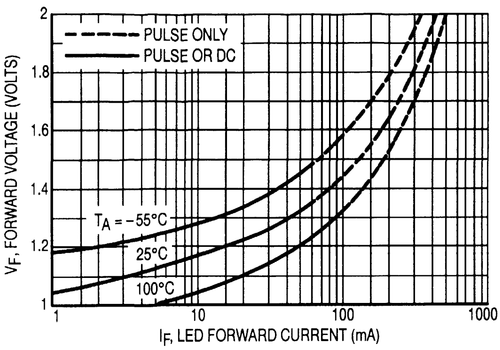


Figure 1. LED Forward Voltage versus Forward Current

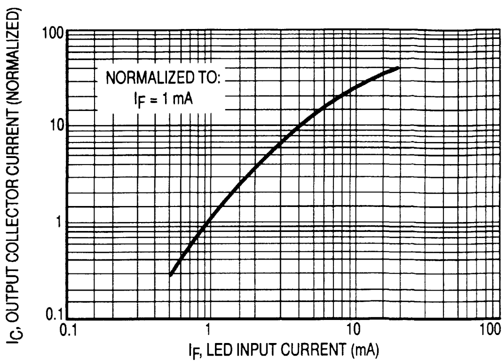


Figure 2. Output Current versus Input Current

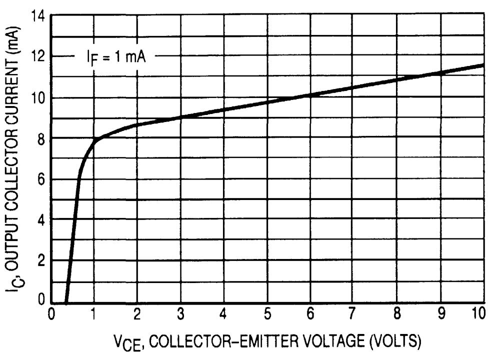


Figure 3. Output Current versus Collector–Emitter Voltage

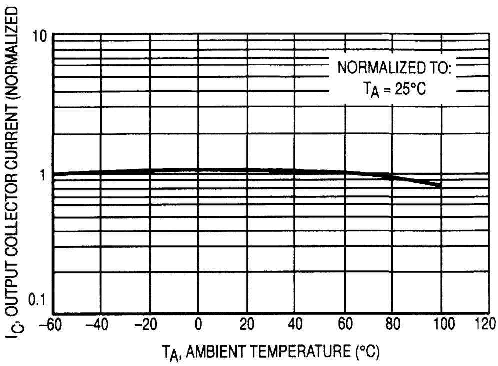


Figure 4. Output Current versus Ambient Temperature

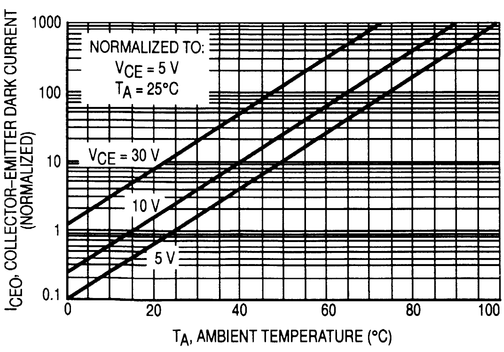


Figure 5. Dark Current versus Ambient Temperature

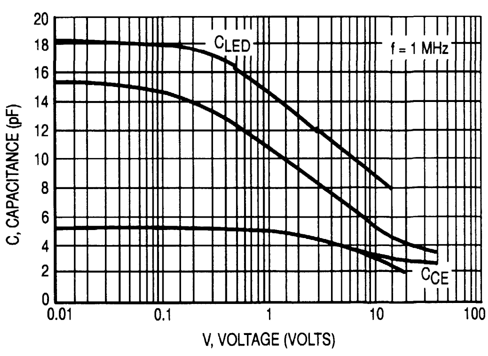


Figure 6. Capacitance versus Voltage

Dual Channel Small Outline Optoisolators
Transistor Output

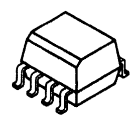
MOCD207
[CTR = 100–200%]
MOCD208
[CTR = 40–125%]

Motorola Preferred Devices

These devices consist of two gallium arsenide infrared emitting diodes optically coupled to two monolithic silicon phototransistor detectors, in a surface mountable, small outline, plastic package. They are ideally suited for high density applications and eliminate the need for through–the–board mounting.

- Dual Channel Coupler
- Convenient Plastic SOIC–8 Surface Mountable Package Style
- Closely Matched Current Transfer Ratios to Minimize Unit–to–Unit Variation
- Minimum $V_{(BR)CEO}$ of 70 Volts Guaranteed
- Standard SOIC–8 Footprint, with 0.050″ Lead Spacing
- Shipped in Tape and Reel, which Conforms to EIA Standard RS481A
- Compatible with Dual Wave, Vapor Phase and IR Reflow Soldering
- High Input–Output Isolation of 3000 Vac (rms) Guaranteed
- Meets U.L. Regulatory Requirements, File #E54915

DUAL CHANNEL SMALL OUTLINE OPTOISOLATORS TRANSISTOR OUTPUT



CASE 846–01, STYLE 3 PLASTIC

Ordering Information:

- To obtain MOCD207, 208 in tape and reel, add R2 suffix to device numbers as follows:
  R2 = 2500 units on 13″ reel
- To obtain MOCD207, 208 in quantities of 50 (shipped in sleeves) — no suffix

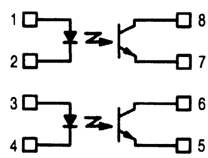
Marking Information:

- MOCD207 = D207
- MOCD208 = D208

Applications:

- Feedback Control Circuits
- Interfacing and Coupling Systems of Different Potentials and Impedances
- General Purpose Switching Circuits
- Monitor and Detection Circuits

SCHEMATIC



1. ANODE 1
2. CATHODE 1
3. ANODE 2
4. CATHODE 2
5. EMITTER 2
6. COLLECTOR 2
7. EMITTER 1
8. COLLECTOR 1

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Forward Current — Continuous	I_F	60	mA
Forward Current — Peak (PW = 100 μs, 120 pps)	$I_{F(pk)}$	1.0	A
Reverse Voltage	V_R	6.0	V
LED Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	90 0.8	mW mW/°C
OUTPUT TRANSISTOR			
Collector–Emitter Voltage	V_{CEO}	70	V
Collector–Base Voltage	V_{CBO}	70	V
Emitter–Collector Voltage	V_{ECO}	7.0	V
Collector Current — Continuous	I_C	150	mA
Detector Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 1.76	mW mW/°C

NOTE: Thickness through insulation between input and output is ≥ 0.5 mm.

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 1

MAXIMUM RATINGS—continued (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
TOTAL DEVICE			
Input–Output Isolation Voltage)(1,2) (60 Hz, 1.0 sec. duration)	V_{ISO}	3000	Vac(rms)
Total Device Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Ambient Operating Temperature Range	T_A	–55 to +100	°C
Storage Temperature Range	T_{stg}	–55 to +150	°C
Lead Soldering Temperature (1/16″ from case, 10 sec. duration)	—	260	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)(3)

Characteristic	Symbol	Min	Typ(3)	Max	Unit
INPUT LED					
Forward Voltage (I_F = 30 mA)	V_F	—	1.2	1.55	V
Reverse Leakage Current (V_R = 6.0 V)	I_R	—	0.1	100	μA
Capacitance	C	—	18	—	pF
OUTPUT TRANSISTOR					
Collector–Emitter Dark Current (V_{CE} = 10 V, T_A = 25°C)	I_{CEO1}	—	1.0	50	nA
(V_{CE} = 10 V, T_A = 100°C)	I_{CEO2}	—	1.0	—	μA
Collector–Emitter Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CEO}$	70	120	—	V
Emitter–Collector Breakdown Voltage (I_E = 100 μA)	$V_{(BR)ECO}$	7.0	7.8	—	V
Collector–Emitter Capacitance (f = 1.0 MHz, V_{CE} = 0)	C_{CE}	—	7.0	—	pF
COUPLED					
Output Collector Current (I_F = 10 mA, V_{CE} = 5 V) MOCD207 MOCD208	I_C (CTR)(4)	10 (100) 4.0 (40)	15 (150) —	20 (200) 12.5 (125)	mA (%)
Output Collector Current (I_F = 1 mA, V_{CE} = 5 V) MOCD207 MOCD208	I_C	3.4 1.3	7.0 3.0	— —	mA
Collector–Emitter Saturation Voltage (I_C = 2.0 mA, I_F = 10 mA)	$V_{CE(sat)}$	—	0.15	0.4	V
Turn–On Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_{on}	—	3.0	—	μs
Turn–Off Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_{off}	—	2.8	—	μs
Rise Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_r	—	1.6	—	μs
Fall Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_f	—	2.2	—	μs
Input–Output Isolation Voltage (f = 60 Hz, t = 1.0 sec)(1,2)	V_{ISO}	3000	—	—	Vac(rms)
Isolation Resistance (V_{I-O} = 500 V)(2)	R_{ISO}	10^{11}	—	—	Ω
Isolation Capacitance (V_{I-O} = 0, f = 1.0 MHz)(2)	C_{ISO}	—	0.2	—	pF

1. Input–Output Isolation Voltage, V_{ISO}, is an internal device dielectric breakdown rating.
2. For this test, pins 1, 2, 3 and 4 are common, and pins 5, 6 and 7 are common.
3. Always design to the specified minimum/maximum electrical limits (where applicable).
4. Current Transfer Ratio (CTR) = I_C/I_F x 100%.

TYPICAL CHARACTERISTICS

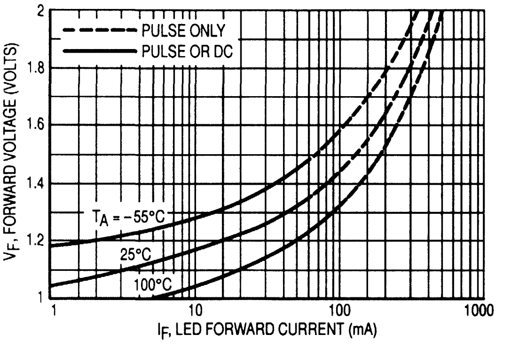


Figure 1. LED Forward Voltage versus Forward Current

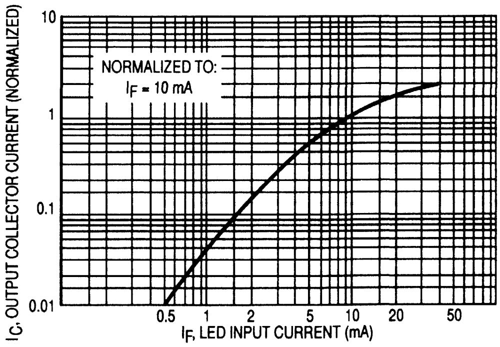


Figure 2. Output Current versus Input Current

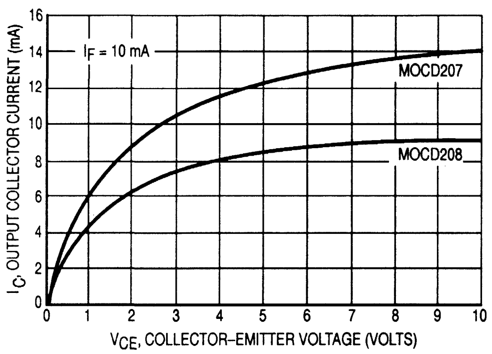


Figure 3. Output Current versus Collector–Emitter Voltage

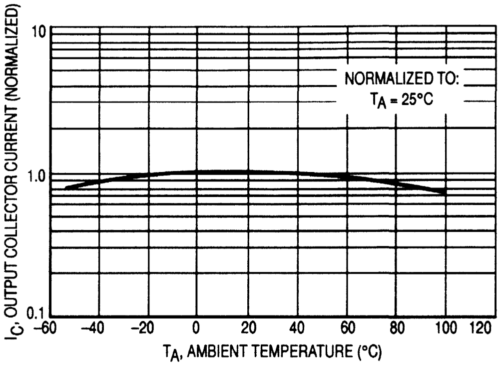


Figure 4. Output Current versus Ambient Temperature

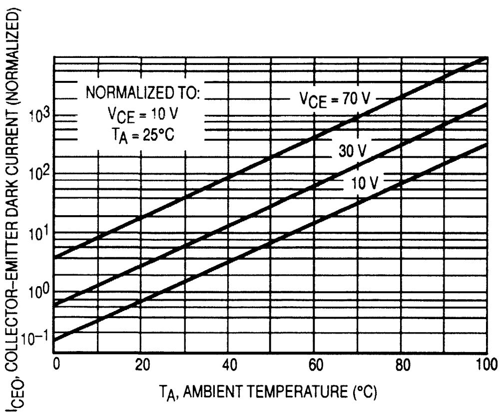


Figure 5. Dark Current versus Ambient Temperature

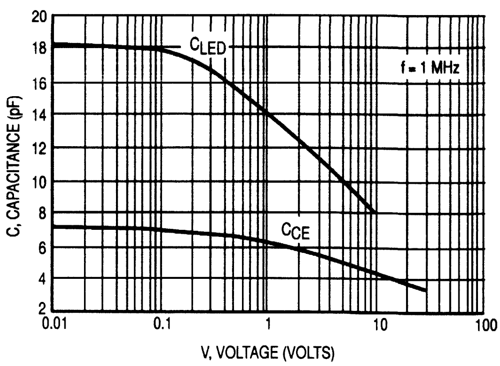


Figure 6. Capacitance versus Voltage

Dual Channel Small Outline Optoisolators
Transistor Output

The MOCD211 device consists of two gallium arsenide infrared emitting diodes optically coupled to two monolithic silicon phototransistor detectors, in a surface mountable, small outline, plastic package. It is ideally suited for high density applications and eliminates the need for through–the–board mounting.

- Dual Channel Coupler
- Convenient Plastic SOIC–8 Surface Mountable Package Style
- Minimum $V_{(BR)CEO}$ of 30 Volts Guaranteed
- Standard SOIC–8 Footprint, with 0.050″ Lead Spacing
- Shipped in Tape and Reel, which conforms to EIA Standard RS481A
- Compatible with Dual Wave, Vapor Phase and IR Reflow Soldering
- High Input–Output Isolation of 3000 Vac (rms) Guaranteed
- Meets U.L. Regulatory Requirements, File #E54915

Ordering Information:

- To obtain MOCD211 in tape and reel, add R2 suffix to device number as follows:
  R2 = 2500 units on 13″ reel
- To obtain MOCD211 in quantities of 50 (shipped in sleeves) — no suffix

Marking Information:

- MOCD211 = D211

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

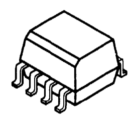
Rating	Symbol	Value	Unit
INPUT LED			
Forward Current — Continuous	I_F	60	mA
Forward Current — Peak (PW = 100 µs, 120 pps)	I_F(pk)	1.0	A
Reverse Voltage	V_R	6.0	V
LED Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	90 0.8	mW mW/°C
OUTPUT TRANSISTOR			
Collector–Emitter Voltage	V_{CEO}	30	V
Collector–Base Voltage	V_{CBO}	70	V
Emitter–Collector Voltage	V_{ECO}	7.0	V
Collector Current — Continuous	I_C	150	mA
Detector Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 1.76	mW mW/°C

NOTE: Thickness through insulation between input and output is ≥ 0.5 mm.

MOCD211
[CTR = 20% Min]

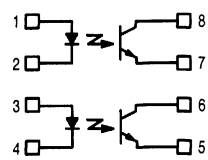
Motorola Preferred Device

DUAL CHANNEL SMALL OUTLINE OPTOISOLATOR TRANSISTOR OUTPUT



CASE 846–01, STYLE 3
PLASTIC

SCHEMATIC



1. ANODE 1
2. CATHODE 1
3. ANODE 2
4. CATHODE 2
5. EMITTER 2
6. COLLECTOR 2
7. EMITTER 1
8. COLLECTOR 1

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 1

MAXIMUM RATINGS — continued (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
TOTAL DEVICE			
Input–Output Isolation Voltage[1,2] (60 Hz, 1.0 sec. duration)	V_{ISO}	3000	Vac(rms)
Total Device Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Ambient Operating Temperature Range[3]	T_A	–55 to +100	°C
Storage Temperature Range[3]	T_{stg}	–55 to +150	°C
Lead Soldering Temperature (1/16″ from case, 10 sec. duration)	—	260	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)[4]

Characteristic	Symbol	Min	Typ[4]	Max	Unit
INPUT LED					
Forward Voltage (I_F = 1.0 mA)	V_F	—	1.15	1.5	V
Reverse Leakage Current (V_R = 6.0 V)	I_R	—	0.1	100	μA
Capacitance	C	—	18	—	pF
OUTPUT TRANSISTOR					
Collector–Emitter Dark Current (V_{CE} = 5.0 V, T_A = 25°C)	$I_{CEO}1$	—	1.0	50	nA
(V_{CE} = 5.0 V, T_A = 100°C)	$I_{CEO}2$	—	1.0	—	μA
Collector–Emitter Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CEO}$	30	90	—	V
Emitter–Collector Breakdown Voltage (I_E = 100 μA)	$V_{(BR)ECO}$	7.0	7.8	—	V
Collector–Emitter Capacitance (f = 1.0 MHz, V_{CE} = 0)	C_{CE}	—	7.0	—	pF
COUPLED					
Output Collector Current MOCD211 (I_F = 10 mA, V_{CE} = 10 V)	I_C (CTR)[5]	2.0 (20)	6.5 (65)	—	mA (%)
Collector–Emitter Saturation Voltage (I_C = 2.0 mA, I_F = 1.0 mA)	$V_{CE(sat)}$	—	0.15	0.4	V
Turn–On Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_{on}	—	7.5	—	μs
Turn–Off Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_{off}	—	5.7	—	μs
Rise Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_r	—	3.2	—	μs
Fall Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_f	—	4.7	—	μs
Input–Output Isolation Voltage (f = 60 Hz, t = 1.0 sec.)[1,2]	V_{ISO}	3000	—	—	Vac(rms)
Isolation Resistance (V_{I-O} = 500 V)[2]	R_{ISO}	10^{11}	—	—	Ω
Isolation Capacitance (V_{I-O} = 0, f = 1.0 MHz)[2]	C_{ISO}	—	0.2	—	pF

1. Input–Output Isolation Voltage, V_{ISO}, is an internal device dielectric breakdown rating.
2. For this test, pins 1, 2, 3 and 4 are common, and pins 5, 6, 7 and 8 are common.
3. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.
4. Always design to the specified minimum/maximum electrical limits (where applicable).
5. Current Transfer Ratio (CTR) = I_C/I_F x 100%.

TYPICAL CHARACTERISTICS

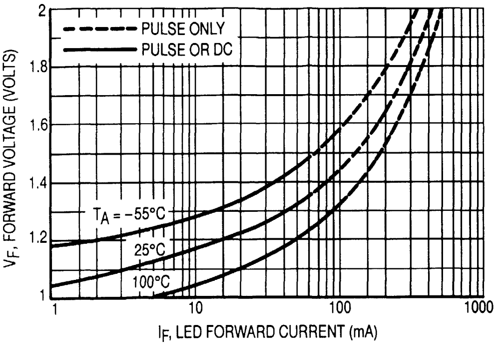


Figure 1. LED Forward Voltage versus Forward Current

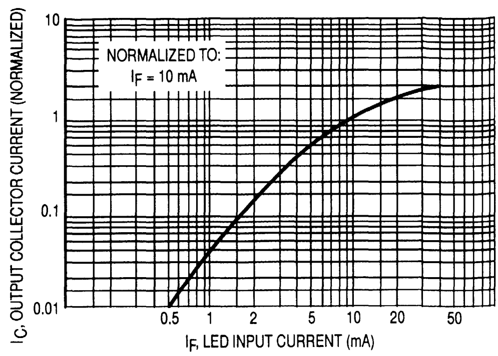


Figure 2. Output Current versus Input Current

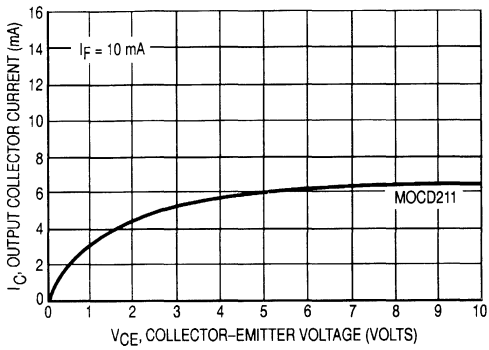


Figure 3. Output Current versus Collector–Emitter Voltage

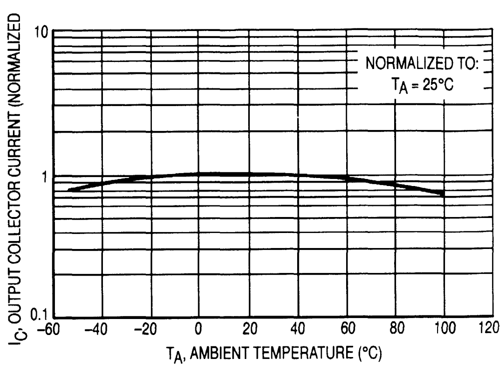


Figure 4. Output Current versus Ambient Temperature

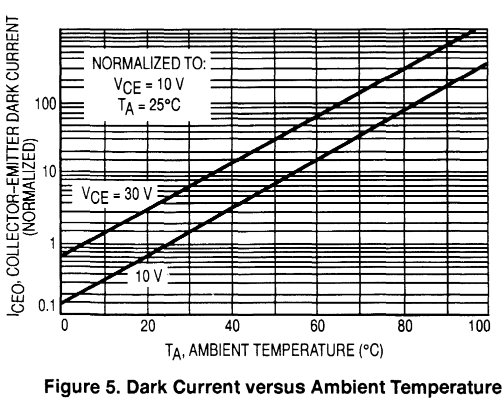


Figure 5. Dark Current versus Ambient Temperature

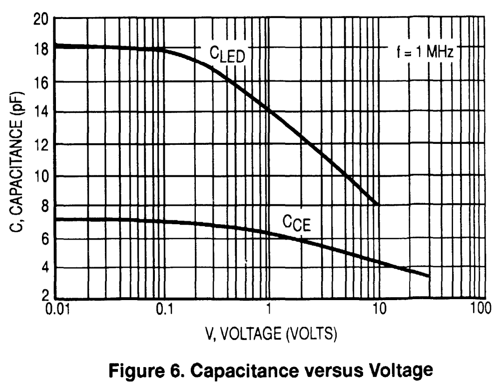


Figure 6. Capacitance versus Voltage

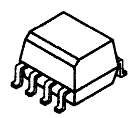
Dual Channel Small Outline Optoisolator
Transistor Output

MOCD213
[CTR = 100% Min]

DUAL CHANNEL SMALL OUTLINE OPTOISOLATOR TRANSISTOR OUTPUT

This device consists of two gallium arsenide infrared emitting diodes optically coupled to two monolithic silicon phototransistor detectors, in a surface mountable, small outline, plastic package. It is ideally suited for high density applications and eliminates the need for through–the–board mounting.

- Dual Channel Coupler
- Convenient Plastic SOIC–8 Surface Mountable Package Style
- Minimum Current Transfer Ratio 100% with Input Current of 10 mA
- Minimum $V_{(BR)CEO}$ of 70 Volts Guaranteed
- Standard SOIC–8 Footprint, with 0.050″ Lead Spacing
- Shipped in Tape and Reel, which Conforms to EIA Standard RS481A
- Compatible with Dual Wave, Vapor Phase and IR Reflow Soldering
- High Input–Output Isolation of 3000 Vac (rms) Guaranteed
- Meets U.L. Regulatory Requirements, File #E54915



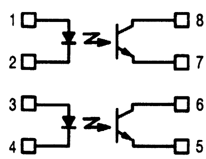
CASE 846–01, STYLE 3
PLASTIC

Ordering Information:
- To obtain MOCD213 in tape and reel, add R2 suffix to device number as follows:
  R2 = 2500 units on 13″ reel
- To obtain MOCD213 in quantities of 50 (shipped in sleeves) — no suffix

Marking Information:
- MOCD213 = D213

Applications:
- Feedback Control Circuits
- Interfacing and Coupling Systems of Different Potentials and Impedances
- General Purpose Switching Circuits
- Monitor and Detection Circuits

SCHEMATIC



1. ANODE 1
2. CATHODE 1
3. ANODE 2
4. CATHODE 2
5. EMITTER 2
6. COLLECTOR 2
7. EMITTER 1
8. COLLECTOR 1

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Forward Current — Continuous	I_F	60	mA
Forward Current — Peak (PW = 100 µs, 120 pps)	$I_{F(pk)}$	1.0	A
Reverse Voltage	V_R	6.0	V
LED Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	90 0.8	mW mW/°C
OUTPUT TRANSISTOR			
Collector–Emitter Voltage	V_{CEO}	70	V
Collector–Base Voltage	V_{CBO}	70	V
Emitter–Collector Voltage	V_{ECO}	7.0	V
Collector Current — Continuous	I_C	150	mA
Detector Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 1.76	mW mW/°C

NOTE: Thickness through insulation between input and output is ≥ 0.5 mm.

REV 2

MAXIMUM RATINGS—continued (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
TOTAL DEVICE			
Input–Output Isolation Voltage(1,2) (60 Hz, 1.0 sec. duration)	V_{ISO}	3000	Vac(rms)
Total Device Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Ambient Operating Temperature Range(3)	T_A	–55 to +100	°C
Storage Temperature Range(3)	T_{stg}	–55 to +150	°C
Lead Soldering Temperature (1/16″ from case, 10 sec. duration)	—	260	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)(4)

Characteristic	Symbol	Min	Typ(4)	Max	Unit
INPUT LED					
Forward Voltage (I_F = 30 mA)	V_F	—	1.2	1.55	V
Reverse Leakage Current (V_R = 6.0 V)	I_R	—	0.1	100	μA
Capacitance	C	—	18	—	pF
OUTPUT TRANSISTOR					
Collector–Emitter Dark Current (V_{CE} = 10 V, T_A = 25°C)	I_{CEO1}	—	1.0	50	nA
(V_{CE} = 10 V, T_A = 100°C)	I_{CEO2}	—	1.0	—	μA
Collector–Emitter Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CEO}$	70	120	—	V
Emitter–Collector Breakdown Voltage (I_E = 100 μA)	$V_{(BR)ECO}$	7.0	7.8	—	V
Collector–Emitter Capacitance (f = 1.0 MHz, V_{CE} = 0)	C_{CE}	—	7.0	—	pF
COUPLED					
Output Collector Current MOCD213 (I_F = 10 mA, V_{CE} = 5 V)	I_C (CTR)(5)	10 (100)	—	—	mA (%)
Collector–Emitter Saturation Voltage (I_C = 2.0 mA, I_F = 10 mA)	$V_{CE(sat)}$	—	0.15	0.4	V
Turn–On Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_{on}	—	3.0	—	μs
Turn–Off Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_{off}	—	2.8	—	μs
Rise Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_r	—	1.6	—	μs
Fall Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_f	—	2.2	—	μs
Input–Output Isolation Voltage (f = 60 Hz, t = 1.0 sec)(1,2)	V_{ISO}	3000	—	—	Vac(rms)
Isolation Resistance ($V_{I–O}$ = 500 V)(2)	R_{ISO}	10^{11}	—	—	Ω
Isolation Capacitance ($V_{I–O}$ = 0, f = 1.0 MHz)(2)	C_{ISO}	—	0.2	—	pF

1. Input–Output Isolation Voltage, V_{ISO}, is an internal device dielectric breakdown rating.
2. For this test, pins 1, 2, 3, and 4 are common, and pins 5, 6, 7 and 8 are common.
3. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.
4. Always design to the specified minimum/maximum electrical limits (where applicable).
5. Current Transfer Ratio (CTR) = I_C/I_F x 100%.

TYPICAL CHARACTERISTICS

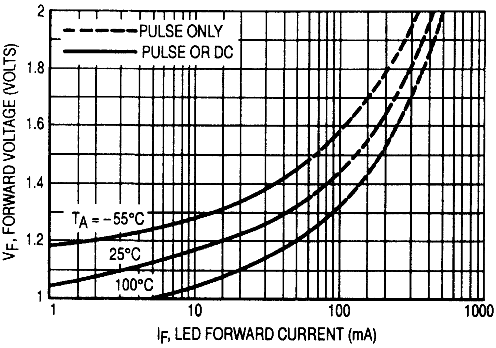


Figure 1. LED Forward Voltage versus Forward Current

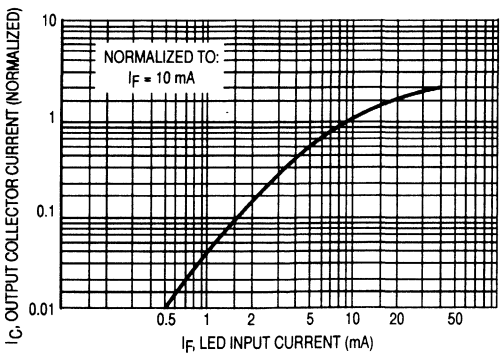


Figure 2. Output Current versus Input Current

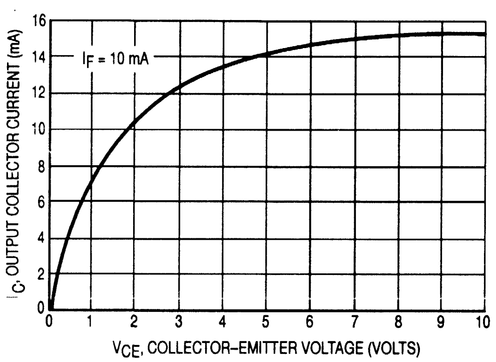


Figure 3. Output Current versus Collector–Emitter Voltage

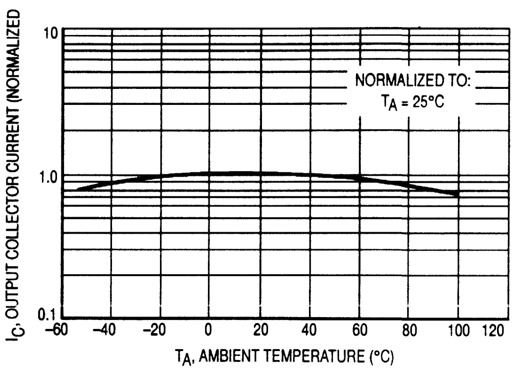


Figure 4. Output Current versus Ambient Temperature

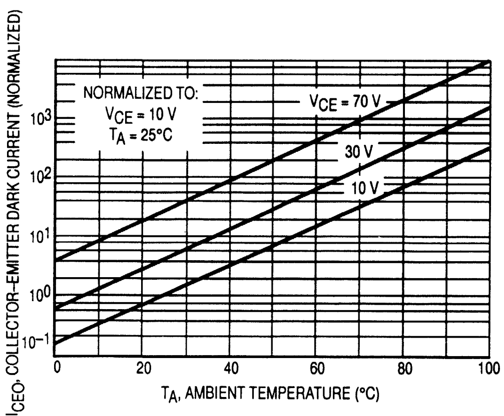


Figure 5. Dark Current versus Ambient Temperature

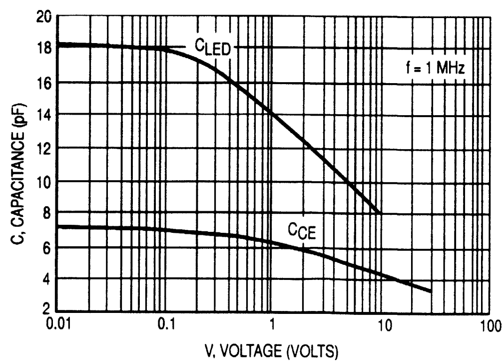


Figure 6. Capacitance versus Voltage

Dual Channel Small Outline Optoisolators
Transistor Output (Low Input Current)

MOCD217
[CTR = 100% Min]

Motorola Preferred Device

The MOCD217 device consists of two gallium arsenide infrared emitting diodes optically coupled to two monolithic silicon phototransistor detectors, in a surface mountable, small outline, plastic package. It is ideally suited for high density applications and eliminates the need for through–the–board mounting.

- Dual Channel Coupler
- Convenient Plastic SOIC–8 Surface Mountable Package Style
- Low Input Current (Specified @ 1 mA)
- Minimum $V_{(BR)CEO}$ of 30 Volts Guaranteed
- Standard SOIC–8 Footprint, with 0.050″ Lead Spacing
- Shipped in Tape and Reel, which conforms to EIA Standard RS481A
- Compatible with Dual Wave, Vapor Phase and IR Reflow Soldering
- High Input–Output Isolation of 3000 Vac (rms) Guaranteed
- Meets U.L. Regulatory Requirements, File #E54915

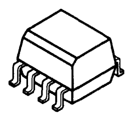
Ordering Information:

- To obtain MOCD217 in tape and reel, add R2 suffix to device number as follows:
  R2 = 2500 units on 13″ reel
- To obtain MOCD217 in quantities of 50 (shipped in sleeves) — no suffix

Marking Information:

- MOCD217 = D217

DUAL CHANNEL SMALL OUTLINE OPTOISOLATOR TRANSISTOR OUTPUT



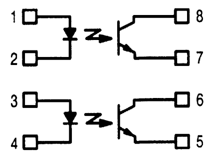
CASE 846–01, STYLE 3
PLASTIC

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Forward Current — Continuous	I_F	60	mA
Forward Current — Peak (PW = 100 μs, 120 pps)	$I_{F(pk)}$	1.0	A
Reverse Voltage	V_R	6.0	V
LED Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	90 0.8	mW mW/°C
OUTPUT TRANSISTOR			
Collector–Emitter Voltage	V_{CEO}	30	V
Collector–Base Voltage	V_{CBO}	70	V
Emitter–Collector Voltage	V_{ECO}	7.0	V
Collector Current — Continuous	I_C	150	mA
Detector Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 1.76	mW mW/°C

NOTE: Thickness through insulation between input and output is ≥ 0.5 mm.

SCHEMATIC



1. ANODE 1
2. CATHODE 1
3. ANODE 2
4. CATHODE 2
5. EMITTER 2
6. COLLECTOR 2
7. EMITTER 1
8. COLLECTOR 1

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 2

MAXIMUM RATINGS — continued (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
TOTAL DEVICE			
Input–Output Isolation Voltage(1,2) (60 Hz, 1.0 sec. duration)	V_{ISO}	3000	Vac(rms)
Total Device Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Ambient Operating Temperature Range(3)	T_A	–55 to +100	°C
Storage Temperature Range(3)	T_{stg}	–55 to +150	°C
Lead Soldering Temperature (1/16″ from case, 10 sec. duration)	—	260	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)(4)

Characteristic	Symbol	Min	Typ(4)	Max	Unit
INPUT LED					
Forward Voltage (I_F = 1.0 mA)	V_F	—	1.05	1.3	V
Reverse Leakage Current (V_R = 6.0 V)	I_R	—	0.1	100	μA
Capacitance	C	—	18	—	pF
OUTPUT TRANSISTOR					
Collector–Emitter Dark Current (V_{CE} = 5.0 V, T_A = 25°C)	I_{CEO1}	—	1.0	50	nA
(V_{CE} = 5.0 V, T_A = 100°C)	I_{CEO2}	—	1.0	—	μA
Collector–Emitter Breakdown Voltage (I_C = 100 μA)	$V_{(BR)CEO}$	30	90	—	V
Emitter–Collector Breakdown Voltage (I_E = 100 μA)	$V_{(BR)ECO}$	7.0	7.8	—	V
Collector–Emitter Capacitance (f = 1.0 MHz, V_{CE} = 0)	C_{CE}	—	7.0	—	pF
COUPLED					
Output Collector Current MOCD217 (I_F = 1.0 mA, V_{CE} = 5.0 V)	I_C (CTR)(5)	1.0 (100)	1.3 (130)	—	mA (%)
Collector–Emitter Saturation Voltage (I_C = 100 μA, I_F = 1.0 mA)	$V_{CE(sat)}$	—	0.35	0.4	V
Turn–On Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_{on}	—	7.5	—	μs
Turn–Off Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_{off}	—	5.7	—	μs
Rise Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_r	—	3.2	—	μs
Fall Time (I_C = 2.0 mA, V_{CC} = 10 V, R_L = 100 Ω)	t_f	—	4.7	—	μs
Input–Output Isolation Voltage (f = 60 Hz, t = 1.0 sec.)(1,2)	V_{ISO}	3000	—	—	Vac(rms)
Isolation Resistance (V_{I-O} = 500 V)(2)	R_{ISO}	10^{11}	—	—	Ω
Isolation Capacitance (V_{I-O} = 0, f = 1.0 MHz)(2)	C_{ISO}	—	0.2	—	pF

1. Input–Output Isolation Voltage, V_{ISO}, is an internal device dielectric breakdown rating.
2. For this test, pins 1, 2, 3 and 4 are common, and pins 5, 6, 7 and 8 are common.
3. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.
4. Always design to the specified minimum/maximum electrical limits (where applicable).
5. Current Transfer Ratio (CTR) = I_C/I_F x 100%.

TYPICAL CHARACTERISTICS

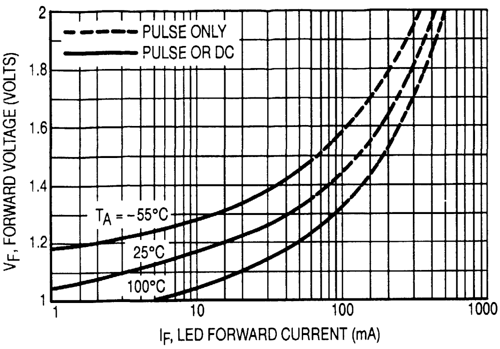


Figure 1. LED Forward Voltage versus Forward Current

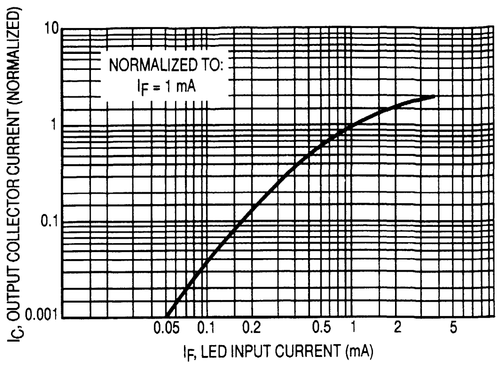


Figure 2. Output Current versus Input Current

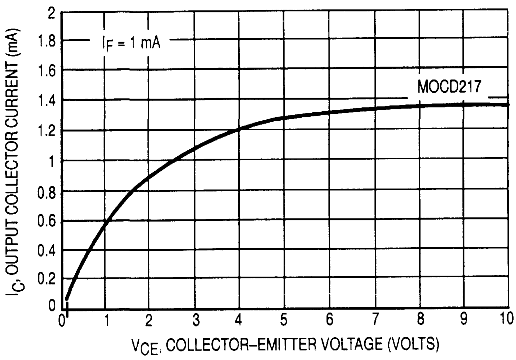


Figure 3. Output Current versus Collector–Emitter Voltage

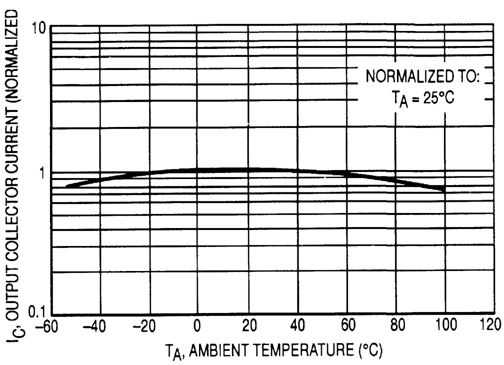


Figure 4. Output Current versus Ambient Temperature

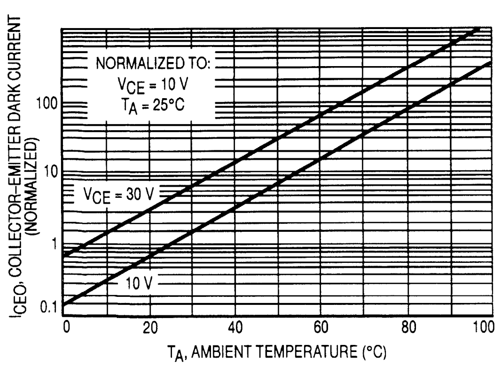


Figure 5. Dark Current versus Ambient Temperature

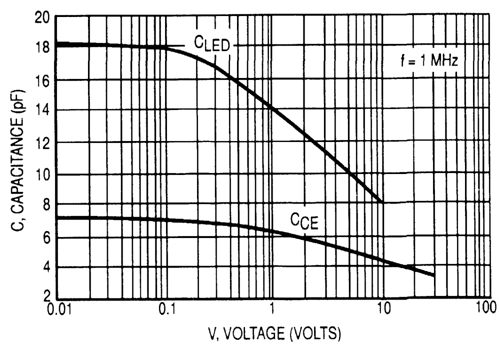


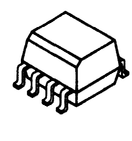
Figure 6. Capacitance versus Voltage

Dual Channel Small Outline Optoisolators
Darlington Output

MOCD223
[CTR = 500% Min]

Motorola Preferred Device

DUAL CHANNEL SMALL OUTLINE OPTOISOLATOR DARLINGTON OUTPUT



CASE 846–01, STYLE 3
PLASTIC

The MOCD223 device consists of two gallium arsenide infrared emitting diodes optically coupled to two monolithic silicon phototransistor darlington detectors, in a surface mountable, small outline, plastic package. It is ideally suited for high density applications that require low input current and eliminates the need for through–the–board mounting.

- Dual Channel Coupler
- Convenient Plastic SOIC–8 Surface Mountable Package Style
- High Output Current (I_C) (500% min) @ 1 mA Input Current
- Minimum $V_{(BR)CEO}$ of 30 Volts Guaranteed
- Standard SOIC–8 Footprint, with 0.050″ Lead Spacing
- Shipped in Tape and Reel, which conforms to EIA Standard RS481A
- Compatible with Dual Wave, Vapor Phase and IR Reflow Soldering
- High Input–Output Isolation of 3000 Vac (rms) Guaranteed
- Meets U.L. Regulatory Requirements, File #E54915

Ordering Information:

- To obtain MOCD223 in tape and reel, add R2 suffix to device number as follows:
  R2 = 2500 units on 13″ reel
- To obtain MOCD223 in quantities of 50 (shipped in sleeves) — no suffix

Marking Information:

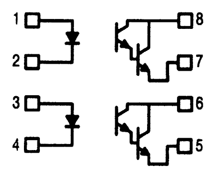
- MOCD223 = D223

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Forward Current — Continuous	I_F	60	mA
Forward Current — Peak (PW = 100 µs, 120 pps)	$I_{F(pk)}$	1.0	A
Reverse Voltage	V_R	6.0	V
LED Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	90 0.8	mW mW/°C
OUTPUT DARLINGTON			
Collector–Emitter Voltage	V_{CEO}	30	V
Collector–Base Voltage	V_{CBO}	70	V
Emitter–Collector Voltage	V_{ECO}	7.0	V
Collector Current — Continuous	I_C	150	mA
Detector Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 1.76	mW mW/°C

NOTE: Thickness through insulation between input and output is ≥ 0.5 mm.

SCHEMATIC



1. LED 1 ANODE
2. LED 1 CATHODE
3. LED 2 ANODE
4. LED 2 CATHODE
5. EMITTER 2
6. COLLECTOR 2
7. EMITTER 1
8. COLLECTOR 1

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 2

MOCD223

MAXIMUM RATINGS — continued (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
TOTAL DEVICE			
Input–Output Isolation Voltage[1,2] (60 Hz, 1.0 sec. duration)	V_{ISO}	3000	Vac(rms)
Total Device Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 2.94	mW mW/°C
Ambient Operating Temperature Range[3]	T_A	–55 to +100	°C
Storage Temperature Range[3]	T_{stg}	–55 to +150	°C
Lead Soldering Temperature (1/16″ from case, 10 sec. duration)	—	260	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)[4]

Characteristic		Symbol	Min	Typ[4]	Max	Unit
INPUT LED						
Forward Voltage (I_F = 1.0 mA)		V_F	—	1.05	1.3	V
Reverse Leakage Current (V_R = 6.0 V)		I_R	—	0.1	100	µA
Capacitance		C	—	18	—	pF
OUTPUT DARLINGTON						
Collector–Emitter Dark Current	(V_{CE} = 5.0 V, T_A = 25°C)	$I_{CEO}1$	—	1.0	50	nA
	(V_{CE} = 5.0 V, T_A = 100°C)	$I_{CEO}2$	—	1.0	—	µA
Collector–Emitter Breakdown Voltage (I_C = 100 µA)		$V_{(BR)CEO}$	30	90	—	V
Emitter–Collector Breakdown Voltage (I_E = 100 µA)		$V_{(BR)ECO}$	7.0	7.8	—	V
Collector–Emitter Capacitance (f = 1.0 MHz, V_{CE} = 0)		C_{CE}	—	5.5	—	pF
COUPLED						
Output Collector Current (I_F = 1.0 mA, V_{CE} = 5.0 V)	MOCD223	I_C (CTR)[5]	5.0 (500)	10 (1000)	—	mA (%)
Collector–Emitter Saturation Voltage (I_C = 500 µA, I_F = 1.0 mA)		$V_{CE(sat)}$	—	—	1.0	V
Turn–On Time (I_F = 5.0 mA, V_{CC} = 10 V, R_L = 100 Ω)		t_{on}	—	3.5	—	µs
Turn–Off Time (I_F = 5.0 mA, V_{CC} = 10 V, R_L = 100 Ω)		t_{off}	—	95	—	µs
Rise Time (I_F = 5.0 mA, V_{CC} = 10 V, R_L = 100 Ω)		t_r	—	1.0	—	µs
Fall Time (I_F = 5.0 mA, V_{CC} = 10 V, R_L = 100 Ω)		t_f	—	2.0	—	µs
Input–Output Isolation Voltage (f = 60 Hz, t = 1.0 sec.)[1,2]		V_{ISO}	3000	—	—	Vac(rms)
Isolation Resistance (V_{I-O} = 500 V)[2]		R_{ISO}	10^{11}	—	—	Ω
Isolation Capacitance (V_{I-O} = 0, f = 1.0 MHz)[2]		C_{ISO}	—	0.2	—	pF

1. Input–Output Isolation Voltage, V_{ISO}, is an internal device dielectric breakdown rating.
2. For this test, pins 1, 2, 3 and 4 are common, and pins 5, 6, 7 and 8 are common.
3. Refer to Quality and Reliability Section in Opto Data Book for information on test conditions.
4. Always design to the specified minimum/maximum electrical limits (where applicable).
5. Current Transfer Ratio (CTR) = I_C/I_F x 100%.

TYPICAL CHARACTERISTICS

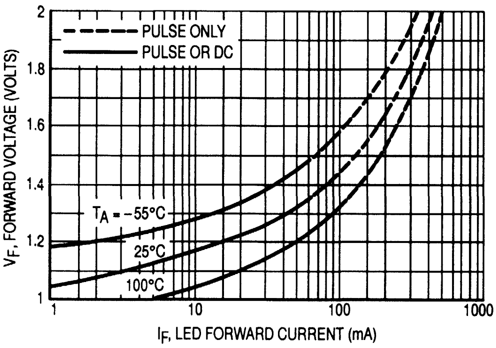


Figure 1. LED Forward Voltage versus Forward Current

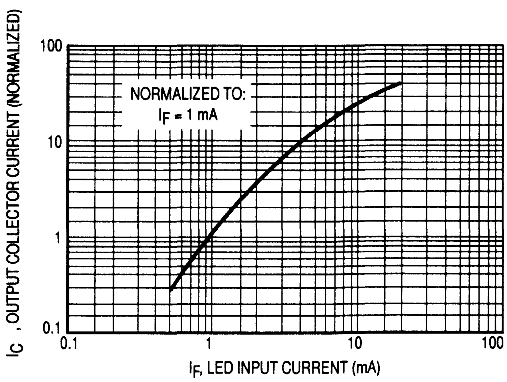


Figure 2. Output Current versus Input Current

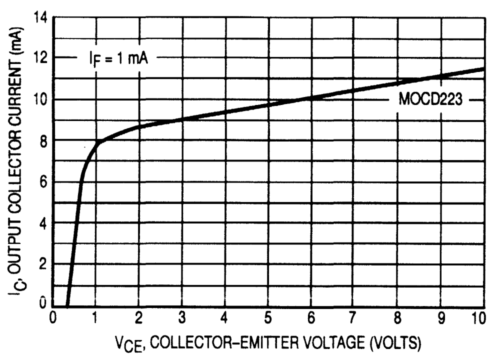


Figure 3. Output Current versus Collector–Emitter Voltage

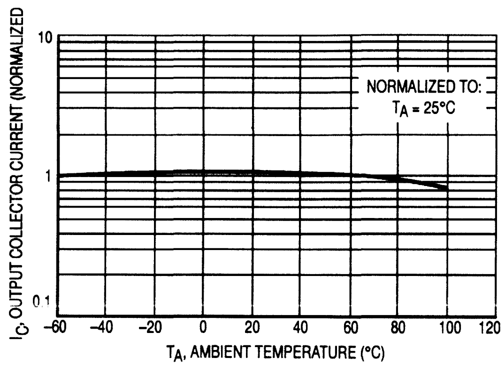


Figure 4. Output Current versus Ambient Temperature

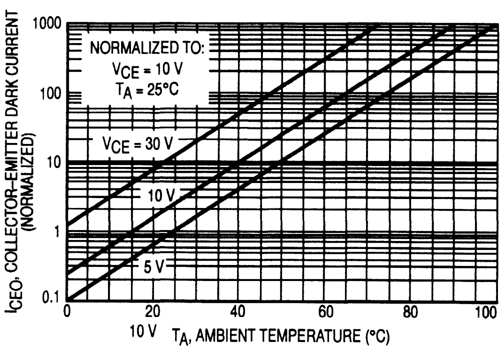


Figure 5. Dark Current versus Ambient Temperature

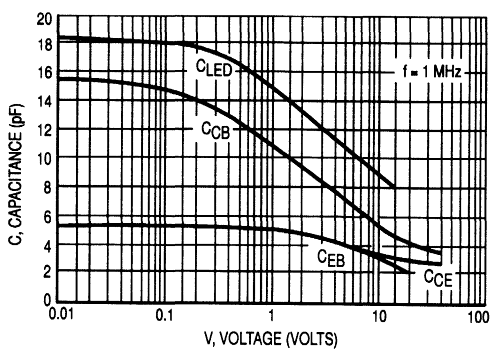
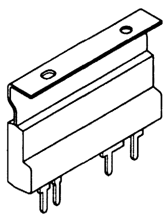


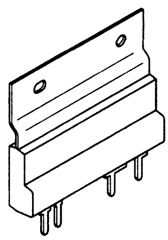
Figure 6. Capacitance versus Voltage

Section 7

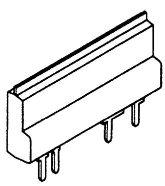
POWER OPTO™ Isolators



CASE 417–02
STANDARD



CASE 417A–02
"F" SUFFIX

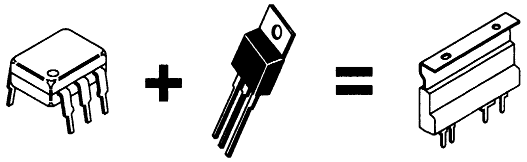


CASE 417B–01
"C" SUFFIX

POWER OPTO™

ISOLATORS

General Information



Equivalent Discrete Semiconductors

The MOC2A40 and MOC2A60 Series are the first members of the POWER OPTO™ Isolator family from Motorola. The MOC2A40/MOC2A60 are 2 Amp @ 40°C/Zero–Crossing/Optically Coupled Triacs. These isolated AC output devices are ruggedized to survive the harsh operating environments inherent in Industrial Controller applications. Additionally, their thermally optimized SIP package profile allows for high density stacking on 0.200″ centers and can handle 2 Amps @ 40°C (Free–Air Rating) without the need for heatsinks, thermal grease, etc.

General Characteristics

- 2 Amp @ 40°C, Zero–Cross, Optically Coupled Triac.
- 3,750 Vac (rms) Isolation Voltage.
- Zero–Voltage Turn–on. Zero–Current Turn–off.
- 70 Amp Single Cycle Surge Withstand Capability.
- Meets NEMA 2–230 & IEEE 472 Noise Immunity Standards.
- Guaranteed 400 V µsec dv/dt (Static).
- Low 0.96 V (Typical) On–State Voltage.
- Thermally Efficient Package yields 8.0°C/W $R_{\theta JC}$.
- Single In–Line Package Mounts on 0.200″ Centers for High Density Applications.
- U.L. Recognized. C.S.A. approved, V.D.E. (in process).
- SEMKO (IEC 950) approved for Europe.

Types of Applications and Loads

- Programmable Logic Controllers
- Distributive Process Controls
- Industrial Controls and Automation Systems
- Temperature Controllers
- HVAC & Energy Management Systems
- Gaming Machines
- Vending Machines
- Gas Pumps
- Photocopiers
- AC Motor Starters
- EM Contactors
- AC Solenoids/Valves

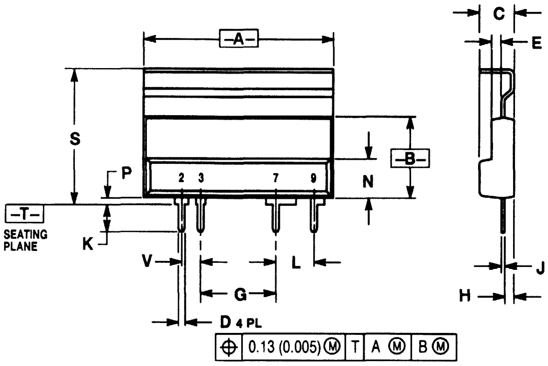
Customer Benefits

- A World Class POWER OPTO™ Isolator
- Protects Loads from High In–Rush Currents
- Robust Surge Withstand Performance
- Stability against Noise–Induced False Turn–on
- Good Inductive Load Switching Capability
- Generates 30–50% Less Heat than Competitive Devices
- No Heatsink, Grease or Hardware Required
- Allows for Optimal Channel Density in Programmable Controller Applications

Literature

- Data Sheets **MOC2A40–10/D and MOC2A60–10/D**
- Sample Pack **KITMOC2A40–10/D, KITMOC2A60–5/D**

PACKAGE DIMENSIONS



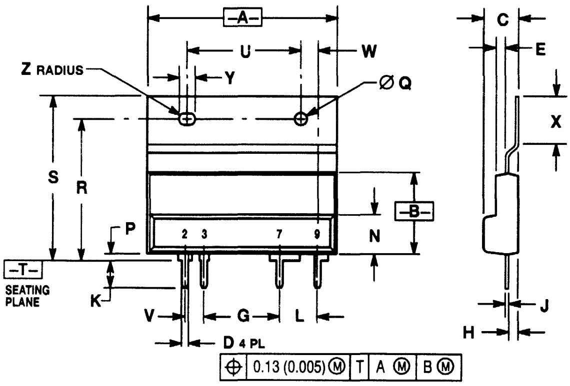
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.965	1.005	24.51	25.53
B	0.416	0.436	10.57	11.07
C	0.170	0.190	4.32	4.83
D	0.025	0.035	0.64	0.89
E	0.040	0.060	1.02	1.52
G	0.400 BSC		10.16 BSC	
H	0.040	0.060	1.02	1.52
J	0.012	0.018	0.30	0.46
K	0.134	0.154	3.40	3.91
L	0.200 BSC		5.08 BSC	
N	0.190	0.210	4.83	5.33
P	0.023	0.043	0.58	1.09
S	0.695	0.715	17.65	18.16
V	0.100 BSC		2.54 BSC	

STYLE 2:
PIN 2. LED CATHODE
3. LED ANODE
7. TRIAC MT
9. TRIAC MT

CASE 417–02
PLASTIC
STANDARD HEAT TAB
ISSUE C

ORDER "F" SUFFIX
HEAT TAB OPTION
(EX: MOC2A60–10F)



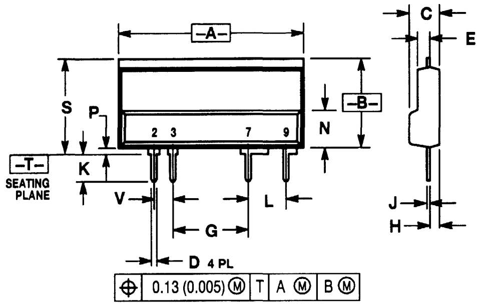
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.965	1.005	24.51	25.53
B	0.416	0.436	10.57	11.07
C	0.170	0.190	4.32	4.83
D	0.025	0.035	0.64	0.89
E	0.040	0.060	1.02	1.52
G	0.400 BSC		10.16 BSC	
H	0.040	0.060	1.02	1.52
J	0.012	0.018	0.30	0.46
K	0.134	0.154	3.40	3.91
L	0.200 BSC		5.08 BSC	
N	0.190	0.210	4.83	5.33
P	0.023	0.043	0.58	1.09
Q	0.057	0.067	1.45	1.70
R	0.734	0.754	18.64	19.15
S	0.840	0.870	21.34	22.10
U	0.593	0.613	15.06	15.57
V	0.100 BSC		2.54 BSC	
W	0.074	0.094	1.88	2.39
X	0.265	0.295	6.73	7.49
Y	0.079	0.089	2.01	2.26
Z	0.026	0.036	0.66	0.91

STYLE 1:
PIN 2. LED CATHODE
3. LED ANODE
7. TRIAC MT
9. TRIAC MT

CASE 417A–02
PLASTIC
FLUSH MOUNT HEAT TAB
ISSUE A

ORDER "C" SUFFIX
HEAT TAB OPTION
(EX: MOC2A60–10C)



NOTES:
6. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
7. CONTROLLING DIMENSION: INCH.

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0.965	1.005	24.51	25.53
B	0.416	0.436	10.57	11.07
C	0.170	0.190	4.32	4.83
D	0.025	0.035	0.64	0.89
E	0.040	0.060	1.02	1.52
G	0.400 BSC		10.16 BSC	
H	0.040	0.060	1.02	1.52
J	0.012	0.060	0.30	0.46
K	0.134	0.154	3.40	3.91
L	0.200 BSC		5.08 BSC	
N	0.190	0.210	4.83	5.33
P	0.023	0.043	0.58	1.09
S	0.439	0.529	11.15	13.44
V	0.100 BSC		2.54 BSC	

STYLE 1:
PIN 2. LED CATHODE
3. LED ANODE
7. TRIAC MT
9. TRIAC MT

CASE 417B–01
PLASTIC
CUT HEAT TAB
ISSUE O

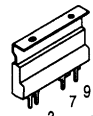
POWER OPTO™ Isolator
2 Amp Zero–Cross Triac Output

MOC2A40-10
MOC2A40-5*
*Motorola Preferred Device

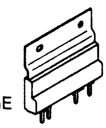
OPTOISOLATOR
2 AMP ZERO CROSS
TRIAC OUTPUT
400 VOLTS

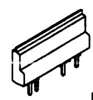
This device consists of a gallium arsenide infrared emitting diode optically coupled to a zero–cross triac driver circuit and a power triac. It is capable of driving a load of up to 2 amp (rms) directly, on line voltages from 20 to 140 volts ac (rms).

- Provides Normally Open Solid State A.C. Output With 2 Amp Rating
- 60 Amp Single Cycle Surge Capability
- Zero–Voltage Turn–on and Zero–Current Turn–off
- High Input–Output Isolation of 3750 vac (rms)
- Static dv/dt Rating of 400 Volts/µs Guaranteed
- 2 Amp Pilot Duty Rating Per UL508 ¶117 (Overload Test) and ¶118 (Endurance Test) UL [File No. 129224]
- CSA Approved [File No. CA77170–1].
- SEMKO Approved Certificate #9507228
- Exceeds NEMA 2–230 and IEEE472 Noise Immunity Test Requirements (See Fig.15)

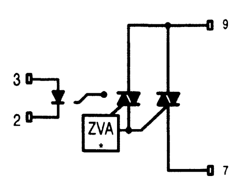


CASE 417–02
Style 2
PLASTIC PACKAGE


CASE 417A–02
Style 1
PLASTIC PACKAGE


CASE 417B–01
Style 1
PLASTIC PACKAGE

DEVICE SCHEMATIC



* Zero Voltage Activate Circuit

1, 4, 5, 6, 8. NO PIN
2. LED CATHODE
3. LED ANODE
7. MAIN TERMINAL 2
9. MAIN TERMINAL 1

DEVICE RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Forward Current — Maximum Continuous	I_F	50	mA
Forward Current — Maximum Peak (PW = 100µs, 120 pps)	I_F(pk)	1.0	A
Reverse Voltage — Maximum	V_R	6.0	V
OUTPUT TRIAC			
Off–State Output Terminal Voltage — Maximum(1)	V_{DRM}	400	Vac(pk)
Recommended Operating Voltage Range (f = 47 – 63 Hz)	V_T	20 to 140	Vac(rms)
On–State Current Range (Free Air, Power Factor ≥ 0.3)	I_T(rms)	0.01 to 2.0	A
Non–Repetitive Peak Overcurrent — Max (f = 60 Hz, t = 1.0 sec)	$I_{TSM}1$	24	A
Non–Repetitive Single Cycle Surge Current — Maximum Peak (t = 16.7 ms)	$I_{TSM}2$	70	A
Main Terminal Fusing Current (t = 8.3 ms)	I^2T	26	A^2sec
Load Power Factor Range	PF	0.3 to 1.0	—
Junction Temperature Range	T_J	– 40 to 125	°C
TOTAL DEVICE			
Input–Output Isolation Voltage — Maximum(2) 47 – 63 Hz, 1 sec Duration	V_{ISO}	3750	Vac(rms)
Thermal Resistance — Power Triac Junction to Case (See Fig. 16)	$R_{\theta JC}$	8.0	°C/W
Ambient Operating Temperature Range	T_{oper}	– 40 to +100	°C
Storage Temperature Range	T_{stg}	– 40 to +150	°C
Lead Soldering Temperature — Maximum (1/16″ From Case, 10 sec Duration)	—	260	°C

1. Test voltages must be applied within dv/dt rating.
2. Input–Output isolation voltage, V_{ISO}, is an internal device dielectric breakdown rating. For this test, pins 2, 3 and the heat tab are common, and pins 7 and 9 are common.

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 2

MOC2A40-10 MOC2A40-5

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

Characteristic	Symbol	Min	Typ	Max	Unit
INPUT LED					
Forward Voltage (I_F = 10 mA)	V_F	1.00	1.17	1.50	V
Reverse Leakage Current (V_R = 6.0 V)	I_R	—	1.0	100	μA
Capacitance	C	—	18	—	pF
OUTPUT TRIAC					
Off–State Leakage, Either Direction (I_F = 0, V_{DRM} = 400 V)	I_{DRM}	—	0.25	10	μA
Critical Rate of Rise of Off–State Voltage (Static) V_{in} = 200 vac(pk))(1)(2)	dv/dt(s)	400	—	—	V/μs
Holding Current, Either Direction (I_F = 0, V_D = 12 V, I_T = 200 mA)	I_H	—	10	—	mA
COUPLED					
LED Trigger Current Required to Latch Output MOC2A40–10	$I_{FT}(on)$	—	7.0	10	mA
Either Direction (Main Terminal Voltage = 2.0 V)(3)(4) MOC2A40–5	$I_{FT}(on)$	—	3.5	5.0	mA
On–State Voltage, Either Direction (I_F = Rated $I_{FT}(on)$, I_{TM} = 2.0 A)	V_{TM}	—	0.96	1.3	V
Inhibit Voltage, Either Direction (I_F = Rated $I_{FT}(on)$)(5) (Main Terminal Voltage above which device will not Trigger)	V_{INH}	—	8.0	10	V
Commutating dv/dt (Rated V_{DRM}, I_T = 30 mA – 2.0 A(rms), T_A = – 40 ± 100°C, f = 60 Hz)(2)	dv/dt (c)	5.0	—	—	V/μS
Common–mode Input–Output dv/dt(2)	dv/dt(cm)	—	40,000	—	V/μS
Input–Output Capacitance (V = 0, f = 1.0 MHz)	C_{ISO}	—	1.3	—	pF
Isolation Resistance (V_{I-O} = 500 V)	R_{ISO}	10^{12}	10^{14}	—	Ω

1. Per EIA/NARM standard RS–443, with V_P = 200 V, which is the instantaneous peak of the maximum operating voltage.
2. Additional dv/dt information, including test methods, can be found in Motorola applications note AN1048/D, Figure 43.
3. All devices are guaranteed to trigger at an I_F value less than or equal to the max I_{FT}. Therefore, the recommended operating I_F lies between the device's maximum $I_{FT}(on)$ limit and the Maximum Rating of 50 mA.
4. Current–limiting resistor required in series with LED.
5. Also known as "Zero Voltage Turn–On".

TYPICAL CHARACTERISTICS

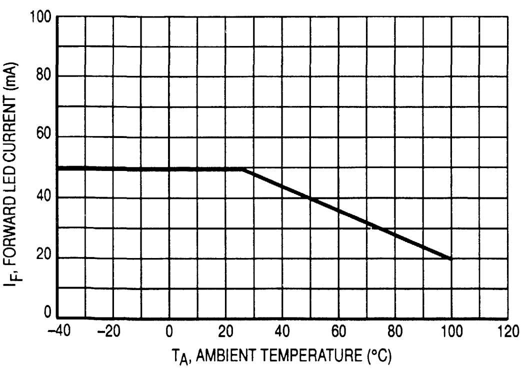


Figure 1. Maximum Allowable Forward LED Current versus Ambient Temperature

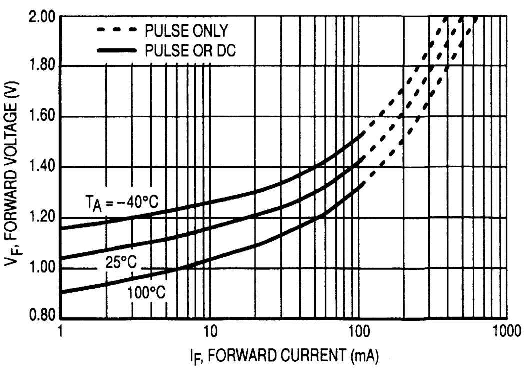


Figure 2. LED Forward Voltage versus LED Forward Current

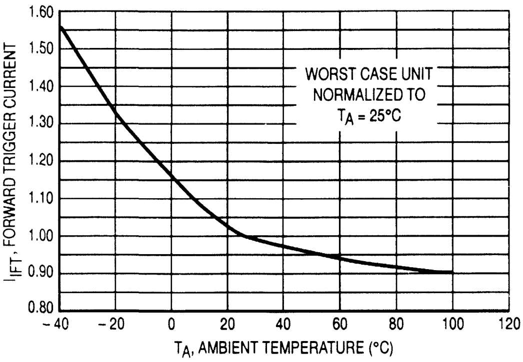


Figure 3. Forward LED Trigger Current versus Ambient Temperature

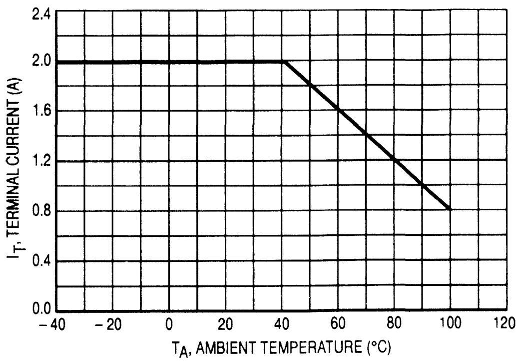


Figure 4. Maximum Allowable On–State RMS Output Current (Free Air) versus Ambient Temperature

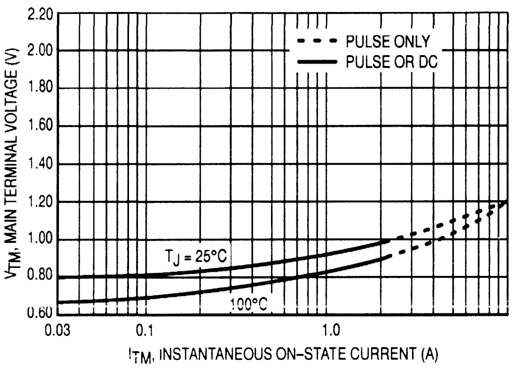


Figure 5. On–State Voltage Drop versus Output Terminal Current

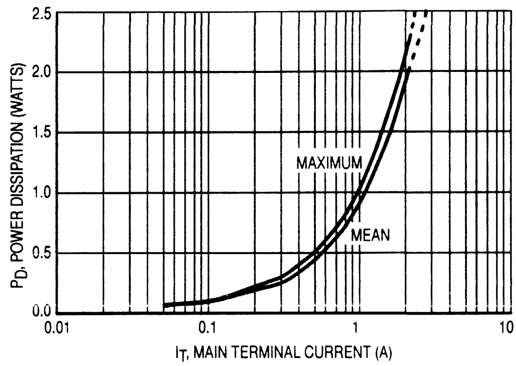


Figure 6. Power Dissipation versus Main Terminal Current

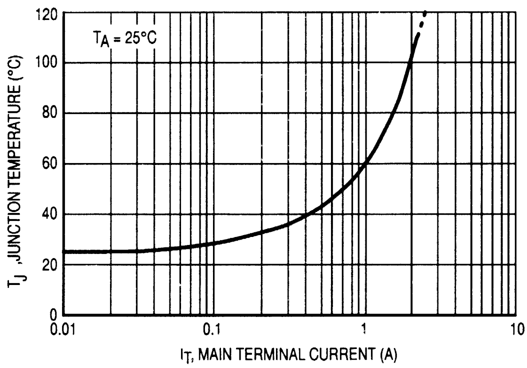


Figure 7. Junction Temperature versus Main Terminal RMS Current (Free Air)

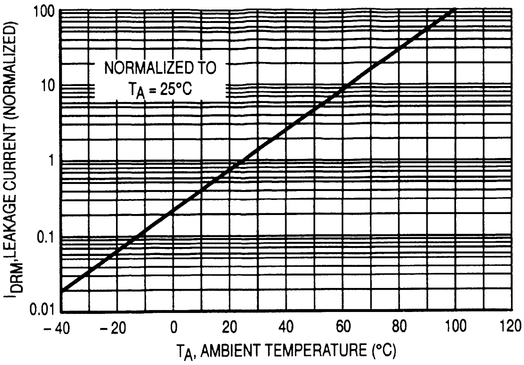


Figure 8. Leakage with LED Off versus Ambient Temperature

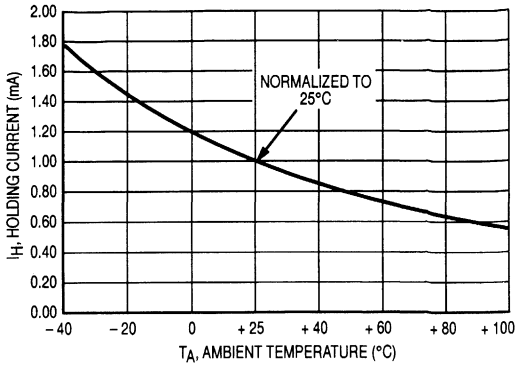


Figure 9. Holding Current versus Ambient Temperature

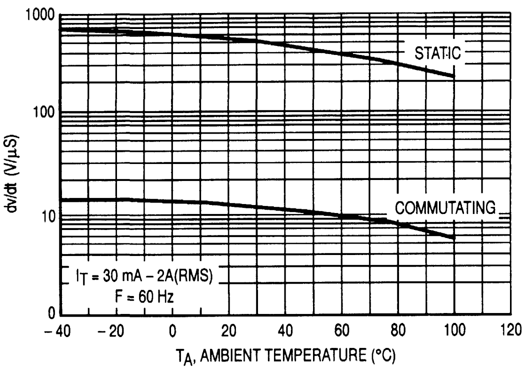


Figure 10. dv/dt versus Ambient Temperature

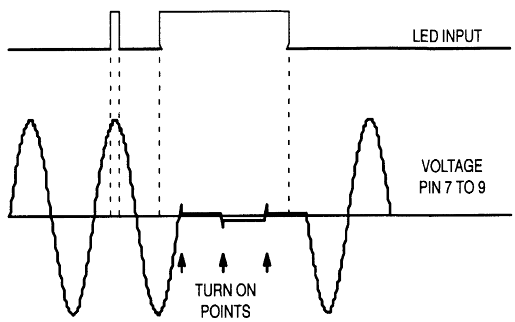


Figure 11. Operating Waveforms

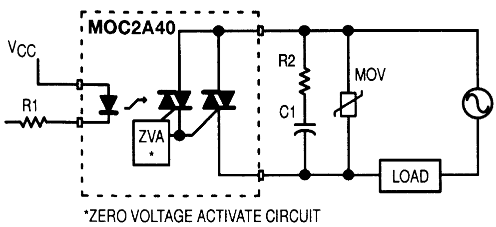


Figure 12. Typical Application Circuit

Select the value of R1 according to the following formulas:

[1] $R1 = (V_{CC} - V_F)$ / Max. I_{FT} (on) per spec.
[2] $R1 = (V_{CC} - V_F) / 0.050$

Typical values for C1 and R2 are 0.01 μF and 39 Ω, respectively. You may adjust these values for specific applications. The maximum recommended value of C1 is 0.022 μF. See application note AN1048 for additional information on component values.

The MOV may or may not be needed depending upon the characteristics of the applied ac line voltage. For applications where line spikes may exceed the 400 V rating of the MOC2A40, an MOV is required.

Use care to maintain the minimum spacings as shown. Safety and regulatory requirements dictate a minimum of 8.0 mm between the closest points between input and output conducting paths, Pins 3 and 7. Also, 0.070 inches distance is required between the two output Pins, 7 and 9.

Keep pad sizes on Pins 7 and 9 as large as possible for optimal performance.

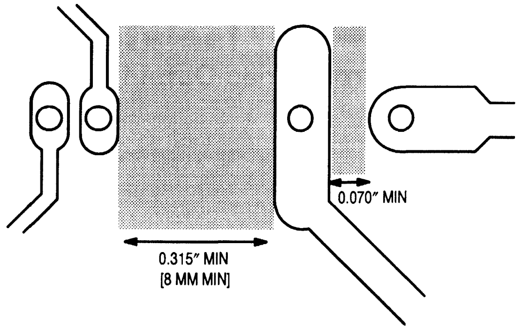


Figure 13. PC Board Layout Recommendations

Each device, when installed in the circuit shown in Figure 15, shall be capable of passing the following conducted noise tests:

- IEEE 472 (2.5 KV)
- Lamp Dimmer (NEMA Part DC33, § 3.4.2.1)
- NEMA ICS 2–230.45 Showering Arc
- MIL–STD–461A CS01, CS02 and CS06

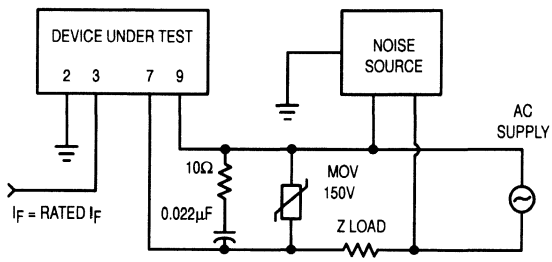
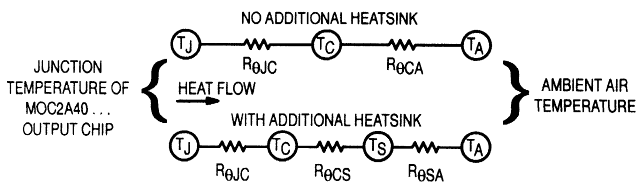


Figure 14. Test Circuit for Conducted Noise Tests



Terms in the model signify:

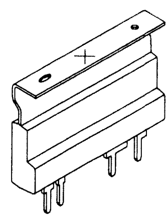
T_A = Ambient temperature
T_S = Optional additional heat sink temperature
T_C = Case temperature
T_J = Junction temperature
P_D = Power dissipation

$R_{\theta SA}$ = Thermal resistance, heat sink to ambient
$R_{\theta CA}$ = Thermal resistance, case to ambient
$R_{\theta CS}$ = Thermal resistance, heat sink to case
$R_{\theta JC}$ = Thermal resistance, junction to case

Values for thermal resistance components are: $R_{\theta CA}$ = 36°C/W/in maximum
$R_{\theta JC}$ = 8.0°C/W maximum

The design of any additional heatsink will determine the values of $R_{\theta SA}$ and $R_{\theta CS}$.

$T_C - T_A = P_D (R_{\theta CA})$
$= P_D (R_{\theta JC}) + R_{\theta SA})$, where P_D = Power Dissipation in Watts.



Thermal measurements of $R_{\theta JC}$ are referenced to the point on the heat tab indicated with an 'X'. Measurements should be taken with device orientated along its vertical axis.

Figure 15. Approximate Thermal Circuit Model

POWER OPTO™ Isolator

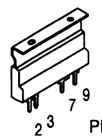
2 Amp Zero–Cross Triac Output

MOC2A60-10
MOC2A60-5*
*Motorola Preferred Device

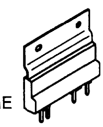
OPTOISOLATOR
2 AMP ZERO CROSS
TRIAC OUTPUT
600 VOLTS

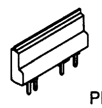
This device consists of a gallium arsenide infrared emitting diode optically coupled to a zero–cross triac driver circuit and a power triac. It is capable of driving a load of up to 2 amps (rms) directly, on line voltages from 20 to 280 volts ac (rms).

- Provides Normally Open Solid State AC Output with 2 Amp Rating
- 70 Amp Single Cycle Surge Capability
- Zero–Voltage Turn–on and Zero–Current Turn–off
- High Input–Output Isolation of 3750 vac (rms)
- Static dv/dt Rating of 400 Volts/μs Guaranteed
- 2 Amp Pilot Duty Rating Per UL508 ¶117 (Overload Test) and ¶118 (Endurance Test) [File No. 129224]
- CSA Approved [File No. CA77170–1].
- SEMKO Approved Certificate #9507228
- Exceeds NEMA 2–230 and IEEE472 Noise Immunity Test Requirements (See Fig.14)



CASE 417–02
Style 2
PLASTIC PACKAGE


CASE 417A–02
Style 1
PLASTIC PACKAGE

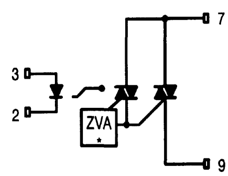

CASE 417B–01
Style 1
PLASTIC PACKAGE

DEVICE RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Forward Current — Maximum Continuous	I_F	50	mA
Forward Current — Maximum Peak (PW = 100μs, 120 pps)	$I_{F(pk)}$	1.0	A
Reverse Voltage — Maximum	V_R	6.0	V
OUTPUT TRIAC			
Output Terminal Voltage — Maximum Transient (1)	V_{DRM}	600	V(pk)
Operating Voltage Range — Maximum Continuous (f = 47 – 63 Hz)	V_T	20 to 280	Vac(rms)
On–State Current Range (Free Air, Power Factor ≥ 0.3)	$I_{T(rms)}$	0.03 to 2.0	A
Non–Repetitive Single Cycle Surge Current — Maximum Peak (t = 16.7 ms)	I_{TSM}	70	A
Main Terminal Fusing Current (t = 8.3 ms)	I^2T	26	A^2sec
Load Power Factor Range	PF	0.3 to 1.0	—
Junction Temperature Range	T_J	– 40 to 125	°C
TOTAL DEVICE			
Input–Output Isolation Voltage — Maximum(2) 47 – 63 Hz, 1 sec Duration	V_{ISO}	3750	Vac(rms)
Thermal Resistance — Power Triac Junction to Case (See Fig. 15)	$R_{\theta JC}$	8.0	°C/W
Ambient Operating Temperature Range	T_{oper}	– 40 to +100	°C
Storage Temperature Range	T_{stg}	– 40 to +150	°C
Lead Soldering Temperature — Maximum (1/16″ from Case, 10 sec Duration)	T_L	260	°C

1. Test voltages must be applied within dv/dt rating.
2. Input–Output isolation voltage, V_{ISO}, is an internal device dielectric breakdown rating. For this test, pins 2, 3 and the heat tab are common, and pins 7 and 9 are common.

DEVICE SCHEMATIC



* Zero Voltage Activate Circuit

1, 4, 5, 6, 8. NO PIN
2. LED CATHODE
3. LED ANODE
7. MAIN TERMINAL 2
9. MAIN TERMINAL 1

Preferred devices are Motorola recommended choices for future use and best overall value.

REV 2

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

Characteristic		Symbol	Min	Typ	Max	Unit
INPUT LED						
Forward Voltage (I_F = 10 mA)		V_F	1.00	1.17	1.50	V
Reverse Leakage Current (V_R = 6.0 V)		I_R	—	1.0	100	μA
Capacitance		C	—	18	—	pF
OUTPUT TRIAC						
Off–State Leakage, Either Direction (I_F = 0, V_{DRM} = 600 V)		I_{DRM}	—	0.25	10	μA
Critical Rate of Rise of Off–State Voltage (Static) V_{in} = 400 vac(pk)) (1)(2)		dv/dt(s)	400	—	—	V/μs
Holding Current, Either Direction (I_F = 0, V_D = 12 V, I_T = 200 mA)		I_H	—	10	—	mA
COUPLED						
LED Trigger Current Required to Latch Output Either Direction (Main Terminal Voltage = 2.0 V)(3)(4)	MOC2A60–10	I_{FT}(on)	—	7.0	10	mA
	MOC2A60–5	I_{FT}(on)	—	3.5	5.0	mA
On–State Voltage, Either Direction (I_F = Rated I_{FT}(on), I_{TM} = 2.0 A)		V_{TM}	—	0.96	1.3	V
Inhibit Voltage, Either Direction (I_F = Rated I_{FT}(on))(5) (Main Terminal Voltage above which device will not trigger)		V_{INH}	—	8.0	10	V
Commutating dv/dt (Rated V_{DRM}, I_T = 30 mA – 2.0 A(rms), T_A = – 40 ± 100°C, f = 60 Hz)(2)		dv/dt (c)	5.0	—	—	V/μS
Common–mode Input–Output dv/dt(2)		dv/dt(cm)	—	40,000	—	V/μS
Input–Output Capacitance (V = 0, f = 1.0 MHz)		C_{ISO}	—	1.3	—	pF
Isolation Resistance (V_{I-O} = 500 V)		R_{ISO}	10^{12}	10^{14}	—	Ω

1. Per EIA/NARM standard RS–443, with V_P = 200 V, which is the instantaneous peak of the maximum operating voltage.
2. Additional dv/dt information, including test methods, can be found in Motorola applications note AN1048/D, Figure 43.
3. All devices are guaranteed to trigger at an I_F value less than or equal to the max I_{FT}. Therefore, the recommended operating I_F lies between the device's maximum I_{FT}(on) limit and the Maximum Rating of 50 mA.
4. Current–limiting resistor required in series with LED.
5. Also known as "Zero Voltage Turn–On."

TYPICAL CHARACTERISTICS

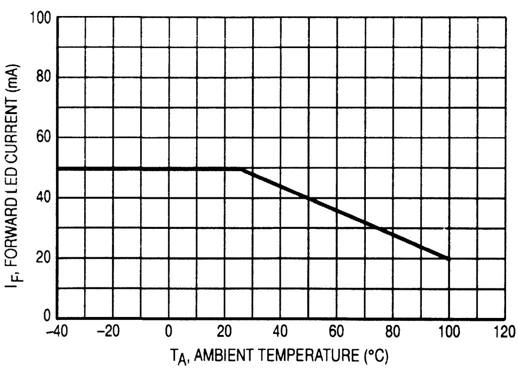


Figure 1. Maximum Allowable Forward LED Current versus Ambient Temperature

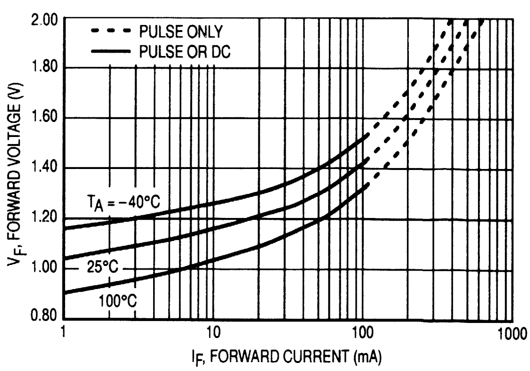


Figure 2. LED Forward Voltage versus LED Forward Current

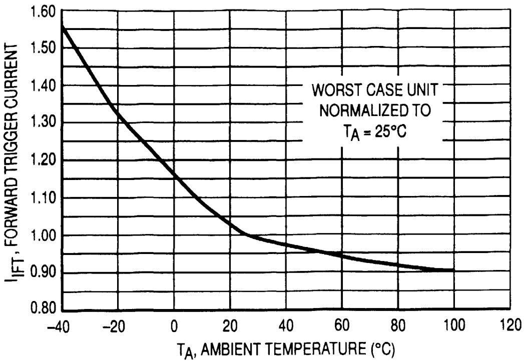


Figure 3. Forward LED Trigger Current versus Ambient Temperature

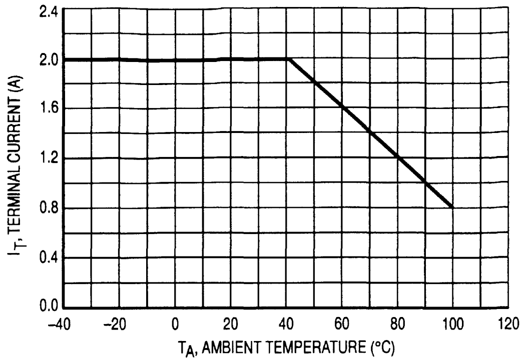


Figure 4. Maximum Allowable On–State RMS Output Current (Free Air) versus Ambient Temperature

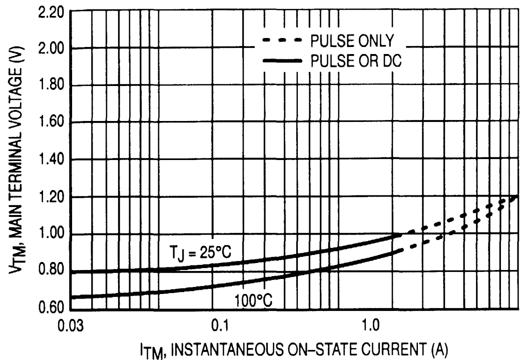


Figure 5. On–State Voltage Drop versus Output Terminal Current

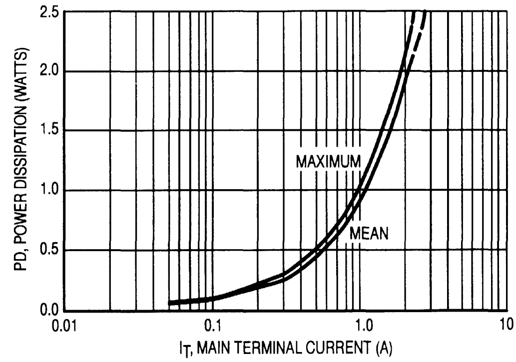


Figure 6. Power Dissipation versus Main Terminal Current

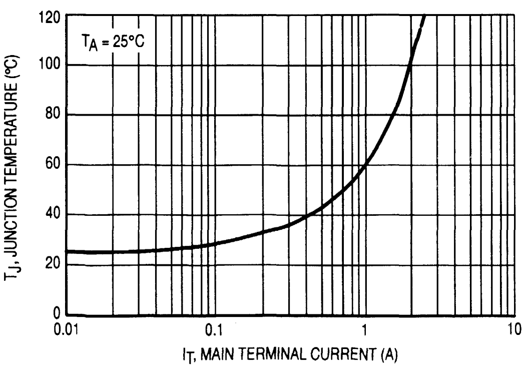


Figure 7. Junction Temperature versus Main Terminal RMS Current (Free Air)

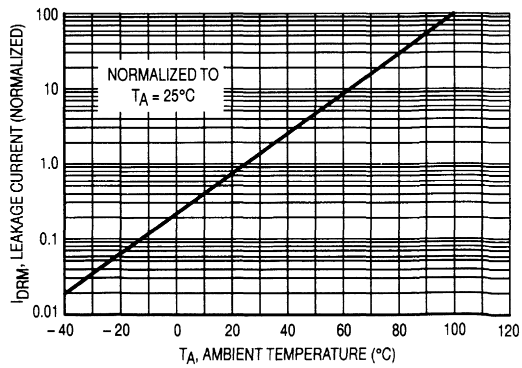


Figure 8. Leakage with LED Off versus Ambient Temperature

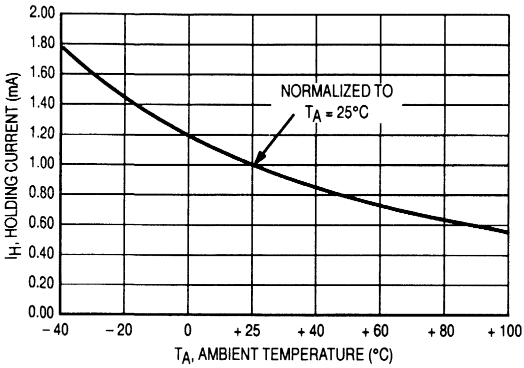


Figure 9. Holding Current versus Ambient Temperature

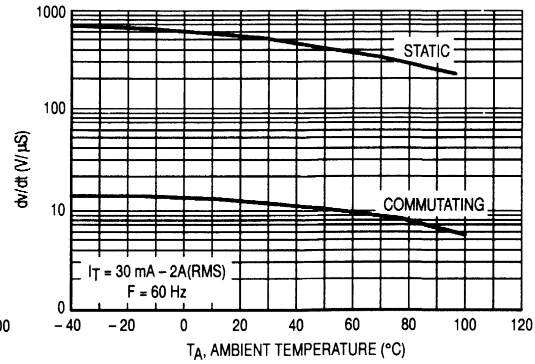


Figure 10. dv/dt versus Ambient Temperature

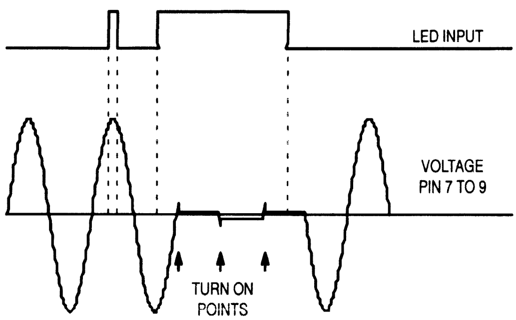


Figure 11. Operating Waveforms

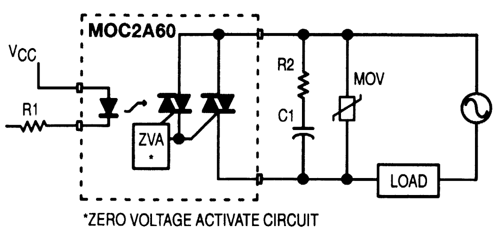


Figure 12. Typical Application Circuit

Select the value of R1 according to the following formulas:

[1] $R1 = (V_{CC} - V_F) / \text{Max. } I_{FT}$ (on) per spec.

[2] $R1 = (V_{CC} - V_F) / 0.050$

Typical values for C1 and R2 are 0.01 µF and 39 Ω, respectively. You may adjust these values for specific applications. The maximum recommended value of C1 is 0.022 µF. See application note AN1048 for additional information on component values.

The MOV may or may not be needed depending upon the characteristics of the applied ac line voltage. For applications where line spikes may exceed the 600 V rating of the MOC2A60, an MOV is required.

Use care to maintain the minimum spacings as shown. Safety and regulatory requirements dictate a minimum of 8.0 mm between the closest points between input and output conducting paths, Pins 3 and 7. Also, 0.070 inches distance is required between the two output Pins, 7 and 9.

Keep pad sizes on Pins 7 and 9 as large as possible for optimal performance.

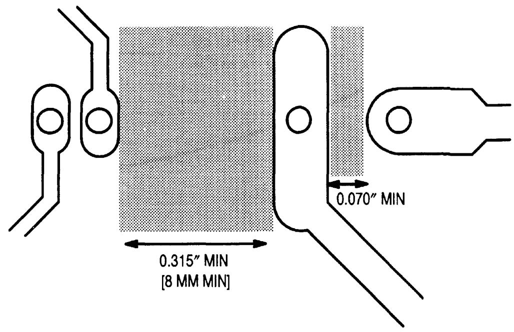


Figure 13. PC Board Layout Recommendations

Each device, when installed in the circuit shown in Figure 14, shall be capable of passing the following conducted noise tests:

- IEEE 472 (2.5 KV)
- Lamp Dimmer (NEMA Part DC33, § 3.4.2.1)
- NEMA ICS 2–230.45 Showering Arc
- MIL–STD–461A CS01, CS02 and CS06

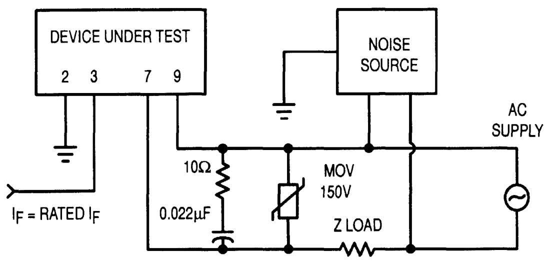
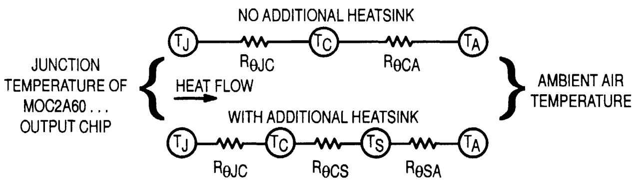


Figure 14. Test Circuit for Conducted Noise Tests



Terms in the model signify:

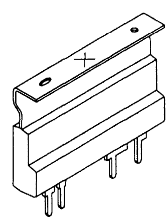
T_A = Ambient temperature
T_S = Optional additional heat sink temperature
T_C = Case temperature
T_J = Junction temperature
P_D = Power dissipation

$R_{\theta SA}$ = Thermal resistance, heat sink to ambient
$R_{\theta CA}$ = Thermal resistance, case to ambient
$R_{\theta CS}$ = Thermal resistance, heat sink to case
$R_{\theta JC}$ = Thermal resistance, junction to case

Values for thermal resistance components are: $R_{\theta CA}$ = 36°C/W/in maximum
$R_{\theta JC}$ = 8.0°C/W maximum

The design of any additional heatsink will determine the values of $R_{\theta SA}$ and $R_{\theta CS}$.

$T_C - T_A = P_D (R_{\theta CA})$
$= P_D (R_{\theta JC}) + R_{\theta SA})$, where P_D = Power Dissipation in Watts.



Thermal measurements of $R_{\theta JC}$ are referenced to the point on the heat tab indicated with an 'X'. Measurements should be taken with device orientated along its vertical axis.

Figure 15. Approximate Thermal Circuit Model

Advance Information

POWER OPTO™ Isolator

2 Amp Random-Phase Triac Output

MOC2R60-10*

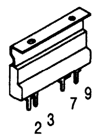
MOC2R60-15

***Motorola Preferred Devices**

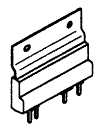
This device consists of a gallium arsenide infrared emitting diode optically coupled to a random phase triac driver circuit and a power triac. It is capable of driving a load of up to 2 amps (rms) directly, on line voltages from 20 to 280 volts AC (rms).

- Provides Normally Open Solid State AC Output with 2 Amp Rating
- 70 Amp Single Cycle Surge Capability
- Phase Controllable
- High Input-Output Isolation of 3750 vac (rms)
- Static dv/dt Rating of 400 Volts/μs Guaranteed
- 2 Amp Pilot Duty Rating Per UL508 ¶117 (Overload Test) and ¶118 (Endurance Test) [File No. 129224]
- CSA Approved [File No. CA77170-1]. VDE Approval in Process.
- Exceeds NEMA 2-230 and IEEE472 Noise Immunity Test Requirements (See Figure 17)

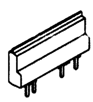
OPTOISOLATOR
2 AMPS
RANDOM–PHASE
TRIAC OUTPUT
600 VOLTS



CASE 417-02
Style 2
PLASTIC PACKAGE

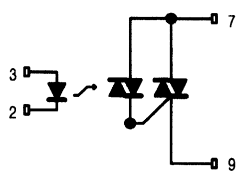


CASE 417A-02
Style 1
PLASTIC PACKAGE



CASE 417B-01
Style 1
PLASTIC PACKAGE

DEVICE SCHEMATIC



1, 4, 5, 6, 8. NO PIN
2. LED CATHODE
3. LED ANODE
7. MAIN TERMINAL 2
9. MAIN TERMINAL 1

DEVICE RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
INPUT LED			
Forward Current — Maximum Continuous	I_F	50	mA
Forward Current — Maximum Peak (PW = 100μs, 120 pps)	I_F(pk)	1.0	A
Reverse Voltage — Maximum	V_R	6.0	V
OUTPUT TRIAC			
Output Terminal Voltage — Maximum Transient (1)	V_{DRM}	600	V(pk)
Operating Voltage Range — Maximum Continuous (f = 47–63 Hz)	V_T	20 to 280	Vac(rms)
On-State Current Range (Free Air, Power Factor ≥ 0.3)	I_T(rms)	0.03 to 2.0	A
Non-Repetitive Single Cycle Surge Current — Maximum Peak (t = 16.7 ms)	I_{TSM}	70	A
Main Terminal Fusing Current (t = 8.3 ms)	I^2T	26	A^2sec
Load Power Factor Range	PF	0.3 to 1.0	—
Junction Temperature Range	T_J	– 40 to 125	°C
TOTAL DEVICE			
Input-Output Isolation Voltage — Maximum (2) 47–63 Hz, 1 sec Duration	V_{ISO}	3750	Vac(rms)
Thermal Resistance — Power Triac Junction to Case (See Figure 18)	$R_{\theta JC}$	8.0	°C/W
Ambient Operating Temperature Range	T_{oper}	– 40 to +100	°C
Storage Temperature Range	T_{stg}	– 40 to +150	°C
Lead Soldering Temperature — Maximum (1/16″ From Case, 10 sec Duration)	T_L	260	°C

1. Test voltages must be applied within dv/dt rating.
2. Input-Output isolation voltage, V_{ISO}, is an internal device dielectric breakdown rating. For this test, pins 2, 3 and the heat tab are common, and pins 7 and 9 are common.

This document contains information on a new product. Specifications and information herein are subject to change without notice.
Preferred devices are Motorola recommended choices for future use and best overall value.

REV 1

MOC2R60-10 MOC2R60-15

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

Characteristic	Symbol	Min	Typ	Max	Unit
INPUT LED					
Forward Voltage (I_F = 10 mA)	V_F	1.00	1.17	1.50	V
Reverse Leakage Current (V_R = 6.0 V)	I_R	—	1.0	100	μA
Capacitance	C	—	18	—	pF
OUTPUT TRIAC					
Off-State Leakage, Either Direction (I_F = 0, V_{DRM} = 400 V)	I_{DRM}(1)	—	0.25	100	μA
Critical Rate of Rise of Off-State Voltage (Static) (V_{in} = 400 vac(pk)) (1) (2)	dv/dt(s)	400	—	—	V/μs
Holding Current, Either Direction (I_F = 0, V_D = 12 V, I_T = 200 mA)	I_H	—	10	—	mA
COUPLED					
LED Trigger Current Required to Latch Output Either Direction (Main Terminal Voltage = 2.0 V) (3) (4) MOC2R60-10 MOC2R60-15	I_{FT}(on)	—	7.0 12	10 15	mA
On-State Voltage, Either Direction (I_F = Rated I_{FT}(on), I_{TM} = 2.0 A)	V_{TM}	—	0.96	1.3	V
Commutating dv/dt (Rated V_{DRM}, I_T = 30 mA – 2.0 A(rms), T_A = – 40 + 100°C, f = 60 Hz) (2)	dv/dt (c)	5.0	—	—	V/μS
Common-mode Input-Output dv/dt (2)	dv/dt(cm)	—	40,000	—	V/μS
Input-Output Capacitance (V = 0, f = 1.0 MHz)	C_{ISO}	—	1.3	—	pF
Isolation Resistance (V_{I-O} = 500 V)	R_{ISO}	10^{12}	10^{14}	—	Ω

1. Per EIA/NARM standard RS–443, with V_P = 200 V, which is the instantaneous peak of the maximum operating voltage.
2. Additional dv/dt information, including test methods, can be found in Motorola applications note AN1048/D.
3. All devices are guaranteed to trigger at an I_F value less than or equal to the max I_{FT}. Therefore, the recommended operating I_F lies between the device's maximum I_{FT}(on) limit and the Maximum Rating of 50 mA.
4. Current–limiting resistor required in series with LED.

TYPICAL CHARACTERISTICS

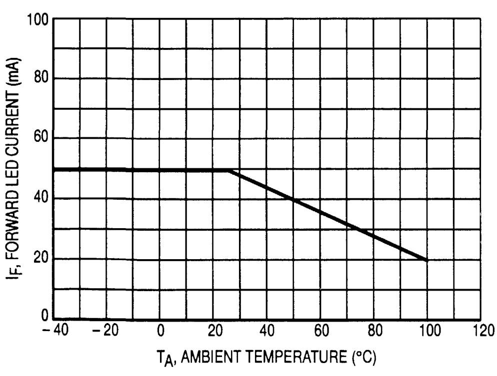


Figure 1. Maximum Allowable Forward LED Current versus Ambient Temperature

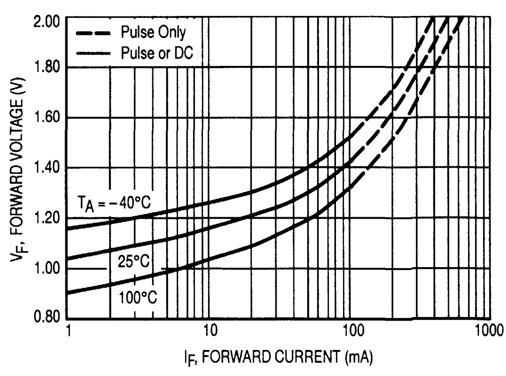


Figure 2. LED Forward Voltage versus LED Forward Current

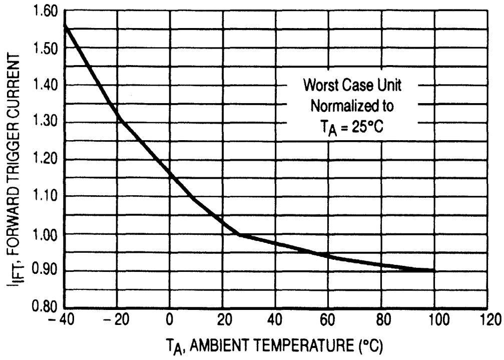


Figure 3. Forward LED Trigger Current versus Ambient Temperature

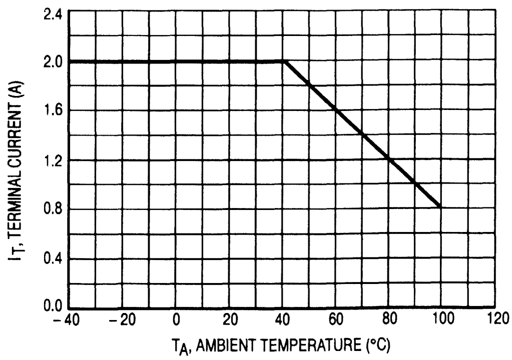


Figure 4. Maximum Allowable On-State RMS Output Current (Free Air) versus Ambient Temperature

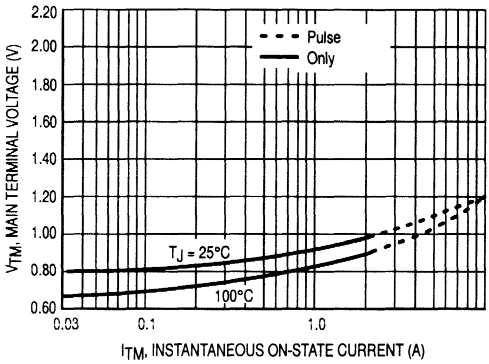


Figure 5. On-State Voltage Drop versus Output Terminal Current

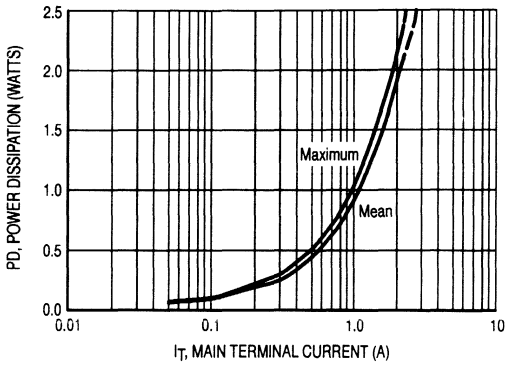


Figure 6. Power Dissipation versus Main Terminal Current

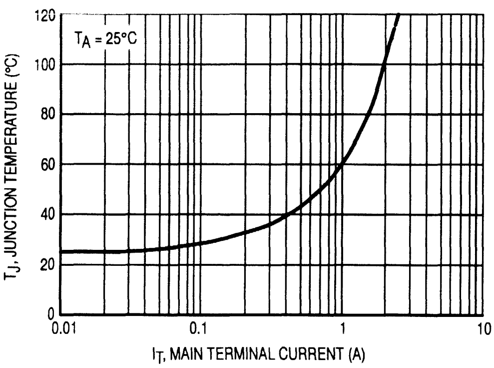


Figure 7. Junction Temperature versus Main Terminal RMS Current (Free Air)

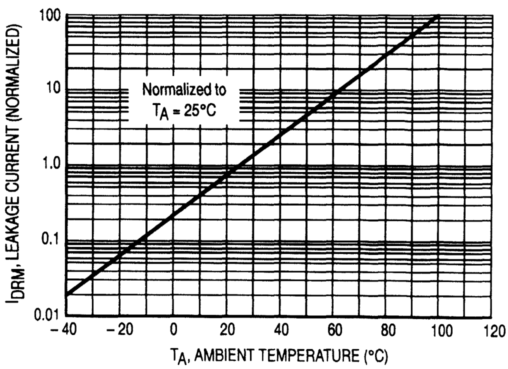


Figure 8. Leakage with LED Off versus Ambient Temperature

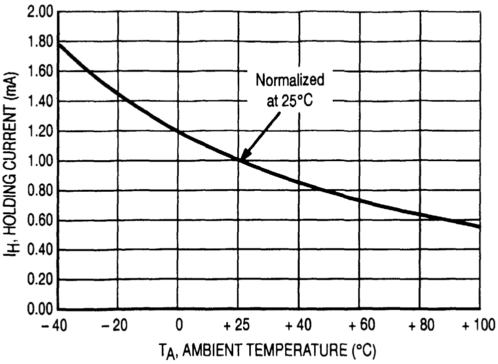


Figure 9. Holding Current versus Ambient Temperature

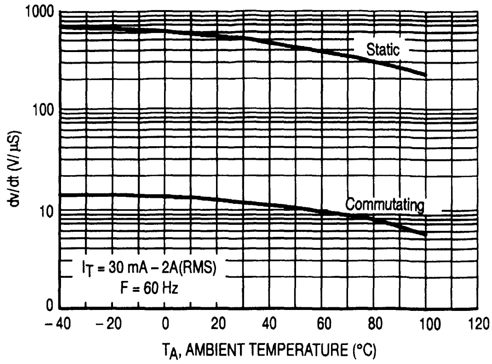


Figure 10. dv/dt versus Ambient Temperature

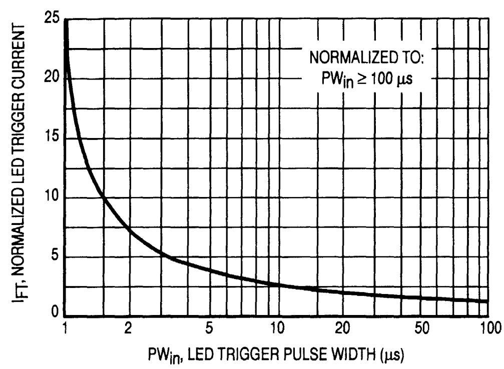


Figure 11. LED Current Required to Trigger versus LED Pulse Width

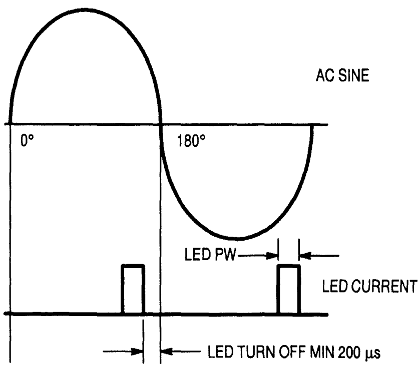


Figure 12. Minimum Time for LED Turn-Off to Zero Cross of AC Trailing Edge

Phase Control Considerations

LED Trigger Current versus PW (normalized)

The Random Phase POWER OPTO Isolators are designed to be phase controllable. They may be triggered at any phase angle within the AC sine wave. Phase control may be accomplished by an AC line zero cross detector and a variable pulse delay generator which is synchronized to the zero cross detector. The same task can be accomplished by a microprocessor which is synchronized to the AC zero crossing. The phase controlled trigger current may be a very short pulse which saves energy delivered to the input LED. LED trigger pulse currents shorter than 100 µs must have an increased amplitude as shown on Figure 11. This graph shows the dependency of the trigger current I_{FT} versus the pulse width t (PW). The reason for the I_{FT} dependency on the pulse width can be seen on the chart delay t(d) versus the LED trigger current.

I_{FT} in the graph I_{FT} versus (PW) is normalized in respect to the minimum specified I_{FT} for static condition, which is specified in the device characteristic. The normalized I_{FT} has to be multiplied with the devices guaranteed static trigger current.

Example:
Guaranteed I_{FT} = 10 mA, Trigger pulse width PW = 3 µs
I_{FT} (pulsed) = 10 mA x 5 = 50 mA

Minimum LED Off Time in Phase Control Applications

In phase control applications one intends to be able to control each AC sine half wave from 0 to 180 degrees. Turn on at zero degrees means full power, and turn on at 180 degrees means zero power. This is not quite possible in reality because triac driver and triac have a fixed turn on time when activated at zero degrees. At a phase control angle close to 180 degrees the turn on pulse at the trailing edge of the AC sine wave must be limited to end 200 µs before AC zero cross as shown in Figure 12. This assures that the device has time to switch off. Shorter times may cause loss off control at the following half cycle.

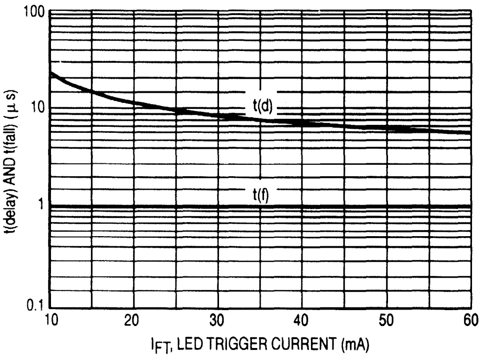


Figure 13. Delay Time, t(d), and Fall Time, t(f), versus LED Trigger Current

t(delay), t(f) versus I_{FT}

The POWER OPTO Isolators turn on switching speed consists of a turn on delay time t(d) and a fall time t(f). Figure 13 shows that the delay time depends on the LED trigger current, while the actual trigger transition time t(f) stays constant with about one micro second.

The delay time is important in very short pulsed operation because it demands a higher trigger current at very short trigger pulses. This dependency is shown in the graph I_{FT} versus LED PW.

The turn on transition time t(f) combined with the power triacs turn on time is important to the power dissipation of this device.

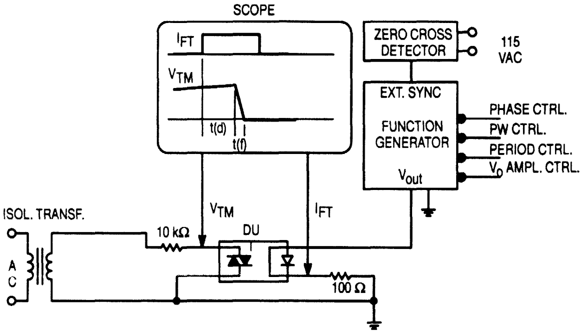


Figure 14. Switching Time Test Circuit

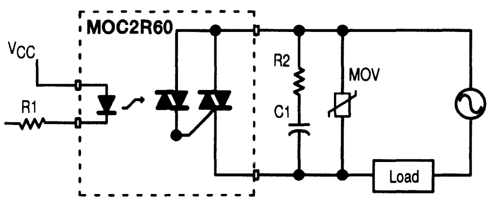


Figure 15. Typical Application Circuit

Select the value of R1 according to the following formulas:

(1) $R1 = (V_{CC} - V_F)$ / Max. I_{FT} (on) per spec.

(2) $R1 = (V_{CC} - V_F) / 0.050$

Typical values for C1 and R2 are 0.01 μF and 39 Ω, respectively. You may adjust these values for specific applications. The maximum recommended value of C1 is 0.022 μF. See application note AN1048 for additional information on component values.

The MOV may or may not be needed depending upon the characteristics of the applied AC line voltage. For applications where line spikes may exceed the 600 volts rating of the MOC2R60, an MOV is required.

Use care to maintain the minimum spacings as shown. Safety and regulatory requirements dictate a minimum of 8.0 mm between the closest points between input and output conducting paths, Pins 3 and 7. Also, 0.070 inches distance is required between the two output Pins, 7 and 9.

Keep pad sizes on Pins 7 and 9 as large as possible for optimal performance.

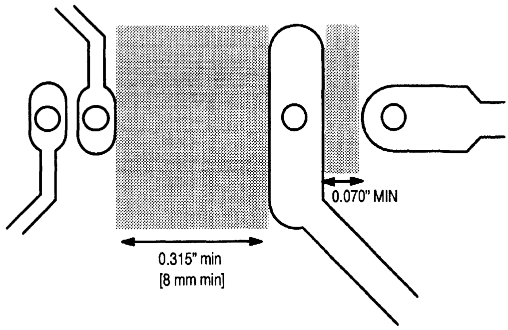


Figure 16. PC Board Layout Recommendations

Each device, when installed in the circuit shown in Figure 17, shall be capable of passing the following conducted noise tests:

- IEEE 472 (2.5 KV)
- Lamp Dimmer (NEMA Part DC33, § 3.4.2.1)
- NEMA ICS 2-230.45 Showering Arc
- MIL-STD-461A CS01, CS02 and CS06

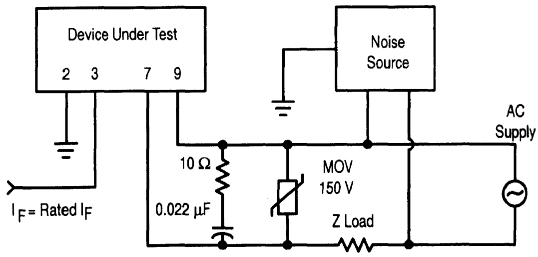


Figure 17. Test Circuit for Conducted Noise Tests

Junction Temperature of MOC2R60 . . . Output Chip

No Additional Heatsink

T_J — $R_{\theta JC}$ — T_C — $R_{\theta CA}$ — T_A

Heat Flow →

With Additional Heatsink

T_J — $R_{\theta JC}$ — T_C — $R_{\theta CS}$ — T_S — $R_{\theta SA}$ — T_A

Ambient Air Temperature

Terms in the model signify:

T_A = Ambient temperature
T_S = Optional additional heat sink temperature
T_C = Case temperature
T_J = Junction temperature
P_D = Power dissipation

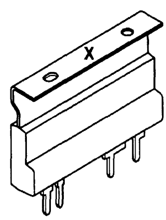
$R_{\theta SA}$ = Thermal resistance, heat sink to ambient
$R_{\theta CA}$ = Thermal resistance, case to ambient
$R_{\theta CS}$ = Thermal resistance, heat sink to case
$R_{\theta JC}$ = Thermal resistance, junction to case

Values for thermal resistance components are: $R_{\theta CA}$ = 36°C/W/in maximum
$R_{\theta JC}$ = 8.0°C/W maximum

The design of any additional heatsink will determine the values of $R_{\theta SA}$ and $R_{\theta CS}$.

$T_C - T_A = P_D (R_{\theta CA})$

$= P_D (R_{\theta JC}) + R_{\theta SA})$, where P_D = Power Dissipation in Watts.



Thermal measurements of $R_{\theta JC}$ are referenced to the point on the heat tab indicated with an 'X'. Measurements should be taken with device orientated along its vertical axis.

Figure 18. Approximate Thermal Circuit Model

Section 8

Applications Information

Optoisolator (Transistor Output) Application Circuits

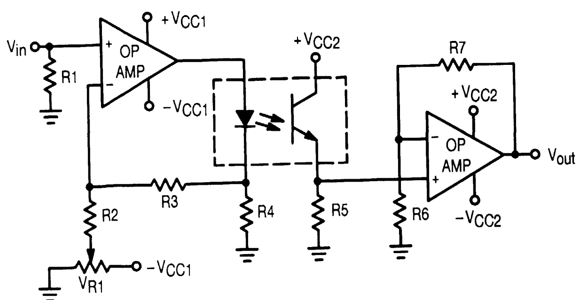


Figure 1. Isolation Amplifier

The circuit in Figure 1 is a non–modulated isolation amplifier that operates with low–frequency signals. The optoisolator input is biased by a DC forward current superimposed on a low–frequency signal. The DC bias current is adjusted by VR.

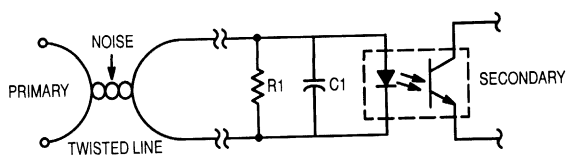
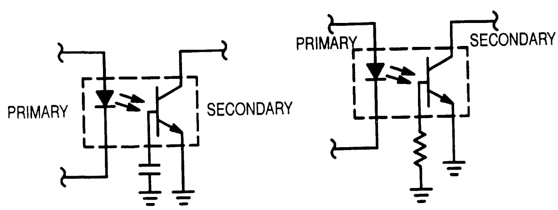


Figure 2. Noise Protection Circuits

The circuit in Figure 2 includes the parallel connection of a Resistor (R1) and capacitor (C1) across the input of the optoisolator useful when relatively long signal lines are connected (i.e., between a compute and terminal). The larger the value of C1 the more the effect, with a sacrifice to signal propagation.



Circuit A **Circuit B**

Figure 3. Noise Protection Circuits

In Figure 3, Circuit A is effective against noise, but sacrifices response time. Circuit B is also effective against noise with a sacrifice in CTR due to the base resistor. If the optoisolator is operated in a switching mode, it is best to use isolators without the base–chip to pin connection (i.e., MOC8101 series).

Optoisolator (Transistor Output) Application Circuits (continued)

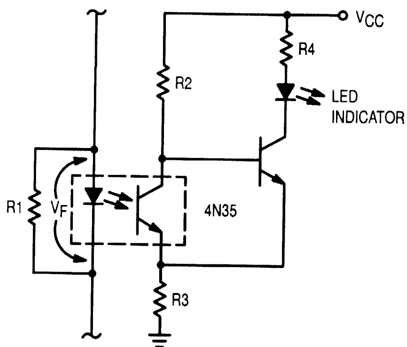


Figure 4. Current Monitor Circuit

The circuit in Figure 4 is designed to detect any leakage current in a circuit. The LED indicator turns on if the leak current exceeds the $V_F/R1$ value.

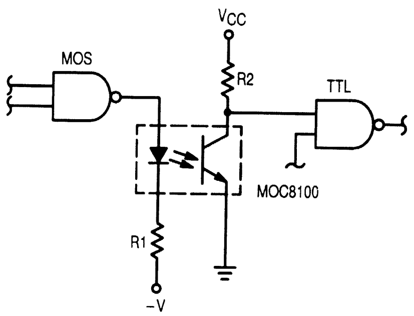


Figure 5. Level Conversion Circuit

The circuit in Figure 5 shows a simple level converter using an optoisolator. This circuit converts the MOS level to TTL levels. Because of the small currents supplied from the MOS IC, an optoisolator with a high CTR at low input current is required.

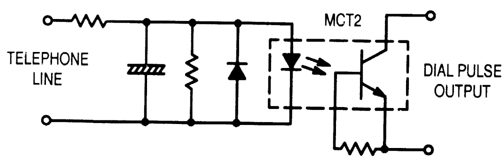


Figure 6. Dial Pulse Monitor Circuit

The circuit in Figure 6 shows an optoisolator that is actuated by dial pulse currents when connected to the telephone line. The output is used as a dial pulse monitor.

Optoisolator (Transistor Output) Application Circuits (continued)

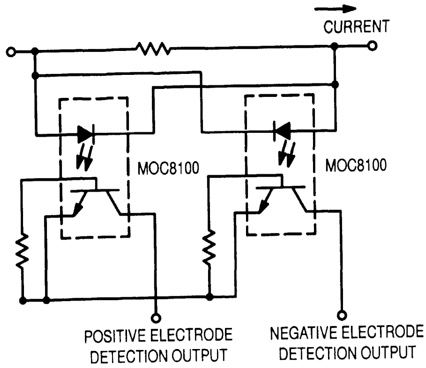


Figure 7. Telephone Line Polarity Detection Circuit

The circuit in Figure 7 shows an example of an optoisolator used to detect the polarity on a telephone line.

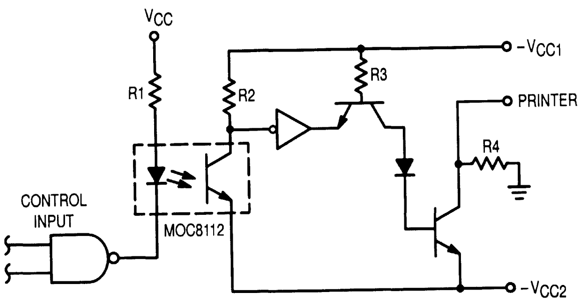


Figure 8. Print Head Circuit Control

The circuit in Figure 8 shows an electrostatic printer control circuit utilizing an optoisolator. The high voltage print head driving circuit is optically isolated from the low voltage control input.

Optoisolator (AC Input/Transistor Output) Application Circuits

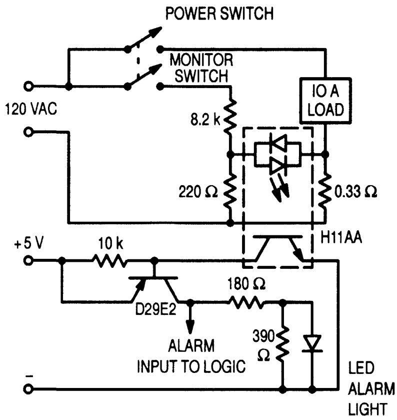


Figure 1. Load Monitor and Alarm

The circuit in Figure 1 is a simple AC power monitor that will light an alarm lamp and provide a "1" input to a microprocessor if either of the following occurs:

1) Load dropout due to filament burn out, fusing, etc.
2) Uncalled–for load power due to switch failure.

The optoisolator provides complete electrical isolation between logic and power levels.

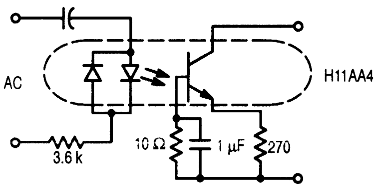


Figure 2. Ring Detector

The circuit in Figure 2 will detect the presence of an incoming ring signal causing the output transistor to be turned on.

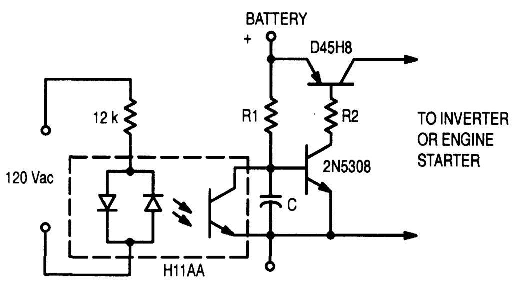


Figure 3. UPS Solid State Turn–On Switch

The circuit in Figure 3 detects when the 120 Vac power line is interrupted causing the output transistor to turn off. This allows C to change and turn on the 2N5308–D45H8 combination which then activates the auxiliary power supply. A fixed number of "dropped cycles" can be ignored by the choice of value C.

Optoisolator (AC Input/Transistor Output) Application Circuits (continued)

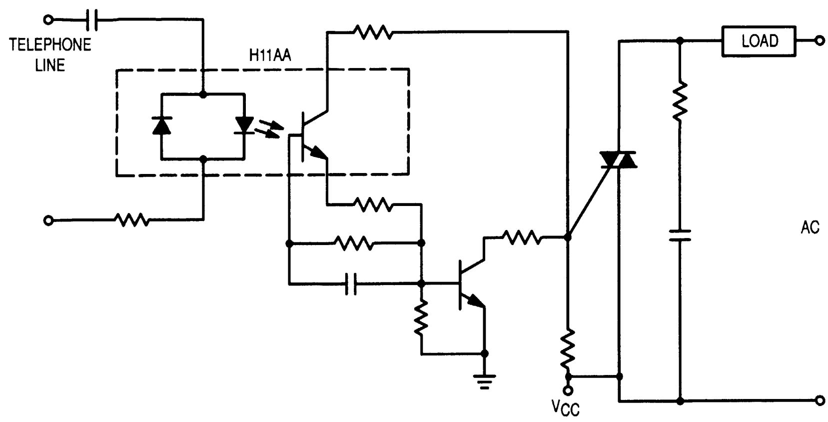


Figure 4. Power Control by Bell Signal Circuit

The circuit in Figure 4 is an application example for ON/OFF switching of AC loads by a telephone bell signal.

Optoisolator (Triac Driver) Application Circuits

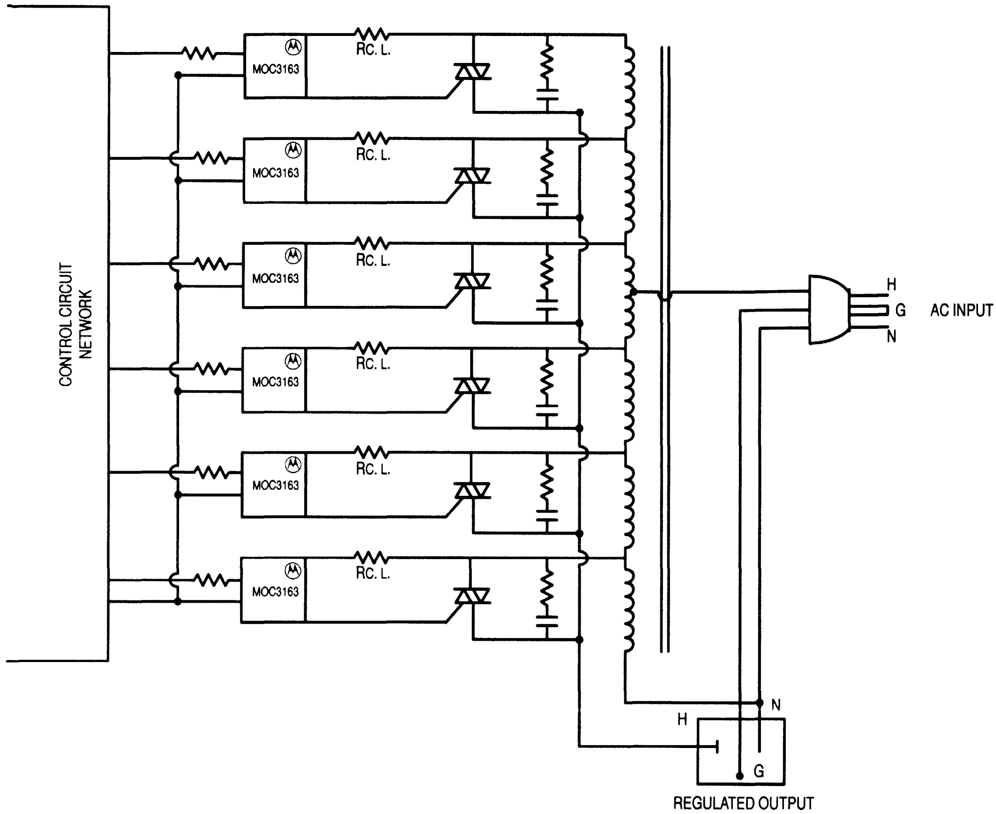


Figure 1. Line Voltage Regulator (Tap Switching)

- Step Up or Step Down Regulation
- Regulated up to 240 Vac
- Isolated Control Network Built–In
- Zero Crossing Control Limiting Current Surges

Optoisolator (Triac Driver) Application Circuits (continued)

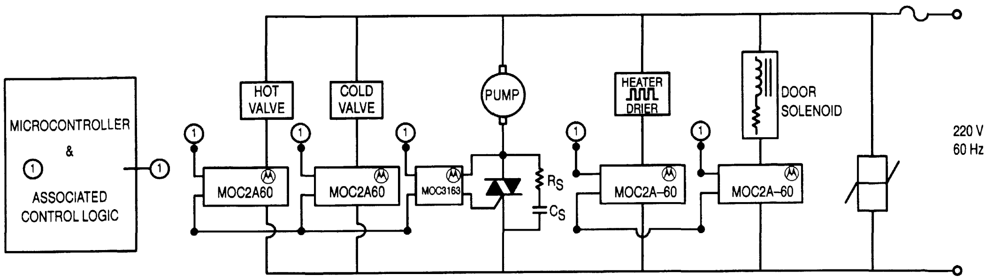


Figure 2. Commercial Appliance Control (Dishwasher/Washing Machine/Dryer) Application

- Microprocessor Controlled and Isolated from AC Power
- Zero–Crossing Protection
- Limits Surge Currents Protecting Hardware Added
- Noise Immunity (Passes NEMA 2–230, IEEE472)

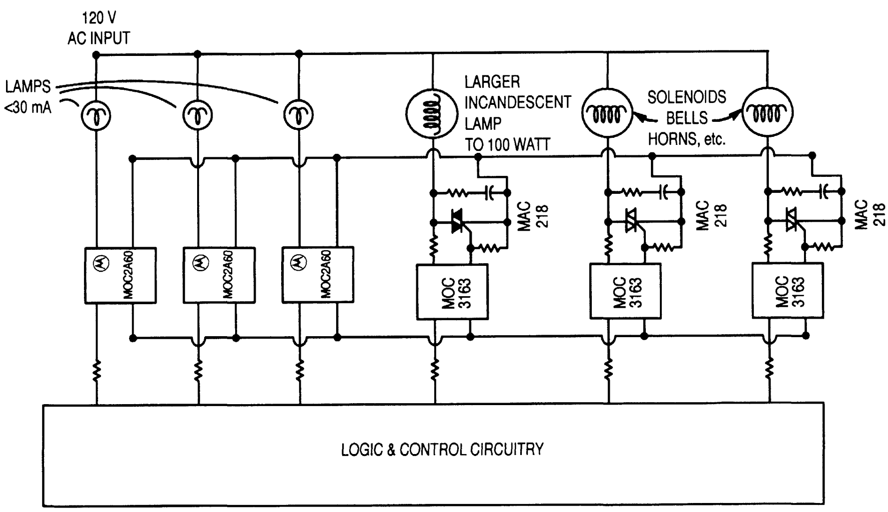


Figure 3. Gaming Machine or Lamp Control Application

- Low Cost Solid–State Control
- Multiple Purpose Zero Cross Switching
- Isolated for Control Circuit Protection

Optoisolator (Triac Driver) Application Circuits (continued)

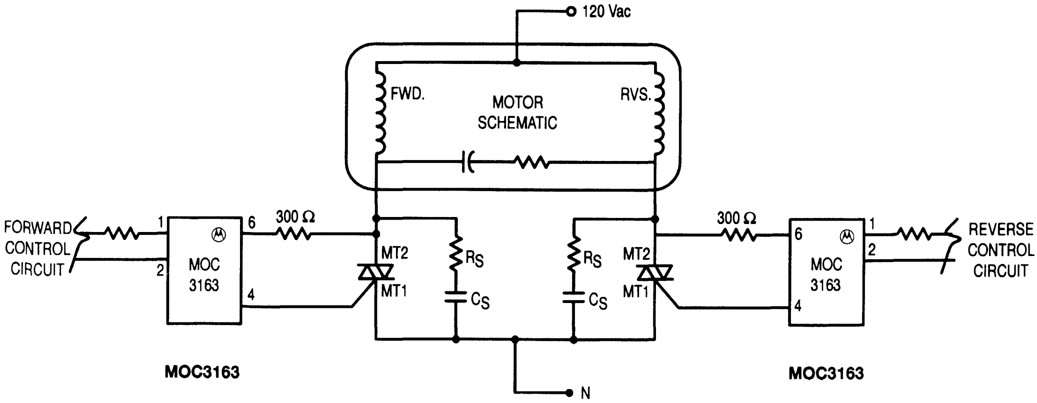


Figure 4. Reversing Motor Application

- Ideal for Up/Down or Forward/Reversing Applications
  - Security Gates
  - Recliner Chairs
  - Hospital Beds
- Zero Crossing Control

AN571A

Isolation Techniques Using Optical Couplers

Prepared by:
Francis Christian

INTRODUCTION

The optical coupler is a venerable device that offers the design engineer new freedoms in designing circuits and systems. Problems such as ground loop isolation, common mode noise rejection, power supply transformations, and many more problems can be solved or simplified with the use of an optical coupler.

Operation is based on the principle of detecting emitted light. The input to the coupler is connected to a light emitter and the output is a photodector, the two elements being separated by a transparent insulator and housed in a light–excluding package. There are many types of optical couplers; for example, the light source could be an incandescent lamp or a light emitting diode (LED). Also, the detector could be photovoltaic cell, photoconductive cell, photodiode, phototransistor, or a light–sensitive SCR. By various combinations of emitters and detectors, a number of different types of optical couplers could be assembled.

Once an emitter and detector have been assembled as a coupler, the optical portion is permanently established so that device use is only electronic in nature. This eliminates the need for the circuit designer to have knowledge of optics. However, for effective application, he must know something of the electrical characteristics, capabilities, and limitations of the emitter and detector.

COUPLER CHARACTERISTICS

The 4N25 is an optical coupler consisting of a gallium arsenide (GaAs) LED and a silicon phototransistor. (For more information on LEDs and phototransistors, see References 1 and 2.)

The coupler's characteristics are given in the following sequence: LED characteristics, phototransistor characteristics, coupled characteristics, and switching characteristics. Table 1 shows all four for the 4N25 series.

INPUT

For most applications the basic LED parameters I_F and V_F are all that are needed to define the input. Figure 1 shows these forward characteristics, providing the necessary information to design the LED drive circuit. Most circuit applications will require a current limiting resistor in series with the LED input. The circuit in Figure 2 is a typical drive circuit.

The current limiting resistor can be calculated from the following equation:

$$R = \frac{V_{IN} - V_F}{I_F},$$

where V_F = diode forward voltage
I_F = diode forward current

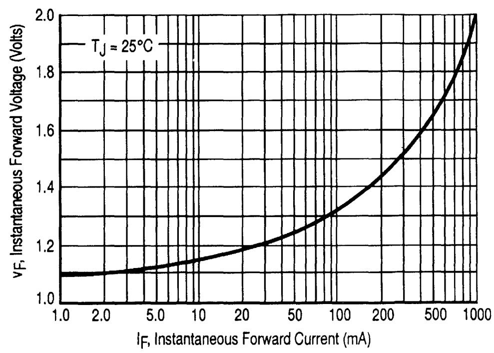


Figure 1. Input Diode Forward Characteristic

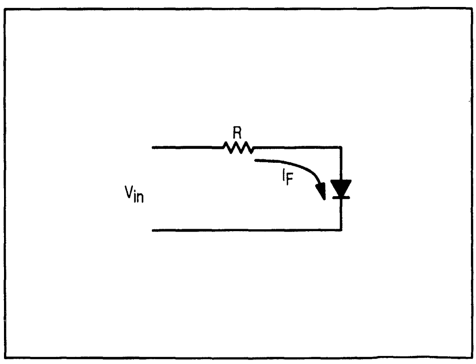


Figure 2. Simple Drive Circuit for an LED

REV 1

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

Characteristic	Symbol	Min	Typ	Max	Unit
*Reverse Leakage Current (V_R = 3.0 V, R_L = 1.0 M ohms)	I_R	—	0.05	100	μA
*Forward Voltage (I_F = 50 mA)	V_F	—	1.2	1.5	Volts
Capacitance (V_R = 0 V, f = 1.0 MHz)	C	—	150	—	pF

PHOTOTRANSISTOR CHARACTERISTICS (T_A = 25°C and I_F = 0 unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
*Collector–Emitter Dark Current (V_{CE} = 10 V, Base Open)	4N25, 4N26, 4N27 4N28	I_{CEO}	— —	3.5 —	50 100	nA
*Collector–Base Dark Current (V_{CB} = 10 V, Emitter Open)		I_{CBO}	—	—	20	nA
*Collector–Base Breakdown Voltage (I_C = 100 μA, I_E = 0)		$V_{(BR)CBO}$	70	—	—	Volts
*Collector–Emitter Breakdown Voltage (I_C = 1.0 mA, I_B = 0)		$V_{(BR)CEO}$	30	—	—	Volts
*Emitter–Collector Breakdown Voltage (I_E = 100 μA, I_B = 0)		$V_{(BR)ECO}$	7.0	—	—	Volts
DC Current Gain (V_{CE} = 5.0 V, I_C = 500 μA)		h_{FE}	—	250	—	—

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

Characteristic		Symbol	Min	Typ	Max	Unit
*Collector Output Current(1) (V_{CE} = 10 V, I_F = 10 mA, I_B = 0)	4N25, 4N26 4N27, 4N28	I_C	2.0 1.0	5.0 3.0	— —	mA
*Isolation Voltage(2)	4N25 4N26, 4N27 4N28	V_{ISO}	2500 1500 500	— — —	— — —	Volts
Isolation Resistance(2) (V = 500 V)		—	—	10^{11}	—	Ohms
*Collector–Emitter Saturation (I_C = 2.0 mA, I_F = 50 mA)		$V_{CE(sat)}$	—	0.2	0.5	Volts
Isolation Capacitance(2) (V = 0, f = 1.0 MHz)		—	—	1.3	—	pF
Bandwidth(3) (I_C = 2.0 mA, R_L = 100 ohms, Figure 11)		—	—	300	—	kHz

SWITCHING CHARACTERISTICS

			Symbol	Min	Typ	Max	Unit
Delay Time	(I_C = 10 mA, V_{CC} = 10 V) Figures 6 and 8	4N25, 4N26 4N27, 4N28	t_d	— —	0.07 0.10	— —	μs
Rise Time	(I_C = 10 mA, V_{CC} = 10 V) Figures 6 and 8	4N25, 4N26 4N27, 4N28	t_r	— —	0.8 2.0	— —	μs
Storage Time	(I_C = 10 mA, V_{CC} = 10 V) Figures 7 and 8	4N25, 4N26 4N27, 4N28	t_s	— —	4.0 2.0	— —	μs
Fall Time	(I_C = 10 mA, V_{CC} = 10 V) Figures 7 and 8	4N25, 4N26 4N27, 4N28	t_f	— —	7.0 3.0	— —	μs

* indicates JEDEC Registered Data 1. Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.
2. For this test LED pins 1 and 2 are common and Photo Transistor pins 4, 5 and 6 are common.
3. I_F adjusted to yield I_C = 2.0 mA and I_C = 2.0 mAp p at 10 kHz.

OUTPUT

The output of the coupler is the phototransistor. The basic parameters of interest are the collector current I_C and collector emitter voltage, V_{CE}. Figure 3 is a curve of $V_{CE(sat)}$ versus I_C for two different drive levels.

COUPLING

To fully characterize the coupler, a new parameter, the dc current transfer ratio or coupling efficiency (η) must be defined. This is the ratio of the transistor collector current to diode current I_C/I_F. Figures 4A and 4B show the typical dc current transfer functions for the couplers at V_{CE} = 10 volts. Note that η varies with I_F and V_{CE}.

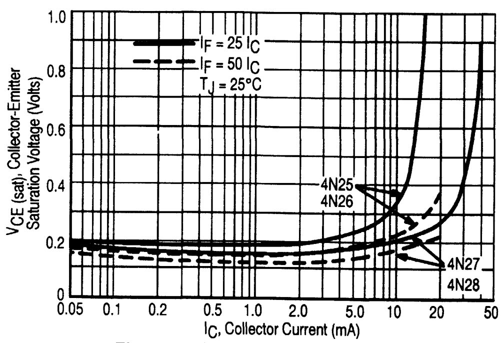


Figure 3. Collector Saturation Voltage

Once the required output collector current I_C is known, the input diode current can be calculated by

$$I_F = I_C/\eta,$$

where I_F is the forward diode current
I_C is the collector current
η is the coupling efficiency or transfer ratio.

4N25, 4N26

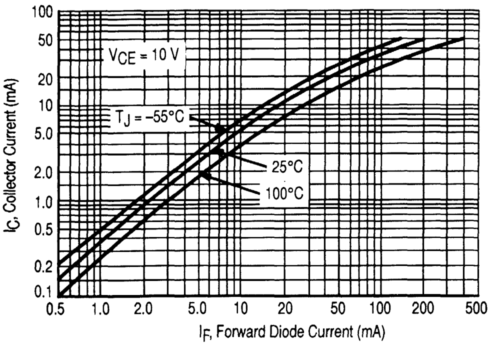


Figure 4A. DC Current Transfer Ratio

4N27, 4N28

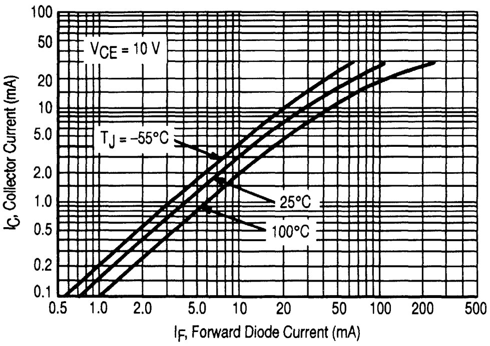


Figure 4B. DC Current Transfer Ratio

RESPONSE TIME

The switching times for the couplers are shown in Figures 5A and 5B. The speed is fairly slow compared to switching transistors, but is typical of phototransistors because of the large base–collector area. The switching time or bandwidth of the coupler is a function of the load resistor R_L because of the R_LC_O time constant where C_O is the parallel combination of the device and load capacitances. Figure 6 is a curve of frequency response versus R_L.

TURN–ON TIME

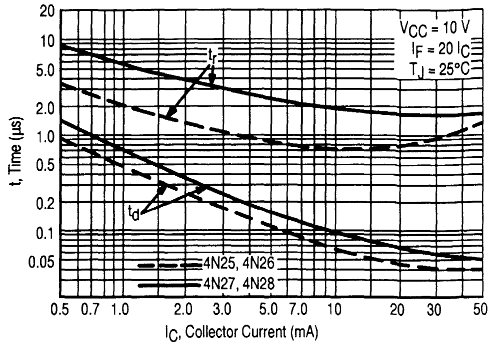


Figure 5A. Switching Times

TURN–OFF TIME

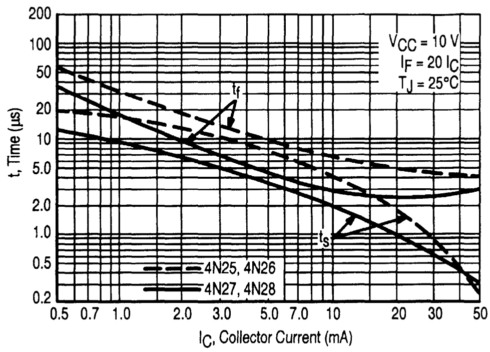


Figure 5B. Switching Times

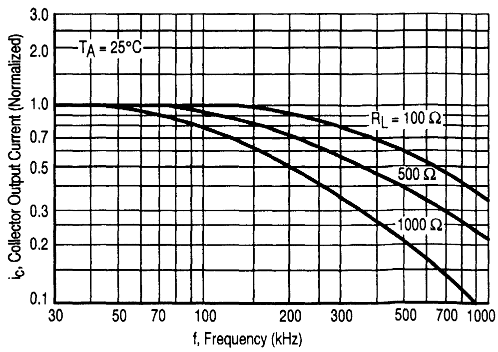


Figure 6. Frequency Response

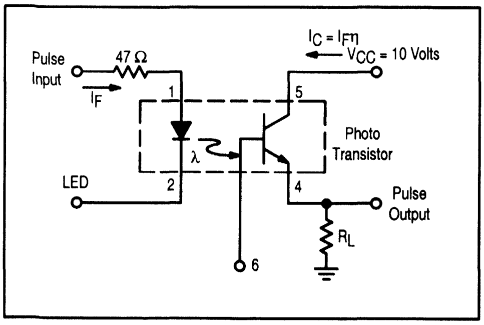


Figure 7. Pulse Mode Circuit

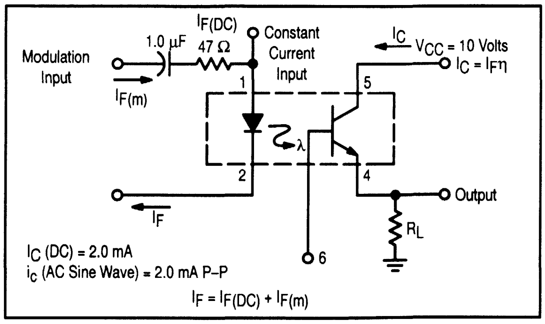


Figure 8. Linear Mode Circuit

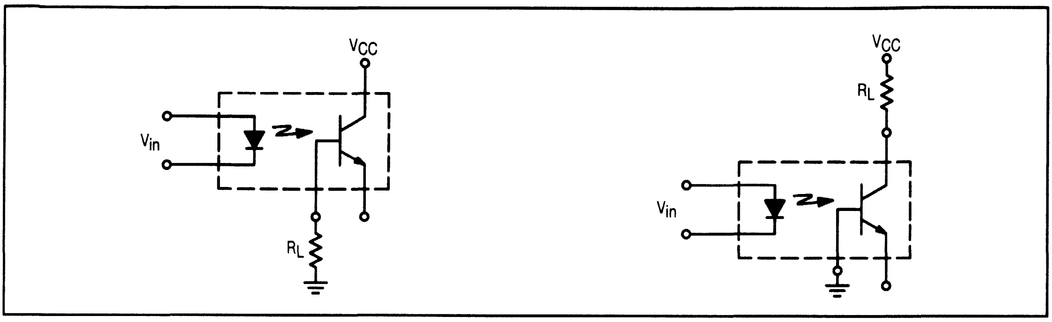


Figure 9. Circuit Connections for Using the 4N26 as a Diode–Diode Coupler

OPERATING MODE

The two basic modes of operation are pulsed and linear. In the pulsed mode of operation, the LED will be switched on or off. The output will also be pulses either in phase or 180° out of phase with the input depending on where the output is taken. The output will be 180° out of phase if the collector is used and in phase if the emitter is used for the output.

In the linear mode of operation, the input is biased at a dc operating point and then the input is changed about this dc point. The output signal will have an ac and dc component in the signal.

Figures 7 and 8 show typical circuits for the two modes of operation.

THE 4N26 AS A DIODE–DIODE COUPLER

The 4N26, which is a diode–transistor coupler, can be used as a diode–diode coupler. To do this the output is taken between the collector and base instead of the collector and emitter. The circuits in Figure 9 show the connections to use the coupler in the diode–diode mode.

The advantage of using the 4N26 as a diode–diode coupler is increased speed. For example, the pulse rise time for adiode–transistor coupler is in the order of 2 to 5 μs, where the diode–diode coupler is 50 to 100 ns. The one disadvantage with the diode–diode coupler is that the output current is much lower than the diode–transistor coupler. This is because the base current is being used as signal current and the β multiplication of the transistor is omitted. Figure 10 is a graph of I_B versus I_F using the coupler in the diode–diode mode.

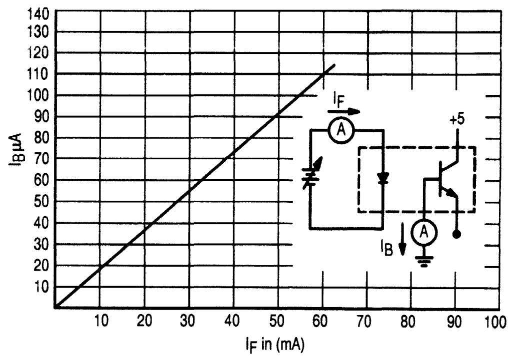


Figure 10. I_B versus I_F Curve for Using the 4N26 as a Diode–Diode Coupler

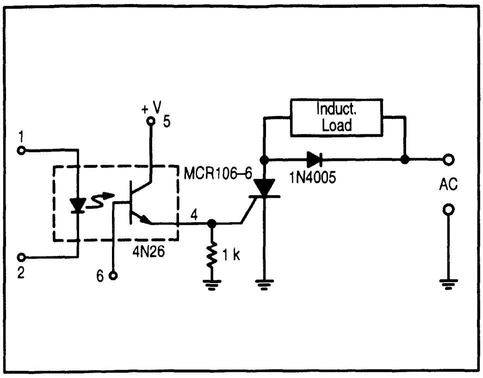


Figure 11. Coupler–Driven SCR

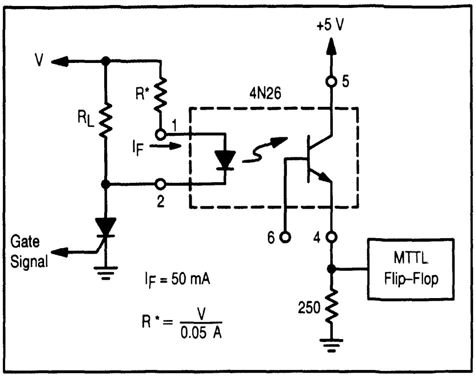


Figure 12. Opto Coupler in a Load to Logic Translation

APPLICATIONS

The following circuits are presented to give the designer ideas of how the 4N26 can be used. The circuits have been bread–boarded and tested, but the values of the circuit components have not been selected for optimum performance over all temperatures.

Figure 11 shows a coupler driving a silicon controlled rectifier (SCR). The SCR is used to control an inductive load, and the SCR is driven by a coupler. The SCR used is a sensitive gate device that requires only 1 mA of gate current and the coupler has a minimum current transfer ratio of 0.2 so the input current to the coupler, I_F, need only be 5 mA. The 1 k resistor connected to the gate of the SCR is used to hold off the SCR. The 1N4005 diode is used to supress the self–induced voltage when the SCR turns off.

Figure 12 is a circuit that couples a high voltage load to a low voltage logic circuit. To ensure that the voltage to the MTTL flip–flop exceeds the logic–one level, the coupler output current must be at least 10 mA. To guarantee 10 mA of output current, the input current to the LED must be 50 mA. The current limiting resistor R can be calculated from the equation $R = \frac{V - V_F}{0.05}$. If the power supply voltage, V, is much greater than V_F, the equation for R reduces to $R = \frac{V}{0.05}$.

The circuit of Figure 13 shows a coupler driving an operational amplifier. In this application an ac signal is passed through the coupler and then amplified by the op amp. To pass an ac signal through the coupler with minimum distortion, it is necessary to bias the LED with a dc current. The ac signal is summed with the dc current so the output voltage of the coupler will have an ac and a dc component. Since the op amp is capacitively coupled to the coupler, only the ac signal will appear at the output.

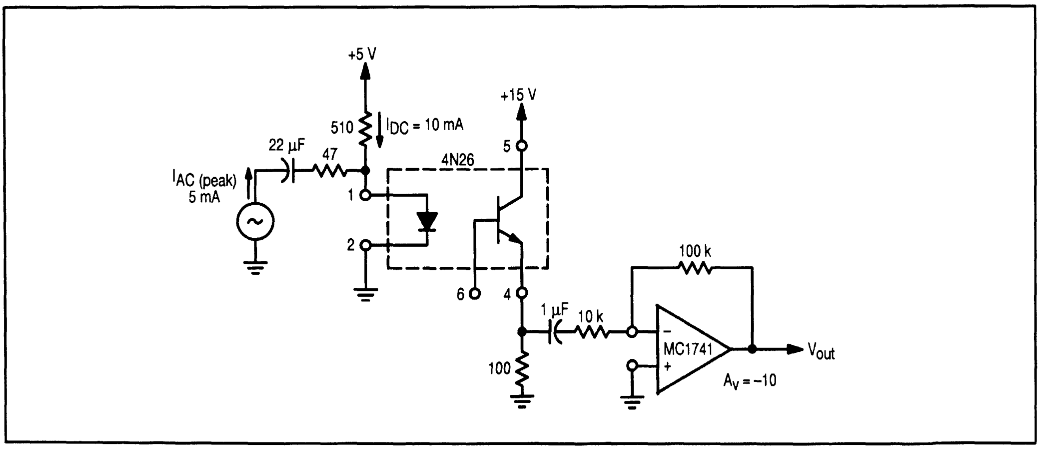


Figure 13. Coupling an AC Signal to an Operational Amplifier

The circuit of Figure 14 shows the 4N26 being used as a diode–diode coupler, the output being taken from the collector–base diode. In this mode of operation, the emitter is left open, the load resistor is connected between the base and ground, and the collector is tied to the positive voltage supply. Using the coupler in this way reduces the switching time from 2 to 3 μs to 100 ns.

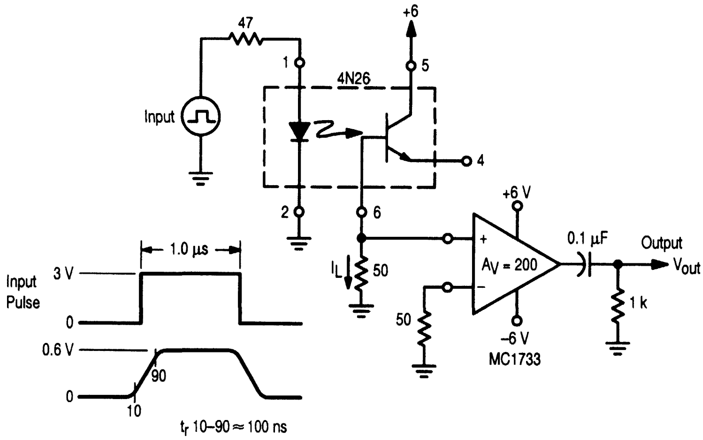


Figure 14. Using the 4N26 as a Diode–Diode Coupler

The circuit of Figure 15 is a standard two–transistor one–shot, with one transistor being the output transistor of the coupler. The trigger to the one–shot is the LED input to the coupler. A pulse of 3 μs in duration and 15 mA will trigger the circuit. The output pulse width (PW_O) is equal to 0.7 RC + PW_1 + 6 μs where PW_1 is the input pulse width and 6 μs is the turn–off delay of the coupler. The amplitude of the output pulse is a function of the power supply voltage of the output side and independent of the input.

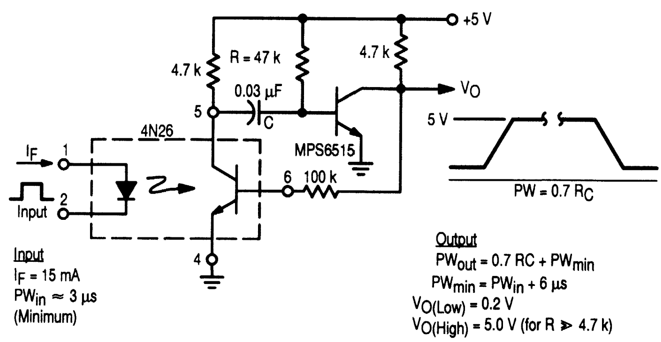


Figure 15. Pulse Stretcher

The circuit of Figure 16 is basically a Schmitt trigger. One of the Schmitt trigger transistors is the output transistor of a coupler. The input to the Schmitt trigger is the LED of the coupler. When the base voltage of the coupler's transistor exceeds V_e+V_{be} the output transistor of the coupler will switch on. This will cause Q2 to conduct and the output will be in a high state. When the input to the LED is removed, the coupler's output transistor will shut off and the output voltage will be in a low state. Because of the high impedance in the base of the coupler transistor, the turn–off delay is about 6μs.

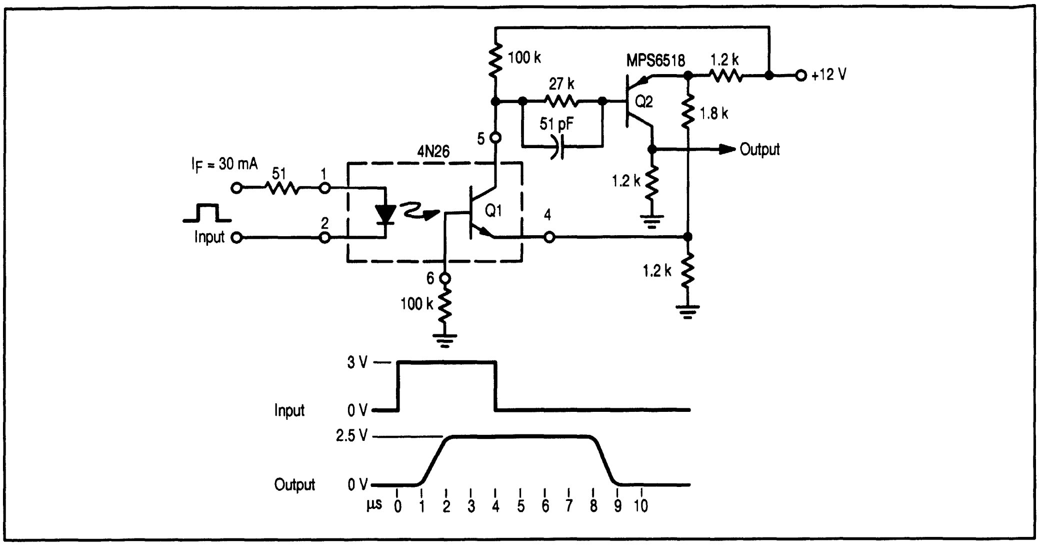


Figure 16. Optically Coupled Schmitt Trigger

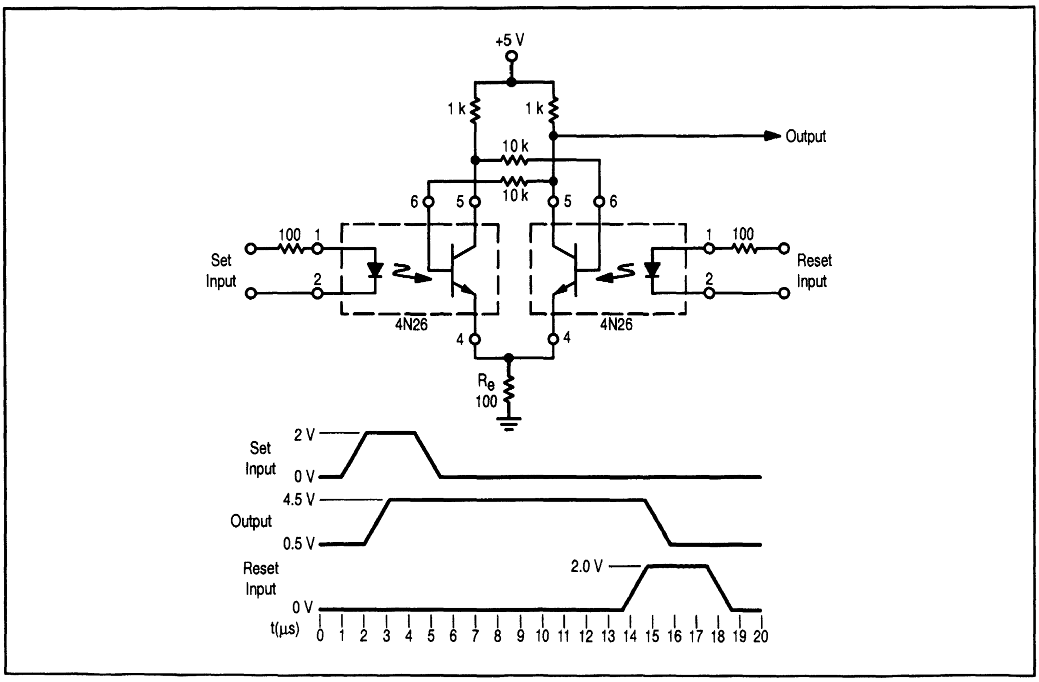


Figure 17. Optically Coupled R–S Flip–Flop

The high base impedance (100 k ohms) represents a compromise between sensitivity (input drive required) and frequency response. A low value base resistor would improve speed but would also increase the drive requirements.

The circuit in Figure 17 can be used as an optically coupled R–S flip–flop. The circuit uses two 4N26 couplers cross coupled to produce two stable states. To change the output from a low state to a high state requires a positive 2 V pulse at the set input. The minimum width of the set pulse is 3 μs. To switch the output back to the low state needs only a pulse on the reset input. The reset–operation is similar to the set operation.

Motorola integrated voltage regulators provide an input for the express purpose of shutting the regulator off. For large systems, various subsystems may be placed in a stand–by mode to conserve power until actually needed. Or the power may be turned OFF in response to occurrences such as overheating, over–voltage, shorted output, etc.

With the use of the 4N26 optically coupler, the regulator can be shut down while the controlling signal is isolated from the regulator. The circuit of Figure 18 shows a positive regulator connected to an optical coupler.

To ensure that the drive to the regulator shut down control is 1 mA, (the required current), it is necessary to drive the LED in the coupler with 5 mA of current, an adequate level for logic circuits.

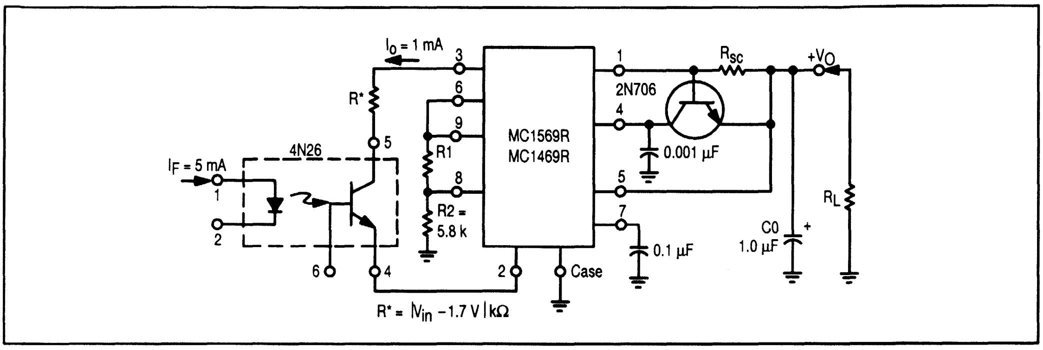


Figure 18. Optical Coupler Controlling the Shut Down of MC1569 Voltage Regulator

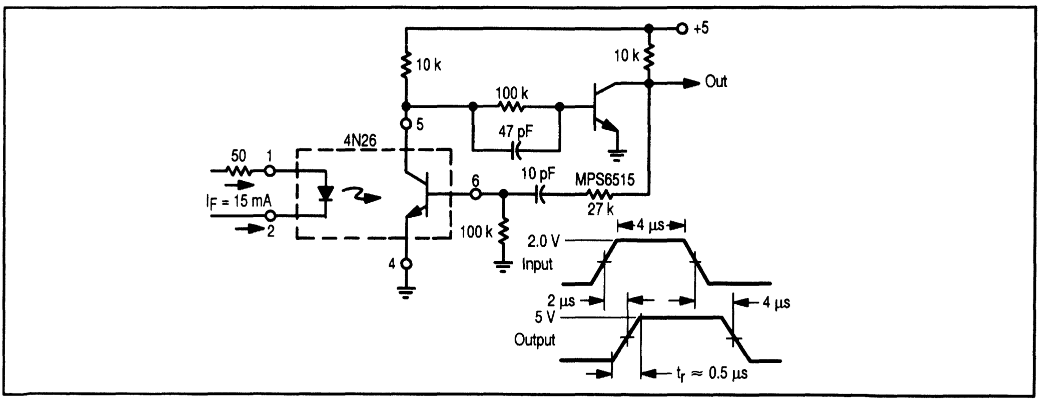


Figure 19. Simple Pulse Amplifier

The circuit in Figure 19 is a simple pulse amplifier using positive, ac feedback into the base of the 4N26. The advantage of the feedback is in faster switching time. Without the feedback, the pulse rise time is about 2.0 μs, but with the positive feedback, the pulse rise time is about 0.5 μs. Figure 17A shows the input and output wave–forms of the pulse amplifier.

REFERENCES

1. "Theory and Characteristics of Phototransistors," Motorola Application Note AN440.
2. "Motorola Switching Transistor Handbook."
3. Deboo, G.J. and C.N. Burrous, *Integrated Circuits and Semiconductor Devices Theory and Application.* New York: McGraw–Hill, 1971.

AN780A

Applications of the MOC3011 Triac Driver

Prepared by:
Pat O'Neil

DESCRIPTIONS OF THE MOC3011

Construction

The MOC3011 consists of a gallium arsenide infrared LED optically exciting a silicon detector chip, which is especially designed to drive triacs controlling loads on the 115 Vac power line. The detector chip is a complex device which functions in much the same manner as a small triac, generating the signals necessary to drive the gate of a larger triac. The MOC3011 allows a low power exciting signal to drive a high power load with a very small number of components, and at the same time provides practically complete isolation of the driving circuitry from the power line.

Basic Electrical Description

The GaAs LED has nominal 1.3 V forward drop at 10 mA and a reverse breakdown voltage greater than 3 V. The maximum current to be passed through the LED is 50 mA.

The detector has a minimum blocking voltage of 250 Vdc in either direction in the off state. In the on state, the detector will pass 100 mA in either direction with less than 3 V drop across the device. Once triggered into the on (conducting) state, the detector will remain there until the current drops below the holding current (typically 100 µA) at which time the detector reverts to the off (non–conducting) state. The detector may be triggered into the on state by exceeding the forward blocking voltage, by voltage ramps across the detector at rates exceeding the static dv/dt rating, or by photons from the LED. The LED is guaranteed by the specifications to trigger the detector into the on state when 10 mA or more is passed through the LED. A similar device, the MOC3010, has exactly the same characteristics except it requires 15 mA to trigger.

Since the MOC3011 looks essentially like a small optically triggered triac, we have chosen to represent it as shown on Figure 1.

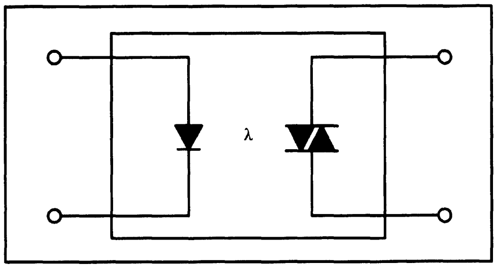


Figure 1. Schematic Representation of MOC3011 and MOC3010

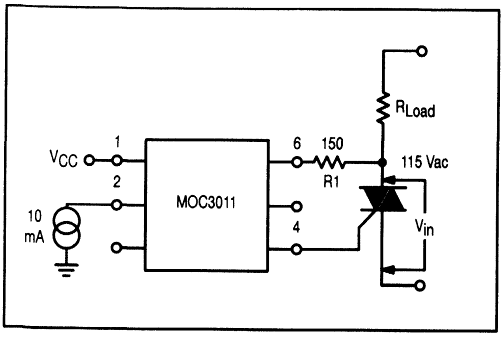
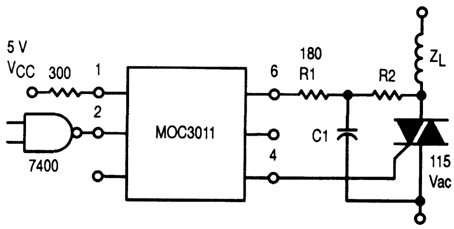


Figure 2. Simple Triac Gating Circuit



NOTE: Circuit supplies 25 mA drive to gate of triac at V_{in} = 25 V and $T_A \leq 70°C$.

TRIAC		
I_{GT}	R2	C
15 mA	2400	0.1
30 mA	1200	0.2
50 mA	800	0.3

Figure 3. Logic to Inductive Load Interface

USING THE MOC3011 AS A TRIAC DRIVER

Triac Driving Requirements

Figure 2 shows a simple triac driving circuit using the MOC3011. The maximum surge current rating of the MOC3011 sets the minimum value of R1 through the equation:

$$R1(min) = V_{in}(pk)/1.2\ A$$

If we are operating on the 115 Vac nominal line voltage, $V_{in}(pk)$ = 180 V, then

$$R1(min) = V_{in}(pk)/1.2\ A = 150\ ohms.$$

In practice, this would be a 150 or 180 ohm resistor. If the triac has I_{GT} = 100 mA and V_{GT} = 2 V, then the voltage V_{in} necessary to trigger the triac will be given by $V_{inT} = R1 \cdot I_{GT} + V_{GT} + V_{TM} = 20$ V.

Resistive Loads

When driving resistive loads, the circuit of Figure 2 may be used. Incandescent lamps and resistive heating elements are the two main classes of resistive loads for which 115 Vac is utilized. The main restriction is that the triac must be properly chosen to sustain the proper inrush loads. Incandescent lamps can sometimes draw a peak current known as "flash-over" which can be extremely high, and the triac should be protected by a fuse or rated high enough to sustain this current.

Line Transients–Static dv/dt

Occasionally transient voltage disturbance on the ac line will exceed the static dv/dt rating of the MOC3011. In this case, it is possible that the MOC3011 and the associated triac will be triggered on. This is usually not a problem, except in unusually noisy environments, because the MOC3011 and its triac will commute off at the next zero crossing of the line voltage, and most loads are not noticeably affected by an occasional single half–cycle of applied power. See Figure 4 for typical dv/dt versus temperature curves.

Inductive Loads–Commutating dv/dt

Inductive loads (motors, solenoids, magnets, etc.) present a problem both for triacs and for the MOC3011 because the voltage and current are not in phase with each other. Since the triac turns off at zero current, it may be trying to turn off when the applied current is zero but the applied voltage is high. This appears to the triac like a sudden rise in applied voltage, which turns on the triac if the rate of rise exceeds the commutating dv/dt of the triac or the static dv/dt of the MOC3011.

Snubber Networks

The solution to this problem is provided by the use of "snubber" networks to reduce the rate of voltage rise seen by the device. In some cases, this may require two snubbers–one for the triac and one for the MOC3011. The triac snubber is dependent upon the triac and load used and will not be discussed here. In many applications the snubber used for the MOC3011 will also adequately protect the triac.

In order to design a snubber properly, one should really know the power factor of the reactive load, which is defined as the cosine of the phase shift caused by the load. Unfortunately, this is not always known, and this makes snubbing network design somewhat empirical. However, a method of designing a snubber network may be defined, based upon a typical power factor. This can be used as a "first cut" and later modified based upon experiment.

Assuming an inductive load with a power factor of PF = 0.1 is to be driven. The triac might be trying to turn off when the applied voltage is given by

$$V_{to} = V_{pk} \sin \emptyset \approx V_{pk} \approx 180\ V$$

First, one must choose R1 (Figure 3) to limit the peak capacitor discharge current through the MOC3011. This resistor is given by

$$R1 = V_{pk}/I_{max} = 180/1.2\ A = 150\ \Omega$$

A standard value, 180 ohm resistor can be used in practice for R1.

It is necessary to set the time constant for $\tau = R_2C$. Assuming that the triac turns off very quickly, we have a peak rate of rise at the MOC3011 given by

$$dv/dt = V_{to}/\tau = V_{to}/R_2C$$

Setting this equal to the worst case dv/dt (static) for the MOC3011 which we can obtain from Figure 4 and solving for R_2C:

$$dv/dt(T_J = 70°C) = 0.8\ V/\mu s = 8 \times 10^5$$

$$R_2C = V_{to}/(dv/dt) = 180/(8 \times 10^5) \approx 230 \times 10^{-6}$$

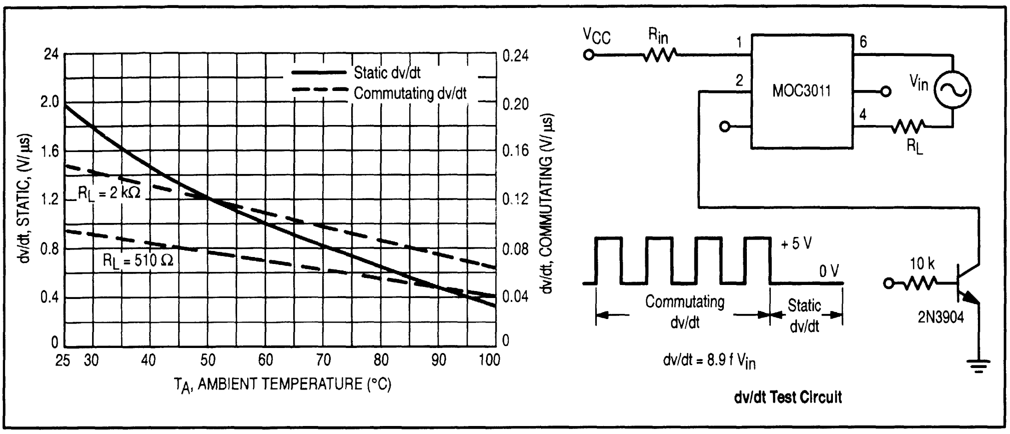


Figure 4. dv/dt versus Temperature

The largest value of R2 available is found, taking into consideration the triac gate requirements. If a sensitive gate triac is used, such as a 2N6071B, I_{GT} = 15 mA @ –40°C. If the triac is to be triggered when $V_{in} \leq 40$ V

$$(R1 + R2) \approx V_{in}/I_{GT} \approx 40/0.015 \approx 2.3\ k$$

If we let R2 = 2400 ohms and C = 0.1 µF, the snubbing requirements are met. Triacs having less sensitive gates will require that R2 be lower and C be correspondingly higher as shown in Figure 3.

INPUT CIRCUITRY

Resistor Input

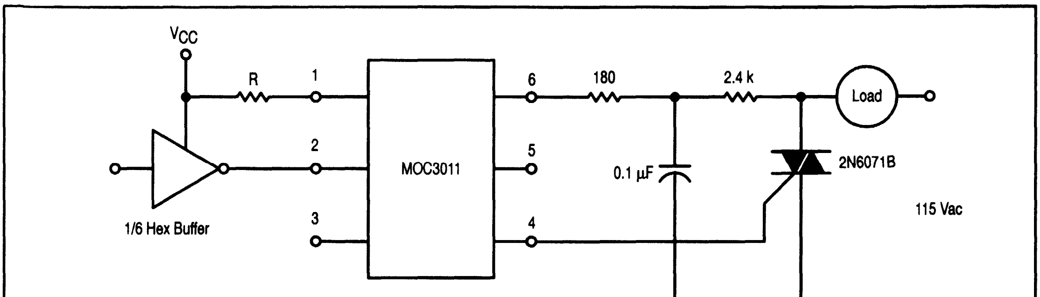
When the input conditions are well controlled, as for example when driving the MOC3011 from a TTL, DTL, or HTL gate, only a single resistor is necessary to interface the gate to the input LED of the MOC3011. The resistor should be chosen to set the current into the LED to be a minimum of 10 mA but no more than 50 mA. 15 mA is a suitable value, which allows for considerable degradation of the LED over time, and assures a long operating life for the coupler. Currents higher than 15 mA do not improve performance and may hasten the aging process inherent in LED's. Assuming the forward drop to be 1.5 V at 15 mA allows a simple formula to calculate the input resistor.

$$R_i = (V_{CC} - 1.5)/0.015$$

Examples of resistive input circuits are seen in Figures 1 and 5.

Increasing Input Sensitivity

In some cases, the logic gate may not be able to source or sink 15 mA directly. CMOS, for example, is specified to have only 0.5 mA output, which must then be increased to drive the MOC3011. There are numerous ways to increase this current to a level compatible with the MOC3011 input requirements; an efficient way is to use the MC14049B shown in Figure 5. Since there are six such buffers in a single package, the user can have a small package count when using several MOC3011's in one system.



VCC	R	HEX BUFFER
5.0 V	220 Ω	MC75492
10 V	600 Ω	MC75492
15 V	910 Ω	MC14049B

Figure 5. MOS to ac Load Interface

Input Protection Circuits

In some applications, such as solid state relays, in which the input voltage varies widely the designer may want to limit the current applied to the LED of the MOC3011. The circuit shown in Figure 6 allows a non–critical range of input voltages to properly drive the MOC3011 and at the same time protects the input LED from inadvertent application of reverse polarity.

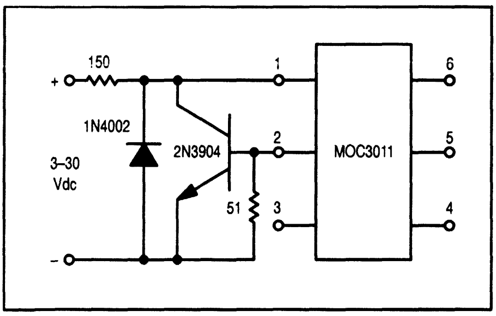


Figure 6. MOC3011 Input Protection Circuit

LED Lifetime

All light emitting diodes slowly decrease in brightness during their useful life, an effect accelerated by high temperatures and high LED currents. To allow a safety margin and ensure long service life, the MOC3011 is actually tested to trigger at a value lower than the specified 10 mA input threshold current. The designer can therefore design the input circuitry to supply 10 mA to the LED and still be sure of satisfactory operation over a long operating lifetime. On the other hand, care should be taken to ensure that the maximum LED input current (50 mA) is not exceeded or the lifetime of the MOC3011 may be shortened.

APPLICATIONS EXAMPLES

Using the MOC3011 on 240 Vac Lines

The rated voltage of a MOC3011 is not sufficiently high for it to be used directly on 240 Vac line; however, the designer may stack two of them in series. When used this way, two resistors are required to equalize the voltage dropped across them as shown in Figure 7.

Remote Control of ac Voltage

Local building codes frequently require all 115 Vac light switch wiring to be enclosed in conduit. By using a MOC3011, a triac, and a low voltage source, it is possible to control a large lighting load from a long distance through low voltage signal wiring which is completely isolated from the ac line. Such wiring usually is not required to be put in conduit, so the cost savings in installing a lighting system in commercial or residential buildings can be considerable. An example is shown in Figure 8. Naturally, the load could also be a motor, fan, pool pump, etc.

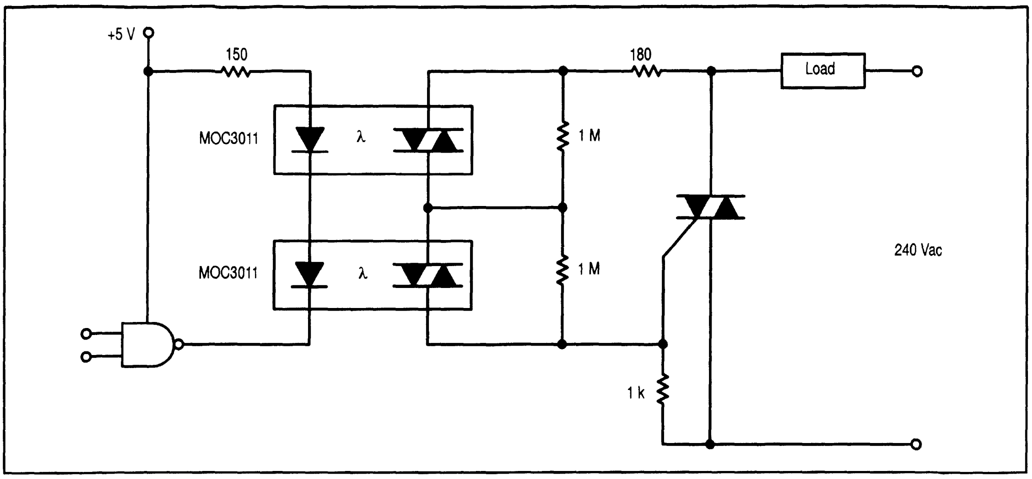


Figure 7. 2 MOC3011 Triac Drivers in Series to Drive 240 V Triac

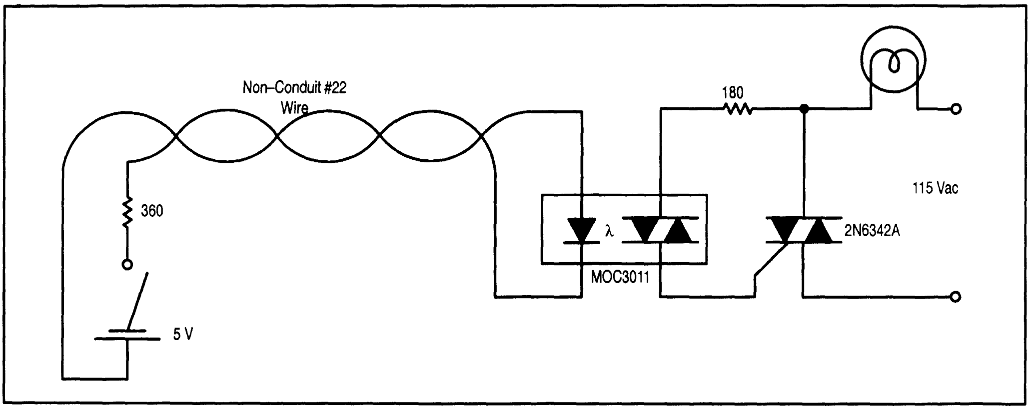


Figure 8. Remote Control of ac Loads Through Low Voltage Non–Conduit Cable

Solid State Relay

Figure 9 shows a complete general purpose, solid state relay snubbed for inductive loads with input protection. When the designer has more control of the input and output conditions, he can eliminate those components which are not needed for his particular application to make the circuit more cost effective.

Interfacing Microprocessors to 115 Vac Peripherals

The output of a typical microcomputer input–output (I/O) port is a TTL–compatible terminal capable of driving one or two TTL loads. This is not quite enough to drive the MOC3011, nor can it be connected directly to an SCR or triac, because computer common is not normally referenced to one side of the ac supply. Standard 7400 series gates can provide an input compatible with the output of an MC6820, MC6821, MC6846 or similar peripheral interface adaptor and can directly drive the MOC3011. If the second input of a 2 input gate is tied to a simple timing circuit, it will also provide energization of the triac only at the zero crossing of the ac line voltage as shown in Figure 10. This technique extends the life of incandescent lamps, reduces EMI generated by load switching. Of course, zero crossing can be generated within the microcomputer itself, but this requires considerable software overhead and usually just as much hardware to generate the zero–crossing timing signals.

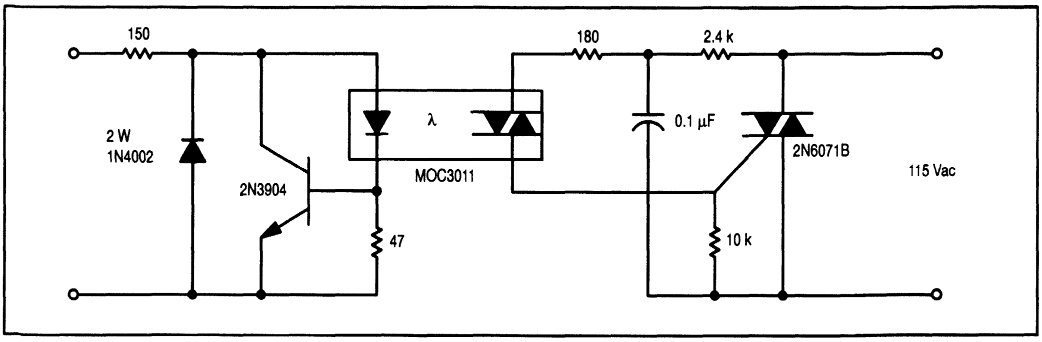


Figure 9. Solid–State Relay

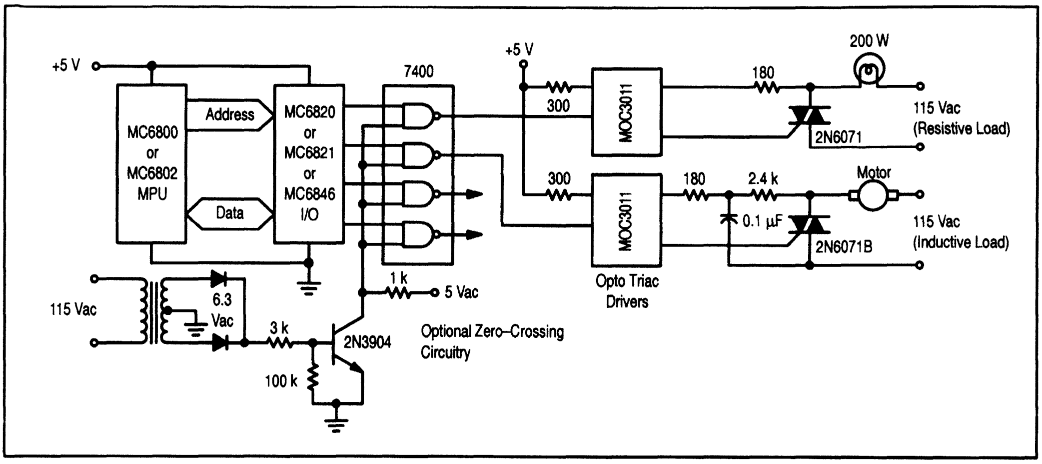


Figure 10. Interfacing an M6800 Microcomputer System to 115 Vac Loads

AN982

Applications of Zero Voltage Crossing Optically Isolated Triac Drivers

Prepared by Horst Gempe

INTRODUCTION

The zero–cross family of optically isolated triac drivers in an inexpensive, simple and effective solution for interface applications between low current dc control circuits such as logic gates and microprocessors and ac power loads (120, 240 or 380 volt, single or 3–phase).

These devices provide sufficient gate trigger current for high current, high voltage thyristors, while providing a guaranteed 7.5 kV dielectric withstand voltage between the line and the control circuitry. An integrated, zero–crossing switch on the detector chip eliminates current surges and the resulting electromagnetic interference (EMI) and reliability problems for many applications. The high transient immunity of 5000 V/µs, combined with the features of low coupling capacitance, high isolation resistance and up to 800 volt specified V_{DRM} ratings qualify this triac driver family as the ideal link between sensitive control circuitry and the ac power system environment.

Optically isolated triac drivers are not intended for stand alone service as are such devices as solid state relays. They will, however, replace costly and space demanding discrete drive circuitry having high component count consisting of standard transistor optoisolators, support components including a full wave rectifier bridge, discrete transistors, trigger SCRs and various resistor and capacitor combinations.

This paper describes the operation of a basic driving circuit and the determination of circuit values needed for proper implementation of the triac driver. Inductive loads are discussed along with the special networks required to use triacs in their presence. Brief examples of typical applications are presented.

CONSTRUCTION

The zero–cross family consists of a liquid phase EPI, infrared, light emitting diode which optically triggers a silicon detector chip. A schematic representation of the triac driver is shown in Figure 1. Both chips are housed in a small, 6–pin dual–in–line (DIP) package which provides mechanical integrity and protection for the semiconductor chips from external impurities. The chips are insulated by an infrared transmissive medium which reliably isolates the LED input drive circuits from the environment of the ac power load. This insulation system meets the stringent requirements for isolation set forth by regulatory agencies such as UL and VDE.

THE DETECTOR CHIP

The detector chip is a complex monolithic IC which contains two infrared sensitive, inverse parallel, high voltage SCRs which function as a light sensitive triac. Gates of the individual SCRs are connected to high speed zero crossing detection circuits. This insures that with a continuous forward current through the LED, the detector will not switch to the conducting state until the applied ac voltage passes through a point near zero. Such a feature not only insures lower generated noise (EMI) and inrush (Surge) currents into resistive loads and moderate inductive loads but it also provides high noise immunity (several thousand V/µs) for the detection circuit.

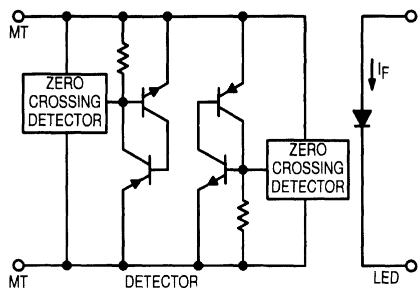


Figure 1. Schematic of Zero Crossing Optically Isolated Triac Driver

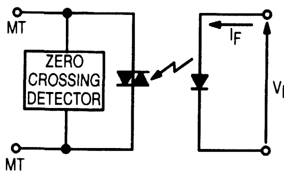


Figure 2. Simplified Schematic of Isolator

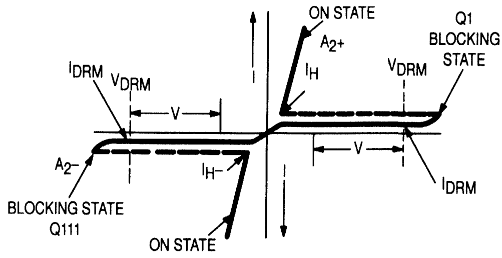


Figure 3. Triac Voltage–Current Characteristic

ELECTRICAL CHARACTERISTICS

A simplified schematic of the optically isolated triac driver is shown in Figure 2. This model is sufficient to describe all important characteristics. A forward current flow through the LED generates infrared radiation which triggers the detector. This LED trigger current (I_{FT}) is the maximum guaranteed current necessary to latch the triac driver and ranges from 5 mA for the MOC3063 to 15 mA for the MOC3061. The LED's forward voltage drop at I_F = 30 mA is 1.5 V maximum. Voltage–current characteristics of the triac are identified in Figure 3.

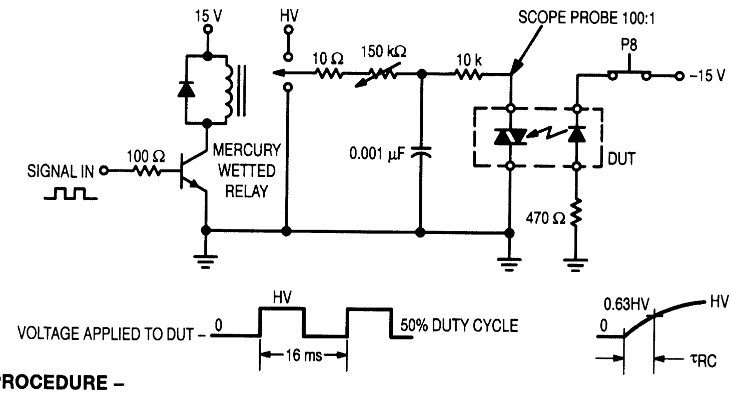
Once triggered, the detector stays latched in the "on state" until the current flow through the detector drops below the holding current (I_H) which is typically 100 μA. At this time, the detector reverts to the "off" (non–conducting) state. The detector may be triggered "on" not only by I_{FT} but also by exceeding the forward blocking voltage between the two main terminals (MT1 and MT2) which is a minimum of 600 volts for all MOC3061 family members. Also, voltage ramps (transients, noise, etc.) which are common in ac power lines may trigger the detector accidentally if they exceed the static dV/dt rating. Since the fast switching, zero–crossing switch provides a minimum dV/dt of 500 V/μs even at an ambient temperature of 70°C, accidental triggering of the triac driver is unlikely. Accidental triggering of the main triac is a more likely occurrence. Where high dV/dt transients on the ac line are anticipated, a form of suppression network commonly called a "snubber" must be used to prevent false "turn on" of the main triac. A detailed discussion of a "snubber" network is given under the section "Inductive and Resistive Loads."

Figure 4 shows a static dV/dt test circuit which can be used to test triac drivers and power triacs. The proposed test method is per EIA/NARM standard RS–443.

Tests on the MOC3061 family of triac drivers using the test circuit of Figure 4 have resulted in data showing the effects of temperature and voltage transient amplitude on static dV/dt. Figure 5 is a plot of dV/dt versus ambient temperature while Figure 6 is a similar plot versus transient amplitude.

BASIC DRIVING CIRCUIT

Assuming the circuit shown in Figure 7 is in the blocking or "off" state (which means I_F is zero), the full ac line voltage appears across the main terminals of both the triac and the triac driver. When sufficient LED current (I_{FT}) is supplied and the ac line voltage is below the inhibit voltage (I_H in Figure 3), the triac driver latches "on." This action introduces a gate current in the main triac triggering it from the blocking state into full conduction. Once triggered, the voltage across the main terminals collapses to a very low value which results in the triac driver output current decreasing to a value lower than its holding current, thus forcing the triac driver into the "off" state, even when I_{FT} is still applied.



TEST PROCEDURE –

Turn the D.U.T. on, while applying sufficient dV/dt to ensure that it remains on, even after the trigger current is removed. Then decrease dV/dt until the D.U.T. turns off. Measure τ_{RC}, the time it takes to rise to 0.63 HV, and divide 0.63 HV by τ_{RC} to get dV/dt.

Figure 4. Static dV/dt Test Circuit

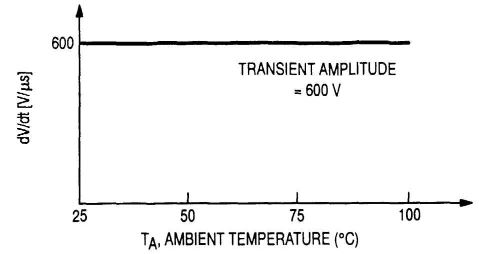


Figure 5. Static dV/dt versus Temperature

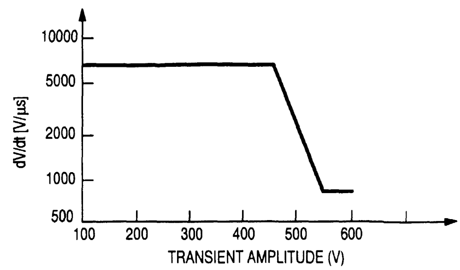


Figure 6. Static dV/dt versus Transient Amplitude

The power triac remains in the conducting state until the load current drops below the power triac's holding current, a situation that occurs every half cycle. The actual duty cycle for the triac driver is very short (in the 1 to 3 µs region). When I_{FT} is present, the power triac will be retriggered every half cycle of the ac line voltage until I_{FT} is switched "off" and the power triac has gone through a zero current point. (See Figure 8).

Resistor R (shown in Figure 7) is not mandatory when R_L is a resistive load since the current is limited by the gate trigger current (I_{GT}) of the power triac. However, resistor R (in combination with R–C snubber networks that are described in the section "Inductive and Resistive Loads") prevents possible destruction of the triac driver in applications where the load is highly inductive.

Unintentional phase control of the main triac may happen if the current limiting resistor R is too high in value. The function of this resistor is to limit the current through the triac driver in case the main triac is forced into the non–conductive state close to the peak of the line voltage and the energy stored in a "snubber" capacitor is discharged into the triac driver. A calculation for the current limiting resistor R is shown below for a typical 220 volt application: Assume the line voltage is 220 volts RMS. Also assume the maximum peak repetitive driver current (normally for a 10 micro second maximum time interval) is 1 ampere. Then

$$R = \frac{V_{peak}}{I_{peak}} = \frac{220\ \sqrt{2}\,\text{volts}}{1\ \text{amp}} = 311\ \text{ohms}$$

One should select a standard resistor value >311 ohms → 330 ohms.

The gate resistor R_G (also shown in Figure 7) is only necessary when the internal gate impedance of the triac or SCR is very high which is the case with sensitive gate thyristors. These devices display very poor noise immunity and thermal stability without R_G. Value of the gate resistor in this case should be between 100 and 500. The circuit designer should be aware that use of a gate resistor increases the required trigger current (I_{GT}) since R_G drains off part of I_{GT}. Use of a gate resistor combined with the current limiting resistor R can result in an unintended delay or phase shift between the zero–cross point and the time the power triac triggers.

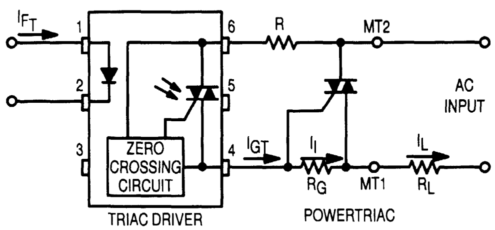


Figure 7. Basic Driving Circuit — Triac Driver, Triac and Load

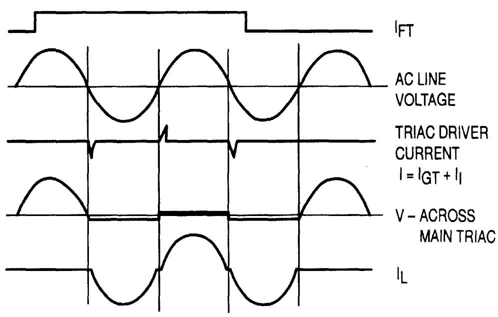


Figure 8. Waveforms of a Basic Driving Circuit

UNINTENDED TRIGGER DELAY TIME

To calculate the unintended time delay, one must remember that power triacs require a specified trigger current (I_{GT}) and trigger voltage (V_{GT}) to cause the triac to become conductive. This necessitates a minimum line voltage V_T to be present between terminals MT1 and MT2 (see Figure 7), even when the triac driver is already triggered "on." The value of minimum line voltage V_T is calculated by adding all the voltage drops in the trigger circuit:

$V_T = V_R + V_{TM} + V_{GT}$.

Current I in the trigger circuit consists not only of I_{GT} but also the current through R_G:

$I = I_{RG} + I_{GT}$.

Likewise, I_{RG} is calculated by dividing the required gate trigger voltage V_{GT} for the power triac by the chosen value of gate resistor R_G:

$I_{RG} = V_{GT}/R_G$

Thus, $I = V_{GT}/R_G + I_{GT}$.

All voltage drops in the trigger circuit can now be determined as follows:

$V_R = I \times R = V_{GT}/R_G \times R + I_{GT} \times R = R(V_{GT}/R_G + I_{GT})$

VTM = From triac driver data sheet

V_{GT} = From power triac data sheet.

I_{GT} = From power triac data sheet.

With V_{TM}, V_{GT} and I_{GT} taken from data sheets, it can be seen that V_T is only dependent on R and R_G.

Knowing the minimum voltage between MT1 and MT2 (line voltage) required to trigger the power triac, the unintended phase delay angle θ_d (between the ideal zero crossing of the ac line voltage and the trigger point of the power triac) and the trigger delay time t_d can be determined as follows:

$$\theta_d = \sin^{-1} V_T/V_{peak}$$

$$= \sin^{-1} \frac{R(V_{GT}/R_G + I_{GT}) + V_{TM} + V_{GT}}{V_{peak}}$$

The time delay t_d is the ratio of θ_d to θ_{Vpeak} (which is 90 degrees) multiplied by the time it takes the line voltage to go from zero voltage to peak voltage (simply 1/4f, where f is the line frequency). Thus

$t_d = \theta_d/90 \times 1/4f$.

Figure 9 shows the trigger delay of the main triac versus the value of the current limiting resistor R for assumed values of I_{GT}. Other assumptions made in plotting the equation for t_d are that line voltage is 220 V RMS which leads to V_{peak} = 311 volts; R_G = 300 ohms; V_{GT} = 2 volts and f = 60 Hz. Even though the triac driver triggers close to the zero cross point of the ac voltage, the power triac cannot be triggered until the voltage of the ac line rises high enough to create enough current flow to latch the power triac in the "on" state. It is apparent that significant time delays from the zero crossing point can be observed when R is a large value along with a high value of I_{GT} and/or a low value of R_G. It should be remembered that low values of the gate resistor improve the dV/dt ratinigs of the power triac and minimize self latching problems that might otherwise occur at high junction temperatures.

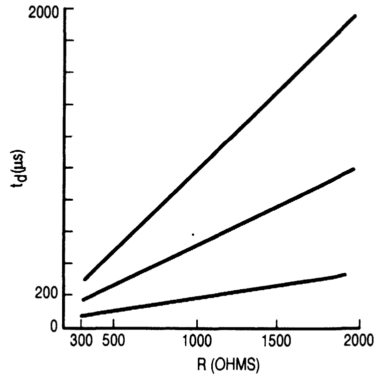


Figure 9. Time Delay t_d versus Current Limiting Resistor R

SWITCHING SPEED

The switching speed of the triac driver is a composition of the LED's turn on time and the detector's delay, rise and fall times. The harder the LED is driven the shorter becomes the LED's rise time and the detector's delay time. Very short I_{FT} duty cycles require higher LED currents to guarantee "turn on" of the triac driver consistent with the speed required by the short trigger pulses.

Figure 10 shows the dependency of the required LED current normalized to the dc trigger current required to trigger the triac driver versus the pulse width of the LED current. LED trigger pulses which are less than 100 µs in width need to be higher in amplitude than specified on the data sheet in order to assure reliable triggering of the triac driver detector.

The switching speed test circuit is shown in Figure 11. Note that the pulse generator must be synchronized with the 60 Hz line voltage and the LED trigger pulse must occur near the zero cross point of the ac line voltage. Peak ac current in the curve tracer should be limited to 10 mA. This can be done by setting the internal load resistor to 3 k ohms.

Motorola isolated triac drivers are trigger devices and designed to work in conjunction with triacs or reverse parallel SCRs which are able to take rated load current. However, as soon as the power triac is triggered there is no current flow through the triac driver. The time to turn the triac driver "off" depends on the switching speed of the triac, which is typically on the order of 1–2 μs.

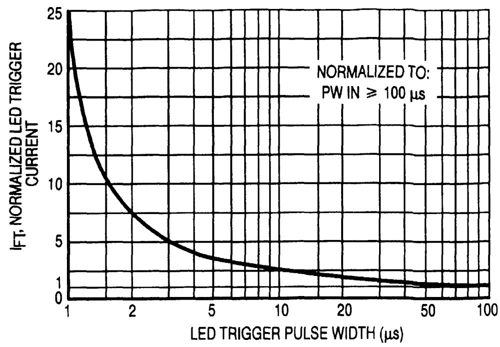


Figure 10. I_{FT} Normalized to I_{FT} dc As Specified on the Data Sheet

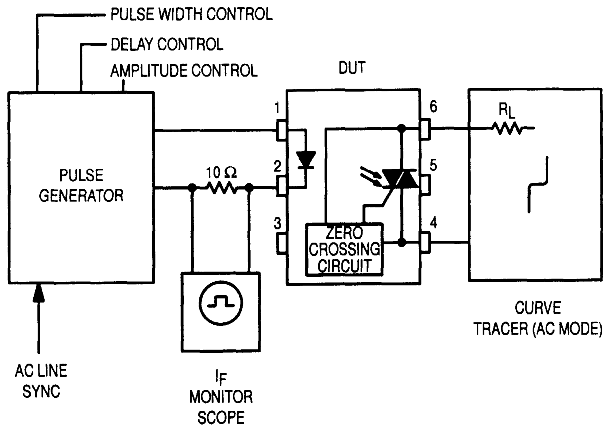


Figure 11. Test Circuit for LED Forward Trigger Current versus Pulse Width

INDUCTIVE AND RESISTIVE LOADS

Inductive loads (motors, solenoids, etc.) present a problem for the power triac because the current is not in phase with the voltage. An important fact to remember is that since a triac can conduct current in both directions, it has only a brief interval during which the sine wave current is passing through zero to recover and revert to its blocking state. For inductive loads, the phase shift between voltage and current means that at the time the current of the power handling triac falls below the holding current and the triac ceases to conduct, there exists a certain voltage which must appear across the triac. If this voltage appears too rapidly, the triac will resume conduction and control is lost. In order to achieve control with certain inductive loads, the rate of rise in voltage (dV/dt) must be limited by a series RC network placed in parallel with the power triac. The capacitor C_S will limit the dV/dt across the triac.

The resistor R_S is necessary to limit the surge current from C_S when the triac conducts and to damp the ringing of the capacitance with the load inductance L_L. Such an RC network is commonly referred to as a "snubber."

Figure 12 shows current and voltage wave forms for the power triac. Commutating dV/dt for a resistive load is typically only 0.13 V/μs for a 240 V, 50 Hz line source and 0.063 V/μs for a 120 V, 60 Hz line source. For inductive loads the "turn off" time and commutating dV/dt stress are more difficult to define and are affected by a number of variables such as back EMF of motors and the ratio of inductance to resistance (power factor). Although it may appear from the inductive load that the rate or rise is extremely fast, closer circuit evaluation reveals that the commutating dV/dt generated is restricted to some finite value which is a function of the load reactance L_L and the device capacitance C but still may exceed the triac's critical commuting dV/dt rating which is about 50 V/μs. It is generally good practice to use an RC snubber network across the triac to limit the rate of rise (dV/dt) to a value below the maximum allowable rating. This snubber network not only limits the voltage rise during commutation but also suppresses transient voltages that may occur as a result of ac line disturbances.

There are no easy methods for selecting the values for R_S and C_S of a snubber network. The circuit of Figure 13 is a damped, tuned circuit comprised of R_S, C_S, R_L and L_L, and to a minor extent the junction capacitance of the triac. When the triac ceases to conduct (this occurs every half cycle of the line voltage when the current falls below the holding current), the load current receives a step impulse of line voltage which depends on the power factor of the load. A given load fixes R_L and L_L; however, the circuit designer can vary R_S and C_S. Commutating dV/dt can be lowered by increasing C_S while R_S can be increased to decrease resonant "over ringing" of the tuned circuit. Generally this is done experimentally beginning with values calculated as shown in the next section and, then, adjusting R_S and C_S values to achieve critical damping and a low critical rate of rise of voltage.

Less sensitive to commutating dV/dt are two SCRs in an inverse parallel mode often referred to as a back–to–back SCR pair (see Figure 15). This circuit uses the SCRs in an alternating mode which allows each device to recover and turn "off" during a full half cycle. Once in the "off" state, each SCR can resist dV/dt to the critical value of about 100 V/μs. Optically isolated triac drivers are ideal in this application since both gates can be triggered by one triac driver which also provides isolation between the low voltage control circuit and the ac power line.

It should be mentioned that the triac driver detector does not see the commutating dV/dt generated by the inductive load during its commutation; therefore, the commutating dV/dt appears as a static dV/dt across the two main terminals of the triac driver.

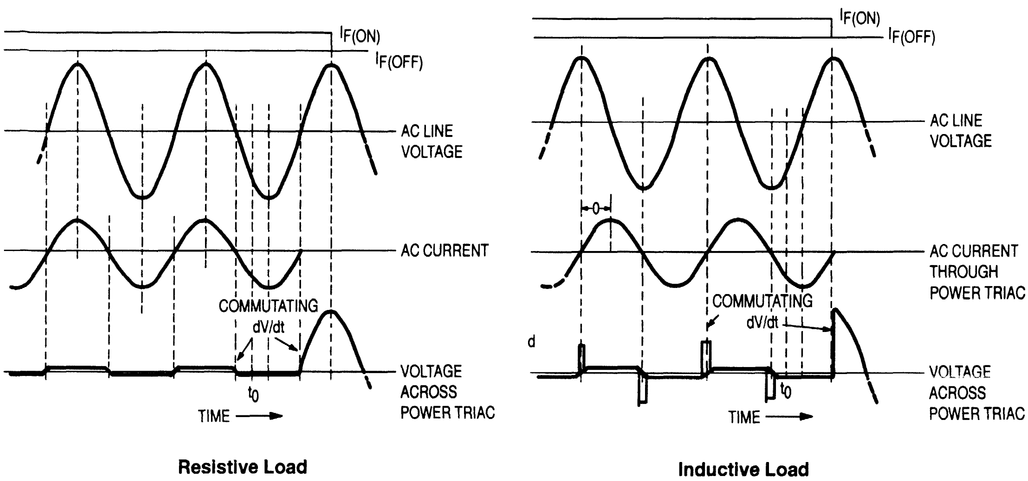


Figure 12. Current and Voltage Waveforms During Commutation

SNUBBER DESIGN — THE RESONANT METHOD

If R, L and C are chosen to resonate, the voltage waveform on dV/dt will look like Figure 14. This is the result of a damped quarter–cycle of oscillation. In order to calculate the components for snubbing, the dV/dt must be related to frequency. Since, for a sine wave,

$V(t) = V_P \sin \omega t$
$dV/dt = V_P \omega \cos \omega t$
$dV/dt_{(max)} = V_P \omega = V_P 2\pi f$

$$f = \frac{dV/dt}{2\pi V_{A(max)}}$$

Where dV/dt is the maximum value of off state dV/dt specified by the manufacturer.

From:

$$f = \frac{1}{2\pi\sqrt{LC}}$$

$$C = \frac{1}{(2\pi f)^2 L}$$

We can choose the inductor for convenience. Assuming the resistor is chosen for the usual 30% overshoot:

$$R = \sqrt{\frac{L}{C}}$$

Assuming L is 50 μH, then:

$$f = \frac{(dV/dt)_{min}}{2\pi V_{A(max)}} = \frac{50\ V/\mu s}{2\pi(294\ V)} = 27\ kHz$$

$$C = \frac{1}{(2\pi f)^2 L} = 0.69\ \mu F$$

$$R = \sqrt{\frac{L}{C}} = \sqrt{\frac{50\ \mu H}{0.69\ \mu F}} = 8.5\ \Omega$$

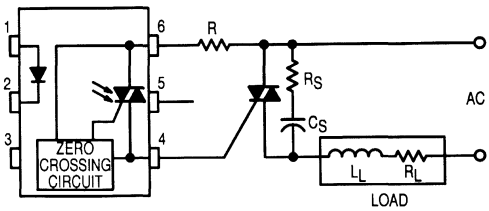


Figure 13. Triac Driving Circuit — with Snubber

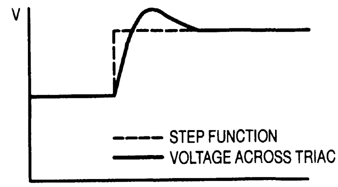


Figure 14. Voltage Waveform After Step Voltage Rise – Resonant Snubbing

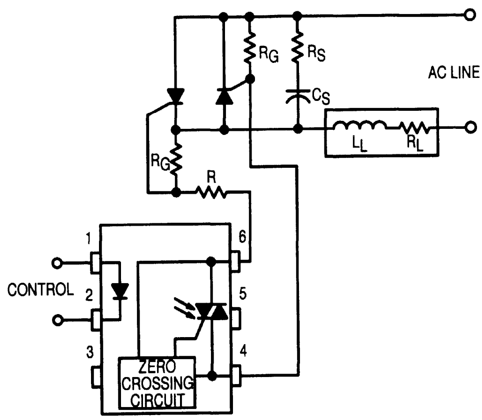


Figure 15. A Circuit Using Inverse Parallel SCRs

INRUSH (SURGE) CURRENTS

The zero crossing feature of the triac driver insures lower generated noise and sudden inrush currents on resistive loads and moderate inductive loads. However, the user should be aware that many loads even when started at close to the ac zero crossing point present a very low impedance. For example, incandescent lamp filaments when energized at the zero crossing may draw ten to twenty times the steady state current that is drawn when the filament is hot. A motor when started pulls a "locked rotor" current of, perhaps, six times its running current. This means the power triac switching these loads must be capable of handling current surges without junction overheating and subsequent degradation of its electrical parameters.

Almost pure inductive loads with saturable ferromagnetic cores may display excessive inrush currents of 30 to 40 times the operating current for several cycles when switched "on" at the zero crossing point. For these loads, a random phase triac driver (MOC3020 family) with special circuitry to provide initial "turn on" of the power triac at ac peak voltage may be the optimized solution.

ZERO CROSS, THREE PHASE CONTROL

The growing demand for solid state switching of ac power heating controls and other industrial applications has resulted in the increased use of triac circuits in the control of three phase power. Isolation of the dc logic circuitry from the ac line, the triac and the load is often desirable even in single phase power control applications. In control circuits for poly phase power systems, this type of isolation is mandatory because the common point of the dc logic circuitry cannot be referred to a common line in all phases. The MOC3061 family's characteristics of high off–state blocking voltage and high isolation capability make the isolated triac drivers devices for a simplified, effective control circuit with low component count as shown in Figure 16. Each phase is controlled individually by

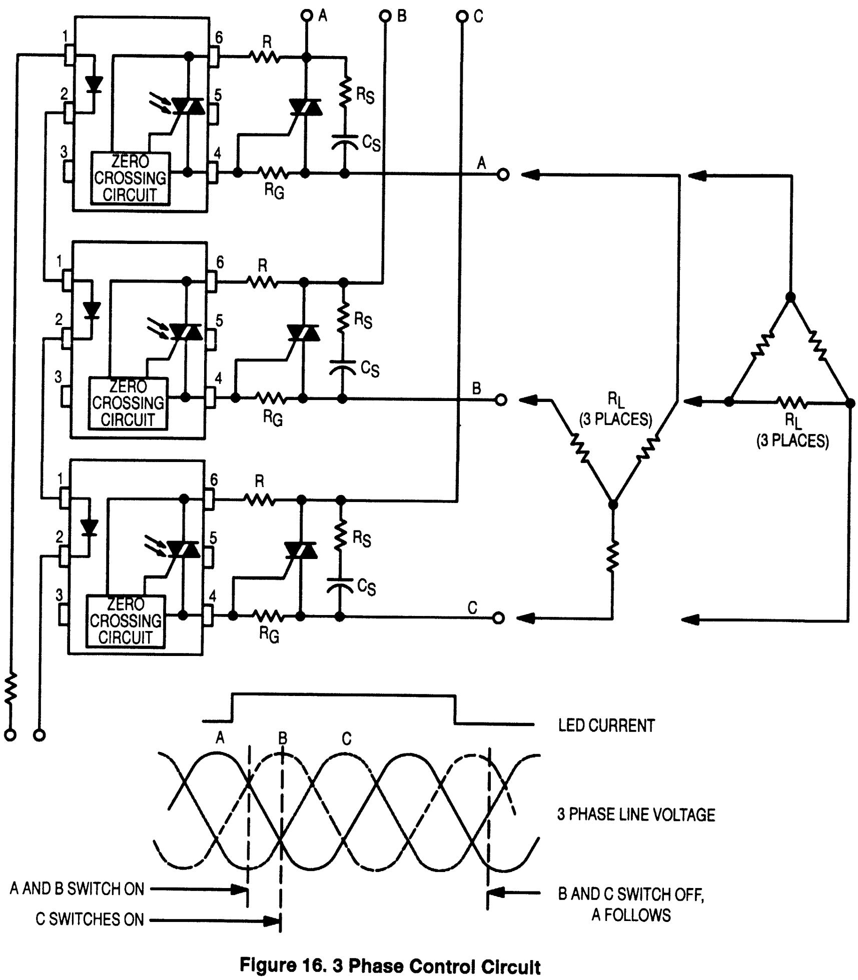


Figure 16. 3 Phase Control Circuit

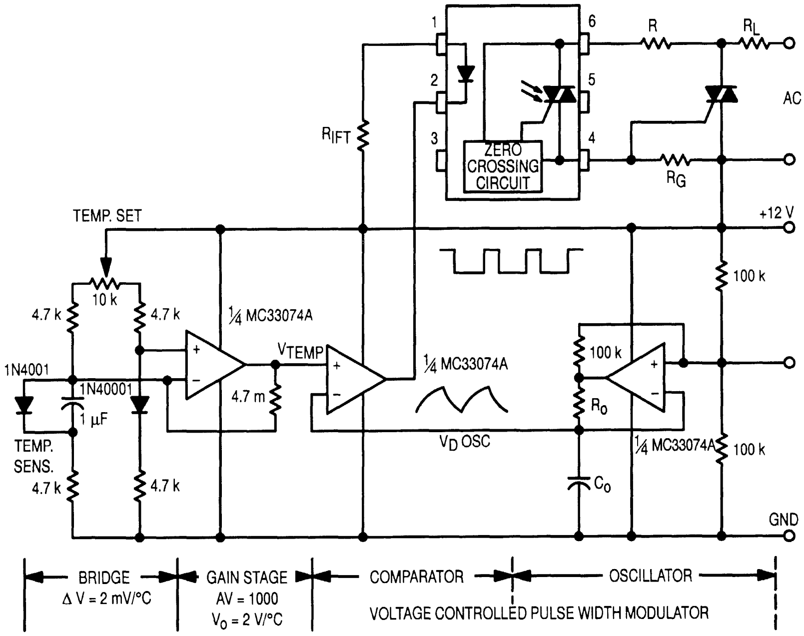


Figure 17. Proportional Zero Voltage Switching Temperature Controller

a power triac with optional snubber network (R_S, C_S) and an isolated triac driver with current limiting resistor R. All LEDs are connected in series and can be controlled by one logic gate or controller. An example is shown in Figure 17.

At startup, by applying I_F, the two triac drivers which see zero voltage differential between phase A and B or A and C or C and B (which occurs every 60 electrical degrees of the ac line voltage) will switch "on" first. The third driver (still in the "off" state) switches "on" when the voltage difference between the phase to which it is connected approaches the same voltage as the sum voltage (superimposed voltage) of the phases already switched "on." This guarantees zero current "turn on" of all three branches of the load which can be in Y or Delta configuration. When the LEDs are switched "off," all phases switch "off" when the current (voltage difference) between any two of the three phases drops below the holding current of the power triacs. Two phases switched "off" create zero current. In the remaining phase, the third triac switches "off" at the same time.

PROPORTIONAL ZERO VOLTAGE SWITCHING

The built–in zero voltage switching feature of the zero–cross triac drivers can be extended to applications in which it is desirable to have constant control of the load and a minimization of system hysteresis as required in industrial heater applications, oven controls, etc. A closed loop heater control in which the temperature of the heater element or the chamber is sensed and maintained at a particular value is a good example of such applications. Proportional zero voltage switching provides accurate temperature control, minimizes overshoots and reduces the generation of line noise transients.

Figure 17 shows a low cost MC33074 quad op amp which provides the task of temperature sensing, amplification, voltage controlled pulse width modulation and triac driver LED control. One of the two 1N4001 diodes (which are in a Wheatstone bridge configuration) senses the temperature in the oven chamber with an output signal of about 2 mV/°C. This signal is amplified in an inverting gain stage by a factor of

1000 and compared to a triangle wave generated by an oscillator. The comparator and triangle oscillator form a voltage controlled pulse width modulator which controls the triac driver. When the temperature in the chamber is below the desired value, the comparator output is low, the triac driver and the triac are in the conducting state and full power is applied to the load. When the oven temperature comes close to the desired value (determined by the "temp set" potentiometer), a duty cycle of less than 100% is introduced providing the heater with proportionally less power until equilibrium is reached. The proportional band can be controlled by the amplification of the gain stage — more gain provides a narrow band; less gain a wider band. Typical waveforms are shown in Figure 18.

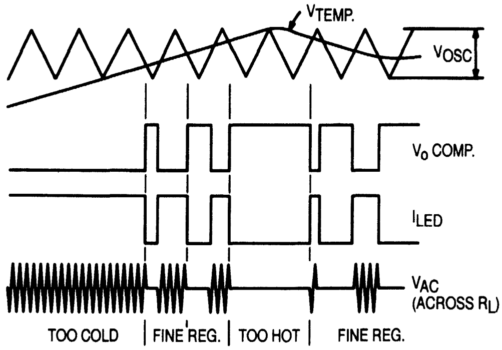


Figure 18. Typical Waveforms of Temperature Controller

AN1048

RC Snubber Networks For Thyristor Power Control and Transient Suppression

By George Templeton
Thyristor Applications Engineer

INTRODUCTION

RC networks are used to control voltage transients that could falsely turn-on a thyristor. These networks are called snubbers.

The simple snubber consists of a series resistor and capacitor placed around the thyristor. These components along with the load inductance form a series CRL circuit. Snubber theory follows from the solution of the circuit's differential equation.

Many RC combinations are capable of providing acceptable performance. However, improperly used snubbers can cause unreliable circuit operation and damage to the semiconductor device.

Both turn-on and turn-off protection may be necessary for reliability. Sometimes the thyristor must function with a range of load values. The type of thyristors used, circuit configuration, and load characteristics are influential.

Snubber design involves compromises. They include cost, voltage rate, peak voltage, and turn-on stress. Practical solutions depend on device and circuit physics.

STATIC $\frac{dV}{dt}$

WHAT IS STATIC $\frac{dV}{dt}$?

Static $\frac{dV}{dt}$ is a measure of the ability of a thyristor to retain a blocking state under the influence of a voltage transient.

$\left(\frac{dV}{dt}\right)_s$ DEVICE PHYSICS

Static $\frac{dV}{dt}$ turn-on is a consequence of the Miller effect and regeneration (Figure 1). A change in voltage across the junction capacitance induces a current through it. This current is proportional to the rate of voltage change $\left(\frac{dV}{dt}\right)$. It triggers the device on when it becomes large enough to raise the sum of the NPN and PNP transistor alphas to unity.

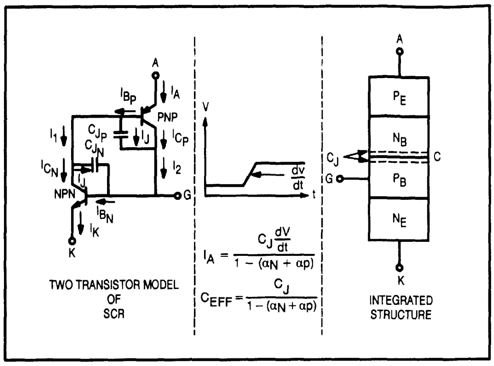


Figure 1. $\left(\frac{dV}{dt}\right)_s$ Model

CONDITIONS INFLUENCING $\left(\frac{dV}{dt}\right)_s$

Transients occurring at line crossing or when there is no initial voltage across the thyristor are worst case. The collector junction capacitance is greatest then because the depletion layer widens at higher voltage.

Small transients are incapable of charging the self-capacitance of the gate layer to its forward biased threshold voltage (Figure 2). Capacitance voltage divider

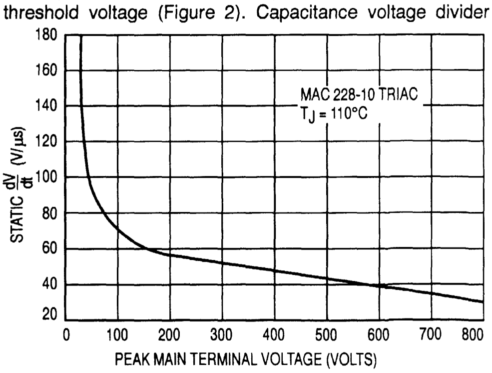


Figure 2. Exponential $\left(\frac{dV}{dt}\right)_s$ versus Peak Voltage

REV 1

action between the collector and gate-cathode junctions and built-in resistors that shunt current away from the cathode emitter are responsible for this effect.

Static $\frac{dV}{dt}$ does not depend strongly on voltage for operation below the maximum voltage and temperature rating. Avalanche multiplication will increase leakage current and reduce $\frac{dV}{dt}$ capability if a transient is within roughly 50 volts of the actual device breakover voltage.

A higher rated voltage device guarantees increased $\frac{dV}{dt}$ at lower voltage. This is a consequence of the exponential rating method where a 400 V device rated at 50 V/μs has a higher $\frac{dV}{dt}$ to 200 V than a 200 V device with an identical rating. However, the same diffusion recipe usually applies for all voltages. So actual capabilities of the product are not much different.

Heat increases current gain and leakage, lowering $\left(\frac{dV}{dt}\right)_s$, the gate trigger voltage and noise immunity (Figure 3).

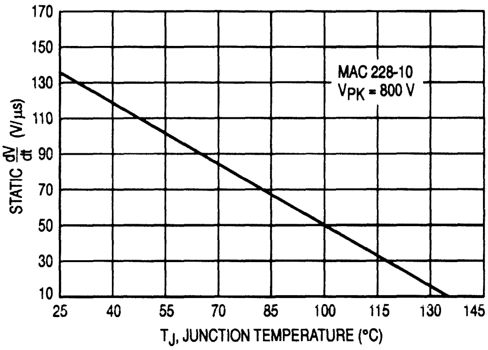


Figure 3. Exponential $\left(\frac{dV}{dt}\right)_s$ versus Temperature

$\left(\frac{dV}{dt}\right)_s$ FAILURE MODE

Occasional unwanted turn-on by a transient may be acceptable in a heater circuit but isn't in a fire prevention sprinkler system or for the control of a large motor. Turn-on is destructive when the follow-on current amplitude or rate is excessive. If the thyristor shorts the power line or a charged capacitor, it will be damaged.

Static $\frac{dV}{dt}$ turn-on is non-destructive when series impedance limits the surge. The thyristor turns off after a half-cycle of conduction. High $\frac{dV}{dt}$ aids current spreading in the thyristor, improving its ability to withstand $\frac{dI}{dt}$. Breakdown turn-on does not have this benefit and should be prevented.

IMPROVING $\left(\frac{dV}{dt}\right)_s$

Static $\frac{dV}{dt}$ can be improved by adding an external resistor from the gate to MT1 (Figure 4). The resistor provides a path for leakage and $\frac{dV}{dt}$ induced currents that originate in the drive circuit or the thyristor itself.

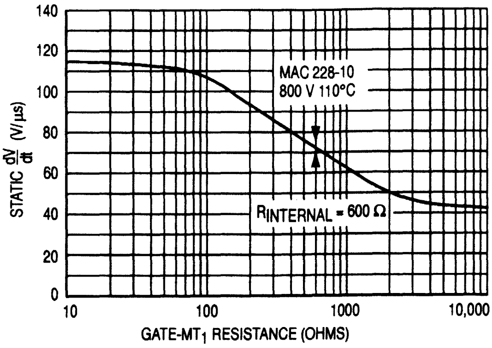


Figure 4. Exponential $\left(\frac{dV}{dt}\right)_s$ versus Gate to MT_1 Resistance

Non-sensitive devices (Figure 5) have internal shorting resistors dispersed throughout the chip's cathode area. This design feature improves noise immunity and high temperature blocking stability at the expense of increased trigger and holding current. External resistors are optional for non-sensitive SCRs and TRIACs. They should be comparable in size to the internal shorting resistance of the device (20 to 100 ohms) to provide maximum improvement. The internal resistance of the thyristor should be measured with an ohmmeter that does not forward bias a diode junction.

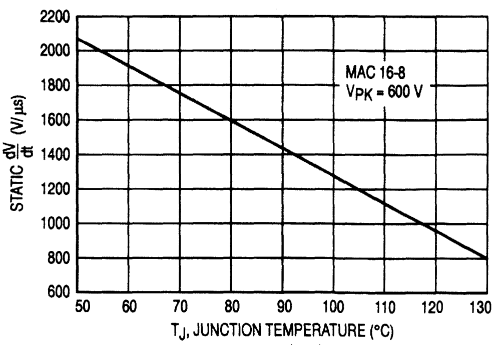


Figure 5. Exponential $\left(\frac{dV}{dt}\right)_s$ versus Junction Temperature

Sensitive gate TRIACs run 100 to 1000 ohms. With an external resistor, their $\frac{dV}{dt}$ capability remains inferior to non-sensitive devices because lateral resistance within the gate layer reduces its benefit.

Sensitive gate SCRs (I_{GT} < 200 μA) have no built-in resistor. They should be used with an external resistor. The recommended value of the resistor is 1000 ohms. Higher values reduce maximum operating temperature and $\left(\frac{dV}{dt}\right)_s$ (Figure 6). The capability of these parts varies by more than 100 to 1 depending on gate-cathode termination.

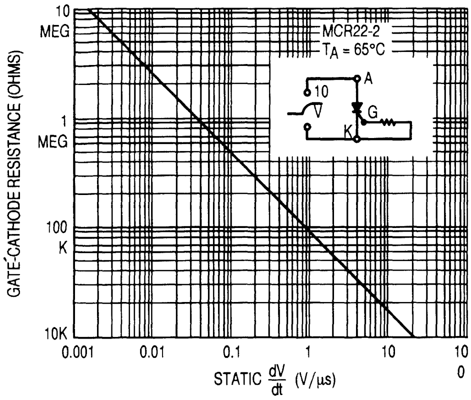


Figure 6. Exponential $\left(\frac{dV}{dt}\right)_s$ versus Gate-Cathode Resistance

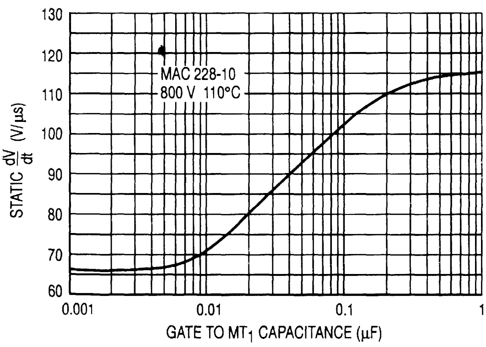


Figure 7. Exponential $\left(\frac{dV}{dt}\right)_s$ versus Gate to MT_1 Capacitance

A gate-cathode capacitor (Figure 7) provides a shunt path for transient currents in the same manner as the resistor. It also filters noise currents from the drive circuit and enhances the built-in gate-cathode capacitance voltage divider effect. The gate drive circuit needs to be able to charge the capacitor without excessive delay, but it does not need to supply continuous current as it would for a resistor that increases $\frac{dV}{dt}$ the same amount. However, the capacitor does not enhance static thermal stability.

The maximum $\left(\frac{dV}{dt}\right)_s$ improvement occurs with a short. Actual improvement stops before this because of spreading resistance in the thyristor. An external capacitor of about 0.1 μF allows the maximum enhancement at a higher value of R_{GK}.

One should keep the thyristor cool for the highest $\left(\frac{dV}{dt}\right)_s$. Also devices should be tested in the application circuit at the highest possible temperature using thyristors with the lowest measured trigger current.

TRIAC COMMUTATING $\frac{dV}{dt}$

WHAT IS COMMUTATING $\frac{dV}{dt}$?

The commutating $\frac{dV}{dt}$ rating applies when a TRIAC has been conducting and attempts to turn-off with an inductive load. The current and voltage are out of phase (Figure 8). The TRIAC attempts to turn-off as the current drops below the holding value. Now the line voltage is high and in the opposite polarity to the direction of conduction. Successful turn-off requires the voltage across the TRIAC to rise to the instantaneous line voltage at a rate slow enough to prevent retriggering of the device.

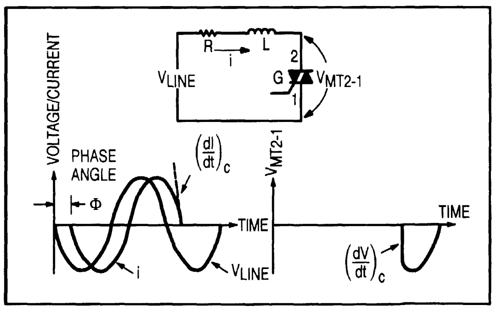


Figure 8. TRIAC Inductive Load Turn-Off $\left(\frac{dV}{dt}\right)_c$

$\left(\frac{dV}{dt}\right)_c$ DEVICE PHYSICS

A TRIAC functions like two SCRs connected in inverse-parallel. So, a transient of either polarity turns it on.

There is charge within the crystal's volume because of prior conduction (Figure 9). The charge at the boundaries of

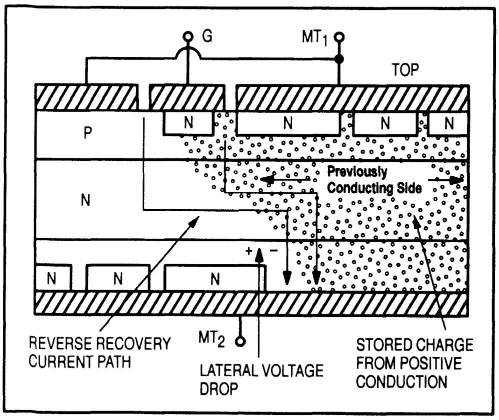


Figure 9. TRIAC Structure and Current Flow at Commutation

the collector junction depletion layer responsible for $\left(\frac{dV}{dt}\right)_s$ is also present. TRIACs have lower $\left(\frac{dV}{dt}\right)_c$ than $\left(\frac{dV}{dt}\right)_s$ because of this additional charge.

The volume charge storage within the TRIAC depends on the peak current before turn-off and its rate of zero crossing $\left(\frac{dI}{dt}\right)_c$. In the classic circuit, the load impedance and line frequency determine $\left(\frac{dI}{dt}\right)_c$. The rate of crossing for sinusoidal currents is given by the slope of the secant line between the 50% and 0% levels as:

$$\left(\frac{dI}{dt}\right)_c = \frac{6\,fI_{TM}}{1000}\ \text{A/ms}$$

where f = line frequency and I_{TM} = maximum on-state current in the TRIAC.

Turn-off depends on both the Miller effect displacement current generated by $\frac{dV}{dt}$ across the collector capacitance and the currents resulting from internal charge storage within the volume of the device (Figure 10). If the reverse recovery current resulting from both these components is high, the lateral IR drop within the TRIAC base layer will forward bias the emitter and turn the TRIAC on. Commutating $\frac{dV}{dt}$ capability is lower when turning off from the positive direction of current conduction because of device geometry. The gate is on the top of the die and obstructs current flow.

Recombination takes place throughout the conduction period and along the back side of the current wave as it declines to zero. Turn-off capability depends on its shape. If the current amplitude is small and its zero crossing $\left(\frac{dI}{dt}\right)_c$ is low, there is little volume charge storage and turn-off becomes limited by $\left(\frac{dV}{dt}\right)_s$. At moderate current amplitudes, the volume charge begins to influence turn-off, requiring a larger snubber. When the current is large or has rapid zero crossing, $\left(\frac{dV}{dt}\right)_c$ has little influence. Commutating $\frac{dI}{dt}$ and delay time to voltage reapplication determine whether turn-off will be successful or not (Figures 11, 12).

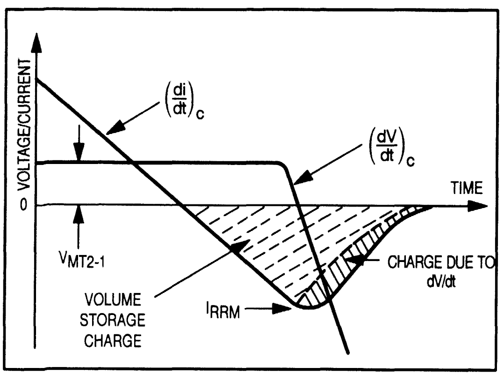


Figure 10. TRIAC Current and Voltage at Commutation

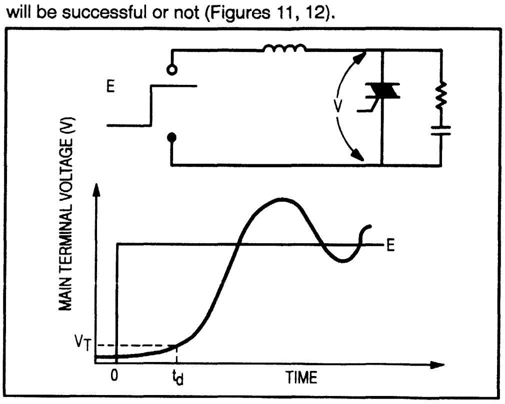


Figure 11. Snubber Delay Time

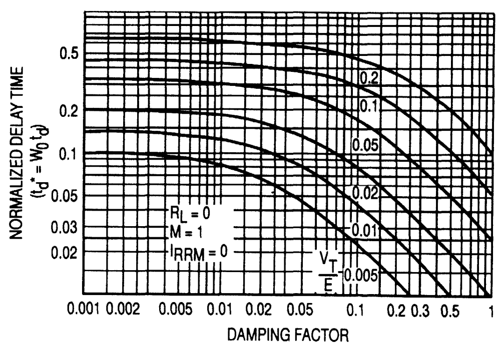


Figure 12. Delay Time To Normalized Voltage

CONDITIONS INFLUENCING $\left(\frac{dV}{dt}\right)_c$

Commutating $\frac{dV}{dt}$ depends on charge storage and recovery dynamics in addition to the variables influencing static $\frac{dV}{dt}$. High temperatures increase minority carrier life-time and the size of recovery currents, making turn-off more difficult. Loads that slow the rate of current zero-crossing aid turn-off. Those with harmonic content hinder turn-off.

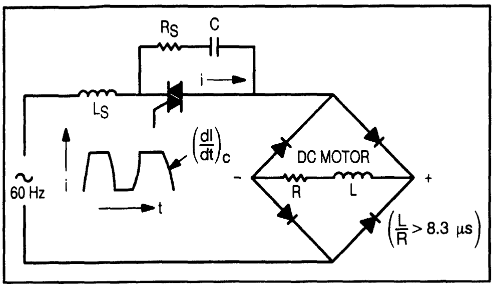


Figure 13. Phase Controlling a Motor in a Bridge

Circuit Examples

Figure 13 shows a TRIAC controlling an inductive load in a bridge. The inductive load has a time constant longer than the line period. This causes the load current to remain constant and the TRIAC current to switch rapidly as the line voltage reverses. This application is notorious for causing TRIAC turn-off difficulty because of high $\left(\frac{dI}{dt}\right)_c$.

High currents lead to high junction temperatures and rates of current crossing. Motors can have 5 to 6 times the normal current amplitude at start-up. This increases both junction temperature and the rate of current crossing, leading to turn-off problems.

The line frequency causes high rates of current crossing in 400 Hz applications. Resonant transformer circuits are doubly periodic and have current harmonics at both the primary and secondary resonance. Non-sinusoidal currents can lead to turn-off difficulty even if the current amplitude is low before zero-crossing.

$\left(\frac{dV}{dt}\right)_c$ FAILURE MODE

$\left(\frac{dV}{dt}\right)_c$ failure causes a loss of phase control. Temporary turn-on or total turn-off failure is possible. This can be destructive if the TRIAC conducts asymmetrically causing a dc current component and magnetic saturation. The winding resistance limits the current. Failure results because of excessive surge current and junction temperature.

IMPROVING $\left(\frac{dV}{dt}\right)_c$

The same steps that improve $\left(\frac{dV}{dt}\right)_s$ aid $\left(\frac{dV}{dt}\right)_c$ except when stored charge dominates turn-off. Steps that reduce the stored charge or soften the commutation are necessary then.

Larger TRIACs have better turn-off capability than smaller ones with a given load. The current density is lower in the larger device allowing recombination to claim a greater proportion of the internal charge. Also junction temperatures are lower.

TRIACs with high gate trigger currents have greater turn-off ability because of lower spreading resistance in the gate layer, reduced Miller effect, or shorter lifetime.

The rate of current crossing can be adjusted by adding a commutation softening inductor in series with the load. Small high permeability "square loop" inductors saturate causing no significant disturbance to the load current. The inductor resets as the current crosses zero introducing a large inductance into the snubber circuit at that time. This slows the current crossing and delays the reapplication of blocking voltage aiding turn-off.

The commutation inductor is a circuit element that introduces time delay, as opposed to inductance, into the circuit. It will have little influence on observed $\frac{dV}{dt}$ at the device. The following example illustrates the improvement resulting from the addition of an inductor constructed by winding 33 turns of number 18 wire on a tape wound core (52000-1A). This core is very small having an outside diameter of 3/4 inch and a thickness of 1/8 inch. The delay time can be calculated from:

$$t_S = \frac{(N\ A\ B\ 10^{-8})}{E} \quad \text{where:}$$

t_S = time delay to saturation in seconds.
B = saturating flux density in Gauss
A = effective core cross sectional area in cm^2
N = number of turns.

For the described inductor:

$$t_S = (33 \text{ turns})\ (0.076\ cm^2)\ (28000 \text{ Gauss})\ (1 \times 10^{-8})\ /\ (175\ V) = 4.0\ \mu s.$$

The saturation current of the inductor does not need to be much larger than the TRIAC trigger current. Turn-off failure will result before recovery currents become greater than this value. This criterion allows sizing the inductor with the following equation:

$$I_S = \frac{H_S\ M_L}{0.4\ \pi\ N} \quad \text{where :}$$

H_S = MMF to saturate = 0.5 Oersted
ML = mean magnetic path length = 4.99 cm.

$$I_S = \frac{(.5)\ (4.99)}{.4\ \pi\ 33} = 60 \text{ mA.}$$

SNUBBER PHYSICS

UNDAMPED NATURAL RESONANCE

$$\omega_0 = \frac{1}{\sqrt{LC}} \text{ Radians/second}$$

Resonance determines $\frac{dV}{dt}$ and boosts the peak capacitor voltage when the snubber resistor is small. C and L are related to one another by ω_0^2. $\frac{dV}{dt}$ scales linearly with ω_0 when the damping factor is held constant. A ten to one reduction in $\frac{dV}{dt}$ requires a 100 to 1 increase in either component.

DAMPING FACTOR

$$\rho = \frac{R}{2}\sqrt{\frac{C}{L}}$$

The damping factor is proportional to the ratio of the circuit loss and its surge impedance. It determines the trade off between $\frac{dV}{dt}$ and peak voltage. Damping factors between 0.01 and 1.0 are recommended.

The Snubber Resistor

Damping and $\frac{dV}{dt}$

When $\rho < 0.5$, the snubber resistor is small, and $\frac{dV}{dt}$ depends mostly on resonance. There is little improvement in $\frac{dV}{dt}$ for damping factors less than 0.3, but peak voltage and snubber discharge current increase. The voltage wave has a 1-COS (θ) shape with overshoot and ringing. Maximum $\frac{dV}{dt}$ occurs at a time later than t = 0. There is a time delay before the voltage rise, and the peak voltage almost doubles.

When $\rho > 0.5$, the voltage wave is nearly exponential in shape. The maximum instantaneous $\frac{dV}{dt}$ occurs at t = 0. There is little time delay and moderate voltage overshoot.

When $\rho > 1.0$, the snubber resistor is large and $\frac{dV}{dt}$ depends mostly on its value. There is some overshoot even through the circuit is overdamped.

High load inductance requires large snubber resistors and small snubber capacitors. Low inductances imply small resistors and large capacitors.

Damping and Transient Voltages

Figure 14 shows a series inductor and filter capacitor connected across the ac main line. The peak to peak voltage of a transient disturbance increases by nearly four times. Also the duration of the disturbance spreads because of ringing, increasing the chance of malfunction or damage to the voltage sensitive circuit. Closing a switch causes this behavior. The problem can be reduced by adding a damping resistor in series with the capacitor.

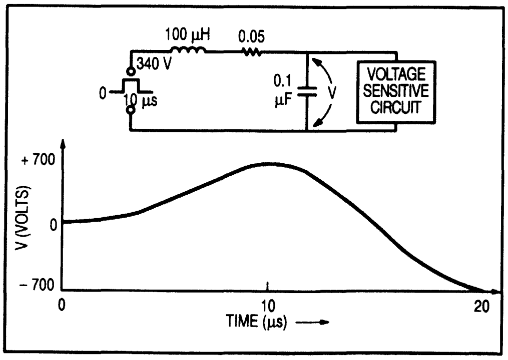


Figure 14. Undamped LC Filter Magnifies and Lengthens a Transient

$\frac{dI}{dt}$

Non-Inductive Resistor

The snubber resistor limits the capacitor discharge current and reduces $\frac{dI}{dt}$ stress. High $\frac{dI}{dt}$ destroys the thyristor even though the pulse duration is very short.

The rate of current rise is directly proportional to circuit voltage and inversely proportional to series inductance. The snubber is often the major offender because of its low inductance and close proximity to the thyristor.

With no transient suppressor, breakdown of the thyristor sets the maximum voltage on the capacitor. It is possible to exceed the highest rated voltage in the device series because high voltage devices are often used to supply low voltage specifications.

The minimum value of the snubber resistor depends on the type of thyristor, triggering quadrants, gate current amplitude, voltage, repetitive or non-repetitive operation, and required life expectancy. There is no simple way to predict the rate of current rise because it depends on turn-on speed of the thyristor, circuit layout, type and size of snubber capacitor, and inductance in the snubber resistor. The equations in Appendix D describe the circuit. However, the values required for the model are not easily obtained except by testing. Therefore, reliability should be verified in the actual application circuit.

Table 1 shows suggested minimum resistor values estimated (Appendix A) by testing a 20 piece sample from the four different TRIAC die sizes.

Table 1. Minimum Non-Inductive Snubber Resistor for Four Quadrant Triggering.

TRIAC Type	Peak V_C Volts	R_s Ohms	$\frac{dI}{dt}$ A/µs
Non-Sensitive	200	3.3	170
Gate	300	6.8	250
(I_{GT} > 10 mA)	400	11	308
8 to 40 $A_{(RMS)}$	600	39	400
	800	51	400

Reducing $\frac{dI}{dt}$

TRIAC $\frac{dI}{dt}$ can be improved by avoiding quadrant 4 triggering. Most optocoupler circuits operate the TRIAC in quadrants 1 and 3. Integrated circuit drivers use quadrants 2 and 3. Zero crossing trigger devices are helpful because they prohibit triggering when the voltage is high.

Driving the gate with a high amplitude fast rise pulse increases $\frac{dI}{dt}$ capability. The gate ratings section defines the maximum allowed current.

Inductance in series with the snubber capacitor reduces $\frac{dI}{dt}$. It should not be more than five percent of the load inductance to prevent degradation of the snubber's $\frac{dV}{dt}$ suppression capability. Wirewound snubber resistors sometimes serve this purpose. Alternatively, a separate inductor can be added in series with the snubber capacitor. It can be small because it does not need to carry the load current. For example, 18 turns of AWG No. 20 wire on a T50-3 (1/2 inch) powdered iron core creates a non-saturating 6.0 μH inductor.

A 10 ohm, 0.33 μF snubber charged to 650 volts resulted in a 1000 A/μs $\frac{dI}{dt}$. Replacement of the non-inductive snubber resistor with a 20 watt wirewound unit lowered the rate of rise to a non-destructive 170 A/μs at 800 V. The inductor gave an 80 A/μs rise at 800 V with the non-inductive resistor.

The Snubber Capacitor

A damping factor of 0.3 minimizes the size of the snubber capacitor for a given value of $\frac{dV}{dt}$. This reduces the cost and physical dimensions of the capacitor. However, it raises voltage causing a counter balancing cost increase.

Snubber operation relies on the charging of the snubber capacitor. Turn-off snubbers need a minimum conduction angle long enough to discharge the capacitor. It should be at least several time constants ($R_S C_S$).

STORED ENERGY

Inductive Switching Transients

$$E = \frac{1}{2} L I_0^2 \text{ Watt-seconds or Joules}$$

I_0 = current in Amperes flowing in the inductor at t = 0.

Resonant charging cannot boost the supply voltage at turn-off by more than 2. If there is an initial current flowing in the load inductance at turn-off, much higher voltages are possible. Energy storage is negligible when a TRIAC turns off because of its low holding or recovery current.

The presence of an additional switch such as a relay, thermostat or breaker allows the interruption of load current and the generation of high spike voltages at switch opening. The energy in the inductance transfers into the circuit capacitance and determines the peak voltage (Figure 15).

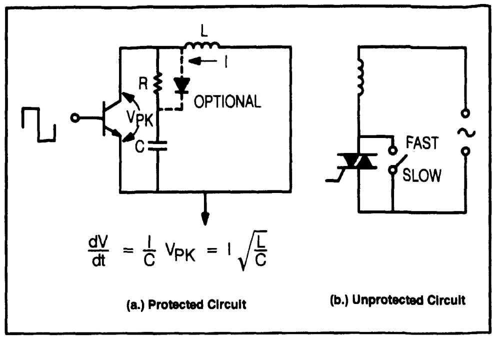


Figure 15. Interrupting Inductive Load Current

Capacitor Discharge

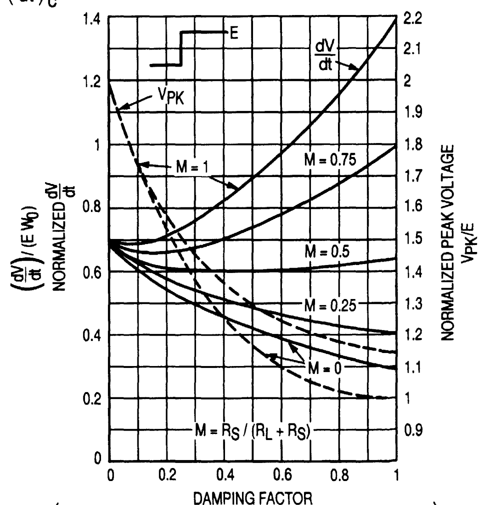
The energy stored in the snubber capacitor $\left(E_C = \frac{1}{2} C V^2\right)$ transfers to the snubber resistor and thyristor every time it turns on. The power loss is proportional to frequency (P_{AV} = 120 E_C @ 60 Hz).

CURRENT DIVERSION

The current flowing in the load inductor cannot change instantly. This current diverts through the snubber resistor causing a spike of theoretically infinite $\frac{dV}{dt}$ with magnitude equal to (I_{RRM} R) or (I_H R).

LOAD PHASE ANGLE

Highly inductive loads cause increased voltage and $\left(\frac{dV}{dt}\right)_c$ at turn-off. However, they help to protect the



$$\left(M = \text{RESISTIVE DIVISION RATIO} = \frac{R_S}{R_L + R_S}\right)$$

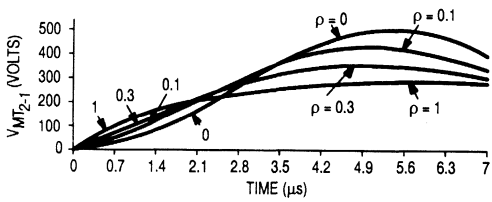
$$I_{RRM} = 0$$

Figure 16. 0 To 63% $\frac{dV}{dt}$

thyristor from transients and $\left(\frac{dV}{dt}\right)_S$. The load serves as the snubber inductor and limits the rate of inrush current if the device does turn on. Resistance in the load lowers $\frac{dV}{dt}$ and V_{PK} (Figure 16).

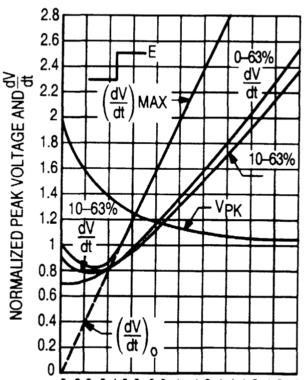
CHARACTERISTIC VOLTAGE WAVES

Damping factor and reverse recovery current determine the shape of the voltage wave. It is not exponential when the snubber damping factor is less than 0.5 (Figure 17) or when significant recovery currents are present.



$$\left[\ 0\text{–}63\%\ \left(\frac{dV}{dt}\right)_S = 100\ V/\mu s,\ E = 250\ V,\ R_L = 0,\ I_{RRM} = 0\ \right]$$

Figure 17. Voltage Waves For Different Damping Factors



$(R_L = 0,\ M = 1,\ I_{RRM} = 0)$

$$\text{NORMALIZED } \frac{dV}{dt} = \frac{dV/dt}{E\ \omega_0} \qquad \text{NORMALIZED } V_{PK} = \frac{V_{PK}}{E}$$

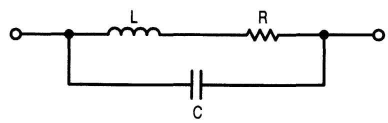
Figure 18. Trade-Off Between V_{PK} and $\frac{dV}{dt}$

A variety of wave parameters (Figure 18) describe $\frac{dV}{dt}$. Some are easy to solve for and assist understanding. These include the initial $\frac{dV}{dt}$, the maximum instantaneous $\frac{dV}{dt}$, and the average $\frac{dV}{dt}$ to the peak reapplied voltage. The 0 to 63% $\left(\frac{dV}{dt}\right)_S$ and 10 to 63% $\left(\frac{dV}{dt}\right)_C$ definitions on device data sheets are easy to measure but difficult to compute.

NON-IDEAL BEHAVIORS

CORE LOSSES

The magnetic core materials in typical 60 Hz loads introduce losses at the snubber natural frequency. They appear as a resistance in series with the load inductance and winding dc resistance (Figure 19). This causes actual $\frac{dV}{dt}$ to be less than the theoretical value.



L DEPENDS ON CURRENT AMPLITUDE, CORE SATURATION

R INCLUDES CORE LOSS, WINDING R. INCREASES WITH FREQUENCY

C WINDING CAPACITANCE. DEPENDS ON INSULATION, WIRE SIZE, GEOMETRY

Figure 19. Inductor Model

COMPLEX LOADS

Many real-world inductances are non-linear. Their core materials are not gapped causing inductance to vary with current amplitude. Small signal measurements poorly characterize them. For modeling purposes, it is best to measure them in the actual application.

Complex load circuits should be checked for transient voltages and currents at turn-on and off. With a capacitive load, turn-on at peak input voltage causes the maximum surge current. Motor starting current runs 4 to 6 times the steady state value. Generator action can boost voltages above the line value. Incandescent lamps have cold start currents 10 to 20 times the steady state value. Transformers generate voltage spikes when they are energized. Power factor correction circuits and switching devices create complex loads. In most cases, the simple CRL model allows an approximate snubber design. However, there is no substitute for testing and measuring the worst case load conditions.

SURGE CURRENTS IN INDUCTIVE CIRCUITS

Inductive loads with long L/R time constants cause asymmetric multi-cycle surges at start up (Figure 20). Triggering at zero voltage crossing is the worst case condition. The surge can be eliminated by triggering at the zero current crossing angle.

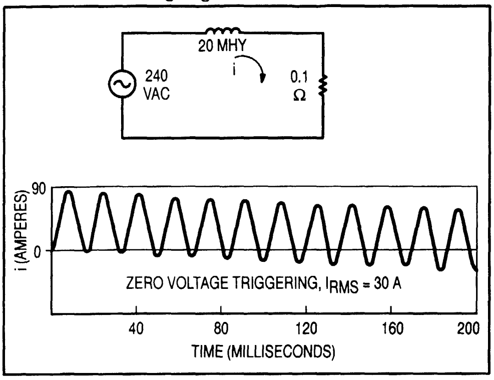


Figure 20. Start-Up Surge For Inductive Circuit

Core remanence and saturation cause surge currents. They depend on trigger angle, line impedance, core characteristics, and direction of the residual magnetization. For example, a 2.8 kVA 120 V 1:1 transformer with a 1.0 ampere load produced 160 ampere currents at start-up. Soft starting the circuit at a small conduction angle reduces this current.

Transformer cores are usually not gapped and saturate easily. A small asymmetry in the conduction angle causes magnetic saturation and multi-cycle current surges.

Steps to achieve reliable operation include:

1. Supply sufficient trigger current amplitude. TRIACs have different trigger currents depending on their quadrant of operation. Marginal gate current or optocoupler LED current causes halfwave operation.
2. Supply sufficient gate current duration to achieve latching. Inductive loads slow down the main terminal current rise. The gate current must remain above the specified I_{GT} until the main terminal current exceeds the latching value. Both a resistive bleeder around the load and the snubber discharge current help latching.
3. Use a snubber to prevent TRIAC $\left(\frac{dV}{dt}\right)_c$ failure.
4. Minimize designed-in trigger asymmetry. Triggering must be correct every half-cycle including the first. Use a storage scope to investigate circuit behavior during the first few cycles of turn-on. Alternatively, get the gate circuit up and running before energizing the load.
5. Derive the trigger synchronization from the line instead of the TRIAC main terminal voltage. This avoids regenerative interaction between the core hysteresis and the triggering angle preventing trigger runaway, halfwave operation, and core saturation.
6. Avoid high surge currents at start-up. Use a current probe to determine surge amplitude. Use a soft start circuit to reduce inrush current.

DISTRIBUTED WINDING CAPACITANCE

There are small capacitances between the turns and layers of a coil. Lumped together, they model as a single shunt capacitance. The load inductor behaves like a capacitor at frequencies above its self-resonance. It becomes ineffective in controlling $\frac{dV}{dt}$ and V_{PK} when a fast transient such as that resulting from the closing of a switch occurs. This problem can be solved by adding a small snubber across the line.

SELF-CAPACITANCE

A thyristor has self-capacitance which limits $\frac{dV}{dt}$ when the load inductance is large. Large load inductances, high power factors, and low voltages may allow snubberless operation.

SNUBBER EXAMPLES

WITHOUT INDUCTANCE

Power TRIAC Example

Figure 21 shows a transient voltage applied to a TRIAC controlling a resistive load. Theoretically there will be an instantaneous step of voltage across the TRIAC. The only elements slowing this rate are the inductance of the wiring and the self-capacitance of the thyristor. There is an exponential capacitor charging component added along with a decaying component because of the IR drop in the snubber resistor. The non-inductive snubber circuit is useful when the load resistance is much larger than the snubber resistor.

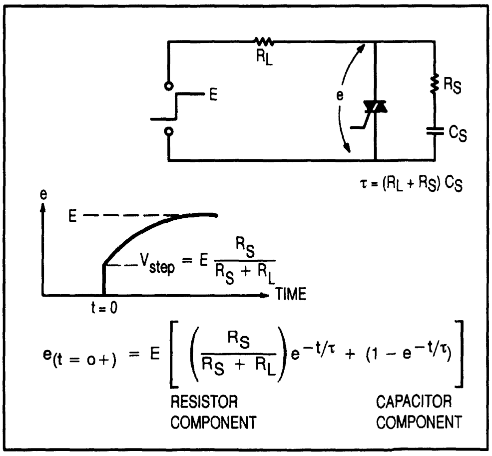


Figure 21. Non-Inductive Snubber Circuit

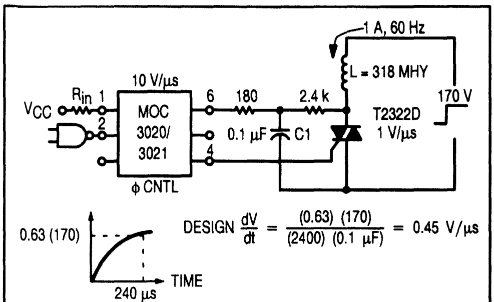
Opto-TRIAC Examples

Single Snubber, Time Constant Design

Figure 22 illustrates the use of the RC time constant design method. The optocoupler sees only the voltage across the snubber capacitor. The resistor R1 supplies the trigger current of the power TRIAC. A worst case design procedure assumes that the voltage across the power TRIAC changes instantly. The capacitor voltage rises to 63% of the maximum in one time constant. Then:

$$R_1\,C_S = \tau = \frac{0.63\ E}{\left(\frac{dV}{dt}\right)_S}\ \text{where}\ \left(\frac{dV}{dt}\right)_S\ \text{is the rated static}\ \frac{dV}{dt}$$

for the optocoupler.



$\frac{dV}{dt}$ (V/µs)	
Power TRIAC	Optocoupler
0.99	0.35

Figure 22. Single Snubber For Sensitive Gate TRIAC and Phase Controllable Optocoupler ($\rho = 0.67$)

The optocoupler conducts current only long enough to trigger the power device. When it turns on, the voltage between MT2 and the gate drops below the forward threshold voltage of the opto-TRIAC causing turn-off. The optocoupler sees $\left(\frac{dV}{dt}\right)_S$ when the power TRIAC turns off later in the conduction cycle at zero current crossing. Therefore, it is not necessary to design for the lower optocoupler $\left(\frac{dV}{dt}\right)_C$ rating. In this example, a single snubber designed for the optocoupler protects both devices.

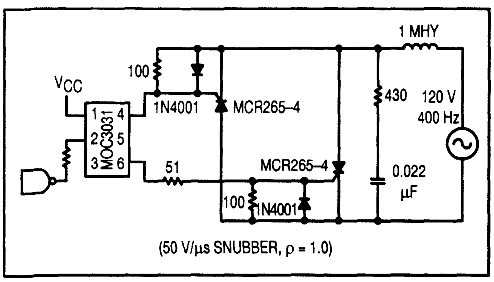


Figure 23. Anti-Parallel SCR Driver

Optocouplers with SCRs

Anti-parallel SCR circuits result in the same $\frac{dV}{dt}$ across the optocoupler and SCR (Figure 23). Phase controllable optocouplers require the SCRs to be snubbed to their lower $\frac{dV}{dt}$ rating. Anti-parallel SCR circuits are free from the charge storage behaviors that reduce the turn-off capability of TRIACs. Each SCR conducts for a half-cycle and has the next half cycle of the ac line in which to recover. The turn-off $\frac{dV}{dt}$ of the conducting SCR becomes a static forward blocking $\frac{dV}{dt}$ for the other device. Use the SCR data sheet $\left(\frac{dV}{dt}\right)_S$ rating in the snubber design.

A SCR used inside a rectifier bridge to control an ac load will not have a half cycle in which to recover. The available time decreases with increasing line voltage. This makes the circuit less attractive. Inductive transients can be suppressed by a snubber at the input to the bridge or across the SCR. However, the time limitation still applies.

OPTO $\left(\frac{dV}{dt}\right)_C$

Zero-crossing optocouplers can be used to switch inductive loads at currents less than 100 mA (Figure 24). However a power TRIAC along with the optocoupler should be used for higher load currents.

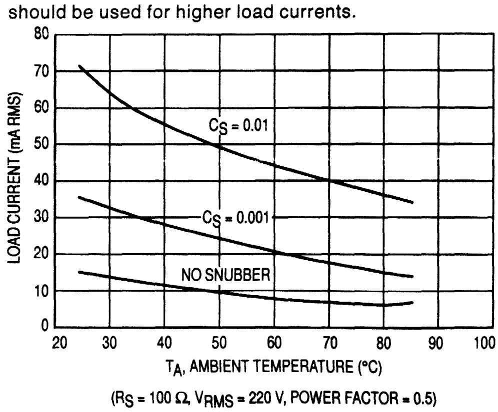


Figure 24. MOC3062 Inductive Load Current versus T_A

A phase controllable optocoupler is recommended with a power device. When the load current is small, a MAC97 TRIAC is suitable.

Unusual circuit conditions sometimes lead to unwanted operation of an optocoupler in $\left(\frac{dV}{dt}\right)_C$ mode. Very large currents in the power device cause increased voltages between MT2 and the gate that hold the optocoupler on. Use of a larger TRIAC or other measures that limit inrush current solve this problem.

Very short conduction times leave residual charge in the optocoupler. A minimum conduction angle allows recovery before voltage reapplication.

THE SNUBBER WITH INDUCTANCE

Consider an overdamped snubber using a large capacitor whose voltage changes insignificantly during the time under consideration. The circuit reduces to an equivalent L/R series charging circuit.

The current through the snubber resistor is:

$$i = \frac{V}{R_\tau}\left(1 - e^{-\frac{t}{\tau}}\right),$$

and the voltage across the TRIAC is:

$$e = i\ R_S.$$

The voltage wave across the TRIAC has an exponential rise with maximum rate at t = 0. Taking its derivative gives its value as:

$$\left(\frac{dV}{dt}\right)_0 = \frac{V\ R_S}{L}.$$

Highly overdamped snubber circuits are not practical designs. The example illustrates several properties:

1. The initial voltage appears completely across the circuit inductance. Thus, it determines the rate of change of current through the snubber resistor and the initial $\frac{dV}{dt}$. This result does not change when there is resistance in the load and holds true for all damping factors.
2. The snubber works because the inductor controls the rate of current change through the resistor and the rate of capacitor charging. Snubber design cannot ignore the inductance. This approach suggests that the snubber capacitance is not important but that is only true for this hypothetical condition. The snubber resistor shunts the thyristor causing unacceptable leakage when the capacitor is not present. If the power loss is tolerable, $\frac{dV}{dt}$ can be controlled without the capacitor. An example is the soft-start circuit used to limit inrush current in switching power supplies (Figure 25).

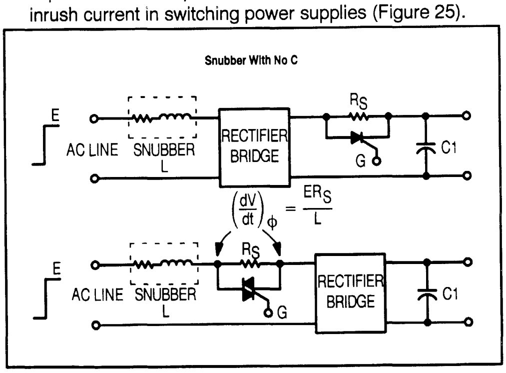


Figure 25. Surge Current Limiting For a Switching Power Supply

TRIAC DESIGN PROCEDURE $\left(\frac{dV}{dt}\right)_c$

1. Refer to Figure 18 and select a particular damping factor (ρ) giving a suitable trade-off between V_{PK} and $\frac{dV}{dt}$. Determine the normalized $\frac{dV}{dt}$ corresponding to the chosen damping factor.

The voltage E depends on the load phase angle:

$$E = \sqrt{2}\ V_{RMS}\ \text{Sin}\ (\phi)\ \text{where}\ \phi = \tan^{-1}\left(\frac{X_L}{R_L}\right)\ \text{where}$$

ϕ = measured phase angle between line V and load I
R_L = measured dc resistance of the load.

Then

$$Z = \frac{V_{RMS}}{I_{RMS}}\sqrt{R_L{}^2 + X_L{}^2} \quad X_L = \sqrt{Z^2 - R_L{}^2}\ \text{and}$$

$$L = \frac{X_L}{2\ \pi\ f_{Line}}.$$

If only the load current is known, assume a pure inductance. This gives a conservative design. Then:

$$L = \frac{V_{RMS}}{2\ \pi\ f_{Line}\ I_{RMS}}\ \text{where}\ E = \sqrt{2}\ V_{RMS}.$$

For example:

$$E = \sqrt{2}\ 120 = 170\ V;\ L = \frac{120}{(8\ A)\ (377\ rps)} = 39.8\ mH.$$

Read from the graph at ρ = 0.6, V_{PK} = (1.25) 170 = 213 V. Use 400 V TRIAC. Read $\frac{dV}{dt}_{(\rho = 0.6)}$ = 1.0.

2. Apply the resonance criterion:

$$\omega_0 = \left(\text{spec}\ \frac{dV}{dt}\right) / \left(\frac{dV}{dt_{(P)}}\ E\right).$$

$$\omega_0 = \frac{5 \times 10^6\ V/S}{(1)\ (170\ V)} = 29.4 \times 10^3\ rps.$$

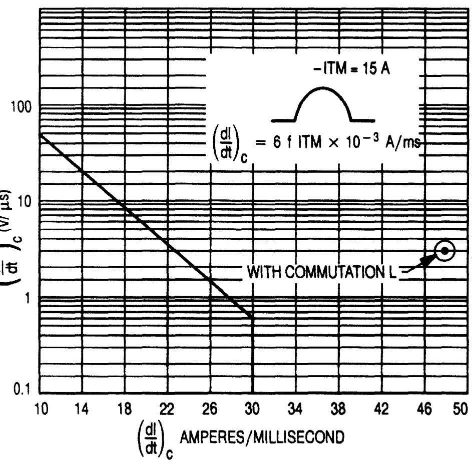
$$C = \frac{1}{\omega_0{}^2\ L} = 0.029\ \mu F$$

3. Apply the damping criterion:

$$R_S = 2\rho\sqrt{\frac{L}{C}} = 2(0.6)\sqrt{\frac{39.8 \times 10^{-3}}{0.029 \times 10^{-6}}} = 1400\,\text{ohms}.$$

$\left(\frac{dV}{dt}\right)_c$ SAFE AREA CURVE

Figure 26 shows a MAC16 TRIAC turn-off safe operating area curve. Turn-off occurs without problem under the curve. The region is bounded by static $\frac{dV}{dt}$ at low values of $\left(\frac{dI}{dt}\right)_c$ and delay time at high currents. Reduction of the peak current permits operation at higher line frequency. This TRIAC operated at f = 400 Hz, T_J = 125°C, and I_{TM} = 6.0 amperes using a 30 ohm and 0.068 µF snubber. Low damping factors extend operation to higher $\left(\frac{dI}{dt}\right)_c$, but capacitor sizes increase. The addition of a small, saturable commutation inductor extends the allowed current rate by introducing recovery delay time.



(MAC 16-8, COMMUTATIONAL L = 33 TURNS #18, 52000-1A TAPE WOUND CORE 3/4 INCH OD)

Figure 26. $\left(\frac{dV}{dt}\right)_c$ versus $\left(\frac{dI}{dt}\right)_c$ T_J = 125°C

STATIC $\frac{dV}{dt}$ DESIGN

There is usually some inductance in the ac main and power wiring. The inductance may be more than 100 µH if there is a transformer in the circuit or nearly zero when a shunt power factor correction capacitor is present. Usually the line inductance is roughly several µH. The minimum

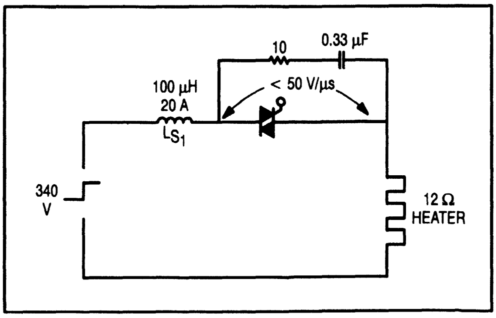


Figure 27. Snubbing For a Resistive Load

inductance must be known or defined by adding a series inductor to insure reliable operation (Figure 27).

One hundred µH is a suggested value for starting the design. Plug the assumed inductance into the equation for C. Larger values of inductance result in higher snubber resistance and reduced $\frac{dI}{dt}$. For example:

Given E = 240 $\sqrt{2}$ = 340 V.

Pick ρ = 0.3.

Then from Figure 18, V_{PK} = 1.42 (340) = 483 V.

Thus, it will be necessary to use a 600 V device. Using the previously stated formulas for ω_0, C and R we find:

$$\omega_0 = \frac{50 \times 10^6 \text{ V/S}}{(0.73)\ (340\text{ V})} = 201450 \text{ rps}$$

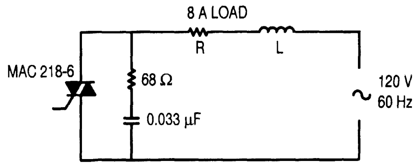
$$C = \frac{1}{(201450)^2\ (100 \times 10^{-6})} = 0.2464\ \mu F$$

$$R = 2\ (0.3) \sqrt{\frac{100 \times 10^{-6}}{0.2464 \times 10^{-6}}} = 12 \text{ ohms}$$

VARIABLE LOADS

The snubber should be designed for the smallest load inductance because $\frac{dV}{dt}$ will then be highest because of its dependence on ω_0. This requires a higher voltage device for operation with the largest inductance because of the corresponding low damping factor.

Figure 28 describes $\frac{dV}{dt}$ for an 8.0 ampere load at various power factors. The minimum inductance is a component added to prevent static $\frac{dV}{dt}$ firing with a resistive load.



$\left(\frac{dV}{dt}\right)_s = 100\ V/\mu s \quad \left(\frac{dV}{dt}\right)_c = 5\ V/\mu s$

ρ	R	L	V_{step}	V_{PK}	$\frac{dv}{dt}$
	Ω	MHY	V	V	V/μs
0.75	15	0.1	170	191	86
0.03	0	39.8	170	325	4.0
0.04	10.6	28.1	120	225	3.3
0.06	13.5	17.3	74	136	2.6

Figure 28. Snubber For a Variable Load

EXAMPLES OF SNUBBER DESIGNS

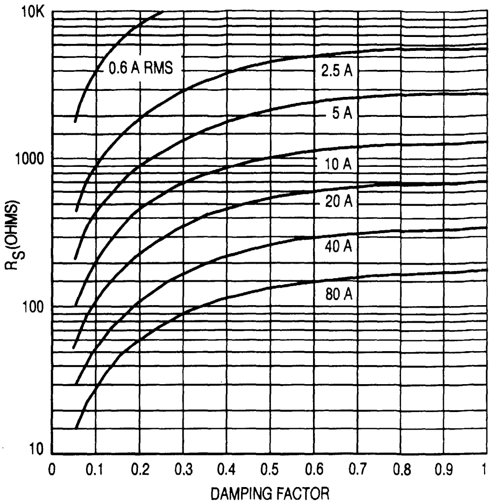
Table 2 describes snubber RC values for $\left(\frac{dV}{dt}\right)_s$. Figures 31 and 32 show possible R and C values for a 5.0 V/μs $\left(\frac{dV}{dt}\right)_c$ assuming a pure inductive load.

Table 2. Static $\frac{dV}{dt}$ Designs
(E = 340 V, V_{peak} = 500 V, ρ = 0.3)

	5.0 V/μs		50 V/μs		100 V/μs	
L μH	C μF	R Ohm	C μF	R Ohm	C μF	R Ohm
47					0.15	10
100			0.33	10	0.1	20
220			0.15	22	0.033	47
500			0.068	51	0.015	110
1000	3.0	11	0.033	100		

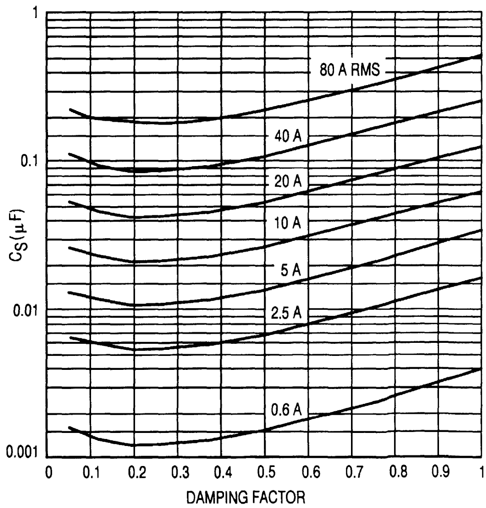
TRANSIENT AND NOISE SUPPRESSION

Transients arise internally from normal circuit operation or externally from the environment. The latter is particularly frustrating because the transient characteristics are undefined. A statistical description applies. Greater or smaller stresses are possible. Long duration high voltage transients are much less probable than those of lower amplitude and higher frequency. Environments with infrequent lightning and load switching see transient voltages below 3.0 kV.



(PURE INDUCTIVE LOAD, V = 120 V_{RMS}, I_{RRM} = 0)

Figure 29. Snubber Resistor For $\left(\frac{dV}{dt}\right)_c$ = 5.0 V/μs



(PURE INDUCTIVE LOAD, V = 120 V_{RMS}, I_{RRM} = 0)

Figure 30. Snubber Capacitor For $\left(\frac{dV}{dt}\right)_c$ = 5.0 V/μs

The natural frequencies and impedances of indoor ac wiring result in damped oscillatory surges with typical frequencies ranging from 30 kHz to 1.5 MHz. Surge amplitude depends on both the wiring and the source of surge energy. Disturbances tend to die out at locations far away from the source. Spark-over (6.0 kV in indoor ac wiring) sets the maximum voltage when transient suppressors are not present. Transients closer to the service entrance or in heavy wiring have higher amplitudes, longer durations, and more damping because of the lower inductance at those locations.

The simple CRL snubber is a low pass filter attenuating frequencies above its natural resonance. A steady state sinusoidal input voltage results in a sine wave output at the same frequency. With no snubber resistor, the rate of roll off approaches 12 dB per octave. The corner frequency is at the snubber's natural resonance. If the damping factor is low, the response peaks at this frequency. The snubber resistor degrades filter characteristics introducing an up-turn at $\omega = 1 / (RC)$. The roll-off approaches 6.0 dB/octave at frequencies above this. Inductance in the snubber resistor further reduces the roll-off rate.

Figure 32 describes the frequency response of the circuit in Figure 27. Figure 31 gives the theoretical response to a 3.0 kV 100 kHz ring-wave. The snubber reduces the peak voltage across the thyristor. However, the fast rise input causes a high $\frac{dV}{dt}$ step when series inductance is added to the snubber resistor. Limiting the input voltage with a transient suppressor reduces the step.

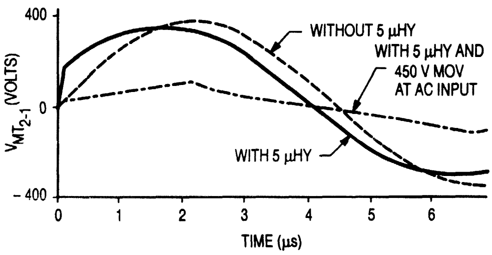


Figure 31. Theoretical Response of Figure 33 Circuit to3.0 kV IEEE 587 Ring Wave (R_{SC} = 27.5 Ω)

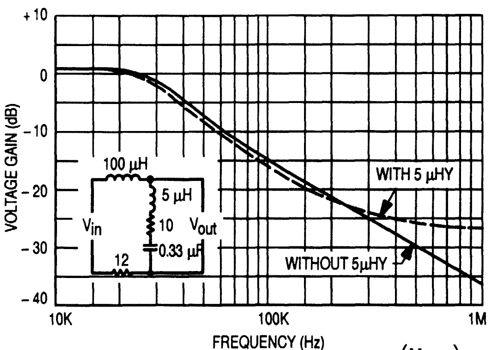


Figure 32. Snubber Frequency Response $\left(\frac{V_{out}}{V_{in}}\right)$

The noise induced into a circuit is proportional to $\frac{dV}{dt}$ when coupling is by stray capacitance, and $\frac{dI}{dt}$ when the coupling is by mutual inductance. Best suppression requires the use of a voltage limiting device along with a rate limiting CRL snubber.

The thyristor is best protected by preventing turn-on from $\frac{dV}{dt}$ or breakover. The circuit should be designed for what can happen instead of what normally occurs.

In Figure 30, a MOV connected across the line protects many parallel circuit branches and their loads. The MOV defines the maximum input voltage and $\frac{dI}{dt}$ through the load. With the snubber, it sets the maximum $\frac{dV}{dt}$ and peak voltage across the thyristor. The MOV must be large because there is little surge limiting impedance to prevent its burn-out.

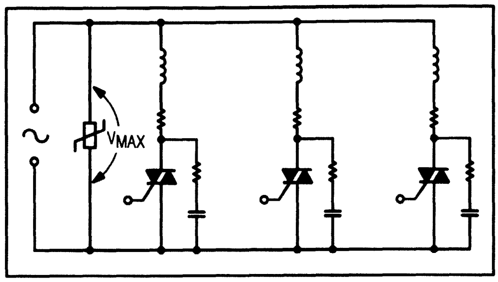


Figure 33. Limiting Line Voltage

In Figure 32, there is a separate suppressor across each thyristor. The load impedance limits the surge energy delivered from the line. This allows the use of a smaller device but omits load protection. This arrangement protects each thyristor when its load is a possible transient source.

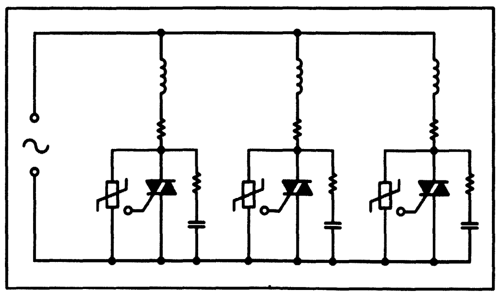


Figure 34. Limiting Thyristor Voltage

It is desirable to place the suppression device directly across the source of transient energy to prevent the induction of energy into other circuits. However, there is no protection for energy injected between the load and its controlling thyristor. Placing the suppressor directly across each thyristor positively limits maximum voltage and snubber discharge $\frac{dI}{dt}$.

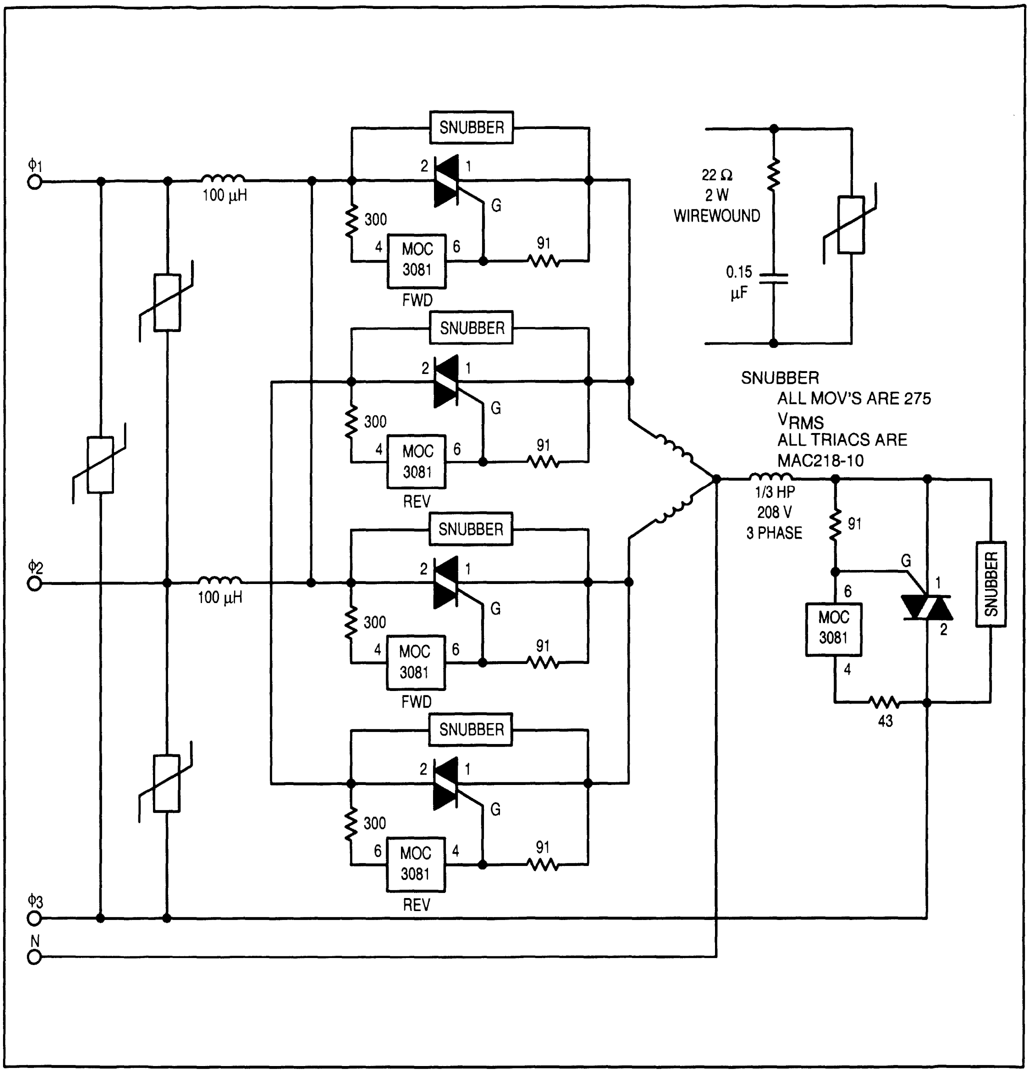


Figure 35. 3 Phase Reversing Motor

EXAMPLES OF SNUBBER APPLICATIONS

In Figure 35, TRIACs switch a 3 phase motor on and off and reverse its rotation. Each TRIAC pair functions as a SPDT switch. The turn-on of one TRIAC applies the differential voltage between line phases across the blocking device without the benefit of the motor impedance to constrain the rate of voltage rise. The inductors are added to prevent static $\frac{dV}{dt}$ firing and a line-to-line short.

Figure 36 shows a split phase capacitor-run motor with reversing accomplished by switching the capacitor in series with one or the other winding. The forward and reverse TRIACs function as a SPDT switch. Reversing the motor applies the voltage on the capacitor abruptly across the blocking thyristor. Again, the inductor L is added to prevent $\left(\frac{dV}{dt}\right)_s$ firing of the blocking TRIAC. If turn-on occurs, the forward and reverse TRIACs short the capacitors (C_S) resulting in damage to them. It is wise to add the resistor R_S to limit the discharge current.

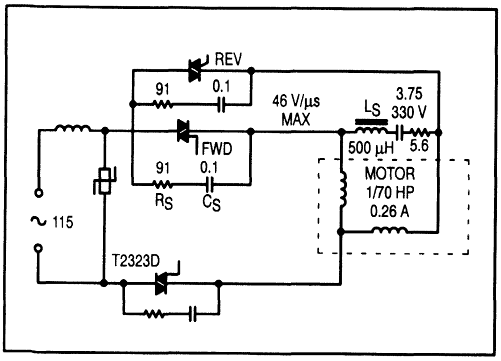


Figure 36. Split Phase Reversing Motor

Figure 37 shows a "tap changer." This circuit allows the operation of switching power supplies from a 120 or 240 vac line. When the TRIAC is on, the circuit functions as a conventional voltage doubler with diodes D1 and D2 conducting on alternate half-cycles. In this mode of operation, inrush current and $\frac{dI}{dt}$ are hazards to TRIAC reliability. Series impedance is necessary to prevent damage to the TRIAC.

The TRIAC is off when the circuit is not doubling. In this state, the TRIAC sees the difference between the line voltage and the voltage at the intersection of C1 and C2. Transients on the line cause $\left(\frac{dV}{dt}\right)_s$ firing of the TRIAC. High inrush current, $\frac{dI}{dt}$, and overvoltage damage to the filter capacitor are possibilities. Prevention requires the addition of a RC snubber across the TRIAC and an inductor in series with the line.

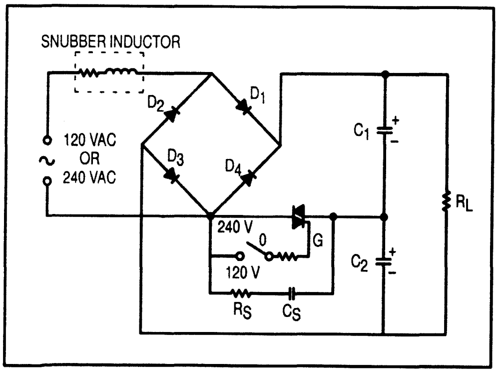


Figure 37. Tap Changer For Dual Voltage Switching Power Supply

THYRISTOR TYPES

Sensitive gate thyristors are easy to turn-on because of their low trigger current requirements. However, they have less $\frac{dV}{dt}$ capability than similar non-sensitive devices. A non-sensitive thyristor should be used for high $\frac{dV}{dt}$.

TRIAC commutating $\frac{dV}{dt}$ ratings are 5 to 20 times less than static $\frac{dV}{dt}$ ratings.

Phase controllable optocouplers have lower $\frac{dV}{dt}$ ratings than zero crossing optocouplers and power TRIACs. These should be used when a dc voltage component is present, or to prevent turn-on delay.

Zero crossing optocouplers have more $\frac{dV}{dt}$ capability than power thyristors; and they should be used in place of phase controllable devices in static switching applications.

APPENDIX A

TESTING SNUBBER DISCHARGE $\frac{dI}{dt}$

The equations in Appendix D do not consider the thyristor's turn-on time or on-state resistance, thus, they predict high values of $\frac{dI}{dt}$.

Figure 38 shows the circuit used to test snubber discharge $\frac{dI}{dt}$. A MBS4991 supplies the trigger pulse while the quadrants of operation are switch selectable. The snubber was mounted as close to the TRIAC under test as possible to reduce inductance, and the current transformer remained in the circuit to allow results to be compared with the measured $\frac{dI}{dt}$ value.

What should the peak capacitor voltage be? A conservative approach is to test at maximum rated V_{DRM}, or the clamp voltage of the MOV.

What is the largest capacitor that can be used without limiting resistance? Figure 39 is a photo showing the current pulse resulting from a 0.001 μF capacitor charged to 800 V. The 1200 A/μs $\frac{dI}{dt}$ destroyed the TRIAC.

Is it possible for MOV self-capacitance to damage the TRIAC? A large 40 Joule, 2200 A peak current rated MOV was tested. The MOV measured 440 pF and had an 878 volt breakover voltage. Its peak discharge current (12 A) was half that of a 470 pF capacitor. This condition was safe.

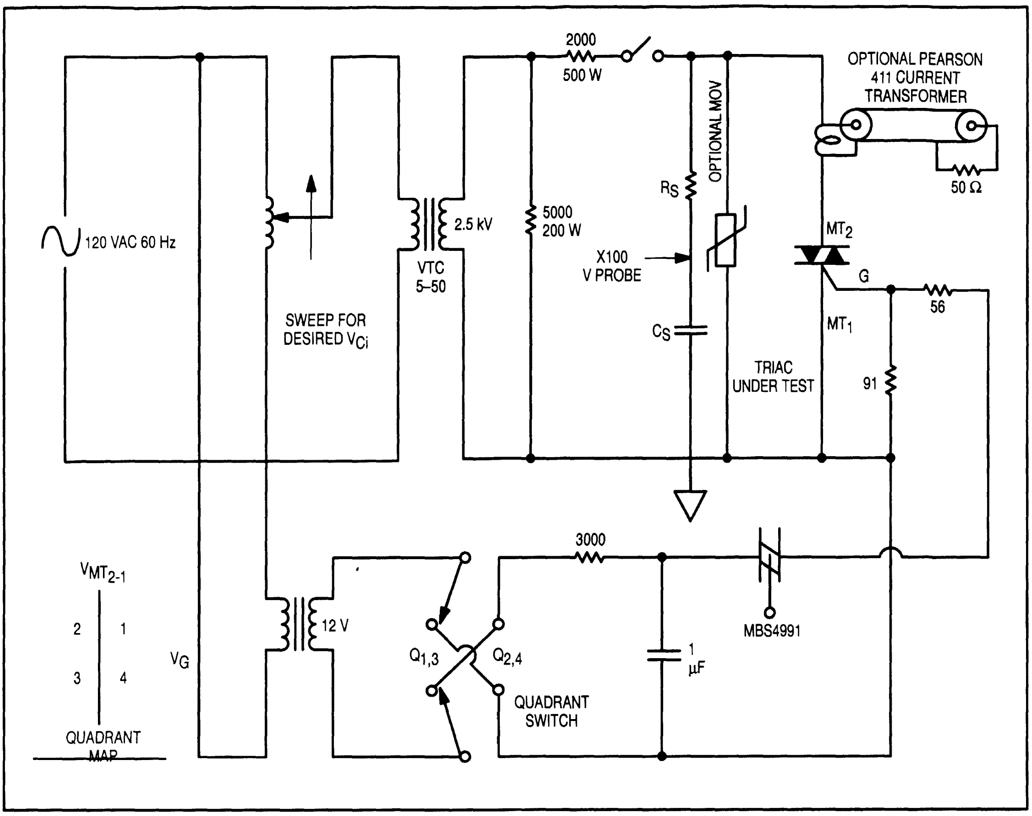
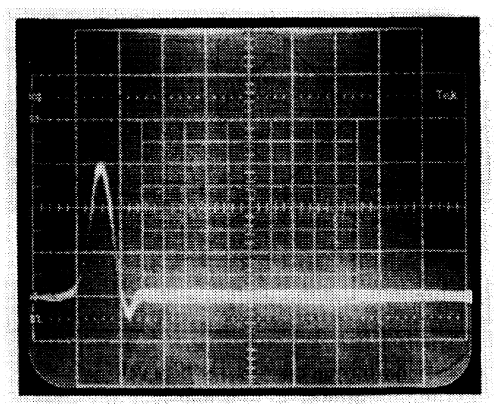


Figure 38. Snubber Discharge dI/dt Test

APPENDIX B

MEASURING $\left(\frac{dV}{dt}\right)_s$

Figure 40 shows a test circuit for measuring the static $\frac{dV}{dt}$ of power thyristors. A 1000 volt FET switch insures that the voltage across the device under test (D.U.T.) rises rapidly from zero. A differential preamp allows the use of a N-channel device while keeping the storage scope chassis at ground for safety purposes. The rate of voltage rise is adjusted by a variable RC time constant. The charging resistance is low to avoid waveform distortion because of the thyristor's self-capacitance but is large enough to prevent damage to the D.U.T. from turn-on $\frac{dI}{dt}$. Mounting the miniature range switches, capacitors, and G-K network close to the device under test reduces stray inductance and allows testing at more than 10 kV/µs.



HORIZONTAL SCALE — 50 ms/DIV.
VERTICAL SCALE — 10 A/DIV.
C_S = 0.001 µF, V_{Ci} = 800 V, R_S = 0, L = 250 mH, R_{TRAIC} = 10 OHMS

Figure 39. Discharge Current From 0.001 µF Capacitor

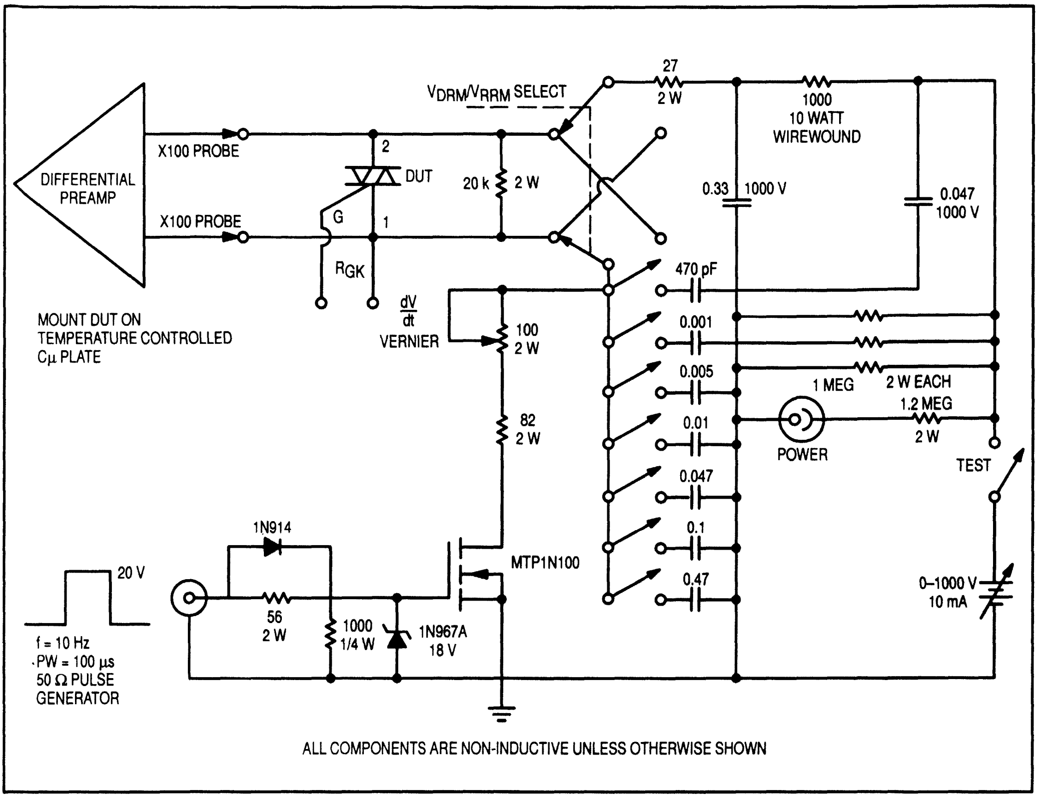


Figure 40. Circuit For Static $\frac{dV}{dt}$ Measurement of Power Thyristors

APPENDIX C
MEASURING $\left(\frac{dV}{dt}\right)_c$

A test fixture to measure commutating $\frac{dV}{dt}$ is shown in Figure 41. It is a capacitor discharge circuit with the load series resonant. The single pulse test aids temperature control and allows the use of lower power components. The limited energy in the load capacitor reduces burn and shock hazards. The conventional load and snubber circuit provides recovery and damping behaviors like those in the application.

The voltage across the load capacitor triggers the D.U.T. It terminates the gate current when the load capacitor voltage crosses zero and the TRIAC current is at its peak.

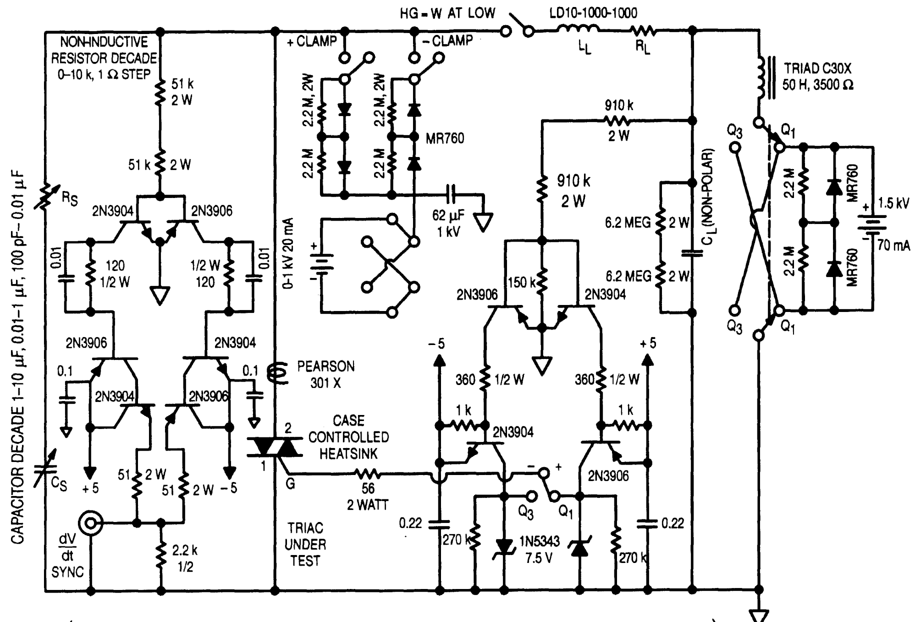
Each V_{DRM}, I_{TM} combination requires different components. Calculate their values using the equations given in Figure 41.

Commercial chokes simplify the construction of the necessary inductors. Their inductance should be adjusted by increasing the air gap in the core. Removal of the magnetic pole piece reduces inductance by 4 to 6 but extends the current without saturation.

The load capacitor consists of a parallel bank of 1500 Vdc non-polar units, with individual bleeders mounted at each capacitor for safety purposes.

An optional adjustable voltage clamp prevents TRIAC breakdown.

To measure $\left(\frac{dV}{dt}\right)_c$, synchronize the storage scope on the current waveform and verify the proper current amplitude and period. Increase the initial voltage on the capacitor to compensate for losses within the coil if necessary. Adjust the snubber until the device fails to turn off after the first half-cycle. Inspect the rate of voltage rise at the fastest passing condition.



$$\left(C_L = \frac{I_{PK}}{W_0\, V_{Ci}} = \frac{I_P\, T}{2\pi\, V_{Ci}} \quad L_L = \frac{V_{Ci}}{W_0\, I_{PK}} = \frac{T^2}{4\pi^2 C_L} \quad W_0 = \frac{1}{\sqrt{L_L}} \quad \left(\frac{dI}{dt}\right)_c = 6f\, I_{PK} \times 10^{-6}\ \text{A}/\mu\text{s} \right)$$

Figure 41. $\left(\frac{dV}{dt}\right)_c$ Test Circuit For Power TRIACs

APPENDIX D
$\frac{dV}{dt}$ DERIVATIONS

DEFINITIONS

1.0 $R_T = R_L + R_S$ = Total Resistance

1.1 $M = \frac{R_S}{R_T}$ = Snubber Divider Ratio

1.2 $\omega_0 = \frac{1}{\sqrt{L\,C_S}}$ = Undamped Natural Frequency

ω = Damped Natural Frequency

1.3 $\alpha = \frac{R_T}{2\,L}$ = Wave Decrement Factor

1.4 $\chi^2 = \frac{1/2\,LI^2}{1/2\,CV^2} = \frac{\text{Initial Energy In Inductor}}{\text{Final Energy In Capacitor}}$

1.5 $\chi = \frac{I}{E}\sqrt{\frac{L}{C}}$ = Initial Current Factor

1.6 $\rho = \frac{R_T}{2}\sqrt{\frac{C}{L}} = \frac{\alpha}{\omega_0}$ = Damping Factor

1.7 $V_{0_L} = E - R_S\,I$ = Initial Voltage drop at t = 0 across the load

1.8 $\xi = \frac{I}{C_S} - \frac{E\,R_L}{L}$

$\left(\frac{dV}{dt}\right)_0$ = Initial instantaneous $\frac{dV}{dt}$ at t = 0, ignoring any initial instantaneous voltage step at t = 0 because of I_{RRM}

1.9 $\left(\frac{dV}{dt}\right)_0 = V_{OL}\frac{R_T}{L} + \xi$. For all damping conditions

2.0 When I = 0, $\left(\frac{dV}{dt}\right)_0 = \frac{E\,R_S}{L}$

$\left(\frac{dV}{dt}\right)_{max}$ = Maximum instantaneous $\frac{dV}{dt}$

t_{max} = Time of maximum instantaneous $\frac{dV}{dt}$

t_{peak} = Time of maximum instantaneous peak voltage across thyristor

Average $\frac{dV}{dt} = V_{PK}/t_{PK}$ = Slope of the secant line from t = 0 through V_{PK}

V_{PK} = Maximum instantaneous voltage across the thyristor.

CONSTANTS (depending on the damping factor):

2.1 No Damping ($\rho = 0$)
$\omega = \omega_0$
$R_T = \alpha = \rho = 0$

2.2 Underdamped ($0 < \rho < 1$)
$\omega = \sqrt{\omega_0^2 - \alpha^2} = \omega_0\sqrt{1 - \rho^2}$

2.3 Critical Damped ($\rho = 1$)
$\alpha = \omega_0,\quad \omega = 0,\quad R = 2\sqrt{\frac{L}{C}},\quad C = \frac{2}{\alpha\,R_T}$

2.4 Overdamped ($\rho > 1$)
$\omega = \sqrt{\alpha^2 - \omega_0^2} = \omega_0\sqrt{\rho^2 - 1}$

Laplace transforms for the current and voltage in Figure 42 are:

3.0 $i_{(S)} = \frac{E/L + SI}{S^2 + S\frac{R_T}{L} + \frac{1}{LC}};\quad e = \frac{E}{S} - \frac{S\,V_{0_L} - \xi}{S^2 + \frac{R_T}{L}S + \frac{1}{LC}}$

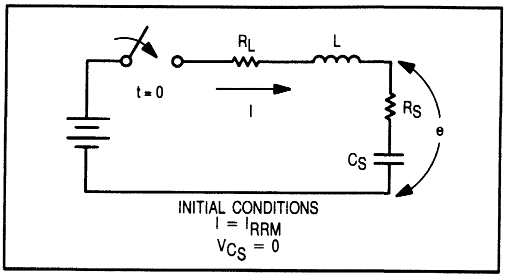


Figure 42. Equivalent Circuit for Load and Snubber

The inverse laplace transform for each of the conditions gives:

UNDERDAMPED (Typical Snubber Design)

4.0 $e = E - V_{0_L}\left[\cos(\omega t) - \frac{\alpha}{\omega}\sin(\omega t)\right]e^{-\alpha t} + \frac{\xi}{\omega}\sin(\omega t)\,e^{-\alpha t}$

4.1 $\frac{de}{dt} = V_{0_L}\left[2\alpha\cos(\omega t) + \frac{(\omega^2 - \alpha^2)}{\omega}\sin(\omega t)\right]e^{-\alpha t} + \xi\left[\cos(\omega t) - \frac{\alpha}{\omega}\sin(\omega t)\right]e^{-\alpha t}$

4.2 $t_{PK} = \frac{1}{\omega}\tan^{-1}\left[-\frac{2\alpha\,V_{0_L} + \xi}{V_{0_L}\left(\frac{\omega^2 - \alpha^2}{\omega}\right) - \frac{\xi\alpha}{\omega}}\right]$

When M = 0, $R_S = 0$, I = 0 : $\omega\,t_{PK} = \pi$

4.3 $V_{PK} = E + \frac{\alpha}{\omega_0} - \alpha\,t_{PK}\sqrt{\omega_0^2\,V_{0_L}^{\,2} + 2\alpha\xi\,V_{0_L} + \xi^2}$

When I = 0, $R_L = 0$, M = 1:

4.4 $\frac{V_{PK}}{E} = (1 + e^{-\alpha\,t_{PK}})$

Average $\frac{dV}{dt} = \frac{V_{PK}}{t_{PK}}$

4.5 $t_{max} = \frac{1}{\omega} ATN \left[\frac{\omega (2\alpha\xi - V_{0L} (\omega^2 - 3\alpha^2))}{V_{0L}(\alpha^3 - 3\alpha\omega^2) + \xi(\alpha^2 - \omega^2)} \right]$

4.6 $\left(\frac{dV}{dt}\right)_{max} = \sqrt{V_{0L}^{2}\ \omega_0^2 + 2\alpha\xi\ V_{0L} + \xi^2}\ e^{-\alpha t_{max}}$

NO DAMPING

5.0 $e = E\ (1 - Cos\ (\omega_0 t)) + \frac{I}{C\ \omega_0} \sin\ (\omega_0 t)$

5.1 $\frac{de}{dt} = E\ \omega_0 \sin\ (\omega_0 t) + \frac{I}{C} Cos\ (\omega_0 t)$

5.2 $\left(\frac{dV}{dt}\right)_0 = \frac{I}{C} = 0$ when $I = 0$

5.3 $t_{PK} = \frac{\pi - \tan^{-1}\left(\frac{I}{CE\ \omega_0}\right)}{\omega_0}$

5.4 $V_{PK} = E + \sqrt{E^2 + \frac{I^2}{\omega_0^2 C^2}}$

5.5 $\left(\frac{dV}{dt}\right)_{AVG} = \frac{V_{PK}}{t_{PK}}$

5.6 $t_{max} = \frac{1}{\omega_0}\left[\tan^{-1}\left(\frac{\omega_0\ EC}{I}\right)\right] = \frac{1}{\omega_0}\ \frac{\pi}{2}$ when $I = 0$

5.7 $\left(\frac{dV}{dt}\right)_{max} = \frac{I}{C}\ \sqrt{E^2\omega_0^2\ C^2 + I^2} = \omega_0 E$ when $I = 0$

CRITICAL DAMPING

6.0 $e = E - V_{0L}(1 - \alpha t)e^{-\alpha t} + \xi t e^{-\alpha t}$

6.1 $\frac{de}{dt} = \left[\alpha\ V_{0L}\ (2 - \alpha t) + \xi(1 - \alpha t)\right]e^{-\alpha t}$

6.2 $t_{PK} = \frac{2 + \frac{\xi}{2\ V_{0L}}}{\alpha + \frac{\xi}{V_{0L}}}$

6.3 $V_{PK} = E - \left[V_{0L}\ (1-\alpha\ t_{PK}) - \xi\ t_{PK}\right]e^{-\alpha\ t_{PK}}$

6.4 Average $\frac{dV}{dt} = \frac{V_{PK}}{t_{PK}}$

When $I = 0, R_S = 0, M = 0$

e(t) rises asymptotically to E. t_{PK} and average $\frac{dV}{dt}$ do not exist.

6.5 $t_{max} = \frac{3\alpha V_{0L} + 2\xi}{\alpha^2 V_{0L} + \alpha\xi}$

When $I = 0$, $t_{max} = 0$

For $\frac{R_S}{R_T} \geq 3/4$,

then $\frac{dV}{dt}_{max} = \left(\frac{dV}{dt}\right)_0$

6.6 $\left(\frac{dV}{dt}\right)_{max}$

$= \left[\alpha\ V_{0L}\ (2-\alpha\ t_{max}) + \xi\ (1-\alpha\ t_{max})\right]e^{-\alpha\ t_{max}}$

APPENDIX E
SNUBBER DISCHARGE $\frac{dI}{dt}$ DERIVATIONS

OVERDAMPED

1.0 $i = \frac{V_{CS}}{\omega\ L_S}\alpha^{-\alpha t} \sinh\ (\omega t)$

1.1 $i_{PK} = V_{CS}\sqrt{\frac{C_S}{L_S}}\quad e^{-\alpha\ t_{PK}}$

1.2 $t_{PK} = \frac{1}{\omega}\tanh^{-1}\left[\frac{\omega}{\alpha}\right]$

CRITICAL DAMPED

2.0 $i = \frac{V_{CS}}{L_S}\ te^{-\alpha t}$

2.1 $i_{PK} = 0.736\frac{V_{CS}}{R_S}$

2.2 $t_{PK} = \frac{1}{\alpha}$

UNDERDAMPED

3.0 $i = \frac{V_{CS}}{\omega\ L_S}\ e^{-\alpha t} \sin\ (\omega t)$

3.1 $i_{PK} = V_{CS}\sqrt{\frac{C_S}{L_S}}\ e^{-\alpha\ t_{PK}}$

3.2 $t_{PK} = \frac{1}{\omega}\tan^{-1}\left(\frac{\omega}{\alpha}\right)$

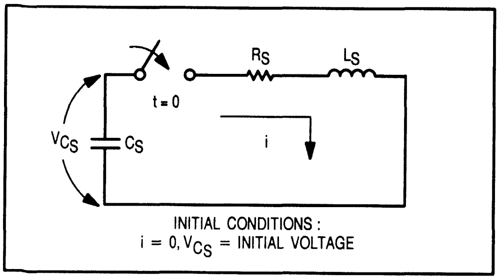


Figure 43. Equivalent Circuit for Snubber Discharge

NO DAMPING

4.0 $i = \frac{V_{CS}}{\omega L_S} \sin(\omega t)$

4.1 $i_{PK} = V_{CS} \sqrt{\frac{C_S}{L_S}}$

4.2 $t_{PK} = \frac{\pi}{2\omega}$

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AN1511

Applications of the MOC2A40 and MOC2A60 Series POWER OPTO™ ISOLATORS

Prepared by: Horst Gempe
Discrete Applications Engineering

INTRODUCTION

Electronic controls of AC power loads based on micro–processor controllers, digital or linear sensor circuits are increasing in popularity. Consequently, there is an increasing need for a simple and robust interface between the low voltage control circuitry and the AC line and loads. This interface must galvanically isolate the AC power line and its superimposed transients from the noise sensitive, low–voltage dc control circuits. It also must be simple to use, regulatory approved, consume little PC board space and be able to switch the most common loads such as small motors, power relays, incandescent lights and resistive loads without generating excessive heat.

The MOC2A40 and MOC2A60 POWER OPTO Isolator families meet all the above requirements and offer an ideal system solution.

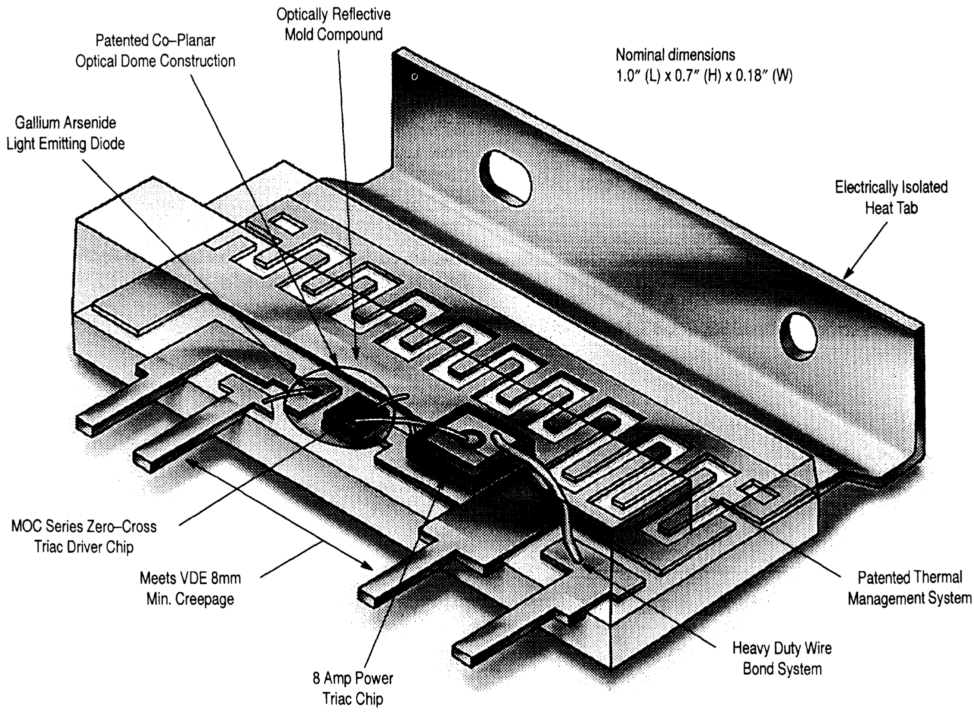

Figure 1. Internal Construction of the POWER OPTO Isolator

PRODUCT DESCRIPTION

The Motorola AC POWER OPTO Isolator is a hybrid device containing three individual active semiconductor chips. Figure 1 shows the internal structure of this device. An infrared light emitting diode on the input side converts the input current signal of several milliamps into an infrared radiation of 940 nm. This is transferred through a transparent isolation barrier onto the photo sensitive area of an AC compatible detector which controls the gate of a power triac. This creates galvanic isolation between the dc input control circuit and the output AC line voltage potential. The light sensitive detector contains a AC zero voltage detector which allows turn on of the detector chip by the LED only when the AC line voltage is below the specified inhibit voltage of ±10 V. This feature guarantees turn on of the load close to the AC line zero cross point and prevents excessive inrush surge currents for most loads. High inrush currents are still experienced for loads such as motor startup and inductors which saturate at turn–on. For this reason, a guaranteed inrush surge current capability of 60 A is provided. This extremely high surge capability can be attributed to the rugged 120 x 120 mil power triac chip which is mounted on a large internal copper heat spreader. A patented interdigitated interface between the internal heat spreader and the devices integral heat tab provides optimized heat transfer and meets the regulatory requirements for safe (reinforced) isolation. This regulatory requirement mandates an external 8.0 mm creepage and clearance between the input and output leads and the isolated heat tab of the device. A 0.4 mm thick isolation barrier which must be able to withstand a surge voltage of 3750 V_{rms} is also mandated. The isolation barrier between dc input and the AC output leads is formed by the silicone optical dome. The isolation barrier for the integral heat sink is formed by the package epoxy which isolates the interlaced internal heat spreader from the external heat tab. A heavy duty 15 mil aluminum wire bond on the output side of the power triac ensures high surge capability.

Equivalent Electrical Circuit Diagram

Figure 2 shows in detail the internal circuitry of the MOC2A40 and MOC2A60 POWER OPTO Isolator families. Details of the of the triac driver ICs internal circuitry is shown and discussed to explain the theory of operation for these devices.

LED D1 emits light which is received by the detector light sensitive integrated circuit which is commonly named triac driver. PNP transistor, Q1, and light sensitive NPN transistor, Q2, form a light sensitive SCR with a gate resistor R1. Diode, D2, and FET, Q3, form the inhibiting network. The leakage current of D2 transfers the main terminal voltage to the FET gate and Zener diode, D3, clamps this voltage to about 15 V to prevent gate oxide breakdown when the main terminal voltage rises with the line voltage. A voltage on the main terminals above the gate threshold voltage of Q3 switches FET Q3 on, which shorts the photo sensitive gate and inhibits it to latch on. Q1', Q2', Q3', R1', D2', D3' form the same circuit as described above.

The two circuits are connected inverse parallel and may be described as two inverse parallel light sensitive photo SCRs with zero cross voltage detectors. This circuit can be further simplified and described as an optically controlled small signal triac with an AC zero cross detection circuit. The triac driver controls the gate of the main triac. Resistor R2 limits the current through the triac driver.

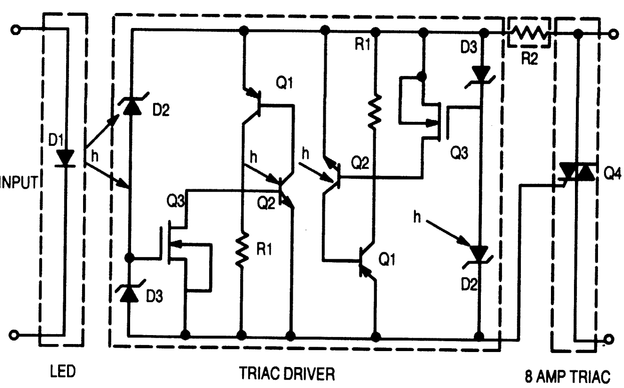

Figure 2. 2 Amp Optocoupler Circuit

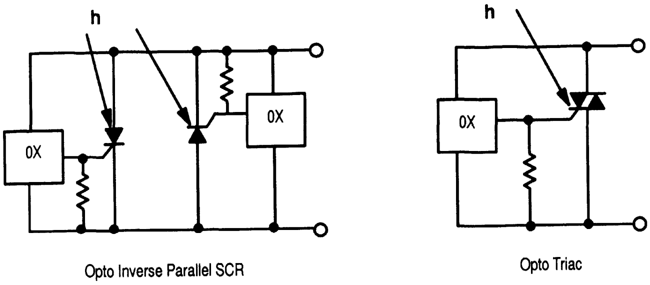

Figure 3. Triac Driver Simplified Circuits

OPERATION

An LED current of several mA will generate a photo current of several tens of micro amps in the collector base junctions of the NPN transistors of the triac driver chip. The SCR formed by the NPN–PNP transistor combination latches on when the photo generated current is present and the line voltage is below the inhibit voltage window, or in other words, within the zero cross window. Once the triac driver is latched on it allows sufficient current flow to the gate of the main triac which in turn latches on and carries the load current.

If the LED is turned on at a time when the line voltage exceeds the inhibit voltage, the driver is effectively disabled and will wait to latch on until the line voltage falls below the inhibit voltage. The driver and triac, however, are not able to switch on at absolute zero line voltage because they need a minimum voltage and current to be able to latch on. For example, if the LED is switched on when the line voltage is zero, the LED flux generates a photo current in the detector of several tens of micro amps, but the triac driver is not able to latch on until the line voltage rises to the driver's minimum main terminal voltage of about 1.0 V and a latching current of several 100 μA is present. A further increase in line voltage is necessary to trigger the main triac because its minimum gate voltage requirement in respect to MT1 voltage is also about 1.0 V and has to be added to the voltage drop across the triac driver. The main triac is able to turn on when at least 2.0 V are across its main terminals and enough gate current is generated to meet the triacs gate trigger current requirement. This is the earliest possible turn–on point within the zero–cross window. Conversely, the maximum inhibit voltage represents the last possible opportunity to turn on within the zero–cross window.

When the main triac is triggered, the voltage across its main terminals collapses to about 1.0 V. Figure 4 shows the zero voltage turn–on characteristic of a POWER OPTO Isolator as observed with an oscilloscope by monitoring the voltage across the main terminals of the device. Figure 5 shows a curve tracer plot which gives information about the voltage and current characteristic.

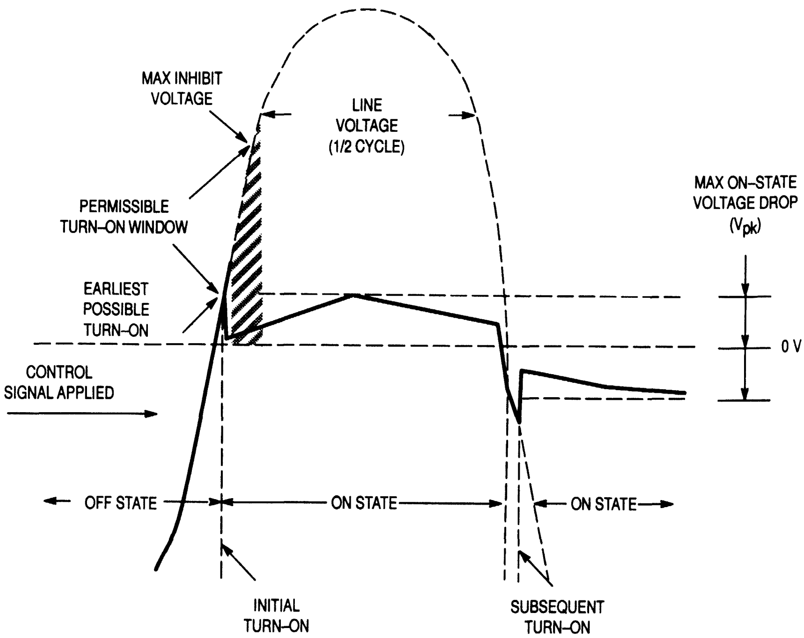

Figure 4. Zero–Voltage Turn–On Voltage Characteristics

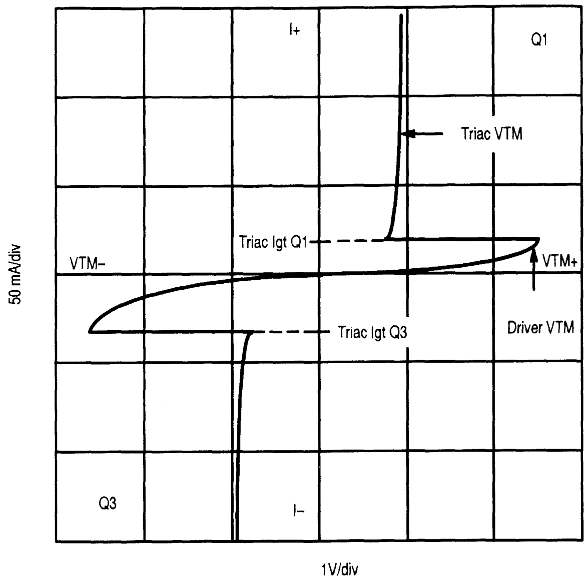

Figure 5. Curve Tracer Voltage versus Current Plot

After the power triac is turned on, the triac driver conducts only several hundred micro amps when the LED is still on but switches off and stays off when the LED current is removed. The main triac remains latched on until the load current falls below the triacs holding current. After this transition point, the driver will exclusively conduct the load current until the current falls below several 100 micro amps. At this point only the photo generated current of several tens of micro amps remains. Triac driver and main triac are switched off and are retriggered every half cycle until the LED is turned off. As the LED is switched off the triac driver is switched off, and the main triac falls out of conduction when the load current falls below the main triac's holding current (typically 20 mA).

The fact that the triac driver has an extremely low holding current allows the minimum load currents to be below the main triac trigger and holding current. In this triac driver only mode, the main triac never conducts and the load is only carried by the triac driver. In this low current triac driver only mode, commutating dv/dt is no longer a function of the main triac commutating capability, but is dependent on the triac drivers commutating dv/dt capability. This is only about 0.5 V/µs and should be considered marginal. Therefore, the use of a snubber is absolutely mandatory when switching loads in triac driver only mode is anticipated.

APPLICATIONS

Snubber Requirements

The application of the 2 amp POWER OPTO Isolators is very simple. Most loads ranging from 30 mA up to 2 A rms, including complex loads as discussed below, may be controlled without the use of a snubber network. Snubbers are required when the static and commutating dv/dt either generated by the load switched by the POWER OPTO Isolators or generated elsewhere on the AC line exceed the device's dv/dt ratings. In industrial environments where large inductive loads are switched on and off by contactors, transients may be generated which surpass the devices static dv/dt rating or the maximum V_{DRM} rating. For these cases a snubber consisting of a resistor and a capacitor will attenuate the rate of rise of the transient. A voltage clipping device (Metal Oxide Varistor MOV) which limits the amplitude of the transients should be used when the amplitude of the transients exceed the devices V_{DRM} ratings. Snubber and transient suppressors are connected across the main terminals of the POWER OPTO Isolator as shown in Figure 6.

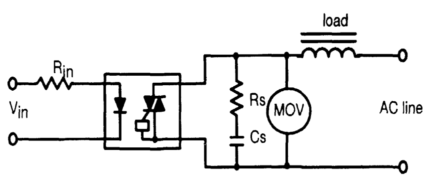

Figure 6. Application with Snubber and MOV

Typical values for the snubber capacitor C's and snubber resistor R's are 0.01 µF and 39 Ω respectively. These values may be adjusted for specific applications. See Application Note AN1048 for detailed information about snubber design considerations.

The placement of the load has no influence on the opto–coupler's performance. It may be switched from the line neutral to the phase (hot) side or from the phase to neutral.

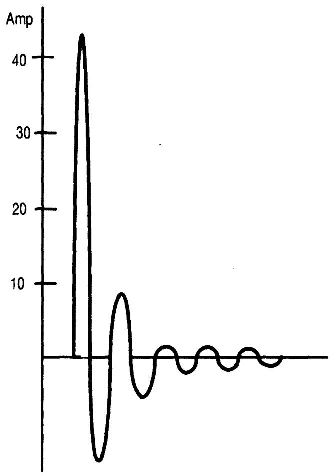

Figure 7. Size No. 4 Contactor Inrush Current

Input Current Requirement

It is very important to supply the data sheet specified input current to the device. Less input current may prevent turn–on of either both light sensitive SCRs or worse, be able to turn on only one SCR due to slight differences in I_{FT} for the positive and negative AC half wave. This situation causes half–waving of the load. Most inductive loads draw excessive current under this condition which may destroy either the load or the opto-coupler. Low temperature operation requires increased input LED current as shown on the data sheet's I_{FT} vs. Temperature graph .

For example:

The I_{FT} for a MOC2A40–10 at 25°C is 10 mA, but is at –40°C 15,5 mA (I_{FT} @ 25°C*factor 1.55 as shown on the graph).

This minimum control current requirement dictates the value of the input current limiting resistor R_{in} for a given input voltage.

$$R_{in(max)} = \frac{V_{in} - V_{F(LED)}}{I_{FT(on)}}$$

$$R_{in(min)} = \frac{V_{in} - V_{FL(LED)}}{I_{Fmax}}$$

V_{in} = Input Voltage

$V_{F(LED)}$ = voltage drop across LED = 1.3 V

$I_{FT(on)}$ = specified LED trigger current*factor for low temperature operation

$I_{F(max)}$ = maximum continues LED forward current (50mA)

Complex Loads

Surge Currents In Inductive Loads

Inductive loads may cause very high inrush surge currents because their magnetic core is forced into saturation as observed with transformers or the inductance is low at the initial startup which is typical for relays, solenoids and motors.

Example 1: Size No. 4 Contactor Control

The MOC2A40 has demonstrated its ability to handle large inrush currents by driving a size No. 4 contactor out to 2 million cycles without failure. The device is cycled one second on and one second off. The 115 V_{rms} input coil generates a 50 A peak in the first half cycle, and 20 A peak in the second half cycle as shown in Figure 7. The RMS steady state current is below 1 A. A MOC2A40 in free air is able to control this load without additional heat sinking and without the use of a snubber.

Two million device cycles without failure represent a reliability of M.T.B.F of >19.8 million device cycles.

Example 2: Transformer Inrush Current

It is mandatory in this application to make certain that the inrush current does not exceed the maximum 60 A specified surge current of the device. Residual core magnetization combined with zero cross turn–on may force the transformer into saturation with only the winding resistance left as effective load current limitation. For example, a 150 VA transformer with a 1.5 Ω winding resistance may draw in the first half–cycle up to 80 A of surge current. This excessive surge current can be avoided by using a NTC thermistor in series with the load as shown in Figure 8. A negative temperature coefficient thermistor has a relative high initial resistance when cold, which fast becomes lower due to self–heating in the steady–state operation.

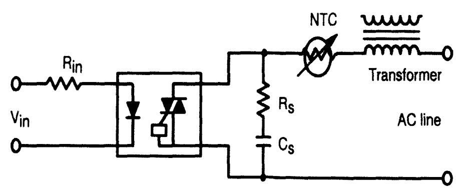

Figure 8. Thermistor Limits Excessive Inrush Current

Example 3: Surge Currents in Capacitive Loads

A rectifier bridge or a single diode in combination with a large capacitor in the micro Farad range represent a very low impedance at startup when the capacitor is being charged. When this type of load is switched on at the peak of the line voltage, the inrush peak current is only limited by the wiring resistance and the ESR of the capacitor. However, the maximum inrush current Ip at zero voltage turn–on is limited by the AC line frequency and the peak line voltage and can be calculated as Ip= C 2π f Vp, where C is the capacitance in Farad, f the line frequency in Hertz and Vp the peak line voltage. For an AC line voltage of 120 V_{rms} 60 Hz and a capacitor of 100 μF, the surge current Ip is 6.4 A.

The above calculation for Ip applies to absolute zero voltage turn–on. Turn–on within the zero cross window voltage range of the POWER OPTO Isolators generates considerable higher inrush currents. A 100 μF capacitor switched on at 5.0 V already produced an inrush current of 25 A. Accidental turn–on of the device at the peak of the line voltage charging a 100 μF capacitor without current limitation leads to certain destruction of the power triac. Turn on outside the zero–cross window may be caused by line transients exceeding the devices VTM or dv/dt ratings. A inrush current limiting resistor or NTC Thermistor connected in series to the AC side of the rectifier and the POWER OPTO Isolators output can prevent this potential problem.

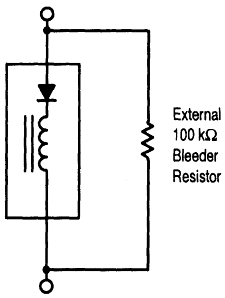

Figure 9. AC–DC Solenoid with Integral Diode

Example 4: AC–DC Solenoid with Internal Rectifier Diode

Some AC–DC relays and solenoids are made ac–dc compatible by using an internal rectifier diode in series with the coil. This poses a problem to a zero–crossing switch because the rectifier diode allows a dc build up across the input terminals. This DC forces the zero–cross switch into the inhibit mode which prevents the load from being switched on. A 100 K bleeder resistor across the input terminals of this type of load prevents dc build up thus allowing proper control. The wattage rating of this resistor is

$$P = \frac{Vms^2}{R}$$ where P = 1/2 W for 220 V_{rms} and 1/4 W for 115 V_{rms}

Example 5: Controlling an Inductive Load in a Rectifier Bridge

This configuration may cause triac switch off difficulties when the L/R time constant of the inductor to be switched is longer than 1/2 cycle of the line AC. In this case, the load current is not sinusoidal but constant, which causes the current to be switched off rapidly as the line voltage changes polarity. The resulting high commutating di/dt may prevent the triac from turning off. The effect of this commutating dv/dt can be minimized by using a snubber across the device in combination with a commutating softening inductor Ls as shown in Figure 10. Ls is a small high permeability "square loop" inductor which can be constructed by using a ferrite torroid of 3/4″ outside diameter with 33 turns of a number 18 gauge wire. Its core saturates when the load current is high but adds a high inductance when the load current falls below the holding current of the triac. This arrangement slows the rapid di/dt and delays the reapplication of the line voltage which improves the dv/dt capability of the triac.

Thermal Management

To insure proper and reliable operation of the isolated 2 A power switch, it is mandatory to operate the junction of the power triac within or below the maximum specified junction temperature. Temperatures above 125°C may lead to a possible loss of control (permanent latch on) and shortened life of the semiconductors. Junction over temperature problems can be avoided in the application when the devices thermal ratings are properly observed.

Free Standing Power Rating

The 2 Amp POWER OPTO Isolator device families are designed to be able to switch 2 A of AC rms and dissipate 2 W at an ambient free air temperature of up to 40°C without any additional heat sink. The single device rating only applies when free air circulation around the device – i.e., natural air convection is allowed. There are major differences in effective air convection and the resulting temperature drop between the junction–to–air, depending on the amount and position of the devices on the PC board, and the PC board itself in respect to the natural air flow. Other power dissipating devices in close vicinity of the power switch will raise the ambient temperature which means less power can be dissipated by the switch. This also holds true for enclosures which inhibit or restrict the free air flow around the power switch and result in an increased ambient temperature. The maximum allowed power dissipation versus the increase of ambient temperature is shown in Figure 11. A horizontally positioned PC board with the device in its center will restrict natural air convection, while a vertical positioned PC board with the device positioned along the vertical axis will result in an optimized air convection. Free air flow around the epoxy body of the device and its heat sink creates a thermal air convection that cools the power semiconductor junction. Pin 7 conducts some of the generated heat to the PC board because it is part of the internal power semiconductor heat spreader. This heat transfer can be enhanced when one allows a large metalized area on the PC board at the vicinity of this pin for increased heat spreading.

Thermal Resistances of the Device

The heat of the power semiconductor junction is conducted to the internal heat spreader where it is then distributed to the epoxy body and the integral and electrically isolated heat tab of the device. Some of the heat in the heat spreader is transferred to the printed circuit board through main terminal pin 7. The epoxy body, integral heat sink and the PC board transfer this heat to the ambient air. Each heat path has its own thermal resistance. All these thermal resistances are in parallel and grouped together in the device's thermal rating of $R_{\theta JA}$ which is 40°C/W for a free–standing, single device mounted on a PC board.

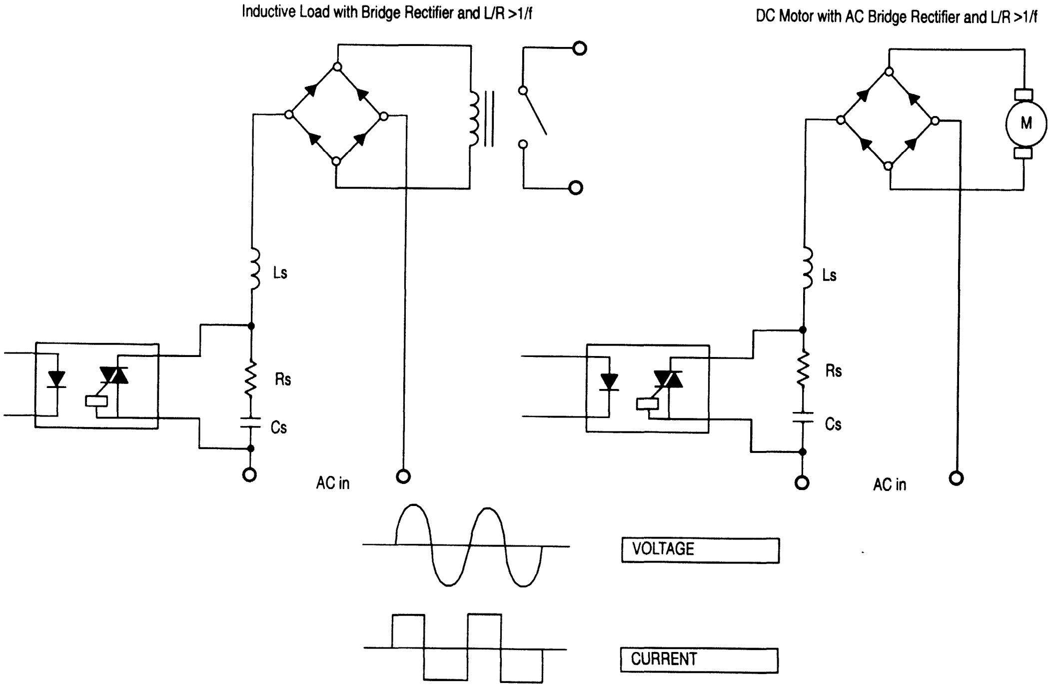

Figure 10. Inductive Loads with Bridge Rectifier

Thermal resistances are as follows:

$R_{\theta JA}$ Thermal resistance from junction to ambient air = 40°C/W

$R_{\theta JC}$ Thermal resistance junction to case (epoxy body back side and heat tab) = 8°C/W

$R_{\theta JT}$ Thermal resistance junction to heat tab only ~14°C/W. (This is not specified in the data sheet)

$R_{\theta J}$ p7 Junction to pin 7 (thermocouple on pin 7) ~10°C/W (This is not specified in the data sheet).

$R_{\theta SA}$ Thermal resistance of additional heat sink to ambient.

The junction temperature for a free standing single device is calculated as follows:

$T_J = (VTM*Irms*R_{\theta JA}) + T_A$.

Power dissipation equals P = VTM*Irms which is approximately 1 W per Ampere RMS flowing through the main terminals of the device. For exact calculation use the data sheet VTM value for a given current.

The maximum power dissipation for a free standing device is

$$P_{(max)} = \frac{T_{J(max)} - T_A}{R_{\theta JA}}$$

For example, the maximum power dissipation for a free standing MOC2A40 at an ambient temperature of 70°C is

$$P_{(max)} = \frac{125°C - 70°C}{40°C/W} = 1.375 \text{ W or } I_{(max)} \text{ is } 1.37 \text{ A.}$$

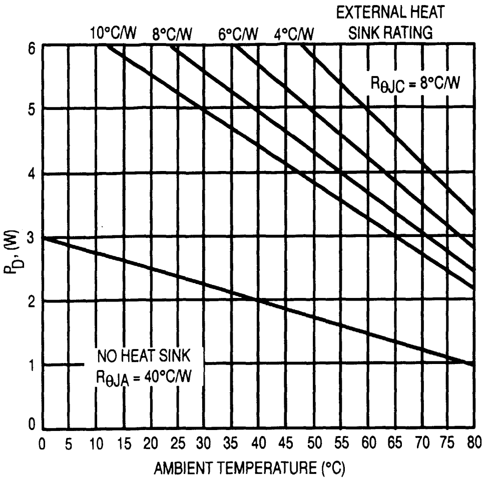

Figure 11. Power Derating versus Ambient Temperature

Material	Conductivity Watts in °C	Resistivity °C in/Watt
Air (100°C)	0.001	1,000
Aluminum	5.63	0.178
Alumina (Al Oxide)	0.55	1.82
Brass	2.97	0.337
Copper	9.93	0.101
Epoxy (Conductive)	0.02	50.0
Iron (Pure)	1.90	0.526
Nickel	1.52	0.658
Nickel Silver	0.84	1.19
Phosphor Bronze	1.80	0.555
Steel (1045)	1.27	0.787
Steel, Stainless (347)	0.41	2.44
Tin	1.60	0.625
Zinc	2.87	0.348

Figure 12. Thermal Resistance of Common Materials Used for Heat Sinking

Devices with Additional Heat Sink

All AC POWER OPTO Isolators contain an 8 A triac chip, but the maximum allowable switching current is limited by the heat dissipation of the package. Significant increase in switching current and the consequent power dissipation is possible by the use of an additional heat sink.

Since the integral sink and the epoxy body of these devices transfer heat, the best results are seen when the devices' entire back side is held in contact with the external heat sink, and thermal grease is used. This mounting method results in optimized heat conduction with the lowest practical possible thermal resistance of 8°C/W which is specified as $R_{\theta JC}$. This includes the thermal resistance of the interface between the device and the heat sink.

Connecting the heat tab only to the external heat sink results in an thermal resistance $R_{\theta JT}$ of 14°C/W which includes the thermal interface resistance between the integral heat sink to the external heat sink .

The external heat sink can be of an extruded type which is commercially available, a flat aluminum plate or simply a part of a sheet metal frame or housing to which the device is held by a steel spring clip. External heat sinks are characterized by $R_{\theta SA}$ which is the thermal resistance from the heat sink to the ambient air. The lower the rating of the heat sink in terms of °C/W the better its thermal efficiency is. Figure 12 shows the thermal resistance of common heat sink materials. This thermal resistance must be added to the optocouplers thermal resistance $R_{\theta JC}$ or $R_{\theta JT}$ where applicable.

There are no electrical safety considerations because the device's heat sink is electrically isolated and regulatory approved.

It is possible to calculate the devices junction temperature T_J as follows, $T_J = ((VTM*Irms*(R_{\theta JC} + R_{\theta CA})) + T_A$.

We are also able to calculate the maximum current and power dissipation allowed as follows,

$$P_{(max)} = \frac{T_{J(max)} - T_A}{R_{\theta JC} + R_{\theta CA}}$$

For example, a MOC2A40 device is mounted with its entire back side to a flat aluminum heat sink with a thermal rating $R_{\theta SA}$ of 5°C/W. Thermal grease is used on the interface and the ambient temperature is maximum 70°C.

$$P_{(max)} = \frac{125°C - 70°C}{8°C/W + 5°C/W} = 4.23\ W$$

The same external heat sink is used but only the device's heat tab is connected to aluminum heat sink which increases the thermal resistance from the semiconductor junction to the external heat sink. Note the considerable loss of power handling capability.

$$P_{(max)} = \frac{125°C - 70°C}{14°C/W + 5°C/W} = 2.89\ W$$

Figure 11 shows the maximum allowed power dissipation for a single free standing device without heat sink and for devices with various external heat sinks versus the ambient temperature.

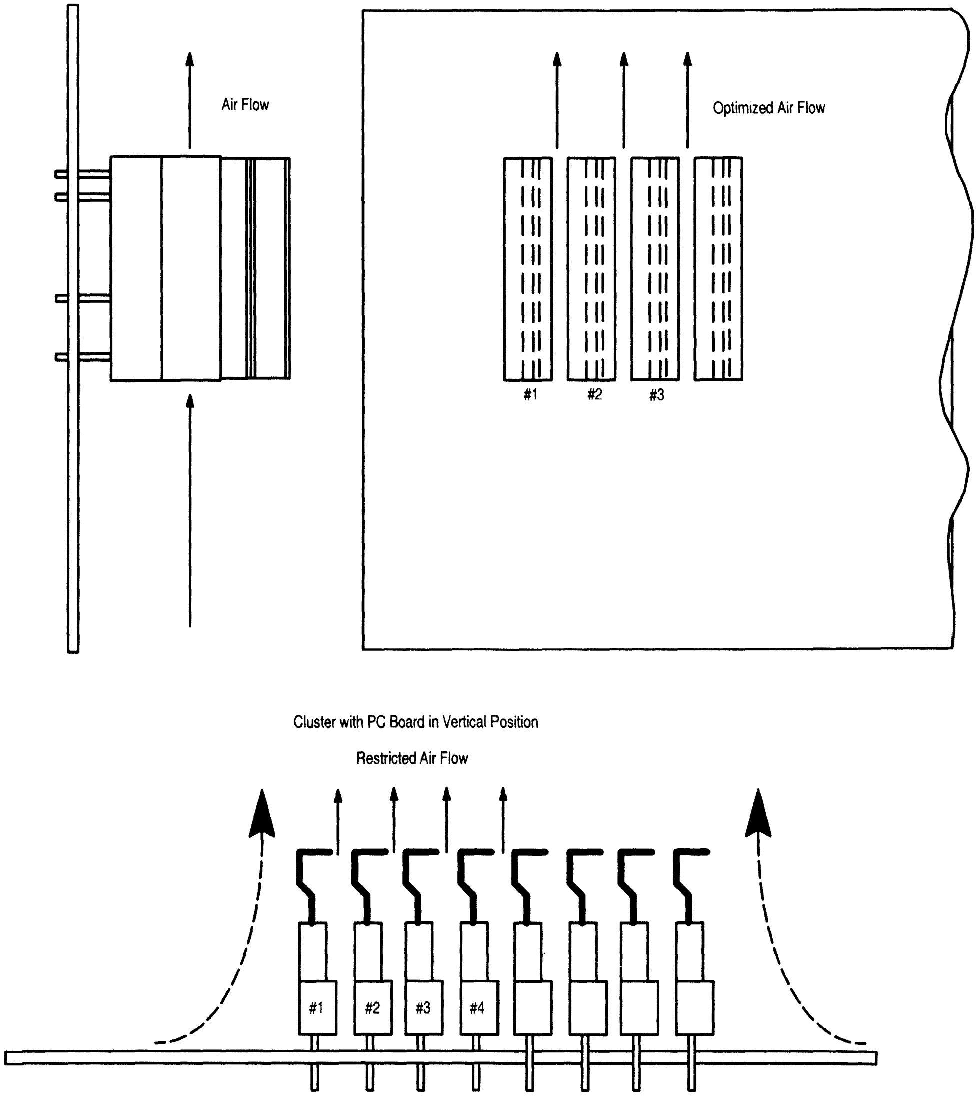

Figure 13. Clusters of Devices on a PC Board

Devices Stacked in Clusters with Minimal Spacing of 200 Mils

One of the great advantages of the 2 A optocoupler family is its small footprint on a PC board. This enables the user to cluster many devices in one row with only 200 mil spacing from lead to lead as shown in Figure 13. Devices in this close approximation influence each other thermally by heat transfer through the epoxy bodies, the integral heat sinks and by heat conduction through pin 7 to the PC board. Prudence would suggests that clustered devices are running much hotter than a single free standing device and the maximum power handling must be derated when all devices within this cluster are switched on. It can be also predicted that devices in the center of the cluster run much hotter than the devices at each end. This also means the individual devices within the cluster are not able to dissipate the full rated power but must be thermally derated. The following study with clusters show the impact of this derating. Of course, the position of this cluster in respect to the natural air convection is also very important. Clusters on a horizontal positioned circuit board run much hotter than devices on a vertical oriented circuit board. Vertical orientation of the devices and the circuit board allow optimized heat flow due to the "chimney" effect. Figure 14 shows the heat distribution for each individual device in a cluster of 10 devices for vertical and horizontal circuit board positions. All devices are conducting 1 A of current which is about 1 W of power dissipation. As predicted, the devices in the center of the cluster show the highest temperature, while the devices at the end run cooler but are still much hotter than the stand alone rating would predict. The graph also demonstrates the importance of free air flow versus restricted air flow caused by a horizontal positioned PC board. It is important to note that the junction temperature of the center devices on the vertical positioned board exceeds the maximum rating of 125°C with a input power of only 1 watt! The dissipated power for these devices has to be lowered in order to stay within their maximum junction temperature rating.

It is now of interest to know the maximum power dissipation allowed for devices in various sized clusters or the maximum power allowed for devices within a large cluster versus the amount of devices switched on at the same time. The graph in Figure 15 is taken from a cluster of 25 devices where the X axis shows the number of units which are turned on with the same power dissipation and the Y axis shows the resulting maximum allowed power dissipation for each unit. The power is first applied to device#1 then to device#1 and device #2 then to device#1 and 2 and 3, and so on. The junction temperature of the hottest unit in the cluster (which is always in the center of the units turned on within the cluster) is the limiting factor. It is also interesting to note that the power derating is not a linear function of the cluster size but asymptotically levels out to a steady value for cluster sizes exceeding 20 devices.

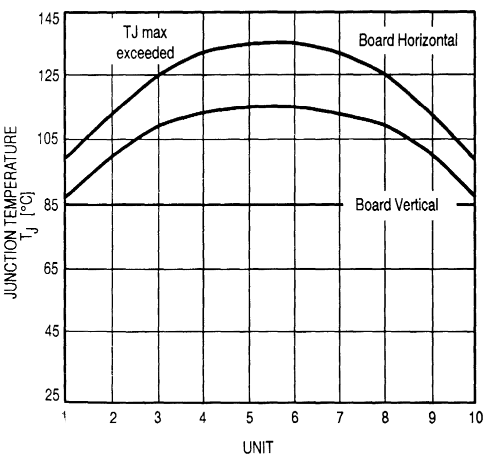

Figure 14. Cluster T_J Junction Temperature Distribution in a Cluster of 10 T_A = 25°C, All Devices on with I = 1 Arms

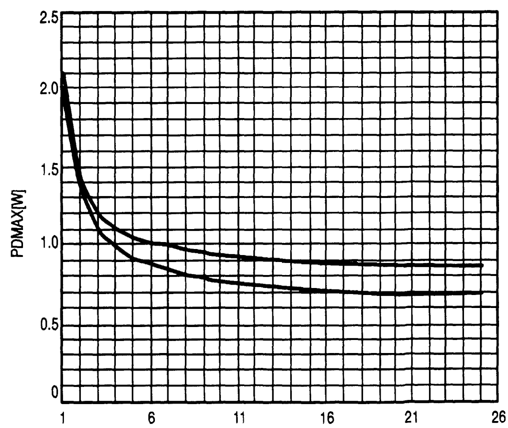

Figure 15. Maximum Allowed Power Dissipation per Device versus Cluster Size

AN1515

Optically Isolated Phase Controlling Circuit Solution

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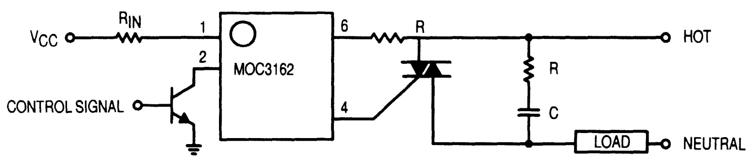
INTRODUCTION

Optocouplers simplify logic isolation from the ac line, power supply transformations, and the control of polyphase power systems. They help solve problems by kunidueeping ac line noise and transients out of sensitive logic. Motorola's 6–Pin Dip Optocoupler family, with high surge voltage capability (7500 volts peak ac, 60 HZ, 1 second duration), allows designers to achieve their goals. This paper presents a power triac phase control circuit and contrasts it with the traditional zero–crossing circuit. The example circuit isolates the low level control circuitry from the ac line. It is able to control the speed of a universal motor or brilliance of a lamp. The universal motor is capable of high starting torque and wide speed range — commonly used in mixers, blenders, floor polishers, electric hand and woodworking tools, etc.

ZERO–CROSSING AND RANDOM PHASE TRIAC DRIVERS

The zero–crossing triac driver optocouplers are the MOC3162/3 and MOC3081/2/3 series. The random phase optocouplers are the MOC3012, MOC3023 and MOC3051/2 series. All families have the same type of gallium arsenide infrared light–emitting diode but optically couple to different monolithic silicon detector chips. The zero–cross family is designed for interface applications between control circuit and power loads. The advantage of using zero–crossing switching is less surge current and resulting electromagnetic interference (EMI). This reduces reliability problems in many applications such as solid–state relay, industrial controls, motors, solenoids and consumer appliances. The high–speed zero–crossing switch provides a minimum dv/dt from 500 V/µs to 2000 V/µs, protecting the device from accidental triggering by ac power line transients.

The circuit in Figure 1 is the basic circuit for on–off power control. With a continuous forward current through the LED, the detector of the zero–crossing optocoupler switches to the conducting state only when the applied ac voltage passes through a point near zero. Phase control applications, such as controlling the speed of a motor or brilliance of a lamp, require triggering at points along the ac voltage wave. This necessitates a random phase triac driver optocoupler.



DESIGN RULE: V_{peak} / I_{peak} = 180 /1 amp = 180 ohms
(Assume the line voltage is 115 volts RMS)

Figure 1. Zero–Cross Switching Using MOC3061

PHASE CONTROLLING A POWER TRIAC USING MOC3023

Design Objective

The following application circuit is an example of phase controlling a power triac. The random phase triac driver is Motorola's MOC3023. It has an LED trigger current I_{FT} of 5 mA and off–state output terminal voltage V_{DRM} of 400 V. The power triac used in this example is Motorola's MAC15–8. It has an on–state (RMS) current of 15 Amps at T_C = 80°C. The load is a 1/3 HP, single phase induction motor driving a fan with maximum speed of 1750 rpm. This circuit can be applied to different power triacs and loads with larger rating. The design objective is to phase control a power triac that drives a motor or a light dimmer powered from the 115 VAC line. This is accomplished by using a variable pulse width generated from an optically isolated logic system with a control voltage of 5 to 15 VDC.

System Block Diagram

The full wave zero–crossing sensor is connected to an optically isolated variable pulse width oscillator. The oscillator controls the conduction time of the optically isolated power triac, thus providing phase control to the load.

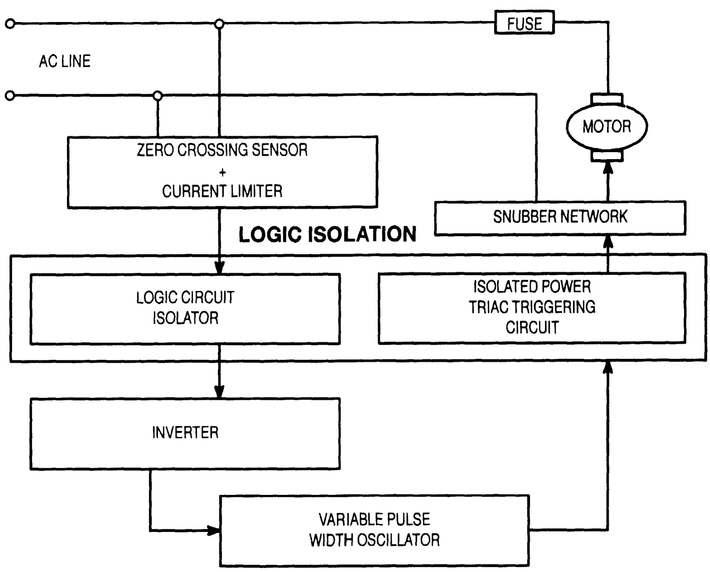


Figure 2. System Block Diagram

CIRCUIT DESCRIPTION

Full Wave AC to Logic Coupling

The circuit begins with the ac line input voltage. It is rectified by the 1N4001 diode bridge rectifier and connected to the gallium arsenide LED of the MOC5009 logic output optocoupler. A forward current (set between 10 and 50 mA) flows through the optocoupler LED, generating infrared radiation that triggers the high speed Schmitt trigger output stage into conduction. This occurs every half ac cycle, near the line zero crossing, at a constant input voltage defined by the zener diode.

Current Limiters

R1 is the limiting resistor for both the zener diode and the input LED of the optocoupler. R2 provides a small bias current to ensure the zener operates on the linear portion of its characteristic above the knee. It facilitates on–off switching of the LED by providing a path for leakage currents.

R1 = (VIN – VF) / IF where
VF = diode forward voltage
IF = diode forward current

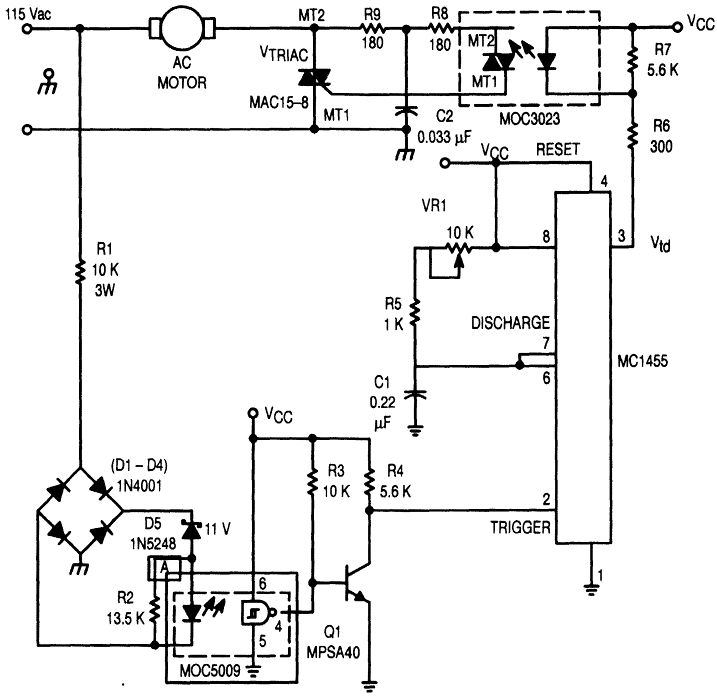


Figure 3. Schematic Diagram
Phase Controlling a Power Triac Using MOC3023

Optically Isolated Triggering of the Variable Pulse Width Oscillator

A dc signal with a pulse width of 720 µs is generated at the output detector of the MOC5009. The purpose of the MPSA40 NPN transistor is to generate an inverted signal, which goes into the trigger pin 2 of the MC1455 monolithic timing circuit. See Figure 4 for the input trigger pulse versus the line voltage.

The Variable Pulse Width Oscillator

At every falling edge of the input trigger signal, the MC1455 monolithic timing circuit generates a positive going pulse with duty cycle controlled by C1, VR1 and R5. The pulse duration is measured in time constants of $t = 1.1 * (VR1+R5) * C1$. See Figure 5 for the voltage across capacitor C1 versus the input trigger signal of the MC1455.

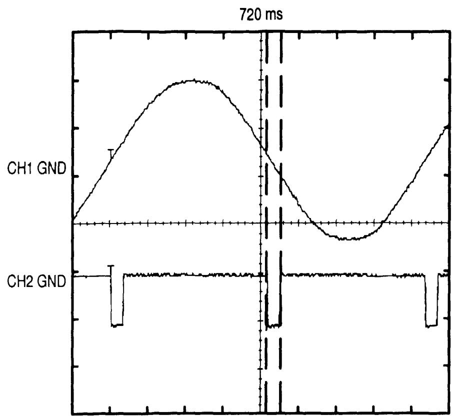
Isolated Triac Triggering

The output signal (V_{td}) from the oscillator goes to the MOC3023 triac driver LED. When sufficient LED current (I_{FT}) passes through the LED, the triac driver latches on and generates a gate current in the power triac, triggering it into the conducting state.

Once the power triac latches on, the triac driver will be forced into off–state even when I_{FT} is applied. The power triac MT2 to gate voltage falls to a low value below the optocoupler's threshold voltage and cannot hold the optocoupler on. See Figure 8 for voltage across the power triac terminals (V_{TRIAC}) versus power triac gate trigger signal (V_{td}).

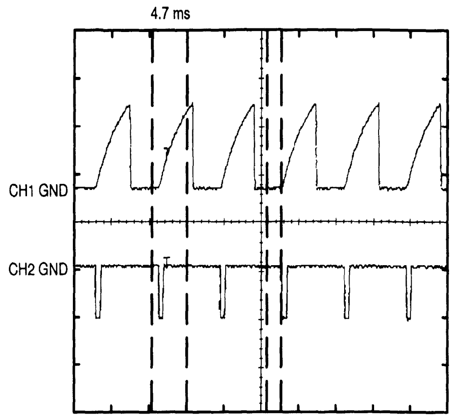
Minimum Load Power for Phase Control

The average power applied to the load is modulated by the duration of the waveform input to the triac driver. The longer the phase delay, the smaller the conduction angle and power delivered to the load. R5, VR1 and C1 set the minimum load power. This ensures power triac latching and optocoupler turn–off. This prevents optocoupler commutating dv/dt failure. The circuit in Figure 3 has a minimum conduction angle of 12 degrees. See Figure 9 for the voltage across the power triac terminals versus the input signal of the triac driver.



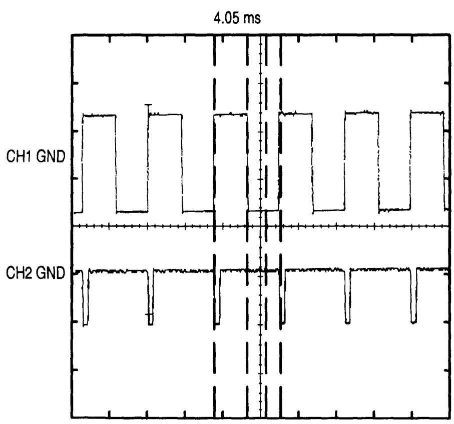
Time: 2 ms/div
CH1: Line voltage waveform (100 V/div)
CH2: Trigger signal measured at Pin 2 of the MC1455

Figure 4. Zero Cross AC to Logic Coupling



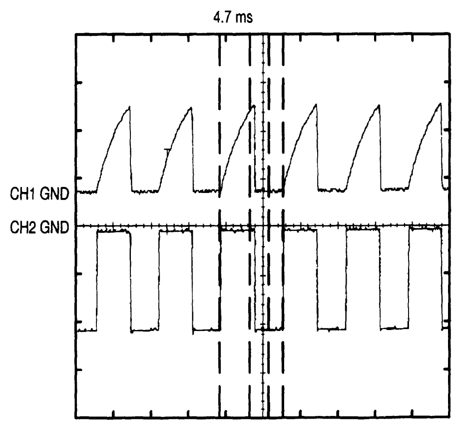
Time: 5 ms/div
CH1: Output voltage across C1 (2 V/div)
CH2: Input trigger pulse to MC1455 (5 V/div)

Figure 5. Capacitor C1 starts to charge up at the falling edge of the input trigger pulse with a time constant equal to 1.1*R5*C1



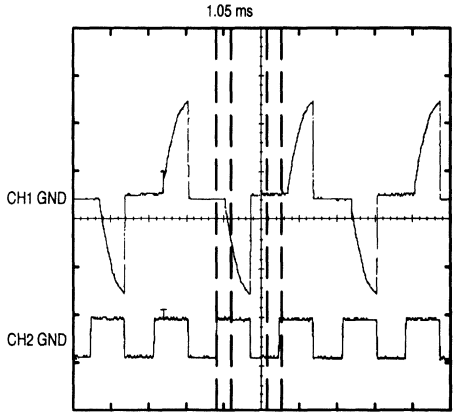
Time: 5 ms/div
CH1: Output signal measured at Pin 3 of the MC1455 (2 V/div)
CH2: Input trigger pulse to MC1455 (5 V/div)

Figure 6. Square Wave with Pulse Width of 4.2 ms Generated at Output Pin of the MC1455



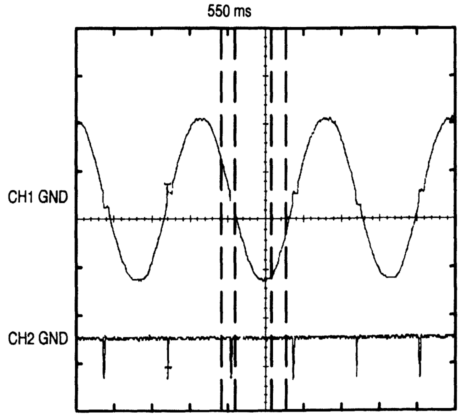
Time: 5 ms/div
CH1: C1 starts to discharge when voltage reaches 2/3 of the V_{CC} (2 V/div)
CH2: Power triac gate trigger signal (V_{td}) with pulse duration of 4.7 ms (2 V/div)

Figure 7. Capacitor Voltage versus Power Triac Gate Trigger Signal



Time: 5 ms/div
CH1: Voltage across the power triac terminals (V_{TRIAC}) (100 V/div)
CH2: Power triac gate trigger signal, V_{td} (5 V/div)

Figure 8. Power Triac



Time: 5 ms/div
CH1: Voltage across the power triac terminals (V_{TRIAC}) (100 V/div)
CH2: Power triac gate trigger, V_{td} (5 V/div)

Figure 9. Minimum Load Power

Snubber Network

The power triac can be switched on unintentionally if the rate of rise in applied voltage exceeds its dv/dt or the dv/dt of the triac driver. To prevent this false triggering, a single snubber limits the maximum dv/dt seen by the power triac and optocoupler. Snubber networks can be defined by assuming a power factor for the inductive load and modified later by measuring the actual dv/dt and adjusting the snubber as required. The snubber network used in Figure 3 results in a worst case dv/dt at the coupler of:

dv/dt $= V_{to} / (R9 * C2) = 180 / (180 * 0.033)$
$= 30.3$ V/ µs
V_{to} = instantaneous peak line voltage

The presence of load inductance (for example, when the load is a motor) results in significantly lower values of dv/dt. For details on designing the snubber network, refer to Motorola application note AN1048.

R8 limits the peak capacitor discharge current through the triac driver. Its minimum value calculates as:

$R8 = V_{pk} / I_{max} = 180 / 1.2$ A = 150 ohm (1/2 W)
V_{pk} – gate trigger required voltage
I_{max} – rated surge current of the optocoupler

The author selected 180 ohms for the limiting resistor.

CONCLUSION

This application note demonstrates the use of triac drivers and power triacs in an ac logic isolation phase control application. The circuit designs are easily accomplished with relatively few components.

ACKNOWLEDGMENTS

The author expresses her appreciation to Horst Gempe, George Templeton, John Salina, Andy Williams and Niraj Kohli for extensive constructive discussions on the device theory for optocouplers and power triac. The author also wishes to thank Sharon Mason for supporting the setup of the experiments.

AN1538

Water Level Control for Wells Using Small Surface Mount Devices

Prepared by: Pierre Mongrand
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The following circuit (Figure 1) has been designed to monitor liquid level control. It uses Motorola small–signal devices (surface mount) and a power optoisolator that can drive motors/solenoids until 2 amps rms.

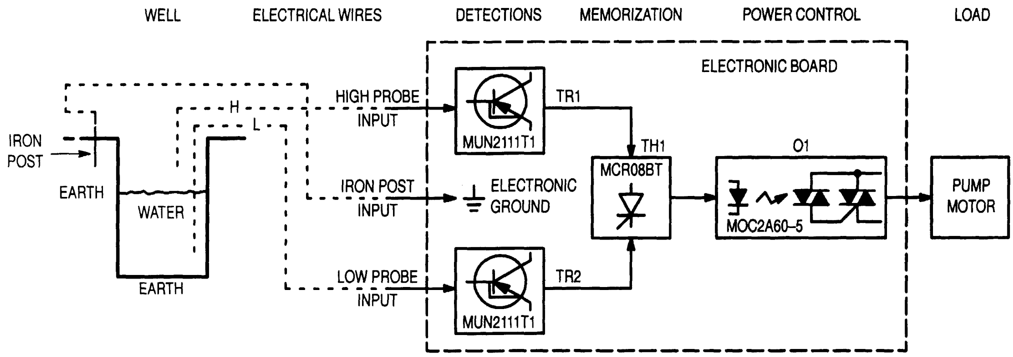


Figure 1. General Diagram Circuit

GENERAL CHARACTERISTICS

— Any electrical tuning of circuitry.

— Low power consumption (<15 mA at +8 Vdc).

— Hysteresis: Adjustable, depends on the vertical distance between electrical probes Min Max.

— Safety optical isolation between electronic detection (low voltage) and high voltage ac line motor pump.

COMPONENTS PRESENTATION

— **MUN2111T1** (Detections) TR1/TR2
This new series of digital transistors (SC–59 package) is designed to replace a single device and its external resistor bias network. The BRT eliminates these individual components by integrating them on the same die into a single device. The use of BRTs can reduce both system cost and board space.

— **MCR08BT** (Memorization) TH1
The MCR08BT1 series of SCRs (SOT–223 package) are sensitive gate devices, turning on with only 200 µA of gate current. It is a PNPN device designed for line–powered consumer applications.

— **MOC2A60–5** (Power) 01
This device is a Power Optoisolator and consists of a gallium arsenide infrared emitting diode optically coupled to a zero–cross triac driver circuit and a power triac. It is capable of driving a load of 2 A(rms) directly with a line voltages from 20 to 240 volts ac(rms). With additional heatsink, it can drive 4 A(rms).

DETAILED CIRCUIT DESCRIPTION

Electronic Board Detection

The two detection stages TR1(max) and TR2(min) are exactly the same. Without polarization on bases (+V supply), TR1, TR2 collectors are grounded. In the same way, when TR1, TR2 bases are grounded, devices TR1/TR2 turn on.

Levels Configurations

1. With bases TR1 and TR2 equal to V supply, the two PNP transistors turn off.
   TR1 collector voltage equals zero (ground), and therefore the SCR TH1 sees its gate trigger voltage at the same potential as the TR1 collector. TH1 is like an open switch.
2. TR2(min) base is grounded, but TR1(max) is always at V supply.
   TR2 turns on, TR1 and TH1 stay OFF. No current flows through the light–emitting diode D4 and the LED power optoisolator MOC2A60–5.
3. TR1 and TR2 bases are grounded. The devices turn on.
   TR1 collector voltage moves to $V_{CC}–V_{CE(sat)}$, and D3 turns on. TH1 turns on also (gate trigger voltage is around 0.7 volts). D4 turns on. MOC2A60–5 turns on.
4. TR2 base stays grounded, but TR1 base becomes at V supply.
   TR1 turns off, D3 turns off and prevents gate SCRs voltage from passing to zero. Without D3, TH1 is off. D4 and MOC2A60–5 stay on.
5. To stop the conduction of D4 and MOC2A60–5, it is necessary to put TR2 base to +V supply.

Here is a synthesis of well levels configurations:

Probe L	Probe H	TR1	TR2	TH1	D4/01
Open	Open	Off	Off	Off	Off
Earth	Open	Off	On	Off	Off
Earth	Earth	On	On	On	On
Earth	Open	Off	On	On	On
Open	Open	Off	Off	Off	Off

Output Power Stage

For safety reasons, it is important to prevent any direct contact between the ac main power and water environment of the well earth. To maintain full isolation between the detection circuitry and the main power, the solid state relay is placed between the low voltage circuit (detection/memorization) and the ac line used by the motor pump. TR2 (MUN2111T1) and TH1 (MCR08BT) are used to drive the LED of the MOC2A60–5. Resistor R4 limits the current into the opto–LED around 12 mA and guarantees a perfect drive of the solid state relay. D4 is an indicator light. It turns on when the load is under power.

The solid state relay MOC2A60–5 is an opto triac driving a power triac. This detection is a zero crossing which limits the power line disturbance problems when fast switching selfic loads. An RC network placed in parallel with the output of the solid state relay is not mandatory, but to prevent any voltage spikes coming from the inductive load commutation, it is a good design practice to use it.

As defined on the components presentation, the MOC2A60–5 can drive 4 A(rms) on the main ac line (220 volts). If more power is required >4 A(rms), this device must be replaced by an opto triac driver (MOC3163) that will drive a power triac (MACH16N). (See Figure 2.)

< = To 4 A or 880 WATTS **From 4 A until 16 A**

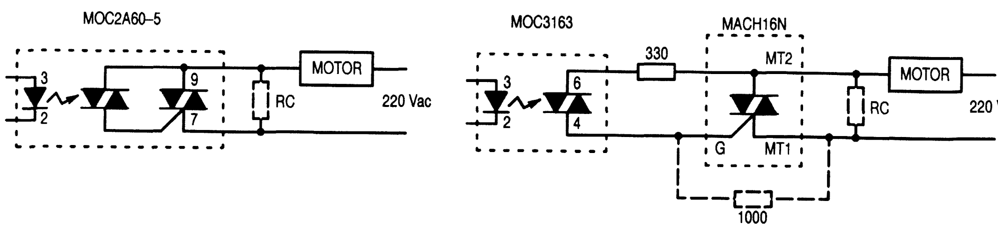


Figure 2.

Electrical Well Layout: Iron Post/Wires Probes

Iron Post

The probe is very important and must be connected to electronic ground (must be different from ac main line ground).

Length probe: around 45 to 65 centimeters vertically buried in the earth.

Location: near the well (up to 30 centimeters).

Wires Probes

These two probes consist of electrical wires isolated (lay bare wire strip which may be in contact with the water around 5 to 8 centimeters) hanging vertically inside the well, not in contact with the well walls.

To obtain a good standing of the wires:

Tie the wires mechanically at the top of the well; they must be perfectly isolated and connected respectively at the electronic set level low (L) and high (H).

Load the other ends (which will be in contact with the water) with little weights.

How to Adjust Wires Levels

First, it is necessary to be familiar with the well: the average maximum level of water and the flow (the two parameters depend on the seasons).

Place the low level wire probe (L) just above the stainer of the pump.

Place the high level wire probe (H) just below the maximum average water (10 to 15 centimeters).

Remark: High level is critical sometimes: Filling the well is slow, and the maximum water level changes. For these reasons, this probe (H) must be adjusted.

How to Check Your Probes Electrically

This paragraph is very important. The resistance between the iron post probe and the two others can influence the operation of the level circuit.

Two solutions to check:

1. With an ohmeter/voltmeter controller, take a few measurements.
   Values found between the iron post and probe L or probe H (when they are in the water) must be equal or lower than 30 k ohms. If not, the earth is too resistive for the application.
   To resolve this unusual problem, increase the length of the iron post in the earth. If this is not enough, move this probe in the bottom of the well.
   When probes are in contact with the water and connected with the circuit board, voltage between the iron probe and the two others, respectively, must be equal or lower than 5.3 V. With these last two conditions, the current through each probe (L/H) must be higher than 180 microamperes. This limit guarantees an LED opto triac current of 12 mA.

2. If a measurement cannot be performed:
   Connect the three probes to the circuit. Turn on the power main line. Verify that the two probes L and H are in the water. LED D4 must light (for this test, a motor is not necessary).
   If nothing appears, shortcircuit the electronic circuit board and probes L and H with an electronic ground to be sure that the problem comes from the iron probe post. D4 turns on. In this case, go to line.

COMPONENTS DESCRIPTION

R1 = 5.6 K R2 = 4.7 K R3 = 1 K R4 = 330
(All Resistors: CMS 1/4 watts)
D1 = BAW56LT1 D2 = BAV74LT1
D3 = BAS16LT1 D4 = MLED96
REG = MC78L08ACD (8 Vdc)
TR1, TR2 = MUN2111T1 TH1 = MCR08BT
C1 = 47 μF 40 V
O1 = MOC2A60–5
TR = TRANSFORMER 220 V/9 V/1 VA

ELECTRONIC LEVEL

Probe L	Probe H	TR1	TR2	TH1	D4 / 01
Open	Open	Off	Off	Off	Off
Earth	Open	Off	On	Off	Off
Earth	Earth	On	On	On	On
Earth	Open	Off	On	On	On
Open	Open	Off	Off	Off	Off

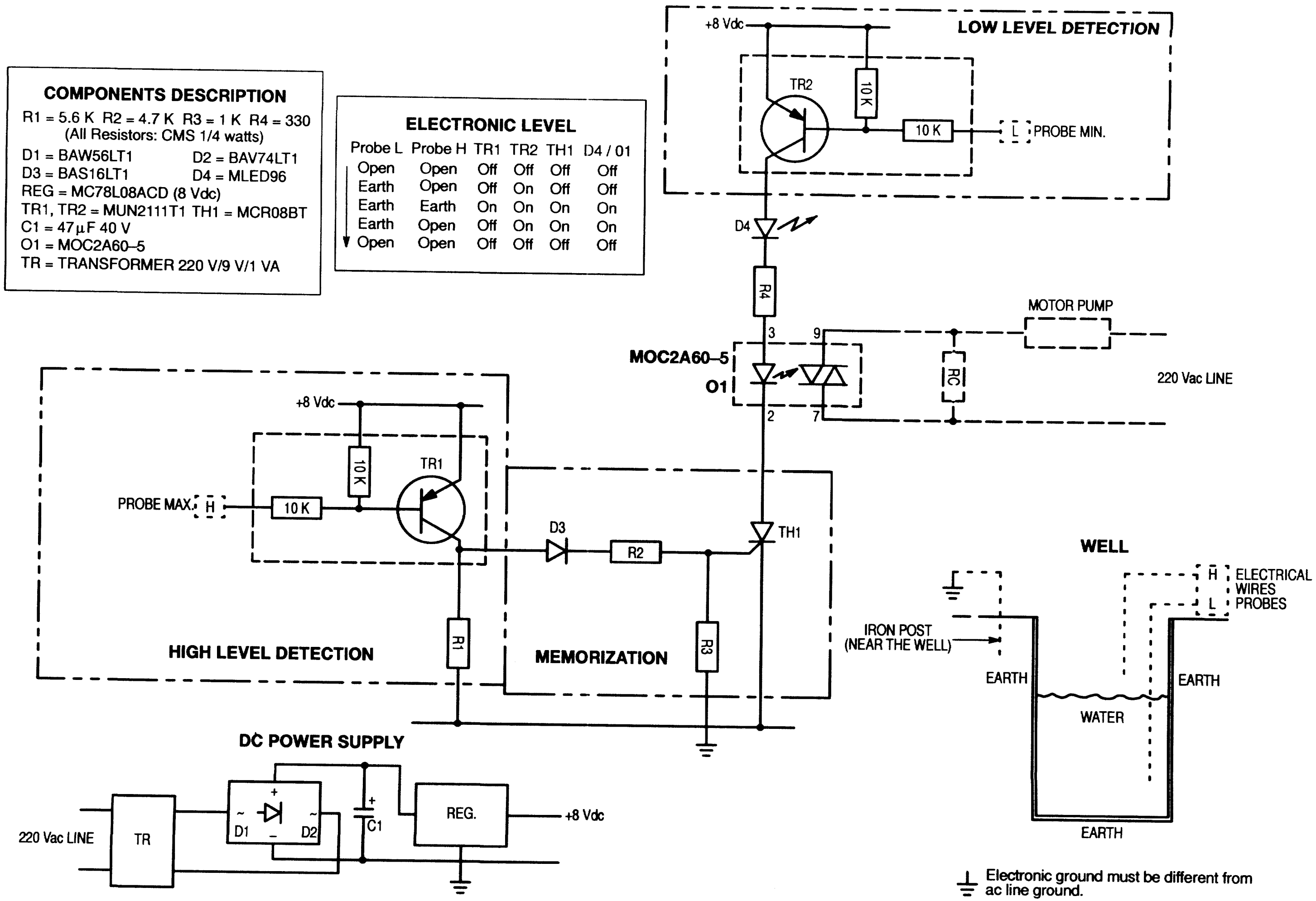


Figure 3. Water Level Control for Wells Using Small Surface Mount Devices

Optoisolators for Switching Power Supplies

Prepared by: Larry Hayes
Warren Schultz
Discrete Applications Engineering

In switching power supplies, optoisolators usually provide isolated feedback for the regulation loop. In this application, they do an excellent job of isolation, minimizing circuit complexity and reducing cost. The trade–offs are wide unit–to–unit variations in current transfer ratio, noise susceptibility, and long–term gain stability. But by using devices specifically designed for power supplies, these deficiencies can be minimized. A new series of devices, MOC8103 through MOC8105, combines an application–specific approach with technology improvements. The result is a significant performance increase in switching power supplies.

The biggest design challenge associated with optoisolators is the large unit–to–unit variation in current–transfer ratio (CTR). The statistical distribution of CTR within a given lot is characteristically large, and most standard devices are specified with only a minimum CTR, or at best, with a widely spaced minimum and maximum. This is a first–order design issue because open–loop gain is directly proportional to the optoisolator's CTR.

Consider a typical 100–W flyback power supply. Total loop gain is found by multiplying the individual gains of each stage. For this power supply, the loop gain, A_V, is equal to the product of the individual gains of the error amplifier (A_e), comparator (A_c), power stage (A_{ps}), TL431 (g_m) and optoisolator (CTR). Looking at only the TL431 and optoisolator together, the gain is expressed as:

$$\left[\frac{(R_{11} \times R_{12})}{(R_{11} + R_{12})}\right] (gm)(CTR) \left[\frac{(R_5 \times R_6)}{(R_5 + R_6)}\right]$$

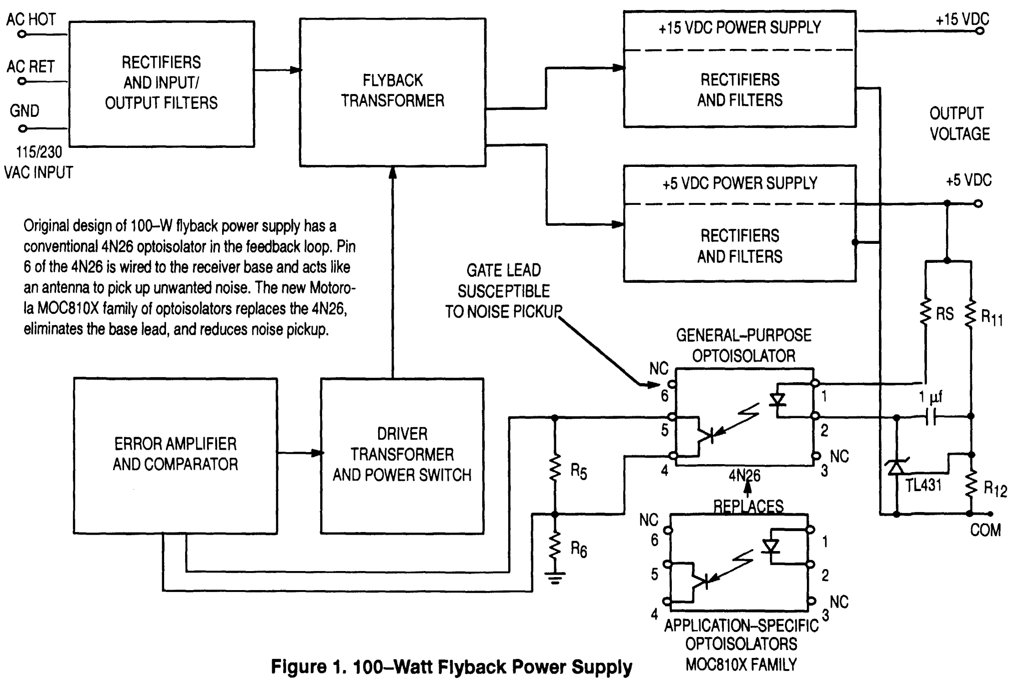


Figure 1. 100–Watt Flyback Power Supply

REV 1

Noise is further reduced by coplanar die placement of the LED and phototransistor. This reduces the internal capacitance to 0.2 pF and minimizes the coupled noise injected by the optoisolator.

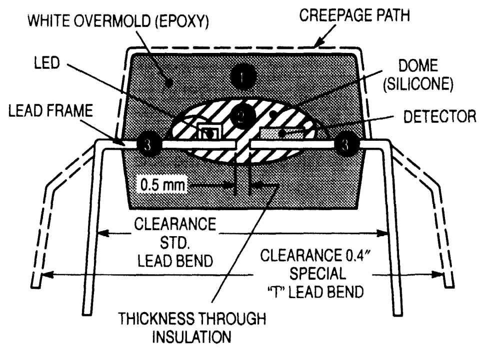


Figure 2. Coplanar Die Placement

Plugging in values for the resistors, g_m, CTR, and gains of the other amplifiers, the product yields a loop gain of 7,100 or 77 dB.

When minimum and maximum values for the optoisolator's CTR are factored into this calculation, the results are eye opening. For the widely used 4N26, the specified minimum is 0.2, and no maximum is guaranteed. The CTR can be as high as the upper limit of the supplier's statistical distribution; thus, values as high as 6.0 are common. Plugging this range back into the open–loop gain calculation results in a minimum of 3,500 (71 dB) and a maximum of 106,000 (101 dB). Because load regulation is proportional to open–loop gain, the same 30:1 variation follows through directly to output performance. In other words, a disturbance that produces a 1–mV change in the 101 dB supply will product a 30 mV change in the 71 dB unit.

Motorola Optoisolator CTR		
Part Number	**Minimum**	**Maximum**
MOC8105	65%	133%
MOC8103	108%	173%
MOC8104	160%	256%

Current–transfer ratios (CTRs) for the new family of optoisolators have a guaranteed range of values, unlike the 4N26 that had a guaranteed minimum of 0.2, but no maximum. Designers can now better predict loop gains and overall control performance.

The new MOC810X series devices, manufactured specifically for switching supplies, improves the situation by more than an order of magnitude. The result is better regulation, additional gain margin, or a combination of the two.

General–purpose optoisolators, such as 4N26, use a 5–lead configuration. Here, the optotransistor's base is pinned out to provide flexibility for the general–purpose user. However, in switching supplies, the internal chip–to–pin wire and the external lead together act as an antenna to pick up switching noise, which is introduced into the feedback loop. To minimize this problem, noise–decoupling networks are often added from base to emitter. Another approach is to cut off the external pin 6 (base) lead, which provides a partial improvement, but still leaves the internal chip–to–pin connected inside the package.

The MOC810X series optoisolators minimizes noise susceptibilty by eliminating the base connection. Only anode, cathode, collector, and emitter connections are provided, resulting in a four–terminal device that is housed in a six–pin DIP with two unconnected pins. The need for the extra passive components is eliminated, along with added cost and complexity.

Noise is further minimized by coplanar die placement, which puts the LED and phototransistor end to end, rather than one above the other. The result is a mere 0.2 pF coupled capacitance (C_{iso}), which minimizes the amount of capacitively coupled noise injected by the optoisolator.

In addition to the rather large unit–to–unit CTR variation, optoisolators have been known to exhibit CTR degradation over time. Fortunately, improvements in gallium–arsenide (GaAs) processing and handling now virtually eliminate this concern. These recent improvements have been incorporated into the MOC810X family.

The MOC810X series devices have remarkable gain stability. Under the strongly accelerated LED drive condition of I_F = 50 mA continuous, MOC810X series devices have now completed a total of 5,000 h of operation with a mean gain shift of only 0.7%.

VDE Circuit Board Layout Design Rules

The most demanding and stringent safety requirements are on interfaces between a safety low–voltage circuit [SELV] and a hazardous voltage (240 V power line). The requirements for creepage path and clearance dimensioning are different for each individual equipment norm and also depend on the isolation group and safety class of the equipment and the circuit board's resistance to tracking. Isolation materials are classified for their resistance to tracking creepage current stability from KB 100 to KB ≤600 (see VDE 303). On circuit board materials with a low KB value, the creepage path distance requirements are higher than for materials with a high KB value. In the following examples we therefore show creepage path dimensions for KB 100, the lowest value which is easily met by most circuit board materials.

The least stringent requirements on optocouplers, as well as printboard layouts, are within and in between SELV or ELV loops or circuits. (ELV = Electrical Low Voltage which does not meet the safety low voltage requirements.)

In studying the individual equipment norms, the designer will discover that optocouplers are not mentioned in most of the norms. He has to use the requirements for transformers or potted components instead.

Spacing requirements between two live tracks on a PC board within a low or high voltage loop (circuit) should generally meet the VDE requirements for minimum clearance and creepage path dimensions. If they do not, the circuit has to show some sort of current limiting (fuse, high–impedance, etc.) which prevents fire hazard due to an eventual short or sparkover between the two tracks. The VDE testing institute will conduct, in this case, a shorting test and a tracking test (arcing). See VDE 804. Classical cases are rectifiers, thyristors and high–voltage transistors which, sometimes due to their close pinout, might not meet the VDE equipment requirements at a certain voltage.

PRINTED CIRCUIT BOARD LAYOUT FOR SELV–POWER INTERFACES

The circuit board layout examples shown here are dimensioned so that they provide a safe electrical isolation between metal parts carrying line voltage (called Power Interface) and conductors connected to a SELV circuit.

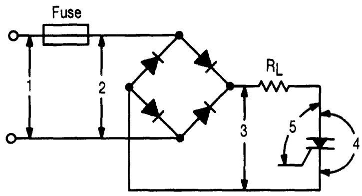
The required thickness through insulation for the optocoupler can be found in the individual VDE equipment norms. (See examples for safety applications, Table 1.)

Many Class I equipment norms permit the use of parts (modules, PC boards) which meet the Safety Class II dimension and isolation requirements. This enables the designer to take advantage of the less complex and space demanding design of the Class II PC board layout also in Class I classified equipment.

Optocoupler Mounting on PC Boards for Safety Class I

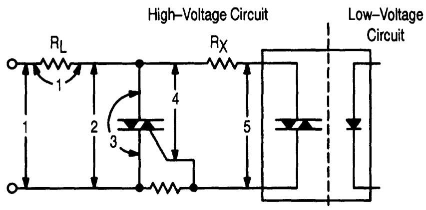
SELV transformers for Class I equipment have a Faraday shield which is connected to earth ground between primary and secondary windings. This is **not** applicable to optocouplers, but creepage path and clearance requirements from safety Class II can be applied. Class I also demands an earth ground track on the circuit board between SELV — and power circuit. Applying the Class I rules, this earth ground track should be between the coupler input and output. However, this cannot be done without violating the minimum creepage path and clearance requirements. A possible solution is shown on Figure 9 and Figure 10.

Figure 1.



1 — Clearance and creepage path **must** meet min requirements*
2 — Current limited due to fuse
3, 4 — Current limited due to R_L and fuse
5 — Current limited due to I_{GT}, R_L and fuse
2, 3, 4, 5 — Clearance and creepage path may be smaller than VDE min requirements but **must** meet fire hazard requirements due to short and arcing between the tracks. There shall be no flames or explosion during the test.

Figure 2.



1 Clearance and creepage path **must** meet min requirements*
2 Current limited due to R_L
3 Current limited due to R_L
4 Current limited due to I_{GT}
5 Current limited due to I_{GT} and R_X

* See Table 1 and Appendix Table 2 and 3 for minimum spacings and voltage requirements.

The earth ground track itself has to show a minimum distance to the equipment body (i.e., frame, circuit board enclosure) or to any inactive, active or hazardous track on the circuit board. According to many VDE equipment norms, this creepage path distance for 250 V Max is 4 mm. A mechanically unsecured circuit board which can be plugged in and out without a tool and is electrically connected through a standard PC board connector, has to show an isolation of the earth ground track to Class II, which is 8 mm. This is because a standard PC connector, as shown in Figure 9, does not guarantee earthing contact **before** there is termination of the life 220 V tracks on the circuit board when plugged in. Another reason for increased spacing is when the circuit board metal enclosure is not securely earth grounded. This is the case when the connection is done with the PC module mounting screws through lacquer or oxide layers to a grounded rack or frame. (See Figure 10.) PC board designs per Figures 9 and 10 account for these possibilities and, therefore, show dimensions M, N and A, B and D as 8 mm instead of 4 mm.

Table 1. Examples for Safety Applications for Motorola VDE Approved Optoisolators

Standard (2)			Requirements for reinforced (double) or safe insulation for equipment with an operating voltage up to 250 Vrms (line voltage to ELV or SELV interfaces)				
VDE	DIN IEC	Equipment	Creepage	Clearance (1)	Isolation Barrier	Dielectric Strength	Isolation Resistance
			[mm]	[mm]	[mm]	[kV RMS]	[Ω]
0806	950	Office Machines	8.0	8.0	0.4	3.75	7×10^6
0805	950	Data Processing	8.0	8.0	0.4	3.75	7×10^6
0804	—	Telecommunication	8.0	8.0	—	2.5	2×10^6
0860	65	Electrical Household	6.0	6.0	0.4	3.0 (10)*	4×10^6
0113	204	Industrial Controls	8.0	8.0	—	2.5	1×10^6
0160	—	Power Installations with Electronic Equipment	8.0	8.0	—	2.7	1×10^6
0832	—	Traffic Light Controls	8.0	8.0	—	2.5	4×10^6
0883	—	Alarm Systems	8.0	8.0	—	2.5	2×10^6
0831	—	Electrical Signal System for Railroads	8.0	8.0	—	2.0	2×10^6
0110	—	General Std. for Electrical Equipment	8.0	8.0	—	2.0	—
0883	—	Optoisolator Component Standard (obsolete 12/31/91)	8.5	8.3 (10) (1)	0.5	3.75 (10)*	10×10^{11}
0884(4)	—	Optoisolator Component Standard (replaces VDE0883)	>7.5	>7.5	0.5	—	10×10^{12}
			VDE Rating for Motorola 6–pin DIP Optoisolators				

All Motorola 6–pin DIP Optoisolators meet or exceed the requirements of above listed VDE and DIN IEC Standards.

* Impulse discharge withstand voltage.

1. To satisfy 8.0 mm creepage path on a PC board Motorola offers a special lead bend of 0.4 inch on all 6–pin dual–in–line optoisolators. Order by attaching "T" to the end of the Motorola part number.
2. VDE standards (translated into English language) and IEC standards can be ordered from the American National Standard Institute ANSI 1430 Broadway, N. Y., N. Y. 10018, Sales Department 212–642–4900.
3. Creepage path distances are measured from lead to lead across the top, bottom and ends of the package body.
4. VDE 0884 testing is an option; the suffix letter "V" must be added to the standard number.

Figure 3. Optocoupler Mounting on PC Boards for Safety Class II with Creepage Path and Clearance

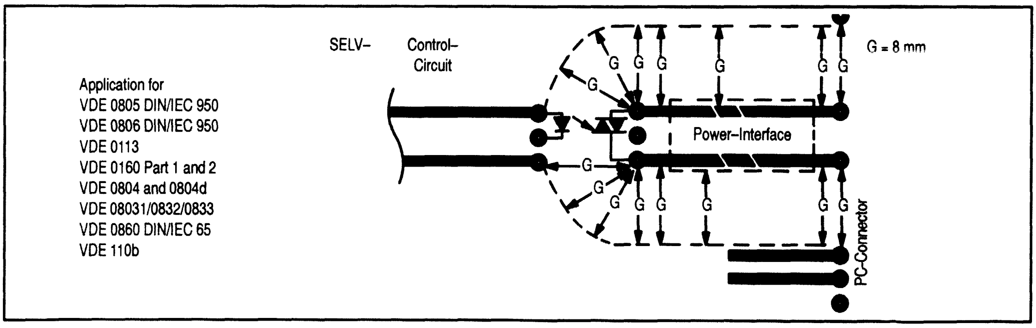
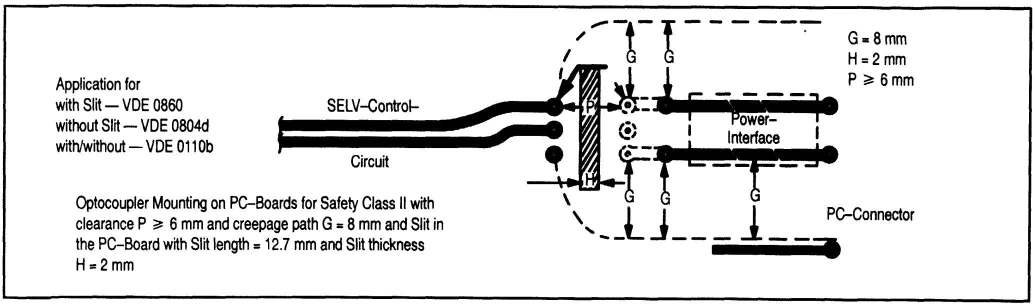
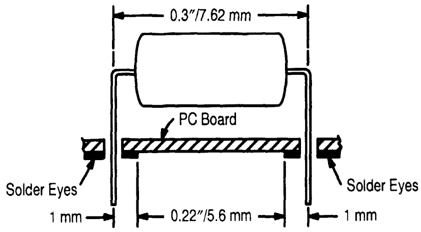


Figure 4. Optocoupler Mounting on PC Boards for Safety Class II with Clearance



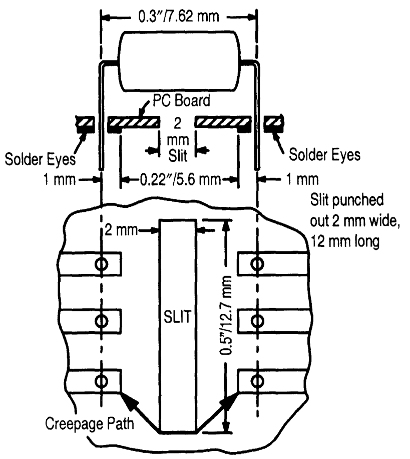
COUPLER MOUNTING ON A CIRCUIT BOARD
Clearance and Creepage Path Between Input and Output for Optocouplers on a PC Board

Figure 5.



Input/Output Leads — L = 0.3″/7.62 mm
Clearance Limited Due to PC Board
Solder Eyes — 0.22″/5.6 mm
Creepage Path on PC Board — 0.22″/5.6 mm

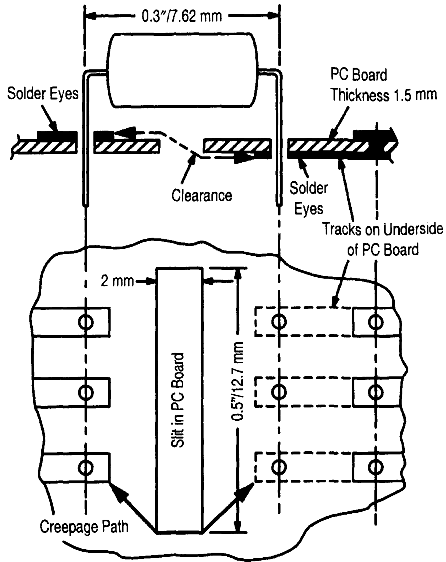
Figure 6.



VDE equipment norms demanding longer creepage path than 0.22″/5.6 mm can be accomplished by a slit in the PC board between the coupler input and output solder eyes of 2 mm width.

Input/Output Leads — L = 0.3″/7.62 mm
Clearance on PC Boards — 0.22″/5.6 mm Min
Creepage Path on PC Board — 0.31/8 mm Min

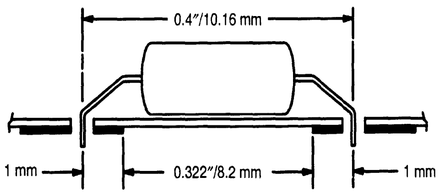
Figure 7.



If a clearance of 0.23″/6 mm and a creepage path of minimum 8 mm is required, this is a possible solution.

Slit — 0.5″/12.7 mm long, 2 mm wide
PC Board Thickness — 1.5 mm
Clearance — 6 mm Min
Creepage Path — 8 mm Min

Figure 8.



Where the equipment norms demand a clearance and creepage path of 8 mm Min, the coupler input and output leads should be bent to 0.4″/10.16 mm and the printboard layout should be as shown.

Safety Coupler Mounting with Spacing — L = 0.4″/10.16 mm
Clearance on PC Boards — 0.322″/8.2 mm
Creepage Path on PC Board — 0.322″/8.2 mm

All Motorola 6–pin dual–in–line optoisolators are available in 0.400″ lead form. Attach "T" to any Motorola 6–pin dual–in–line part number, for wide–spaced 0.400″ lead form.

Figure 9. Optocoupler Mounting on PC Board According to Safety Class I with Only One PC Board Plug Connection

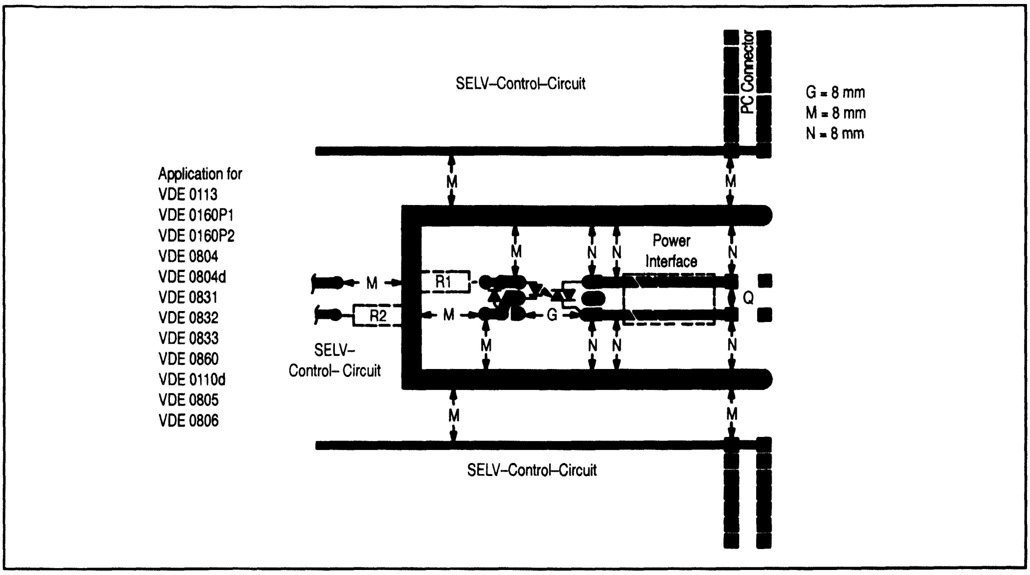
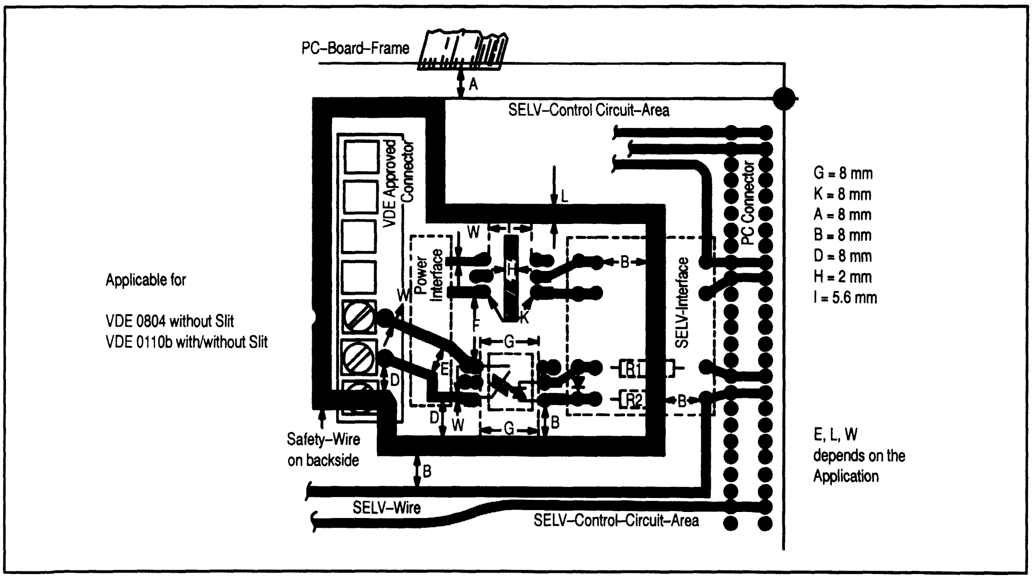


Figure 10. Optocoupler Mounting on PC Board According to Safety Class I with One Plug–Connection for the SELV–Control Circuit and One Screw–Connection for the Power–Interface



DEFINITION OF TERMS

The following paragraphs define terms used by the regulatories and international standard initiators. A separate discussion is given for:

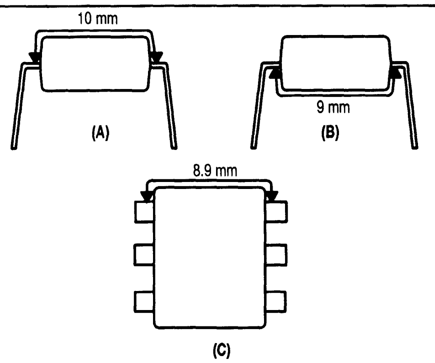
1. Creepage and Clearance
2. Voltage
3. Insulations
4. Circuits
5. Equipment

1. CREEPAGE AND CLEARANCE

ISOLATION CREEPAGE PATH

Denotes the shortest path between two conductive parts measured along the surface of the insulation, i.e., on the optocouplers, it is the shortest distance on the surface of the package between the input and output leads. On the circuit board in which the coupler is mounted, it is the shortest distance across the surface on the board between the solder eyes of the coupler input/output leads. Coupler and circuit board creepage path have to meet the minimum specified distances for the individual VDE equipment norms.

Figure 11.

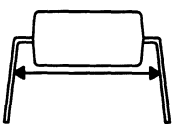


*Approximate measurements. For minimum measurements required, see Table 1.

CLEARANCE

Denotes the shortest distance between two conductive parts or between a conductive part and the bonding surface of the equipment, measured through air.

Figure 12.



2. VOLTAGES

HAZARDOUS VOLTAGE: A voltage exceeding 42.4 V peak or dc, existing in a circuit which does not meet the requirements for a limited current circuit.

WORKING VOLTAGE shall be the voltage which exists across the insulation under normal working conditions. Where the rms value is used, a sinusoidal ac waveform shall be assumed. Where the dc value is used, the peak value of any superimposed ripple shall be considered.

EXTRA–LOW VOLTAGE (ELV): A voltage between conductors or between a conductor and earth not exceeding 42.4 V peak or dc, existing in a secondary circuit which is separated from hazardous voltages by at least basic insulation, but which does not meet the requirements for a SELV circuit nor those for a limited current circuit.

ISOLATION WITHSTAND VOLTAGE: An ac or dc test voltage insulation has to withstand without breakdown or damage. It should not be confused with working or operating voltage.

ISOLATION SURGE VOLTAGE: A positive or negative transient voltage of defined energy and rise and fall times which the insulation has to withstand without breakdown or damage.

3. INSULATIONS

INSULATION, OPERATIONAL (functional): Insulation which is necessary for the correct operation of the equipment.
- Between parts of different potential.
- Between ELV or SELV circuits and earthed conductive parts.

INSULATION, BASIC: Insulation to provide basic protection against electric shock.
- Between a part at hazardous voltage and an earthed conductive part.
- Between a part at hazardous voltage and a SELV circuit which relies on being earthed for its integrity.
- Between a primary power conductor and the earthed screen or core for a primary power transformer.
- As an element of double insulation.

INSULATION, SUPPLEMENTARY: Independent insulation applied in addition to basic insulation in order to ensure protection against electric shock in the event of a failure of the basic insulation.
- Between an accessible conductive part and a part which could assume a hazardous voltage in the event of a failure of basic insulation.
- Between the outer surface of handles, knobs, grips and the like, and their shafts unless earthed.
- Between a floating non–SELV secondary circuit and an unearthed conductive part of the body.

INSULATION, DOUBLE: Insulation comprising both basic insulation and supplementary insulation.

INSULATION, REINFORCED: A single insulation system which provides a degree of protection against electric shock equivalent to double insulation under the conditions specified in the standard.

SAFE ELECTRICAL ISOLATION: Denotes an insulation system isolating a hazardous voltage circuit from a SELV circuit such that an insulation breakdown either is unlikely or does not cause a hazardous condition on the SELV circuit.
- Between an unearthed accessible conductive part or a floating SELV circuit, and a primary circuit.

4. CIRCUITS

PRIMARY CIRCUIT: An internal circuit which is directly connected to the external supply mains or other equivalent source (such as motor–alternator set) which supplies the electric power. It includes the primary windings of transformers, motors, other loading devices and the means of connection to the supply mains.

SECONDARY CIRCUIT: A circuit which has no direct connection to primary power and derives its power from a transformer, converter or equivalent isolation device situated within the equipment.

SAFETY EXTRA–LOW VOLTAGE (SELV) CIRCUIT: A circuit which is so designed and protected that under normal and single fault conditions the voltage between any two accessible parts, one of which may be the body or earth, does not exceed a safe value.

5. EQUIPMENTS

CLASS I EQUIPMENT: denotes equipment in which protection against electric shock does not rely on basic insulation only, but which includes an additional safety precaution in that operator–accessible conductive parts are connected to the protective earthing conductor in the fixed wiring of the installation in such a way that the operator–accessible conductive parts cannot become hazardous in the event of a failure of the basic insulation.

Class I equipment may have parts with double insulation or reinforced insulation, or parts operating at safety extra–low voltage.

CLASS II EQUIPMENT denotes equipment in which protection against electric shock does not rely on basic insulation only, but in which additional safety precautions, such as double insulation or reinforced insulation, are provided, there being no provision for protective earthing or reliance upon installation conditions.

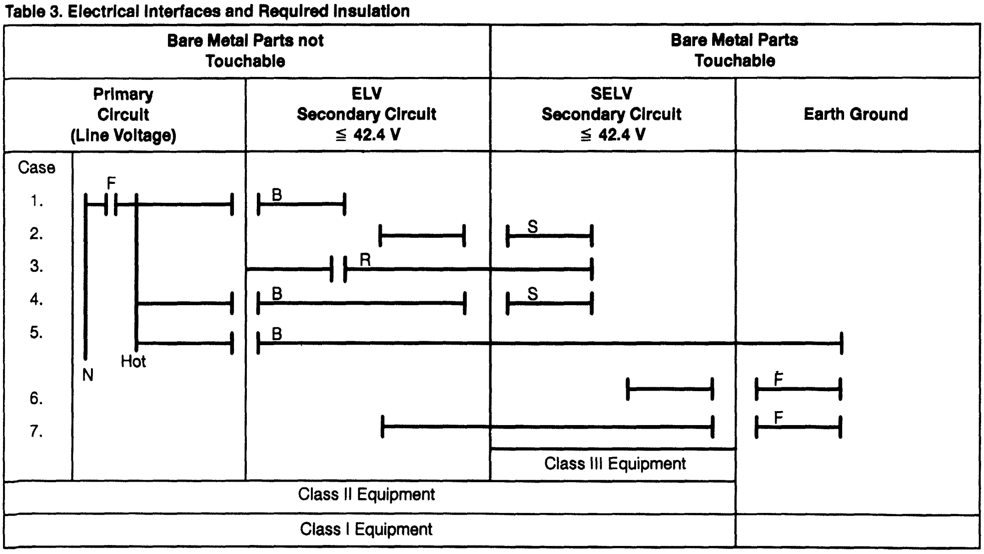
CLASS III EQUIPMENT: Equipment in which protection against electric shock relies upon supply from SELV circuits and in which hazardous voltages are not generated.

Table 2. Minimum Rating Requirements for a Working Voltage up to 250 Vrms

Insulation	Creepage [mm]	Clearance [mm]	Isolation Barrier [mm]	Diel. Strength [kV ac rms]	Isolation Resistance Ω
Operational	2.5	3	—	0.5	—
Basic	3	4	—	1.5	2 10^6
Supplementary	4	4	– to 2	2.5	5 10^6
Reinforced	8	8	– to 2*	2.5 to 3.75*	7 10^6

* See Table 1 for details.

Table 3. Electrical Interfaces and Required Insulation



B = Basic Insulation F = Functional (Operation Insulation)
R = Reinforced or Safe Insulation S = Supplementary Insulation

Application Note Abstracts

(Application Notes are available upon request.)

AN1126 Evaluation Systems for Remote Control Devices on an Infrared Link

The discussion provides information for constructing the basic building blocks for evaluation of both the IR transmitter/ receiver and the most popular remote control devices. Schematics and single–sided PC board layouts are presented which enable the designer to put together a basic control link and evaluate its suitability in terms of data rate, effective distance, error rate, and cost.

AN1078 New Components Simplify Brush DC Motor Drives

Brush motor drive design is simplified by combining multiple power MOSFETs, a new MOS turn–off device and gain stable opto level shifters. The discussion describes circuits which can be combined to make practical drive circuits which control speed in both directions and operate from a single power supply.

AN703 Designing Digitally–Controlled Power Supplies

Two design approaches are discussed: basic low voltage supply using an inexpensive MC1723 voltage regulator and a high current, high voltage supply using the MC1466 floating regulator with optoelectronic isolation. Various circuit options are shown to allow the designer maximum flexibility in any application.

AN575A Variable Speed Control System for Induction Motors

This note describes a method of controlling the speed of standard induction motors above and below their rated speeds. A unique variable frequency drive system is used to maintain the rated output torque at speeds below the nameplate rating.

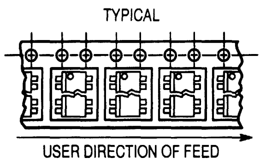
Section 9

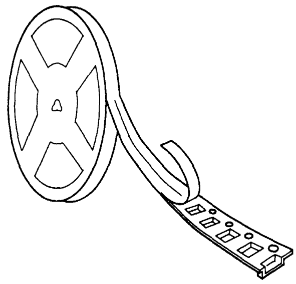
Tape and Reel Specifications and Surface Mount Package Information

SO–8 and 6–Pin Optocouplers Tape and Reel Specifications

Motorola has now added the convenience of Tape and Reel packaging for our growing family of Opto products. The packaging fully conforms to the latest EIA–481 standard. The conductive embossed tape provides a secure cavity, sealed with a peel–back anti–static cover tape.

MECHANICAL POLARIZATION

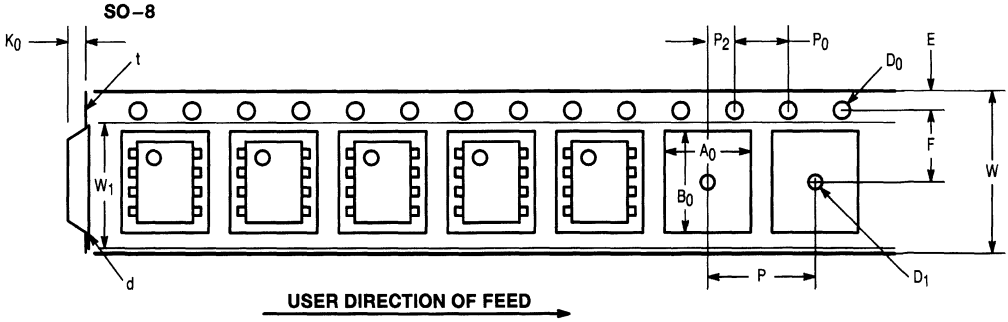




Opto SO–8

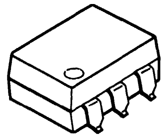
Package	Tape Width (mm)	Device(1) per Reel	Reel Size (mm)	Device Suffix
Opto SO–8	12	2,500	330	R2

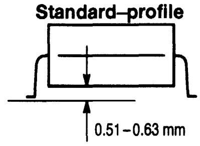
1. Minimum order quantity is one reel. Distributors/OEM customers may break lots or reels at their option; however, broken reels may not be returned.



SO–8 AND 6–PIN TAPE AND REEL SPECIFICATIONS (continued)

All 6–Pin surface mount devices are available in Tape & Reel format.





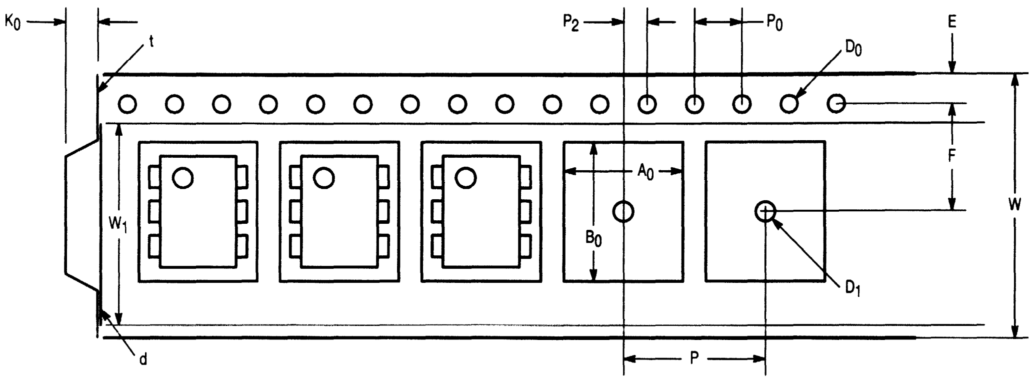
Package	Tape Width (mm)	Device[1] per Reel	Reel Size (mm)	Device Suffix
6–Pin Optoisolators	24	1,000	330	R2

1. Minimum order quantity is one reel. Distributors/OEM customers may break lots or reels at their option; however, broken reels may not be returned.

Add the following suffix to the standard DIP–6 part number to obtain the following option:

Standard–profile surface mount Tape & Reel option = "SR2"

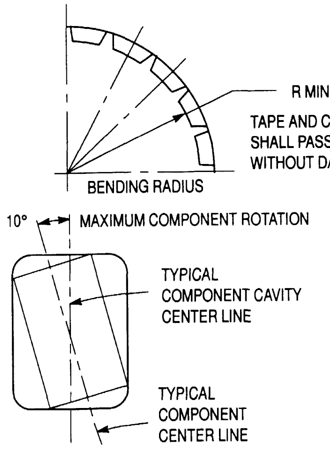
6–PIN OPTO DOME COUPLERS

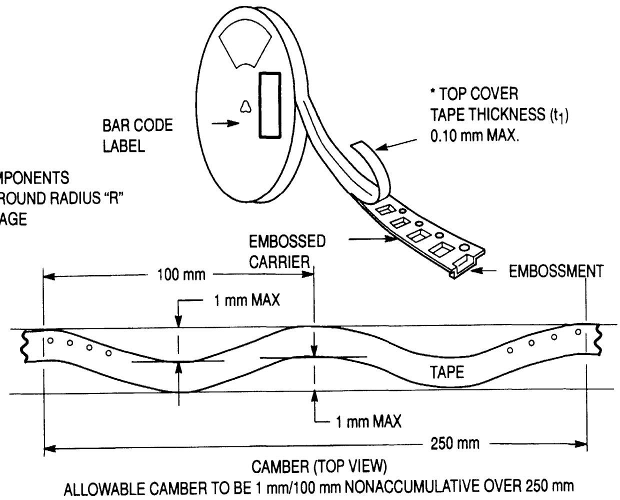


USER DIRECTION OF FEED

Description	Symbol	Dimensions in mm SO–8	Dimensions in mm 6 Pin
Tape Width	W	12 ± 0.3	24 ± 0.3
Tape Thickness	t	0.3 max	0.3 max
Sprocket Hole Pitch	P^0	4 ± 0.1	4 ± 0.1
Sprocket Hole Dia.	D^0	1.5 min	1.5 min
Sprocket Hole Location	E	1.75 ± 0.1	1.75 ± 0.1
Pocket Location	F	5.5 ± 0.05	11.5 ± 1.0
	P^2	2 ± 0.05	2 ± 0.05
Pocket Pitch	P	8 ± 0.1	16 ± 0.1
Pocket Dimensions	A^0	6.4 ± 0.2	10.1 ± 0.2
	B^0	5.2 ± 0.2	9.1 ± 0.2
	K^0	3.5 ± 0.2	4.5 ± 0.2
Pocket Hole Dia.	D^1	1.5 + 0.1/–0	1.5 + 0.1/–0
Cover Tape Width	W^1	8.3 ± 0.1	21 ± 0.1
Cover Tape Thickness	d	0.1 max	0.1 max
Max. Component Rotation or Tilt		15°	10°
Min. Bending Radius	R	30	30

SO–8 AND 6–PIN TAPE AND REEL SPECIFICATIONS (continued)

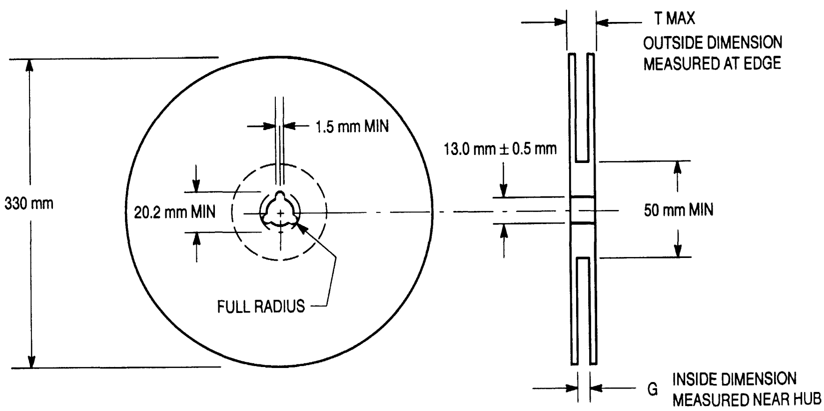




EMBOSSED TAPE AND REEL DATA FOR OPTO

Reel Dimensions

Metric Dimensions Given



Surface Mount Package Information

SOLDER STENCIL GUIDELINES

Prior to placing surface mount components onto a printed circuit board, solder paste must be applied to the pads. A solder stencil is required to screen the optimum amount of solder paste onto the footprint. The stencil is made of brass or stainless steel with a typical thickness of 0.008 inches. The stencil opening size for the SOIC–8 package should be the same as the pad size on the printed circuit board, i.e., a 1:1 registration.

SOLDERING PRECAUTIONS

The melting temperature of solder is higher than the rated temperature of the device. When the entire device is heated to a high temperature, failure to complete soldering within a short time could result in device failure. Therefore, the following items should always be observed in order to minimize the thermal stress to which the devices are subjected.

- Always preheat the device.
- The delta temperature between the preheat and soldering should be 100°C or less.*
- When preheating and soldering, the temperature of the leads and the case must not exceed the maximum temperature ratings as shown on the data sheet. When using infrared heating with the reflow soldering method, the difference shall be a maximum of 10°C.
- The soldering temperature and time shall not exceed 260°C for more than 10 seconds.
- When shifting from preheating to soldering, the maximum temperature gradient shall be 5°C or less.
- After soldering has been completed, the device should be allowed to cool naturally for at least three minutes. Gradual cooling should be used as the use of forced cooling will increase the temperature gradient and result in latent failure due to mechanical stress.
- Mechanical stress or shock should not be applied during cooling

* Soldering a device without preheating can cause excessive thermal shock and stress which can result in damage to the device.

TYPICAL SOLDER HEATING PROFILE

For any given circuit board, there will be a group of control settings that will give the desired heat pattern. The operator must set temperatures for several heating zones, and a figure for belt speed. Taken together, these control settings make up a heating "profile" for that particular circuit board. On machines controlled by a computer, the computer remembers these profiles from one operating session to the next. Figure 1 shows a typical heating profile for use when soldering a surface mount device to a printed circuit board. This profile will vary among soldering systems but it is a good starting point. Factors that can affect the profile include the type of soldering system in use, density and types of components on the board, type of solder used, and the type of board or substrate material being used. This profile shows temperature versus time. The line on the graph shows the actual temperature that might be experienced on the surface of a test board at or near a central solder joint. The two profiles are based on a high density and a low density board. The Vitronics SMD310 convection/infrared reflow soldering system was used to generate this profile. The type of solder used was 62/36/2 Tin Lead Silver with a melting point between 177–189°C. When this type of furnace is used for solder reflow work, the circuit boards and solder joints tend to heat first. The components on the board are then heated by conduction. The circuit board, because it has a large surface area, absorbs the thermal energy more efficiently, then distributes this energy to the components. Because of this effect, the main body of a component may be up to 30 degrees cooler than the adjacent solder joints.

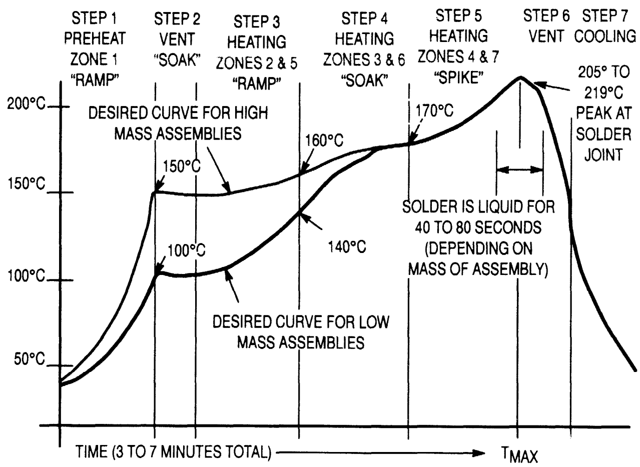
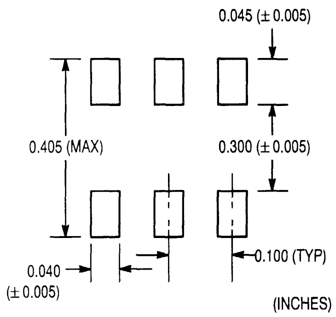


Figure 1. Typical Solder Heating Profile

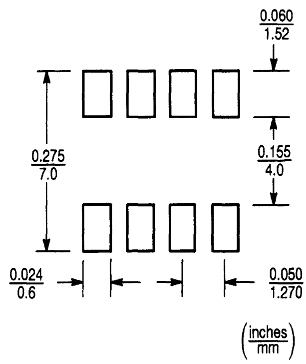
Footprints for Soldering

6–PIN DIP
GULL–WING



"S" Suffix Option
Surface Mount

OPTO SO–8
SMALL OUTLINE SURFACE MOUNT



Bar Code Labeling

The Intermediate Package Label shall contain, as a minimum, the Motorola part number, Motorola lot number, Motorola manufacturing date (date code), and quantity as shown in Figure 1. Customer part number (CPN) label, Figure 2, shall be added when CPN is available.

Data Identifier Codes

Data identifier codes shall be included on the Intermediate Labels. On these labels a data identifier code in the first position following the start code of the bar code symbol is used to identify the information to follow. This character is not to be included in the human readable line, but is shown in the human readable title for the appropriate data area. See Figures 1 and 2.

No additional bar code symbols will be placed on the Intermediate Package Label unless it contains a data identifier to differentiate it from other bar code symbols.

Motorola had initially attempted to standardize on a set of data identifiers which it believed to be the preferred standard. However, with the establishment of the EIA STANDARD EIA–556A, Electronic Industries Association Shipping Container Bar Code Label Standard and their adoption of the "Standard of the Federation of Automated Coding Technologies" (FACT) identifiers, we have altered our standards to comply with this new Industry Standard. Therefore, the following identifiers will be used to identify data found on our labels:

- P — Customer Product Identification — (Customer part number)
- 1P — Motorola Part Number
- Q — Quantity
- 9D — Manufacturing Date (Date Code — YYWW)
- 1T — Motorola Manufacturing Lot Number for traceability
- V — Vendor Code assigned by Customer
- 2V — Vendor Code, UCC Code, the Universal Product Code Manufacturing ID Number assigned to Motorola (0784990) by the Uniform Code Council, Inc.

Example:

Motorola part number in human readable form = MOC8103

Bar code symbol for Motorola part number = MOC8103

Customer part number in human readable form = 406520940

Bar code symbol for Customer part number = 406520940

The human readable part number characters shall be bold and a minimum 3 mm high. The bar code symbol of the part number shall be directly below the human readable characters and shall be a minimum 6.35 mm high. Depending on the nominal dimension of the narrow bar code elements, part numbers of varying lengths can be printed on one line. The maximum length of any bar code symbol should not exceed 89 mm. The part number shall be designated by Motorola for Standard Devices or by the customer for Special Devices. The maximum length anticipated for the part number is sixteen (16) characters plus the data identifier ("P" for Customer Part Number or "1P" for Motorola Part Number).

Bar Code Symbology

Bar Codes shall be of the 3–of–9 (Code 39) type and shall conform to the Bar Code Symbology Standard for 3–of–9 Bar Codes published by EIA–556A. In addition to this symbology specification, the following paragraphs cover specific requirements for the Motorola Intermediate and Shipping Labels.

Code Configuration

The Code 39 configuration is in accordance with (AIM) USS 39 Symbol specification.

Code Density and Dimensions

The bar heights shall be a minimum of 6.35 mm. The width of the narrow elements ("X" dimension) shall be within the range of 0.18 to 0.41 mm. The ratio of the nominal width of the wide to narrow elements shall be 3:1, with an allowable range of 2.8:1 to 3.2:1.

Check Digits

Check digits shall not be used in the bar codes.

Reflectivity and Contrast

The printed bar code symbols shall meet the contrast and reflectivity requirements specified in EIA–556A, at all electromagnetic wave lengths from B633 to B900 nanometers.

Quiet Zone

The minimum quiet zone for each bar coded data element shall be 6.35 mm.

Special Labels

While we hope that these specifications will cover most situations, there will be circumstances where requirements will dictate special arrangements between customers and Motorola. Every effort to minimize these situations should be a goal of all so that complexities and costs are not added.

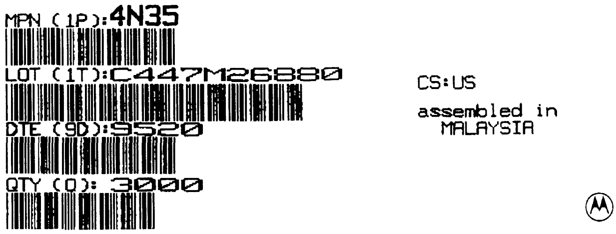


Figure 1. Motorola "Internal Use" Intermediate Container Label

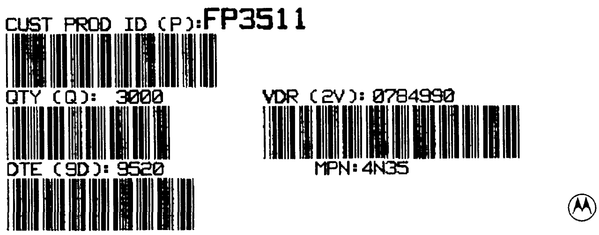


Figure 2. Customer Part Number Intermediate Container Label

CUSTOMER PART NUMBER INTERMEDIATE CONTAINER LABEL

(Added to container when customer part number is available)
Label size may be adjusted to fit intermediate packing, but it shall contain all Bar Code information shown above as a minimum.

Section 10

Appendices

APPENDIX 1

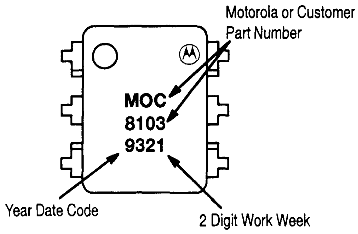
Marking Information for Optoelectronic Products

Optoisolators/Optocouplers

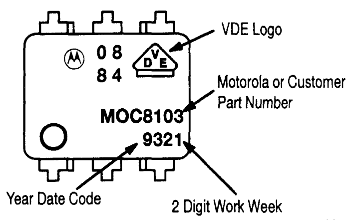
Motorola 6–PIN DIP and SOIC–8 devices are **NOT** marked with the various option suffixes listed below:

Suffix	Description
"S"	Standard profile surface mount leadform (6–PIN only)
"SR2"	Tape and Reel for standard profile S/M (6–PIN only)
"T"	Wide spaced 0.400″ leadform (6–PIN only)
"V"	VDE 0884(1) tested and marked (6–PIN only)*
"R2"	2500 piece Tape and Reel (SOIC–8 only)

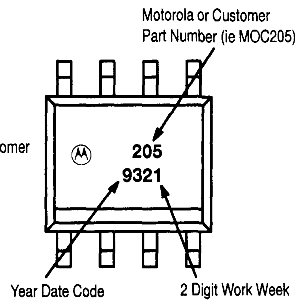
NOTE: All of the above special option suffixes will be marked on Reels, and boxes.
* "V" suffix devices have a special partial discharge test and are marked with the VDE logo and 0884. The "V" will not be marked on the device.



Standard 6–PIN Optoisolator Marking



"V" Suffix 6–PIN Optoisolator (VDE0884 Marking)



Small Outline SOIC–8 Optoisolator Marking

Device No.	Marking
MOC205	205
MOC206	206
MOC207	207
MOC208	208
MOC211	211
MOC213	213
MOC215	215
MOC216	216
MOC217	217
MOC223	223
MOC256	256
MOC263	263
Dual Channel	
MOCD207	D207
MOCD208	D208
MOCD211	D211
MOCD213	D213
MOCD217	D217
MOCD223	D223

APPENDIX 2

The following devices are included in the Motorola Optoisolator portfolio, however they do not have individual dedicated Data Sheets. Refer to the suggested standard Data Sheet for typical electrical values and complete graphs.

Device Number	Refer to Data Sheet	Page #
TIL111	4N25	5–6
MCT2	4N25	5–6
MCT2E	4N25	5–6
MCT271	CNY17–1	5–22
TIL117	MOC8100	5–111

Device Number	Refer to Data Sheet	Page #
MCT275	CNY17–2	5–22
MCT272	MOC8100	5–111
MCA231	H11B2	5–37
TIL113	4N32	5–10

APPENDIX 3

Definitions, Characteristics, and Ratings

CTR Current Transfer Ratio — The ratio of output current to input current, at a specified bias, of an opto coupler.

CTR = Detector Output Current (I_C) / LED Input Current (I_F) * 100%

dv/dt Commutating dv/dt — A measure of the ability of a triac to block a rapidly rising voltage immediately after conduction of the opposite polarity.

Coupled dv/dt — A measure of the ability of an opto thyristor coupler to block when the coupler is subjected to rapidly changing isolation voltage.

I_{CEO} Collector Dark Current — The maximum current through the collector terminal of the device measured under dark conditions, (H ≈ 0), with a stated collector voltage, load resistance, and ambient temperature. (Base open)

I_D Dark Current — The maximum reverse leakage current through the device measured under dark conditions, (H ≈ 0), with a stated reverse voltage, load resistance, and ambient temperature.

I_{FT} Input Trigger Current — Emitter current necessary to trigger the coupled thyristor.

R_S Series Resistance — The maximum dynamic series resistance measured at stated forward current and ambient temperature.

SCR Silicon Controlled Rectifier — A reverse blocking thyristor which can block or conduct in forward bias, conduction between the anode and cathode being initiated by forward bias of the gate cathode junction.

Triac A thyristor which can block or conduct in either polarity. Conduction is initiated by forward bias of a gate–MTI junction.

T_{stg} Storage Temperature

$V_{(BR)R}$ Reverse Breakdown Voltage — The minimum dc reverse breakdown voltage at stated diode current and ambient temperature.

$V_{(BR)CBO}$ Collector–Base Breakdown Voltage — The minimum dc breakdown voltage, collector to base, at stated collector current and ambient temperature (Emitter open and H ≈ 0)

$V_{(BR)CEO}$ Collector–Emitter Breakdown Voltage — The minimum dc breakdown voltage, collector to emitter, at stated collector current and ambient temperature. (Base open and H ≈ 0)

$V_{(BR)ECO}$ Emitter–Collector Breakdown Voltage — The minimum dc breakdown voltage, emitter to collector, at stated emitter current and ambient temperature. (Base open and H ≈ 0)

V_{CBO} Collector–Base Voltage — The maximum allowable value of the collector–base voltage which can be applied to the device at the rated temperature. (Base open)

V_{CEO} Collector–Emitter Voltage — The maximum allowable value of collector–emitter voltage which can be applied to the device at the rated temperature. (Base open)

V_{ECO} Emitter–Collector Voltage — The maximum allowable value of emitter–collector voltage which can be applied to the device at the rated temperature. (Base open)

V_F Forward Voltage — The maximum forward voltage drop across the diode at stated diode current and ambient temperature.

V_{ISO} Isolation Surge Voltage — The dielectric withstanding voltage capability of an optocoupler under defined conditions and time.

V_R Reverse Voltage — The maximum allowable value of dc reverse voltage which can be applied to the device at the rated temperature.

APPENDIX 4

Standard Warranty Clause

Seller warrants that its products sold hereunder will at the time of shipment be free from defects in material and workmanship, and will conform to Seller's approved specifications. If products are not as warranted, Seller shall, at its option and as Buyer's exclusive remedy, either refund the purchase price, or repair, or replace the product, provided proof of purchase and written notice of nonconformance are received within the applicable periods noted below and provided said nonconforming products are, with Seller's written authorization, returned in protected shipping containers FOB Seller's plant within thirty (30) days after expiration of the warranty period unless otherwise specified herein. If product does not conform to this warranty, Seller will pay for the reasonable cost of transporting the goods to and from Seller's plant. This warranty shall not apply to any products Seller determines have been, by Buyer or otherwise, subjected to improper testing, or have been the subject of mishandling or misuse.

THIS WARRANTY EXTENDS TO BUYER ONLY AND MAY BE INVOKED BY BUYER ONLY FOR ITS CUSTOMERS. SELLER WILL NOT ACCEPT WARRANTY RETURNS DIRECTLY FROM BUYER'S CUSTOMERS OR USERS OF BUYER'S PRODUCTS. THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES WHETHER EXPRESS, IMPLIED OR STATUTORY INCLUDING IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

Seller's warranty shall not be enlarged, and no obligation or liability shall arise out of Seller's rendering of technical advice and/or assistance.

A. Time periods, products, exceptions and other restrictions applicable to the above warranty are:

   (1) Unless otherwise stated herein, products are warranted for a period of one (1) year from date of shipment.

   (2) Device Chips/Wafers. Seller warrants that device chips or wafers have, at shipment, been subjected to electrical test/probe and visual inspection. Warranty shall apply to products returned to Seller within ninety (90) days from date of shipment. This warranty shall not apply to any chips or wafers improperly removed from their original shipping container and/or subjected to testing or operational procedures not approved by Seller in writing.

B. Development products and Licensed Programs are licensed on an "AS IS" basis. IN NO EVENT SHALL SELLER BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES.

APPENDIX 5

Soldering Techniques for Standard OptoIsolator Components

SOLDER STENCIL GUIDELINES

Prior to placing surface mount components onto a printed circuit board, solder paste must be applied to the pads. A solder stencil is required to screen the optimum amount of solder paste onto the footprint. The stencil is made of brass or stainless steel with a typical thickness of 0.008 inches. The stencil opening size for the SOIC-8 package should be the same as the pad size on the printed circuit board, i.e., a 1:1 registration.

SOLDERING PRECAUTIONS

The melting temperature of solder is higher than the rated temperature of the device. When the entire device is heated to a high temperature, failure to complete soldering within a short time could result in device failure. Therefore, the following items should always be observed in order to minimize the thermal stress to which the devices are subjected.

- Always preheat the device.
- The delta temperature between the preheat and soldering should be 100°C or less.*
- When preheating and soldering, the temperature of the leads and the case must not exceed the maximum temperature ratings as shown on the data sheet. When using infrared heating with the reflow soldering method, the difference shall be a maximum of 10°C.
- The soldering temperature and time shall not exceed 260°C for more than 10 seconds.
- When shifting from preheating to soldering, the maximum temperature gradient shall be 5°C or less.
- After soldering has been completed, the device should be allowed to cool naturally for at least three minutes. Gradual cooling should be used as the use of forced cooling will increase the temperature gradient and result in latent failure due to mechanical stress.
- Mechanical stress or shock should not be applied during cooling

* Soldering a device without preheating can cause excessive thermal shock and stress which can result in damage to the device.

TYPICAL SOLDER HEATING PROFILE

For any given circuit board, there will be a group of control settings that will give the desired heat pattern. The operator must set temperatures for several heating zones, and a figure for belt speed. Taken together, these control settings make up a heating "profile" for that particular circuit board. On machines controlled by a computer, the computer remembers these profiles from one operating session to the next. Figure 1 shows a typical heating profile for use when soldering a surface mount device to a printed circuit board. This profile will vary among soldering systems but it is a good starting point. Factors that can affect the profile include the type of soldering system in use, density and types of components on the board, type of solder used, and the type of board or substrate material being used. This profile shows temperature versus time. The line on the graph shows the actual temperature that might be experienced on the surface of a test board at or near a central solder joint. The two profiles are based on a high density and a low density board. The Vitronics SMD310 convection/infrared reflow soldering system was used to generate this profile. The type of solder used was 62/36/2 Tin Lead Silver with a melting point between 177–189°C. When this type of furnace is used for solder reflow work, the circuit boards and solder joints tend to heat first. The components on the board are then heated by conduction. The circuit board, because it has a large surface area, absorbs the thermal energy more efficiently, then distributes this energy to the components. Because of this effect, the main body of a component may be up to 30 degrees cooler than the adjacent solder joints.

SOLDERING TECHNIQUES FOR OPTOISOLATORS (continued)

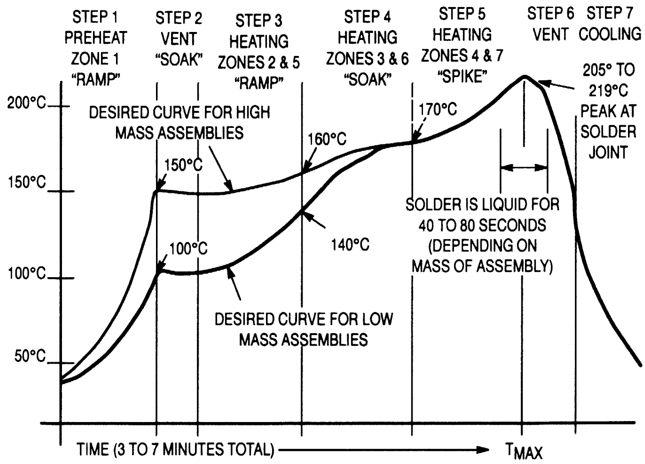
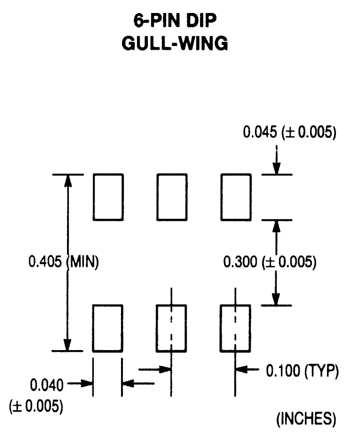
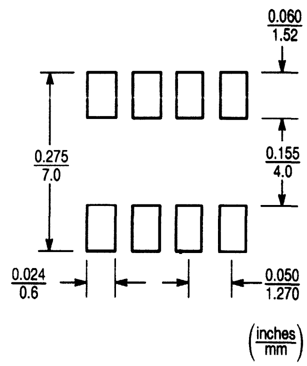


Figure 1. Typical Solder Heating Profile

Footprints for Soldering



Standard "S" Option



OPTO SO-8

Section 11

Index and Cross Reference

Index and Cross Reference

The following table represents a cross-reference guide for all Opto devices which are manufactured by Motorola. Where the Motorola part number differs from the Industry part number, the Motorola device is a "form, fit and function" replacement for the Industry part number; however, some differences in characteristics and/or specifications may exist.

Industry Part Number	Motorola Nearest Replacement	Motorola Similar Replacement	Page Number
4N25	4N25		5–6
4N29A	4N29A		5–10
4N36	4N36		5–14
CLI–10		4N33	5–10
CNY17–N	CNY17–3		5–22
CNY47A		MCT271	
CQY40	4N26		5–6
FCD825C		TIL117	
FCD836		4N28	5–6
GE3011	MOC3011		5–59
GFH600 III		CNY17–3	5–22
H11G3	H11G3		5–44
H11L2	H11L2		5–48
IL12		4N35	5–14
IL207	MOC207		6–3
MCA11G1	H11G1		5–44
MCP3012	MOC3012		5–59
MCP3032	MOC3032		5–73
MCT2	MCT2		5–51
MCT271	MCT271		
MCT2E	MCT2E		5–51
MOC1003	4N28		5–6
MOC207	MOC207		6–3
MOC3040	MOC3041		5–77
MOC3063	MOC3063		5–81
MOC5009	MOC5009		5–96
MOC604A	4N35		5–14
MOC627A	MOC8050		5–103
MOC635A	MOC3022		5–63
MOC661B	MOC3061		5–81
MOC8100	MOC8100		5–111
MOC8113	MOC8113		5–118
OPI2250	4N28		5–6
OPI2501		H11AA1	5–30
OPI3022	MOC3022		5–63
OPI3041	MOC3041		5–77
OPI3250	4N33		5–10
OPI6100	MOC8204		5–122
SPX103	4N35		5–14
SPX36	4N35		5–14
SPX7272	CNY17–2		5–22
TIL156		4N32	5–10
TIL190		MOC8020	5–99
TLP155	4N35		5–14
TLP3041	MOC3041		5–77
TLP503		4N25	5–6
TLP635F		CNY17–2T	5–22
TLP665G		MOC3022	5–63
TLP676		MOC8020	5–99
H11AV1A	H11AV1A		5–33
IL410		MOC3063	5–81
MOC3021	MOC3021		5–63
TIL115		4N35	5–14
4N25A	4N25A		5–6

Industry Part Number	Motorola Nearest Replacement	Motorola Similar Replacement	Page Number
4N26	4N26		5–6
4N27	4N27		5–6
4N28	4N28		5–6
4N29	4N29		5–10
4N30	4N30		5–10
4N31	4N31		5–10
4N32	4N32		5–10
4N32	4N32		5–10
4N33	4N33		5–10
4N35	4N35		5–14
4N37	4N37		5–14
4N38	4N38		5–18
CLI–2		4N38	5–18
CLI–3		4N35	5–14
CLI–5	4N26		5–6
CNY17G–F–1		CNY17–1	5–22
CNY17G–F–2		CNY17–2	5–22
CNY17G–F–3		CNY17–3	5–22
CNY17–1	CNY17–1		5–22
CNY17–2	CNY17–2		5–22
CNY17–3	CNY17–3		5–22
CNY17–4		CNY17–3	5–22
CNY17–L	CNY17–2		5–22
CNY17–M	CNY17–3		5–22
CNY18	4N25		5–6
CNY21		4N25	5–6
CNY33		H11D1	5–41
CNY35		H11AA2	5–30
CNY47		MCT271	
CNY48		4N32	5–10
CNY51		CNY17–3	5–22
CQY13		4N26	5–6
CQY14		4N25	5–6
CQY15		4N26	5–6
CQY41	4N26		5–6
CQY80		4N26	5–6
EP2		4N26	5–6
FCD810	4N28		5–6
FCD810A	4N28		5–6
FCD810B	4N28		5–6
FCD810C	4N28		5–6
FCD810D	4N28		5–6
FCD825		TIL117	
FCD825A		TIL117	
FCD825B		TIL117	
FCD825D		TIL117	
FCD836C		4N28	5–6
FCD836D		4N28	5–6
FCD850		4N29	5–10
FCD850C		4N29	5–10
FCD850D		4N29	5–10
GE3010	MOC3010		5–59
GE3012	MOC3012		5–59
GE3023	MOC3023		5–63

Industry Part Number	Motorola Nearest Replacement	Motorola Similar Replacement	Page Number
GEPS2001			
GFH600 I	CNY17–2		5–22
GFH600 II	CNY17–3		5–22
GFH601 I	CNY17–1		5–22
GFH601 II	CNY17–2		5–22
GFH601 III	CNY17–3		5–22
GFH601 IV		CNY17–3	5–22
H11A1	H11A1		5–26
H11A5			
H11AA1	H11AA1		5–30
H11AA2	H11AA2		5–30
H11AA3	H11AA3		5–30
H11AA4	H11AA4		5–30
H11AV1	H11AV1		5–33
H11AV2	H11AV2		5–33
H11AV2A	H11AV2A		5–33
H11B1	H11B1		5–37
H11B3	H11B3		5–37
H11D1	H11D1		5–41
H11D2	H11D2		5–41
H11D3	H11D1		5–41
H11D4	H11D2		5–41
H11G1	H11G1		5–44
H11G2	H11G2		5–44
H11J1	MOC3011		5–59
H11J2	MOC3010		5–59
H11J3	MOC3011		5–59
H11J4	MOC3010		5–59
H11J5	MOC3010		5–59
H11L1	H11L1		5–48
H74A1		4N26	5–6
H74C1		MOC5008	5–96
IL1		4N25	5–6
IL16		4N25	5–6
IL2		CNY17–3	5–22
IL201		CNY17–2	5–22
IL202		CNY17–3	5–22
IL205	MOC205		6–3
IL206	MOC206		6–3
IL211	MOC211		6–6
IL212	MOC212		6–6
IL213	MOC213		6–6
IL215	MOC215		6–9
IL216	MOC216		6–9
IL217	MOC217		6–9
IL223	MOC223		6–12
IL250	H11AA1		5–30
IL251	H11AA1		5–30
IL252	H11AA4		5–30
IL256	MOC256		6–15
IL31	MCA231		
IL5		4N25	5–6
IL74		4N35	5–14
ILA30		4N33	5–10
ILA55		4N33	5–10
MCA11G2	H11G2		5–44
MCA11G3	H11G3		5–44
MCA2231		4N33	5–10
MCA2255		4N33	5–10
MCA231	MCA231		

Industry Part Number	Motorola Nearest Replacement	Motorola Similar Replacement	Page Number
MCP3010	MOC3010		5–59
MCP3011	MOC3011		5–59
MCP3021	MOC3021		5–63
MCP3022	MOC3022		5–63
MCP3023	MOC3023		5–63
MCP3030	MOC3031		5–73
MCP3031	MOC3031		5–73
MCP3033	MOC3033		5–73
MCP3040	MOC3041		5–77
MCP3041	MOC3041		5–77
MCP3042	MOC3042		5–77
MCP3043	MOC3043		5–77
MCT210		4N35	5–14
MCT2200		4N35	5–14
MCT2201		4N35	5–14
MCT2202		CNY17–2	5–22
MCT26	4N26		5–6
MCT270		4N35	5–14
MCT272	MCT272		
MCT273	MCT273		
MCT276		CNY17–1	5–22
MCT277	4N35		5–14
MCT5200		CNY17–3	5–22
MCT5201		CNY17–3	5–22
MOC1000	4N26		5–6
MOC1001	4N25		5–6
MOC1002	4N27		5–6
MOC1005	4N26		5–6
MOC1006		4N38	5–18
MOC119	MOC119		5–55
MOC1200	4N29		5–10
MOC205	MOC205		6–3
MOC206	MOC206		6–3
MOC208	MOC208		6–3
MOC211	MOC211		6–6
MOC212	MOC212		6–6
MOC213	MOC213		6–6
MOC215	MOC215		6–9
MOC216	MOC216		6–9
MOC217	MOC217		6–9
MOC223	MOC223		6–12
MOC3010	MOC3010		5–59
MOC3011	MOC3011		5–59
MOC3012	MOC3012		5–59
MOC3022	MOC3022		5–63
MOC3023	MOC3023		5–63
MOC3030	MOC3031		5–73
MOC3031	MOC3031		5–73
MOC3032	MOC3032		5–73
MOC3033	MOC3033		5–73
MOC3041	MOC3041		5–77
MOC3042	MOC3042		5–77
MOC3043	MOC3043		5–77
MOC3051	MOC3051		5–67
MOC3052	MOC3052		5–67
MOC3060	MOC3061		5–81
MOC3061	MOC3061		5–81
MOC3062	MOC3062		5–81
MOC3080	MOC3081		5–92
MOC3081	MOC3081		5–92

Industry Part Number	Motorola Nearest Replacement	Motorola Similar Replacement	Page Number
MOC3082	MOC3082		5–92
MOC3083	MOC3083		5–92
MOC5007	MOC5007		5–96
MOC5008	MOC5008		5–96
MOC601A	4N27		5–6
MOC601B	4N27		5–6
MOC602A	4N26		5–6
MOC602B	4N26		5–6
MOC603A	4N35		5–14
MOC603B	4N35		5–14
MOC604B	4N35		5–14
MOC622A	4N29		5–10
MOC623A	4N32		5–10
MOC624A	4N32		5–10
MOC625A	H11G2		5–44
MOC626A	MOC8030		5–103
MOC628A	MOC8050		5–103
MOC629A	MOC8021		5–99
MOC634A	MOC3021		5–63
MOC634B	MOC3021		5–63
MOC635B	MOC3022		5–63
MOC640A	MOC3041		5–77
MOC640B	MOC3041		5–77
MOC641A	MOC3041		5–77
MOC641B	MOC3041		5–77
MOC660B	MOC3061		5–81
MOC662B	MOC3062		5–81
MOC680B	MOC3081		5–92
MOC681B	MOC3081		5–92
MOC682B	MOC3082		5–92
MOC8020	MOC8020		5–99
MOC8021	MOC8021		5–99
MOC8030	MOC8030		5–103
MOC8050	MOC8050		5–103
MOC8080	MOC8080		5–107
MOC8101	MOC8101		5–115
MOC8102	MOC8102		5–115
MOC8103	MOC8103		5–115
MOC8104	MOC8104		5–115
MOC8111	MOC8111		5–118
MOC8112	MOC8112		5–118
MOC8204	MOC8204		5–122
MOC8205	MOC8204		5–122
MOC8206	MOC8204		5–122
OPI2150	4N28		5–6
OPI2151	4N28		5–6
OPI2152	4N26		5–6
OPI2153	TIL117		
OPI2154	4N26		5–6
OPI2155	4N35		5–14
OPI2251	4N28		5–6
OPI2252	4N26		5–6
OPI2253	TIL117		
OPI2254	4N26		5–6
OPI2255	4N35		5–14
OPI2500	H11AA1		5–30
OPI3010	MOC3010		5–59
OPI3011	MOC3011		5–59
OPI3012	MOC3012		5–59
OPI3021	MOC3021		5–63

Industry Part Number	Motorola Nearest Replacement	Motorola Similar Replacement	Page Number
OPI3023	MOC3023		5–63
OPI3030	MOC3031		5–73
OPI3031	MOC3031		5–73
OPI3032	MOC3032		5–73
OPI3033	MOC3033		5–73
OPI3040	MOC3041		5–77
OPI3042	MOC3042		5–77
OPI3043	MOC3043		5–77
OPI3150	4N33		5–10
OPI3151	4N33		5–10
OPI3153		H11B1	5–37
OPI3251	4N33		5–10
OPI3253		H11B1	5–37
OPI6000	MOC8204		5–122
OPI8015	MOC5009		5–96
PC503	4N26		5–6
SFH600–0	CNY17–1		5–22
SFH600–1	CNY17–2		5–22
SFH600–2	CNY17–3		5–22
SFH601G–2	CNY17–2T		5–22
SFH601G–3	CNY17–3T		5–22
SFH601–1	CNY17–1		5–22
SFH601–2	CNY17–2		5–22
SFH601–3	CNY17–3		5–22
SFH609–1		CNY17–1	5–22
SFH609–2		CNY17–2	5–22
SFH609–3		CNY17–3	5–22
SPX103	4N35		5–14
SPX2	4N35		5–14
SPX26	4N27		5–6
SPX28	4N27		5–6
SPX2E	4N35		5–14
SPX35	4N35		5–14
SPX37	4N35		5–14
SPX4	4N35		5–14
SPX5	4N35		5–14
SPX53	H11A550		
SPX6	4N35		5–14
SPX7271	CNY17–1		5–22
SPX7273	CNY17–3		5–22
TFH601–L		CNY17–2	5–22
TFH601–M		CNY17–3	5–22
TIL111	TIL111		
TIL113	TIL113		
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