marconi instruments

# catalogue
# 1983



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Longacres Plant

# MARCONI INSTRUMENTS LIMITED

**HEADQUARTERS for General Instrumentation, TV, PCM Test Equipment and ATE**
**Longacres · St. Albans · Hertfordshire AL4 0JN**
**Telephone (0727) 59292 · Telex 23350**
*A GEC-Marconi Electronics Company*



*Fleetville Plant St. Albans*

Marconi Instruments is one of the world's leading suppliers of advanced instrumentation and electronics test equipment. Headquartered in St. Albans, England, the company ranks as Europe's leading instrument and test equipment manufacturer.

With a history dating back to the formation of Marconi's pioneering radio equipment company in 1897, Marconi Instruments has a long and distinguished record of supplying state-of-the-art instrumentation and test equipment to users operating at the forefront of the most advanced electronics and communication technologies of the day. Now part of the wide-ranging GEC Marconi Electronics group, Marconi Instruments has the resources, skills and commitment that will ensure that this record of the past and present leadership is matched by continued leadership in the future.

## Instruments

As a leading electronics instrument manufacturer, Marconi Instruments supplies instruments and test equipment suitable for a very wide range of electronics applications. Nevertheless – as might be expected of a company tracing its origins back to the 'Father of Radio' himself – it has a special commitment to meeting the instrumentation needs of users working in the fields of radio communication, sound and television broadcasting, telecommunications and microwave applications. For users working in these fast-moving fields, Marconi Instruments manufactures an unequalled range of both traditional and new-generation instruments designed to provide between them the most sophisticated measurement and test facilities currently attainable.

## Ate

Marconi Instruments is also a leading manufacturer of advanced automatic test systems and related industrial equipment. Since the pioneering development of its original range of in-circuit automatic test systems well over a decade ago, the company has constantly extended its lead in this field, and currently ranks as the largest manufacturer of such equipment in Europe.

More recently, Marconi Instruments has also expanded its automatic testing activities to cover a number of important complementary areas, including advanced functional testing and the computer-aided repair of tested p.c.bs – areas in which it has already firmly established itself by the development of

**MICROWAVE PRODUCTS DIVISION**
**for Microwave Instrumentation, Components, Flexiguide**

Marconi Instruments Limited
Gunnels Wood Road, Stevenage,
Hertfordshire SG1 2AU
Tel: (0438) 2311 Telex: 82159

**SERVICE DIVISION,**
**for Calibration, Repair, Maintenance, Spares**

Marconi Instruments Limited
The Airport
Luton, Bedfordshire LU2 9NS
Tel: (0582) 33866 Telex: 825248

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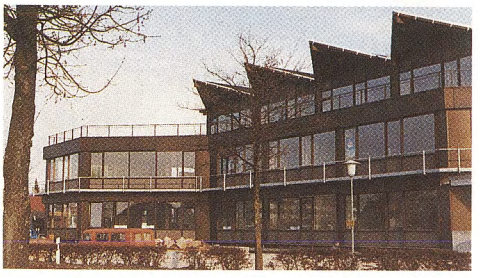
Marconi Instruments Limited
Napier Building
Donibristle Industrial Estate
Near Dunfermline
Fife, KY11 5JE
Tel: (0383) 822131 Telex: 727445

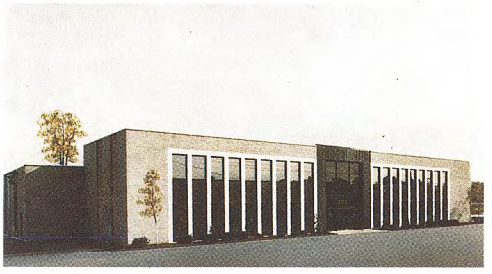










**SALES and SERVICE in FRANCE**

Marconi Instruments
3 avenue Maréchal Devaux
91550 Paray-Vieille-Poste
Tel: (1) 687 36 25 Telex: 203882

**W. GERMANY**

Marconi Messtechnik G.m.b.H.
8034 Germering
Landsberger Strasse 65
Tel: 8984 50 85 Telex: 5212642

**and USA**

Marconi Instruments
100 Stonehurst Court, Northvale
New Jersey, 07647
Tel: (201) 767 7250 Telex: 710 991 9752
and
Marconi Instruments
Automatic Test Equipment Division
292 Gibraltar Drive, Bldg. A-2,
Sunnyvale, CA 94086
Tel: (408) 745-7561 Telex: 910-379-0001

highly innovative new product ranges. In addition, for specialist applications in both the military and civilian sectors, a separate Marconi Instruments' division undertakes a wide variety of design and manufacturing projects encompassing not only advanced automatic test equipment but also other complex computer-based systems such as operational trainers and simulators.

## Support

Marconi Instruments' leading position in the present-day instrumentation and test-equipment industry owes much to its well-earned reputation for the quality of both its products and its user-support services. Typical of the latter are the services offered by the company's three standards laboratories, each officially certified to provide instrument calibration facilities directly traceable to international standards. For product servicing, users have direct access to Marconi Instruments' highly efficient worldwide service organisation, headquartered at Britain's Luton Airport and offering expert servicing and repair of both the company's own products and those of other manufacturers. Special emphasis is also placed on training and the provision of full applications advice.

A full list of Marconi Instruments' worldwide network of associated companies and sales offices appears at the rear of this volume. Your local Marconi Instruments' sales staff will be pleased to supply you with full details of any of the products or services featured. They will also be able to tell you of the new Marconi Instruments' products that—given the company's high rate of product development – will almost certainly have been added to the range since this catalogue was printed.

# Selection guide for Signal Generators and Radio Test Sets

| TYPE NUMBER | APPLICATIONS | FEATURES |
|---|---|---|
| **TF 2015A series** | Production and maintenance testing of commercial and military mobile radio receivers. | Small size. Modest price. |
| **TF 2171** | Synchronizer for use with signal generators in the TF 2015A series. | Provides synthesizer accuracy and stability. |
| **TF 2016A series** | Development, production and maintenance testing of receivers used for AM/FM broadcast, AM and SSB communications, low-band VHF mobile and low-band VHF military. | High output level. Protected against reverse power. Modest price. Small size. |
| **TF 2173** | Synchronizer for use with signal generators in the TF 2016A series. | Provides synthesizer accuracy and stability. |
| **TF 2169** | Used with signal generators to provide a high grade pulse modulation facility for testing radar i.f. systems. | Excellent carrier suppression. Small size. |
| **2017** | Research, development and production testing of a wide range of receivers in the LF, MF, HF, VHF and UHF bands | High output level. Keyboard control. Sweep facility. Low noise. Stable. GPIB programmable. |
| **2018**<br>**2019** | Receiver testing for development, production and maintenance. | Microprocessor control provides simple and rapid operation. Non-volatile memory with 50 settings. GPIB programmable. High output level. Comprehensive amplitude and frequency modulation. |
| **TF 2950 series** | Maintenance testing of VHF and UHF mobile radio equipment. | Internal battery operation. Compact and portable. |
| **2951** | Maintenance and servicing of hand-held, mobile and base station simplex and duplex radio telephones. | Combines all radio servicing instruments in one compact and portable unit. |
| **TF 2952** | Production and maintenance testing of VHF and UHF mobile radio equipment and airborne communications equipment. | Compact. Comprehensive range of measurements. |

marconi instruments

# Signal Generators and Radio Test Sets


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| Mobile Radio Test Set (23 to 520 MHz) | TF 2950 series | 26 |
| Mobile Radio Test Set (24 to 480 MHz) | 2951 | 29 |
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# 10 to 520 MHz AM/FM Signal Generator and Digital Synchronizer

# TF 2015A series TF 2171




- ☐ **Wide frequency range: 10 to 520 MHz**
- ☐ **Three models with peak frequency deviations from 2·5 to 500 kHz**
- ☐ **Amplitude modulation up to 80% depth**
- ☐ **Excellent output level accuracy**
- ☐ **Reverse power protection**
- ☐ **Versatile performance gives good value for money**
- ☐ **Fundamental oscillators for each range— no non-harmonic components**
- ☐ **Optional synchronizer gives frequency stability of ± 1 in $10^7$**
- ☐ **Optional i.f. probes simplify tuning to receivers**

This series of general purpose AM/FM Signal Generators covers the carrier frequency range of 10 to 520 MHz and offers a first-class specification at an economical price. The three models in the series all provide amplitude modulation up to 80% depth and they differ principally in their frequency deviation ranges.

TF 2015A is useful as a general laboratory instrument having two deviation ranges with full-scale settings of 10 kHz and 100 kHz.

TF 2015A/1 is a narrow deviation model with three ranges of 2·5, 5 and 25 kHz peak deviation. It is particularly suitable for mobile radio and other narrow band applications. The ease of setting of low deviations makes it of value in design laboratories as well as for manufacturing and servicing.

TF 2015A/2 is a wide deviation model with ranges of 20, 100 and 500 kHz. It is particularly applicable to measurements on multichannel systems such as those used in data communication and telemetry.

For applications demanding greater frequency accuracy and stability the Digital Synchronizer TF 2171 can be used with TF 2015A series to form a manually synthesized signal generator with an accuracy and long term frequency stability of 1 part in $10^7$.

TF 2015A employs fundamental frequency generation, the range being covered in eleven switched bands using separate voltage-tuned oscillators. Each band has an easily-read scale, with only the scale in use visible at any time. Within each band three tuning controls operate: an 18 section TUNE switch which positions the cursor within 2% of the frequency required, a variable FINE TUNE control linked to the cursor providing interpolation between switched steps, and a ten-turn EXTRA FINE TUNE control which permits frequency adjustment within the smallest pass bands.

Versatile modulation facilities are provided, including internal and external FM and AM. Mixed AM and FM operation is also possible using the internal modulation

oscillator as one source and an external oscillator as the other.

RF output level can be varied from 0·2 μV to 200 mV e.m.f. (–127 dBm to –7 dBm) by means of a coarse attenuator with 10 dB steps and a continuously variable fine attenuator. Automatic level control using a PIN diode attenuator ensures very good output accuracy at all frequencies and level settings, and the instrument's very low r.f. leakage enables output accuracy to be maintained down to the minimum r.f. output level of 0·2 μV.

TF 2015A has an RF OUTPUT scale calibrated in dBm. For TF 2015A/1 and TF 2015A/2 two optional RF OUTPUT scales are available. One is calibrated in dBμV e.m.f. on one side and dBμV p.d. on the reverse. The second is calibrated in dBm on one side and μV and mV p.d. on the reverse. The top cover of all models carries a scale giving conversion between all units.

Due to the fundamental frequency generation employed no non-harmonically related components are present, and incidental modulation is very low. Microphony is also low and frequency stability is good.

Since TF 2015A is tuned by applying a d.c. voltage it readily lends itself to sweep frequency testing applications ranging from the narrow sweeps used for testing the overall response of narrow band receivers to the wider sweeps associated with broadband amplifiers.*

A reverse power protection circuit is incorporated to provide protection of the output circuits against accidental application of r.f. power up to 25 watts. The circuit employs non-linear passive devices at the output terminal which start to conduct at a voltage above normal working levels and thus reflect reverse power from an effective short circuit.

The small size and light weight of the TF 2015A series make them suitable for field servicing, and this is aided by the facility for use on external d.c. supplies and the availability of an optional carrying case. Among the optional accessories available is a range of plug-in, crystal-controlled IF oscillator probes, which simplify tuning to receivers fitted with squelch or battery economizer circuits.

Pulse Modulator TF 2169 is available for use with TF 2015A series enabling high quality pulsed r.f. signals to be generated when pulse waveforms form an external source are fed into the unit. An r.f. output attenuator is included in the modulator. TF 2169 is particularly suitable for testing modern radar receivers.

**An application note (Measuretest No. 20A) is available which discusses the use of TF 2015A for swept frequency testing using narrow sweep widths.*

| TYPE NUMBER | TF 2015A | TF 2015A/1 | TF 2015A/2 |
|---|---|---|---|
| **FREQUENCY** | | | |
| **Range** | 10 MHz to 520 MHz in 11 ranges:<br>10·0 MHz to 14·3 MHz  14·3 MHz to 20·5 MHz<br>20·5 MHz to 29·4 MHz  29·4 MHz to 42·0 MHz<br>42 MHz to 60 MHz  60 MHz to 86 MHz<br>86 MHz to 124 MHz  124 MHz to 177 MHz<br>177 MHz to 254 MHz  254 MHz to 363 MHz<br>363 MHz to 520 MHz | | |
| **Discrimination** | Suitable for tuning into a receiver with a 6 kHz bandwidth (±3 kHz at −3 dB points). | | |
| **Calibration accuracy** | ±1·5% with EXTRA FINE TUNE control centred. | | |
| **Stability** | At a constant ambient temperature in the range 10°C to 35°C and after 2 hours from switch on the drift does not exceed 2 parts in $10^5$ in 5 mins. | | |
| **RF OUTPUT** | | | |
| **Level** | 0·2 μV to 200 mV e.m.f. (−127 dBm to −7 dBm) with up to 80% a.m. Up to 400 mV e.m.f. (−1 dBm) on f.m. and c.w. | | |
| **Attenuators** | *Coarse:* 11 steps of 10 dB. *Fine:* 0 to 10 dB continuously variable. | | |
| **Calibration** | Output calibrated in dBm. | Output calibrated in μV and mV e.m.f. with optional calibrations in μV and mV p.d., dBμV e.m.f. dBμV p.d. and dBm. | |
| **ALC** | With a terminated output, automatic level control maintains the level meter indication substantially constant. | | |
| **Total level accuracy (above 2 μV e.m.f.)** | With CARRIER switch in the ON position. ±1 dB up to 100 MHz ±2 dB above 100 MHz. This includes the ALC loop response. | | |
| **Source impedance** | 50 Ω. VSWR better than 1·3:1 with 10 or more dB inserted in the coarse attenuator. | | |
| **Counter output** | Greater than 80 mV into 50 Ω. | | |
| **Leakage radiation** | Up to 520 MHz with a receiver sensitivity set at 1·0 μV, a 25 mm 2 turn loop feeding the receiver cannot detect a signal of this level at a distance greater than 25 mm from the generator. This permits measurements to be made on receivers with sensitivities down to 0·1 μV. | | |
| **Reverse power protection** | Protects the signal generator output from accidental application of r.f. power from a transmitter at up to 25 W over the frequency range 10 MHz to 520 MHz and at d.c. voltages up to ±50 V. | | |
| **AMPLITUDE MODULATION** | Performance using internal modulating oscillator at 1 kHz. | | |
| **Depth** | Continuously variable up to an indicated 80% by directly calibrated control. | | |
| **Calibration accuracy** | ±5% mod depth at an indicated 30% rising to ±10% mod depth at an indicated 80%. | | |
| **Monitor** | Reference level indicator. | | |

# TF 2015A series

| TYPE NUMBER | TF 2015A | TF 2015A/1 | TF 2015A/2 |
|---|---|---|---|
| **Envelope distortion** | Less than 5% at indicated modulation depths up to 30%. | | |
| **Internal frequency** | 1 kHz ±10%. | | 1 kHz ±10% and 5 kHz ±10%. |
| **AF output** | Fixed level greater than 1·5 V r.m.s. into 10 kΩ. | | |
| **External frequency range** | 50 Hz to 20 kHz. | | |
| **External input requirement** | Less than 1·5 V r.m.s. into 1 kΩ to set reference level. | | Less than 1·75 V r.m.s. into 1 kΩ to set reference level. |
| **FREQUENCY MODULATION** | | | |
| **Deviation** | Continuously variable in two ranges with full scale settings of 10 kHz and 100 kHz peak deviation. | Continuously variable in three ranges with full scale settings of 2·6 kHz, 5·2 kHz and 26 kHz peak deviation. | Continuously variable in three ranges with full scale settings of 20 kHz, 100 kHz and 500 kHz peak deviation. |
| **Monitor** | Reference level indicator. | | |
| **Frequency mod. performance** | Performance using internal modulating oscillator at 1 kHz. | | |
| *Accuracy* | Within 15% of range full scale (20% for deviation above 15 kHz at carrier frequencies between 11 and 60 MHz). | | Within 15% of range full scale subject to maximum deviation limits below. |
| *Distortion* | Less than 3% (5% for deviation above 15 kHz at carrier frequencies between 11 and 60 MHz). | | Less than 3% |
| *Maximum deviation* | 100 kHz. | 25 kHz. | 400 kHz for carrier frequencies above 60 MHz. Usable to 500 kHz with reduced performance. 100 kHz for carrier frequencies below 60 MHz. |
| **Internal frequency** | 1 kHz ±10%. | | 1 kHz ±10% and 5 kHz ±10%. |
| **External frequency response characteristics** | 50 Hz to 20 kHz within ±1 dB of the response at 1 kHz. Usable over the modulation frequency range 30 Hz to 100 kHz. | 50 Hz to 20 kHz within ±1 dB of the response at 1 kHz. | 30 Hz to 100 kHz within ±1 dB of the response at 1 kHz with no connection to the SYNC/SWEEP socket. |
| **External input requirements** | Less than 1·5 V r.m.s. into 1 kΩ to set reference level. | | Less than 1·75 V r.m.s. into 1 kΩ to set reference level. |
| **SPURIOUS SIGNALS** | | | |
| **Carrier harmonics** | At least 26 dB below carrier up to output levels of −7 dBm. | For output levels up to 200 mV e.m.f. and frequencies below 200 MHz harmonics are at least 26 dB below carrier. Up to 200 mV e.m.f. and above 200 MHz, harmonics are at least 20 dB below carrier. | |
| **Non-harmonic components** | None | | |
| **FM on CW** | With telephone psophometric weighting equivalent deviation is less than 60 Hz up to 254 MHz, and less than 100 Hz up to 520 MHz. | | In a bandwidth of 50 Hz to 15 kHz the signal-to-noise ratio with 400 kHz deviation is 72 dB at 60 MHz carrier frequency decreasing to 58 dB at 520 MHz. With 100 kHz deviation the ratio is 68 dB at 10 MHz decreasing to 62 dB at 60 MHz. In a bandwidth of 30 Hz to 200 kHz the signal-to-noise ratio is reduced by 16 dB. |
| **AM on CW** | With telephone psophometric weighting less than 0·2% modulation depth. | | Less than 0·2% modulation depth in a 50 Hz to 20 kHz bandwidth. |
| **FM on AM** | Less than 500 Hz deviation at 30% a.m. with 1 kHz modulating frequency. | | |
| **AM on FM** | With telephone psophometric weighting at 30 kHz deviation less than 3% a.m. above 21 MHz, and less than 5% a.m. below 21 MHz. | With telephone psophometric weighting at 25 kHz deviation less than 3% a.m. above 21 MHz, and less than 5% a.m. below 21 MHz. | Less than 5% modulation depth at maximum deviation for carrier frequencies above 21 MHz, Less than 5% modulation depth at 30 kHz deviation for carrier frequencies below 21 MHz. |
| **POWER REQUIREMENTS** | | | |
| **AC supply** | Any voltage within the extreme limits 190 to 264 V or 95 to 132 V; 10 VA. | | |
| | 45 to 500 Hz. | | 45 to 65 Hz, usable to 500 Hz. |
| **External d.c.** | 24 to 32 V negative earth. | | |

| TYPE NUMBER | TF 2015A | TF 2015A/1 | TF 2015A/2 |
|---|---|---|---|
| SAFETY | Complies with IEC 348. | | |
| RADIO FREQUENCY INTERFERENCE | Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference. | | |
| LIMIT RANGE OF OPERATION<br>Temperature | 0 to 55°C. | | |
| CONDITIONS OF STORAGE AND TRANSPORT<br>Temperature<br>Humidity<br>Altitude | −40°C to +70°C.<br>Up to 90% relative humidity.<br>Up to 2500 m (pressurised freight at 27 kPa differential, i.e. 3·9 lbf/in²). | | |
| DIMENSIONS AND WEIGHT | Height 140 mm 5·5 in; Width 286 mm 11·25 in; Depth 311 mm 12·25 in; Weight 6·1kg* 12 lb<br>*Weight with all supplied accessories 6·9 kg. | | |
| VERSIONS<br>Ordering number and description | 52015–304M AM/FM Signal Generator TF 2015A. | 52015–305C AM/FM Signal Generator TF 2015A/1. | 52015–306R AM/FM Signal Generator TF 2015A/2. |
| SUPPLIED ACCESSORIES | RF Connecting Cable 43126–012S (TM 4969/3). BNC, 50 Ω 1524 mm (60 in) long.<br>TNC to BNC Adaptor 23443–814X for counter output socket.<br>Protective front panel cover 41690–102S.<br>AC Supply Lead 43129–071D.<br>Instruction Manual. | | |
| OPTIONAL ACCESSORIES<br>Ordering number and description | 41690–044B Carrying Case.<br>43281–007C RF Fuse Unit TM 9884 for protection of attenuator resistors when connecting to active loads.<br>54411–051X Matching Unit. BNC connectors. Converts source impedance to 75 Ω. and retains output voltage calibration of signal generator.<br>44411–019G Matching Pad TM 5573/3. BNC connectors. Matches 50 Ω generator to 75 Ω load, voltage ratio loss 2:1.<br>44425–501E 20 dB Pad TM 5573, BNC to BNC.<br>54451–061Y IF Probe 470 kHz.<br>54451–071S IF Probe 10·7 MHz.<br>54451–121B IF Probe 455 kHz.<br>54127–231P Rack Mounting Kit (for rack mounting TF 2015A or TF 2171 alone).<br>54127–241A Rack Mounting Kit (for rack mounting TF 2015A and TF 2171 together). | | |
| | | 35901–628E Output Calibration Plate, marked in dBμV e.m.f. on one side and dBμV p.d. on the other side.<br>35901–701E Output Calibration Plate, marked in dBm on one side and μV and mV p.d. on the other side.<br>TF 2015/1 and TF 2015/2 can be supplied with either of these plates fitted if specified at time of ordering. | |
| ASSOCIATED EQUIPMENT<br>Ordering number and description | 52171–900B Digital Synchronizer TF 2171.<br>52169–900J Pulse Modulator TF 2169. | | |

# Digital Synchronizer

# TF 2171

- ☐ **Provides digital frequency setting facility for Signal Generator TF 2015A series**
- ☐ **Short term frequency stability ± 1 in $10^7$**
- ☐ **Decade controls indicate synchronized frequency to 2 parts in $10^7$**
- ☐ **No degradation of generator leakage**
- ☐ **Full generator modulation facilities retained**




*TF 2171 clipped to TF 2015A* *15157/7*

Digital Synchronizer TF 2171 has been designed for use with Signal Generators in the TF 2015A series to give them a digital setting facility and a frequency stability of 1 part in $10^7$.

The function of the synchronizer is to provide a high stability reference frequency to which the generator can be phase locked. Once the lock condition has been achieved any subsequent drift in the generator's frequency is automatically corrected by a control voltage produced in the synchronizer and fed back to the f.m. circuitry of the generator. All the generator facilities are unimpaired, including a.m. and f.m. capabilities, and warm-up drift is eliminated.

Operation of the synchronizer is very simple. The required frequency is first set up digitally on seven panel switches on TF 2171, giving setting at increments of 100 Hz. Having selected the appropriate frequency range on the signal generator all that is necessary is to tune the switched TUNE control until the synchronizer OUT OF LOCK lamp is extinguished. Once this has been done the TF 2171 takes over the tuning process and automatically sets the generator to the required frequency. Once synchronization has been achieved the decade controls of TF 2171 can be used to digitally increment the generator frequency over a range of approximately 1% of the setting in 100 Hz steps. Use of the synchronizer renders completely unnecessary the use of a counter for accurate setting of the generator frequency, eliminating the associated radiation problems.

TF 2171 is mounted in a case of similar dimensions to TF 2015A and is supplied with the necessary interconnecting leads and a set of clips to enable the two instruments to be rigidly fixed together if required.

| | |
|---|---|
| **CARRIER FREQUENCY** | |
| Range | 10 MHz to 520 MHz. Specifically for use with Signal Generator TF 2015A. |
| Selection | Seven decade switch controls 100 Hz steps. |
| Incremental frequency control | After synchronization, the decade controls can be used to increment digitally the generator carrier frequency over a range of typically ±0·5% without retuning the generator. |
| **INTERNAL FREQUENCY STANDARD** | |
| Ageing rate | Not greater than ±1 in $10^7$ per month after 3 months continuous use. |
| Temperature coefficient | Not greater than ±1 in $10^7$ frequency change over the range 0 to +40°C. Adjustment: by rear panel pre-set control. |
| Warm-up time | Typically 10 minutes for the frequency to be within ±2 in $10^7$ of the final value. |
| Output level | Not less than 2 V p-p square wave at 1 MHz. |
| **EXTERNAL STANDARD INPUT** | Switched socket providing internally generated 1 MHz standard signal, or accepting 1 MHz input signal from external standard. |
| Input level | 2·5 V p-p at 1 MHz. Maximum input 5 V p-p. |
| **RF INPUT LEVEL** | Compatible with TF 2015A series counter output. |
| **RF LEAKAGE** | When used with TF 2015A series and the internal frequency standard, the r.f. leakage specification of the generator is maintained. |
| **POWER REQUIREMENTS** | |
| AC supply | Any voltage within the limits 95 V to 130 V and 190 V to 264 V. 45 to 500 Hz. 30 VA. |
| **SAFETY** | Complies with IEC 348. |

| | |
|---|---|
| **RADIO FREQUENCY INTERFERENCE** | Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference. |
| **LIMIT RANGE OF OPERATION** | |
| Temperature | 0 to 40°C. |
| **CONDITIONS OF STORAGE AND TRANSPORT** | |
| Temperature | −40°C to +70°C. |
| Humidity | Up to 90% relative humidity. |
| Altitude | Up to 2500 m (pressurised freight at 27 kPa differential, i.e. 3·9 lbf/in²). |
| **DIMENSIONS AND WEIGHT** | Height 140 mm 5·5 in; Width 286 mm 11·25 in; Depth 311 mm 12·25 in; Weight 5·7 kg 12·5 lb |

**VERSIONS AND ACCESSORIES**

*When ordering, please quote eight-digit code numbers*

| Ordering numbers | |
|---|---|
| 52171–900B | **Versions**<br>Digital Synchronizer TF 2171. |
| | **Supplied Accessories**<br>RF Lead 43129–063F, 50 Ω BNC to BNC.<br>RF Lead 43129–190H, 50 Ω TNC to TNC.<br>Mounting Kit 46883–214N, for fixing TF 2171 rigidly to TF 2015A series.<br>AC Supply Lead 43129–071D.<br>Instruction Manual 46881–236H. |
| 41690–044B<br>43129–103V | **Optional Accessories**<br>Carrying Case.<br>RF Lead, 50 Ω, TNC to BNC.<br>Rack Mounting Kits. (See optional accessories for TF 2015A.) |

# IF Probes

# 54451 series

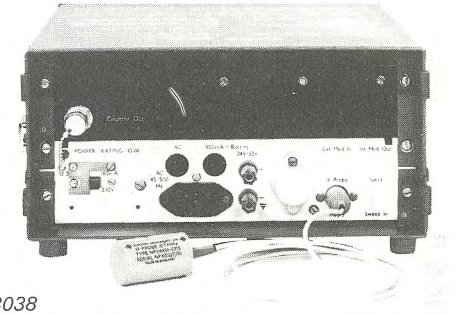
## ☐ Crystal-controlled oscillators simplify tuning to receivers

These three IF Probes have been designed for use with AM/FM Signal Generator TF 2015A series. They consist of crystal-controlled oscillators available at the most commonly used intermediate frequencies and they are powered from a 22 V supply outlet on the rear panel of TF 2015A via a lead attached to the probe.

The probes make it easy to tune in to receivers fitted with squelch or battery economizer circuits by turning on the receiver when they are brought into close proximity with the IF strip. A second use is for ensuring that the generator is accurately tuned to the r.f. circuits in the receiver. With the generator tuned to the nominal channel frequency any difference between the receiver i.f. and the probe frequency will produce a beat note in the receiver output. The generator tuning can then be adjusted to give zero beat.

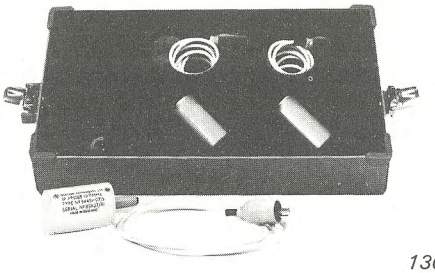
| | | | |
|---|---|---|---|
| **ORDERING NUMBER** | 54451 – 121B | 54451 – 061Y | 54451 – 071S |
| **NOMINAL FREQUENCY** | 455 kHz | 470 kHz | 10·7 MHz |
| **FREQUENCY ACCURACY (at 20°C and 22 V supply)** | ±1 in $10^4$ | ±1 in $10^4$ | ±2 in $10^5$ |
| **TEMPERATURE COEFFICIENT OF FREQUENCY (0 to 55°C)** | Less than ±10 p.p.m. per °C | Less than ±10 p.p.m. per °C | Less than ±1 p.p.m. per °C |
| **OUTPUT** | Suitable for introducing a signal into the receiver IF strip by proximity of radiated r.f. field. | | |
| **CONNECTOR** | 2-pin, non-reversible DIN 41529 to fit power socket on TF 2015A series. | | |
| **POWER REQUIREMENTS** | | | |
| DC supply | +19 V to +24 V. 2 mA. Obtained from socket on TF 2015A series via cable attached to probe. | | |
| **DIMENSIONS** | Length 45 mm 1·75 in | Diameter 27 mm 1·06 in | Lead Length 1067 mm 42 in |

## ☐ Range covers commonly-used intermediate frequencies



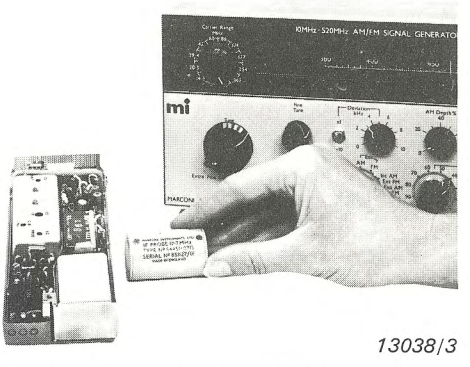
13038

*Rear view of TF 2015A showing connection of IF Probe*



13038/1

*IF Probes are stored in protective lid of the Signal Generator. A foam insert is supplied with each probe.*



13038/3

*Probe used in proximity to i.f. strip.*

# 10 kHz to 120 MHz AM/FM
# Signal Generator TF 2016A series




14662/1

- ☐ **Wide frequency range: 10 kHz to 120 MHz**
- ☐ **Amplitude modulation up to 100% depth**
- ☐ **Frequency modulation up to 75 kHz deviation**
- ☐ **Output levels from 0·2 μV to 4 V e.m.f.**
- ☐ **Reverse power protection**
- ☐ **Excellent output level accuracy**
- ☐ **Fundamental frequency generation – no spurious signals**
- ☐ **Compact and portable – 24 V battery supply can be used**
- ☐ **Optional digital synchronizer with frequency stability of ± 1 in $10^7$**

TF 2016A is a general purpose AM/FM Signal Generator covering the frequency range 10 kHz to 120 MHz and is a complementary instrument to the VHF/UHF Signal Generator TF 2015. Apart from its value as a general laboratory instrument it will find particular application in the production and maintenance testing of HF and low band VHF receivers. It has been designed for reliable operation over a wide range of environmental conditions and its robust construction and simplicity of operation make it especially suitable for military use.

For applications demanding a greater frequency accuracy and stability the Digital Synchronizer TF 2173 can be used with TF 2016A to form a manually synthesized signal generator with a long term stability of ±1 part in $10^7$ per month.

A system of fundamental frequency generation is employed, the range being covered in twelve switched bands, so ensuring complete freedom from non-harmonically related spurious signals. Each band has an easily-read scale, with only the scale in use visible at any time. Tuning within each band is carried out by an 18 position TUNE switch which positions the cursor close to the frequency required, and a variable FINE TUNE control linked to the cursor provides interpolation between the switched steps. A ten-turn EXTRA FINE TUNE control permits precise frequency adjustment to be made when

tuning the generator to a receiver channel frequency. Monitoring of the tuned frequency is made possible by the provision of a counter output socket on the rear panel of the instrument. During normal operation this socket is covered by a cap to prevent r.f. leakage. A suitable adapter giving a BNC connection facility is available and a retaining clip for this unit is also on the rear panel.

Versatile modulation facilities are provided, including internal and external FM and AM with deviations up to 75 kHz (three switched ranges of 5, 25 and 75 kHz full scale) and AM depth up to 100%. Mixed AM and FM operation is also possible using the internal modulation oscillator as one source and an external oscillator as the other. A front-panel modulation on/off switch aids in making rapid signal-to-noise ratio measurements.

Since TF 2016A is tuned by applying a direct voltage it readily lends itself to sweep frequency testing applications ranging from the narrow sweeps used for testing the overall response of narrow band receivers to the wider sweeps associated with broadband amplifiers.*

An alternative model of the generator is available with a preset f.m. facility for testing receivers in which a 150 Hz tone is used to lift the audio muting circuits, so overcoming the need for separate signal injection.

RF output level can be varied from 0·2 μV to 4 V e.m.f. (open circuit voltage) by means of coarse and fine attenuators, the coarse attenuator introducing 10 dB steps and the continuously variable fine attenuator allowing interpolation between the steps. The output attenuator is calibrated in μV, mV and V e.m.f., but alternative output calibration plates can be fitted giving calibration either in voltage p.d. (across 50 Ω) and dBm, or in dB μV e.m.f. and dB μV p.d. Automatic level control, together with a carefully designed attenuator, ensures ±1 dB output level accuracy across the full range of frequency and for output level settings above 2 μV e.m.f. The low leakage of the generator enables accurate measurements to be made on receivers with sensitivities down to 0·1 μV.

A specially-designed coaxial relay circuit is used which offers protection against input powers up to 100 watts without any degradation of the level accuracy and v.s.w.r. of TF 2016A. Reverse power overloads are detected by a diode, causing the relay to open and so preventing damage to the output attenuator or the output amplifer. The relay is then held in its open condition and a front-panel TRIP light is illuminated to warn the operator that an overload has been detected and that the output is disconnected. Pressing the RESET button closes the relay and, if the overload has been removed, allows the normal output to be obtained, but if the overload is still present the relay will be opened again and the TRIP light will remain illuminated.

A further safety feature of the protection circuit is that the relay automatically switches to its open position when the power supply (a.c. or d.c.) to the instrument is disconnected. This ensures that the instrument cannot be damaged by accidental application of r.f. or d.c. power to its output socket even when it is in a non-operational state.

The small size and light weight of TF 2016A make it suitable for field servicing and this is aided by the ability of the instrument to operate from a 24 V d.c. supply. A carrying case, available as an optional accessory, protects the instrument during transit. Other optional accessories include crystal controlled IF oscillator probes and a range of impedance matching units.

Pulse Modulator TF 2169 is available for use with TF 2016A enabling high quality pulsed r.f. signals to be generated for testing i.f. units of modern radar systems.

**An application note (Measuretest No. 20A) is available which discusses the use of TF 2016A for swept frequency testing using narrow sweep widths.*

## MODEL 52016-910C

| FREQUENCY | |
|---|---|
| Range | 10 kHz to 120 MHz in 12 ranges<br>10 to 22 kHz 1·1 to 2·4 MHz<br>22 to 48 kHz 2·4 to 5·2 MHz<br>48 to 105 kHz 5·2 to 11·4 MHz<br>105 to 230 kHz 10 to 23 MHz<br>230 to 500 kHz 23 to 53 MHz<br>0·5 to 1·1 MHz 53 to 120 MHz |
| Discrimination | Suitable for tuning into a narrow band receiver (tuning discrimination better than 1 in $10^3$). |
| Scale accuracy | ±2% with EXTRA FINE TUNE control centred. |
| Stability | At a constant ambient temperature in the range 10°C to 35°C and after 2 hours from switch on the drift does not exceed 25 Hz per 5 min up to 200 kHz and 20 p.p.m. +100 Hz per 5 min above 200 kHz. |
| Frequency sweep input | A direct voltage applied to the SYNC/SWEEP IN connector can be used to vary the carrier frequency over the frequency cover of any one range. |

| RF OUTPUT | |
|---|---|
| Level | 0·2 μV to 2 V e.m.f. with up to 100% AM. Up to 4 V e.m.f. in CW and FM modes. |
| Attenuators | *Coarse:* 13 steps of 10 dB.<br>*Fine:* 0 to 10 dB continuously variable. |
| Calibration | Output calibrated in μV, mV and V e.m.f. Alternative plates are available giving calibration in μV, mV and V p.d., dBm, dB μV p.d. and dB μV e.m.f. |
| ALC | With output terminated automatic level control maintains the level substantially constant. |
| Total level accuracy (above 2 μV e.m.f.) | With CARRIER switch in the ON position the output level is within ±1 dB of the indicated value. |
| Source impedance | 50 Ω; VSWR better than 1·2:1 with 10 or more dB inserted in the coarse attenuator. Front panel BNC socket. |
| Counter output | Greater than 50 mV into 50 Ω from rear panel TNC socket. |

# TF 2016A series

**Leakage radiation**
Less than 0·5 μV in a 2 turn 25 mm diameter loop, 25 mm or more from the instrument. This permits measurements to be made on receivers with sensitivities down to 0·1 μV.

**Reverse power protection**
Protects the signal generator output from accidental application of r.f. power up to 100 W from 10 kHz to 120 MHz, and direct voltages up to ±50 V. LED indication and reset push-button are provided.

## AMPLITUDE MODULATION

**Carrier frequency range**
100 kHz to 120 MHz. Usable down to 10 kHz.

**Depth**
Continuously variable up to an indicated 100% by directly calibrated control.

**Monitor**
Reference Level Indicator.

**Accuracy and distortion at 1 kHz (with internal modulation oscillator)**
Over the carrier frequency range 0·1 to 120 MHz the accuracy of AM indication and the envelope distortion are given by the following table.

| Carrier Frequency Range (MHz) | AM Depth | | | |
|---|---|---|---|---|
| | 30% | | 80% | |
| | Accuracy within* | Distortion less than | Accuracy within* | Distortion less than |
| 0·1–30 | ±3·5% | 1·5% | ±4% | 3% |
| 30–90 | ±4·5% | 3% | ±6% | 6% |
| 90–120 | ±5·5% | 3% | ±8% | 6% |

*Figures quoted are in terms of ± modulation depth.

**Internal modulation frequency**
Switch selected 400 Hz or 1 kHz ±5%.

**AF output**
Fixed level greater than 1 V r.m.s. into 10 kΩ from rear panel BNC socket.

**External frequency response characteristic**
100 Hz to 10 kHz within 0·5 dB of the response at 1 kHz.

**External input requirement**
Less than 1·5 V r.m.s. into 1 kΩ to set reference level.

## FREQUENCY MODULATION

**Carrier frequency range**
1·1 to 120 MHz.

**Deviation**
Continuously variable in three ranges with full scale settings of 5 kHz. 25 kHz and 75 kHz.

**Monitor**
Reference Level Indicator.

**Accuracy**
±15% of f.s.d. at 1 kHz modulating frequency.

**FM distortion (using internal 1 kHz modulation oscillator)**
The maximum deviation obtainable for values of total harmonic distortion not exceeding 2% and 4% are given by the following table.

| Carrier Frequency Range (MHz) | Maximum deviation obtainable for t.h.d of | |
|---|---|---|
| | 2% | 4% |
| 1·1–2·4 | — | 5 kHz |
| 2·4–5·2 | 5 kHz | 25 kHz |
| 5·2–11·4 | 25 kHz | 75 kHz |
| 10–120 | 75 kHz | — |

**Internal modulation frequency**
Switch selected 400 Hz or 1 kHz ±5%.

**AF output**
Fixed level greater than 1 V r.m.s. into 10 kΩ from rear panel BNC socket.

**External frequency response characteristic**
With f.m. deviation up to the maximum shown in the table above, 50 Hz to 10 kHz within 1 dB of the response at 1 kHz. Usable to 100 kHz at carrier frequencies above 30 MHz.

**FM stereo performance (88 to 108 MHz and 10·7 MHz on 5·2 to 11·4 MHz range only)**
Channel separation better than 30 dB at 1 kHz modulation frequency. FM distortion typically less than 0·5% t.h.d. for deviations up to 75 kHz with carrier frequencies between 88 and 108 MHz.

**External input requirement**
Less than 1·5 V r.m.s. into 1 kΩ to set reference level.

## SPURIOUS SIGNALS

**Carrier harmonics**
At least 26 dB below carrier at output levels up to 2 V e.m.f.

**Non-harmonically related coherent components**
None. Fundamental frequency generation produces no non-harmonically related coherent components.

**FM on CW**
With telephone psophometric weighting (CCITT P53 network), equivalent deviation is less than 10 Hz up to 53 MHz and less than 20 Hz up to 120 MHz.

**AM on CW**
With telephone psophometric weighting (CCITT P53) less than 0·05% modulation depth.

## SAFETY

Complies with IEC 348.

## RADIO FREQUENCY INTERFERENCE

Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference.

## LIMIT RANGE OF OPERATION

**Temperature**
0 to 55°C.

## CONDITIONS OF STORAGE AND TRANSPORT

**Temperature**
−40°C to +70°C.

**Humidity**
Up to 90% relative humidity.

**Altitude**
Up to 2500 m (pressurised freight at 27 kPa differential, i.e. 3·9 lbf/in²).

## POWER REQUIREMENTS

**AC supply**
Any voltage within the extreme limits 190 to 264 V or 95 to 132 V, at any frequency between 45 Hz and 65 Hz, usable to 500 Hz.
40 VA (32 W) maximum.

**External d.c.**
23 to 32 V negative earth. 0·7 A maximum current consumption

## IF PROBE SUPPLY

Rear panel socket provides power for optional IF Probes (+20 V behind 470 Ω).

## DIMENSIONS AND WEIGHT

| Height | Width | Depth | Weight |
|---|---|---|---|
| 140 mm | 286 mm | 311 mm | 6·6 kg* |
| 5·5 in | 11·25 in | 12·25 in | 15·4 lb |

*Weight with all supplied accessories 7·2 kg.

## MODEL 52016-302E

The specification for this model is the same as that given above with the following exceptions.

| | |
|---|---|
| **AMPLITUDE MODULATION** | |
| Internal modulation frequency | 1 kHz ±5%. |
| **FREQUENCY MODULATION** | |
| Internal modulation frequency | 1 kHz ±5%. |
| **PRESET FM** | |
| Operation | ON/OFF switch selects preset frequency modulation irrespective of position of main function switch. |
| Carrier frequency range | 1·1 to 120 MHz. |
| Deviation | 3 kHz ±15% (adjustable by internal preset control). |
| Modulating frequency | 150 ±2 Hz (adjustable by internal preset control). |
| AF output | When the preset modulation facility is in use output is available at a 2 mm socket on the rear panel for monitoring by a frequency counter. |

### VERSIONS AND ACCESSORIES

*When ordering please quote eight digit code numbers*

| Ordering numbers | Versions |
|---|---|
| **52016–910C** | AM/FM Signal Generator TF 2016A. (Nato Cat. No. 6625–99–654–0885) |
| **52016–302E** | AM/FM Signal Generator TF 2016A with preset pilot tone f.m. |

| | |
|---|---|
| | **Supplied Accessories**<br>Protective Front Panel Cover 41690–102S.<br>AC Supply Lead 43129–071D.<br>Instruction Manual 46881–341H (H52016–910C). |
| | **Optional Accessories** |
| **35902–255P** | Conversion plate for output attenuator. Reversible plate calibrated in µV p.d. and dBm. |
| **35902–256X** | Conversion plate for output attenuator. Reversible plate calibrated in dB µV e.m.f. and dB µV p.d.<br>TF 2016A can be supplied with either of these conversion plates fitted if specified at the time of ordering. |
| **41690–044B** | Carrying Case. |
| **43126–012S** | RF Connecting Cable 50 Ω, BNC, 1·5 m. (59 in.). |
| **44411–001M** | Matching Unit TM 5569. A series 25 Ω resistor converts the effective source resistance from 50 Ω to 75 Ω. BNC socket to Belling-Lee L734/P plug. |
| **44411–019G** | Matching Pad TM 5573/3 for matching 50 Ω Generator to 75 Ω load, BNC, voltage ratio loss 2:1. |
| **54127–231P** | Rack Mounting Kit (for rack mounting TF 2016A or TF 2173 alone). |
| **54127–241A** | Rack Mounting Kit (for rack mounting TF 2016A and TF 2173 together). |
| **54311–071Z** | Adapter TNC to BNC for counter output socket. |
| **54451–061Y** | IF Probe 470 kHz. |
| **54451–071S** | IF Probe 10·7 MHz. |
| **54451–121B** | IF Probe 455 kHz.<br>The IF Probes provide crystal controlled signals at standard IF frequencies for use in receiver alignment. For details see page 7 |
| | **Associated Equipment** |
| **52169–900J** | Pulse Modulator TF 2169.<br>For details see page 14 |

# Digital Synchronizer TF 2173




14662/5

- ☐ **Provides digital frequency setting facility for Signal Generator TF 2016A**
- ☐ **Frequency stability ± 1 in $10^7$**
- ☐ **Decade controls set synchronized frequency with 10 Hz resolution**
- ☐ **No degradation of generator leakage**
- ☐ **Full generator modulation facilities retained**

Digital Synchronizer TF 2173 has been designed for use with Signal Generator TF 2016A to give a digital setting facility and a frequency stability of better than 1 part in $10^7$.

The function of the synchronizer is to provide a high stability reference frequency to which the generator can be phase locked. Once the lock condition has been achieved any subsequent drift in the generator's frequency is automatically corrected by a control voltage produced by the synchronizer and fed back to the d.c. coupled tuning circuitry of the TF 2016A. All the generator facilities are unimpaired, including a.m. and f.m. capabilities, and warm-up drift is eliminated.

Operation of the synchronizer is very simple. The required frequency is first set up digitally on the seven panel switches of TF 2173, giving setting increments of

10 Hz. Having selected the appropriate frequency range on the signal generator all that is necessary is to tune the generator to approximately the correct frequency until the Synchronizer OUT OF LOCK lamp is extinguished. Once this has been done the TF 2173 takes over the tuning process and automatically sets the generator to the required frequency. Once synchronization has been achieved the decade controls of TF 2173 can be used to increment digitally the generator frequency over a range of approximately 2% of the setting in steps as small as 10 Hz. This facility is particularly useful when testing channelised equipment – for example at frequencies above 50 MHz digital settings alone can be used to alter the generated frequency by at least 1 MHz in steps equal to the channel spacing. Use of the synchronizer renders completely unnecessary the use of a counter for accurate setting of the generator frequency, eliminating the associated radiation problems.

TF 2173 is mounted in a case of similar dimensions to TF 2016A, and is supplied with the necessary interconnecting leads and fitted with clips to enable the two instruments to be securely fixed together if required.



*TF 2016A and TF 2173 being used to test a military transceiver* 14702/1

| | |
|---|---|
| **CARRIER FREQUENCY** | |
| Range | 10 kHz to 119·99999 MHz. Specifically for use with Signal Generator TF 2016A. |
| Selection | Seven decade switch controls. 10 Hz steps. |
| Incremental frequency control | After synchronization, the decade controls may be used to increment digitally the generator carrier frequency over a range of typically 2% without retuning the generator. |
| **INTERNAL FREQUENCY STANDARD** | |
| Ageing rate | Not greater than ±1 in $10^7$ per month after 3 months continuous use. |
| Temperature coefficient | Not greater than ±1 in $10^7$ frequency change over the temperature range 0 to +40°C. Adjustment by rear panel pre-set control. |
| Warm-up time | Typically 10 min for the frequency to be within ±2 in $10^7$ of the final value. |
| Output level | Not less than 2 V p-p square wave at 1 MHz. |
| **EXTERNAL STANDARD INPUT** | Switched socket providing internally generated 1 MHz standard signal, or accepting a 1 MHz input signal from an external standard. |
| Input level | 2·5 V p-p at 1 MHz. Maximum input 5 V p-p. |
| **RF INPUT LEVEL** | Compatible with TF 2016A counter output. |
| **RF LEAKAGE** | When used with TF 2016A on the internal frequency standard, the r.f. leakage specification of the generator is maintained. |
| **SAFETY** | Complies with IEC 348. |
| **RADIO FREQUENCY INTERFERENCE** | Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference. |

| | |
|---|---|
| **LIMIT RANGE OF OPERATION** | |
| Temperature | 0 to 55°C. |
| **CONDITIONS OF STORAGE AND TRANSPORT** | |
| Temperature | −40°C to +70°C. |
| Humidity | Up to 90% relative humidity. |
| Altitude | Up to 2500 m (pressurised freight at 27 kPa differential, i.e. 3·9 lbf/in²). |
| **POWER REQUIREMENTS** | |
| AC supply | Any voltage within the limits 95 to 132 V and 190 to 264 V. 45 to 500 Hz. 30 VA. |
| **DIMENSIONS AND WEIGHT** | |

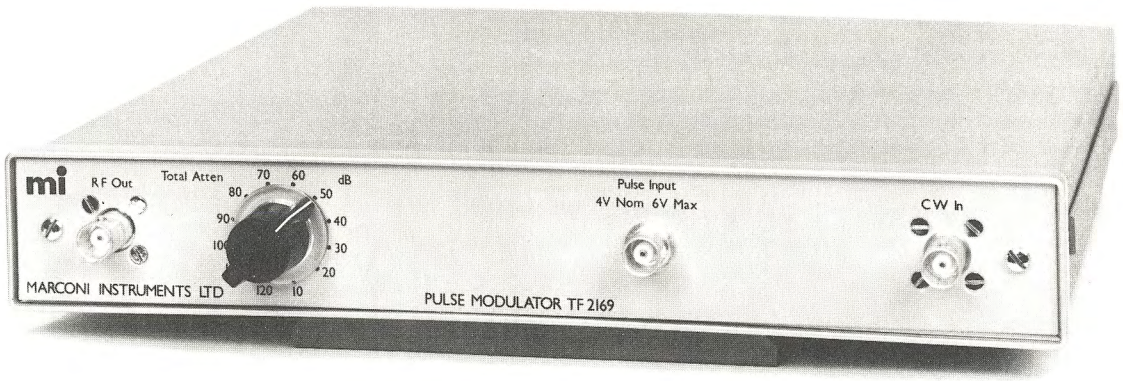
| Height | Width | Depth | Weight |
|---|---|---|---|
| 140 mm | 286 mm | 311 mm | 5·7 kg |
| 5·5 in | 11·25 in | 12·25 in | 12·5 lb |

## VERSIONS AND ACCESSORIES

*When ordering please quote eight digit code numbers*

| Ordering numbers | |
|---|---|
| 52173–900M | **Versions**<br>Digital Synchronizer TF 2173. (Nato Cat. No. 6625–99–645–9552). |
| | **Supplied Accessories**<br>Protective Front Panel Cover 41690–102S.<br>RF Lead 43129–063F, 50 Ω, BNC to BNC.<br>RF Lead 43129–190H, 50 Ω, TNC to TNC.<br>AC Supply Lead 43129–071D.<br>Instruction Manual 46881–318V (H52173–900M). |
| 41690–044B<br>54127–231P | **Optional Accessories**<br>Carrying Case.<br>Rack Mounting Kit (for TF 2016A or TF 2173). |

# Pulse Modulator TF 2169




14177/1

- ☐ **For use with Signal Generators TF 2015A and TF 2016A series and other generators**
- ☐ **Frequency range: 10 to 520 MHz**
- ☐ **Particularly suitable for testing radar intermediate frequencies**
- ☐ **Accurate output attenuator**
- ☐ **Excellent carrier suppression**
- ☐ **Narrow pulses, fast rise times suitable for high discrimination radar**

Pulse Modulator TF 2169 is particularly suitable for use with signal generators in the TF 2015A and TF 2016A series to enable high quality pulsed r.f. signals to be generated. It may also be used with many other signal generators.

The modulator requires two inputs, the r.f. carrier from a signal generator and a pulse waveform from an external pulse generator. Two ring modulators are used to produce the modulated signal, giving excellent r.f. carrier suppression. The output is taken via an accurate built-in r.f. attenuator with a range of 0 to 110 dB in 10 dB steps. When the instrument is used with TF 2015A or TF 2016A, fine adjustment of the output can be obtained by use of the generator's fine attenuator control.

TF 2169 will find particular application in the manufacture, commissioning, maintenance or operation of radar systems, both military and commercial, including marine and meteorological systems. Its wide frequency cover includes all the standard radar intermediate frequencies. Important features are the excellent carrier suppression, which is necessary when checking the linearity of the logarithmic amplifiers used in the latest radar systems, and the ability to provide the narrow pulses with fast rise times needed for testing high discrimination systems.

TF 2169 is built into a small case suitable for connection to the TF 2015 or TF 2016A and mounting kits are available for clipping the two instruments together.

Higher level pulse outputs than are available with TF 2169 alone can be obtained by using it in conjunction with RF Amplifier TF 2167 which has a bandwidth of 50 kHz to 80 MHz and a gain of 47 dB.

| | |
|---|---|
| **CW INPUT** | |
| Frequency | 10 to 520 MHz. |
| Level | 100 mV to 30 mV p.d. (−7 dBm to −17 dBm). |
| Impedance | Approximately 50 Ω. |
| **PULSE INPUT** | |
| Minimum level | 3·5 V. |
| Maximum level | 6 V. |
| Polarity | Positive or negative going. |
| Impedance | 50 Ω. |
| **RF OUTPUT** | |
| Carrier insertion loss | 10 dB ±2 dB. |
| Attenuator range | 0 to 110 dB in 11 steps of 10 dB (panel marked 10 to 120 dB to allow for insertion loss of 10 dB). |
| Attenuator accuracy | Each step of 10 dB is within ±0·3 dB. The maximum cumulative error is ±1 dB. |
| Output impedance | 50 Ω. |
| Pulse duration | 100 ns to infinity (d.c. coupled). |
| Pulse rise time | Less than 25 ns. |
| Carrier suppression | At least 70 dB up to 80 MHz, falling to 50 dB at 520 MHz (typically 90 dB up to 80 MHz). |
| Input pulse present at output | Less than 10% of peak carrier amplitude. |
| **CONNECTORS** | BNC sockets for CW IN, PULSE IN and RF OUT. |
| **RADIO FREQUENCY INTERFERENCE** | Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference. |
| **SAFETY** | Complies with IEC 348. |

| | |
|---|---|
| **LIMIT RANGE OF OPERATION** | |
| Temperature | 0 to 55°C. |
| **CONDITIONS OF STORAGE AND TRANSPORT** | |
| Temperature | −40°C to +70°C. |
| Humidity | Up to 90% relative humidity. |
| Altitude | Up to 2500 m (Pressurized freight at 27 kPa differential, i.e., 3·9 lbf/in²). |

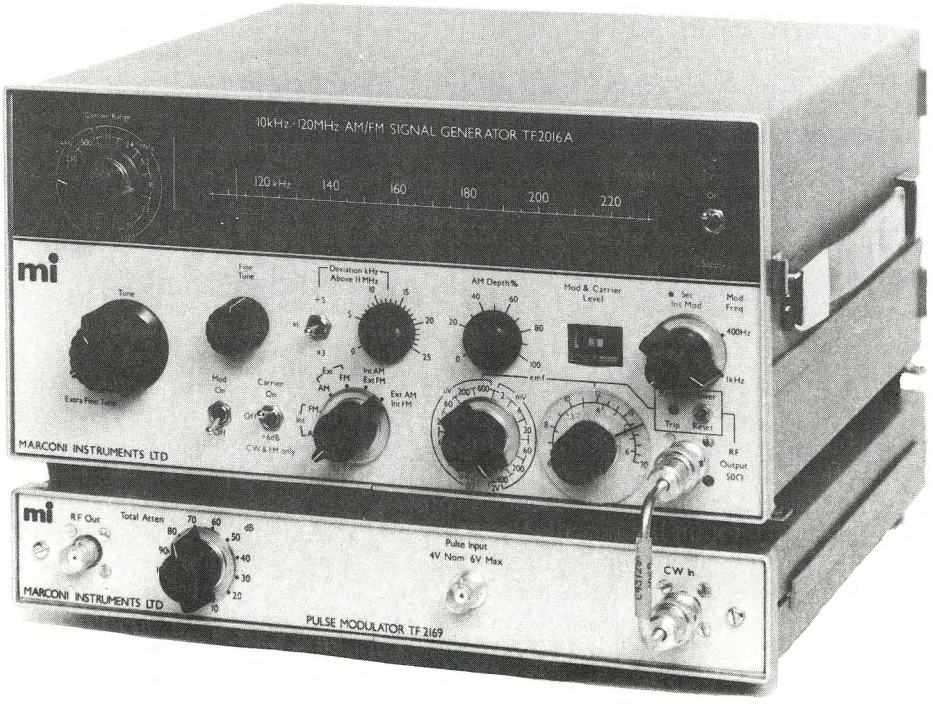
**DIMENSIONS AND WEIGHT**

| Height | Width | Depth | Weight |
|---|---|---|---|
| 52 mm | 274 mm | 268 mm | 1·7 kg |
| 2·05 in | 10·8 in | 10·55 in | 3·75 lb |

## VERSIONS AND ACCESSORIES

*When ordering please quote eight-digit code numbers*

| Ordering numbers | |
|---|---|
| **52169-900J** | **Versions**<br>Pulse Modulator TF 2169. (NATO Cat. No. 6625-99-645-9235.) |
| | **Supplied Accessories**<br>Instruction Manual 46881-277J. |
| **43129-106D** | **Optional Accessories**<br>Lead Assembly. To connect TF 2169 to TF 2015A or TF 2016A. |
| **54127-291S** | Mounting Kit. To fit to TF 2015A for connection to TF 2169. (This kit is not needed for fitting TF 2016A to TF 2169.) |
| **46883-220F** | Mounting Kit. To fit to TF 2169 for connection to TF 2015A or TF 2016A. |




*TF 2169 attached to TF 2016A*

# 10 kHz to 1024 MHz
# AM/FM Signal Generator 2017




15041/1

- ☐ **Wide frequency range: 10 kHz to 1024 MHz**
- ☐ **High output level: up to 4 V e.m.f. (+19 dBm)**
- ☐ **Simple operation by keyboard entry of settings**
- ☐ **GPIB programmable**
- ☐ **Frequency modulation up to 2·56 MHz deviation**
- ☐ **Amplitude modulation up to 99% depth**
- ☐ **Low noise**
- ☐ **Excellent output level accuracy**
- ☐ **Built-in frequency sweep facility**
- ☐ **Microprocessor control with memory facilities**

Signal Generator 2017 is a stable, low-noise generator offering high outputs over the frequency range 10 kHz to 1024 MHz. Microprocessor control makes the instrument easy to use by direct keyboard entry or by the use of rotary controls. Programmability via the General Purpose Interface Bus extends the range of applications of the 2017 to include automatic testing either as part of a simple bench-top system or in a full a.t.e. assembly.

## Tuning

The 2017's wide frequency range allows measurements to be made over the full spectrum from 10 kHz to 1024 MHz and tuning is accomplished using manual controls (range selection, coarse and fine tuning) or by direct entry via the keyboard. In the manual mode the instrument can be freely tuned and locked whenever the operator wishes. An incrementing facility allows the carrier frequency to be stepped up or down in steps of any size and a key can be pressed to indicate the total shift – a useful benefit for bandwidth measurements.

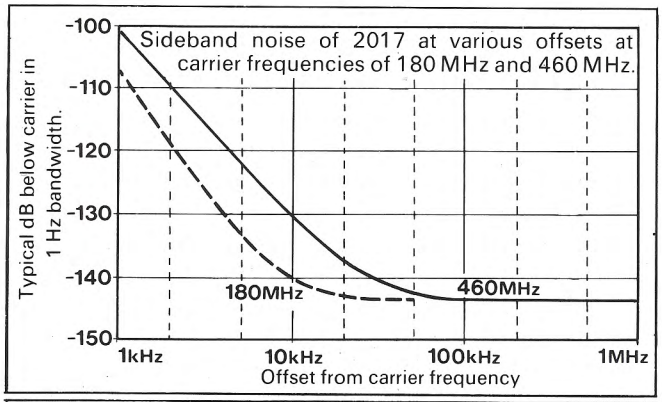
Measurements of receiver spurious responses are made easier by the provision of a slow sweep mode operating between any two frequencies on a carrier frequency range. The full spectral purity of the output signal is retained in the sweep mode.

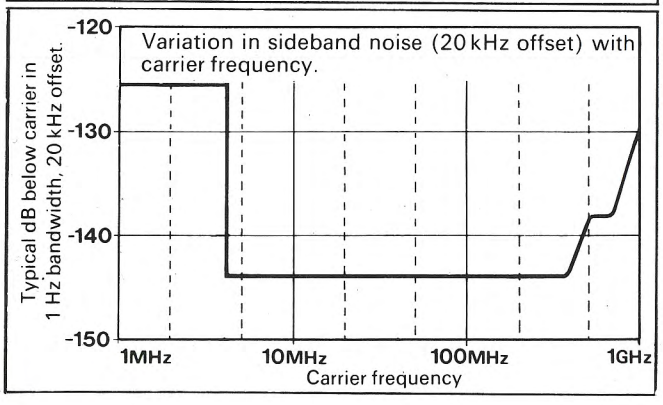
## Spectral purity

A low noise cavity-tuned oscillator forms the heart of the 2017 and provides a sideband noise figure of better than −135 dBc/Hz at 20 kHz offset at 470 MHz. At lower frequencies the noise is even lower as 2017 uses a series of digital dividers and filters to obtain output frequencies below 256 MHz.

The oscillator does not generate any non-harmonically related spurious signals and consequently the output has unrivalled purity over its frequency range.

In-band noise components (FM on CW and AM on CW) are also low enough to permit accurate measurements of signal to noise ratio on all types of receiver.




## Output

Levels up to 4 V e.m.f. (+19 dBm) are available under full keyboard control or by means of rotary coarse and fine attenuator controls. The fine attenuator is continuously variable and has a generous amount of overlap with the steps of the switched coarse attenuator to make squelch (or mute) tests simple to perform. A choice of five r.f. calibration units is available to the operator on a front panel switch.

Reverse power protection is fitted as standard to prevent damage to the output circuits due to the accidental application of power up to 50 W when testing transceivers. This protection in no way degrades the excellent output level accuracy or v.s.w.r. of the generator. Tripping of the protection completely disables the instrument and this condition is indicated by the continual flashing of the front panel RF OFF annunciator. When operating under remote control an indication is sent over the bus. After removal of the overload the instrument can be reset either manually, by depressing the front panel RF ON/OFF key, or via the bus. When the generator is switched off the output socket is automatically disconnected from the output attenuator as a further safety precaution.

## Modulation

Comprehensive a.m., f.m. and pulse modulation facilities are provided for testing all types of receivers and radar modules. A wide range modulation oscillator allows frequency response tests to be made without the need for any external a.f. source.

DC coupled a.m. circuits allow 2017 to be used in the testing of aircraft landing systems and the wideband input for f.m. handles stereo-encoded signals.

External modulation to the full rated accuracy is made possible by the provision of a levelling circuit which automatically maintains a constant peak voltage for use by the modulation circuits. Inputs in the range 0·5 to 1·5 V r.m.s. can easily be accommodated by this facility, but where it is desired to control the amount of modulation by means of the external signal, the levelling amplifier can be disabled.

## Microprocessor control

The use of a microprocessor in 2017 makes the generator simple to operate and gives the user the choice of keyboard entry or rotary control. Digital displays and annunciators clearly indicate the settings of the instrument at all times.

Conversion of r.f. calibration units is simply performed by the microprocessor along with such routine operations as r.f. range selection, limits detection, f.m. calibration, etc.

A memory facility allows storage of up to ten complete generator settings (carrier frequency, f.m. deviation, a.m. modulation depth, r.f. level, frequency increment value or sweep end frequency). Any of the ten sets of data can be simply recalled when required for later use.

## Programming

2017 is fully compatible with GPIB programming and is configured as a talker and listener. All signal generator functions are set in the listen mode by simple instructions and, under program control, the rotary controls can be made available for operator adjustment. Frequency and r.f. level information can then be retrieved in the talk mode.

Ease of programming is ensured by careful selection of mnemonics. For example to send a carrier frequency of 523·4 MHz with an output level of 1·25 µV it is only

necessary to send the instruction CF 523·4 MZ, LV 1·25 UV over the bus. The bus address can be easily changed by means of a set of rear panel switches. Front panel indication of the address selected appears in the frequency display area for a short time whenever the instrument is switched on.

## Counter

Access is provided to the generator's frequency counting function for measurement of frequencies, for example from the internal modulation oscillator or from an external device. The measured frequency can be talked back over the bus.

### CARRIER FREQUENCY

**Range**
10 kHz to 1024 MHz in 9 ranges.

| | | |
|---|---|---|
| 1. | 10 kHz to | 4 MHz |
| 2. | 4 MHz to | 8 MHz |
| 3. | 8 MHz to | 16 MHz |
| 4. | 16 MHz to | 32 MHz |
| 5. | 32 MHz to | 64 MHz |
| 6. | 64 MHz to | 128 MHz |
| 7. | 128 MHz to | 256 MHz |
| 8. | 256 MHz to | 512 MHz |
| 9. | 512 MHz to | 1024 MHz |

**Selection**
Manual: Eleven-turn main tuning control with separate three-turn fine-tune control.
Keyboard: Provides for entry of up to 8 significant digits, decimal point and frequency units.
Counter transfer: A manually tuned frequency may be locked by pressing the LOCK key.

**Indication**
7½ digit LED, seven segment indicators showing carrier frequency. RF range shown by 9 LEDs.

**Resolution**
10 Hz for carrier frequencies up to 128 MHz. 100 Hz for carrier frequencies above 128 MHz.

**Accuracy**
Unlocked: Refer to frequency counter accuracy.
Locked: Refer to internal reference standard.

**Stability**
Locked mode. Refer to reference standard specification. Less than 7s is required for the generator to regain frequency lock after a frequency change is made.

**Frequency sweep**
Single shot sweep for use with X-Y plotter. Maximum sweep width is one carrier frequency range.
Sweep rate: 35 to 150s for a full range sweep adjustable by a front panel control.
Horizontal output: 1 to 9 V over one frequency range.

### RF OUTPUT

**Level**
0·13 µV to 2 V e.m.f. (−131 to +13 dBm) in a.m. mode.
0·13 µV to 4 V e.m.f. (−131 to +19 dBm) in c.w., f.m. and pulse modes.

**Selection**
Manual: Two concentric knob controls; switched coarse attenuator with 6 dB steps and continuously variable fine attenuator with 8 dB range.
Keyboard: Allows entry of up to 4 significant digits, decimal point, sign and units.

**Indication**
3½ digit LED, seven segment indicators with illuminated legend showing e.m.f., p.d., dBµV e.m.f., dBµV p.d., and dBm. Units are selected by front panel switch.

**Total level accuracy**
±1 dB from 10 kHz to 512 MHz.
±2 dB from 512 MHz to 1024 MHz.

**Source impedance**
50 Ω.
VSWR at r.f. levels below 0·5 V e.m.f.
Better than 1·15:1 up to 256 MHz.
Better than 1·25:1 up to 512 MHz.
Better than 1·35:1 up to 1024 MHz.

**RF leakage**
Less than 1 µV generated in a 50 Ω load by a 2 turn, 25 mm dia. loop, 100 mm or more from the generator.

**Reverse power protection**
Protects the generator output system against accidental reverse power from a transmitter of up to 50 W capacity from 10 kHz to 1024 MHz, or applied d.c. of up to ±40 V.

### AMPLITUDE MODULATION

**Carrier frequency range**
10 kHz to 400 MHz, usable up to 1024 MHz.

**Depth**
Up to 99% in 1% steps. 2 digit LED, seven segment indicators. Entered via keyboard or remote programming.

**Accuracy (At 1 kHz modulation rate)**
Better than ±3% depth up to 80%.

**Envelope distortion (using internal 1 kHz modulation oscillator)**
Better than 2% total harmonic distortion up to 30% depth.
Better than 3·5% total harmonic distortion up to 80% depth.

**External modulation**
Frequency range: 20 Hz to 50 kHz, d.c. coupled.
Frequency response: ±0·3 dB from 20 Hz to 50 kHz (±0·5 dB in levelled mode).
Input level: 0·5 to 1·5 V r.m.s. into 600 Ω to set reference level, indicated by an illuminated legend in the levelled mode only.
1 V r.m.s. into 600 Ω to set reference level in unlevelled mode.

### FREQUENCY MODULATION

**Deviation**
Entered via keyboard or remote programming and displayed by 3 digit LED, seven segment indicators.

| RF Range | Maximum Deviation |
|---|---|
| 1 | 40 kHz |
| 2 | 40 kHz |
| 3 | 80 kHz |
| 4 | 160 kHz |
| 5 | 320 kHz |
| 6 | 640 kHz |
| 7 | 1·28 MHz |
| 8 | 2·56 MHz |
| 9 | 200 kHz |

**Accuracy**
±4% of deviation selected ±50 Hz.

**Distortion**
Using the internal 1 kHz fixed modulation oscillator, less than 2% total harmonic distortion at maximum deviation on each r.f. range.

**External modulation**
Frequency range: 20 Hz to 125 kHz, d.c. coupled, at maximum deviation and up to 260 kHz at half maximum deviation.
Frequency response: ±0·3 dB from 20 Hz to 125 kHz (±0·5 dB in levelled mode).
Input level: As for AM.

**INTERNAL MODULATION OSCILLATOR**

| | |
|---|---|
| Frequency | 20 Hz to 20 kHz continuously variable in 3 decade ranges. Also 2 fixed frequencies, switch selected, of 400 Hz and 1 kHz. |
| Accuracy | ±5% for fixed frequencies. |

**PULSE MODULATION**

| | |
|---|---|
| Carrier frequency range | 4 to 1024 MHz. |
| Pulse carrier rise time | Less than 25 ns for carrier frequencies above 25 MHz. |
| Pulse duration | 100 ns to infinity. |
| Carrier suppression | Better than 70 dB up to 80 MHz; 50 dB up to 512 MHz. |
| Additional carrier level error | ±2 dB. |
| Input characteristic | Positive-going modulation up to +1 V input.<br>Saturation level: +1·1 V.<br>Maximum input: +5 V.<br>Input impedance: 50 Ω.<br>Effective bandwidth d.c. to 15 MHz reduced below 25 MHz carrier. |

**FREQUENCY COUNTER (External mode)**

| | |
|---|---|
| Frequency range | 10 Hz to 520 MHz. |
| Resolution | 1 Hz, from 10 Hz to 10 MHz.<br>10 Hz, from 1 to 100 MHz.<br>100 Hz, from 10 to 520 MHz. |
| Sensitivity | 100 mV p.d. into 50 Ω from 1 to 520 MHz.<br>100 mV p.d. into 1 MΩ from 10 Hz to 10 MHz. |
| Accuracy | ±1 digit + reference standard accuracy. |

**INTERNAL REFERENCE STANDARD**

| | |
|---|---|
| Temperature stability | Better than ±2 in $10^7$ over the temperature range 0 to 40°C. |
| Warm-up time | Within 0·5 p.p.m. of final frequency within 5 min from switch-on at 20°C ambient. |

**SPURIOUS SIGNALS**

| | |
|---|---|
| Carrier harmonics | Better than −27 dBc, typically better than −40 dBc. |
| Carrier sub-harmonics | For carrier frequencies up to 512 MHz no carrier sub-harmonics are generated.<br>−60 dBc above 512 MHz. |
| Non-harmonic components | For carrier frequencies between 4 and 1024 MHz no non-harmonically related signals are generated. −50 dBc below 4 MHz. |
| FM on CW (CCITT telephone psophometric weighted) | Less than 3 Hz equivalent deviation up to 512 MHz and less than 6 Hz up to 1024 MHz. Reduces by approximately 6 dB/octave as the carrier frequency is reduced (down to 4 MHz). |
| AM on CW (−3 dB bandwidth 20 Hz to 20 kHz) | Less than −70 dBc.<br>Equivalent to less than 0·06% modulation depth. |
| Single sideband phase noise (at 20 kHz offset) | Better than −135 dBc/Hz at 470 MHz. For performance at other carrier frequencies see sideband noise curves on page 17. |

**AUXILIARY FACILITIES**

| | |
|---|---|
| Remote operation | All major front panel functions may be remotely controlled via the GPIB. Complies with the following subsets as defined in IEEE 488-1978.<br>SH1, AH1, T5, TEØ, L4, LEØ<br>SR1, RL1, PPØ, DC1, DTØ, CØ, E1.<br>(Marconi Instruments General Purpose Interface Bus in accordance with IEEE Standard 488-1978 and IEC Publication 625-1, first edition.) |
| Modulation oscillator output | Front panel socket provides approximately 1 V r.m.s. into 600 Ω. |
| Frequency standard output | Switch selected output providing 1 MHz TTL compatible signal. |
| External frequency standard input | Switch selected input accepting 4 V p-p at 1 MHz.<br>Input impedance: approximately 1 kΩ. |

**RADIO FREQUENCY INTERFERENCE**

Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference.

**SAFETY**

Complies with IEC 348.

**LIMIT RANGE OF OPERATION**

| | |
|---|---|
| Temperature | 0 to 55°C. |

**CONDITIONS OF STORAGE AND TRANSPORT**

| | |
|---|---|
| Temperature | −40°C to +70°C. |
| Humidity | Up to 90% relative humidity. |
| Altitude | Up to 2500 m (pressurised freight at 27 kPa differential, i.e. 3·9 lbf/in²). |

**POWER REQUIREMENTS**

| | |
|---|---|
| AC supply | 105 to 120 V ±10% and 210 to 240 V ±10%. 45 to 65 Hz. 140 VA maximum. |

**DIMENSIONS AND WEIGHT (over projections)**

| Height | Width | Depth | Weight |
|---|---|---|---|
| 195 mm | 453 mm | 543 mm | 29 kg |
| 7·7 in. | 17·8 in. | 21·4 in. | 63 lb |

**VERSIONS AND ACCESSORIES**

*When ordering please quote eight digit code numbers*

| Ordering numbers | Versions |
|---|---|
| **52017-900K** | 10 kHz to 1024 MHz Signal Generator 2017. |
| | **Supplied Accessories** |
| | AC Supply Lead 43129-071D.<br>Operating Manual 46881-388D (H 52017-900K Vol. 1.) |
| | **Optional Accessories** |
| **46883-482E** | Rack Mounting Kit. |
| **54711-032H** | Maintenance Kit (including l.f. and r.f. extender cables). |
| **46881-389T** | Service Manual H 52017-900K (Vol. 2). |
| **46881-365R** | GPIB Manual H 54811-010P. |
| **43129-189U** | GPIB Lead Assembly. |
| **46883-408K** | IEEE/IEC Adapter Block for GPIB Socket. |
| **43126-012S** | RF Connecting Cable TM 4969/3 50 Ω, 1·5 m (5 ft) BNC. |
| **54311-092P** | Adapter, type N male to BNC female. |

# AM/FM Signal Generators 2018 2019




15080/1

- ☐ **2018: 80 kHz to 520 MHz**
  **2019: 80 kHz to 1040 MHz**
- ☐ **Frequency resolution 10 Hz up to 520 MHz, 20 Hz above 520 MHz**
- ☐ **High output level: up to 2 V e.m.f. (+13 dBm)**
- ☐ **Excellent output level accuracy**
- ☐ **Reverse power protection up to 50 W**
- ☐ **Choice of nine output calibration units**
- ☐ **Offset calibration**
- ☐ **Comprehensive amplitude and frequency modulation**
- ☐ **Optional GPIB programmability**
- ☐ **Non-volatile memory with 50 settings**
- ☐ **Powerful fault diagnostic system**

Signal Generators 2018 and 2019 are synthesized generators identical except for their frequency range – 80 kHz to 520 MHz and 80 kHz to 1040 MHz respectively. Microprocessor control provides simple and rapid operation by direct keyboard entry of settings and the non-volatile memory which can store up to fifty settings further reduces measurement time. The optional GPIB programmability extends the range of applications to include automatic test systems.

Comprehensive frequency and amplitude modulation are included, with provision for external modulation. The excellent overall performance and wide range of facilities provided ensure that the generators have many uses in receiver testing for development, production and maintenance areas and for military use.

## Tuning

Tuning of carrier frequency is accomplished by direct entry via the keyboard or over the general purpose interface bus, with indication by eight-digit liquid crystal display and units annunciators. Frequency resolution is 10 Hz up to 520 MHz and 20 Hz above 520 MHz. Carrier frequencies can be stored in the non-volatile memory with instant recall when required. A Carrier on/off switch is provided to completely disable the output. Provision is made for operation with an external frequency reference standard if required.

Selection of frequencies above the upper limit of each generator is inhibited, but carrier frequencies below 80 kHz can be set with a warning appearing on the display. The generators are usable down to 30 kHz with minimal degradation of performance.

An incrementing facility permits stepping of carrier frequency in precisely defined increments of any size with an indication of total shift available by use of the TOTAL SHIFT key and with provision for instant return to the starting frequency.

## Output

RF output levels up to 2 V e.m.f. (+13 dBm) can be set by direct keyboard entry or via the GPIB, with resolution of at least 0·1 dB over the entire range and a total accuracy of ±1 dB up to 520 MHz and ±2 dB above 520 MHz. Levels are indicated on a four-digit liquid crystal display with units annunciators. Output levels can be incremented in steps of any size and up to ten level settings can be stored in the memory.

A choice of nine calibration units is available to the operator, so eliminating the possibility of errors made in conversion of units. Calibration data for the output level is held in the memory and may be altered from the front panel or over the interface bus.

The output level can be offset by up to ±2 dB from the calibrated value to compensate for cable or switching losses external to the generator. The operator may also use this facility as a means of deliberately offsetting the output level to ensure that all generators in an area give identical measurements. While using the offsetting facility the main calibration of the generator is not lost and may be returned to at any time.

Reverse power protection is fitted as standard and provides protection up to 50 W to prevent damage to the output circuits due to the accidental application of power when testing transceivers. This protection in no way degrades the excellent output level accuracy or v.s.w.r. of the generator. Tripping of the protection completely disables the instrument and this condition is indicated by the continual flashing of the front panel RF LEVEL l.e.d. and the setting of the REV PWR LIMIT annunciator on the RF LEVEL display. When operating under remote control an indication is sent over the bus. After removal of the overload the instrument can be reset either manually, by depressing the front panel RF LEVEL key, or via the bus. When the generator is switched off the output socket is automatically disconnected from the output attenuator as a further safety precaution.

## Modulation

Comprehensive a.m. and f.m. facilities are provided for testing all types of receivers. A MODULATION ON/OFF key is fitted to allow signal to noise ratio checks to be made, and a five-frequency modulation oscillator is included to facilitate frequency response measurements. These frequencies can be changed within the range of 100 Hz to 10 kHz to suit individual user requirements.

The wide range frequency modulation provides f.m. deviation up to 5·2 MHz for 2018 and up to 10·4 MHz for 2019. Excellent f.m. accuracy is ensured by the storage of calibration values in the memory. Amplitude modulation is provided with steps of 1% up to 99% depth. FM deviations and a.m. depths can be stored in the memory for recall when required. It is also possible to increment the deviation and depth settings.

External modulation is possible with a wide band input of 50 Hz to 100 kHz for f.m. and 20 Hz to 50 kHz (d.c. coupled) for a.m. A modulation levelling function is included which can be disabled when not required.

## Incrementing

All parameters can be incremented or decremented in steps of any size which can be simply entered via the keyboard or the GPIB. If no step size is entered for a parameter the steps are pre-set to 1 kHz for carrier frequency, 1 kHz for f.m. deviation, 1% for a.m. depth and 1 dB for output level.

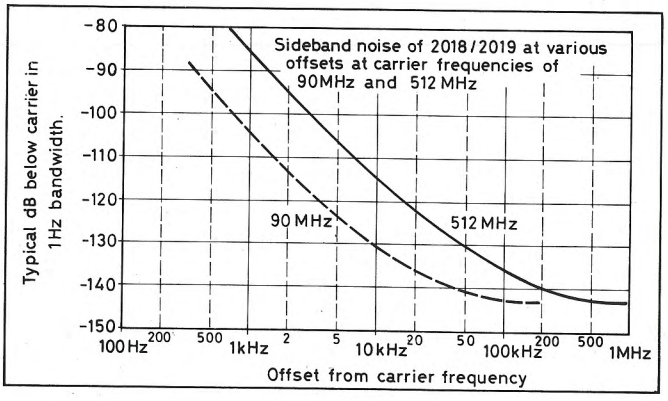
A single tap on either the up or down key moves the parameter by one step. If the key is held down the parameter steps once, waits one second and then moves at three steps per second. For search purposes it is possible to reverse this stepping direction without the one second delay.

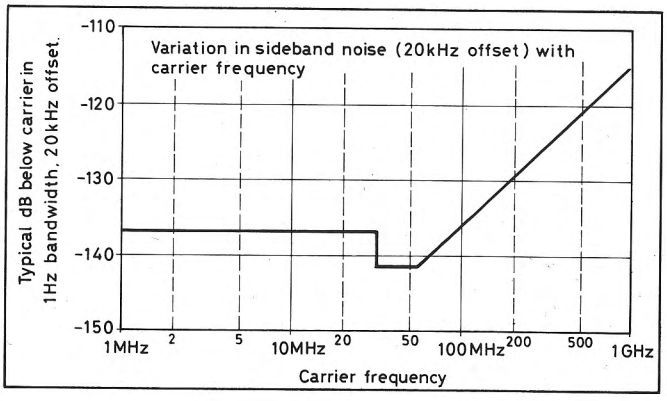
Operation of the TOTAL SHIFT key displays the variations in all parameters from their original settings. Use of the RETURN key sets the selected parameter back to its start value.

## Spectral purity

Good in-band and sideband noise performance allows the generators to be used for all in-band tests and many out-of-band tests. Sideband noise figures better than −130 dBc/Hz at 20 kHz offset and at 90 MHz are obtained. Sideband noise improves at a rate of 6 dB per octave as carrier frequency is reduced. Typical sideband noise curves are shown below.

Harmonically related signals are better than −30 dBc for carrier frequencies up to 520 MHz and better than −20 dBc above 520 MHz. Non-harmonics are better than −70 dBc above 2·03126 MHz and −60 dBc below.



## Non-volatile memory

The inclusion of a non-volatile, semiconductor memory for storage of up to ten generator settings and a further forty carrier frequencies ensures that settings are retained even when the generator is switched off, without relying on a battery. Functions which can be stored are carrier frequency, f.m. deviation, a.m. depth, modulation oscillator frequency, modulation on/off, internal/external modulation selection, r.f. level, carrier on/off and a.l.c. on/off. Any of the sets of data can be instantly recalled when required for later use.

The memory is also used to store calibration data on r.f. level and f.m. accuracy, r.f. calibration units, output level offset values, offset on/off, internal/external standard, and for the storage of GPIB address.

## Programming

2018 and 2019 can be simply fitted with the optional GPIB interface so that all functions can be controlled over the bus. The instruments function as talkers as well as listeners. In the listen mode the generators' functions are set by simple instructions, and in the talk mode a string of information containing the instruments' complete settings can be sent back over the bus, allowing the controller to check that information has been transferred without error or to learn settings for later use.

Ease of programming is ensured by careful selection of mnemonics. For example to send a carrier frequency of 123·456 MHz a frequency deviation of 3·5 kHz and an output level of 1·74 µV, and to place these settings in store 10 of the memory, it is only necessary to send over the bus the instruction:

CF123.456MZ,FM3.5KZ,LV1.74UV,ST10

The use of commas as delimiters in the instruction string is not essential but often aids interpretation of program lines.

Service requests (SRQ) are sent for a variety of reasons including reverse power protection tripped and illegal characters received. SRQs may be inhibited if desired by setting flags in the generator using a second function.

## Maintenance and calibration

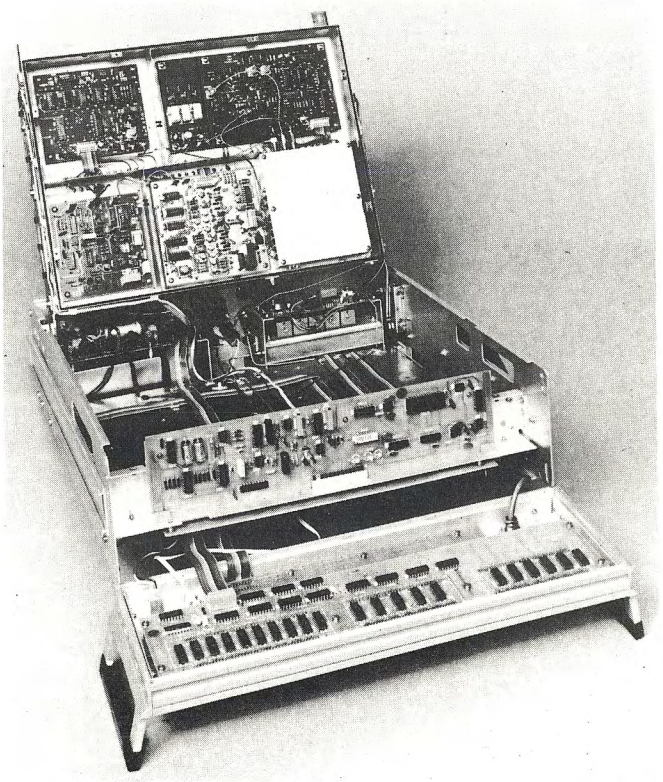
The generators have been designed to have excellent reliability. The use of liquid crystal displays to reduce power consumption ensures cool running without the need for a cooling fan, so eliminating all the associated routine maintenance and cleaning of filters. The packing density of the instruments has been deliberately kept low to aid cooling and to improve access.

The microprocessors 'second function' mode provides powerful fault diagnostic facilities from the front panel or via the GPIB by allowing the operator to send data directly to individual latches in the instrument. The resulting changes in output conditions can be monitored and the area in which the fault lies can be localized.

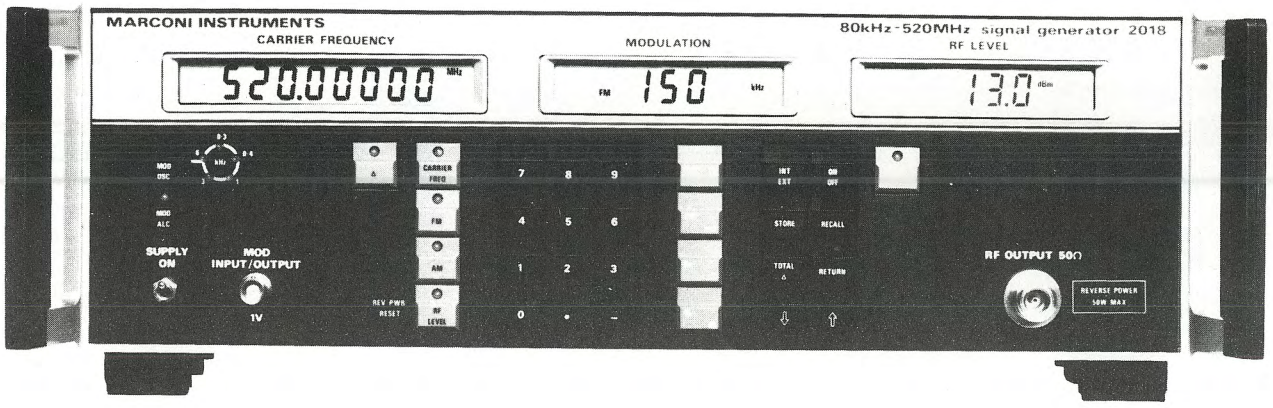
RF level, f.m. accuracy and frequency accuracy can be adjusted without removing the instruments covers. Level and f.m. accuracy can be adjusted over the GPIB, leading to fully automatic calibration routines.

Careful mechanical design of the instruments ensures rapid access to all circuits for component replacement. The main r.f. assembly is hinged and the front panel can be lowered as shown in the photograph. Printed boards interconnect by means of plugs and sockets and all except the r.f. oscillator board can be changed without affecting calibration, so simplifying first line maintenance.

A full servicing manual is available and an optional maintenance kit provides the necessary r.f. extension cables, l.c.d. insertion and extraction tools, etc.



*Interior view of 2019* *15080/7*




15093

## GENERAL DESCRIPTION

2018 and 2019 are synthesized signal generators covering the frequency range 80 kHz to 520 MHz and 80 kHz to 1040 MHz respectively. The output may be amplitude or frequency modulated using either the built-in modulation oscillator or an external source. All control settings are entered from a front panel keyboard. Three liquid crystal displays give simultaneous readout of frequency, modulation and output level. Remote control via the General Purpose Interface Bus is available as an option.

## CARRIER FREQUENCY

**Range** — **2018:** 80 kHz to 520 MHz, usable down to 30 kHz.
**2019:** 80 kHz to 1040 MHz, usable down to 30 kHz.

**Selection** — By keyboard entry.

**Indication** — 8 digit LCD – see under KEYBOARD AND DISPLAYS.

**Resolution** — 10 Hz up to 520 MHz, 20 Hz from 520 to 1040 MHz.

**Accuracy** — Equal to the frequency standard accuracy. See FREQUENCY STANDARD.

## RF OUTPUT

**Level** — 0·2 µV to 2 V e.m.f. in c.w. and f.m. modes. 0·2 µV to 1 V e.m.f. in a.m. mode.

**Selection** — By keyboard entry. Units may be µV, mV, V e.m.f. or p.d.; dB relative to 1 µV, 1 mV, 1 V e.m.f. or p.d.; dBm.

**Indication** — 4 digit LCD with units annunciators. See KEYBOARD AND DISPLAYS.

**Resolution** — 0·1 dB or better over entire voltage range.

**Output level accuracy** — ±1 dB up to 520 MHz.
±2 dB above 520 MHz.

**Output impedance** — 50 Ω, type N female socket
For output levels below 300 mV e.m.f. the VSWR is better than 1·2:1 for carrier frequencies up to 520 MHz and better than 1·5:1 for carrier frequencies above 520 MHz.

**Reverse power protection** — An electronic trip protects the generator output against reverse power of up to 50 W from d.c. to 1 GHz. The trip may be reset from the front panel or via the GPIB.

## SPURIOUS SIGNALS

**Harmonically related signals** — For output levels less than 1 V e.m.f. Better than −30 dBc for carrier frequencies up to 520 MHz and better than −20 dBc for carrier frequencies above 520 MHz.

**Sub-harmonics** — None for carrier frequencies up to 520 MHz.
−20 dBc for carrier frequencies above 520 MHz.

**Non-harmonically related signals** — −70 dBc for carrier frequencies from 2·03126 MHz to 1040 MHz
−60 dBc for carrier frequencies from 80 kHz to 2·03125 MHz.

**Residual f.m.** — Less than 6 Hz r.m.s. in CCITT telephone psophometric band at 520 MHz and improving by approximately 6 dB per octave with reducing carrier frequency down to 2·5 MHz.

**Single sideband phase noise** — Better than −130 dBc/Hz at 90 MHz and 20 kHz offset from the carrier. Typical performance curves are shown in the text.

**RF leakage** — Less than 0·5 µV p.d. generated in a 50 Ω load by a two-turn, 25 mm loop, 25 mm or more from the case of the generator with the output level set to less than −10 dBm and the output terminated in a 50 Ω sealed load.

## FREQUENCY MODULATION

**Range** — Peak deviation from 10 Hz to 100 kHz for carrier frequencies up to 2·03125 MHz.
Peak deviation from 10 Hz up to 1% of carrier frequency for carrier frequencies from 2·03126 MHz to 520 MHz.
Peak deviation from 20 Hz up to 1% of carrier frequency for carrier frequencies above 520 MHz.

**Selection** — By front panel keyboard. Internal modulation oscillator (see MODULATION OSCILLATOR) or external modulation input may be selected.

| | |
|---|---|
| **Display** | 3 digit LCD. See KEYBOARD AND DISPLAYS. |
| **Deviation accuracy** | ±5% of deviation at 1 kHz modulating frequency excluding residual f.m. |
| **Frequency response** | ±1 dB from 50 Hz to 100 kHz relative to 1 kHz. Usable down to 10 Hz with reduced deviation. |
| **Distortion** | Better than 3% total harmonic distortion at 1 kHz modulating frequency and a deviation of up to 70% of maximum available at any carrier frequency. Better than 0·3% total harmonic distortion at 75 kHz deviation at carrier frequencies from 88 MHz to 108 MHz at 1 kHz modulating frequency. |
| **External modulation** | With modulation a.l.c. on, the deviation is calibrated for input levels between 0·8 V and 1·2 V p.d. With modulation a.l.c. off, the deviation is calibrated for an input level of 1 V p.d.<br>Input impedance; 100 kΩ nominal. |

## AMPLITUDE MODULATION

| | |
|---|---|
| **Range** | 0 to 99% in 1% steps. |
| **Selection** | By front panel keyboard. Internal modulation oscillator (see MODULATION OSCILLATOR) or rear panel external modulation input may be selected. |
| **Display** | 2 digit. See KEYBOARD AND DISPLAYS. |
| **Accuracy** | Better than ± (4% of depth setting +1%) for modulation depths up to 95% at 1 kHz modulating frequency and carrier frequencies up to 400 MHz. |
| **Frequency response** | ±1 dB from 20 Hz to 50 kHz relative to 1 kHz at 80% depth, d.c. coupled. |
| **Envelope distortion** | Better than 3% total harmonic distortion for modulation depths up to 80% at 1 kHz modulating frequency and carrier frequencies up to 400 MHz. Better than 2% total harmonic distortion for modulation depths up to 90% at 1 kHz modulating frequency for carrier frequencies up to 32 MHz. |
| **External modulation input** | With the modulation a.l.c. on, the modulation depth is calibrated for input levels between 0·8 V and 1·2 V p.d. With the modulation a.l.c. off, the modulation depth is calibrated for an input level of 1 V p.d.<br>Input impedance: 100 kΩ nominal, d.c. coupled. |

## MODULATION OSCILLATOR

| | |
|---|---|
| **Frequencies** | 300 Hz, 400 Hz, 1 kHz, 3 kHz and 6 kHz selected sequentially by repetitive pressing of the Mod. Osc. key. |
| **Display** | Five LEDs indicate selected frequency. |
| **Frequency accuracy** | ±5%. |

## FREQUENCY STANDARD

Internal or external frequency standard may be selected from the front panel. Annunciators show which is selected.

| | |
|---|---|
| **Frequency standard input/output** | A rear-panel BNC socket provides an output from the internal frequency standard when internal standard is selected and becomes the external standard input when external standard is selected. |

## INTERNAL FREQUENCY STANDARD

| | |
|---|---|
| **Frequency** | 10 MHz. |
| **Temperature stability** | Better than ±0·1 p.p.m. over the temperature range 0 to 40°C. |
| **Warm-up time** | Within 0·5 p.p.m. of final frequency 5 min. from switch-on at 20°C ambient. |
| **Internal standard output** | 10 MHz at nominally 3 V p-p square wave. Source impedance: 100 Ω nominal. |

## EXTERNAL FREQUENCY STANDARD

| | |
|---|---|
| **External standard input** | Accepts a 10 MHz signal of at least 1 V r.m.s.<br>Maximum input 2·5 V r.m.s. |

## AUXILIARY INPUTS AND OUTPUTS

| | |
|---|---|
| **Modulation input/output** | A front-panel BNC socket provides an output from the modulation oscillator when internal modulation is selected and becomes the external modulation input when external modulation is selected. |
| **Internal modulation oscillator output** | 1 V e.m.f. nominal from 1 kΩ source impedance at selected modulation frequency. |
| **External modulation input** | Input level nominally 1 V into 100 kΩ. See FREQUENCY MODULATION and AMPLITUDE MODULATION. |
| **Alternative RF output** | A blanked hole is provided so an RF output socket can be fitted to the rear panel for systems use. |

## KEYBOARD AND DISPLAYS

| | |
|---|---|
| **Main keyboard functions** | All instrument settings are controlled by the front panel keyboard.<br>The main key functions are:<br>CARRIER FREQ. 7 8 9 MHz/V<br>FM 4 5 6 kHz/mV<br>AM 1 2 3 Hz/μV<br>RF LEVEL 0 – %/dB<br>Settings are entered by selecting the required function, keying in the value and pressing the appropriate units key.<br>Other functions provided are: |
| **△** | Increment key. When pressed before a function key, an increment value is entered for that function. |
| **↑ and ↓** | Increment or decrement the selected function. |
| **TOTAL △** | Display total incremental shift from last keyed-in value. |
| **RETURN** | Return setting to last previously keyed-in value for the selected function. (In remote operation requests return to local control). |
| **INT EXT** | If pressed after Carrier Freq., toggles between internal and external frequency standard. If pressed after AM or FM, toggles between internal and external modulation. |
| **ON OFF** | If pressed after Carrier Freq., toggles between RF output on and off.<br>If pressed after AM or FM, toggles between modulation on and off. |
| **MOD OSC** | Sequentially selects one of five internal modulation oscillator frequencies. |
| **MOD ALC** | Toggles between modulation a.l.c. on and off. |

**STORE and RECALL**

Provides storage and recall of instrument settings in non-volatile memory. Up to 10 complete instrument settings and up to 40 carrier frequencies may be stored.

**SECOND FUNCT**

Selects second function entry mode.

**Secondary keyboard functions**

The following secondary functions may be selected using the Second Function key followed by a number key.

- Ø Second function protection
- 1 Display instrument status (GPIB address, RF output level units etc.)
- 2 Display/change GPIB address
- 3 Direct addressing of internal bus system (servicing aid)
- 4 Display/change GPIB SRQ mask
- 5 Display/change RF level units (i.e. voltage e.m.f. or p.d. and dB reference)
- 6 Display/change RF level calibration offset.
  Functions 4, 5, 6 are protected functions
- 7 RF calibration
- 8 FM calibration
- 9 2018/2019 software switch
  Functions 7, 8 and 9 are doubly protected functions intended for use in manufacture and servicing only

**Displays**

Three liquid crystal displays provide simultaneous readout of Carrier Frequency, Modulation and RF Level.

Carrier frequency display: 8 digit display with annunciators to show frequency units, external frequency standard, frequency limit exceeded, remote operation and GPIB address displayed (second functions 1 & 2).
Modulation display: 3 digit display with annunciators to show modulation units FM, AM, modulation off, external modulation selected and modulation limit exceeded.
RF level display: 3 digit display with annunciators to show RF level units, RF output off, reverse power trip operated and RF level limit exceeded.

**GPIB INTERFACE**

A GPIB interface is available as an accessory for the customer to fit. All functions except the supply switch are remotely programmable.

**Capabilities**

Complies with the following subsets as defined in IEEE 488–1978.
SH1, AH1, T6, TEØ, L4, LEØ, SR1, RL1, PRØ, DC1, DT1, CØ, E1.

**RADIO FREQUENCY INTERFERENCE**

Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference.

**SAFETY**

Complies with IEC 348.

**RATED RANGE OF USE**

**Temperature**

0 to 55°C.

**CONDITIONS OF STORAGE AND TRANSPORT**

**Temperature**

−40°C to +70°C.

**Humidity**

Up to 90% relative humidity.

**Altitude**

Up to 2500 m (pressurised freight at 27 kPa differential, i.e. 3·9 lbf/in²).

**POWER REQUIREMENTS**

**AC supply**

Switchable voltage ranges 105 to 110 V, 115 to 120 V, 210 to 220 V, 230 to 240 V, all ±10%.
45 to 440 Hz.
70 VA maximum.

**DIMENSIONS AND WEIGHT (over projections but excluding handles)**

| Height | Width | Depth | Weight |
|---|---|---|---|
| 152 mm | 425 mm | 525 mm | 16 kg |
| 6 in | 16·7 in | 20·7 in | 35·2 lb |

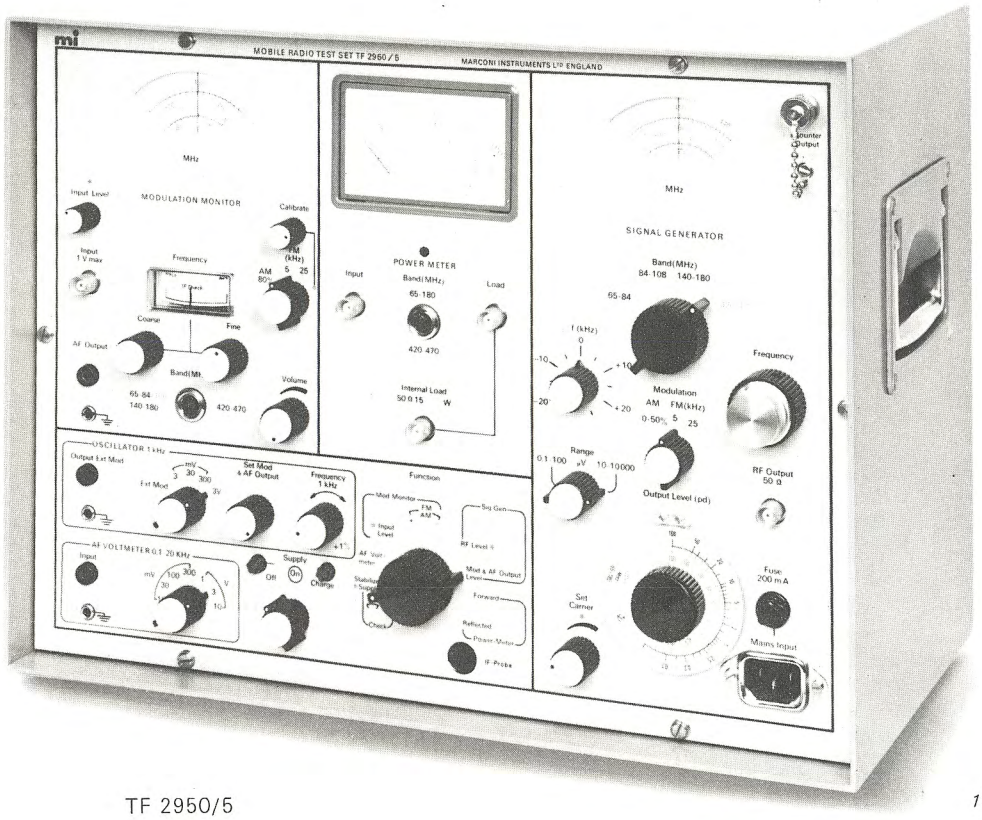
## VERSIONS AND ACCESSORIES

*When ordering please quote eight digit code numbers.*

| Ordering numbers | Versions |
|---|---|
| **52018–900F** | 80 kHz to 520 MHz Signal Generator 2018. |
| **52019–900C** | 80 kHz to 1040 MHz Signal Generator 2019 |
| | **Supplied Accessories** |
| | AC supply lead 43129–071D. |
| | Operating manual 46881–419G (H52018–900F Vol. 1) for 2018 and 2019. |
| | **Optional Accessories** |
| **54433–001U** | GPIB Module. |
| **43129–189U** | GPIB Lead Assembly. |
| **46881–365R** | GPIB Manual H 54811–010P. |
| **46883–408K** | IEEE/IEC Adapter Block for GPIB Socket. |
| **54711–033E** | Maintenance Kit. |
| **46883–511R** | Front Handle Kit. |
| **46883–506M** | Rack Mounting Kit. |
| **54311–092P** | Adaptor, Type N male to BNC female. |
| **43126–012S** | RF Connecting Cable (TM 4969/3) 50 Ω, 1·5 m, BNC. |
| **54411–051X** | Impedance Adaptor 50/75 Ω. |
| **46881–420J** | Service Manual H52018–900F Vol. 2 (for 2018 and 2019). |

# Mobile Radio Test Set

# TF 2950
series




TF 2950/5

14061/1

- ☐ **Combines all mobile radio servicing instruments in one unit**
- ☐ **Alternative versions give choice of frequency ranges**
- ☐ **AM/FM signal generator and modulation meter cover the main mobile bands**
- ☐ **1 kHz a.f. test oscillator**
- ☐ **Absorption and in-line power meter for measurements up to 25W**
- ☐ **AF Voltmeter**
- ☐ **Internal battery operation with trickle charge facility**
- ☐ **Light and compact**

TF 2950 is an extremely useful and versatile mobile radio test set combining in one unit, many instruments needed to service the type of equipment used in this field. It is portable, lightweight and compact, and is operated from internal batteries, which can be recharged simply by plugging the test set into the mains.

Included in the instrument are an am/fm signal generator, a modulation monitor, a power meter that can be used as an absorption or in-line type, a 1 kHz audio oscillator with independent ±1% frequency control, and an a.f. voltmeter. The instrument has a clean and neat external appearance with an orderly layout of front panel controls. Internally it is of open construction giving ready access to all parts for servicing.

The signal generator covers the main mobile radio telephone bands. It can be amplitude or frequency modulated from the internal 1 kHz oscillator or from an external source. The same r.f. range is covered by the

modulation monitor which can be used to measure the f.m. deviation or a.m. depth of mobile radio transmitters. The demodulated output of the transmitter signal can be checked for the type of distortion on a built-in loudspeaker and can be taken from front panel sockers for headphones or other tests. The power meter, which measures forward and reflected power, covers the frequency range in two bands. Audio frequency voltages can be measured on the a.f. meter, which can be set to any one of a series of full-scale deflections between 10 mV and 10 volts.

The TF 2950 provides a range of facilities that, in general, are not available elsewhere or can be obtained only at a much higher price. In most cases the same essential range of tests can be carried out only by using additional instruments, some of which are not battery operated. Several versions of the instrument are available, differing only in the frequency ranges covered.

## Signal Generator

The v.h.f. and u.h.f. ranges are covered by the signal generator in a number of switch selected bands. Frequency accuracy and stability are more than adequate for the type of application for which the test set has been designed.

Tests on narrow band receivers are facilitated by the incremental tuning control, which enables the user to vary the frequency by up to 20 kHz either side of the nominal frequency. Output voltage is continuously variable from 0·1 μV to 10 mV in two ranges. The lower range covers voltages up to 100 μV and the upper range from 10 μV to 10 mV. A calibrated SET LEVEL dial is used for both ranges. The accuracy of the output level has been ensured by fitting a SET-CARRIER control.

The signal generator can be amplitude or frequency modulated, internally or externally, the internal modulating signal being obtained from the a.f. oscillator. Amplitude modulation is variable up to 50% for carrier frequencies up to 180 MHz. FM deviation can be set from 0 to 5 kHz f.s. or 0 to 25 kHz f.s. The signal generator section can be externally modulated over the range 0·3 to 5 kHz.

TF 2950 is fitted with an output socket providing a power supply for the range of IF probes available as optional accessories.

## Modulation Monitor

Measurements of amplitude and frequency modulation can be made with the modulation monitor, which gives the same frequency cover as the signal generator. The amplitude modulation depth measurement range is between 0 and 80%. FM deviation is measured in two ranges with maximum readings of 5 kHz and 25 kHz, respectively.

The modulation is indicated on the test set's main meter. Any asymmetry of the deviation can be checked by moving the switch from FM + to FM −.

The demodulated output from the modulation monitor is connected to the internal loudspeaker so that the modulation can be audibly monitored. For maximum modulation accuracy the loudspeaker should be in the OFF position. The demodulated output is also present at the front panel sockets.

Modulation measurements up to full power rating can be made by connecting a transmitter output to the power meter section INTERNAL LOAD. Sufficient signal is then fed to the modulation monitor section for measurements to be taken.

## Power Meter

The power meter will measure both forward and reflected power up to 15 watts continuously and up to 25 watts for short periods. The r.f. power output from the mobile radio transmitter is connected to the INPUT socket and passes through the power meter to the LOAD socket. From there it can be connected to the antenna terminal of the radio telephone or to some other load when carrying out in-line measurements. Alternatively, the power can be dissipated in the internal 50 Ω load by connecting the LOAD socket to the INTERNAL LOAD socket.

The power measurement can be made in two bands, giving the same overall frequency cover as the signal generator.

Continuous power up to 30 watts, and short-term power up to 50 watts can be measured by using the optional attenuator type 6536/1.

## AF Oscillator

This useful signal source has a front panel control to vary the nominal 1 kHz output frequency of the a.f. oscillator by up to ±1%. The ±1% control is particularly useful when making SINAD measurements. The output from the oscillator is internally connected to, and can frequency or amplitude modulate, the signal generator. The output from the oscillator is variable between 0 and 3 volts in four switch selected ranges. The actual value of the output voltage is shown on the main meter of the test set.

## AF Voltmeter

External audio-frequency voltages in the 100 Hz to 20 kHz range are measured by connecting them to the front panel INPUT sockets on the a.f. voltmeter section. The voltmeter has an input impedance of 100 kΩ. Seven switch selected ranges with full-scale deflections of 10, 30, 100 and 300 mV, 1, 3 and 10 volts are provided. The value of the voltage being measured is indicated on the test set's main meter to an accuracy of ±5% f.s.

## Power Supply

A front panel switch with three positions – OFF, ON and CHARGE – controls the power supply to the test set. When connected to the mains and switched to the ON position, the TF 2950 is supplied by the internal batteries which are being automatically trickle charged by the mains. When the switch is moved to the CHARGE position the batteries are placed on charge but the test set itself is switched off. Protection circuits are fitted to prevent overcharging and to prevent excessive discharge of the battery. The condition of the battery at any time can be checked by moving the front panel FUNCTION switch to the appropriate position. The battery "state" is then shown on the test set's main meter.

# TF 2950 series

## SIGNAL GENERATOR

| | |
|---|---|
| Frequency range | |
| TF 2950/5 | 65 to 84 MHz, 84 to 108 MHz, 138 to 180 MHz, 420 to 470 MHz. |
| TF 2950/6 | 84 to 108 MHz, 108 to 140 MHz, 138 to 180 MHz, 420 to 470 MHz. |
| TF 2950/8 | 23 to 32 MHz, 32 to 44 MHz, 44 to 62 MHz, 62 to 88 MHz, 138 to 180 MHz, 400 to 470 MHz, |
| TF 2950/9 | 65 to 84 MHz, 84 to 108 MHz, 138 to 180 MHz, 400 to 520 MHz. |
| Frequency accuracy | ±0·5% of reading. |
| Frequency stability | Approximately $2{\cdot}5 \times 10^{-5}$/10 min. after 30 min. warm up. |
| Incremental tuning | ±20 kHz, accuracy ±20% f.s. |
| Int. mod. frequency | 1 kHz with ±1% variable control. |
| Ext. mod. frequency | 0·3 to 5 kHz. |
| AM | 0 to 50% mod. depth on ranges up to 180 MHz, accuracy ±10% f.s. |
| Spurious f.m. on a.m. | Less than 1 kHz at 30% a.m. |
| FM deviation | 0 to 5 kHz and 0 to 25 kHz. accuracy ±10% f.s. |
| Output voltage | Continuously variable from 0·1 µV to 10 mV, accuracy ±2·5 dB, ±0·1 µV. |
| Leakage | Less than 1 µV at a distance of 25 mm, using a two-turn loop with a loop diameter of 25 mm. |
| Counter output | 30 mV r.m.s. into 50·Ω. |
| IF probe output | A 2-pin, non-reversible DIN 41529 connector fitted to the front panel provides a d.c. output supply of 20·7 V for the optional IF Probes. |

## MODULATION MONITOR

| | |
|---|---|
| Frequency range | |
| TF 2950/5 | 65 to 84 MHz, 84 to 108 MHz, 140 to 180 MHz, 420 to 470 MHz. |
| TF 2950/6 | 84 to 108 MHz, 108 to 140 MHz, 138 to 180 MHz, 420 to 470 MHz. |
| TF 2950/8 | 23 to 35 MHz, 35 to 55 MHz. 55 to 75 MHz, 75 to 90 MHz, 138 to 180 MHz, 400 to 470 MHz. |
| TF 2950/9 | 65 to 84 MHz, 84 to 108 MHz, 138 to 180 MHz, 400 to 520 MHz. |
| Accuracy | ±1% of reading. |
| FM measurements | *Deviation range:* 0 to 5 kHz and 0 to 25 kHz.<br>*Accuracy*, ±5% f.s. for sinuosoidal signals.<br>*Sensitivity*, 10 mV (maximum input voltage 1 V). 15 mV on top frequency range of TF 2950/9. |
| AM measurements | *Modulation depth*, 0 to 80% up to 180 MHz.<br>*Sensitivity*, 50 mV (maximum input voltage 300 mV).<br>*Accuracy*, ±10% f.s.d. |
| Monitor indication | Positive and negative peak deviation Peak and trough amplitude modulation depth. |
| Demodulated output | From front panel sockets with internal loudspeaker. |

## RF POWER METER

| | |
|---|---|
| Range | *Using external load*, 0 to 25 W in-line.<br>*Using internal load*, 0 to 15 W continuous, 15 to 25 W short term (3 min.). |
| Accuracy | ±10% f.s. |
| Impedance | 50 Ω ±20%. |

| | |
|---|---|
| Frequency range | |
| TF 2950/5 | 65 to 180 MHz, 420 to 470 MHz. |
| TF 2950/6 | 80 to 180 MHz, 420 to 470 MHz. |
| TF 2950/8 | 23 to 88 MHz, 138 to 480 MHz. |
| TF 2950/9 | 65 to 180 MHz, 400 to 520 MHz. |

## AF OSCILLATOR

| | |
|---|---|
| Frequency | 1 kHz with ±1% variable control. |
| Output | 0 to 3, 0 to 30, 0 to 300 mV and 0 to 3 V. |
| Accuracy | ±5% f.s. |
| Output impedance | 200 Ω on 3 V range, 40 Ω on all other ranges. |
| Distortion | Less than 1%. |

## AF VOLTMETER

| | |
|---|---|
| Input range | 10, 30, 100, 300 mV f.s. 1, 3 and 10 V f.s. |
| Frequency range | 100 Hz to 20 kHz. |
| Accuracy | ±5% f.s. |
| Input impedance | 100 kΩ. |

| | |
|---|---|
| RADIO FREQUENCY INTERFERENCE | Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference. |
| SAFETY | Complies with IEC 348. |
| LIMIT RANGE OF OPERATION | |
| Temperature | 0 to 55°C. |
| CONDITIONS OF STORAGE AND TRANSPORT | |
| Temperature | –40°C to +70°C. |
| Humidity | Up to 90% relative humidity. |
| Altitude | Up to 2500m (pressurised freight at 27 kPa differential, i.e. 3·9 lbf/in²). |
| POWER REQUIREMENTS | |
| AC mains for battery charging | 110 V ±15% or 220 V ± 15%; 40 to 60 Hz, 10 W. |
| Internal battery operation time | 6 to 8 hours. |
| Batteries | Internal standard re-chargeable cells. |

DIMENSIONS AND WEIGHT

| Height | Width | Depth | Weight |
|---|---|---|---|
| 315 mm | 420 mm | 230 mm | 16 kg |
| 12 in | 16 in | 9 in | 35 lb |

## VERSIONS AND ACCESSORIES

*When ordering, please quote eight-digit code numbers*

| Ordering Numbers | |
|---|---|
| | **Versions** |
| **52950–905Z** | TF 2950/5 |
| **52950–906H** | TF 2950/6 |
| **52950–908U** | TF 2950/8 |
| **52950–909Y** | TF 2950/9 |
| | These versions differ only in frequency cover. For details see specification above. |
| | **Supplied Accessories** |
| | 3 Free BNC Plugs. |
| | Power Meter Link, 50 Ω. |
| | 4 Wander Plugs. |
| | Mains Lead |
| | Instruction Manual. |
| | **Optional Accessories** |
| **6536/1** | Coaxial Attenuator, Increases power measurement capability to 30 W continuous, 50 W short-term. |
| **54451–061Y** | IF Probe, 470 kHz. |
| **54451–071S** | IF Probe, 10·7 MHz. |
| **54451–121B** | IF Probe, 455 kHz. |
| | For details see page 7 |

Made in West Germany

# Mobile Radio Test Set 2951




- ☐ **Combines all radio servicing instruments in one compact and portable unit**
- ☐ **AM, FM, and phase modulation measurements**
- ☐ **Semi and full duplex measurements**
- ☐ **Built-in synchronizer for high stability**
- ☐ **Operates from a.c. supply, external battery or internal rechargeable battery**
- ☐ **Ideal for field and workshop measurements on hand-held, mobile and base station radio telephones**

2951 is a comprehensive test set combining in one case all of the measurement facilities required for testing mobile radio equipment in the v.h.f. and u.h.f. bands. Its main application will be for maintenance and servicing of hand-held, mobile and base station simplex and duplex radio telephones using frequency, amplitude or phase modulation.

Seven separate instruments are included in the test set: signal generator, frequency counter, a.f. generator, a.f. voltmeter, distortion factor meter, modulation monitor and r.f. power meter. The function selector switches organise all the necessary interconnections eliminating the need for the many external connections required when separate instruments are used. Each instrument can also be operated independently as required. The front panel is divided into sections corresponding to the major facilities offered, with a layout designed to permit simple and rapid operation.

### Signal Generator

The signal generator covers seven frequency bands from 24 to 180 MHz and from 400 to 480 MHz, with the frequency being displayed on an eight-digit l.e.d. counter readout. A switchable frequency synchronizer is included to give high frequency stability. When the generator is

operating in the synchronized mode, touching the main COARSE TUNE control automatically disables the synchronizer to allow full manual tuning. Releasing the control causes the synchronizer to regain control and stabilize the output frequency. Fine tuning can then be carried out with the FINE TUNE control. The ability to be able to alter the output frequency while the instrument is operating under locked conditions is particularly useful when bandwidth measurements are being made on a receiver.

RF output level is controlled by a ten-stage divider giving outputs from 0·1 μV to 100 mV, switch selected for e.m.f. or p.d. across 50 Ω output level is displayed on a meter.

Comprehensive modulation facilities include amplitude, frequency and phase modulation. The modulation source can be either the internal a.f. generator with three fixed frequencies and a continuously variable range of 0·3 to 7 kHz, or an external source. Modulation frequency can be displayed on the counter and modulation level on the meter. A modulation on/off switch is included to assist in making signal-to-noise ratio checks.

Operation of the signal generator is totally independent of the other instruments, so the generator can provide an output signal at one frequency while simultaneous modulation or power measurements are made at another frequency. This permits single port duplex measurements to be made, i.e. between duplexer and antenna.

An output socket is fitted to provide a power supply for the range of oscillator probes available as optional accessories to assist in tuning to receivers fitted with squelch or battery economizer circuits.

### Frequency Counter

A built-in frequency counter operates over the frequency range 10 Hz to 500 MHz with frequency indication by an eight digit l.e.d. display. When used in its internal mode signals are automatically routed to the counter for measurement. It can measure generator carrier frequency, or signals from the a.f. generator, modulation monitor or r.f. power meter. The counter can also be used to measure signals from an external source.

A rapid warm-up, oven-controlled crystal oscillator provides the reference frequency for the counter and also provides the comparison frequencies used in the phaselock circuits associated with the signal generator.

### AF Generator

The a.f. generator provides three fixed frequencies of 300 Hz, 1 kHz and 3 kHz as well as two continuously variable ranges of 300 Hz to 1·4 kHz and 1·4 kHz to 7 kHz. Using the frequency counter the variable frequency can be set to an accuracy of ± 1 Hz.

The generator output can be used to modulate the signal generator output and is also available at a front panel socket for testing transmitters. Output level of the generator is monitored by the internal voltmeter and is continuously variable in seven switched ranges from 3 mV to 3 V full scale.

### AF Voltmeter

The a.f. voltmeter section can be used to measure the audio signals developed by the receiver and also those derived from the modulation monitor section, allowing transmitter signal-to-noise ratio and modulation bandwidth measurements to be made. Voltages from 0 to 10 volts from external sources can be measured in eight switched bands over the frequency range 100 Hz to 20 kHz. A three-position switch routes the a.f. voltmeter to measure the level at the input socket, the a.f. generator volts or the modulation monitor a.f. output level.

### Distortion Factor Meter

The distortion factor meter operates at a frequency of 1 kHz, with an automatic levelling system overcoming the need for manual adjustment of level. Two distortion ranges are provided: 1 to 10% for receiver and transmitter modulation measurements and 0 to 30% for SINAD indications associated with receiver sensitivity tests. Results of the distortion measurements are displayed on a meter which also has markings for 12 dB and 20 dB SINAD.

### Modulation Monitor

Automatic levelling and frequency control are features of the modulation monitor which provides accurate measurement of amplitude, frequency and phase modulation over the carrier frequency ranges of 25 to 180 MHz and 400 to 480 MHz. Modulation level is indicated on a panel meter and the modulation frequency is displayed on the counter readout. A demodulated output is available at a front panel socket for external monitoring if desired. This demodulated output is also connected to an internal loudspeaker with volume control and on/off switch for audible monitoring.

### RF Power Meter

RF power can be measured over the frequency range of 25 to 500 MHz in two power ranges of 0 to 3 W, suitable for hand-held portable equipment, and 0 to 30 W for vehicle mounted transmitters and base station units.

### Power Supply

A front panel switch with three positions – OFF, ON and CHARGE – controls the power supply to the test set. When connected to the mains and switched to the ON position, the internal batteries are automatically trickle charged by the mains. When the switch is moved to the CHARGE position the batteries are placed on charge but the test set itself is switched off. Protection circuits are fitted to prevent overcharging and to prevent excessive discharge of the battery. The condition of the battery at any time can be checked by means of the front panel BATT push button. The battery "state" is then shown on the test set's main meter.

## SIGNAL GENERATOR

| | |
|---|---|
| **FREQUENCY** | 24 to 180 MHz and 400 to 480 MHz in seven switched bands: |
| Range | 24 to 33 MHz.<br>33 to 46 MHz.<br>46 to 65 MHz.<br>65 to 90 MHz.<br>90 to 130 MHz.<br>130 to 180 MHz.<br>400 to 480 MHz. |
| Indication | 8 digit frequency counter. |
| Accuracy | As for frequency counter. |
| Resolution | Using 1 s gate time resolution is 10 Hz. Using 0·1 s gate time resolution is 100 Hz. |
| Fine tuning (when synchronized) | *Fine:* 0·02% of carrier.<br>*Coarse:* 0·08% of carrier. |
| Stability | With synchronizer switched on and after 10 minutes warm-up, the frequency drift will be better than $2 \times 10^{-7}$ per 10 minute period. |
| Synchronization | When the synchronizer is switched on, touching the main tuning control automatically inhibits the synchronizing system allowing manual tuning. The generator reverts to synchronized operation when the control is released. |
| **FM/PHASE MODULATION** | |
| FM ranges | 0 to 5 kHz and 0 to 25 kHz peak deviation. |
| Phase modulation range | 0 to 2·5 radians. |
| Accuracy | ± 5% f.s.d. at 1 kHz modulation frequency. |
| Modulation frequency range | 300 Hz to 7 kHz derived from internal a.f. generator or from external source. |
| Modulation distortion | Less than 1·5% total harmonic distortion at 1 kHz modulation frequency up to 15 kHz deviation and less than 2% total harmonic distortion up to 25 kHz deviation. |
| **AMPLITUDE MODULATION** | |
| Carrier frequency range | 24 to 180 MHz. |
| AM range | 0 to 90%. |
| Accuracy | ± 7% f.s.d. at 1 kHz modulation frequency. |
| Modulation frequency range | 300 Hz to 7 kHz derived from internal a.f. generator or from external source. |
| Modulation distortion | At 1 kHz modulation frequency:<br>Less than 2% t.h.d. for a.m. up to 30%.<br>Less than 5% t.h.d. for a.m. up to 80%. |
| **OUTPUT** | |
| Indicated level | 0·1 μV to 100 mV p.d. or e.m.f. as selected by front panel switch. |
| Attenuator range | *Fine:* 15 dB continuously variable.<br>*Coarse:* 90 dB in 10 dB steps. |
| Total level accuracy | ±2·5 dB (Accuracy of fine attenuator ±1 dB). |
| Calibration | Direct reading in μV or mV. |
| Protection | Central socket automatically protected by the 30 W power attenuator. |
| Impedance | 50 Ω.<br>VSWR less than 1·15 : 1 (typically less than 1·1 : 1). |
| Leakage | With a receiver sensitivity set at 1 μV, a 25 mm diameter 2 turn loop feeding the receiver cannot detect a signal of this level at a distance greater than 25 mm from the generator. This permits measurements to be made on receivers with sensitivities down to 0·1 μV. |
| IF Probe output | A 2-pin non-reversible DIN 41529 connector fitted to the front panel provides a d.c. output supply of 15 V for the optional i.f. probes. |
| **SPURIOUS SIGNALS** | |
| Harmonically related signals | Better than –25 dBc (typically –30 dBc). |
| FM on CW | With telephone psophometric weighting equivalent deviation is less than 20 Hz. |
| AM on CW | With telephone psophometric weighting less than 0·1% equivalent modulation depth. |
| AM on FM | Less than 1% equivalent modulation depth for a deviation of 25 kHz at a modulation frequency of 1 kHz. |
| FM on AM | Less than 200 Hz equivalent deviation for a modulation depth of 30% at a modulation frequency of 1 kHz. |
| Sideband noise | Better than –115 dBc/Hz at an offset of 20 kHz from the carrier. |

## FREQUENCY COUNTER

| | |
|---|---|
| **INPUT** | |
| Signal routeing | Signals are automatically routed to the frequency counter within the test set. A switch allows the counter to be used to measure low level signals from external sources. |
| Sensitivity | *Internal routeing:* an input level between 0·1 and 30 W to the central socket at frequencies between 10 MHz and 500 MHz will allow the counter to function correctly.<br>*High impedance input:* using a front panel control the sensitivity can be varied from 20 mV to 25 V for input signals in the range 10 Hz to 50 MHz.<br>*Low impedance input:* 20 mV to 2 V for signals in the range 15 to 500 MHz. |
| Impedance | *10 to 500 MHz input:* 50 Ω nominal.<br>*10 Hz to 50 MHz input:* high impedance (> 30 k Ω) in paralled with 100 pF. |
| **DISPLAY** | Eight digit with memory using seven segment LED's of 10 mm height. Frequency indication in kHz and MHz with automatic positioning of the decimal points. |
| **FREQUENCY** | |
| Range | 10 Hz to 500 MHz. |
| Resolution | Using the 1 second gate time a resolution of 1 Hz is obtained for the 10 Hz to 50 MHz input and 10 Hz for the 10 to 500 MHz input. Use of the 0·1 second gate time provides resolutions of 10 Hz and 100 Hz respectively. |
| Accuracy | ± 1 count ± stability of frequency standard. |
| **FREQUENCY STANDARD** | |
| Type | Crystal oscillator: a fast warm-up 5 MHz crystal oscillator contained in a proportionally controlled oven and having the following specifications. |
| Short-term stability | $\pm 5 \times 10^{-10}$ in a 1 s time interval. |
| Long-term stability | $\pm 5 \times 10^{-8}$ over a period of 24 h. |
| Ageing rate | $3 \times 10^{-9}$ per day after 30 days continuous operation. |
| Temperature stability | $\pm 1 \times 10^{-7}$ over the temperature range 13 to 33°C. |

# 2951

| | |
|---|---|
| Stability with supply variations | ± 1 x $10^{-8}$ for a.c. supply variations of ± 10% around 110 V and 220 V. |
| Warm-up time | Stabilizes to within 1 x $10^{-6}$ of the final frequency in 5 min. from switch on and within 1 x $10^{-7}$ of the final frequency after 10 min. from switch on. |

## AF GENERATOR

| | |
|---|---|
| **FREQUENCY** | |
| Range | 300 Hz to 7 kHz with two variable frequency ranges (0·3 to 1·4 kHz and 1·4 to 7 kHz) and three fixed frequencies (300 Hz, 1 kHz and 3 kHz). |
| Accuracy | Using frequency counter ± 1 Hz. Fixed frequencies are set to an accuracy of better than ± 2% during manufacture. |
| **OUTPUT** | |
| Level | Seven switched ranges 3, 10, 30, 100, 300 mV, 1 and 3 V f.s.d. Calibrated also from −70 to + 12 dBm into 600 Ω. |
| Accuracy | ± 3% of f.s.d. |
| Distortion | Less than 0·8% t.h.d. |
| Impedance | Less than 200 Ω on the 3 V range. 40 Ω nominal on all other ranges. |

## AF VOLTMETER

| | |
|---|---|
| **VOLTAGE** | |
| Ranges | 0 to 3, 10, 30, 100, 300 mV, 1, 3, 10 V. Calibrated also from −70 to + 22 dBm into 600 Ω. |
| Accuracy | ± 3% of f.s.d. |
| **INPUT** | |
| Frequency range | 100 Hz to 20 kHz. |
| Impedance | 100 kΩ nominal. |

## DISTORTION FACTOR METER

| | |
|---|---|
| Ranges | 0 to 10%, 0 to 30%. |
| Accuracy | 7% of f.s.d. |
| Frequency | 1 kHz. |
| SINAD | Marks are provided on the 30% distortion scale showing 12 dB and 20 dB SINAD ratio values. |

## MODULATION MONITOR

| | |
|---|---|
| **FM/PHASE MODULATION MEASUREMENT** | |
| FM ranges | 0 to 5 kHz and 0 to 25 kHz peak deviation. |
| Phase modulation range | 0 to 2·5 radians. |
| Accuracy | ± 5% of f.s.d. at 1 kHz modulation frequency. |
| Frequency range | 300 Hz to 7 kHz. |
| Signal-to-noise ratio | Better than 35 dB relative to 3 kHz deviation for carrier frequencies up to 180 MHz and better than 30 dB for carrier frequencies up to 470 MHz. Measured using a CCITT telephone noise weighting network. |

| | |
|---|---|
| **AM MEASUREMENT** | |
| AM range | 0 to 90% modulation depth. |
| Accuracy | ± 7% f.s.d. at 1 kHz modulation frequency. |
| Frequency range | 300 Hz to 7 kHz. |
| Signal-to-noise ratio | Better than 35 dB relative to 30% a.m. for carrier frequency up to 180 MHz. Measured using a CCITT telephone noise weighted network. |
| **INPUT** | |
| Selection | Switch selection of either a direct input socket or from a tapping on the 30 W load. |
| Impedance | 50 Ω nominal. |
| Frequency range | 25 to 180 MHz and 400 to 480 MHz in six switched bands:<br>25 to 40 MHz.<br>40 to 60 MHz.<br>60 to 90 MHz.<br>90 to 130 MHz.<br>130 to 180 MHz.<br>400 to 500 MHz. |
| Sensitivity: AM/FM/Phase via the central socket | The modulation monitor will give a correct indication for input power levels between 0·1 W and 30 W. |
| via the direct input socket | The sensitivity is typically 10 mV for input frequencies up to 180 MHz. For FM and phase modulation only the sensitivity is 20 mV for frequencies between 400 and 470 MHz. |
| Frequency response | From 300 Hz to 5 kHz flat within ± 0·2 dB. |
| Maximum input | 30 W using central input socket.<br>300 mV using direct input socket for a.m.<br>1 V using direct input socket for f.m. |
| **OUTPUT** | |
| LF | 0 to 1 V nominal from the front panel socket, dependent on the level of modulation. |
| Loudspeaker | A built-in loudspeaker is provided for monitoring purposes and is controlled by a front panel on/off switch and volume control. |

## RF POWER METER

| | |
|---|---|
| Frequency range | 25 to 500 MHz. |
| Power range | 0 to 3 W, 0 to 30 W. |
| Minimum indication | 20 mW. |
| Accuracy | ± 8% f.s.d. |
| **LOAD (Central socket)** | |
| Impedance | 50 Ω, VSWR less than 1·15 : 1 (typically 1·1 : 1). |
| Maximum input | 30 W. |

## GENERAL

| | |
|---|---|
| **SAFETY** | Complies with IEC 348. |
| **RADIO FREQUENCY INTERFERENCE** | Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference. |

| | |
|---|---|
| **LIMIT RANGE OF OPERATION** | |
| Temperature | 0 to 45°C. |
| **CONDITIONS OF STORAGE AND TRANSPORT** | |
| Temperature | –40° to + 70°C. |
| Humidity | Up to 90% relative humidity. |
| Altitude | Up to 2500 m (pressurized freight at 27 kPa differential, i.e. 3·9 lbf/in$^2$). |
| **POWER REQUIREMENTS** | |
| AC supply | 110 V or 220 V ± 10%.<br>45 to 65 Hz.<br>Consumption 50 W. |
| Batteries | a) Internal battery: single 12 V sealed lead acid battery. Capacity 6·5 Ah. Normal use from fully charged condition is 2 hours. Automatic cut-off when battery has discharged to 10·8 V. Supply switch selects either full or trickle charge mode.<br>b) External battery: 11 to 14 V, consumption 1·5 to 2 A.<br>Main meter monitors either internal or external battery voltage when selected. |

**DIMENSIONS AND WEIGHT**

| | Height | Width | Depth | Weight |
|---|---|---|---|---|
| Without front panel protection cover | 301 mm<br>11·85 in | 450 mm<br>17·72 in | 325 mm<br>12·80 in | 19·2 kg<br>42·3 lb |
| With front panel protection cover | 303 mm<br>11·93 in | 477 mm<br>18·78 in | 366 mm<br>14·41 in | 20·6 kg<br>45·4 lb |

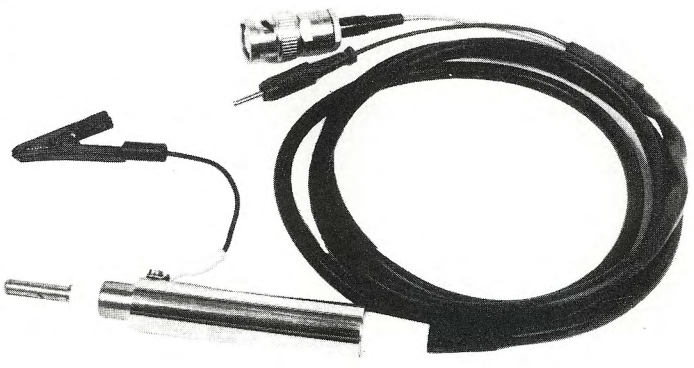
**VERSIONS AND ACCESSORIES**

| Ordering Numbers | |
|---|---|
| | **Versions** |
| **52951 – 900N** | Mobile Radio Test Set 2951 |
| | **Supplied Accessories** |
| | AC Supply Lead |
| | Operating Manual 46881 – 429X (H52951 – 900N Vol. 1) |
| | **Optional Accessories** |
| **54451 – 061Y** | IF Probe, 470 kHz } For details see page 7 |
| **54451 – 071S** | IF Probe, 10·7 MHz } For details see page 7 |
| **54451 – 121B** | IF Probe, 455 kHz } For details see page 7 |
| **54451 – 162U** | High Impedance Counter Probe |
| **54121 – 033J** | Front Panel Protection Cover |
| **46881 – 430T** | Servicing Manual H52951 – 900N Vol. II |

# High Impedance Counter Probe 54451–162U

This high impedance probe can be used in conjunction with the built-in counter to make in-circuit frequency measurements over the range 150 kHz to 500 MHz. The prove derives its power from a socket on the front panel of the 2951.

| | |
|---|---|
| FREQUENCY RANGE | 150 kHz to 500 MHz. |
| IMPEDANCE | 100 kΩ nominal in parallel with 10 pF nominal. |
| GAIN | 0·4 nominal. |
| MAXIMUM INPUT | 2 V r.m.s. |
| POWER REQUIREMENTS | 12 to 15 V. Obtained from socket on counter front panel. |
| DIMENSIONS | Length: 105 mm / 4·13 in<br>Diameter: 13 mm / 0·51 in<br>Lead Length: 115 mm / 4·53 in |



15141/3

# AM/FM Radiotelephone Test Set TF 2952




14752/1

- ☐ **Combines all radio servicing instruments in one compact and portable unit**
- ☐ **AM, FM, and phase modulation measurements**
- ☐ **AM/FM Signal Generator: 400 kHz to 520 MHz**
- ☐ **Semi and full duplex measurements**
- ☐ **Built-in synchronizer for high stability**
- ☐ **Ideal for field and workshop measurements on hand-held, mobile and base station radio telephones**

TF 2952 is a very comprehensive and versatile test set combining in one case all of the measurement facilities required for testing radiotelephone units in the v.h.f. and u.h.f. bands. Its main application will be for testing mobile, marine and airborne radiotelephone equipment in the maintenance workshops of radiotelephone manufacturers, public services, military and commercial users.

Seven separate instruments are included in the test set: Signal Generator, Frequency Counter, AF Generator, AF Voltmeter, Distortion Factor Meter, Modulation Monitor and RF Power Meter. The function selector switches organise all the necessary interconnections, eliminating the need for the many external connections required when separate instruments are used. The front panel is divided into sections corresponding to the major facilities offered, with a layout designed to permit simple and rapid operation.

## Signal Generator

The signal generator has continuous frequency coverage from 400 kHz to 520 MHz, allowing measurements to be made at receiver intermediate frequencies as well as at their tuned input frequencies, and also permitting checks to be made of receiver spurious responses.

A novel tuning system is used which combines all the

benefits of analogue tuning with the high stability offered by the digital control of the built-in synchronizer. When the main coarse tuning control is touched the frequency locking system is automatically disabled and the operator has full analogue control over the oscillator. Releasing the tuning control allows the digital frequency locking system to regain control and stabilise the output frequency. The final fine tuning is then carried out with a pair of concentric controls until the desired frequency is indicated by the digital display. The ability to be able to alter the output frequency while the instrument is operating under locked conditions is particularly useful when bandwidth measurements are being made on a receiver.

RF output level is controlled by a directly calibrated attenuator system, consisting of a coarse attenuator switching in 20 dB steps and a continuously variable fine attenuator providing interpolation between the steps. The output is calibrated in μV/mV and dB relative to 1 μV and the front panel switch provides a choice of e.m.f. or p.d. calibrations – a particularly useful feature when working with receivers produced by different manufacturers. Output to the receiver under test is normally taken from the central output socket but higher levels can be obtained using the direct output socket immediately beneath the attenuator. Both output sockets are protected against the accidental application of r.f. power, the central socket by a high power attenuator pad and the direct output socket by a fast-acting relay.

Comprehensive modulation facilities include amplitude, frequency and phase modulation in ranges which are optimized for narrow band radio applications. The modulation source can be either the internal oscillator with a range of fixed and variable frequencies between 250 Hz and 7 kHz or an external source enabling receivers using special calling techniques (for example sequential tone coding) to be tested.

Operation of the signal generator is totally independent of the other instruments, so the generator can provide an output signal at one frequency while simultaneous modulation or power measurements are made at another frequency. This permits single or two port duplex measurements to be made, i.e. before or after the duplexer. This facility is available only when the signal generator is in the unlocked mode.

An output socket is fitted to provide a power supply for the range of oscillator probes available as optional accessories to assist in tuning to receivers fitted with squelch or battery economizer circuits.

## Frequency Counter

A built-in frequency counter operates over the range 10 Hz to 520 MHz with frequency indication by an eight-digit l.e.d. display. When used in its internal mode the operation of the counter is controlled by the main function switch which automatically routes the correct signal to the counter for measurement. When tuning the signal generator or monitoring a transmitter output the counter is used to measure radio frequencies but it also measures audio frequencies from the a.f. generator or modulation monitor sections. Sockets are also provided for measurement of the frequency of external signals.

A rapid warm-up, oven-controlled crystal oscillator provides the reference frequency for the counter and also provides the comparison frequencies used in the phase-lock circuits associated with the signal generator.

## AF Generator

A low distortion audio frequency generator provides six fixed frequencies between 300 Hz and 6 kHz as well as two variable frequency ranges covering the band 250 Hz to 7 kHz. Using the frequency counter the variable frequency can be set to an accuracy of ±1 Hz.

The generator output can be used to modulate the signal generator output and is also available at a front panel socket for testing transmitters. Output level of the generator is monitored by the internal voltmeter and is continuously variable from less than 1 mV up to 3 volts in six switched ranges.

## AF Voltmeter

The a.f. voltmeter section can be used to measure the audio signals developed by the receiver and also those derived from the modulation monitor section, allowing transmitter signal-to-noise ratio and modulation bandwidth measurements to be made. Voltages from 0 to 30 volts can be measured in eight switched bands over the frequency range 100 Hz to 20 kHz, and with a choice of four input impedances.

A filter with a CCITT P53 telephone psophometric weighting network is included for making the weighted measurements required in testing modern radio receivers.

## Distortion Factor Meter

The distortion factor meter operates at a frequency of 1000 Hz, with an automatic levelling system overcoming the need for manual adjustment of level. Two distortion ranges are provided, 0 to 10% for receiver and transmitter modulation distortion measurements and 0 to 30% for SINAD indications associated with receiver sensitivity tests. Results of the distortion measurements are displayed on a meter which also has markings for 12 dB and 20 dB SINAD. For weighted distortion or SINAD measurements the CCITT P53 weighting network can be switched into circuit.

## Modulation Monitor

Automatic levelling and frequency control are features of the modulation monitor which provides accurate measurement of amplitude, frequency and phase modulation over the carrier frequency range of 25 to 500 MHz, covering all radio telephone transmitter frequencies. Modulation is indicated on a panel meter, and a demodulated output is available at a front panel socket for external monitoring if desired. This demodulated output is also connected to an internal loudspeaker with volume control and on/off switch for audible monitoring.

## RF Power Meter

RF power can be measured over the carrier frequency range of 25 to 520 MHz in two power ranges of 0 to 2 W, suitable for hand-held portable equipment, and 0 to 25 W for vehicle mounted transmitters and base station units. Higher powers can be measured by the use of external high power attenuators.

# TF 2952

## SIGNAL GENERATOR

### FREQUENCY

**Range** 400 kHz to 520 MHz in nine switched bands:
0·4 to 31 MHz 124 to 180 MHz.
31 to 45 MHz 176 to 260 MHz.
45 to 65 MHz 260 to 360 MHz.
62 to 90 MHz 360 to 520 MHz
88 to 130 MHz.

**Indication** 8 digit frequency counter.

**Accuracy** As for frequency counter.

**Resolution** Using 1 s gate time the resolution is 1 Hz up to 31 MHz and 10 Hz above. Using 0·1 s gate time the resolution is 10 Hz up to 31 MHz and 100 Hz above.

**Stability** After 10 min operation at constant ambient temperature with the synchronizer switched on:
$\pm 5 \times 10^{-7}$ per 30 min above 31 MHz.
$\pm 5 \times 10^{-6}$ ±500 Hz per 30 min below 31 MHz.
After 2 hours operation at constant ambient temperature with the synchronizer switched off:
$\pm 5 \times 10^{-5}$ per 5 min above 31 MHz.
$\pm 5 \times 10^{-5}$ ±500 Hz per 5 min below 31 MHz.

**Synchronization** When the synchronizer is switched on, touching the main tuning control automatically inhibits the synchronizing system allowing manual tuning. The generator reverts to synchronized operation when the control is released.

### FM/PHASE MODULATION

**FM ranges** 0 to 5 kHz and 0 to 25 kHz peak deviation.

**Phase modulation ranges** 0 to 2·5 radians and 0 to 10 radians.

**Accuracy** ±5% f.s.d. at 1 kHz modulation frequency.

**Modulation frequency range** 250 Hz to 7 kHz derived from internal a.f. generator or from external source.

**Modulation distortion** Less than 1% total harmonic distortion at 1 kHz modulation frequency.

### AMPLITUDE MODULATION

**AM range** 0 to 100% full scale.

**Accuracy** ±5% modulation depth at 1 kHz for indications up to 80%. Usable at reduced accuracy up to 90%.

**Modulation frequency range** 250 Hz to 7 kHz derived from internal a.f. generator or from external source.

**Modulation distortion** At 1 kHz modulation frequency less than 1% t.h.d. for a.m. up to 50%; less than 2% t.h.d. for a.m. up to 80%.

### OUTPUT

**Indicated level** 0·1 µV to 200 mV p.d. from direct output socket. 0·01 µV to 20 mV p.d. from normal connecting socket.

**Calibration** dB µV, µV and mV e.m.f. or p.d., switch selected.

**Accuracy (above 2 µV e.m.f.)** ±2·5 dB total level accuracy at normal output socket (with selector switch in e.m.f. calibration position).

**Impedance** 50 Ω.
VSWR at normal output socket is less than 1·15:1.

**Protection** Normal output socket is automatically protected by the 25 W power attenuator. The direct output socket is protected by a relay which automatically disconnects the generator from the socket when an overload is detected. The relay resets after the overload is removed.

**Leakage** Up to 520 MHz with a receiver sensitivity set at 1 µV, a 25 mm diameter 2 turn loop feeding the receiver cannot detect a signal of this level at a distance greater than 25 mm from the generator. This permits measurements to be made on receivers with sensitivities down to 0·1 µV.

**IF Probe output** A 2-pin, non-reversible DIN 41529 connector fitted to the front panel provides a d.c. output supply of 20·7 V for the optional IF Probes.

### SPURIOUS SIGNALS

**Harmonically related signals** Not worse than 30 dB relative to the carrier.

**FM on CW** With telephone psophometric weighting the equivalent deviation is less than 20 Hz.

**AM on CW** With telephone psophometric weighting, less than 0·1% equivalent modulation depth.

**AM on FM** Less than 1% equivalent modulation depth for a deviation of 25 kHz at a modulation frequency of 1 kHz.

**FM on AM** Less than 200 Hz equivalent deviation for a modulation depth of 30% at a modulation frequency of 1 kHz.

**Sideband noise** Better than 120 dB/Hz at an offset of 20 kHz from the carrier.

## FREQUENCY COUNTER

### INPUT

**Signal routeing** Signals are automatically routed to the frequency counter within the test set. A switch allows the counter to be used to measure low level signals from external sources.

**Sensitivity** *Internal routeing:* an input level between 0·2 and 25 W to the central socket at frequencies between 25 and 520 MHz will allow the counter to function correctly.
*High impedance input:* using a front panel control the sensitivity can be varied from 20 mV to 25 V for input signals in the range 10 Hz to 30 MHz.
*Low impedance input:* 20 mV to 2 V for signals in the range 15 to 520 MHz.

**Impedance** 10 Hz to 30 MHz input: approximately 100 kΩ in parallel with 30 pF.
15 to 520 MHz input: 50 Ω nominal.

### DISPLAY

Eight digit with memory using seven segment LEDs of 10 mm height. Frequency indication in kHz with automatic positioning of the decimal point.

### FREQUENCY

**Range** 10 Hz to 520 MHz.

**Resolution** Using the 1 s gate time a resolution of 1 Hz is obtained for the 10 Hz to 30 MHz input and 10 Hz for the 15 to 520 MHz input. Use of the 0·1 s gate time provides resolutions of 10 Hz and 100 Hz respectively.

| | |
|---|---|
| Accuracy | ±1 count ±stability of frequency standard. |

**FREQUENCY STANDARD**

| | |
|---|---|
| Type | A fast warm-up 5 MHz crystal oscillator contained in a proportionally controlled oven. |
| Short term stability | ±5 in $10^{10}$ in a 1 s time interval. |
| Long term stability | ±5 in $10^{8}$ over a period of 24 hours. |
| Ageing rate | 3 in $10^{9}$ per day after 30 days continuous operation. |
| Temperature stability | ±1 in $10^{7}$ over the temperature range 13 to 33°C. |
| Stability with supply variations | ±1 in $10^{8}$ for a.c. supply variations of ±10% around 110 or 220 V. |
| Warm-up time | Stabilizes to within 1 in $10^{6}$ of the final frequency in 5 min from switch on, and to within 1 in $10^{7}$ of the final frequency after 10 min from switch on. |

## AF GENERATOR

**FREQUENCY**

| | |
|---|---|
| Range | 250 Hz to 7 kHz with two variable frequency ranges (0·25 to 1·3 kHz and 1·3 to 7 kHz) and six fixed frequencies (300, 400, 1000, 2700, 3000 and 6000 Hz). |
| Accuracy | ±1 Hz using the frequency counter. Fixed frequencies are set to an accuracy of better than ±1% during manufacture. |

**OUTPUT**

| | |
|---|---|
| Level | 0 to 3 V in six switched ranges with full scale values of 10, 30, 100, 300 mV, 1 and 3 V. A variable control allows precise output level settings to be made. |
| Monitor | Output level is automatically monitored by the internal audio voltmeter. |
| Accuracy | ±3% of f.s.d. using the internal voltmeter. |
| Distortion | Less than 0·3% at 1 kHz. |
| Impedance | 40 Ω nominal. |

## AF VOLTMETER

**VOLTAGE**

| | |
|---|---|
| Range | 0 to 30 V in eight switched ranges with full scale indication of 10, 30, 100, 300 mV, 1, 3, 10 and 30 V. The dB scale indicates from −60 to +32 dBm in 600 Ω. |
| Accuracy | ±3% of f.s.d. |
| +20 dB switch | Increases voltmeter sensitivity by 20 dB and automatically disables the signal generator modulation so that the 20 dB signal to noise ratio of a receiver may be checked. |
| Filter | A CCITT telephone noise weighting filter may be switched into circuit to make weighted noise measurements. |

**INPUT**

| | |
|---|---|
| Frequency range | 0·1 to 20 kHz. |
| Impedance | 4, 200, 600 Ω and 100 kΩ switch selected. |
| Maximum input levels | 4 Ω impedance: 4 V.<br>200 Ω impedance: 10 V.<br>Other impedances: 30 V. |
| Selection | The voltmeter may be used to monitor signals present at the AF Voltmeter input socket or from the modulation monitor. |

## DISTORTION FACTOR METER

**DISTORTION**

| | |
|---|---|
| Ranges | Two single ranges, with 10% and 30% full scale indications. |
| Accuracy | ±7% of f.s.d. |
| Frequency | 1 kHz. |
| SINAD | Marks are provided on the 30% distortion scale showing 12 dB and 20 dB SINAD ratio values. |

**INPUT**

| | |
|---|---|
| Selection | A switch allows the distortion factor meter to monitor signals present at the AF Voltmeter terminals or from the modulation monitor. |
| Level | Automatic level control obviates the need for reference level adjustments and operates over an input voltage range of 0·5 to 2 V at the AF Voltmeter input sockets and over the same level range derived from the output of the Modulation Monitor. |
| Filter | A CCITT telephone noise weighting filter may be switched into circuit to make weighted noise measurements. |

## MODULATION MONITOR

**FM/PHASE MODULATION MEASUREMENT**

| | |
|---|---|
| FM ranges | 0 to 5 kHz and 0 to 25 kHz peak deviation. |
| Phase modulation ranges | 0 to 2·5 radians and 0 to 10 radians. |
| Accuracy (at 1 kHz modulation rate) | ±5% of f.s.d. ±250 Hz (f.m.).<br>±5% of f.s.d. ±0·1 radians (phase mod.).<br>Frequency range 250 Hz to 7 kHz. |
| Signal-to-noise ratio | Measured using a CCITT telephone noise weighting network relative to 3 kHz deviation:<br>Better than 50 dB for carrier frequencies up to 190 MHz and better than 45 dB for carrier frequencies up to 500 MHz.<br>Measured in a flat bandwidth of 250 Hz to 7 kHz and relative to 3 kHz deviation the ratio is:<br>Better than 45 dB for carrier frequencies up to 180 MHz and better than 40 dB for carrier frequencies up to 500 MHz. |

**AM MEASUREMENT**

| | |
|---|---|
| AM range | 0 to 100% full scale. |
| Accuracy (at 1 kHz modulation rate) | ±5% modulation depth for indications up to 80%. Usable at reduced accuracy up to 90%. |
| Frequency range | 250 Hz to 7 kHz. |
| Signal-to-noise ratio | Measured in a flat bandwidth of 250 Hz to 7 kHz and relative to 50% modulation depth the signal-to-noise ratio is better than 40 dB. |

**INPUT**

| | |
|---|---|
| Selection | Switch selection of either a direct input socket or from a tapping on the 25 W load. |
| Impedance | 50 Ω. |

# TF 2952

| | |
|---|---|
| Frequency range | 25 to 500 MHz in nine switched ranges, with continuous frequency coverage. |
| Sensitivity | Using the central input socket the modulation monitor will give a correct indication for input power levels between 0·1 and 25 W.<br>Using the direct input socket the sensitivity is typically 10 mV for input frequencies up to 180 MHz and 20 mV for frequencies between 400 and 500 MHz. |
| Maximum input | 25 W using the central input socket. 1 V using the direct input socket. |
| **OUTPUT** | |
| LF | 250 mV to 2 V nominal for full-scale deflection from front panel socket, adjustable by a front panel control. |
| Loudspeaker | A built-in loudspeaker is provided for monitoring purposes and is controlled by a front panel on/off switch and volume control. |

## RF POWER METER

| | |
|---|---|
| **POWER** | |
| Ranges | 0 to 2 W and 0 to 25 W (the scale extends to 30 W). |
| Accuracy | ±5% of range. |
| **INPUT** | |
| Frequency range | 25 to 520 MHz. |
| Impedance | 50 Ω.<br>VSWR less than 1·15:1. |
| Maximum input | 25 W continuous rating. |

## GENERAL

| | |
|---|---|
| **SAFETY** | Complies with IEC 348. |
| **RADIO FREQUENCY INTERFERENCE** | Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference. |
| **POWER REQUIREMENTS** | |
| AC supply | 215 to 240 V ±6% or<br>105 to 120 V ±6%;<br>45 to 60 Hz, 65 W. |
| **DIMENSIONS AND WEIGHT** | |

| Height | Width | Depth | Weight |
|---|---|---|---|
| 340 mm | 490 mm | 375 mm | 25 kg |
| 13·4 in | 19·3 in | 14·8 in | 55 lb |

### VERSIONS AND ACCESSORIES

*When ordering please quote eight-digit code numbers*

| Ordering numbers | |
|---|---|
| **52952-900P** | **Versions**<br>AM/FM Radiotelephone Test Set TF 2952. |
| | **Supplied Accessories**<br>Operating Manual 46881-366B (H52952-900P Vol. 1).<br>Mains Lead. |
| **54451-061Y**<br>**54451-071S**<br>**54451-121B** | **Optional Accessories**<br>IF Probe, 470 kHz.<br>IF Probe, 10·7 MHz.<br>IF Probe, 455 kHz.<br>For details see page 7 |
| **54451-162U** | High Impedance Counter Probe |
| **46881-367K** | Service Manual (H52952-900P Vol. 2). |

**Made in West Germany**

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# Oscillators


| | | |
|---|---|---|
| **AF Signal Source (20 Hz to 20 kHz)** | **TF 2000** | **40** |
| **Two-Tone Signal Source (20 Hz to 20 kHz)** | **TF 2005R** | **42** |
| **200 kHz Function Generator** | **2123** | **44** |

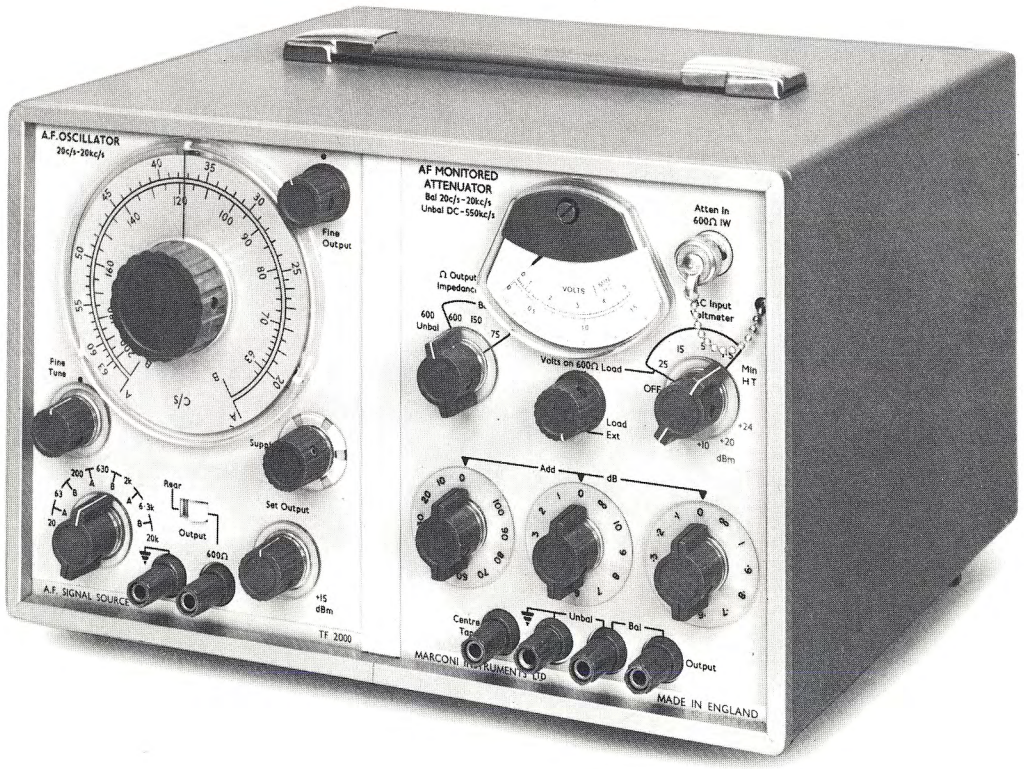

*For further Oscillators see the Microwave Products Section:*


**Gunn Diode Oscillator type 6061A** **266**


## Selection Guide

| TYPE NUMBER | APPLICATIONS | FEATURES |
|---|---|---|
| TF 2000 | General purpose audio frequency testing. | Comprises low distortion a.f. oscillator and monitored attenuator in one unit. |
| TF 2005R | Measurement of intermodulation distortion. | Comprises two low distortion oscillators and monitored attenuator in one unit. |
| TF 2123 | Design, manufacture and servicing of vibration equipment, gyros, d.c. amplifiers, control instrumentation. | Internal sweep facility. Wide frequency range. TTL square wave output. Voltage controlled oscillator. Digital readout. |

# AF Signal Source TF 2000




- ☐ **20 Hz to 20 kHz**
- ☐ **Extremely low distortion**
- ☐ **111 dB attenuator—0·1 dB steps**
- ☐ **Three output impedances**

This AF Signal Source comprises an AF Oscillator together with a three-decade monitored attenuator, combined in a single case to provide a convenient audio-frequency source with very low distortion. If required, the attenuator section can be used alone for external signals.

**FREQUENCY RANGE**
20 Hz to 20 kHz, in six semi-decade bands.
*Accuracy:* ±1% ±0·2 Hz, including warm-up.

**OUTPUT**

**Direct**
*Into 600 Ω:* +15 dBm or 31·6 mW or 4·36 V.
*Open circuit:* At least 8·5 V.
*Control:* At least 40 dB by continuously variable T-network.

**Attenuator**
*Attenuator:* 0 to 111 dB, in 0·1 dB steps.
*Residual Loss:* 0·01 dB.
*Accuracy of Attenuation:* ±1% of dB setting ±0·2 dB.

**Impedance**
*Unbalanced:* 600 Ω.
*Balanced:* 75 Ω, 150 Ω and 600 Ω.
*Centre-tap:* Connected to front panel terminal.
*Internal load:* Switched internal termination effective for all impedance settings.

**Level**
Between −117 dBm and +15 dBm.

**Meter**
*Voltage ranges:* 1·5, 5, 15 and 25 V, f.s.d.
*Accuracy:* ±5% of f.s.d.
*Level range:* −6 dBm to +30 dBm.

**Frequency response**
The output is level within ±0·2 dB between 20 Hz and 20 kHz, at any attenuator setting with the indication of the meter held constant.

**DISTORTION**

**Unbalanced output**
Less than 0·05% between 63 Hz and 6·3 kHz.
Less than 0·1% between 20 and 63 Hz and between 6·3 and 20 kHz.

**Balanced output**
(With matched load.)
Less than 0·1% between 50 Hz and 20 kHz.
Less than 0·3% between 30 and 50 Hz.

**Hum**
Below −80 dB relative to the output signal, or below −90 dBm, whichever is the greater.

**USE OF ATTENUATOR FOR EXTERNAL SIGNALS**

**Maximum input**
+30 dBm or 1 W or 25 V into 600 Ω.

**Input voltmeter**
*Voltage ranges:* 1·5, 5, 15 and 25 V, f.s.d.
*Accuracy:* ±5% of f.s.d. between 20 Hz and 550 kHz.
*Level ranges:* −6 dBm to +30 dBm.

**Unbalanced output**
*Frequency range:* d.c. to 550 kHz.
*Impedance:* 600 Ω.
*Attenuation range:* 0 to 111 dB in 0·1 dB steps.
*Residual loss:* 0·01 dB.
*Attenuation accuracy:* ±1% of dB setting ±0·01 dB at d.c. ±2% of dB setting ±0·2 dB between 20 Hz and 550 kHz.
*Frequency response:* The output is level within ±1 dB between 20 Hz and 550 kHz at any attenuator setting with the indication of the meter held constant.

**Balanced output**
*Frequency range:* 20 Hz to 20 kHz.
*Impedance:* 75 Ω, 150 Ω and 600 Ω.
*Centre tap:* Connected to front panel terminal.
*Attenuation range:* 0 to 111 dB in 0·1 dB steps.
*Residual loss:* 0·2 dB.
*Attenuation accuracy:* ±1% of dB setting ±0·2 dB.
*Frequency response:* The output is level within ±0·2 dB between 20 Hz and 20 kHz at any attenuator setting with the indication of the meter held constant.

**Internal load**
Switched internal termination, effective for all impedance settings.

**RADIO FREQUENCY INTERFERENCE**
Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference.

**SAFETY**
Complies with IEC 348.

**LIMIT RANGE OF OPERATION**

**Temperature**
0 to 55°C.

**CONDITIONS OF STORAGE AND TRANSPORT**

**Temperature**
−40°C to +70°C.

**Humidity**
Up to 90% relative humidity.

**Altitude**
Up to 2500 m (pressurized freight at 27 kPa differential, i.e., 3·9 lbf/in²).

**POWER REQUIREMENTS**

**AC supply**
190 to 260 V and 95 to 130 V, 45 to 500 Hz.
210 to 260 V and 105 to 130 V, 500 to 1000 Hz; 7 VA.

**External DC**
65 to 90 V, 60 mA.

**DIMENSIONS AND WEIGHT**

| Height | Width | Depth | Weight |
|---|---|---|---|
| 200 mm | 290 mm | 270 mm | 9 kg |
| 7¾ in | 11½ in | 10½ in | 20 lb |

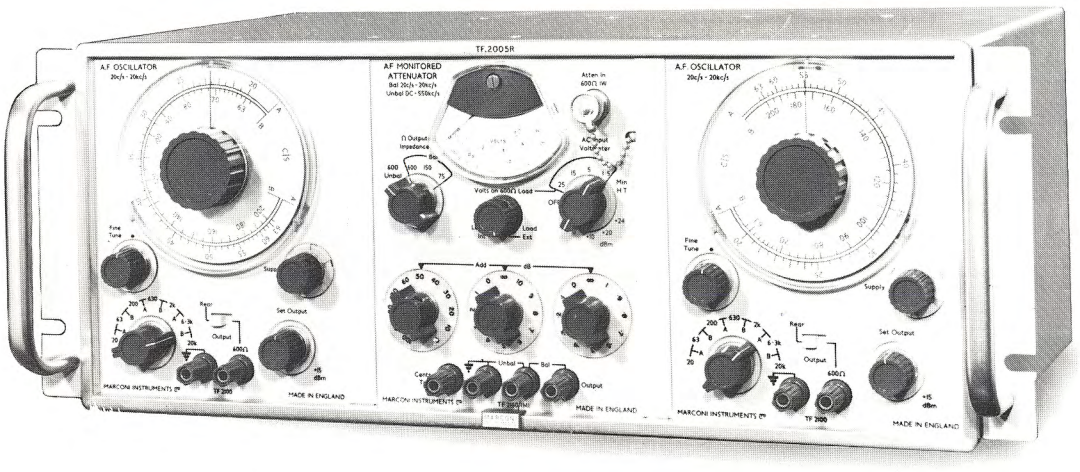
## VERSIONS AND ACCESSORIES

*When ordering please quote eight-digit code numbers*

| Ordering numbers | |
|---|---|
| 52000–900R | **Versions**<br>AF Signal Source TF 2000. |
| | **Supplied Accessories**<br>Lead Assembly (Signal) 43129–492B.<br>Lead Assembly (HT) TM 7053 (43125–029P).<br>AC Supply Lead 43122–017A.<br>Shielded Terminal TB 39868 (43168–008S).<br>BNC Plug, 50 Ω 23443–305B.<br>Instruction Manual 46881–376Y. |
| 41635–041P | **Optional Accessories**<br>Rack Mounting Case TM 7010. |

# Two-Tone Signal Source

# TF 2005R




9756/2

- ☐ **Two identical oscillators covering 20 Hz to 20 kHz**
- ☐ **Less than 0·1% distortion**
- ☐ **For intermodulation measurements on high quality a.f. equipment**

In certain types of a.f. amplifying or transmission equipment intermodulation distortion produced by non-linearity is more important than the harmonic distortion. Standard methods of measurement of intermodulation distortion have, therefore, been recommended by S.M.P.T.E. and C.C.I.F. The TF 2005R Two-Tone Signal Source is an assembly of modular units arranged to form a convenient test set for measurements following these recommendations.

The instrument comprises two AF Oscillators and an AF Monitored Attenuator mounted together in a standard Marconi full-module case. The frequency of each oscillator is indicated on its own calibrated dial. Output levels are set up by temporarily isolating each oscillator in turn from the monitor – by means of the front panel switch – while the output level of the other is being checked. The overall amplitude of the composite signal is adjusted by means of the attenuator controls.

For general purpose applications either oscillator can be used singly with the attenuator to form an AF Signal Source, or the a.f. output can be drawn directly from either oscillator separately.

## AF Oscillator

This is a general purpose low-distortion oscillator that is intended for use as a controllable source of audio frequency signals for measurements on high quality amplifiers, etc.

Its modern electrical design, utilising solid-state active elements throughout, is complemented by an advanced mechanical layout, whereby the instrument can be opened like a book to give free access to all components. No part of the circuit is disconnected in this operation; and the unit remains fully functional even in the open condition – an important feature for ease of servicing.

## AF Monitored Attenuator

The basis of this attenuator is the resistive pad in tee or pi form. The system comprises three switches, each with four symmetrical 600 Ω T-pads which are switched in series combinations to make one decade, and the three decades in series cover 111 dB in 0·1 dB increments, nominally up to 1 MHz.

The attenuator is combined with a wide-range a.c. voltmeter and a high quality a.f. transformer so that accurate measurements can be made in the audio band. Without the transformer in circuit the operating range extends up to 550 kHz, and without the voltmeter to d.c.

# TF 2005R

## AF Oscillator

| | |
|---|---|
| **FREQUENCY RANGE** | 20 Hz to 20 kHz in six semi-decade bands.<br>*Accuracy* ±1% ±0·2 Hz, including warm-up. |
| **OUTPUT** | *Into 600* Ω: + 15 dBm or 31·6 mW or 4·36 V.<br>*Open circuit:* at least 8·5 V.<br>*Control:* at least 40 dB by continuously variable T-network. |
| **Impedance** | 600 Ω unbalanced. |
| **Frequency response** | The output is level within ±0·4 dB between 20 Hz and 20 kHz. |
| **Distortion** | Less than 0·05% between 63 Hz and 6·3 kHz.<br>Less than 0·1% between 20 and 63 Hz, and between 6·3 and 20 kHz. |
| **Hum** | Below –80 dB relative to the output signal, or below –100 dBm, whichever is the greater. |

## AF Monitored Attenuator

| | |
|---|---|
| **IMPEDANCE** | |
| **Input** | 600 Ω unbalanced, when terminated with 600 Ω, 150 Ω or 75 Ω. Switched terminating resistor is incorporated. |
| **Output** | 600 Ω unbalanced, or 600 Ω, 150 Ω or 75 Ω balanced and centre-tapped when 600 Ω source is connected. |
| **FREQUENCY RANGE** | |
| **Unbalanced output** | DC to 550 kHz. |
| **Balanced output** | 20 Hz to 20 kHz. |
| **ATTENUATION** | |
| **Range** | 0 to 111 dB in 0·1 dB steps, and ∞ |
| **Maximum input** | +30 dBm or 1 W or 25 V into 600 Ω. |
| **Minimum attenuation** | Less than 0·01 dB. |
| **Accuracy** | *Unbalanced output:* ±1% of dB setting, ±0·01 dB at d.c.<br>±2% of dB setting, ±0·2 dB at 550 kHz.<br>*Balanced output:* ±1% of dB setting, ±0·2 dB between 20 Hz and 20 kHz. |
| **INPUT VOLTMETER** | |
| **Ranges** | Four switch positions selecting 1·5, 5, 15, 25 V f.s.d. or 0 dBm, +10 dBm, +20 dBm and +24 dBm. |
| **Meter** | Three scales: 0 to 1·5 and 0 to 5 V, and –6 to +6 dBm. |
| **Accuracy** | ±5% of f.s.d. between 20 Hz and 550 kHz. |
| **OUTPUT FREQUENCY RESPONSE** | Within ±0·2 dB between 20 Hz and 20 kHz; within ±1 dB between 20 Hz and 550 kHz; with constant input voltmeter reading. |

## Two-Tone Signal Source 2005R

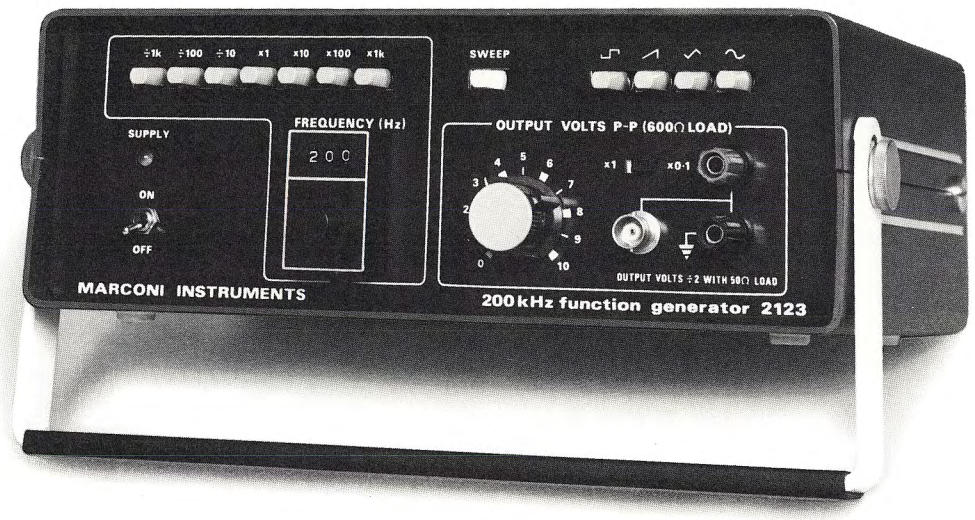
| | |
|---|---|
| | The complete equipment comprises two AF Oscillators and one AF Monitored Attenuator. |
| **Frequency range** | 20 Hz to 20 kHz in six bands. (Each Oscillator can be adjusted independently). |
| **Amplitude** | *Reference level:* up to +10 dBm from each Oscillator.<br>*Attenuator range:* 111 dB in 0·1 dB steps. |
| **Harmonic distortion** | Less than 0·05% between 63 Hz and 6 kHz when using unbalanced output.<br>Generally less than 0·1% under other conditions. |
| **Intermodulation** | Below –80 dB with respect to the wanted signal. |
| **Hum** | Below –80 dB with respect to the wanted signal. |
| **RADIO FREQUENCY INTERFERENCE** | Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference. |
| **SAFETY** | Complies with IEC 348. |
| **LIMIT RANGE OF OPERATION** | |
| **Temperature** | 0 to 55°C. |
| **CONDITIONS OF STORAGE AND TRANSPORT** | |
| **Temperature** | –40°C to +70°C. |
| **Humidity** | Up to 90% relative humidity. |
| **Altitude** | Up to 2500m (pressurised freight at 27 kPa differential, i.e. 3·9 lbf/in²). |
| **POWER REQUIREMENTS** | |
| **AC supply** | 95 V to 130 V or 190 V to 260 V. 45 Hz to 500 Hz; or 105 V to 130 V or 210 to 260 V, 500 Hz to 4000 Hz. 14 VA. |
| **DC supply** | 65 V to 90 V; load 60 mA. |
| **DIMENSIONS AND WEIGHT** | Height 200 mm (7¾ in) · Width 475 mm (18¾ in) · Depth 270 mm (10½) · Weight 16·5 kg (36·3 lb) |

### VERSIONS AND ACCESSORIES

*When ordering please quote eight-digit code numbers*

| Ordering Numbers | |
|---|---|
| **52005–301D** | **Versions**<br>TF 2005R. The basic instrument in rack mounting form. |
| | **Supplied Accessories**<br>Kit of Parts 46883–149V including: 2 Signal Leads TM6958, HT lead TM 7053, Mains Lead TM 7052, Shielded Terminal 43168–008S, Instruction Manual 46881–278F. |

# 200 kHz Function Generator 2123




14931/2

- ☐ **Sine, square, triangle and ramp waveforms**
- ☐ **Frequency range: 0·003 Hz to 200 kHz**
- ☐ **Outputs: 500 mV to 10 V into 600 Ω**
- ☐ **Internal sweep facility**
- ☐ **External frequency control**
- ☐ **TTL compatible square wave output**
- ☐ **Auxiliary triangle output for oscilloscope sweep**

The 200 kHz Function Generator 2123 is a multi-purpose generator designed for laboratory applications. It produces sine, square and triangle waveforms at frequencies between 0·003 Hz and 200 kHz, and ramp waveforms at frequencies between 0·003 Hz and 30 kHz. The source impedance on all functions is 60 Ω.

The main output waveform is selected by four push-button switches and it is available both at a BNC socket and at 4 mm terminals on the front panel. The output level can be varied up to a maximum of 10 V p-p by means of a continuously variable control calibrated for connection to a 600 Ω load. A slider switch enables the output to be attenuated by a factor of 10 (20 dB).

Frequency is set by seven range push-buttons in conjunction with a multi-turn precision potentiometer with a 3 digit readout. The frequency can also be controlled by application of a direct voltage to the rear panel VCF (voltage controlled frequency) sockets. This input also permits frequency modulation of the output signal by means of an external voltage.

An internal logarithmic sweep generator enables the frequency to be swept from the value set on the dial down to one thousandth of the dial range maximum frequency. The sweep control voltage is available at rear panel sockets.

Two auxiliary outputs are available from rear panel sockets – a triangular output which provides a suitable source for an oscilloscope sweep, and a t.t.l. compatible square wave which can supply up to twenty standard loads. These outputs are in synchronism with the main output.

## MAIN OUTPUT

| | |
|---|---|
| **WAVEFORMS** | Sine, square, triangle and ramp waveforms, selected by push-buttons. |
| **FREQUENCY** | 0·003 Hz to 200 kHz (usable to 250 kHz) in seven ranges selected by push-buttons. Maximum frequency of ramp waveform is 30 kHz. Variable adjustment of each range by multi-turn control with three digit readout from 003 to 300. |
| **Setting accuracy** Sine, square, triangle | ±2% of f.s. (with lowest possible multiplier selected) from 0·03 Hz to 150 kHz.<br>±5% of f.s. from 150 kHz to 200 kHz. |
| **Stability** | Better than 0·02% per °C.<br>Better than 0·1% for ±10% supply variation.<br>Better than 0·1% from full load to no load.<br>Better than 0·1% from 1 to 10 V p-p.<br>Frequency pulling at 50 Hz or 100 Hz is less than one digit. |
| **AMPLITUDE** | |
| **Direct** | 20 mV (nominal) to 10 V p-p into 600 Ω load.<br>*Accuracy:* ±5% of full scale for output setting above 500 mV.<br>The output levels into a 50 Ω load are as for 600 Ω load divided by two. |
| **Attenuated** | As for direct output X 0·1 (20 dB).<br>*Accuracy:* As for direct output ±2·5%. |
| **Frequency response** | Amplitude varies by less than:<br>1% over the range 0·003 Hz to 30 kHz.<br>5% over the range 30 kHz to 200 kHz. |
| **Voltage stability** | Better than 0·2% per °C.<br>Better than 0·2% for 10% supply variation. |
| **Source impedance** | 60 Ω. Output calibrated into 600 Ω load |
| **SIGNAL PURITY** | |
| **Sine wave distortion** | Less than 2% over the range 20 Hz to 20 kHz (with lowest possible multiplier selected). |
| **Square wave rise and fall time** | Less than 250 ns. |
| **Ramp rise to fall time ratio** | Less than 1000:1 on divide by 1 k range.<br>Less than 100:1 on divide by 100 range.<br>Less than 10:1 on other ranges. |
| **SWEEP** | Inverse logarithmic variation of frequency from the maximum set on the dial to approximately 1/1000 of dial maximum. |
| **Sweep speed** | 25 ms for 1000:1 variation. The rate at which the frequency is swept is adjustable externally by addition of capacitance (approximately 2 µF per second). |

## OTHER FACILITIES

All via 2 mm sockets on rear panel.

| | |
|---|---|
| **CONSTANT LEVEL OUTPUTS** | Frequency as for the main output. |
| **TTL compatible** | Approximately 5 V square wave (fan-out of 20 logic loads available). |
| **Triangle waveform** | Approximately 7 V p-p from a nominal 600 Ω source. |
| **SWEEP GENERATOR INVERSE LOGARITHMIC OUTPUT** | Approximately 10 V peak with dial setting at maximum. |
| **Output level** | Proportional to dial setting. |
| **Source impedance** | Nominally 600 Ω. |
| **EXTERNAL FREQUENCY CONTROL** | A 10 mV positive voltage applied to the VCF input on the rear panel will increase the frequency by 1 digit setting and a 10 mV negative voltage will decrease the frequency by 1 digit setting. The effect is linear from 1 digit to 300 digits. |
| **Accuracy** | ±10%. |
| **Maximum voltage** | 10 V. |
| **Slew rate** | 0·2 V per µs. |
| **Input impedance** | 10 kΩ. |

## GENERAL

| | |
|---|---|
| **RADIO FREQUENCY INTERFERENCE** | Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference. |
| **SAFETY** | Complies with IEC 348. |
| **LIMIT RANGE OF OPERATION** | |
| **Temperature** | 0 to +50°C. |
| **CONDITIONS OF STORAGE AND TRANSPORT** | |
| **Temperature** | −40° to +70°C. |
| **Humidity** | Up to 90% relative humidity. |
| **Altitude** | Up to 2500 m (pressurized freight at 27 kPa differential, i.e. 3·9 lbf/in²). |
| **POWER REQUIREMENTS** | |
| **AC supply** | 100 to 120 V ±10% and 200 to 240 V ±10%. 25 W maximum.<br>50 to 60 Hz. |
| **DIMENSIONS AND WEIGHT** | |

| Height | Width | Depth | Weight |
|---|---|---|---|
| 11·5 cm | 27·5 cm | 20 cm | 2·75 kg |
| 4·5 in | 10·8 in | 7·9 in | 6·05 lb |

### VERSIONS AND ACCESSORIES

*When ordering please quote eight digit code numbers*

| Ordering number | |
|---|---|
| **52123-900W** | **Versions**<br>200 kHz Function Generator 2123. |
| | **Supplied Accessories**<br>Instruction Manual.<br>2 mm Plugs for rear panel connections (10 supplied). |




## 'The White Noise Book'

**Multichannel communication systems and white noise testing**
**By M. J. Tant**

An aid to the understanding of the technologies associated with multichannel f.d.m. systems, with particular reference to the practice of white noise testing.
The somewhat bewildering quantity of different measuring units encountered in today's telephone industry are defined and the currently published noise objectives for multichannel systems are summarized, together with past and present recommendations for white noise testing.
Charts and tables are also included to enable the engineer involved in white noise loading to apply measurement corrections for maximum accuracy.
As a member of Marconi Instruments Ltd, M. J. Tant is responsible for the worldwide marketing of f.d.m. measuring instruments with particular emphasis on white noise testing. He represents the Electronic Engineering Association on the British Standards Institution committee concerned with instrumentation for terrestrial and satellite microwave systems. He is also a member of International Electro-technical Commission committees charged with similar responsibilities on a world-wide basis.

marconi instruments

# FDM Test Equipment


| | | |
|---|---|---|
| White Noise Test Set | OA 2090B | 48 |
| Automatic White Noise Test Set | OA 2090C | 53 |
| Filters for White Noise Test Sets | | 60 |


## Selection Guide

| TYPE NUMBER | APPLICATIONS | FEATURES |
|---|---|---|
| OA 2090B | R and D, Production, Installation and Maintenance of multichannel f.d.m. systems over terrestrial and satellite radio links and coaxial cable systems. | Conforms to relevant CCIR, CCITT, INTELSAT and BELL Recs. for simple and accurate measurement of basic and intermodulation noise. Portable for field applications. |
| OA 2090C | As OA 2090B with specific features to ease repetitive measurement tasks particularly during production and commissioning. | Enhanced speed and versatility providing wide choice of measuring units together with digital readout and hard copy of results. Programmable for remote or auto testing applications. |

# White Noise Test Set OA 2090B




1254

- ☐ **Measures noise and intermodulation on wide-band multichannel telephony systems**
- ☐ **Suitable for 12 channel to 2700 channel systems**
- ☐ **Accepts all 'A' and 'B' series filters**
- ☐ **Meets all relevant CCIR, CCITT and INTELSAT requirements**

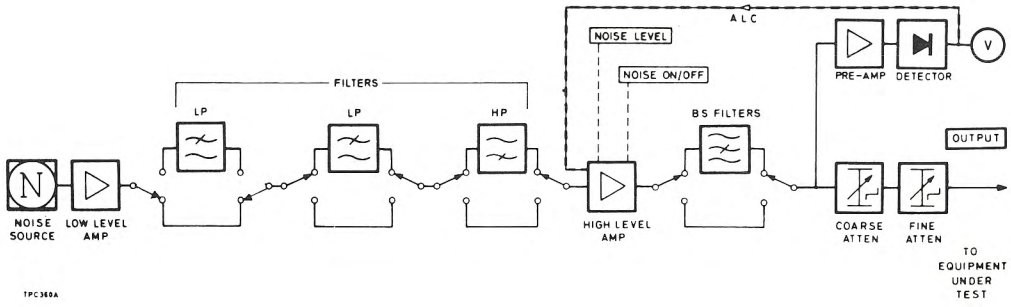
Two compact units form a complete equipment for measurement of noise interference in wideband telecommunication systems by methods based on recommendations of the CCIR (Radio Relay), CCITT (Cable) and INTELSAT. These methods are based on the fact that random noise evenly distributed over the system baseband closely simulates the wideband multiplex signal encountered under operational conditions.

OA 2090B has been specially developed to meet the latest CCIR recommendations when it is used with "B" filters. When fitted with "A" filters OA 2090B conforms to the older CCIR recommendation.

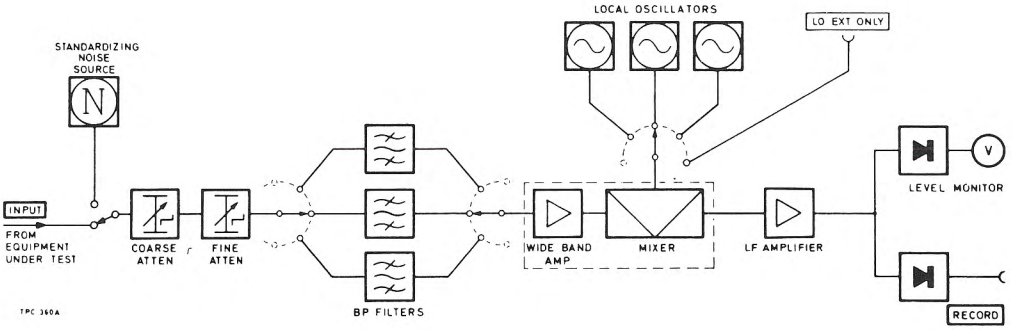
A noise signal which simulates traffic at a specified level of loading, is applied to the communication system from Noise Generator TF 2091B. A quiet test channel is produced by the introduction of a band-stop filter in the generator circuit; and the noise level in this test channel at the output of the system represents the level of interference due to intermodulation and residual noise in an equivalent operational channel. It is measured by means of Noise Receiver TF 2092B, which compares the noise interference with the noise in the same channel in its busy state; i.e., when the band-stop filter is taken out of circuit. The result of this comparison is known as the noise power ratio (n.p.r.).

This system of measurement is applicable to the design, manufacture, commissioning and maintenance of Microwave Links, Tropospheric Scatter Systems, Multichannel Cable Links, Geostationary Communication Satellite Links, and Video Tape Systems.

NOISE GENERATOR




NOISE RECEIVER




## THE NOISE GENERATOR

The generated noise bandwidth extends from below 12 kHz to above 12·36 MHz, and thus accommodates all basebands from 12 channels to 2700 channels.

For realistic simulation of traffic conditions, however, the transmitted noise bandwidth must be equal to the baseband of the system. So the noise signal is passed through a pair of band-limiting filters – a high-pass filter at the low-frequency end and a low-pass filter at the high end. The band-limited signal is then amplified and fed, via the band-stop (slot) filter which produces the quiet test channel, to an output attenuator.

### Flexibility

The mechanical arrangements are such that any of the filters can easily be changed to suit the operational equipment to be tested.

Each filter – band-limiting as well as band-stop – can be switched into and out of circuit by means of a rocker switch; all the filters are mechanically similar, and the instrument is designed to carry a total of nine, this total being made up of any number of high-pass, low-pass and band-stop filters as desired.

By fitting a suitable selection of filters the instrument can, therefore, be arranged for testing two or more different communication systems, the noise bandwidth being changed simply by the operation of the appropriate switches. For easy identification band-limiting filter switches are colour coded grey, and the band-stop filter switches are red. Switch selection of bandstop filters allows the selection of one measurement slot at a time as required by the CCIR recommendations.

### Noise power output

The power level of the noise signal applied to the output attenuators is monitored by a meter scaled in dBm. The final output level, within the range −54 dBm to +20 dBm is obtained by the combined indication of the meter and attenuators.

Suitable loading levels of noise power are recommended by the appropriate authority, i.e. CCIR, CCITT or COMSAT.

The baseband power level is maintained constant when switching in band stop filters by an Automatic Level Control circuit which compensates for the power lost due to the insertion loss of the filter.

## THE NOISE RECEIVER

The receiver, connected at the receiving end of the link system, is switch-tuned to the centre frequency of the test channel appropriate to the band-stop filter in use in the noise generator.

Up to six frequency selectors can be fitted, each comprising a band-pass input filter and a plug-in local-oscillator board. Like the noise generator, the receiver is so constructed that the frequency selector units can be changed easily and quickly. An independent gain control for each reception channel permits equalisation of sensitivity over the frequency range.

The output from the internal local oscillator is available from a coaxial socket; or, alternatively, the same socket is utilised as the inlet for an external local oscillator signal, the channel selector switch being set to a seventh position for this facility. Operated with an external local oscillator, the receiver may be used as a

selective level meter for general analysis of r.f. signals in the frequency range 12 kHz to 12·4 MHz.

## The measurement

The standard way of measuring the n.p.r. is by a slide back method utilising the receiver's input attenuator.

With the communication system fully loaded with white noise, without any quiet channels, the receiver is set to the test frequency, and its sensitivity is adjusted for a deflection of the panel meter pointer to a reference mark. It is then responding to the mean noise level over its 2·2 kHz bandwidth. The appropriate band-stop filter in the noise generator is then switched into circuit, producing the quiet test channel not less than 3 kHz wide, and the receiver's input attenuator is adjusted to bring the meter pointer back to the reference mark. The noise power ratio is then equal to the change in attenuation. It is usual to measure the n.p.r. at several frequencies in the baseband including one near the top, one at the centre and one near the bottom frequency limit. Recommended in-band test channels are shown in the tables following the specification.

## Direct reading in NPR

For convenience of operation the attenuator controls are scaled to be direct reading in noise power ratio; i.e., calibrated in reverse with 0 dB corresponding to high attenuation.

The initial setting up on a busy channel is normally done with the attenuator at the 0 position. In order to cater for various mean power levels, the coarse attenuator dB scale can be rotated (with click stops) relative to the dial.

## Absolute noise measurement

The receiver contains a standard wideband noise source which provides 1 pW per channel power density to the receiver input attenuator. The receiver can then be standardised to measure noise interference in pW per channel over the range 1 pW to $13 \times 10^5$ pW per channel. Conversion graphs are provided for measurements in alternative units, including pWp, dBmp, dBrnc and dBa.

## Residual system noise

The generator output may be switched off or interrupted to allow the measurement of residual system noise without the necessity of disconnecting the noise generator.

## Out of band testing

It is sometimes desirable to monitor the intermodulation and residual noise in a multi-channel system while it is carrying traffic. The usual method is to monitor the noise in a nominal test channel just outside the operational bandwidth of the system.

Noise receiver TF 2092B when used in its absolute noise measurement mode is suitable for out-of-band measurement and filters conforming to CCIR recommendation 398-3 (Geneva 1974) are available as shown in the table. "A" filters at out-of-band frequencies are also available.

## Recorder output

For continuous monitoring of noise interference levels, the receiver is provided with a recorder output jack. The voltage from this socket is derived by rectification of the l.f. noise signal, and the smoothed d.c. output is proportional to the mean noise level.

## Bench or rack mounting

The two units are the same size, conforming to the Marconi modular dimensional standard. As full-module units, they are normally in bench type cases with provision for fitting a protective front cover, which is available as an optional accessory. The instruments can also be supplied ready for mounting into a standard 19 inch rack; or, if required at a later date, a separate rack-mounting conversion kit is available.

# OA 2090B

## Noise Generator TF 2091B

The generator may be fitted with up to nine filters. These include high-pass and low-pass filters corresponding to the baseband of the system under test, and band-stop filters for selected slot frequencies—for details see "Filter characteristics" below and for type numbers see tables.

**NOISE BAND**

White noise is generated over the frequency band from below 12 kHz to above 12360 kHz. Within the bandwidth corresponding to the baseband of the system under test, the r.m.s. voltage of the white noise spectrum measured in a band of about 2 kHz does not vary by more than ±0·5 dB. The noise band is limited by the high-pass and low-pass filters selected.

**OUTPUT**

Noise power density is adjustable to at least −14·5 dBm/kHz with 'B' version filters or −12·5 dBm/kHz with 'A' version filters.
Maximum total power is +20 dBm.
Noise output may be switched off by a front panel switch.

**Peak factor**

Greater than 12 dB up to 17 dBm output level.

**ALC**

Maintains the output level constant when switching band-stop filters, and also when switching band-limiting filters provided the noise power density is within the specified limit. With a meter indication between −1 dB and +1 dB the level is restored to within 0 and −0·25 dB of the original level after inserting a band-stop filter.

**Attenuators**

*Coarse:* Above 0 dBm in four steps of 5 dB to +20 dBm.
Below 0 dBm in four steps of 10 dB to −40 dBm.
*Fine:* 0 to −11 dB in eleven steps of 1 dB.

**Meter calibration**

0 to ±1 dBm in 0·2 dB increments.
0 to −3 dBm in 1 dB increments.
*Accuracy:* ±0·1 dB at ±1 dBm.
±0·3 dB at −3 dBm.

**Output level accuracy**

(when meter indicates 0 dBm).
±0·3 dB at 0 dBm attenuator setting.
Additional error at other levels is ±0·5% of fine attenuator dB setting. ±0·5% of coarse attenuator dB setting, ±0·1 dB.

**Output impedance**

75 Ω.

**Return loss**

Greater than 20 dB when the attenuators are set for 0 dBm and below.

**POWER REQUIREMENTS**

**AC supply**

95 to 130 V or 190 to 260 V;
45 to 500 Hz, 50 VA.

**DIMENSIONS**

| Height | Width | Depth |
|---|---|---|
| 195 mm | 475 mm | 432 mm |
| $7\frac{3}{4}$ in | $18\frac{3}{4}$ in | 17 in |

**WEIGHT**

Instrument without filters 12 kg ($26\frac{1}{2}$ lb).
Weight of typical filter, 0·6 kg ($1\frac{1}{4}$ lb).

## Noise Receiver TF 2092B

The receiver may be fitted with up to six band-pass filters and six local oscillator boards—for details see 'Filter characteristics' below and for type numbers see tables.

**Number of channels**

Up to six, switch selected.

**Effective bandwidth**

Nominally 2·2 kHz.

**Sensitivity**

*With 'B' version filters:*
Better than −130 dBm/kHz.
*With 'A' version filters:*
Better than −120 dBm/kHz.
The gain of each reception band is adjustable to give equal sensitivity for the six bands.

**Inherent noise**

Inherent noise density is equivalent to the sensitivity figure.

**INPUT ATTENUATOR**

Direct reading in noise power ratio and in pW of noise power per 3·1 kHz bandwidth.

**Range**

0 to 91 dB in eight steps of 10 dB and eleven steps of 1 dB.

**Accuracy**

±0·5% of attenuation value ±0·1 dB.

**Calibration**

0 to 91 dB in terms of noise power ratio.
1 pW to $13 \times 10^5$ pW in terms of noise power per 3·1 kHz bandwidth.

**Input impedance**

75 Ω. Return loss greater than 20 dB for all positions of input attenuator when the indicated level exceeds 0·1 pW.

**STANDARDIZING NOISE SOURCE**

**Level**

1 pW (−90 dBm) per 3·1 kHz bandwidth (−95 dBm per kHz bandwidth).

**Characteristic**

Noise is generated over the band 10 kHz to 13 MHz, within which the level does not vary by more than ±0·25 dB.

# OA 2090B

| | |
|---|---|
| **Accuracy** | ±0·5 dB at 1 pW per 3·1 kHz bandwidth. |
| **LOCAL OSCILLATOR** | Up to six local oscillator boards may be fitted. |
| **Local oscillator output** | Between 0·3 and 0·7 V e.m.f. depending on frequency.<br>Source impedance typically 1·5 kΩ in parallel with 75 pF. |
| **External local oscillator input** | 0·6 V ±20%. Input impedance typically 6 kΩ in parallel with 60 pF. |
| **RECORDER OUTPUT** | Suitable for use with 1 mA recorders. |
| **POWER REQUIREMENTS** | |
| **AC supply** | 95 to 130 V or 190 to 260 V;<br>45 to 500 Hz. 15 VA. |
| **DIMENSIONS** | Height 195 mm (7¾ in); Width 475 mm (18¾ in); Depth 432 mm (17 in) |
| **WEIGHT** | Instrument without filters or local oscillators, 12·3 kg (27 lb).<br>Weight of typical filter, 0·6 kg (1¼ lb). |

## Overall equipment

| | |
|---|---|
| **Inherent intermodulation and noise** | Measured as a back-to-back noise power ratio, i.e. with the generator output connected directly to the receiver input and with the power level not greater than that recommended by CCIR as the loading for the bandwidth in use when measured at a zero transmission level point (dBm=dBm0).<br>*With 'B' version filters:*<br>better than 67 dB.<br>*With 'A' version filters:*<br>better than 75 dB above 50 kHz and better than 70 dB at 50 kHz and below. |
| **RADIO FREQUENCY INTERFERENCE** | Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference. |
| **SAFETY** | Complies with IEC 348. |
| **LIMIT RANGE OF OPERATION** | |
| **Temperature** | 0 to 55°C. |

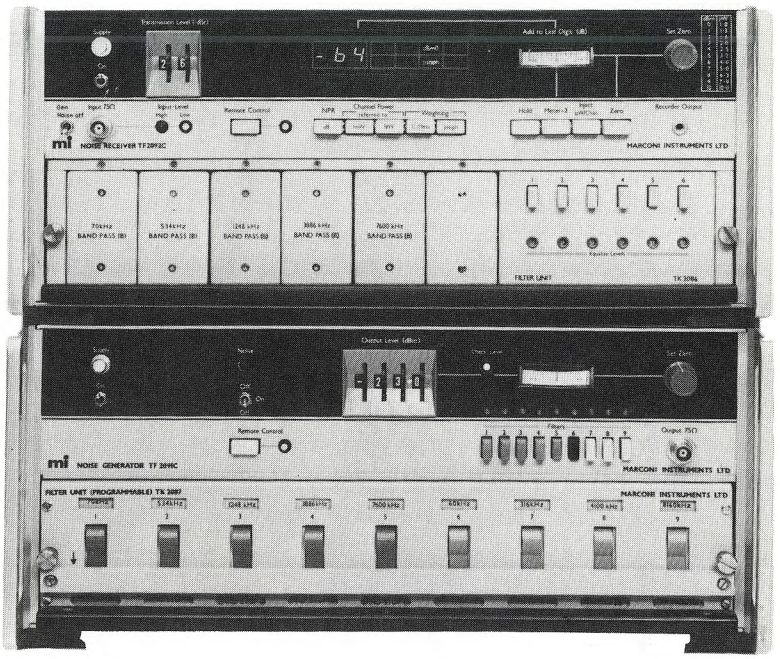
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|---|---|
| **CONDITIONS OF STORAGE AND TRANSPORT** | |
| **Temperature** | −40°C to +70°C. |
| **Humidity** | Up to 90% relative humidity. |
| **Altitude** | Up to 2500 m (pressurized freight at 27 kPa differential, i.e., 3·9 lbf/in²). |

### VERSIONS AND ACCESSORIES

*When ordering please quote eight-digit code numbers*

| Ordering numbers | |
|---|---|
| | **Versions** |
| **52090-035U** | White Noise Test Set OA 2090B. Consisting of: |
| **52091-035D** | Noise Generator TF 2091B. |
| **52092-035Z** | Noise Receiver TF 2092B. |
| | **Supplied Accessories** |
| | Two BNC Plugs, Greenpar type GE 37570C 30. |
| | Telephone Plug, Bulgin type P38. |
| | Two Power Leads TM 7052 (43123-076Y) for bench mounting OA 2090B. |
| | OR |
| | Two Free Sockets, Bulgin type P430/5E for rack mounting OA 2090B. |
| | Instruction Manual 46881-084P. |
| | **Optional Accessories** |
| | Selective Filter Sets comprising band-stop filters, band-pass filters and local oscillator boards. |
| | Band Limiting Filters, high pass and low pass. |
| **54481-011C** | Matching Transformer TM 5955, 75 Ω unbalanced to 150 Ω balanced. |
| **54351-011F** | Connecting Lead TM 4726/260, BNC, 1830 mm (6 ft). |
| **54124-021N** | Front-panel cover (protective) TM 7958/3 for generator or receiver. |
| **54134-011A** | Dummy Front Plate TM 7957, for use in place of one filter. |
| **46883-002Z** | Rack Mounting Kit TM 8270, to fit one unit into a 19 in. rack. |
| **54112-061W** | Carrying case for generator or receiver. |
| **54112-071R** | Carrying case for spare filters. |

# Automatic White Noise Test Set OA 2090C



14395/1

- ☐ Automatic measurements for all noise loading tests
- ☐ Measures n.p.r., dBmOp, dBrnCO and all commonly used units for f.d.m.
- ☐ Digital readout in selected unit
- ☐ Analogue and b.c.d. outputs for recording
- ☐ Semi-automatic control of generator from receiver
- ☐ Remotely programmable
- ☐ Optional Control Unit for automated measurement sequences
- ☐ GPIB operation using suitable bus coupler
- ☐ Plug-in filters and local oscillators in interchangeable units
- ☐ Accepts all 'A' and 'B' series filters
- ☐ Conforms to all relevant CCIR and CCITT recommendations

White Noise Test Set OA 2090C provides an automatic measurement capability for f.d.m. baseband noise loading tests. It has application in research, development, production, installation, commissioning and maintenance of multichannel systems with capacities up to 2700 channels. As a result the test set will be used by PTT Authorities, telephone companies and manufacturers of telephone systems for measurements on coaxial cable, microwave link, tropospheric scatter and communications satellite systems.

OA 2090C consists of a Noise Generator TF 2091C and a Noise Receiver TF 2092C. An optional Control Unit TK 2085 is also available. These units have been designed to form a fully automatic test system, but the generator and receiver may also be used separately, the receiver being suitable for use with any white noise generator, including all generators in the Marconi Instruments TF 2091 series. OA 2090C may be controlled over the General Purpose Interface Bus by the use of a suitable bus coupler. The test set conforms to the CCIR and CCITT recommendations for white noise testing, and it will accept all the Marconi Instruments 'A' and 'B' series filters.

# OA 2090C

For users who do not require the automatic capability provided by OA 2090C the well proven Marconi Instruments White Noise Test Set OA 2090B will continue to be available, providing the same high accuracy for manual measurements.

In addition to automatic measurement, OA 2090C provides digital readout in all the commonly used transmission measurement units and it also provides outputs in both b.c.d. and analogue form for recording purposes.

In the manual mode of operation, measurement functions are selected by front panel push-buttons. Selection of programmable operation transfers the front panel control functions to control lines accessible through sockets on the rear panels. In the programmable mode the control element can be either an automatic test system or the optional remote Control Unit TK 2085. This unit acquires control of all essential front panel functions and also provides for simple programming of measurement channels and power levels for automatic recording of n.p.r. curves on a digital printer.

Plug-in filter units in both generator and receiver permit easy changing of filters, and rapid interchange between systems is also possible by keeping spare units loaded with all the filters necessary for a system. For both generator and receiver a plug-in filter unit is necessary for fitting the filters.

## NOISE GENERATOR TF 2091C

TF 2091C generates noise with Gaussian distribution and a spectrum from below 6 kHz to above 12360 kHz. Output power is variable from +19·9 dBm to −59·9 dBm, and an a.l.c. circuit maintains the selected output within ±0·1 dB irrespective of filter and level switching.

The noise generator when fitted with the plug-in Programmable Filter Unit TK 2087 has a choice of two modes of operation—MANUAL and REMOTE. In the MANUAL mode any combination of filters can be selected by push-buttons on the generator front panel, with lamps indicating which filters are operative. Output power is selected by three thumbwheel switches giving steps of 10, 1 and 0·1 dB, and a SET ZERO control gives variation of ±0·5 dB relative to the switch settings, as displayed on a meter. A NOISE ON/OFF switch, with warning lamp, is provided for use when making measurements of baseband idle noise. In the REMOTE mode, control of filter selection, output level in 0·1 dB steps and NOISE ON/OFF is achieved by signals to the rear panel socket.

With the receiver program board fitted, certain generator functions can be controlled at the receiver by means of an interconnecting cable. Selecting a band-pass filter in the receiver will automatically select the corresponding band-stop filter in the generator. Operation of the receiver SET ZERO switches the selected band-stop filter out for auto-zeroing to reference level on n.p.r. measurement. The NOISE ON/OFF function may also be controlled at the receiver.

The programmable filter unit has provision for nine filters, of which five or six may be band-stop and three or four may be band-limiting. A Manual Filter Unit TK 2087/1 is available for use where the remote facility is not required. Filters are selected by their mechanical rocker switches and other functions by their front panel controls.

## NOISE RECEIVER TF 2092C

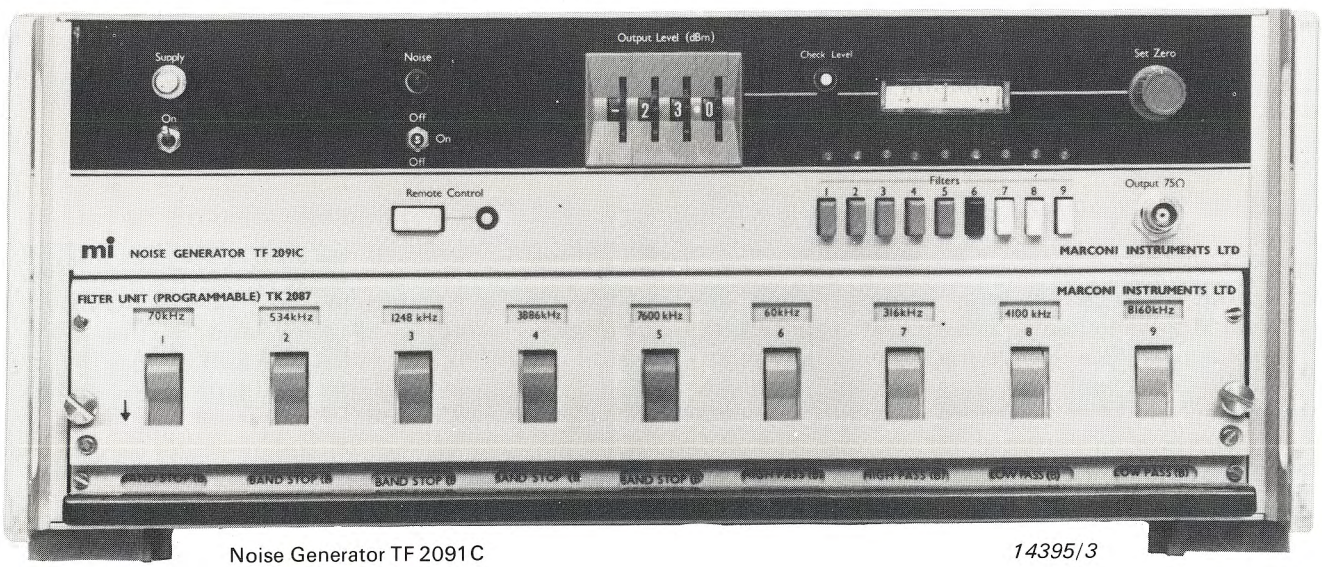
To achieve the desired high accuracy and long-term stability, the noise receiver uses a slide-back measurement technique. The self-balancing attenuator simplifies measurements and removes the need for manual operation of controls.

Signals derived from a level detector control the attenuator. An arithmetic unit converts the attenuator setting into a reading in the selected unit which is presented on a 3 digit display giving readings to the nearest dB. A centre-zero meter provides cover from −2·5 to +2·5 dB and from −5 to +5 dB, switch selected.

The band-pass filters and local oscillators are mounted in a plug-in Filter Unit TK 2086, which has provision for up to six channels and which permits rapid adaptation to different channel capacities.

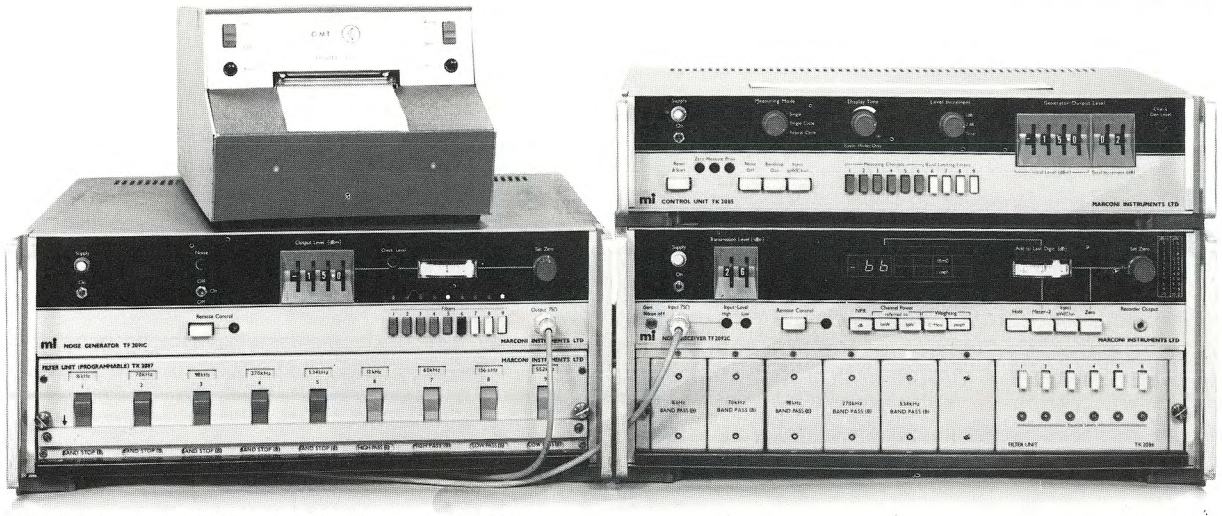
### Automatic measurement of n.p.r.

To make measurements of n.p.r. the system under test is




Noise Generator TF 2091C

*14395/3*



OA 2090C with TK 2085 and Digital Printer GMT 301

*14551/2*

first fully loaded with white noise, with no quiet channels, and the receiver sets automatically to zero reference level at the selected measurement frequency. When the appropriate band-stop filter is switched in at the generator, the receiver automatically measures and displays the reduction in noise level introduced by the quiet channel, i.e. the noise power ratio.

For further n.p.r. measurements at different loading levels the receiver automatically zeros at each increment of power, providing these increments do not individually exceed 19 dB. Results for plotting n.p.r. curves can be automatically recorded on a printer.

## Automatic measurement of channel power

For channel power measurements the incoming noise is automatically compared with an internal standard of 1 pW/channel and computed in terms of noise per channel. Measurements can be made unweighted or weighted to CCITT psophometric or C-message standards to give readout in the following units: dBm, dBrn, dBmp, dBrnp, dBrnC.

In addition, relative transmission level can be selected over the range 0 to −49 dBr in 1 dB steps and the readout then appears directly in the '0' format, relative to standard test tone level in the following units: dBm0, dBrn0, dBm0p, dBrn0p, dBrnC0.

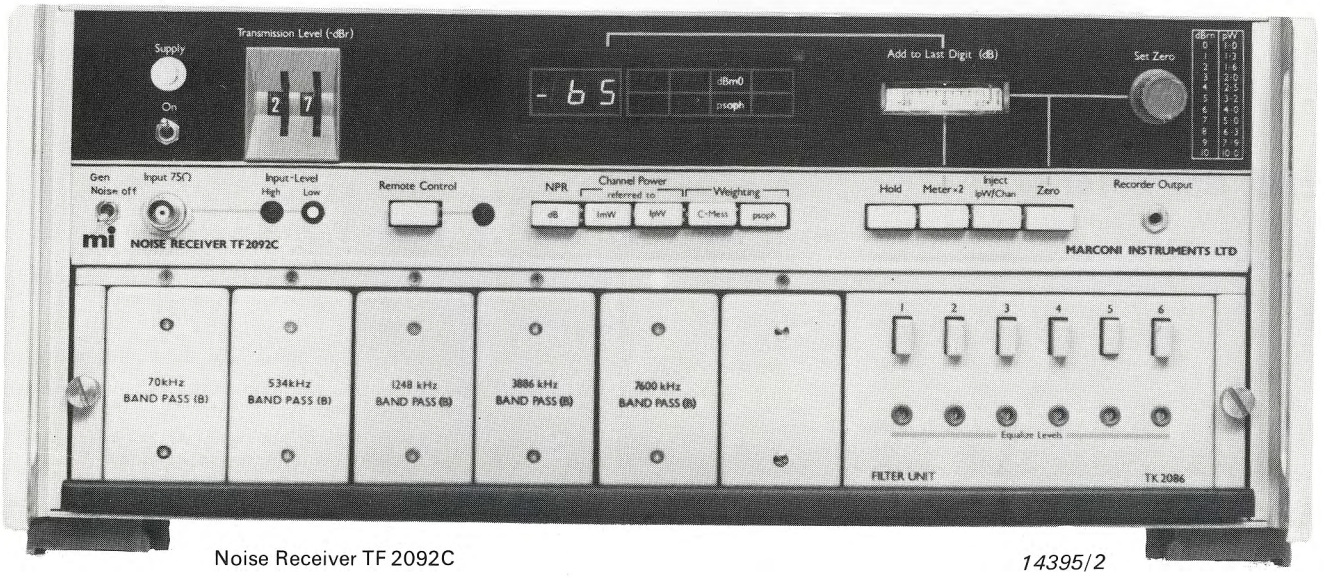
Readout is also available of signal-to-noise ratio, which is the ratio of the level of the standard test tone at a point to the noise at that point. Signal-to-noise ratio is numerically equal to the per channel noise expressed in dBm0 with the sign reversed, as is explained on page 54 of 'The White Noise Book'.

## Readout

The readout consists of a 3-digit display with automatic indication of polarity and units. For interpolation between the last digits there is a panel meter, scaled to ±2·5 dB and ±5 dB, which is also used during initial zero reference setting. An analogue output provides continuous recording of level by chart recorder, a HOLD button disabling the automatic attenuator balancing. The recorder output has a range of −5 dB to +10 dB, linear dB, with reference to the digital display. Selecting METER X2 and HOLD provides a visual analogue display. High and low level warning lamps indicate when the input level is outside the range of the digital readout.

## Programming option

The addition of one optional printed circuit board allows remote control of channel selection and receiver standardisation together with b.c.d. output of the digital




Noise Receiver TF 2092C

*14395/2*

# OA 2090C

display, meter reading and channel number for operating a printer. A print command pulse is produced which is repetitive every two seconds while balance exists or is triggered from an external source. The outputs are suitable for most parallel input column printers and are available whether or not the receiver is switched into the REMOTE mode. The programming board is available as an optional accessory and can easily be fitted to existing receivers. An alternative version of the noise receiver is also available with the programming board already fitted.

## CONTROL UNIT TK 2085

This optional unit controls all programmable functions of the white noise generator and receiver, with capability for carrying out automatically a full sequence of tests and providing a printed record. Generator functions controlled are band-stop and band-limiting filter selection, output level and noise on/off. Receiver functions controlled are band-pass filter and local oscillator selection, inject 1 pW per channel and set zero.

The generator output level is adjusted by means of thumbwheel switches on the control unit front panel. Other functions are selected by panel push-buttons. A cycling mode provides level stepping over a pre-set range in adjustable increments and cycling through a selected number of measuring channels, all level measurements for one channel being completed before moving on to the next channel. If NOISE OFF is selected, each channel is first measured with the generator output off then over the preset level range. The sequence thus automatically measures basic n.p.r. or idle noise as well as loaded noise. Cycling can be either continuous or for one cycle only, which may be started remotely, for example by a time clock, so providing performance data during unattended periods. Cycling speed is variable and the results can be printed out automatically if a suitable printer is connected. Printout signals are available for generator level, receiver measurement and channel number at each step on each channel. Warning signals are also provided for unattainable generator levels and out-of-range receiver inputs.

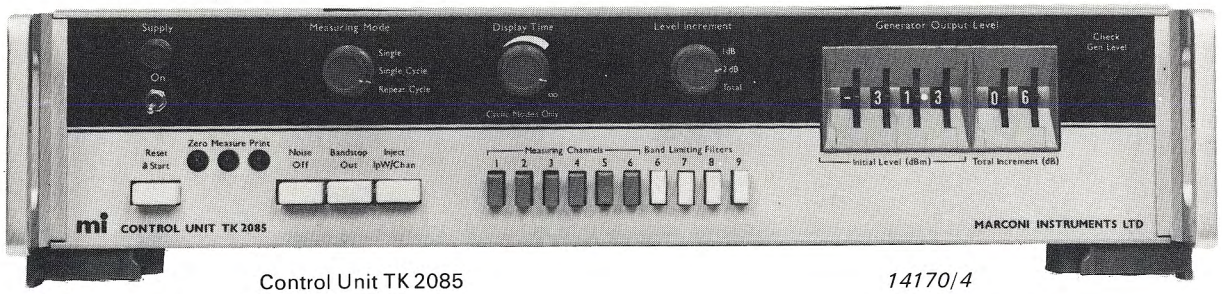
The control unit is usable with most t.t.l. compatible printers (control signals may be internally set to positive or complementary logic levels).

Example of n.p.r. printout

| Generator level in dBm | n.p.r. | Channel |
|---|---|---|
| −11.3 | 56.5 | 1 |
| −09.3 | 54.5 | 1 |
| −07.3 | 51.0 | 1 |
| −11.3 | 53.5 | 3 |
| −09.3 | 51.5 | 3 |
| −07.3 | 47.0 | 3 |
| −11.3 | 54.0 | 5 |
| −09.3 | 52.0 | 5 |
| −07.3 | 49.0 | 5 |

## GPIB CONTROL

OA 2090C may be operated over the General Purpose Interface Bus (GPIB) when a suitable bus coupler is used to convert the parallel b.c.d. information from OA 2090C. Full information about this method of operation, including a typical control program, is given in a Marconi Instruments' application note 'Measuretest' No. 37.




Control Unit TK 2085 *14170/4*

# Noise Generator TF 2091C

**NOISE BAND**

The Generator must be used with either Programmable Filter Unit TK 2087 or Manual Filter Unit TK 2087/1. Either unit may be fitted with up to nine filters, including high-pass, low-pass and band-stop filters for selected slot frequencies. Any filters from the 'A' and 'B' ranges may be used.

White noise is generated over the frequency band from below 6 kHz to above 12360 kHz, complying with CCIR Recommendation 399-2. Within the bandwidth corresponding to the baseband of the system under test the r.m.s. voltage of the white noise spectrum measured in a band of about 2 kHz does not vary by more than ±0·5 dB.
The noise band is limited by the high-pass and low-pass filters selected.

**NOISE POWER OUTPUT**

**Noise power density** — Adjustable to above −14·5 dBm/kHz.

**Peak factor** — Greater than 12 dB up to +15 dBm output level.

**Total power** — Maximum total power is typically +20 dBm in bandwidths of 4 MHz and above.

**Output level range** — Adjustable from +19·9 dBm to −59·9 dBm in 0·1 dB steps, controlled by thumbwheel switches.

| | |
|---|---|
| Output level accuracy | ±0·3 dB at 0 dBm with meter indicating zero.<br>Additional error at other levels is ±0·5% of thumbwheel setting, ±0·1 dB. |
| ALC | Maintains the meter indication within ±0·1 dB of initial setting at constant ambient temperature when switching level and filters. |
| Noise on-off | Noise output may be switched off at front panel, suppressing the level by at least 60 dB. A warning lamp lights when the noise output is switched off. |
| Level control | Level adjustable over at least ±0·5 dB relative to setting of thumbwheel switches. |
| Meter | Centre zero edgewise movement. When the meter reads zero the power output is that indicated on the thumbwheel switches. |
| Meter range | ±0·5 dB calibrated. |
| Over-range indicator | A warning lamp is lit when the meter reads off-scale and/or the output switches are set beyond range. |
| Output impedance | 75 Ω. |
| Return loss | Greater than 20 dB for output levels below 0 dBm.<br>Greater than 26 dB for an output level of −10 dBm. |
| PROGRAMMABILITY | Requires use of Programmable Filter Unit TK 2087. |
| Manual/remote selection | By front panel push-buttons, warning lamp indicating selection of REMOTE control position. In this position the front panel controls for OUTPUT POWER, NOISE ON/OFF and FILTER selection become inoperative. |
| Output level | Controlled by a 12 wire b.c.d. signal.<br>± sign 1 wire ('0' = −, '1' = +)<br>10 dB steps 3 wires<br>1 dB steps 4 wires<br>0·1 dB steps 4 wires |
| Filter selection | 5 or 6 band-stop filters – 3 wires b.c.d.<br>4 or 3 band-limiting filters – 4 wires. |
| Noise on/off | Single wire ('1' = Noise off). |
| Control source | All programmable functions are controlled by feeding the appropriate signals into a socket on the rear panel.<br>*Logic levels:* '0' = 0 to 0·4 V.<br>'1' = 4·75 to 5·25 V. |
| POWER REQUIREMENTS | |
| AC supply | 95 to 130 V and 190 to 260 V.<br>45 to 65 Hz. 45 VA. |
| DIMENSIONS AND WEIGHT | |

| Height | Width | Depth | Weight* |
|---|---|---|---|
| 188 mm | 426 mm | 482 mm | 14 kg |
| 7⅜ in | 16¾ in | 19 in | 31 lb |

*Without filters.

## Programmable Filter Unit TK 2087

| | |
|---|---|
| | Can be used with Noise Generator TF 2091C in either REMOTE OR MANUAL modes. |
| FILTER POSITIONS | Positions 1 to 5 for band-stop filters.<br>Position 6 for either a band-stop or a band-limiting filter.<br>Positions 7 to 9 for band-limiting filters. |
| FILTER SELECTION | By front panel push-buttons on TF 2091C to select up to 6 band-stop or two band-limiting filters in the MANUAL mode. |
| | Filters in use are indicated by lamps above each filter.<br>To ensure that the mechanical switches on all fitted filters are switched in, a locking device is provided. |

## Manual Filter Unit TK 2087/1

| | |
|---|---|
| | Can be used with Noise Generator TF 2091C in the MANUAL mode only. |
| FILTER POSITIONS | Nine Filters may be fitted of which up to 6 may be band-stop filters and up to 4 band-limiting. |
| FILTER SELECTION | Filters are selected by their mechanical switches, the push-buttons on TF 2091C being inoperative. |

## Noise Receiver TF 2092C

| | |
|---|---|
| | The Receiver must be used with Filter Unit TK 2086. |
| OVERALL CAPABILITY | |
| Number of channels | Up to six, selected by push-button or remote control with lamp indication of channel in use. 'A' or 'B' type band-pass filters and local oscillators housed in filter unit. |
| Effective bandwidth | Nominally 2·2 kHz. |
| Sensitivity | Better than −130 dBm/kHz with 'B' version filters (using digital and analogue displays).<br>Better than −120 dBm/kHz with 'A' version filters. |
| Gain equalization | The gain of each reception band is adjustable to give equal sensitivity for the six bands. |
| MEASUREMENTS | |
| Readout | Digital display of the following measurements by push-button selection:<br>1) NPR in dB.<br>2) Channel power relative to:<br>a) 1 mW unweighted in dBm or dBm0.<br>b) 1 mW psophometrically weighted in dBmp or dBm0p.<br>c) 1 pW unweighted in dBrn or dBrn0.<br>d) 1 pW psophometrically weighted in dBrnp or dBrn0p.<br>e) 1 pW C-message weighted in dBrnC or dBrnC0.<br>*Note:* dBm0 and dBm0p are numerically equal to signal-to-noise ratio unweighted and weighted, with sign reversed.<br>For n.p.r. measurements the digital display is self-zeroing for changes of reference level of up to ±19 dB. |
| Digital display | A maximum of 3 digits in steps of 1 dB with a maximum capacity of 159.<br>Indication of polarity and measurement units. |
| Analogue display | Centre zero edgewise meter giving ±2·5 dB with 0·5 dB divisions or ±5 dB with 1 dB divisions, switch selected. |
| Hold | Locks digital display and attenuator to facilitate initial calibration and allows an analogue reading to be displayed relative to a fixed reference. |
| Transmission level | Adjustable in 1 dB steps between 0 and −49 dBr by means of a thumbwheel switch. |
| Input level | Warning of high or low input conditions outside operating range. |

# OA 2090C

| | |
|---|---|
| **INPUT ATTENUATOR** | |
| Range | Automatically ranged in 1 dB steps. With 'B' filters at least 0 dBm/channel to −125 dBm/channel of which a maximum of ±5 dB may be displayed on the meter. |
| Accuracy | ±0·5% of attenuation value ±0·1 dB. |
| Input impedance | 75 Ω. |
| Return loss | Greater than 20 dB for input levels exceeding −100 dBm/channel. |
| **INTERNAL STANDARD** | |
| Function | The internal standard is automatically applied to the receiver for calibration in the SET ZERO mode for absolute power measurements.<br>Used in the INJECT 1 pW/CHAN mode to confirm receiver operation. |
| Characteristic | Noise is generated over the band from 10 kHz to 13 MHz.<br>Within these frequency limits the level does not vary by more than ±0·25 dB when measured in a band of about 2 kHz. |
| Noise power accuracy | ±0·5 dB at 1 pW per 3·1 kHz bandwidth. |
| **LOCAL OSCILLATOR** | Up to six local oscillators may be fitted. |
| Output | Between 0·3 V and 0·7 V depending on frequency. Rear panel socket for monitoring purposes. |
| **PRINTER OUTPUT** | Parallel b.c.d. output of displayed measurement and polarity plus channel number and out-of-range indication. |
| **RECORDER OUTPUT** | |
| Range | 0 to 3 V e.m.f. corresponding with −5 to +10 dB relative to centre zero of analogue meter. |
| Maximum current | 15 mA. |
| **REMOTE CONTROL** | Selection of measuring channel by parallel b.c.d. signals, SET ZERO and INJECT 1 pW/channel. With cable connection to Noise Generator TF 2091C, corresponding band-stop filter can be selected and all band-stop filters can be switched out on the SET ZERO position. |
| **POWER REQUIREMENTS** | |
| AC supply | 95 to 130 V or 190 to 260 V.<br>45 to 500 Hz, 45 VA. |
| **DIMENSIONS AND WEIGHT** | |

| Height | Width | Depth | Weight* |
|---|---|---|---|
| 188 mm | 426 mm | 482 mm | 14 kg |
| 7⅜ in | 16¾ in | 19 in | 31 lb |

*Without filter unit.
Weight of typical filter: 0·6 kg (1¼ lb).
Weight of filter unit with full complement of filters and local oscillators: 7 kg (15½ lb).

## Filter Unit TK 2086

| | |
|---|---|
| | Can be used with Noise Receiver TF 2092C in either the REMOTE CONTROL or MANUAL modes. |
| **FILTER POSITIONS** | Will accept up to 6 band-pass filters and 6 local oscillators of either 'A' or 'B' types. |
| **CHANNEL SELECTION** | By front panel push-button switches when TF 2092C is switched to MANUAL. Can be controlled externally when TF 2092C is switched to REMOTE control. Indication of channel in use is given by a lamp above each filter. |
| **RANGE EQUALIZATION** | By one of 6 front panel preset potentiometers. |

## Control Unit TK 2085

| | |
|---|---|
| **CONTROL FUNCTIONS** | Used in conjunction with TF 2091C and TF 2092C, TK 2085 controls all programmable functions of each instrument, enabling a preset sequence of white noise measurements to be made and results to be printed out automatically by connection to a suitable printer. |
| Control of Noise Receiver TF 2092C | The Control Unit outputs control the following receiver functions:<br>Channel selection (also selects the corresponding generator channel).<br>Set zero.<br>Inject 1 pW per channel.<br>Print trigger. |
| Control of Noise Generator TF 2091C | The Control Unit outputs control the following generator functions:<br>Band-stop filter selection.<br>Band-limiting filter selection.<br>Output level from +19·9 dBm to −59·9 dBm in 0·1 dB steps. (Warning lamp lights when level is abnormal.)<br>Noise on/off. (Warning lamp lights when noise is off.)<br>Band-stop filters in/out. |
| Signal levels | All signals are t.t.l. compatible.<br>Logic levels: '0' = 0 to 0·4 V.<br>'1' = 2·4 to 5·0 V.<br>The maximum permitted length of connecting cable to the generator is not less than 50 m, subject to a maximum cable resistance of 100 Ω. |
| **MEASURING MODE** | The units of measurement are as selected on Noise Receiver TF 2092C. |
| Single | Makes one measurement on lowest selected channel at the level set on the INITIAL LEVEL switch. |
| Single cycle | Makes a series of measurements over a selected range of generator output levels as set on the INITIAL LEVEL and TOTAL INCREMENT switches, and over the channels selected by the MEASURING CHANNEL switches. This complete operation is one cycle. All measurements on one channel are completed before proceeding to the next selected channel. For measuring absolute units, the receiver will zero at the start of each cycle. When measuring in n.p.r. zeroing will take place before each measurement. |
| Repeat cycles | Measurements are as for single cycle except that the sequence will repeat until stopped. |
| All modes | A printout occurs after each measurement. A 'line feed' pulse is available to enable the printout to contain a blank line between the set of measurements for each channel. |
| Interlock system | If the CHECK GENERATOR LEVEL warning lamp is on or if no channel has been selected at the start of the cycle, no measurements will be made. If the CHECK GENERATOR LEVEL warning lamp comes on during a cycle, one measurement will be made in this condition, and if the warning continues the control unit will reset to INITIAL LEVEL and move to the next selected channel (if any). Should the warning persist, the cycle will stop until adjustment of level removes the warning. |
| Display hold | A three-position switch selects hold times of 0 s, 10 s and ∞ which interrupts the cycle on completion of the measurement in progress. |

# OA 2090C

**Remote start**
The measurement sequence may be initiated either by contact closure or by a '1' to '0' pulse transition of at least 50 ms duration. These options are internally selected and the signal is applied to a BNC socket on the the rear panel.

**FRONT PANEL INDICATORS**
Lamps indicate the following:
Receiver in zeroing mode.
Receiver in measuring mode.
Print.
Check generator level.

**FRONT PANEL CONTROLS**

**Reset and start**
Initiates the measurement sequence or causes it to start again from the beginning.

**Level increment**
The level is incremented from the INITIAL LEVEL by the amount set on the TOTAL INCREMENT switch as follows:
1 dB steps.
2 dB steps.
Total increment.
*Notes:* For 2 dB steps if the TOTAL INCREMENT is set to an odd number of decibels, the measurement will finish 1 dB below that set.

**PRINTER**

**Outputs**
The following outputs are available, all using b.c.d. positive logic at t.t.l. levels:
'1' is +2·4 V to +5·0 V.
'0' is 0 V to +0·4 V.
Generator output level and sign.
Level measured by receiver.
Measuring channel.

**Warning signals**
Warning signals are produced for the following conditions:
Generator output level warning lamp on.
Receiver high or low input warning.
Measurement made with noise off.
Print command.
Linefeed Pulse.
Print command and Linefeed Pulse are both of nominally 50 ms duration.
Polarity may be selected internally.

**Input**
'Busy' line to hold output data ('1' or '0' may be selected internally).

**POWER REQUIREMENTS**

**AC supply**
95 to 130 V or 190 to 260 V.
45 to 65 Hz. 20 VA.

**DIMENSIONS AND WEIGHT**

| Height | Width | Depth | Weight |
|---|---|---|---|
| 101 mm | 419 mm | 426 mm | 7 kg |
| 4 in | 16½ in | 16¾ in | 15½ lb |

## General

**RADIO FREQUENCY INTERFERENCE**
Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference.

**SAFETY**
Complies with IEC 348.

**LIMIT RANGE OF OPERATION**

**Temperature**
0 to 55°C.

**CONDITIONS OF STORAGE AND TRANSPORT**

**Temperature**
−40°C to +70°C.

**Humidity**
Up to 90% relative humidity.

**Altitude**
Up to 2500 m (pressurized freight at 27 kPa differential, i.e. 3·9 lbf/in²).

### VERSIONS AND ACCESSORIES

*When ordering please quote eight-digit code numbers*

| Ordering numbers | |
|---|---|
| | **Versions**<br>Automatic White Noise Test Set OA 2090C consisting of: |
| **52091–930D**<br>**52092–930Z**<br>**52092–301P** | Noise Generator TF 2091C with either,<br>Noise Receiver TF 2092C or,<br>Noise Receiver TF 2092C with Programming Board fitted. |
| | **Supplied Accessories**<br>Telephone Plug 23421–610M for recorder output on TF 2092C.<br>AC Supply Leads 43129–003W.<br>Instruction Manuals. |
| | **Optional Accessories**<br>Band-stop, Band-pass, Band-limiting Filters and Local Oscillator Boards as listed below. |
| **52085–900F** | Control Unit TK 2085. |
| **52086–900C** | Filter Unit TK 2086 (for TF 2092C). |
| **52087–900N** | Programmable Filter Unit TK 2087 (for TF 2091C). |
| **52087–901L** | Manual Filter Unit TK 2087/1 (for TF 2091C). |
| **52088–900P** | GPIB Coupler Interface TK 2088. |
| **54490–032H** | Programming Board, complete with multiway lead and rear-panel mounting socket and a 36 way plug (for TF 2092C). |
| **43129–144X** | Interconnecting Lead for TF 2091C, TF 2092C and TK 2085, 1200 mm (47 in), 36 way plug at each end. |
| **46883–271K** | Connecting Kit containing 2 off 36-way plugs. (Can be used if lead larger than 1200 mm is required.) |
| **54481–011C** | Matching Transformer TM 5955, 75 Ω unbalanced to 150 Ω balanced. |
| **54481–021E** | Matching Transformer TM5955/1, 75 Ω unbalanced to 140 Ω balanced. |
| **54351–011F** | Connecting Lead TM 4726/260, 1800 mm (71 in) long with BNC plug at each end. |
| **54127–131M** | Rack Mounting Conversion Kit (for TF 2091C or TF 2092C). |
| **54127–121V** | Rack Mounting Kit (for TK 2085). |
| **54112–101T** | Carrying Case for TF 2091C or TF 2092C. |
| **54112–091V** | Carrying Case for Filter Unit. |
| **54112–071R** | Carrying Case for Filters and Local Oscillator Boards. (Holds six filters.) |
| **41690–079Z** | Front Panel Cover (for TF 2091C or TF 2092C). |
| **54134–011A** | Dummy Front Plate, to fit in unused filter position in TF 2091C or TF 2092C. |
| **59999–704T** | Digital Printer GMT 301–P16 (HI). |

# Filters and Noise Measuring Sets

## "B" Filter Characteristics

**BAND-LIMITING FILTERS (TK 2095 and TK 2096 series)**

Band-limiting and band-stop filters of the TK 2094, TK 2095 and TK 2096 series meet CCIR Recommendation 399-3 or 482-1 at the frequencies specified in the above documents. At other frequencies the characteristics are derived by interpolation from CCIR recommendations.

**Cut-off frequency***

**High-pass (f1)**

| Nom. freq. kHz | Tolerance kHz | Nom. freq. kHz | Tolerance kHz |
|---|---|---|---|
| 12 | ±0·5 | 316 | ±5 |
| 60 | ±1 | 564 | ±9 |

**Low-pass (f2)**

| Nom. freq. kHz | Tolerance kHz | Nom. freq. kHz | Tolerance kHz |
|---|---|---|---|
| 60 | ±0·5 | 2600 | ±20 |
| 108 | ±1 | 3284 | ±25 |
| 156 | ±1 | 4100 | ±30 |
| 204 | ±1·5 | 4892 | ±40 |
| 252 | ±2 | 5600 | ±50 |
| 300 | ±2 | 5884 | ±50 |
| 408 | ±3 | 7284 | ±65 |
| 552 | ±4 | 8160 | ±75 |
| 804 | ±6 | 10164 | ±85 |
| 1052 | ±8 | 11404 | ±90 |
| 1296 | ±8 | 12360 | ±100 |
| 1796 | ±12 | | |

**Insertion loss**

*Within pass-band:* Variation less than 0·2 dB in a band which includes the outer measuring channel.

*Outside pass-band:*

| Frequency | Loss greater than |
|---|---|
| 0·8f1 | 25 dB |
| 1·1f2 | 20 dB |
| 1·2f2 | 25 dB |

**Defined as the cut-off frequency of a hypothetical filter with square cut-off characteristics transmitting the same power as the practical filter.*

**BAND-PASS FILTERS AND LOCAL OSCILLATORS**

**(Part of TK 2094 series)**

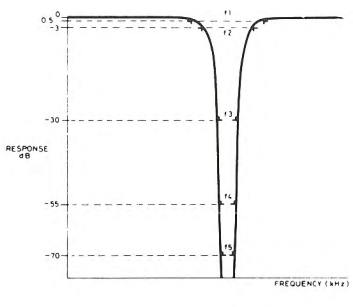
**Characteristic**

Designed to suit the corresponding band-stop filter.

**BAND-STOP FILTERS**

**(Part of TK 2094 series)**

**Characteristic**




| Centre frequency in kHz (fc) | Bandwidth, in kHz relative to fc, over which discrimination is at least | | | Bandwidth, in kHz relative to fc, outside of which the discrimination does not exceed | |
|---|---|---|---|---|---|
| | 70 dB (f5) | 55 dB (f4) | 30 dB (f3) | 3 dB (f2) | 0·5 dB (f1) |
| 16 | ±1·5 | ±2·1 | ±2·7 | ±5 | ±7 |
| 40 | ±1·5 | ±1·8 | ±2·1 | ±4 | — |
| 56 | ±1·5 | ±1·8 | ±2·1 | ±5 | ±10 |
| 70 | ±1·5 | ±2·2 | ±3·5 | ±12 | ±18 |
| 98 | ±1·5 | ±1·8 | ±2·1 | ±4 | ±9 |
| 140 | ±1·5 | ±1·8 | ±2·2 | ±5 | ±14 |
| 185 | ±1·5 | ±1·8 | ±2·2 | ±5 | ±17 |
| 240 | ±1·5 | ±1·8 | ±2·2 | ±5 | ±21 |
| 270 | ±1·5 | ±2·3 | ±2·9 | ±8 | ±24 |
| 394 | ±1·5 | ±3·0 | ±4·5 | ±11 | ±35 |
| 534 | ±1·5 | ±3·5 | ±7·0 | ±15 | ±48 |
| 770 | ±1·5 | ±3·8 | ±8·0 | ±21 | ±70 |
| 1002 | ±1·5 | ±4·0 | ±9·0 | ±27 | ±90 |
| 1248 | ±1·5 | ±4·0 | ±11·0 | ±35 | ±110 |
| 1730 | ±1·5 | ±4·2 | ±14·0 | ±48 | ±155 |
| 2438 | ±1·5 | ±4·5 | ±19·0 | ±60 | ±220 |
| 3150 | ±1·5 | ±9·0 | ±22·0 | ±85 | ±285 |
| 3886 | ±1·5 | ±1·8 | ±3·5 | ±12 | ±100 |
| 4650 | ±1·5 | ±2·0 | ±3·8 | ±13 | ±120 |
| 5340 | ±1·5 | ±2·2 | ±4·0 | ±14 | ±140 |
| 6900 | ±1·5 | ±2·4 | ±4·4 | ±15 | ±185 |
| 7600 | ±1·5 | ±2·4 | ±4·6 | ±16 | ±200 |
| 9624 | ±1·5 | ±2·7 | ±6·0 | ±18 | ±250 |
| 10912 | ±1·5 | ±2·8 | ±6·7 | ±19 | ±280 |
| 11700 | ±1·5 | ±3·0 | ±7·0 | ±20 | ±300 |

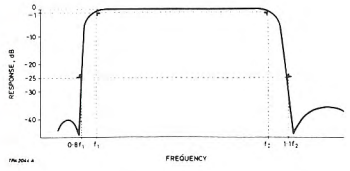
## "A" Filter Characteristics

**BAND-LIMITING FILTERS**

**(TM 7720 and TM 7728 series)**

**Characteristic**

Band-limiting and Band-stop filters of the TM 7720, TM 7728 and TM 7729 series meet CCIR Recommendation 399.



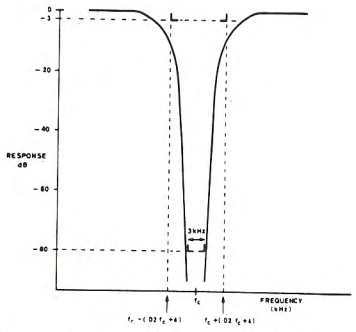

**Insertion loss**

*Within pass-band:* Variation less than 1 dB.

*Outside pass-band:*

| Frequency | Loss greater than |
|---|---|
| 0·81f1 | 25 dB |
| 1·1f2 | 25 dB |

**BAND-STOP FILTERS**
**(TM 7729 series)**
**Characteristic**




Attenuation is greater than 80 dB over a bandwidth of at least 3 kHz and greater than 3 dB at frequencies of ± (0·2fc+4) kHz from the centre frequency, fc.

**BAND-PASS FILTERS**
**(TM 7730 series)**
**Characteristic**

Designed to suit the corresponding band-stop filter.

## Out-of-Band Filter Characteristics

Out-of-band filter sets TK 2084 series consist of a band-stop filter, a band-pass filter and a local oscillator. The filter sets meet CCIR Recommendation 398-3, i.e. the attenuation of the band-stop filters exceeds 50 dB over a minimum frequency band of ± (0·005f+2) kHz* (f being the centre frequency in kHz of the measuring channel). The additional attenuation, caused by the insertion of the band-stop filters at the lower and at the upper edges of the total multiplex signal band, does not exceed 0·3 dB referred to the additional attenuation caused in the centre of the multiplex signal band.

**Except when the centre frequency is 10 kHz; the minimum frequency band is then 10 ± 1 kHz.*

## "B" Filters (CCIR 399-3 and CCIR 482-1)

| Low-Pass Filter (kHz) | Type | Order Code |
|---|---|---|
| 60 * | TK 2095/28 | 52095–328B |
| 108 * | TK 2095/8 | 52095–094E |
| 156 * | TK 2095/18 | 52095–318D |
| 204 * | TK 2095/29 | 52095–329K |
| 252 * | TK 2095/9 | 52095–104L |
| 300 * † | TK 2095 | 52095–014P |
| 408 * | TK 2095/12 | 52095–134Y |
| 552 * † | TK 2095/1 | 52095–024A |
| 804 * | TK 2095/13 | 52095–144S |
| 1052 * | TK 2095/14 | 52095–154C |
| 1296 * † | TK 2095/2 | 52095–034L |
| 1796 * | TK 2095/10 | 52095–114D |
| 2600 * † | TK 2095/3 | 52095–044D |
| 3284 * | TK 2095/11 | 52095–124B |
| 4100 * † | TK 2095/4 | 52095–054B |
| 4892 * | TK 2095/19 | 52095–319T |
| 5600 † | TK 2095/5 | 52095–064Y |
| 5884 | TK 2095/27 | 52095–327U |
| 7284 ‡ | TK 2095/22 | 52095–322T |
| 8160 * † | TK 2095/6 | 52095–074S |
| 10164 ‡ | TK 2095/23 | 52095–323P |
| 11404 ‡ | TK 2095/24 | 52095–324X |
| 12360 † | TK 2095/7 | 52095–084C |

| High-Pass Filter (kHz) | Type | Order Code |
|---|---|---|
| 12 * | TK 2096/2 | 52096–034X |
| 60 † | TK 2096 | 52096–014E |
| 316 † | TK 2096/1 | 52096–024G |
| 564 ‡ | TK 2096/5 | 52096–305D |

*The specification of the above filters are to the following recommendations:*
* *CCIR 482-1*
† *CCIR 399-3*
‡ *North American U-600 Plan, 1500, 2100, 2400 channel capacities.*

| Noise Measuring Sets (kHz) | Type | Order Code |
|---|---|---|
| 16 * | TK 2094/9 | 52094–104R |
| 40 | TK 2094/10 | 52094–114U |
| 56 * | TK 2094/11 | 52094–124V |
| 70 * † | TK 2094 | 52094–014N |
| 98 * | TK 2094/12 | 52094–134M |
| 140 * | TK 2094/26 | 52094–326F |
| 185 * | TK 2094/14 | 52094–154F |
| 240 * | TK 2094/15 | 52094–164P |
| 270 * † | TK 2094/1 | 52094–024W |
| 394 * | TK 2094/16 | 52094–174A |
| 534 * † | TK 2094/2 | 52094–034R |
| 770 * | TK 2094/19 | 52094–204M |
| 1002 * | TK 2094/20 | 52094–214H |
| 1248 * † | TK 2094/3 | 52094–044U |
| 1730 * | TK 2094/17 | 52094–184L |
| 2438 * † | TK 2094/4 | 52094–054V |
| 3150 * | TK 2094/18 | 52094–194D |
| 3886 * † | TK 2094/5 | 52094–064M |
| 4650 * | TK 2094/27 | 52094–327G |
| 5340 * † | TK 2094/6 | 52094–074H |
| 6900 ‡ | TK 2094/29 | 52094–329S |
| 7600 * † | TK 2094/7 | 52094–084F |
| 9624 ‡ | TK 2094/30 | 52094–330G |
| 10912 ‡ | TK 2094/31 | 52094–331V |
| 11700 † | TK 2094/8 | 52094–094P |

*NOTE:* Noise Measuring Sets TK 2094 series consist of one Band-stop Filter for the Noise Generator, and one Band-pass Filter and one Local Oscillator for the Noise Receiver.

## "A" Filters (CCIR 399 Geneva 1963)

| Low-Pass Filter (kHz) | Type | Order Code |
|---|---|---|
| 60 | TM 7720/8 | 46857–118E |
| 108 | TM 7720 | 46857–109R |
| 156 | TM 7720/14 | 46857–124N |
| 204 | TM 7720/10 | 46857–120H |
| 252 | TM 7720/15 | 46857–125L |
| 300 | TM 7720/1 | 46857–111C |
| 552 | TM 7720/2 | 46857–112R |
| 1052 | TM 7720/11 | 46857–121E |
| 1300 | TM 7720/3 | 46857–113B |
| 2660 | TM 7720/12 | 46857–122U |
| 4028 | TM 7720/5 | 46857–115A |
| 4188 | TM 7720/13 | 46857–123Y |
| 5564 | TM 7720/9 | 46857–119U |
| 8204 | TM 7720/6 | 46857–116Z |
| 12388 | TM 7720/7 | 46857–117H |
| **High-Pass Filter (kHz)** | **Type** | **Order Code** |
| 12 | Use 'B' filter TK 2096/2 | |
| 60 | TM 7728/1 | 46855–005B |
| 316 | TM 7728/2 | 46855–004R |

| Noise Measuring Sets (kHz) | Band Stop | Band Pass | Local Osc. | Order Code** |
|---|---|---|---|---|
| 14 | TM 7729 | TM 7730 | TM 7793 | 52093–414V |
| 27 | TM 7729/21 | TM 7730/21 | TM 7793/4 | 52093–424M |
| 34 | TM 7729/12 | TM 7730/12 | TM 7793/2 | 52093–434H |
| 40 | TM 7729/1 | TM 7730/1 | TM 7793/1 | 52093–444F |
| 56 | TM 7729/13 | TM 7730/13 | TM 7793/3 | 52093–454P |
| 70 | TM 7729/2 | TM 7730/2 | TM 7794 | 52093–464A |
| 105 | TM 7729/3 | TM 7730/3 | TM 7794/1 | 52093–474L |
| 185 | TM 7729/4 | TM 7730/4 | TM 7794/2 | 52093–484D |
| 245 | TM 7729/22 | TM 7730/22 | TM 7794/9 | 52093–494B |
| 270 | TM 7729/5 | TM 7730/5 | TM 7794/3 | 52093–504H |
| 342 | TM 7729/16 | TM 7730/16 | TM 7794/6 | 52093–514F |
| 534 | TM 7729/6 | TM 7730/6 | TM 7794/4 | 52093–524P |
| 1002 | TM 7729/15 | TM 7730/15 | TM 7795/5 | 52093–534A |
| 1248 | TM 7729/7 | TM 7730/7 | TM 7795 | 52093–544L |
| 2438 | TM 7729/8 | TM 7730/8 | TM 7795/1 | 52093–554D |
| 3886 | TM 7729/9 | TM 7730/9 | TM 7795/2 | 52093–564B |
| 5340 | TM 7729/17 | TM 7730/17 | TM 7795/6 | 52093–574Y |
| 8002 | TM 7729/10 | TM 7730/10 | TM 7795/3 | 52093–584S |
| 12150 | TM 7729/11 | TM 7730/11 | TM 7795/4 | 52093–594C |

** *Order Code specifies complete Noise Measuring Set.*
*'A' Filters are made in U.S.A.*

## Out-of-Band Filters (CCIR 398-3)

| Noise Measuring Sets (kHz) | Type | Order Code |
|---|---|---|
| 10 | TK 2084 | 52084–014Y |
| 50 | TK 2084/1 | 52084–024S |
| 119 | TK 2084/2 | 52084–034C |
| 270 | TK 2084/3 | 52084–044E |
| 304 | TK 2084/4 | 52084–054G |
| 331 | TK 2084/5 | 52084–064X |
| 600 | TK 2084/6 | 52084–074Z |
| 607 | TK 2084/7 | 52084–084J |
| 1499 | TK 2084/8 | 52084–094T |
| 1549 | TK 2084/9 | 52084–104C |

| Noise Measuring Sets (kHz) | Type | Order Code |
|---|---|---|
| 3200 | TK 2084/10 | 52084–114E |
| 3250 | TK 2084/11 | 52084–124G |
| 4715 | TK 2084/12 | 52084–134X |
| 4765 | TK 2084/13 | 52084–144Z |
| 6199 | TK 2084/14 | 52084–154J |
| 6300 | TK 2084/15 | 52084–164T |
| 9023 | TK 2084/16 | 52084–174K |
| 9073 | TK 2084/17 | 52084–184N |
| 13627 | TK 2084/18 | 52084–194W |
| 13677 | TK 2084/21 | 52084–224J |

*NOTE:* Noise Measuring Sets TK 2084 series consist of one Band-stop Filter, one Band-pass Filter and one Local Oscillator.

## Recommended Filter Frequencies

CCIR 399-3

| System capacity (channels) | Limits of band occupied by telephone channels (kHz) | Effective cut-off frequencies of band-limiting filters (kHz) High-pass | Low-pass | Frequencies of available measuring channels (kHz) |
|---|---|---|---|---|
| 60 | 60-300 | 60±1 | 300±2 | 70 270 |
| 120 | 60-552 | 60±1 | 552±4 | 70 270 534 |
| 300 | 60-1300<br>64-1296 | 60±1 | 1296±8 | 70 270 534 1248 |
| 600 | 60-2540<br>64-2660 | 60±1 | 2600±20 | 70 270 534 1248 2438 |
| 900 | 312-4188 | 316±5 | 4100±30 | 534 1248 2438 3886 |
| 960 | 60-4028<br>64-4024 | 60±1 | 4100±30 | 70 270 534 1248 2438 3886 |
| 1200 | 316-5564 | 316±5 | 5600±50 | 534 1248 2438 3886 5340 |
| 1260 | 60-5636<br>60-5564 | 60±1 | 5600±50 | 70 270 534 1248 2438 3886 5340 |
| 1800 | 312-8120<br>312-8204<br>316-8204 | 316±5 | 8160±75 | 534 1248 2438 3886 5340<br>7600 |
| 2700 | 312-12336<br>316-12388<br>312-12388 | 316±5 | 12360±100 | 534 1248 2438 3886 5340<br>7600 11700 |

CCIR 482-1

| System capacity (channels) | Limits of band occupied by telephone channels (kHz) | Effective cut-off frequencies of band-limiting filters (kHz) High-pass | Low-pass | Frequencies of available measuring channels (kHz) |
|---|---|---|---|---|
| 12 | 12-60 | 12±0·5 | 60±0·5 | 16 56 |
| 24 | 12-108 | 12±0·5 | 108±1 | 16 98 |
| 36 | 12-156 | 12±0·5 | 156±1 | 16 140 |
| 48 | 12-204 | 12±0·5 | 204±1·5 | 16 185 |
| 60 | 12-252 | 12±0·5 | 252±2 | 16 240 |
| 72 | 12-300 | 12±0·5 | 300±2 | 16 270 |
| 96 | 12-408 | 12±0·5 | 408±3 | 16 240 394 |
| 132 | 12-552 | 12±0·5 | 552±4 | 16 240 534 |
| 192 | 12-804* | 12±0·5 | 804±6 | 16 394 770 |
| 252 | 12-1052 | 12±0·5 | 1052±8 | 16 534 1002 |
| 312 | 12-1300 | 12±0·5 | 1296±8 | 16 534 1248 |
| 432 | 12-1796 | 12±0·5 | 1796±12 | 16 534 1002 1730 |
| 612 | 12-2540 | 12±0·5 | 2600±20 | 16 770 1730 2438 |
| 792 | 12-3284 | 12±0·5 | 3284±25 | 16 1002 2438 3150 |
| 972 | 12-4028 | 12±0·5 | 4100±30 | 16 1002 2438 3886 |
| 1092 | 12-4892 | 12±0·5 | 4892±40 | 70 1002 2438 4650 |
| 1332 | 12-5884 | 12±0·5 | 5884±50 | 70 1002 3150 4650 5340 |
| 1872 | 12-8120 | 12±0·5 | 8160±75 | 70 1002 3150 5340 7600 |

marconi instruments

# General Measuring Equipment


| | | |
|---|---|---|
| Dual DC Power Supply | TF 2158 | 64 |
| Attenuator (DC to 1 MHz) | TF 2162 | 65 |
| UHF Attenuator (DC to 1 GHz) | TF 2163S | 66 |
| RF Amplifier (50 kHz to 80 MHz) | TF 2167 | 67 |
| Broadband RF Amplifier | 2177 | 68 |
| True RMS Voltmeter | 2610 | 70 |
| Universal Bridge | TF 2700 | 73 |

*For further Power Supplies see the Microwave Products Section:*

| | |
|---|---|
| Power Supply type 6590 | 242 |

*For further Attenuators and Amplifiers see the Microwave Products Section:*

| | |
|---|---|
| Calibrated Variable Attenuator Grade 2 type 6019 series | 259 |
| Variable Attenuator type 6020 series | 259 |
| Preset Attenuator type 6021/5 | 260 |
| Rotary Vane Attenuator type 6052 | 220 |
| Precision Fixed Coaxial Attenuator type 6530 series | 270 |
| Levelling Amplifier type 6587 | 241 |

# Dual DC Power Supply TF 2158

- ☐ **Two identical power supplies in one case**
- ☐ **Output voltages up to 30 V (60 V in series mode)**
- ☐ **Output currents up to 2 A (4 A in parallel mode)**
- ☐ **Sensing output permits voltage regulation at load**
- ☐ **Overload protection**




TF 2158 is a general purpose dual power supply with wide application in design laboratories, production areas, service workshops and educational establishments.

Two identical power supplies are included in one case. Each supply covers a total voltage of 0 to 30 volts in six switched ranges with continuous variable control over each range. Current limits may be selected from 0 to 2 amps in two switched ranges with variable control over each range. A separate meter for each supply can be switched to read either output voltage or current.

In addition to their separate use the two units can be connected in series to increase the available output voltage to 60 volts, or in parallel to double the current limit to 4 amps.

The supplies have overload protection which operates by reducing the output voltage to zero if the load current rises above the current limit setting. Providing that the cause of the overload has been removed, the output voltage can be restored by operation of a front-panel push-button.

Each unit is equipped with a sensing output which, when connected to the load, permits voltage regulation at the load rather than at the output terminals of the supply. This is particularly useful in high current applications where the voltage drop along the connecting leads may be significant.

| | |
|---|---|
| **OUTPUT** | |
| Voltage | 0 to 30 V in 6 switched ranges of: 0 to 5 V: 5 to 10 V: 10 to 15 V 15 to 20 V: 20 to 25 V: 25 to 30 V with continuous variable control on each range. |
| Current limit | In two continuously variable ranges with full scale setting of 0.2 A and 2 A. Minimum setting 35 mA and 350 mA respectively. |
| Resistance | Typically less than 0·005 Ω. |
| **OVERLOAD PROTECTION** | When the current rises above the current limit setting the overload circuit operates and reduces the output voltage to zero. The output voltage can be reset by operating the RESET push-button, provided that the cause of the overload has been removed. |
| **METER** | |
| Voltage range | 0 to 30 V. |
| Current range | Two ranges, switch selected: 0 to 0·2 A, 0 to 2 A. |
| Accuracy | ±2% f.s.d. Note: The current meter range switch also selects the current limit range. |
| **LINE REGULATION** | Better than 0·01% for a 6% a.c. supply line change. |
| **RIPPLE CONTENT** | Less than 0·8 mV p-p. |
| **TEMPERATURE COEFFICIENT** | Typically less than 0·02% per °C at 23°C. |
| **SAFETY** | Complies with IEC 348. |

| | |
|---|---|
| **RADIO FREQUENCY INTERFERENCE** | Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference. |
| **LIMIT RANGE OF OPERATION** | |
| Temperature | 10° to 30°C on full load. 0 to 45°C at 1A. |
| **CONDITIONS OF STORAGE AND TRANSPORT** | |
| Temperature | −40°C to +70°C. |
| Humidity | Up to 90% relative humidity. |
| Altitude | Up to 2500 m (pressurised freight at 27 kPa differential, i.e. 3·9 lbf/in²). |
| **POWER REQUIREMENTS** | |
| AC supply | 110V, 120V, 220V, 240V, ±6%. 50 to 60 Hz. |
| **DIMENSIONS AND WEIGHT** | |

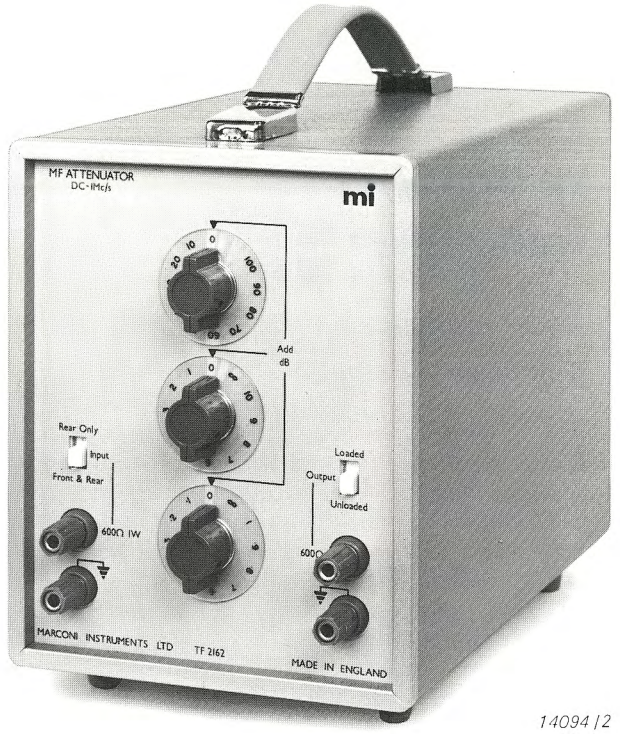
| Height | Width | Depth | Weight |
|---|---|---|---|
| 175 mm | 205 mm | 200 mm | 5·5 kg. |
| 6·9 in | 8·1 in | 7·9 in | 12·1 lb. |

**VERSIONS AND ACCESSORIES**

*When ordering please quote eight-digit code numbers*

| Ordering number | |
|---|---|
| **52158–900R** | **Versions** Dual DC Power Supply TF 2158 |
| | **Supplied Accessories** Instruction Manual. |

# MF Attenuator TF 2162




14094/2

- 0 to 111 dB
- Steps of 0·1 dB

TF 2162 is a general-purpose variable attenuator suitable for use at frequencies up to 1 MHz.

It consists of three ten-step switched attenuators in cascade, covering 0 to 1 dB, 0 to 10 dB, and 0 to 100 dB respectively. An additional "infinity" position of the 1 dB switch and on the 10 dB switch completely isolates the input from the output terminal.

Provision is made for switching an internal terminating resistor into circuit in order to preserve the validity of the calibration when the attenuator is feeding a high impedance load.

| | |
|---|---|
| **IMPEDANCE** | |
| Input | 600 Ω unbalanced, when terminated with 600 Ω. Switched terminating resistor is incorporated. |
| Output | 600 Ω unbalanced, when 600 Ω source is connected. |
| **FREQUENCY RANGE** | DC to 1 MHz. |
| **ATTENUATION** | |
| Range | 0 to 111 dB in 0·1 dB steps, and infinity. |
| Maximum input | +30 dBm or 1 W or 25 V into 600 Ω. |
| Minimum attenuation | Less than 0·01 dB. |
| Accuracy | ±1% of dB setting ±0·01 dB, at d.c.<br>±2% of dB setting ±0·2 dB, at 1 MHz. |
| **SAFETY** | Complies with IEC 348. |
| **LIMIT RANGE OF OPERATION** | |
| Temperature | 0 to 55°C. |
| **CONDITIONS OF STORAGE AND TRANSPORT** | |
| Temperature | −40°C to +70°C. |
| Humidity | Up to 90% relative humidity. |
| Altitude | Up to 2500 m (pressurized freight at 27 kPa differential, i.e., 3·9 lbf/in²). |

**DIMENSIONS AND WEIGHT**

| Height | Width | Depth | Weight |
|---|---|---|---|
| 195 mm | 145 mm | 270 mm | 2·5 kg |
| 7¾ in | 5¾ in | 10½ in | 5½ lb |

## VERSIONS AND ACCESSORIES

*When ordering please quote eight-digit code numbers*

| Ordering numbers | |
|---|---|
| 52162-900L | **Versions**<br>TF 2162. Instrument in case for bench use. |
| | **Supplied Accessories**<br>Accessory Kit 46883-095B comprising:<br>Shielded Adapter TB 39868 (43168-008S).<br>Coaxial Free Plug 23441-014W.<br>Instruction Manual 46881-027A. |
| 41635-041P<br>41674-015P | **Optional Accessories**<br>Rack-mounting Case TM 7010.<br>Blank Panel Unit (⅓ module) TM 6844. |

# UHF Attenuator TF 2163S

- ☐ 0 to 142 dB in 1 dB steps
- ☐ VSWR: 1·1:1 up to 200 MHz
  1·5:1 up to 1 GHz
- ☐ 50 Ω impedance
- ☐ Low insertion loss




11002/2

TF 2163S is a 50 Ω switched attenuator suitable for use at all frequencies up to 1 GHz. Its accuracy and freedom from standing waves has been achieved by the use of a novel design in which special resistive pads are selected by cam-operated microswitches. Careful attention to internal screening prevents errors due to leakage fields at high attenuation settings.

Attenuation is selected by means of two rotary step controls, one covering 120 dB in 20 dB steps and the other covering 22 dB in 1 dB steps. The sum of the settings gives the overall attenuation.

The instrument in its bench mounting form is supplied with a front panel lid equipped to stow a coaxial fuse unit, spare fuses, and two type N to BNC adapters. A rack mounting case is available.

| | |
|---|---|
| **FREQUENCY RANGE** | DC to 1 GHz. |
| **ATTENUATION** | |
| Range | DC to 1 GHz.<br>0 to 142 dB in 1 dB steps. |
| Accuracy | Up to 130 dB at 1 kHz ±0·5% ±0·1 dB.<br>Up to 100 dB at 1 GHz ±1% ±0·2 dB.<br>Up to 130 dB at 1 GHz ±1·5% ±0·2 dB. |
| **IMPEDANCE** | 50 Ω input and output. |
| **VSWR** | Not exceeding:<br>1·1:1 below 200 MHz.<br>1·25:1 below 500 MHz.<br>1·5:1 below 1 GHz. |
| **MAXIMUM POWER INPUT** | 0·5 W. |
| **INSERTION LOSS** | Approx. 0·3 dB per 100 MHz. |
| **CONNECTORS** | Type N input and output sockets. |
| **SAFETY** | Complies with IEC 348. |
| **LIMIT RANGE OF OPERATION** | |
| Temperature | 0 to 55°C. |

| | |
|---|---|
| **CONDITIONS OF STORAGE AND TRANSPORT** | |
| Temperature | −40°C to +70°C. |
| Humidity | Up to 90% relative humidity. |
| Altitude | Up to 2500 m (pressurized freight at 27 kPa differential, i.e., 3·9 lbf/in²). |

**DIMENSIONS AND WEIGHT**

| Height | Width | Depth | Weight |
|---|---|---|---|
| 195 mm | 145 mm | 270 mm | 3·63 kg |
| 7¾ in | 5¾ in | 10½ in | 8 lb |

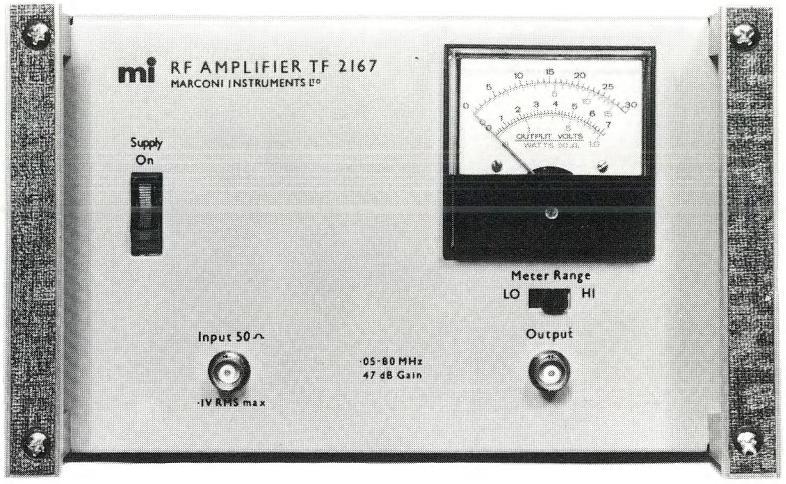
**VERSIONS AND ACCESSORIES**

*When ordering please quote eight-digit numbers*

| Ordering numbers | |
|---|---|
| 52163-025J | **Versions**<br>UHF Attenuator TF 2163S. (NATO Cat. No. 6625-99-519-9976. CT 553). |
| | **Supplied Accessories**<br>Instruction Manual 46881-164A. |
| 43126-026A | **Optional Accessories**<br>Connecting Lead TM 4726/286, 50 Ω, Type N, 457 mm (18 in). |
| 43281-001W | RF Fuse TM 5753. |
| 41635-041P | Rack Mounting Case TM 7010. |
| 41674-015P | Blank Panel Unit TM 6844. (Two required.) |

# RF Amplifier TF 2167

- ☐ Up to 10 W monitored output
- ☐ 50 kHz to 80 MHz bandwidth
- ☐ 47 dB gain




The TF 2167 is a broad-band solid-state power amplifier specified for use over the frequency range 50 kHz to 80 MHz, with a useful gain up to 160 MHz. It is capable of delivering up to 10 watts into a 50 Ω load, with low harmonic and intermodulation distortion, and its 47 dB gain enables the full output to be obtained with an input voltage of less than 100 mV. The output level is accurately monitored by a front-panel meter with two switch selected ranges (0 to 7 volts and 0 to 30 volts), giving good discrimination at low levels.

The instrument is protected against input and output overloads and providing that the input level is within 100 mV the output may be open-circuited or short-circuited without damage to the instrument. Input levels up to 3 volts will not damage the amplifier provided it is correctly loaded. A Thermal cut-out switch provides further protection against overheating.

| | |
|---|---|
| **FREQUENCY** | |
| **Bandwidth** | 50 kHz to 80 MHz. |
| **Response characteristic** | Flat ±1 dB over above bandwidth when feeding 50 Ω load. |
| **OUTPUT LEVEL** | 10 W p.e.p. (max.) into 50 Ω load. |
| **GAIN** | At least 47 dB. |
| **OUTPUT MONITOR** | |
| **Voltage ranges** | 0 to 7 V, 0 to 30 V, switch selected. |
| **Voltage accuracy** | ±6% f.s. |
| **Power ranges** | 0 to 1 W, 0 to 15 W, switch selected |
| **Power accuracy** | ±10%. f.s |
| **SIGNAL PURITY** | |
| **Harmonic distortion** | Individual harmonics at least −30 dB relative to fundamental. |
| **Total harmonic content (up to 160 MHz)** | Better than −26 dB relative to fundamental (typically −30 dB). |
| **Hum and noise** | Less than −70 dB relative to 10 W. |
| **INPUT CONDITIONS** | |
| **Input impedance** | 50 Ω. |
| **VSWR** | 1·15:1. |
| **Maximum rated input level** | 0·1 V. |
| **CONNECTORS** | BNC input and output. |
| **RADIO FREQUENCY INTERFERENCE** | Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference. |

| | |
|---|---|
| **LIMIT RANGE OF OPERATION** | |
| **Temperature** | 0 to 50°C. |
| **CONDITIONS OF STORAGE AND TRANSPORT** | |
| **Temperature** | −40°C to +70°C. |
| **Humidity** | Up to 90% relative humidity. |
| **Altitude** | Up to 2500 m (pressurized freight at 27 kPa differential i.e. 3·9 lbf/in²). |
| **SAFETY** | Complies with IEC 348. |
| **POWER REQUIREMENTS** | |
| **AC supply** | 105 to 125 V and 210 to 250 V 50 to 60 Hz 160 VA. |
| **DIMENSIONS AND WEIGHT** | |

| Height | Width | Depth | Weight |
|---|---|---|---|
| 130 mm | 220 mm | 370 mm | 9 kg |
| 5¼ in | 8½ in | 14¼ in | 20 lb |

## VERSIONS AND ACCESSORIES

*When ordering please quote eight-digit code numbers*

| Ordering numbers | |
|---|---|
| **52167-301Z** | **Versions** RF Amplifier TF 2167. |
| **54127-011N** | **Optional Accessory** Standard 19 inch Rack Mounting Kit, fitted with through connectors. |
| **54127-012L** | Standard 19 inch Rack Mounting Kit. |

Made in U.S.A.

# Broadband RF Amplifier 2177




- ☐ **Wide frequency range – 800 kHz to 1 GHz**
- ☐ **High gain – 40 dB typical**
- ☐ **High linear power output – 3 W p.e.p. to 400 MHz**
- ☐ **High saturated power output – 10 W p.e.p. to 100 MHz**
- ☐ **Unconditionally stable**
- ☐ **Phase and gain matched to allow parallel operation**

Broadband RF Amplifier 2177 is a low-noise solid-state wideband power amplifier operating in Class A conditions whose capabilities include the accurate high-power reproduction of complex modulated signals including AM, FM, SSB, CATV and pulse waveforms. It is unconditionally stable, allowing maximum flexibility in applications where varying load and frequency conditions exist, and is equally suitable for both linear and non-linear applications.

The 2177 provides high gain, 40 dB typical, over the wide frequency range of 800 kHz – 960 MHz, with useful gain being provided up to 1 GHz. It is therefore capable of delivering up to 3 watts into a 50Ω load with low harmonic and intermodulation distortion from an input voltage of 122 mV. The amplifier will give a minimum linear power of 2 W p.e.p. up to 960 MHz, and 5 W p.e.p. saturated power up to 500 MHz, with higher powers at reduced bandwidth. Its bandwidth and power ratings are both conservatively stated.

The 2177 is protected against input overload of up to 16 dB and its stability is such that its forward power will remain constant regardless of the extent of the load mismatch, i.e. from short circuit to open circuit.

# 2177

| | |
|---|---|
| **FREQUENCY RESPONSE** | 0·8 to 960 MHz. |
| **GAIN** | |
| Flatness | 40 dB typical.<br>±1·5 dB to 400 MHz, ±3 dB to 960 MHz.<br>Useful gain to 1 GHz. |
| **POWER OUTPUT** | |
| Max 'linear' output (PEP) | 2 W (0·8 to 960 MHz).<br>3 W (0·8 to 400 MHz). |
| Typical saturated output | 1 W (0·8 to 1000 MHz).<br>5 W (1 to 500 MHz).<br>10 W (1 to 100 MHz). |
| **SIGNAL PURITY** | |
| Harmonic Distortion (at rated 'linear' output) | All single harmonics – 20 dBc at max. power output. Lower distortion at reduced power. |
| Typical 3rd Order Inter-modulation Intercept Point | + 46 dBm. |
| Noise Figure | 10 dB nominal. |
| **INPUT/OUTPUT PORT** | |
| Connectors | 50 Ω N type female. |
| VSWR (typical) | Input 2:1 Output 3:1. |
| **STABILITY** | Unconditionally stable. |
| **PROTECTION** | Unit will withstand a +16 dB overdrive. 1 volt r.m.s. for all output load conditions including short and open circuits. |

| | |
|---|---|
| **RADIO FREQUENCY INTERFERENCE** | Complies with E.E.C. Directive 76/889. |
| **SAFETY** | Complies with IEC 348. |
| **RATED RANGE OF USE** | Temperature +10° to +35°C. |
| **LIMIT RANGE OF OPERATION** | Temperature 0° to +45°C. |
| **CONDITIONS OF STORAGE AND TRANSPORT** | |
| Temperature | –40° to +70°C. |
| Humidity | Up to 90% r h. |
| Altitude | Up to 2500 M (pressurised freight at 27 kPa differential i.e. 3·9 lbf/in$^2$). |
| **POWER REQUIREMENTS** | |
| AC Supply | 230/115 V ±10%.<br>50 – 60 Hz at 120 VA. |
| **DIMENSIONS AND WEIGHT** | |

| Height | Width | Depth | Weight |
|---|---|---|---|
| 107 mm | 203 mm | 406 mm | 4·5 kg |
| 4·2 in | 8·0 in | 16·0 in | 10 lbs |

| | |
|---|---|
| **ACCESSORIES** | |
| Supplied | Instruction Manual |
| Optional | Rack Mounting Kit 54127–303M |
| Ordering Code | 52177–900S |

# True RMS Voltmeter 2610




- ☐ **True r.m.s. voltage measurements on waveforms of any complexity, 5 Hz – 25 MHz plus DC**
- ☐ **Voltage measurements in 7 ranges, 2 mV – 700 V full scale**
- ☐ **High input impedance with either AC or DC coupling**
- ☐ **Decibel (dBV and dBm) readout also available, with analogue dB meter for convenient peaking and nulling operation**
- ☐ **User entry of offset voltage levels and impedance references for dBm readings**
- ☐ **Fully internal GPIB interface/rechargeable-battery options**

True RMS Voltmeter 2610 is a microprocessor-based wideband digital voltmeter employing a closed-loop thermal conversion technique to provide accurate true-r.m.s. measurement of input signals of almost any complexity and with frequencies from 5 Hz to 25 MHz, as well as pure DC. Full autoranging operation is available over 7 voltage ranges covering 2 mV – 700 V full scale, with manual range selection also available, and decibel measurements (dBV and dBm) also provided.

Readout is by a main LCD digital display, with an analogue dB meter also being provided for convenience of operation when making 'peaking' and 'dipping' and similar measurements. Both voltage and dB measurements can be made relative to an 'offset' reference level entered via the front panel keyboard, and the reference impedance value used for dBm measurements may be directly entered in the same way.

An optional GPIB card, fitting entirely within the instrument, makes the 2610 fully bus programmable, and, as an alternative option, an internal rechargeable battery allows fully portable operation.

## Measurement principles

The 2610 guarantees the measurement of true r.m.s. signal levels by the use of a direct thermal-conversion technique – as opposed to the more normal method of providing apparent r.m.s. readings by correcting the outputs of some non r.m.s. measurement technique, producing 'r.m.s.' readings that only approach true r.m.s.values when dealing with more or less pure sine-wave signals. With the 2610, signals of almost any complexity (subject only to certain crest-factor limitations) can be applied directly to the instrument's high impedance input, and guaranteed true r.m.s. readings of

their level, in either volts or decibels, obtained directly from the instrument's digital display.

Coupling between the instrument's input and its thermal-conversion measurement circuits may be either AC or DC, the latter allowing the measurement of asymmetric signals, signals with a DC component, and even pure DC. The thermal-conversion unit itself is a precision integrated thin-film r.m.s. sensor, built to an in-house custom design, which uses a closed-loop control ciruit to balance the heating effect of the input signal with that of a variable DC voltage. This voltage is then digitised, processed by the instrument's controlling microprocessor, and presented for display.

## Measurement ranges

Voltage measurement on the 2610 covers 7 ranges, from 2 mV to 700 V full-scale. Full autoranging is available on all ranges when AC input coupling is selected, and from 20 mV upwards when the inputs are DC coupled. Manual ranging is also available, subject to an automatic up-ranging override to provide overvoltage protection.

The 2610 also offers decibel measurements, with autoranging automatically selected to give an effective single decibel range of 130 dB. For dBV measurements, readings are displayed in dB relative to 1 V r.m.s. For dBm measurements, readings indicate the power relative to 1 mW that *would* be developed in an external load of the specified value, either 50 Ω as standard or as input by the user to the instrument's impedance register. Unlike conventional power meters, which measure the power actually dissipated in a load impedance of the required value, the 2610 always presents a high input impedance to the signal source, producing its dBm outputs from its true r.m.s. voltage measurements by means of calculations carried out by its internal microprocessor. As a result, the dBm measurement facility of the 2610 is far more versatile than that offered by any conventional power meter.

All measurements, whether voltage or decibel, can be made relative to an 'offset' reference value input by the user into the instrument's offset register, simplifying instrument operation in a wide range of circumstances.

## Additional facilities

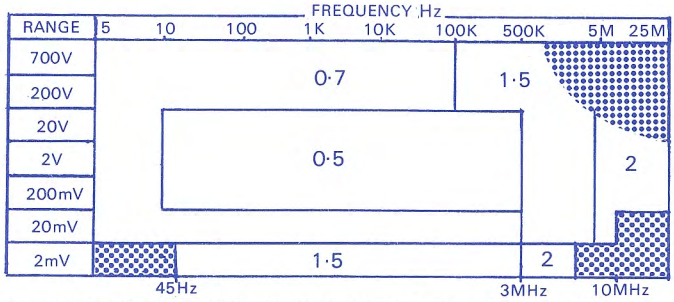
As a further aid to convenient operation, the instrument also allows the user to specify the rate at which the main digital display will be updated during continuous measurement-taking, i.e. the 'reading rate'. Internally, the measurement circuitry functions continuously, generating new voltage measurements at intervals of approximately 40 ms. Where appropriate, each of these new voltage measurements may be displayed directly as soon as it is made, giving a display-update or reading rate of approximately 25 readings/s. Alternatively, a lower reading rate can be chosen, down to 0·2 readings/s (i.e. 5 s per reading), so that the displayed value is subject to much less rapid change. When such a lower reading rate is selected, the internal voltage measurements taken between display updates are subject to a data-averaging process so that the reading eventually displayed is actually the r.m.s. average of all the intervening voltages measurements. This averaging facility is extremely useful with low-frequency input signals, or signals with a low-frequency ripple, and is particularly effective with waveforms having large random fluctuations.

As an alternative when measuring low-frequency signals, the instrument allows an additional damping factor to be switched into the thermal-convertor control loop. This improves display stability with low-frequency signals while allowing the use of a higher reading rate than would be possible with the alternative data-averaging technique.

Both the selection of reading rate and the switching in and out of the low-frequency damping circuit are accomplished by simple front-panel commands. In addition, a given reading on the display may be held indefinitely by a single key depression, locking the display but keeping in operation all other functions of the instrument.

As well as providing a convenient analogue dB meter to supplement the main digital readout, the 2610 also provides an auxiliary DC output of voltage proportional to the true r.m.s. reading, allowing the instrument to drive a pen recorder directly or to function as a true r.m.s. convertor in control applications etc.

| | |
|---|---|
| **MEASUREMENT CAPABILITIES** | High impedance true r.m.s. voltage measurements in either voltage or decibel units on waveforms of any complexity, subject to limitation as below. |
| **Frequency response** | 5 Hz – 25 MHz. |
| **Input coupling** | User selectable as AC or DC, the latter being used with asymmetric or DC – shifted input signals. |
| **VOLTAGE MEASUREMENTS** | |
| **Voltage ranges** | 2 mV – 200 V full scale in x 10 steps, plus 700 V. |
| **Voltage resolution** | 3½ digits (3 digits on 700 V range). |
| **Voltage accuracy** | (As on chart opposite.) |
| **Ranging** | Autoranging available on all ranges when AC coupled, and from the 20 mV range upwards when DC coupled.<br>Manual range selection also available, subject to automatic ranging-up in response to overvoltages. |




*Voltage accuracy (12 months validity) specified by reference to chart, subject to conditions noted below. Accuracy quoted as N implying ±N ±10N counts (2000 counts = f.s.d. for range).*

*DC voltage accuracy is 0·7% ±7 counts (20 mV range), 0·5% + counts (200 mV and higher ranges).*

*Notes:–*

1) *Above accuracy figures apply to 18°C to 28°C only, outside this range correct by factor of (1 + (temperature change)/20).*
2) *Figures apply 10% – 100% f.s.d. only.*
3) *Figures apply equally to either AC or DC coupling, with AC coupling limited to >45 Hz. Selection of L.F. damping function may be required below 45 Hz.*
4) *Figures subject to crest factor of applied waveform not exceeding 7 at f.s.d., increasing down scale by 7 x (voltage range)/(voltage input).*

# 2610

**DECIBEL MEASUREMENTS**

In decibel modes with a.c. coupling, instrument effectively has a single range of 130 dB, with autoranging automatically selected.

**Decibel resolution**
4 digits.

**Decibel references**

*– dBV*
Readings displayed as dB relative to 1 V r.m.s.

*– dBm*
DBm measurements indicate power relative to 1 mW that would be developed in an external impedance equal to user-entered value stored in impedance register Default 50 Ω.

**OFFSET FUNCTION**

Offset level entered into offset register taken as reference level for subsequent V, dBV and dBm readings.

**INPUT CHARACTERISTICS**

**Maximum input**
700 V r.m.s. or 1000 V peak subject to a Volt x Hertz limit of 1 x $10^8$ any range.

**Input connection**
BNC isolated 1 M Ω shunted by approx. 50 pF.

**OUTPUT INDICATIONS**

**Digital display**
4-digit 7-segment LCD with automatic decimal point location and annunciators for V, dBm, dBV, kΩ, AC, DC, LF, MV, OFFSET and BATT LO.

**Analogue meter**
50 mm analogue peaking/dipping meter scaled for dB.

**Reading (display update) rate**
Internal voltage measurements taken at intervals of approx. 40 ms, with successive measurements being r.m.s. – averaged between display updated. User selection allows choice of 8 readings (i.e. display update) rates ranging from 25 per s to 0·2 per s.

**Low-frequency damping**
User selectable damping of thermal-conversion control loop reduces display instability with low-frequency inputs. Damping automatically disabled during range changed.

**Response time**
Within range, worst case to within 1% of final value, typically 2 s max. When damping selected, worst case to within 1% of final value typically 10 s max.

**AUXILIARY OUTPUT**

Rear panel BNC output (e.g. for pen recorder drive or feedback control) proportional to analogue meter deflection with f.s.d. of approx. 2 V DC.

**GPIB INTERFACE**

Optional GPIB card fits inside instrument to offer full facilities for GPIB operation in the following addressing modes:

Talk and Listen
Talk only
Talk only in upper case characters.

**BATTERY OPERATION**

Optional battery-control card fits inside instrument (as alternative to GPIB card) to allow operation from either external 10 – 14 V DC supply or internal rechargeable 6 V Ni-Cd battery unit.

**POWER REQUIREMENTS**

**AC Supply**
Switchable voltage ranges
105 – 120 V and 210 and 240 V both at ±10%
50 – 500 Hz +10%
15 VA approx.

**DIMENSIONS AND WEIGHT**

| Height | Width | Depth | Weight |
|---|---|---|---|
| 108 mm | 215 mm | 338 mm | 3 Kg |
| 4·25 in | 8·5 in | 13·25 in | 6·6 lb |

*(Width measurement does not include 41 mm (1·5 in) for handles.)*

## VERSIONS AND ACCESSORIES

*When ordering please quote eight-digit code numbers.*

| Ordering Numbers | |
|---|---|
| **52610-900X** | True RMS Voltmeter 2610 |
| | **Supplied Accessories**<br>AC supply lead 43129-003W<br>Operating manual 46881-427T (H52610-900X Vol. 1) |
| | **Optional Accessories** |
| **54462-022S** | Battery pack comprising – |
| **44990-414L** | Battery control unit |
| **44990-413N** | Battery Unit |
| **54433-002Y** | GPIB Interface Unit |
| **43129-189U** | GPIB lead assembly, IEEE connector |
| **46883-408K** | GPIB adaptor, IEEE male to IEC female |
| **43126-012S** | Coaxial input lead, BNC connectors |
| **54124-022L** | Front panel cover |
| **46883-536P** | Rack mounting kit |
| **46883-537X** | Blank frame unit, for use with rack mounting kit |
| **46881-428P** | Service Manual (H52610-900X Vol. 2) |
| **46881-365R** | GPIB Manual (H54811-010P) |

# Universal Bridge TF 2700



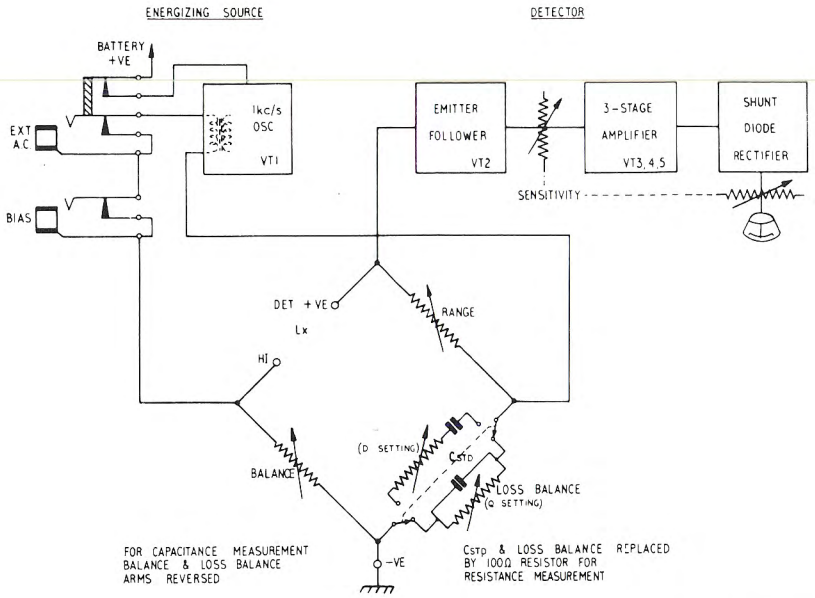

9634

- ☐ **Transistorised oscillator/detector**
- ☐ **Battery operation**
- ☐ **Remarkable versatility**

Although this bridge uses the conventional bridge configurations, provision has been made for the connection of a large number of external facilities, so that a wide-range general-purpose instrument can be rapidly converted for a specialised measurement, without need of modification or special accessories.

The internal battery-powered transistor oscillator provides a bridge source for measurements of L, C, and R at 1 kHz, or an external source can be used between 20 Hz and 20 kHz. The internal aperiodic detector also uses battery-powered transistors, and may be used with both the internal and external bridge drive; an external detector can be used instead with either source. Resistance can also be measured with d.c. using the internal battery and galvanometer, or with either replaced by external equivalents. Finally, mixed a.c. and d.c. can be applied to the bridge when measuring components that require polarisation or for the determination of incremental properties.

# TF 2700




*Functional Diagram for AC Measurements*

## Specification

**MEASUREMENT RANGES**

0·2 µH to 110 H, and 0·5 pF to 1100 µF, each in eight decades, with phase defect value, at 1kHz from internal source, or 20 Hz to 20 kHz from external source; and 0·01 Ω to 11 MΩ in eight decades, at d.c. or 1 kHz from internal sources, or at d.c. or 20 Hz to 20 kHz from external sources, as detailed below.

**INDUCTANCE MEASUREMENT**

**Ranges**

Maxima 11 –110 µH, 1·1 –11 – 110 mH, and 1·1 –11 –110 H.
*Accuracy at 1 kHz* ±1% of reading ±0·1% of range maximum above 11 µH. +2% –10% of reading, +0 –0·3 µH dependent upon Q below 11 µH.
*Residual correction:* –0·2 µH.

**Q**

*At 1 kHz:* 0 to 10.

**CAPACITANCE MEASUREMENT**

**Ranges**

Maxima 110 pF, and 0·0011 – 0·011 –0·11 –1·1 –11 –110 –1100 µF.
*Accuracy at 1 kHz:* ±1% of reading ±0·1% of range maximum below 110 µF.
±2% of reading ±1 µF above 110 µF.
*Residual correction:* –0·2 pF.

**D**

*At 1 kHz:* Two ranges, 0 to 0·1 and 0 to 10.

**RESISTANCE MEASUREMENT**

**Ranges**

Maxima 1·1 –11 –110 Ω.
1·1 –11 –110 kΩ, and 1·1 –11 MΩ.

*Accuracy:* ±1% of reading ±0·1% of range maximum above 1·1 Ω.
±2% reading ±1 mΩ below 1·1 Ω.
*Residual correction:* 0·002 Ω.

**BRIDGE SOURCES**

**AC**

1 kHz (±5%) from internal oscillator, or 20 Hz to 20 kHz from external source, for L, C or R measurements. Additional bridge error with external source is normally less than 0·25%.

**DC**

9 V for internal battery, or external supply for greater discrimination, for R measurement.

**LIMIT RANGE OF OPERATION**

**Temperature**

0 to 55°C.

**CONDITIONS OF STORAGE AND TRANSPORT**

**Temperature**

–40°C to +70°C.

**Humidity**

Up to 90% relative humidity.

**Altitude**

Up to 2500 m (pressurized freight at 27 kPa differential, i.e. 3·9 lbf/in²).

**SAFETY**

Complies with IEC 348.

**POWER REQUIREMENTS**

Internal 9 V battery (consumption approx. 7 mA).

**DIMENSIONS AND WEIGHT**

| Height | Width | Depth | Weight |
|---|---|---|---|
| 235 mm | 290 mm | 235 mm | 3·8 kg |
| 8 in | 11½ in | 8 in | 8½ lb. |

### VERSIONS AND ACCESSORIES

*When ordering please quote eight digit code numbers*

| Ordering numbers | |
|---|---|
| **52700-015L** | **Versions**<br>TF 2700 standard version. |
| | **Supplied Accessories**<br>Jack Plug, type P40. 23421-612R. (Two supplied).<br>Instruction Manual 46881-018X. |
| **43535-009J**<br>**44412-702T** | **Optional Accessories**<br>Isolating Transformer TM 7120.<br>DC Choke Adapter TM 6113. |

marconi instruments

# Modulation and Deviation Meters


| | | |
|---|---|---|
| **FM/AM Modulation Meter (4 to 1200 MHz)** | **TF 2300B** | **76** |
| **FM/AM Modulation Meter (with auto-tuning)** | **TF 2304** | **82** |
| **Modulation Meter (500 kHz to 2 GHz)** | **2305** | **88** |


## Selection Guide

| TYPE NO. | APPLICATIONS | FEATURES |
|---|---|---|
| **TF 2300B** | Development, production and maintenance testing of equipment for fixed and mobile communications, broadcasting (including f.m. stereo), telemetry and multichannel links. | High accuracy and low noise. Optional crystal oscillator. Wide range of carrier frequencies, f.m. deviation and a.m. depth. |
| **TF 2300BM** | As for TF 2300B. Particularly useful for measurements of a.m. on f.m. of broadcast transmitters and measurement of distortion on a.m. waveforms. | As for TF 2300B with additional low distortion auxiliary detector. |
| **TF 2304** | Production testing and servicing of communications equipment for mobile, maritime, aeronautical and military uses. | Automatic tuning and level setting giving ease and speed of use. |
| **TF 2305** | Development, production and maintenance testing of equipment for fixed and mobile communications, broadcasting, telemetry and multichannel links. It can also be used for measuring and calibrating precision signal sources. | High accuracy and low noise. Fast automatic tuning. GPIB programmable. Internal calibrator. |

# FM/AM Modulation Meter TF 2300B series




*TF 2300B with optional Crystal Oscillator TK 2302* *14135/1*

- ☐ **Carrier frequency range: 4 to 1200 MHz**
- ☐ **FM deviation in six ranges: 1·5 to 500 kHz f.s.d.**
- ☐ **AM depth in two ranges: 30 and 100% f.s.d.**
- ☐ **High accuracy and low noise**
- ☐ **Optional crystal oscillator facility**
- ☐ **Broadcast version available**

FM/AM Modulation Meter TF 2300B measures f.m. deviation and a.m. depth, and consists basically of a superheterodyne receiver having very linear, switch-selected f.m. and a.m. demodulators. The demodulated signal is amplified, rectified, and applied to a panel meter which is calibrated directly in kHz peak deviation and per cent modulation depth as appropriate. With its wide range of deviation frequency, modulation bandwidth and carrier frequency it is suitable for development, production and maintenance testing of equipment for fixed and mobile communications, broadcasting, telemetry and multi-channel links in the h.f., v.h.f. and u.h.f. bands. Distortion and channel separation tests on f.m. stereo transmitters can also be made, the performance being more than adequate for testing to FCC and CCIR standards.

TF 2300B has very low internal f.m. noise and includes a filter for f.m. or a.m. noise measurement. A plug-in crystal oscillator unit is available as an accessory where very low noise measurements are required at the higher frequencies.

### FM Measurement

The instrument is capable of indicating peak deviation up to a maximum of 500 kHz at modulation frequencies up to 200 kHz; but it is equally suitable for measurement of the very low values of deviation that are often produced by noise or spurious modulation of the signal under test. The sensitivity of the measuring system can be varied by means of a six-position switch, from 1·5 kHz full scale to 500 kHz full scale; and the instrument can

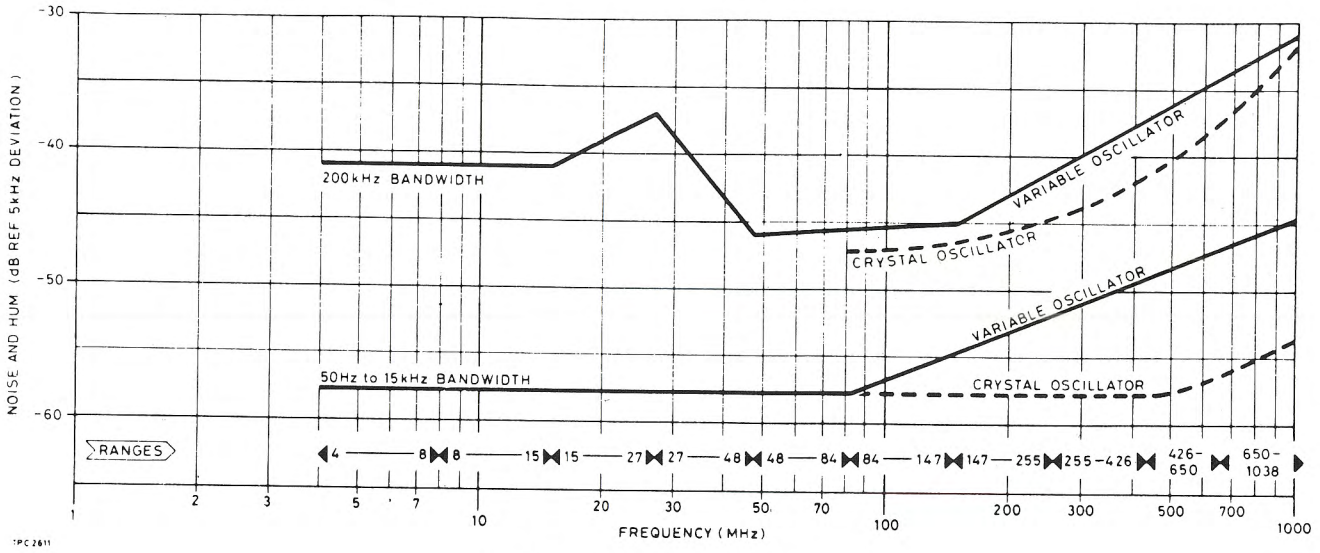



*Fig. 1 Typical modulation meter noise levels*

also be switched to indicate positive or negative peak deviation so that the symmetry of the modulation can be accurately assessed.

For measurement of very low values of deviation there is provision for connecting a sensitive external indicator, via a coaxial socket to the output of the l.f. amplifier. This outlet is also useful for applying the demodulated signal to secondary test equipment – e.g., an oscilloscope, psophometer or wave analyser – for checks on waveform, modulation frequency, etc. This facility for using the instrument as a test receiver is furthered by the provision for switching standard de-emphasis filters of 50, 75 or 750 µs into the l.f. amplifier.

## FM Noise

In order to avoid masking of very small measured deviations it is important that the internally generated f.m. noise shall be commensurately small. In the TF 2300B this noise level is very low. At 200 MHz it is typically –56 dB relative to 5 kHz deviation in the noise measuring bandwidth.

A plug-in crystal oscillator is available as an optional accessory and provides still lower noise levels at the higher carrier frequencies. It is also recommended for use in test situations calling for repeated operation at a few spot frequencies. Up to three crystals can be plugged into the oscillator unit and any one selected by a switch.

Provision is also made for connecting an external local oscillator with a frequency 1·5 MHz above the r.f. input signal and at a level of approximately 200 mV.

## Bandwidth Selection

Measurement can be made in a choice of bandwidths: flat responses up to 200 kHz and 15 kHz for f.m., or 50 kHz for a.m. In addition a noise filter can be switched in to give the conventional response of –3 dB at 50 Hz and 15 kHz for noise measurements on both f.m. and a.m. The high frequency cut-off can be further restricted, if required, by the use of the de-emphasis filters.

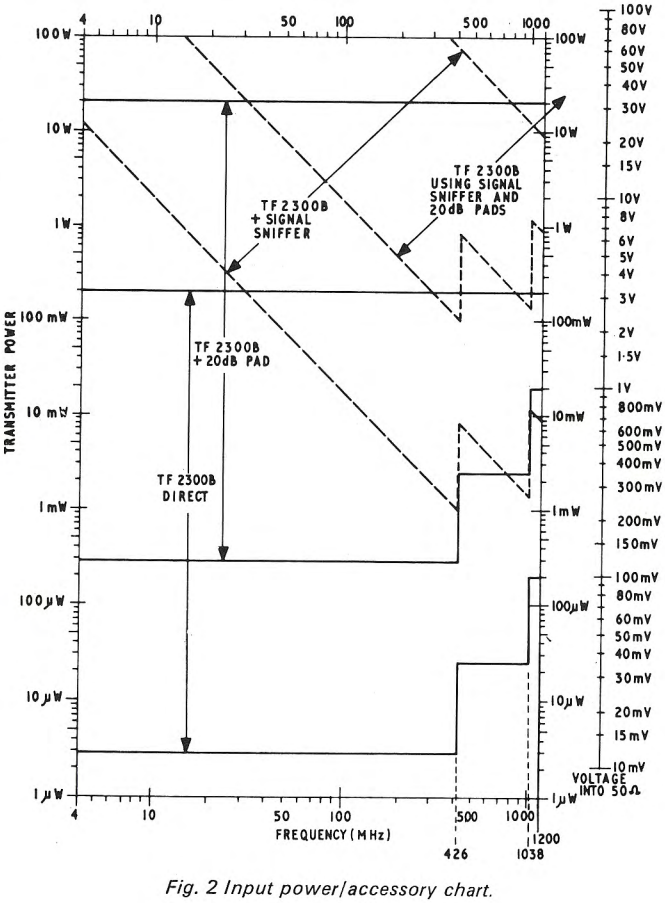



*Fig. 2 Input power/accessory chart.*

## AM Measurement

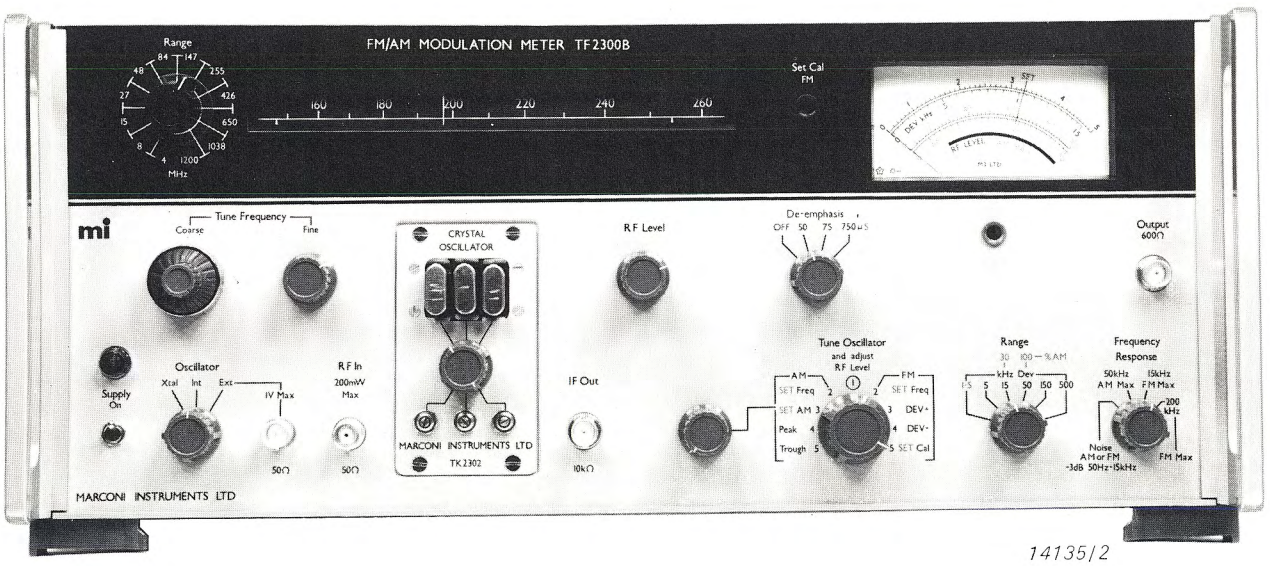
The a.m. section of the instrument is designed to measure modulation depth up to 95% over the carrier frequency range 4 to 400 MHz. The modulation frequency range is nominally 30 Hz to 15 kHz, but the bandwidth of the a.f. system actually extends up to 50 kHz to facilitate measurement of harmonics. In order to give an indication of the symmetry of the modulation envelope, the meter may be switched to indicate the peak or trough amplitude relative to the mean carrier level.

## IF Output

An i.f. output is available at a front-panel socket and can be used for the rapid assessment of distortion of an amplitude modulated envelope by connection to an oscilloscope.

## Accessories

A wide range of optional accessories is available for direct coupling to the transmitter under test. These include attenuator pads, a 50 Ω load and a signal sniffer which can be used to couple a small fraction of a transmitter output to the modulation meter. The input power/accessory chart, Fig. 2, can be used to determine the range of input powers and frequencies over which TF 2300B can be used, alone and with its various accessories.




| | |
|---|---|
| **FM MEASUREMENT** | |
| Carrier frequency range | 4 to 1200 MHz. |
| Deviation range | Six ranges with full scale indications of 1·5– 5– 15– 50– 150 and 500 kHz. Positive or negative deviation indication selected by a switch. |
| Modulation frequency | 30 Hz to 200 kHz on all ranges except the 1·5 kHz deviation range which is limited to 30 Hz to 3·4 kHz. |
| Accuracy | ±3% of f.s.d. for deviations up to 500 kHz and modulating frequencies between 30 Hz and 150 kHz.<br>±5% of f.s.d. on the 1·5 kHz deviation range.<br>±10% of f.s.d. for deviations up to 500 kHz and for modulating frequencies between 150 kHz and 200 kHz. |
| AM rejection | Additional deviation error typically less than 150 Hz in a 15 kHz bandwidth when the a.m. depth is 80% and the modulating frequency is 1 kHz. |
| Inherent noise | Deviation relative to a level of 5 kHz deviation in a –3 dB bandwidth of 50 Hz to 15 kHz is less than:<br>–50 dB from 4 to 200 MHz (typically –56 dB)<br>–40 dB from 200 to 1038 MHz (typically –46 dB). |
| **AM MEASUREMENT** | |
| Carrier frequency range | 4 to 400 MHz. |
| Modulation depth range | Two ranges with full scale indications of 30% and 100%. Peak and trough indications selected by a switch. |
| Accuracy | ±3% of f.s.d. for modulating frequencies between 30 Hz and 15 kHz, and modulation depths up to 80%.<br>±5% of f.s.d. for modulating frequencies between 30 Hz and 50 kHz, and modulation depths up to 95%. |

# Modulation and Deviation Meters
# TF 2300B series

| | |
|---|---|
| **RF INPUT** | |
| Frequency range | 4 MHz to 1200 MHz in 11 bands as follows: 4 to 8, 8 to 15, 15 to 27, 27 to 48, 48 to 84, 84 to 147, 147 to 255, 255 to 426, 426 to 650, 650 to 1038 and 1038 to 1200 MHz. Usable with reduced sensitivity up to 1600 MHz with internal oscillator and at higher frequencies with an external oscillator. |
| Calibration accuracy | ±3%. |
| Sensitivity | Better than 12 mV between 4 and 426 MHz (typically 5 mV).<br>Better than 35 mV between 426 and 1038 MHz (typically 15 mV).<br>Better than 100mV between 1038 and 1200 MHz (typically 50 mV). |
| Maximum input | 3 V r.m.s. (200 mW). |
| Input impedance | Nominally 50 Ω. |
| **IF OUTPUT** | |
| Frequency | Nominally 1·5 MHz. |
| Amplitude | Between at least 220 mV and 1 V e.m.f. |
| Output impedance | Nominally 10 kΩ. |
| **LF OUTPUT** | |
| Frequency range | 30 Hz to 200 kHz with switchable 15 kHz low pass filter on f.m. except on the 1·5 kHz deviation range.<br>30 Hz to 3·4 kHz on the 1·5 kHz deviation range.<br>30 Hz to 50 kHz on a.m. |
| Noise filter | Modifies response to a nominal –3 dB bandwidth of 50 Hz to 15 kHz for noise measurements at output terminals only. Usable for f.m. and a.m. |
| Stereo | Channel separation typically 44 dB from 200 Hz to 15 kHz decreasing to 39 dB at 50 Hz. Suitable for measurements on stereo transmitters designed to meet FCC regulations and CCIR Report 293–2. |
| De-emphasis | Switchable to 0, 50, 75 or 750 μs. |
| Output level | Nominally 0 dBm into 600 Ω when meter reads full scale, except on the 1·5 kHz deviation range when the output is nominally –10 dBm. |
| Distortion, FM | Less than 0·2% for f.m. deviations up to ±75 kHz and modulating frequencies up to 15 kHz (typically less than 0·1%).<br>Less than 1% for f.m. deviations up to ±300 kHz and modulating frequencies up to 25 kHz (typically less than 0.5%).<br>Less than 3% for f.m. deviations up to ±500 kHz and modulating frequencies up to 200 kHz (typically less than 2%). |
| Distortion, AM | Less than 1% for a.m. depths up to 80% (typically less than 0·5% up to 60% depth).<br>Less than 2% for a.m. depths between 80% and 90% (typically less than 1·0% between 60% and 90% depth). |

| | |
|---|---|
| **RADIO FREQUENCY INTERFERENCE** | Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference. |
| **SAFETY** | Complies with IEC 348. |
| **LIMIT RANGE OF OPERATION** | |
| Temperature | 0 to 55°C. |
| **CONDITIONS OF STORAGE AND TRANSPORT** | |
| Temperature | –40°C to +70°C. |
| Humidity | Up to 90% relative humidity. |
| Altitude | Up to 2500m (pressurised freight at 27 kPa differential, i.e. 3·9 lbf/in²). |
| **POWER REQUIREMENTS** | |
| AC supply | 95 to 130 V or 190 to 260 V.<br>45 to 500 Hz. 12 VA. |

| **DIMENSIONS AND WEIGHT** | Height | Width | Depth | Weight |
|---|---|---|---|---|
| | 175 mm | 426 mm | 380 mm | 12·5 kg |
| | 7 in | 16¾ in | 15 in | 27·5 lb |

## VERSIONS AND ACCESSORIES

*When ordering please quote eight-digit code numbers*

| Ordering numbers | |
|---|---|
| | **Versions** |
| **52300–920F** | TF 2300B standard version. |
| | The following version is available to special order. |
| **52300–302F** | TF 2300BM With high-level aperiodic a.m. detector. |
| | **Supplied Accessories** |
| | Extension Board TM 7926 (44688–003C), for use when servicing printed boards (fitted internally). |
| | Mains Lead TM7052 (43129–003W) |
| | Instruction Manual. |
| | **Optional Accessories** |
| **52302–900T** | Crystal Oscillator TK 2302. |
| | Crystals. The required carrier frequencies should be specified. |
| **54452–011E** | Signal Sniffer. |
| **54431–021B** | 20 W, 50 Ω, 20 dB Attenuator. |
| **54431–011D** | 1 W, 50 Ω, 20 dB Attenuator. |
| **54422–011A** | 12 W, 50 Ω Termination. |
| **43281–007C** | RF Fuse Unit TM 9884. |
| **54127–131M** | Rack Mounting Conversion Kit. |
| **41690–079Z** | Protective Front Panel Cover. |
| **43126–012S** | Coaxial Input Lead TM 4969/3. BNC, 1575 mm (62 in). |
| | For details see page 86 |

# TF 2300BM

## Broadcast version




14247/1

### ☐ Low distortion auxiliary a.m. detector

### ☐ Permits measurements of: a.m. on f.m., a.m. distortion, a.m. depth

This model is particularly valuable for making measurements of a.m. on f.m. of broadcast transmitters. The very low distortion of the auxiliary detector also makes it suitable for measuring distortion on a.m. waveforms, with a Distortion Factor Meter such as TF 2331A series connected to the LF OUTPUT socket.

For measurements using the auxiliary detector an external high impedance, sensitive a.f. voltmeter, such as TF 2600 series, must be connected to the LF OUTPUT socket. Modulation depth can be read from the voltmeter with 10 mV being equivalent to 1% modulation depth.

The detector operates over a frequency range of 1·5 to 1000 MHz, with inputs between 1·5 and 3·5 V for 100% a.m. or 1·5 and 5·0 V for 40% a.m. The model retains all functions of the standard model when the auxiliary detector is not in use.

The specification for this model is as for the standard version with the following additions.

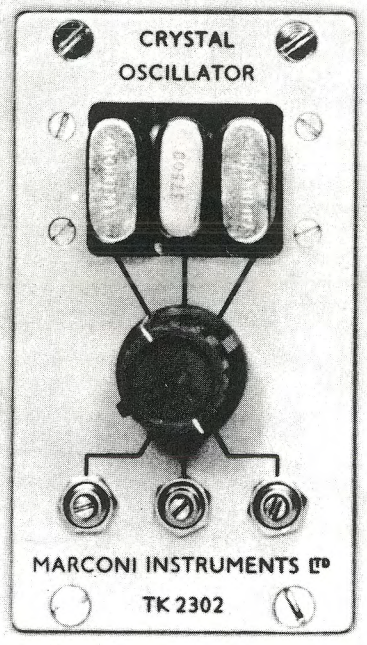
| APERIODIC AM MEASUREMENT | |
|---|---|
| Carrier frequency range | 1·5 to 1000 MHz. |
| Sensitivity | 1·5 V r.m.s. |
| Maximum input | 5 V r.m.s. at 40% a.m.<br>3·5 V r.m.s. at 100% a.m. |
| Input impedance | Nominally 50 Ω. |
| Demodulation distortion | Less than 1% at 95% modulation depth for input levels above 1 V r.m.s. |
| Demodulated output | 10 mV per 1% modulation depth ±10%.<br>i.e. 1 V r.m.s. ±10% for 100% modulation depth. |
| Modulation frequency range for distortion measurements | 30 Hz to 15 kHz. |
| Demodulator bandwidth | 30 Hz to 50 kHz. |

| ORDERING NUMBER | |
|---|---|
| 52300-302F | FM/AM Modulation Meter TF 2300BM |

## Crystal Oscillator TK 2302

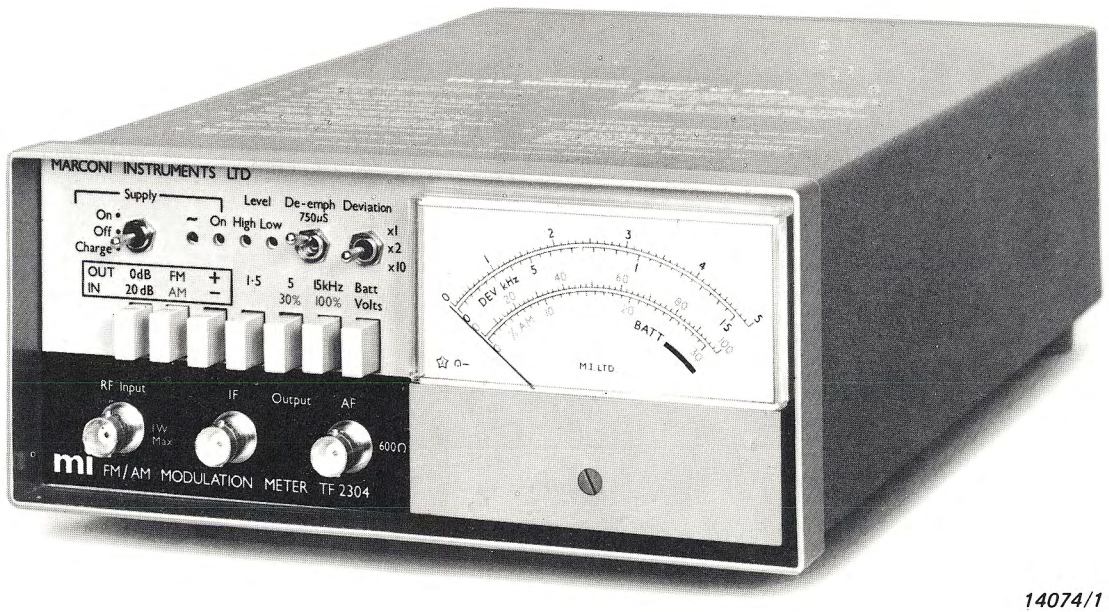
Provides an alternative to the internal variable local oscillator, particularly for low noise measurements at high frequencies. Fits into the recess in the front panel as seen in the illustration of the instrument.

| | |
|---|---|
| FREQUENCY RANGE | 80 to 1000 MHz for f.m.<br>80 to 400 MHz for a.m. |
| SENSITIVITY | Better than 12 mV between 80 and 500 MHz (typically 5 mV).<br>Better than 100mV between 500 and 1000 MHz (typically 30 mV). |
| FM NOISE | Deviation relative to a level of 5 kHz deviation in a 3 dB bandwidth of 50 Hz to 15 kHz is less than:<br>–52 dB up to 800 MHz (typically –56 dB).<br>–50 dB from 800 to 1000 MHz (typically –55 dB). |
| CRYSTALS | Up to three switch selected crystals may be used.<br>Marconi type QO 1670 Series, in fundamental frequency range 40 to 60 MHz. Equivalent series resistance 35 Ω ± 5 Ω.<br>When ordering crystals please specify the r.f. operating frequency and we will advise the correct crystal frequency. |



# FM/AM Modulation Meter

# TF 2304




14074/1

- ☐ **Automatic operation**
- ☐ **Carrier frequency range: 9 to 12·5 MHz and 18 to 1000 MHz**
- ☐ **FM deviation in eight ranges: 1·5 to 150 kHz f.s.d.**
- ☐ **AM depth in three ranges: 10, 30 and 100%**
- ☐ **Input level indication**
- ☐ **AC supply and rechargeable battery operation**

FM/AM Modulation Meter TF 2304 combines high accuracy with automatic tuning and automatic level setting. It has been designed primarily for the servicing and production testing of radio communications systems, particularly mobile radio transmitters, and it covers carrier frequencies from 9 to 12·5 MHz and from 18 to 1000 MHz. FM deviation is measured in eight ranges from 1·5 kHz to 150 kHz full scale, and a.m. depth is measured in two ranges of 30% and 100% full scale, with a further uncalibrated range of 10%. Accuracy for both f.m. and a.m. measurements is ±3% of full scale.

An outstanding feature of this instrument is its ease and speed of use – leading to considerable time savings in production testing. To make a measurement it is only necessary to couple the r.f. signal to the input and select the measurement required, the meter will then tune automatically to the carrier frequency, set the signal level and display the f.m. deviation or a.m. depth on the panel meter. The whole measurement process takes only a few seconds.

## Applications

This new modulation meter has been designed with mobile radio testing in mind, and deviation ranges have been selected as the most suitable for this purpose. It will find application in servicing and production testing of communications equipment for land mobile, maritime, aeronautical and military uses – its carrier frequency range covering all frequencies used for these purposes. The extension of the range down to 9 MHz permits the instrument to be tuned to cover the standard 10·7 MHz intermediate frequency. Other applications for TF 2304 include production line testing of signal generators for which its high deviation range is very valuable and servicing of fixed communication links. Its good accuracy also makes it suitable for use in design laboratories.

# Modulation and Deviation Meters
# TF 2304

## Design features

TF 2304 is basically a superheterodyne receiver consisting of a tuneable local oxcillator, mixer, i.f. amplifier, a.m. and f.m. detectors, audio amplifier and peak voltmeter. The local oscillator is swept in frequency and its output signal is mixed with the incoming signal. The i.f. amplifier operates at 400 kHz and when an output appears at this frequency the instrument locks to the incoming signal and stops sweeping. Once it has locked, automatic levelling takes place. The i.f. output is demodulated and applied to a panel meter calibrated in peak deviation and percentage modulation depth. The low distortion a.m. and f.m. detectors are followed by very effective audio frequency filters which extract the demodulated signal.

A sampling type mixer is used, resulting in a very flat response up to 1000 MHz together with a wide dynamic range. The local oscillator is tuned automatically to the correct frequency, and the correct r.f. input level to the mixer is set automatically. Two l.e.d. lamps on the front panel indicate if the signal level is too low or too high for correct operation, the appropriate lamps lighting when an out-of-range input is present. This prevents unnoticed mixer overloading which is particularly important for a.m. measurements.

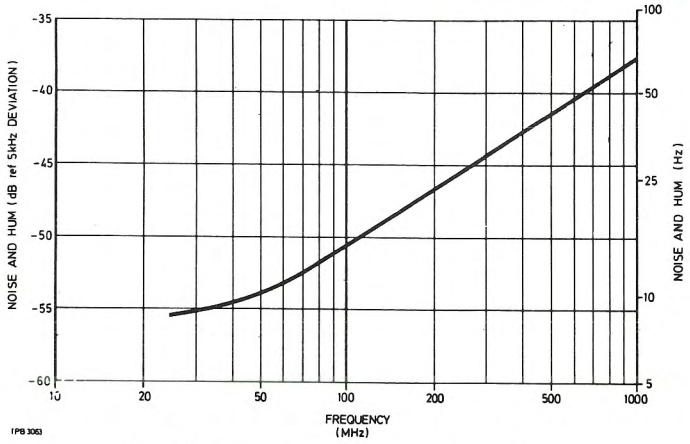



*Fig. 1 Typical modulation meter noise levels*

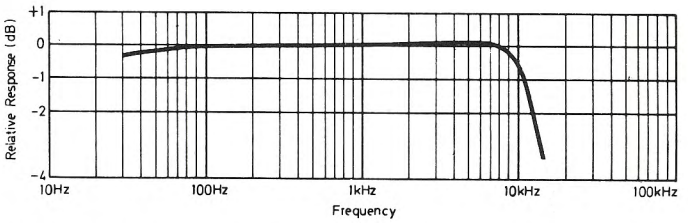



*Fig. 2 Sample audio frequency response to f.m signal on 5 kHz range*

## FM Measurement

Peak deviation can be measured with full-scale deflections from 1·5 kHz to 150 kHz over the modulation frequency range of 50 Hz to 9 kHz. Deviation selection is by three push-buttons in conjunction with a toggle switch giving multiplication factors of ×2 and ×10, and providing a total of eight deviation ranges. Push-button selection of positive or negative peak deviation measurements permits assessment of modulation symmetry.

Internally generated f.m. noise is small, better than 42 dB down on 5 kHz deviation (equivalent to 40 Hz deviation) at 150 MHz. Figure 1 shows typical modulation meter noise levels. With de-emphasis switched in, noise will be reduced further. The modulation frequency response is flat from 300 Hz to 3 kHz, and figure 2 shows the response curve of a sample instrument.

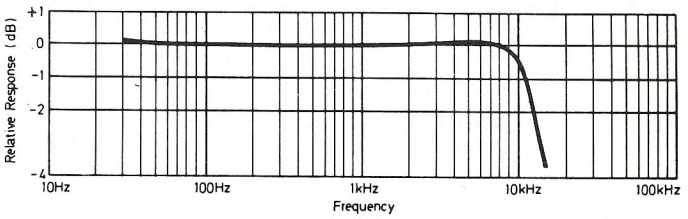



*Fig. 3 Sample audio frequency response to a.m signal on 100% range*

## AM Measurement

Modulation depth can be measured in three ranges of 10% (uncalibrated), 30% and 100% full-scale, selected by push-buttons, over the modulation frequency range of 50 Hz to 9 kHz. Push-button selection of peak or trough amplitude permits assessment of the symmetry of the modulation envelope.

Figure 3 shows the modulation frequency response curve of a sample instrument.

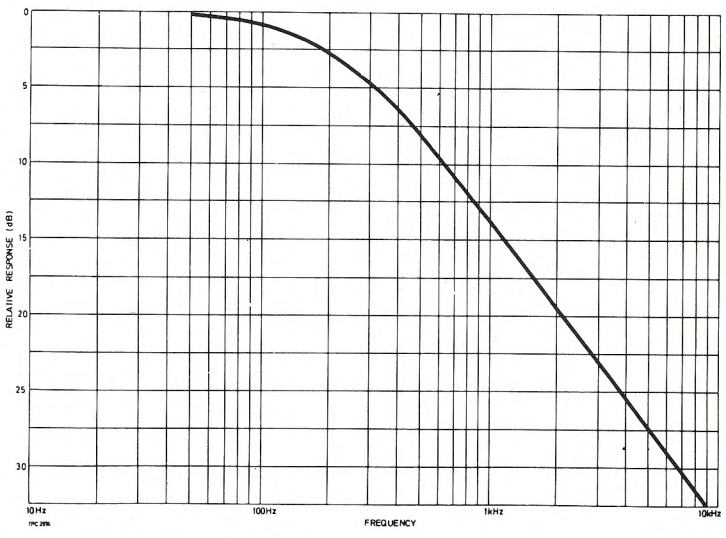



*Fig. 4 Nominal 750 μs de-emphasis response*

## Screening

The instrument has very efficient r.f. screening, enabling it to be operated satisfactorily in areas of high r.f. field. For example, tests have shown that a 9 watt transmitter can be measured in close proximity to a 250 watt transmitter.

The screening also ensures low leakage from the local oscillator so that nearby receivers will not be affected. This good screening and the over-and under-level indication virtually eliminates the possibility of false locking, providing that the instrument is correctly coupled to the source.

## Input Sensitivity

Two versions of TF 2304 are available, providing a choice of r.f. sensitivity.

For transmitter testing on production lines and in servicing, the standard 1 watt version, type 52304–900S, would normally be used. This includes a built-in 20 dB attenuator and accepts input levels between 50 mV and 1 volt r.m.s. The attenuator avoids over-sensitivity of the instrument and also provides extra protection for the mixer which will not be damaged if a high power transmitter is accidentally connected to the input. A second 20 dB attenuator can be inserted by operation of a push-button, extending the maximum input level to 7 volts or 1 watt continuous. With the optional accessories available any input between 50 µW and 1 kW can be accepted.

For laboratory use a high sensitivity version, model 52304–302E, is available. This is similar to the standard version except that the fixed 20 dB attenuator has been omitted. Thus its sensitivity is 5 mV to 100 mV r.m.s., extended to 1 volt by insertion of the switchable 20 dB attenuator. The maximum working input is 20 mW and maximum input without damage is 250 mW. This high sensitivity version is particularly suitable in laboratories and workshops for use with signal generators of limited output.

## Outputs

An i.f. output is available from a front panel BNC socket and it can be used to examine the modulation envelope of an a.m. signal.

An a.f. output with very low harmonic distortion is also available for applying the demodulated signal to external equipment for checks on waveform distortion, noise and modulation frequency. A standard de-emphasis network with time constant 750 µs can be switched in, to provide de-emphasis of 6 dB per octave as shown in Fig. 4. This is useful for measurements of modulation distortion on phase modulated transmitters (as required in the C.E.P.T. specifications of some European countries).

## Power Requirements

The modulation meter operates either from an a.c. supply or from an optional rechargeable nickel-cadmium battery which can be mounted inside the instrument. The battery can be fully charged overnight by connection to an a.c. supply and it will receive a steady trickle charge while the instrument is being operated from the a.c. supply. A fully-charged battery will give eight hours continuous operation and a battery monitor switch is incorporated to enable the battery voltage to be displayed on the meter.

## Construction

In the design of TF 2304 great attention has been paid to achieving small size and light weight together with a mechanically simple construction which provides good accessibility for servicing. The use of a wrap-around welded case and the efficient screening ensure immunity to r.f. interference. Extensive use of integrated circuits has resulted in a low component count and high reliability, which is further ensured by the full environmental testing carried out during the design of the instrument.

## Accessories

A wide range of optional accessories is available for direct coupling to the transmitter under test. These include attenuator pads, a 50 Ω load and a signal sniffer which can be used to couple a small fraction of a transmitter output to the modulation meter.

The input power/accessory chart, Fig. 5, can be used to determine the range of input powers and frequencies over which TF 2304 can be used, alone and with its various accessories.

A carrying case is a useful optional accessory for on-site servicing.

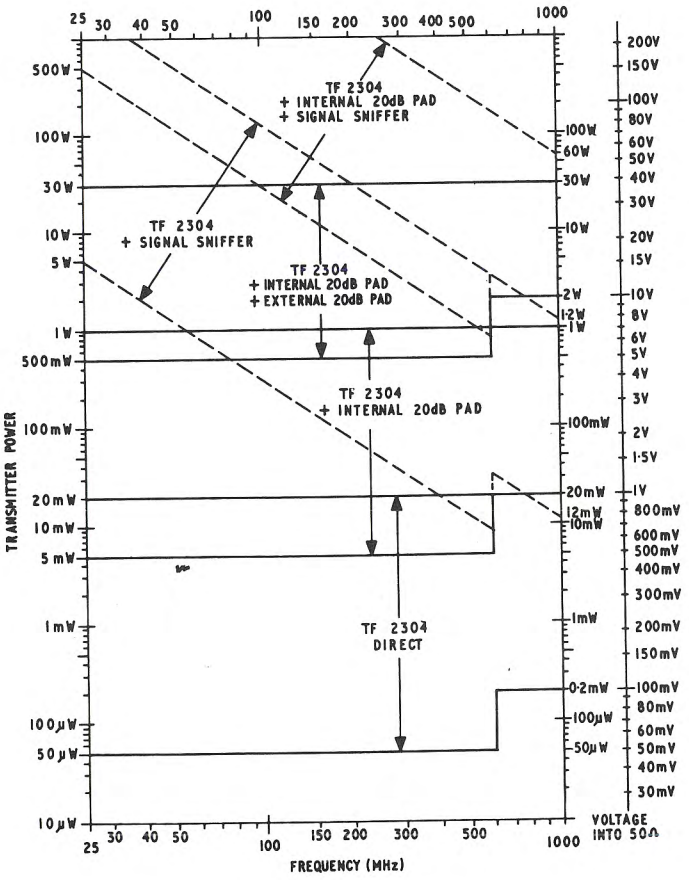



*Fig. 5 Input power/accessory chart*

# Modulation and Deviation Meters
# TF 2304

**RF INPUT**

**Carrier frequency range**
9 to 12·5 MHz and 18 to 1000 MHz with automatic tuning and automatic level setting.
Maximum time to reading: approximately 5 s.

**Sensitivity**
Version 52304–900S
(Standard sensitivity).
Better than 50 mV up to 600 MHz.
Better than 100 mV up to 1000 MHz.

Version 52304–302E
(High sensitivity).
Better than 5 mV up to 600 MHz.
Better than 10 mV from 600 to 800 MHz.
Better than 20 mV from 800 to 1000 MHz.

**Maximum working input**
Version 52304–900S
1 V r.m.s. extending to 7 V with switchable 20 dB nominal pad.

Version 52304–302E
100 mV r.m.s. extending to 1 V with switchable 20 dB nominal pad.

**Maximum safe input**
Version 52304–900S
1 W (7 V into 50 Ω) continuous.
Version 52304–302E
250 mW (3·5 V into 50 Ω) continuous, providing the 20 dB attenuator is switched in.

**Switchable attenuator**
20 dB nominal.

**Input impedance**
50 Ω nominal.

**Level indication**
Two l.e.d. lamps indicate if the input level is too low or too high.

**FREQUENCY MODULATION**

**Deviation ranges**
Eight ranges (using ×2 and ×10 switches) giving full scale peak deviations of 1·5, 3, 5, 10, 15, 30. 50 and 150 kHz. Positive or negative deviation indication is selected by a switch.

**Deviation accuracy**
±3% of f.s.d. at 1 kHz modulation frequency.

**Modulation frequency range**
Over the range 50 Hz to 9 kHz, deviation measurements are within ±0·5 dB w.r.t. 1 kHz.

**Inherent noise**
Deviation due to noise is less than 40 Hz at 150 MHz (42 dB down on 5 kHz deviation), measured in 3 dB bandwidth of 15 kHz nominal with 100 mV input.

**AM rejection**
Better than 26 dB below output corresponding to 5 kHz deviation with 30% a.m. at 1 kHz modulation frequency (normally better than 36 dB).

**AMPLITUDE MODULATION**

**Modulation depth range**
Full scale indication 10%, 30% and 100% (usable up to 95%). Peak or trough indication selected by a switch.

**Depth accuracy**
±3% of f.s.d. on 30% and 100% ranges for depths up to 80% and 1 kHz modulation frequency, at carrier frequencies up to 400 MHz.

**Modulation frequency range**
Over the range 50 Hz to 9 kHz, modulation depth measurements are within ±0·5 dB w.r.t. 1 kHz.

**Noise**
Better than 50 dB down on 100% modulation output in a nominal 3 dB bandwidth of 15 kHz at an input level of 100 mV.

**IF OUTPUT**
Available at front panel socket.

**Frequency**
400 kHz nominal.

**Level**
100 mV e.m.f. nominal from 1 kΩ source.

**AF OUTPUT**
Demodulated a.f. output available at front panel socket.

**Level**
1 mW nominal into 600 Ω with meter at f.s.d.

**3 dB bandwidth**
Nominally 20 Hz to 15 kHz.

**Distortion**
Less than 1% for a.m. up to 80% depth (normally less than 0·5%).
Less than 1% for f.m up to 150 kHz deviation (normally less than 0·5%).

**De-emphasis**
Switchable to 0 or 750 μs. On 750 μs position output falls at nominal 6 dB/octave above 300 Hz.

**CONNECTORS**
BNC sockets for r.f. input, i.f. output and a.f. output.

**POWER REQUIREMENTS**

**AC supply**
95 to 130 V and 190 to 264 V
45 to 500 Hz. 6 VA approximately.

**Internal battery**
21 V rechargeable Nickel Cadmium battery. Nominally eight hours operation on full charge.

**SAFETY**
Complies with IEC 348.

**LIMIT RANGE OF OPERATION**

**Temperature**
0 to 55°C.

**CONDITIONS OF STORAGE AND TRANSPORT**

**Temperature**
–40°C to +70°C.

**Humidity**
Up to 90% relative humidity.

**Altitude**
Up to 2500 m (pressurised freight at 27 kPa differential, i.e. 3·9 lbf/in²).

**RADIO FREQUENCY INTERFERENCE**
Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference.

**DIMENSIONS AND WEIGHT**

| Height | Width | Depth | Weight |
|---|---|---|---|
| 100 mm | 206 mm | 305 mm | 2·7 kg |
| 3·9 in | 8·1 in | 12 in | 6 lb |

(Weight without battery).

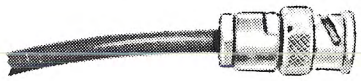
## VERSIONS AND ACCESSORIES

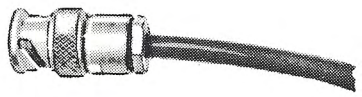
*When ordering please quote eight digit code numbers*

| Ordering numbers | |
|---|---|
| | **Versions** |
| **52304–900S** | FM/AM Modulation Meter TF 2304. |
| **52304–302E** | TF 2304. High Sensitivity version. |
| | **Supplied Accessories** |
| | Mains Lead 43129–003W |
| | Instruction Manual. |
| | **Optional Accessories** |
| **43126–012S** | Coaxial Lead TM 4969/3. |
| **43281–007C** | RF Fuse Unit TM 9884. |
| **54112–121N** | Carrying Case. |
| **54422–011A** | 12 W, 50 Ω Termination. |
| **54431–011D** | 1 W ,50 Ω, 20 dB Attenuator. |
| **54431–021B** | 20 W, 50 Ω, 20 dB Attenuator. |
| **54452–011E** | Signal Sniffer. |
| **54463–011D** | Rechargeable Battery, 21 V. |

# Accessories

OPTIONAL ACCESSORIES





## COAXIAL LEAD, 50 Ω, 43126–012S (TM 4969/3)

| | |
|---|---|
| LENGTH | 1520 mm (5 ft). |
| CONNECTORS | BNC plugs, 50 Ω. |

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## RF FUSE UNIT, 50 Ω, 43281–007C (TM 9884)

Fuse for protection against accidental overload.

| | |
|---|---|
| VSWR | Not greater than 1·5 at 470 MHz. |
| INSERTION LOSS | Not greater than 0·6 dB at 400 MHz.<br>Not greater than 1·0 dB at 470 MHz. |
| RATING | 0·4 W. |
| CONNECTORS | 50 Ω, BNC plug to BNC socket. |
| DIMENSIONS | 88 mm × 14 mm (3·5 in ×0·55 in). |




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## 12 W, 50 Ω TERMINATION, 54422–011A

A good non-radiating termination for transmitters up to 15 W. May also be used with signal sniffer for transmitters up to 12 W at frequencies up to 600 MHz.

| | |
|---|---|
| IMPEDANCE | 50 Ω nominal. |
| FREQUENCY RANGE | DC to 1 GHz. |
| RATING | 12 W continuous, 15 W for up to 5 minutes, with off periods of at least 5 minutes. |
| CONNECTOR | 50 Ω, BNC plug. |
| DIMENSIONS | 50 mm ×25 mm nominal (2 in ×1 in nominal). |

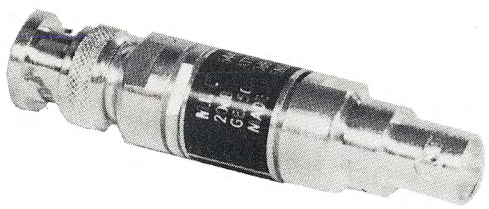


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## 1 W, 50 Ω, 20 dB ATTENUATOR, 54431–011D

Attenuator or termination for transmitters up to 1 W.

| | |
|---|---|
| ATTENUATION | 20 dB nominal. |
| FREQUENCY RANGE | DC to 1 GHz. |
| IMPEDANCE | 50 Ω nominal. |
| RATING | 1 W continuous. |
| CONNECTORS | 50 Ω, BNC plug to BNC socket. |
| DIMENSIONS | 66 mm long ×16.5 mm dia. nominal (2·6 in ×0·65 in nominal). |



---

## 20 W, 50 Ω, 20 dB ATTENUATOR, 54431–021B

Attenuator for use with signal sniffer where additional attenuation and/or termination is required with transmitters up to 30 W, or without sniffer for transmitters up to 20 W.

| | |
|---|---|
| ATTENUATION | 20 dB nominal. |
| FREQUENCY RANGE | DC to 1 GHz. |
| IMPEDANCE | 50 Ω nominal. |
| RATING | 20 W continuous. 30 W for up to 5 minutes with off periods of at least 5 minutes. |
| CONNECTORS | 50 Ω, BNC plug to BNC socket. |



## SIGNAL SNIFFER, 54452–011E

T connector for insertion between transmitter and load with pick-up to give a small signal from the T branch to the modulation meter.



| | |
|---|---|
| ATTENUATION | Dependent upon frequency. Approximate range is –66 dB at 4 MHz, –50 dB at 25 MHz, –24 dB at 500 MHz, –18 dB at 1000 MHz when terminated by 50 Ω. |
| DIMENSIONS | 66 mm ×66 mm ×15 mm (2·6 in ×2·6 in ×0·6 in) |
| CONNECTORS | BNC plug to BNC socket (may be connected either way round). |

## RECHARGEABLE BATTERY, 54463–011D

21 V nickel cadmium battery fitting into the TF 2304. Battery has a lead with polarized connector to mate with a connector in the instrument. A fuse supplied with the TF 2304 must be fitted for battery operation.

| | |
|---|---|
| OPERATIONAL LIFE | Continuous operation approximately 8 hours after full charge. Recharging time from fully discharged is approximately 14 hours. The battery voltage is monitored by the meter. |
| WEIGHT | 0·92 kg (2 lb). |

# Modulation Meter 2305




- ☐ 0·5% basic accuracy
- ☐ 500 kHz to 2 GHz frequency range
- ☐ Internal calibrator
- ☐ Fast automatic tuning
- ☐ Low noise
- ☐ Non-volatile memory
- ☐ GPIB programmable
- ☐ AM, FM and PM measurements
- ☐ Frequency and power measurements
- ☐ Distortion and weighted measurements (with option)
- ☐ Excellent stereo separation
- ☐ Overload protection

Modulation Meter 2305 is an automatic tuning instrument suitable for a wide range of measurements on signal sources. Conventional measurements such as f.m. or p.m. deviation and a.m. depth are made with excellent resolution and high accuracy over a carrier frequency range from 500 kHz to 2 GHz. Additional measurements such as frequency, r.f. power, frequency response, signal to noise ratio, etc. can be made and a high quality demodulated output is provided for monitoring purposes. An internal calibrator is fitted to ensure optimum accuracy for all modulation measurements.

With its wide range of measurement facilities the 2305 is suitable for development, production and maintenance testing of equipment for fixed and mobile communications, broadcasting, telemetry and multi-channel links. The unit can also be used for measuring and calibrating precision signal sources.

### Tuning

In its normal mode the 2305 tunes automatically to the strongest input signal with an acquisition time of typically 500 ms, but a manual facility is provided whereby the instrument can be pre-tuned to a frequency entered via the numerical keypad.

The frequency display is used to indicate the carrier frequency of the input, the error from a previously entered value or the modulation frequency depending on the function selected by the operator.

The 2305 includes input protection against accidentally applied overloads up to 25 watts.

# Modulation and Deviation Meters
# 2305

### Modulation measurement
The 2305 is capable of measuring f.m. deviations up to 500 kHz, phase deviations to 500 radians and a.m. depths up to 99·9% with modulating frequencies up to 300 kHz (50 kHz for a.m.). Ranges are selected automatically by the instrument to give the best possible resolution.

Four detector responses can be selected: average peak for all routine modulation measurements, positive or negative peak where modulation symmetry needs to be established and noise averaging for the measurement of residual noise. A peak hold mode is also provided to hold the highest level of modulation which occurs, allowing the limiting performance of transmitters to be correctly measured.

A relative mode allows measurements to be made in dB relative to a reference value, for example when checking frequency response or signal to noise ratio.

### Power measurement
The 2305 directly indicates power input levels from 10 mW to 1 W and with external attenuator pads this range can be easily extended. The attenuation factor of an external pad or the value of a known power level can be entered into the 2305 and the unit will then automatically correct its reading, to give an indication of the power applied to the input of the attenuator.

### Internal calibrator
The internal calibrator recalibrates the 2305 each time the unit is switched on and whenever the operator presses the calibrate key. Alternatively a software function allows this facility to be changed to provide a confidence check where this is preferred.

### LF processing
A choice of five different l.f. filters is offered to cover the widest range of requirements and they allow the user to restrict the l.f. bandwidth when full coverage is not required. An output giving up to 3 V r.m.s. into 600 Ω is provided for external monitoring of the demodulated signal.

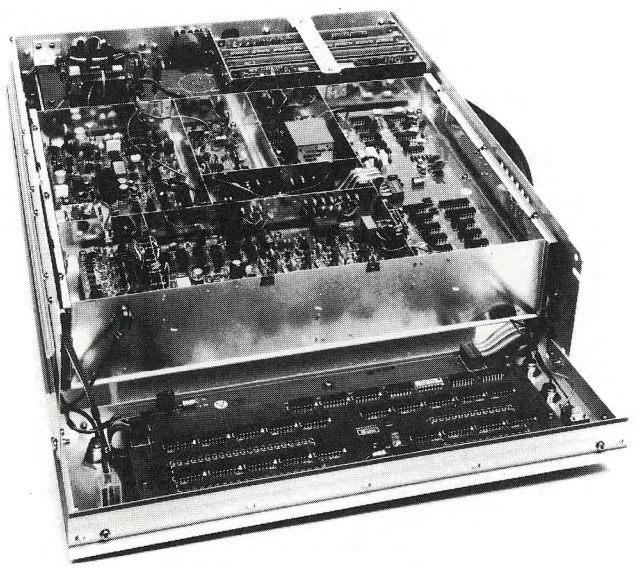
The excellent phase and amplitude linearity of the 2305 allow stereo separation measurements of over 50 dB to be made.

Measurements of residual noise, signal to noise ratio and frequency response can be made with 2305 and an option provides for measurement of distortion (at 300 Hz, 500 Hz and 1 kHz) and also includes psophometric weighting filters for weighted noise and distortion measurements.

### Non-volatile memory
Information on up to 10 settings may be stored in the instrument for later use and the provision of a non-volatile semiconductor memory allows the data to be stored even after switch off without relying on a battery. Recalling a complete setting from the memory only requires a simple keyboard action.

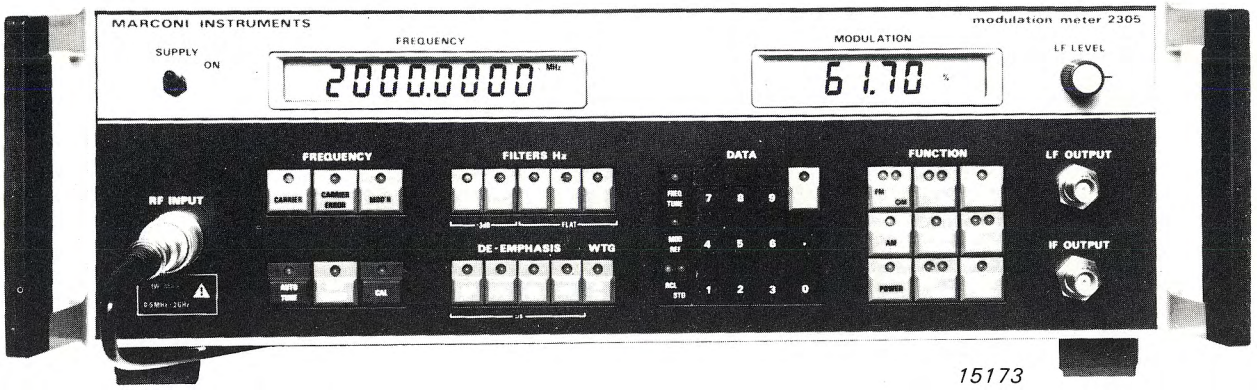
### Programmability
2305 can be simply fitted with the optional GPIB interface so that all functions can be controlled over the bus. Simple commands set up the required measurement conditions and the unit will then send results to the GPIB controller when requested.

### Maintainability
The use of liquid crystal displays reduces power consumption and as a result a cooling fan is not needed, thereby reducing routine maintenance and improving reliability. Self-diagnostic facilities are incorporated within 2305 which, with the aid of other diagnostic features, simplify the localising of faults. Access to the unit is very straightforward and all circuit boards are interconnected by plugs and sockets for ease of removal or replacement. Normal calibration is carried out automatically by the internal calibrator and no adjustable calibration controls are fitted inside the instrument.



*Interior view of 2305* *15173/4*

# 2305




## GENERAL DESCRIPTION

The 2305 is an automatic tuning modulation meter covering the frequency range 500 kHz to 2 GHz, with a basic accuracy of ± 0·5%.

## RF INPUT

**Carrier frequency range** 500 kHz to 2 GHz.

**Automatic tuning** Selecting 'Auto Tune' causes the instrument to tune automatically to the strongest signal in the carrier frequency range. Acquisition time is typically 500 ms.

**Frequency indication** 8 digit LCD – see under FREQUENCY DISPLAY.

**Manual tuning** By front panel keyboard or GPIB entry.

**Sensitivity** –25 dBm (13 mV) from 0·5 MHz to 1 GHz. –18 dBm (28 mV) from 1 GHz to 2 GHz.

**Maximum input** +30 dBm (1 W or 7 V r.m.s. into 50 Ω) from 500 kHz to 2 GHz.

**Overload protection** Automatic trip provides protection against overloads up to 25 W.

**Input connector** Type N female.

**Input impedance** 50 Ω nominal.

## FREQUENCY MODULATION

**Maximum deviation** 500 kHz peak deviation at modulation rates of 30 Hz to 275 kHz at carrier frequencies above 5·5 MHz.
50 kHz peak deviation at modulation rates of 30 Hz to 15 kHz up to 5·5 MHz.

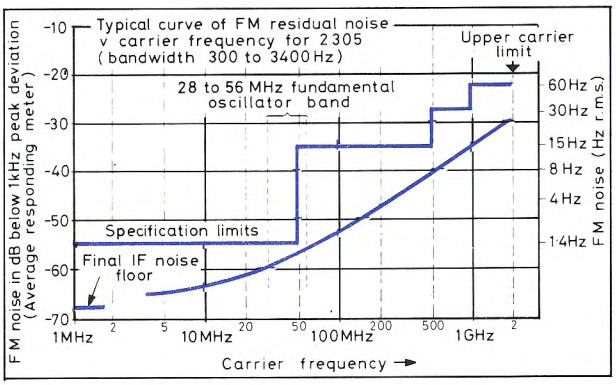
**Range selection** Ranges automatically selected for best resolution.

**Display** 4 digit LCD – see under MODULATION DISPLAY.

**Accuracy** After calibration using internal calibrator, ±0·5% of reading ±1 digit at 1 kHz modulation rate with the 50 Hz to 15 kHz filter selected.
Frequency response relative to 1 kHz modulation rate with the 10 Hz to 300 kHz filter selected:–
±0·5% of reading for modulation rates from 20 Hz to 20 kHz;
+0·5% –1% of reading for modulation rates from 20 Hz to 50 kHz;
+0·5% –5% of reading for modulation rates from 20 Hz to 275 kHz.
Note: Where necessary, allowance must be made for peak residual noise which will contribute to peak readings.

**AM rejection** Typically 40 Hz peak deviation for 50% a.m. at 1 kHz modulation rate with the 300 Hz to 3·4 kHz filter selected.

**Residual f.m. noise**




Notes:

1. Noise in 50 Hz to 15 kHz band is typically 6 dB higher.
2. Noise in CCITT psophometric weighting filter is typically 3 dB lower.

## PHASE MODULATION

**Carrier frequency range** 5·5 MHz to 2 GHz, usable down to 500 kHz.

**Maximum deviation** 500 radians for modulating frequencies up to 1 kHz.
(500/f) radians for modulating frequencies above 1 kHz, where f is the modulating frequency in kHz.

**Range selection** Ranges automatically selected for best resolution.

**Display** 4 digit LCD – see under MODULATION DISPLAY.

**Accuracy** After calibration using internal calibrator, ±2% of reading ±1 digit for 1 kHz modulation rate.
Frequency response relative to 1 kHz modulation rate, ±2% of reading for modulation rates from 300 Hz to 4 kHz. Usable from 50 Hz to 20 kHz.
Note: Where necessary, allowance must be made for peak residual noise which will contribute to peak readings.

**AM rejection** Typically 0·04 radian peak deviation for 50% a.m. at 1 kHz modulation rate.

# Modulation and Deviation Meters
# 2305

## AMPLITUDE MODULATION

**Maximum modulation depth**
99·9%.

**Modulation rates**
30 Hz to 50 kHz for carrier frequencies from 5·5 MHz to 2 GHz.
30 Hz to 15 kHz for carrier frequencies from 0·5 to 5·5 MHz.

**Range selection**
Ranges automatically selected for best resolution.

**Display**
4 digit LCD – see under MODULATION DISPLAY.

**Accuracy**
After calibration using internal calibrator: ±1% of reading ±1 digit at 1 kHz modulation rate for depths up to 95%.
Frequency response relative to 1 kHz: ±1·5% of reading for modulation rates from 30 Hz to 50 kHz.
Notes:
a) These accuracy figures apply with 30 Hz to 50 kHz l.f. filter selected.
b) Where necessary, allowance must be made for peak residual noise which will contribute to peak readings.

**FM rejection**
Less than 0·5% a.m. for 50 kHz peak deviation for carrier frequencies above 5·5 MHz measured with the 50 Hz to 15 kHz filter selected.

**Residual a.m. noise**
Less than 0·02% r.m.s. a.m. measured with the 300 Hz to 3·4 kHz filter selected for input levels above –17 dBm (30 mV).

## POWER MEASUREMENT

**Range**
10 mW to 1 W (+10 to +30 dBm).

**Accuracy**
±1 dB at 800 MHz.

**Frequency response**
±1 dB from 500 kHz to 1·5 GHz usable to 2 GHz.

**VSWR**
Better than 2:1 from 500 kHz to 1·5 GHz.

## FREQUENCY DISPLAY

Front panel keys select display of the following on an 8 digit LCD:
Carrier frequency;
Carrier error – the difference between carrier frequency received and carrier frequency set from the front panel or by GPIB control;
Modulation rate.

**Carrier frequency mode**
Range: 0·5 MHz to 2 GHz.
Resolution: 10 Hz for carrier frequencies up to 1000 MHz, 100 Hz for carrier frequencies up to 2 GHz.

**Carrier error mode**
Resolution: 10 Hz for all carrier frequencies.

**Modulation rate mode**
Range: 20 Hz to 275 kHz.
Resolution: 0·1 Hz up to 5 kHz and 10 Hz above 5 kHz.

**Accuracy (all modes)**
±1 count ± frequency standard error.

## MODULATION DISPLAY

4 digit LCD indicates results in the following units:
AM – % modulation depth
FM – kHz deviation
PM – Radians deviation
Power – dBm or W, as selected
Relative – dB.

**Detector modes**
The following detector modes may be selected:
Average peak [(pk-pk)/2]
Positive peak
Negative peak
Noise averaging.

**Display modes**
The following display modes may be selected:
Absolute – displays absolute value of modulation.
Relative – displays modulation in dB relative to a reference level entered from the front panel.
Peak hold – holds and displays the peak value of the modulation.

## FILTERS

Five l.f. (post detection) filters may be selected:
10 Hz to 300 kHz
30 Hz to 50 kHz
65 Hz to 250 Hz
} flat within 0·1 dB.
50 Hz to 15 kHz
300 Hz to 3·4 kHz
} nominal 3 dB bandwidth.

## DE-EMPHASIS

Three de-emphasis time constants may be selected: 50 μs, 75 μs and 750 μs. (De-emphasis affects only the l.f. output and relative measurements not the modulation reading.)

## IF OUTPUT

IF output is available at a front panel BNC socket.

**Frequency**
As carrier frequency for inputs up to 1·5 MHz.
250 kHz nominal for inputs from 1·5 to 5·5 MHz.
1·5 MHz nominal for inputs above 5·5 MHz

**Amplitude**
100 mV r.m.s. nominal into 50 Ω load.

**Output impedance**
50 Ω nominal.

## LF OUTPUT

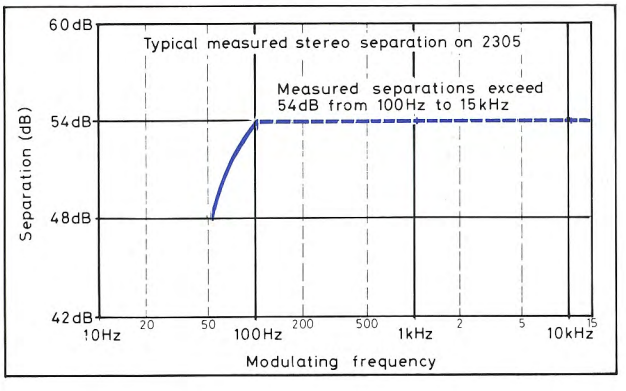
A demodulated, filtered and de-emphasised l.f. output is available at a front panel socket.

**Level**
Front panel control adjusts level from 0 to at least 3 V r.m.s. into 600 Ω for f.m. deviations greater than 300 Hz, a.m. depth greater than 1% or p.m. greater than 0·3 radians (at 1 kHz rate).

**FM distortion**
At modulation rates up to 20 kHz:
Better than 0·1% t.h.d. for deviations up to 100 kHz.
Better than 0·5% t.h.d. for devia ions up to 500 kHz.
At modulation rates up to 100 kHz:
Better than 1% t.h.d. for deviations up to 500 kHz.

**AM distortion**
At a 1 kHz modulation rate:
Better than 0·3% t.h.d. for modulation depths up to 95%.
At modulation rates up to 50 kHz:
Better than 1% t.h.d. for modulation depths up to 95%.

**Stereo separation**
Better than 50 dB at 1 kHz.



# 2305

**FREQUENCY STANDARD**

Internal standard or external input.
Front panel indicator shows when external standard is selected.

**Internal standard**

Frequency: 10 MHz.
Temperature stability: better than ±0·1 p.p.m. over temperature range of 0 to 40°C.
Warm-up time: Within 0·5 p.p.m. of final frequency within 5 min from switch-on at 20°C ambient.

**REAR PANEL INPUTS & OUTPUTS**

**LF output**

Auxiliary l.f. output unaffected by front panel level control is available at a stereo jack socket. Output level is proportional to modulation depth with approximately 5 V peak into greater than 10 kΩ corresponding to full scale on each range.

**External filter**

An external l.f. filter may be connected via a jack socket.

**External local oscillator input**

An external local oscillator may be connected to a BNC socket.
Frequency range: 28 to 56 MHz to cover input signals from 26·5 MHz to 2 GHz.
Input level: 100 mV to 1 V r.m.s.
Input impedance: 50 Ω nominal.

**Internal standard output**

10 MHz internal standard output available at a BNC socket. Output level greater than 100 mV r.m.s. into 50 Ω.

**External standard input**

Accepts a 10 MHz signal of at least 100 mV r.m.s.
Maximum input: 2·5 V r.m.s.
Input impedance: Greater than 1 kΩ.

**SECONDARY FRONT PANEL FACILITIES**

**Store/Recall**

A STORE/RECALL key used with the numeric keypad allows up to 10 instrument settings to be stored in the non-volatile memory for later recall.

**Second functions**

Numerous second functions are available, selected by pressing the blue ENTER key. Four levels of protection are employed to safeguard calibration data against accidental corruption. Full information is given in the handbook.

**GPIB INTERFACE**

A GPIB interface is available either factory fitted or as an accessory for the user to fit (see VERSIONS AND ACCESSORIES for ordering information). All controls except the supply switch and LF OUTPUT LEVEL are remotely programmable.

**Capabilities**

Complies with the following subsets as defined in IEEE 488-1978, IEC 625-1 1979 and BS6146:
SH1, AH1, T6, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT1, C0, and E1.

**DISTORTION/ WEIGHTING FILTER OPTION**

A distortion and SINAD measuring facility (with weighting filters) is available either as a factory fitted option or an accessory for the user to fit (see VERSIONS AND ACCESSORIES for ordering information).

**Distortion/SINAD**

Measurement frequencies: 300 Hz, 500 Hz and 1 kHz (all ±5%).
Fundamental rejection: Greater than 65 dB.
Distortion range: 0·1 to 100%.
SINAD range: 0 to 60 dB.
Accuracy: ±1 dB.

**Weighting filters**

CCITT: Frequency response conforms to CCITT recommendation P53.
CCIR: Frequency response conforms to CCIR recommendation 468-2.

**RADIO FREQUENCY INTERFERENCE**

Conforms to the requirements of EEC directive 76/889.

**SAFETY**

Complies with IEC 348.

**RATED RANGE OF USE**

**Temperature**

0 to 55°C.

**CONDITIONS OF STORAGE AND TRANSPORT**

**Temperature**

–40 to +70°C.

**Humidity**

Up to 90% relative humidity.

**Altitude**

Up to 2500 m (pressurised freight at 27 kPa differential i.e. 3·9 lbf/in$^2$).

**POWER REQUIREMENTS**

**AC supply**

Switchable voltage ranges 105 to 110 V, 115 to 120 V, 210 to 220 V, 230 to 240 V, all ±10%.
45 to 440 Hz.
Approximately 70 VA maximum.

**DIMENSIONS AND WEIGHT** (over projections but excluding handles)

| Height | Width | Depth | Weight |
|---|---|---|---|
| 152 mm | 425 mm | 535 mm | 13·5 kg |
| 6 in | 16·7 in | 21 in | 29·7 kg |

## VERSIONS AND ACCESSORIES

*When ordering please quote eight digit code numbers.*

| Ordering Numbers | Versions |
|---|---|
| 52305-900K | Modulation Meter 2305. |
| | **Supplied Accessories** |
| | AC Supply Lead 43123-076Y. |
| | Operating Manual 46881-431P (H52305-900K Vol. 1). |
| | Stereo Jack Plug 23421-620H. |
| | **Optional Accessories** |
| 54433-001U | GPIB Module. |
| 43129-189U | GPIB Lead Assembly. |
| 46883-527G | Distortion/Weighting Filter Kit. |
| 54711-034U | Maintenance Kit. |
| 46883-511R | Front Handle Kit. |
| 46883-506M | Rack Mounting Kit. |
| 54311-092P | Adaptor, Type N male to BNC female. |
| 43126-012S | RF Connecting Cable (TM4969/3) 50 Ω, 1·5 m, BNC. |
| 43126-026A | RF Connecting Cable 50 Ω, 457 mm, N type. |
| 46881-432X | Service Manual H52305-900K Vol. 2. |
| 54452-011E | Signal Sniffer. |
| 54431-021B | 20 W, 50 Ω, 20 dB Attenuator. |
| 54422-011A | 12 W, 50 Ω Termination. |

marconi instruments

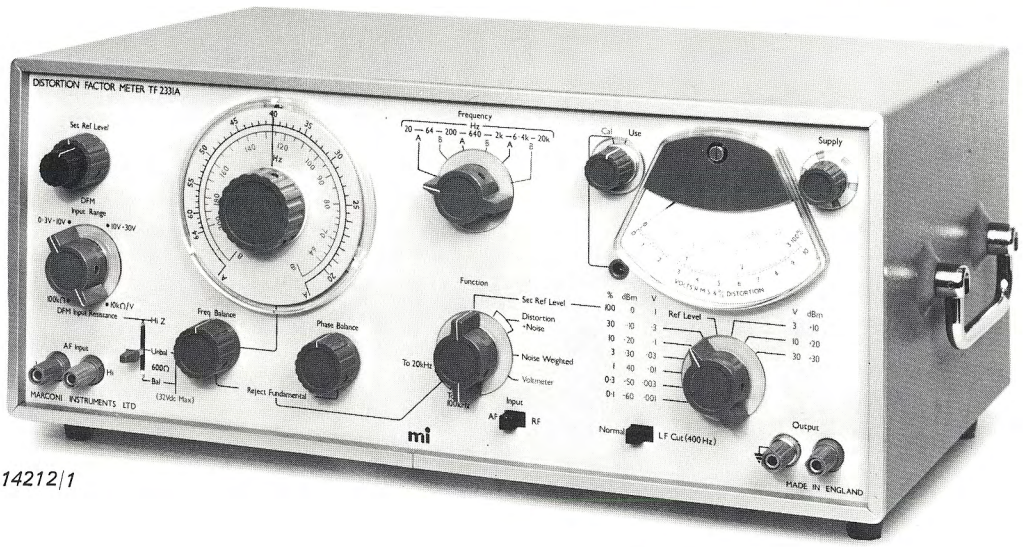
# Analysers


| | | |
|---|---|---|
| Distortion Factor Meter | TF 2331A | 94 |
| Automatic Distortion Meter | TF 2337A | 96 |
| 110 MHz Spectrum Analyser | TF 2370 | 98 |
| 200 MHz Spectrum Analyser | TF 2371 | 106 |
| Frequency Extender (for use with TF 2370) | TK 2373 | 103 |
| Zero Loss Probe (for use with TF 2370 and TF 2371) | TK 2374 series | 105 |

*For further Analysers see the Microwave Products Section:*

Automatic Amplitude Analyser 6500 238

# Distortion Factor Meter TF 2331A




14212/1

- ☐ **Fundamental range: 20 Hz to 20 kHz**
- ☐ **Input frequencies up to 100 kHz**
- ☐ **Distortion and noise from less than 0·05%**
- ☐ **Built-in r.f. demodulation**
- ☐ **Balanced and unbalanced inputs**

Distortion Factor Meter TF 2331A measures the total noise and distortion content of audio signals with fundamental frequencies in the range 20 Hz to 20 kHz. The measurement is made by the conventional method of suppressing the fundamental component, with a fundamental rejection ratio of at least 80 dB, and then comparing the amplitude of the residue with that of the overall signal. A panel meter indicates the distortion factor both in per cent and in decibels; and provision is made for standardising the sensitivity of the instrument so that the amplitudes are indicated directly in absolute terms; i.e., volts or dBm. The indicating system can also be switched directly to the input terminals and used independently of the filtering circuits so that the instrument functions as an electronic voltmeter with 1 MΩ input impedance over the frequency range 20 Hz to 100 kHz. The overall bandwidth of the TF 2331A extends from 20 Hz to 100 kHz; and, for normal operation, the indicated impurity includes all the noise and distortion components within this band. Provision is made, however, for switching into circuit a low pass filter to restrict the upper limit of the noise and distortion measurement band to 20 kHz, thus eliminating frequency components which are beyond the audio range. There is also the facility for introducing an l.f. cut filter for the suppression of hum components that may produce misleading results. This filter reduces 100 Hz components by more than 20 dB, but has negligible attenuation for frequencies above 400 Hz.

With these band limiting filters, the TF 2331A is very suitable for signal-to-noise ratio measurements on amplifiers and receivers. And, to increase its usefulness in this application, a psophometric weighting network is incorporated having a frequency response following the characteristic specified in CCIR Recommendation 468 for broadcast use. The instrument compensates automatically for the loss introduced when this filter is switched in.

For convenience when checking distortion of modulation envelopes the TF 2331A is fitted with a linear r.f. detector, which may be switched into circuit.

The minimum noise level that can be measured is −72 dBm. For distortion measurement, however, the low limit is determined by the amount of distortion introduced by the instrument itself. With fundamental frequencies between 200 Hz and 6 kHz, this is less than 0·025%, and outside the range it may rise to 0·04%. The output from the final amplifier of the instrument is available from a pair of terminals on the front panel, the output level being 150 mV from a source impedance of 1 kΩ. This facilitates the connection of an oscilloscope, for viewing the waveform of the signal or the impurity, or a true r.m.s. meter.

A three position switch selects input impedance of either 600 Ω (balanced or unbalanced) for termination

# TF 2331A

purposes, or a high impedance of 10 kΩ/V or 100 kΩ depending upon the voltage range.

Being easily portable, the TF 2331A is well suited for field use; and although normally powered by a.c. mains, it can be operated from an external battery if desired.

An h.f. screened version is available designed to work in environments with high r.f. fields in the m.f. and h.f. bands. It is particularly suitable for use in transmitter halls.

| | |
|---|---|
| **FUNDAMENTAL FREQUENCY** | |
| Range | 20 Hz to 20 kHz in 6 ranges of 3·16:1 ratio. |
| Accuracy | ±3%. |
| **DISTORTION MEASUREMENT** | |
| Range | Seven ranges in 1-3-10 sequence with full scale indications from 0·1% to 100%. |
| Bandwidth (−3 dB) | Nominally 100 kHz or 20 kHz, switch selected. |
| Instrument distortion | *Unbalanced:*<br>Less than 0·025% from 200 Hz to 6 kHz.<br>Less than 0·04% from 20 Hz to 200 Hz and from 6 kHz to 20 kHz.<br>*Balanced:*<br>Less than 0·025% from 200 Hz to 6 kHz.<br>Less than 0·04% from 100 Hz to 200 Hz and from 6 kHz to 20 kHz.<br>Less than 0·1% from 50 Hz to 100 Hz for inputs up to 10 V.<br>Less than 0·15% from 20 Hz to 50 Hz for inputs up to 3 V. |
| Fundamental rejection | At least 80 dB. |
| 2nd harmonic attenuation | Less than:<br>0·5 dB for fundamentals up to 1 kHz.<br>1 dB for fundamentals up to 6 kHz.<br>2 dB for fundamentals up to 20 kHz. |
| Residual component measurement accuracy (after filtering) | ±2% of full scale ±1% of reading from 50 Hz to 12 kHz.<br>±2% of full scale ±2% of reading from 20 Hz to 100 kHz. |
| LF cut | Can be introduced below 400 Hz to reduce hum components. |
| Input sensitivity 600 Ω and HiZ | 300 mV (less than −8 dBm into 600 Ω) to approximately 30 V (+32 dBm into 600 Ω). |
| Input resistance | 600 Ω: balanced and unbalanced.<br>*Return loss:* better than 25 dB at 1 kHz.<br>*Balance:* better than 50 dB rejection at 1 kHz.<br>HiZ: Nominally 10 kΩ/V up to 10 V input.<br>Nominally 100 kΩ from 10 V to 30 V input. |
| **NOISE MEASUREMENT (Made with tone off)** | |
| Indication | Mean value of noise relative to signal is indicated in 7 ranges in 1-3-10 sequence with full scale indications from 0·1% to 100%.<br>Range of signal to noise ratio measurements is at least 0 to 72 dB. |
| Instrument noise | Less than 0·02% (200 μV) typically 50 μV. |
| Bandwidth | 100 kHz or 20 kHz or via programme weighted network. |
| Programme weighted noise filter | Weighted to CCIR Recommendation 468 (Geneva 1974). |
| **VOLTAGE MEASUREMENT** | |
| Indication | Mean-level meter calibrated in volts r.m.s. (sinewave) and in decibels. |
| Ranges | Ten voltage ranges in 1-3-10 sequence from 1 mV to 30 V full scale.<br>Decibel scale calibrated from −12 to +2 dB relative to 1 mW in 600 Ω. |
| Voltage accuracy (Above 100 μV) | *Unbalanced:* ±2% of full scale ±1% of reading from 50 Hz to 55 kHz.<br>±2% of full scale ±2% of reading from 20 Hz to 100 kHz.<br>*Balanced:* ±2% of full scale ±1% of reading from 50 Hz to 55 kHz.<br>±8% of full scale ±2% of reading from 20 Hz to 100 kHz. |
| Input resistance | *Unbalanced:* 1 MΩ or 600 Ω.<br>*Balanced:* 600 Ω.<br>*Return loss:* better than 30 dB at 1 kHz.<br>*Balance:* better than 50 dB at 1 kHz. |
| **RF INPUT** | |
| Frequency range | 500 kHz to 500 MHz. |
| Input impedance | 50 Ω, type N connector. |
| Amplitude range | 1 V to 4 V at maximum modulation depth. |
| **AF OUTPUT** | 150 mV from a 1 kΩ source with meter reading at full scale. |
| **RADIO FREQUENCY INTERFERENCE** | Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference. |
| **SAFETY** | Complies with IEC 348. |
| **LIMIT RANGE OF OPERATION** | |
| Temperature | 0 to 55°C. |
| **CONDITIONS OF STORAGE AND TRANSPORT** | |
| Temperature | −40°C to +70°C. |
| Humidity | Up to 90% relative humidity. |
| Altitude | Up to 2500 m (pressurized freight at 27 kPa differential, i.e. 3·9 lbf/in²). |
| **POWER REQUIREMENTS** | |
| AC supply | 95 to 130 V and 190 to 260 V. 40 Hz to 500 Hz, 3 VA. |
| External battery | 18 to 45 V d.c., 25 mA. |
| **DIMENSIONS AND WEIGHT** | |

| Height | Width | Depth | Weight |
|---|---|---|---|
| 200 mm | 440 mm | 280 mm | 9·7 kg |
| 8 in | 17¼ in | 11 in | 22 lb |

## VERSIONS AND ACCESSORIES

*When ordering please quote eight digit code numbers.*

| Ordering numbers | |
|---|---|
| | **Versions** |
| **52331–910T** | TF 2331A. Standard version. |
| **52331–309N** | TF 2331AM. HF Screened version. |
| | **Supplied Accessories** |
| | AC Supply Lead 43129–071D<br>Instruction Manual 46881–247G. |
| | **Optional Accessories** |
| **41635–041P** | Rack Mounting Kit TM 7010. |
| **44827–522R** | Telephone Weighting Network. To CCITT Recommendation P53 section A (Geneva 1972). |
| **43168–008S** | Shrouded Adapter TB 39868 to adapt terminals to BNC connection. |

# Automatic Distortion Meter TF 2337A




14151/2

- ☐ **Indicates distortion factor and signal level simultaneously**
- ☐ **Measures distortion down to 0·01% at signal level down to 100 mV**
- ☐ **Rapid measurement of SINAD ratios**
- ☐ **All push-button controls**
- ☐ **No level-calibration or filter-tuning adjustments**
- ☐ **Unaffected by signal frequency variation up to ±5%**

Automatic Distortion Meter TF 2337A enables extremely rapid measurements to be made of both level and distortion factor of audio frequency test signals. Its novel design eliminates the need for setting a reference level and for the usual precise tuning of a fundamental rejection filter. The only controls are push-button switches for selection of input voltage range, distortion range and fundamental frequency.

Once the appropriate ranges have been selected any number of similar distortion and level measurements can be made without further adjustment to the instrument. TF 2337A is thus highly suitable for repetitive measurements, as may occur in factory testing of a.f. amplifiers, oscillators, tape recorders etc.

Internal noise is very low owing to the use of field-effect transistors in the input stages, so that distortion down to 0·01% can be measured with an input signal of 100 mV.

### The measuring system

The instrument measures distortion factor in the conventional way; i.e. by filtering out the fundamental component and comparing the amplitude of the residue with that of the total signal.

Distortion measurements can be made with test signal frequencies of 400 Hz and 1000 Hz using the rejection filters built into the instrument, filter selection being effected by pressing the appropriate push button in the FUNCTION bank. Rejection filters for other frequencies in the range 20 Hz to 2 kHz are available as optional accessories which may be fitted by the customer in place of the standard filters.

### Simultaneous distortion and level measurement

With a test signal frequency appropriate to the selected internal filter the instrument measures distortion factor from 0·01% to 30% at any level of input signal between 100 mV and 100 volts.

Six distortion ranges are provided with full-scale indications ascending in half-decade steps giving clear, open, easy-to-read meter scales. The meter is calibrated both in per cent distortion and in decibels, the distortion factor in decibels being given by the sum of the meter reading and the dB figure associated with the DISTORTION RANGE push button.

# TF 2337A

The instrument has six push-button selected level measurement ranges, with full-scale indications ascending in half-decade steps from 300 mV to 100 volts. In addition to its voltage scale the LEVEL meter also carries a decibel scale which is used in connection with a dB figure above the LEVEL RANGE push button to give the level in decibels relative to 1 volt.

## Wide band level measurement

For measurement of signal amplitude or amplifier response over the audio frequency band, the level measuring facility can be utilised independently of the distortion measuring system, which can be rendered inoperative by pressing the LEVEL button located in the FUNCTION bank. The instrument can then be used for measurement of signal level from 30 mV to 100 volts at any frequency within the range 20 Hz to 20 kHz.

## SINAD measurements

TF 2337A is particularly suitable for rapid production measurements of SINAD ratio (the ratio of signal + noise + distortion to noise + distortion) on mobile radio receivers. The internal 1 kHz band stop filter is used and the SINAD ratio is indicated directly in dB.

| | |
|---|---|
| **FUNDAMENTAL FREQUENCIES** | 400 Hz ± 5%<br>1 kHz ± 5%<br>(Optional frequencies available on application.) |
| **BANDWIDTH** | |
| (Upper – 3dB point) | |
| Level measurement | Nominally 20 kHz. |
| Distortion measurement | Nominally 10 kHz. |
| **INPUT IMPEDANCE** | 100 kΩ ± 10% unbalanced in parallel with less than 50 pF. |
| **DISTORTION MEASUREMENT** | |
| Range | 0·01 to 30·0% in six ranges:<br>0·01 to 0·1%<br>0·03 to 0·3%<br>0·1 to 1·0%<br>0·3 to 3·0%<br>1 to 10%<br>3 to 30%. |
| Measurement accuracy | ± 2% of reading ± 3% of f.s.d. for each range. |
| Minimum input level | 0·1 V r.m.s. |
| Maximum input level | 100 V r.m.s. |
| **FILTER CHARACTERISTICS** | |
| Fundamental rejection | At least 83 dB, within ± 3% of centre frequency.<br>At least 66 dB, within ± 5% of centre frequency. |
| Harmonic frequency response | 400 Hz filter: 760 Hz to 10 kHz within 0·6 dB.<br>1 kHz filter: 1·9 kHz to 10 kHz within 0·6 dB. |
| **LEVEL MEASUREMENT** | |
| Range | 0·03 to 100 V r.m.s. in six ranges:<br>0·03 to 0·3 V r.m.s.<br>0·1 to 1·0 V r.m.s.<br>0·3 to 3·0 V r.m.s.<br>1·0 to 10·0 V r.m.s.<br>3 to 30 V r.m.s.<br>10 to 100 V r.m.s. |
| Accuracy | ± 3% of f.s.d. of each range. |
| Frequency response | Flat to within 1 dB from 20 Hz to 20 kHz. |

| | |
|---|---|
| **RADIO FREQUENCY INTERFERENCE** | Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference. |
| **SAFETY** | Complies with IEC 348. |
| **LIMIT RANGE OF OPERATION** | |
| Temperature | 0 to 55°C. |
| **CONDITIONS OF STORAGE AND TRANSPORT** | |
| Temperature | – 40°C to + 70°C. |
| Humidity | Up to 90% relative humidity. |
| Altitude | Up to 2500 m (pressurized freight at 27 kPa differential, i.e. 3·9 lbf/in$^2$). |
| **POWER REQUIREMENTS** | |
| AC supply | 95 to 125 V and 190 to 250 V, 50 to 60 Hz, 6 VA. |

| **DIMENSIONS AND WEIGHT** | Height | Width | Depth | Weight |
|---|---|---|---|---|
| | 210 mm<br>8·2 in. | 285 mm<br>11·2 in. | 270 mm<br>10·6 in. | 6 kg<br>12 lb. |

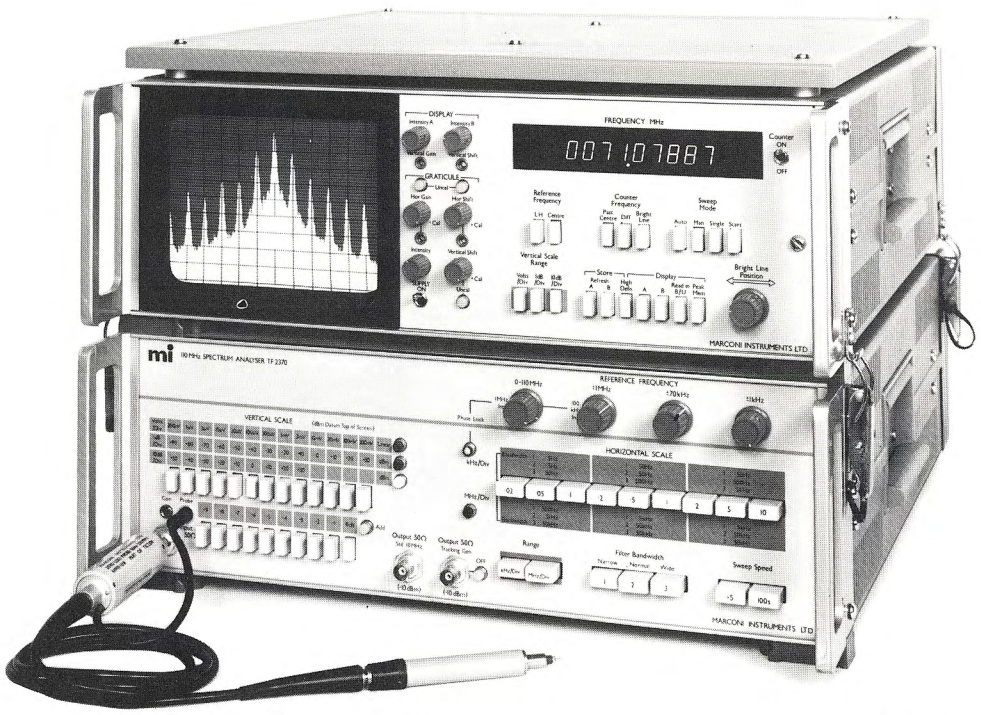
### VERSIONS AND ACCESSORIES

***When ordering please quote eight digit code numbers***

| Ordering Numbers | |
|---|---|
| 52337 – 910N | **Versions**<br>Automatic Distortion Meter TF 2337A. |
| | **Supplied Accessories**<br>AC Supply Lead.<br>Instruction Manual. |
| | **Optional Accessories**<br>Filters at frequencies other than the standard 400 Hz and 1000 Hz are available in the range 20 Hz to 2 kHz. |

Made in Japan

# 110 MHz
# Spectrum Analyser TF 2370 series




*TF 2370 with Zero Loss Probe TK 2374* *14888/3*

- ☐ **100 dB displayed dynamic range**
- ☐ **0·1 dB and 5 Hz resolution**
- ☐ **30 Hz to 110 MHz frequency range**
- ☐ **Frequency measurement to 1 Hz resolution**
- ☐ **Phase lock tuning**
- ☐ **Digital storage of spectral information**
- ☐ **Split store mode gives dual display**
- ☐ **Built-in tracking generator**
- ☐ **1·25 GHz range with optional frequency extender**

TF 2370 is a comprehensive Spectrum Analyser covering the frequency range 30 Hz to 110 MHz. Outstanding features of this unique instrument include 100 dB displayed dynamic range, resolution of 0·1 dB and 5 Hz, and a very advanced data presentation system employing electronic storage.

Thus the TF 2370 has important advantages over all previous spectrum analysers for measurements of communications signals including broadcast, f.d.m., p.c.m., s.s.b. and f.s.k.

Swept selective measurements for the frequency response characterisation of active and passive networks over wide dynamic ranges are made possible by the inclusion of a tracking generator. A dual display mode and the 9-digit frequency counter together enhance the precision measurement capability.

Simplicity of operation is achieved by a logic programme which automatically selects the best r.f./i.f. gain ratio, sweep rate and filter bandwidth, eliminating the possibility of measurement error resulting from incorrect setting of the controls.

The standard model of TF 2370 has input and output impedances of 50 Ω. An alternative version, TF 2370/1, is available for 75 Ω use. In this model the RF input, Tracking Generator output and Calibrator output are all at 75 Ω impedance. TF 2370/1 is particularly suitable for measurements on i.f.s and basebands of f.d.m. systems where the normal impedance is 75 Ω.

## Data Store and Display

The detected output from the receiver section of the analyser is converted to digital form giving a 256 level by 512 ordinate representation which is stored in a m.o.s.f.e.t. recirculatory digital store. The stored information is continuously scanned and displayed on a bright 130 × 100 mm television camera monitor tube as a brightness modulated picture on a vertically scanned raster.

Superimposed on this display is an electronically produced graticule which may be shifted vertically or horizontally and scaled horizontally against the internal counter to give an exact frequency calibration.

A bright line cursor coupled to the counter can also be superimposed on the display after any single sweep recording and it can be positioned to enable the frequency of any point on the screen to be measured. In the MANUAL mode this electronic cursor becomes an edit pointer indicating the manual tune position and enabling the display to be selectively updated around points of interest and the frequency to be measured to a resolution of 1 Hz.

A split-store mode permits the store to be used in two halves, each of 256 ordinates, to superimpose two recorded displays with the facility for updating one store while retaining the other for comparison purposes. One image can be dimmed relative to the other for easy identification.

## Frequency Measurement

The 9-digit electronic counter gives readout in MHz with automatic positioning of the decimal point. Three modes of operation are available: in the PAST CENTRE mode the centre frequency is measured and displayed each time the data is renewed. In the BRIGHT LINE mode the counter displays the frequency corresponding to the position of the bright line, and in the DIFF mode the counter displays the difference between these two values. This is useful, for example, in measuring sideband frequencies relative to a carrier.

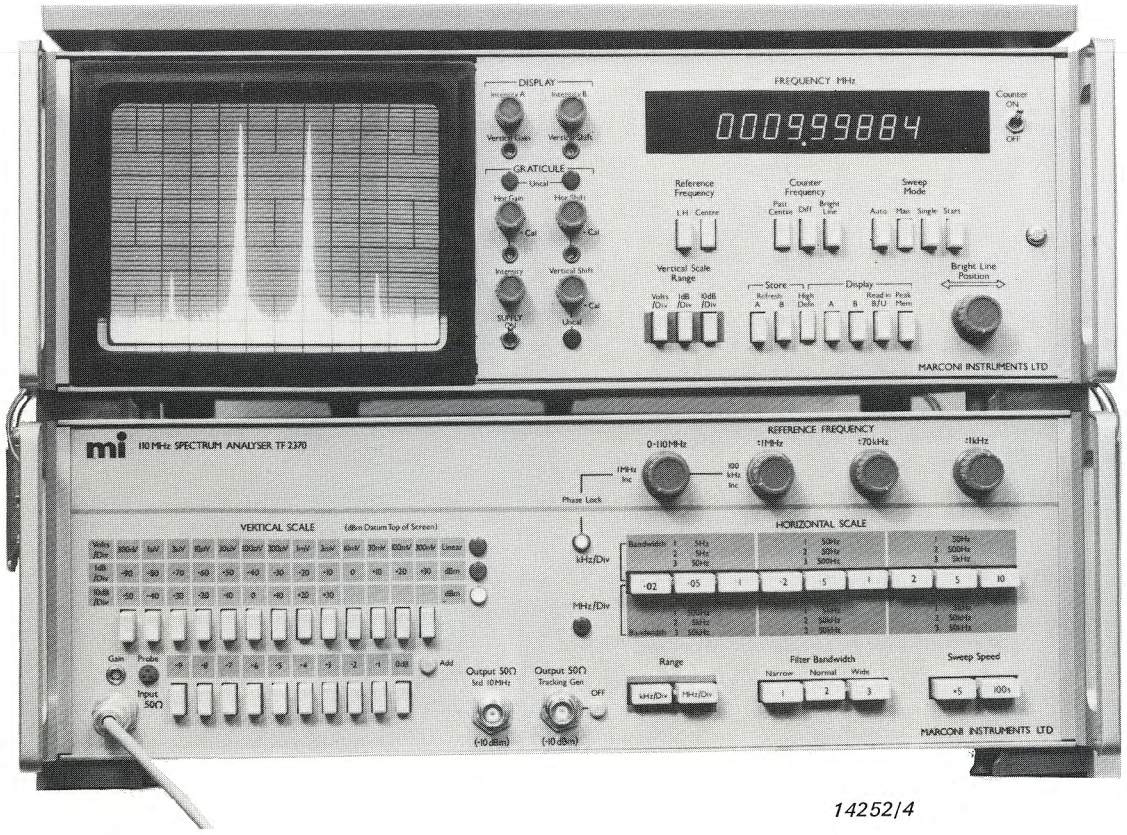
## X-Y Output

X, Y and pen-lift outputs suitable for driving most pen recorders are available at a socket on the rear panel of the display unit.

## Optional Accessories and Associated Equipment

A number of optional accessories are available to increase the usefulness of TF 2370. Among these are two Zero Loss Probes TK 2374 series which provide a high input impedance for the Spectrum Analyser. A camera hood is also available for mounting a camera for photographic recording of the display.

An associated unit, Frequency Extender TK 2373, can be used to extend the frequency range of TF 2370 and TF 2370/1 up to 1·25 GHz, with sweep widths up to the full 50 MHz to 1·25 GHz range of TK 2373. A 200 MHz Spectrum Analyser TF 2371 series is also available.




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# TF 2370 series

## FREQUENCY MEASUREMENT

**Range** 30 Hz to 110 MHz.

**Tuning** Four REFERENCE FREQUENCY controls provide frequency cover of 0 to 110 MHz, ±1 MHz. ±70 kHz and ±1 kHz respectively.

**Reference** The reference frequency for scan width expansion can be selected by front panel push-button to be either the centre or the left hand side of the display.

**Frequency reading** By calibrated electronic graticule and 9-digit electronic counter. The counter resolution is automatically switched to suit the combination of filter/scan width selected.

**Resolution** 1 Hz using the MANUAL MODE, 5 Hz filter and 200 Hz scan width.

## AMPLITUDE MEASUREMENT

There are two logarithmic and one linear vertical scales.

**Vertical scale range** +30 to −159 dBm using 10 dB/div scale.
+30 to −109 dBm using 1 dB/div scale.
(1 div = approx. 1 cm).

**Vertical scale display** *Log:* 10 dB/div for a 100 dB full screen display.
1 dB/div for a 10 dB full screen display.
*Linear:* 300 mV/div to 300 nV/div in a 1, 3, 10 sequence on a 10 division display.

**Vertical scale range accuracy** *10 dB steps:* ±0·3 dB/10 dB; cumulative error less than ±1·5 dB.
*1 dB steps:* ±0·1 dB/1 dB; cumulative error less than ±0·3 dB.

**Vertical scale display accuracy** *Log:* 10 dB/div ±1 dB (0 to −80 dB)
±1·5 dB (−80 to −100 dB)
1 dB/div ±0·1 dB.
Quantization error ±0·25% of full scale for 5 Hz to 5 kHz filter bandwidths.
*Volts/div linearity:* ±1·5% of full-scale range.

**Frequency response (relative to 10 MHz level)** ±1 dB from 100 Hz to 110 MHz
−3 dB at less than 30 Hz.

**Bandwidth/scan width switching accuracy** Maximum error when switching between bandwidths and Hz/div settings (15 to 25°C):
*Log:* ±1 dB ±1% f.s.d.
*Linear:* ±10%.

**Overall accuracy** Accuracy when set against internal calibrator ±0·3 dB at 10 MHz.

**Amplitude stability** ±0·1 dB per °C.

**Maximum input level** +25 dBm continuous (4 V r.m.s. for TF 2370, 4·7 V r.m.s. for TF 2370/1).
+30 dBm for five minutes (7·1 r.m.s. for TF 2370, 8·6 V r.m.s. for TF 2370/1).

**Input impedance** TF 2370: 50 Ω.
TF 2370/1: 75 Ω.
(BNC socket).

**Input v.s.w.r.** Less than 1·2:1.

## SWEEP AND FILTER CHARACTERISTICS

**Sweep modes** AUTO: Analyser sweep free runs.
MANUAL: Tuning point indicated by position of electronic BRIGHT LINE cursor. In this mode the instrument may be used as a selective level measuring set, 1·5 Hz bandwidth video filter for noise averaging being automatically selected.
SINGLE: A single sweep may be initiated by the START control.
START: Initiates a new sweep on either AUTO or SINGLE.

**Frequency scan width (dispersion)** 200 Hz to 100 MHz, 18 calibrated ranges 10 MHz/div to 20 Hz/div in a 1, 2, 5 sequence and in two bands. kHz/div and MHz/div. In the kHz/div position the 0 to 110 MHz and ±1 MHz REFERENCE FREQUENCY controls are phase locked in frequency increments of 1 MHz and 100 kHz respectively.

**Scan width accuracy** ±10% of full-scale ±20 Hz against electronic graticule. May be set to within ±1% ±20 Hz using internal counter.

**Sweep speed** Automatically selected to match the dispersion and filter bandwidth chosen. 100 ms to 100 seconds in 1, 2, 5 sequence.
×5 speed up over the optimum is available by press button operation.
A fixed 100 s sweep can be selected for use with an X-Y recorder.

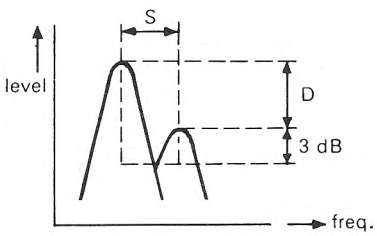
**Filter bandwidth** 5 Hz, 50 Hz, 500 Hz, 5 kHz and 50 kHz at the −3 dB point. Up to three (NARROW, NORMAL and WIDE) are automatically selected from the above five to match the selected dispersion.

**Bandwidth accuracy** ±20% of stated 3 dB bandwidth.

**Bandwidth selectivity** Better than 10:1 from 60 dB to 3 dB.

**Resolution** Using the 5 Hz filter, signals 100 Hz away from a response at 0 dB can be measured to −70 dB.

**Skirt resolution** (The frequency separation of two responses which merge with a 3 dB notch.)




D dB is the level difference and S Hz frequency separation for a 3 dB notch between the signals.
Typical skirt resolution for close-in signals:

| D (dB) | S (Hz) |
|---|---|
| >10 dB | 8 Hz |
| >20 dB | 10 Hz |
| >30 dB | 12 Hz |

**Frequency stability** 100 Hz per 10 min after 2 hours warm up and with the RANGE switch in kHz/div position.

**Temperature drift** 100 Hz per °C with RANGE switch in kHz/div position.

**COUNTER**

The nine digit counter enables frequency measurement to be made on any part of the spectral display.
Modes of operation:
PAST CENTRE: Displays the centre frequency of the last sweep.
BRIGHT LINE: Displays the frequency corresponding to the position of the electronic cursor.
DIFF: Displays the frequency difference between the above two measurements.

**Frequency measurement accuracy**

Using the counter, after 60 minutes warm up and using the internal frequency standard:
AUTO SWEEP: ±20 Hz ±1% of scan width ± counter accuracy.
MANUAL: ±2 Hz ± counter accuracy.
Counter accuracy:
±1 count
$\pm 2 \times 10^{-7}$ (accuracy of setting internal standard)
$\pm 1 \times 10^{-6}$ per year (ageing rate)
$\pm 2 \times 10^{-6}$ (maximum error due to temperature variation).

**DISPLAY**

A digital storage system giving infinite persistence with 100 ms minimum data renewal time provides the following STORE/DISPLAY modes.

HIGH DEFN: Full capacity of electronic store (500 × 200 elements) is used to display the spectrum.

DISPLAY 'A': Half capacity of electronic store (250 × 200 elements) is used to display the spectrum.

DISPLAY 'B': Remaining half capacity of electronic store (250 × 200 elements) is used to display the spectrum.

REFRESH 'A': In this mode, DISPLAY 'A' is continuously refreshed as in HIGH DEFN; DISPLAY 'B' is permanently stored.

REFRESH 'B': In this mode, DISPLAY 'B' is continuously refreshed as in HIGH DEFN; DISPLAY 'A' is permanently stored.

READ IN B/U: Display 'Bright-up' indicates the data renewal point on the display.

PEAK MEMORY: The peak signal level of a spectrum (whose level may be changing) is stored and displayed.

**Display tube** Television camera viewfinder tube with 100 × 130 mm viewing area.

**Intensity 'A'** Controls brightness of the HIGH DEFN and 'A' DISPLAY.

**Intensity 'B'** Controls brightness of the 'B' DISPLAY.

**Vertical gain** This control allows for pre-set adjustment of the display amplitude.

**Vertical shift** This control allows for pre-set adjustment of the vertical display position.

**ELECTRONIC GRATICULE**

Generates nominal 1 cm vertical and horizontal lines sub-divided horizontally to 2 mm.

**Vertical shift** Positions the graticule over greater than 1 major division.

**Horizontal shift** Positions the graticule over greater than 1·5 major divisions.

**Horizontal gain** Expands the graticule. Cover greater than ±15%.

Indicator lamps show when the above controls are being operated in the uncalibrated position.

**Intensity** Controls background brightness of the graticule.

**SPECTRAL PURITY**

**Intermodulation capability (measured on manual sweep)** Better than −70 dB (two tone test) with signals at −40 dBm at input mixer and 500 Hz apart.

**Residual responses**

| | |
|---|---|
| 30 Hz to 20 kHz | less than −90 dBm. |
| 20 kHz to 110 MHz | less than −100 dBm. |

Measured at the input mixer or input socket, whichever is the greater.

**Spurious responses** Better than 70 dB below a single signal at a level of −40 dBm at input mixer.

**Average noise level (between 100 kHz and 110 MHz measured on manual sweep)** Less than −120 dBm with Counter On.
Less than −130 dBm with 50 Hz filter and Counter Off.

**TRACKING GENERATOR**

Enables the transfer characteristics of any network to be measured over a dynamic range of up to 120 dB.

**Frequency** Tracks the input tune frequency within ±2 Hz.

**Amplitude** −10 dBm ±2 dB at 10 MHz.

**Frequency response (relative to 10 MHz level)** ±1 dB from 100 Hz to 100 MHz.
−3 dB at less than 20 Hz and greater than 110 MHz.

**Output impedance** TF 2370: 50 Ω.
TF 2370/1: 75 Ω.
(BNC socket).

**Output v.s.w.r.** Less than 1·2:1.

**CALIBRATOR**

**Frequency** 10 MHz ±20 Hz.

**Amplitude** −10 dBm ±0·3 dB.

**Output impedance** TF 2370: 50 Ω nominal.
TF 2370/1: 75 Ω nominal.
(BNC socket).

# TF 2370 series

| | |
|---|---|
| **EXTERNAL STANDARD INPUT** | Rear BNC socket permits internal 10 MHz standard to be locked to external 1 MHz standard. Green light next to socket glows when adequate signal is applied at the correct frequency to achieve satisfactory lock. |
| Input impedance | Approx. 10 kΩ shunted by 100 pF. |
| Signal level required | 0·25 V to 1·0 V r.m.s. |
| Frequency | 1 MHz. |
| Accuracy required | Better than 1 in $10^7$. |
| **DETECTED OUTPUT** | Rear panel BNC socket provides demodulated output. |
| Output impedance | Approx. 600 Ω. |
| Frequency response | −3 dB at less than 30 Hz to greater than 20 kHz using 50 kHz filter relative to the level at 1 kHz. |
| Maximum output level | 0 dBm ±3 dB into 600 Ω load for 100% a.m. signal. Maximum undistorted output level occurs if the unmodulated carrier is set to the top of the screen on 1 dB/div or 40 dB down from the top of the screen on 10 dB/div. |
| **X-Y RECORDER OUTPUTS** | From 15-way Amphenol socket (type 17–10150), on rear panel of display unit. Enables TF 2370 to be used with X-Y recorder. |
| X output | A ramp of typically 0·8 V/div, 10 V maximum amplitude from source impedance of 1 kΩ. 100 s sweep time. |
| Y output | A detected signal of 0·2 V/div, with typically 2 V corresponding to display at top of screen, from output impedance of 1 kΩ. |
| Pen-lift output | A pair of contacts are closed during the sweep and opened by an internal relay during the flyback period. Enables the pen to be lifted when used with X-Y recorders with automatic pen lift. |
| **PROBE SUPPLY** | Supply available at front panel socket to power Zero Loss Probes TK 2374 and TK 2374/1. |
| **POWER REQUIREMENTS** | |
| AC supply | 200 to 250 V or 100 to 130 V at any frequency between 45 and 440 Hz. *Regulation:* ±10% on the nominal supply voltage. Approximately 130 W (170 VA). |
| **RADIO FREQUENCY INTERFERENCE** | Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference. |
| **SAFETY** | Complies with IEC 348. |
| **LIMIT RANGE OF OPERATION** | |
| Temperature | 0 to 55°C. |
| **CONDITIONS OF STORAGE AND TRANSPORT** | |
| Temperature | −40°C to +70°C. |
| Humidity | Up to 90% relative humidity. |
| Altitude | Up to 2500 m (pressurised freight at 27 kPa differential, i.e. 3·9 lbf/in²). |

**DIMENSIONS AND WEIGHT**

| | Height | Width | Depth | Weight |
|---|---|---|---|---|
| Display unit | 172 mm<br>6¾ in | 440 mm<br>17 5/16 in | 516 mm<br>20 5/16 in | 20 kg<br>44 lb |
| RF unit | 156 mm<br>6⅛ in | 453 mm<br>17 13/16 in | 516 mm<br>20 5/16 in | 19·5 kg<br>43 lb |

## VERSIONS AND ACCESSORIES

*When ordering please quote eight-digit code numbers*

| Ordering numbers | |
|---|---|
| | **Versions** |
| **52370–015F** | TF 2370 Standard version. |
| **52370–901E** | TF 2370/1. Version with 75 Ω input, Tracking Generator output and Calibrator Output, Specification is otherwise as for TF 2370. |
| **52370–301T** | TF 2370, NATO version. Differs from standard model only by accessories supplied. (NATO Cat. No. 6625–99–529–1124). |
| | **Supplied Accessories** |
| | Extender Board 44827–235W, for use when servicing printed boards. |
| | Board Extractor 41700–048A. |
| | Connector Assembly, (umbilical), 170 mm (6·7 in) long, 2-off, 43169–005C. |
| | Protective Cover (2-off) 41690–087N |
| | Fuse Kit 46883–219V comprising: Fuse, quick acting, 250 mA, 23411–004E. Fuse, quick acting, 3·15 A, 23411–008L. Fuse, time-lag, 2·0 A, 23411–060M. Fuse, (2-off) time-lag, 4·0 A, 23411–063B. |
| | Stay Assembly 34900–209W (for use in servicing). |
| | Plug, Amphenol type 17–20150–0, for connection to X-Y recorder output socket. |
| | AC supply lead 43123–076Y. |
| | Operating Manual 46881–241U. |
| | **Optional Accessories** |
| **52374–900C** | Zero Loss Probe TK 2374. |
| **52374–901R** | Zero Loss Probe TK 2374/1. |
| **43281–007C** | RF Fuse Unit TM 9884. |
| **54127–211H** | Rack Mounting Kit. |
| **46883–267B** | Camera Hood. For use with Polaroid CR9 or Shackman Models 77 and 7000 cameras for photographic recording of display. |
| **54112–111K** | Carrying Case. (Two required to carry the two halves of TF 2370). |
| **54431–021B** | 20 W, 20 dB, 50 Ω Attenuator. |
| **43169–010B** | Connector Assembly (umbilical). 762 mm (30 in) long. For use during maintenance to enable TF 2370 to be operated while separated into two halves. (Two required). |
| **43126–012S** | RF Connecting Cable TM 4969/3, 50 Ω BNC, 1520 mm (60 in) long. |
| **54351–011F** | RF Connecting Cable TM 4726/260, 75 Ω BNC, 1830 mm (72 in) long. |
| **54421–001N** | Telescopic Aerial with BNC Plug |
| **46881–240E** | Service Manual. |
| | **Associated Equipment** |
| **52373–900F** | Frequency Extender TK 2373. |

# Frequency Extender TK 2373




14633/5

- **Extends frequency of Spectrum Analyser TF 2370 to 1·25 GHz**
- **All basic features of TF 2370 retained**
- **Range of sweep widths up to full 50 MHz to 1·25 GHz**
- **0 dBm tracking generator output**

TK 2373 is an extender unit which can be used to increase the frequency range of 110 MHz Spectrum Analyser TF 2370 to 1·25 GHz. It provides a range of sweep widths up to the full 50 MHz to 1·25 GHz frequency range, with a resolution defined by TF 2370. All basic features of TF 2370 are retained when it is used with TK 2373.

The Frequency Extender is designed to be mounted beneath TF 2370. The main r.f. input and tracking generator output are on the front panel of TK 2373, and r.f. connections to TF 2370 are also via the front panel. Function selection and control are achieved via rear panel connectors.

The built-in frequency counter in TF 2370 can be switched, by means of push-buttons on TK 2373 front panel, to display the frequency of either TF 2370 or TK 2373.

**FREQUENCY MEASUREMENT**

| | |
|---|---|
| Frequency range | 50 MHz to 1·25 GHz. |
| Sweep range | 50 MHz to 1·25 GHz (full sweep) and 100 MHz/div to 10 MHz/div in a 1, 2, 5 sequence. |
| Sweep speed | Determined by TF 2370. |
| Frequency accuracy | Determined by TF 2370 counter. |
| Resolution | Determined by TF 2370. |
| Band mask | Limits TF 2370 viewing range to typically 45 to 105 MHz. |

**AMPLITUDE MEASUREMENT**

| | |
|---|---|
| Vertical scale range | +30 dBm to −159 dBm at 10 dB/div. +30 dBm to −109 dBm at 1 dB/div. |
| Vertical scale display | As for TF 2370. |
| Vertical scale range accuracy | ±1 dB per 10 dB step. Cumulative error less than ±1·5 dB. |
| Frequency response (relative to 200 MHz level) | For wide sweeps from 10 MHz/div to 100 MHz/div and full sweep: ±1·0 dB with −10 dBm top of screen display (1 dB/div). For narrow sweeps less than 10 MHz/div: ±1·0 dB + TF 2370 specification with −10 dBm top of screen display (1 dB/div). |
| Maximum input level | +30 dBm for five minutes (7·1 V r.m.s.) or +25 dBm continuous (4 V r.m.s.), both with 10 dB or more input attenuation. +20 dBm continuous with no input attenuation. |
| Input impedance | 50 Ω nominal. Type N socket. |
| Input v.s.w.r. | Less than 1·5:1 with at least 10 dB of input attenuation. (Front panel lamp is illuminated when input attenuation is zero.) |

**COUNTER**

| | |
|---|---|
| | The frequency displayed on the TF 2370 counter is either the TF 2370 frequency or the TK 2373 frequency as selected by a front panel switch. |
| Accuracy | As for TF 2370. |

**SPECTRAL PURITY**

| | |
|---|---|
| Intermodulation capability (measured on manual sweep) | Better than −70 dB (two tone test) with signals at −40 dBm to TF 2370 input mixer and 500 Hz apart. |
| Residual responses | From 50 MHz to 1·25 GHz less than −100 dBm measured at the input socket of TF 2370. |

# TK 2373

| | |
|---|---|
| **Spurious responses** | Better than 70 dB below a signal at a level of −40 dBm at the input mixer of TF 2370. |
| **Average noise level (measured on manual sweep)** | Between 50 MHz and 1·25 GHz, less than −105 dBm with counter 'ON' less than −125 dBm with counter 'OFF' and 50 Hz filter selected. |
| **TRACKING GENERATOR** | Enables the transfer characteristic of any network to be measured over a dynamic range of up to at least 90 dB. |
| **Frequency** | 50 MHz to 1·25 GHz within 2 Hz of tuned frequency. |
| **Amplitude** | 0 dBm ±1 dB at 200 MHz (internally levelled). |
| **Frequency response (relative to the 200 MHz level)** | ±1 dB between 50 MHz and 1·25 GHz. |
| **Output impedance** | 50 Ω nominal. Type N socket. |
| **CALIBRATOR** | |
| **Frequency** | 200 MHz ±400 Hz. |
| **Amplitude** | −10 dBm ±0·3 dB. |
| **Output impedance** | 50 Ω nominal. Type N socket. |
| **SAFETY** | Complies with IEC 348. |
| **LIMIT RANGE OF OPERATION** | |
| **Temperature** | 0 to 55°C. |
| **CONDITIONS OF STORAGE AND TRANSPORT** | |
| **Temperature** | −40°C to +70°C. |
| **Humidity** | Up to 90% relative humidity. |
| **Altitude** | Up to 2500 m (pressurized freight at 27 kPa differential, i.e, 3·9 lbf/in²). |

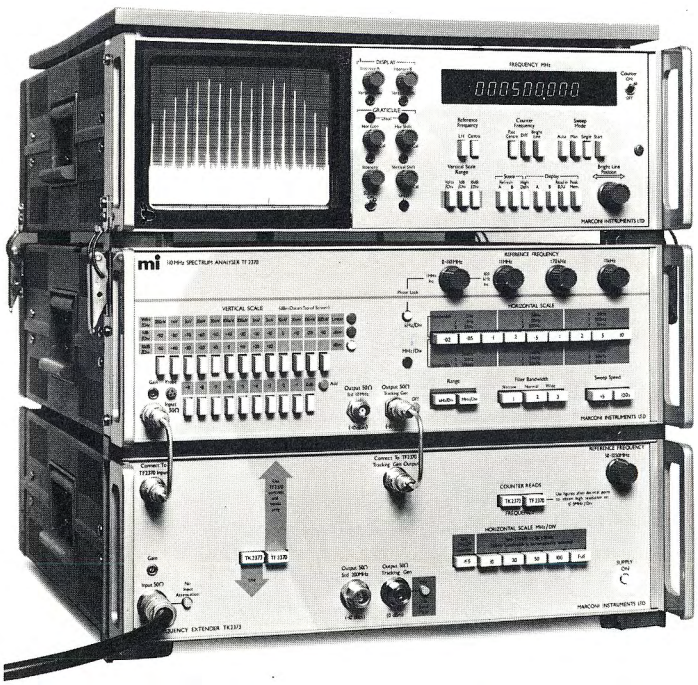
| | |
|---|---|
| **POWER REQUIREMENTS** | |
| **AC supply** | 200 to 250 V or 100 to 130 V at any frequency between 45 and 500 Hz. Approximately 110 VA. When linked to TF 2370, the a.c. supply to TK 2373 is interrupted by use of the TF 2370 supply switch. |
| **DIMENSIONS AND WEIGHT** | |

| Height | Width | Depth | Weight |
|---|---|---|---|
| 156 mm | 453 mm | 516 mm | 19 kg |
| 6·14 in | 17·83 in | 20·31 in | 42 lb |

## VERSIONS AND ACCESSORIES

*When ordering, please quote eight-digit code numbers*

| Ordering numbers | |
|---|---|
| **52373–900F** | **Versions**<br>Frequency Extender TK 2373. |
| | **Supplied Accessories**<br>Front Panel Cover 41690–226Y (with stowage for leads).<br>Connector Assembly (umbilical) 43169–015E.<br>Connector Assembly (umbilical) 43169–016U.<br>Extender Board 44828–323S.<br>Board Extractor 41148–605K.<br>Coaxial Links 43129–306G (two supplied).<br>Spare Fuse Kit 46883–399K.<br>Conversion Kit (two p.c.b.s) 46883–375Z.<br>Supply Lead (provides a.c. power to TF 2370 from TK 2373) 43129–325A.<br>Operating Manual 46881–344Y. |
| **43129–422M**<br>**43129–423C** | **Optional Accessories**<br>Servicing Umbilical (1 pair). |
| **43129–424R** | Servicing Leads, BNC to BNC (2 off). |
| **43129–425B** | Servicing Leads, SMA to SMA (2 off). |
| **44990–311N** | Signal Injector. |
| **46881–345N** | Service Manual. |
| **54127–301P** | Rack Mounting Kit. |



*TK 2373 with Spectrum Analyser TF 2370*

*14633*

# Zero Loss Probe TK 2374 series

- ☐ **Active probe for use with Spectrum Analyser TF 2370 and TF 2371 series**
- ☐ **High input impedance**
- ☐ **Intermodulation performance of spectrum analyser maintained**
- ☐ **Wide range of supplied accessories**

TK 2374 is an active, zero loss probe designed for use with Spectrum Analysers TF 2370 and TF 2371 series to provide a high input impedance, without degradation of the intermodulation performance of the analyser. The high input resistance of the probe, shunted by a relatively low capacitance, ensures that the probe absorbs negligible power from the circuit under test, even at high frequencies. Two versions of the probe are available: TK 2374 for use with the 50 Ω Spectrum Analysers and TK 2374/1 for use with the 75 Ω models.

Thus the probe has many applications where it is required to investigate a 50 Ω or 75 Ω system without loading it. A typical use is the examination of signals in radio transmitters and receivers, in which r.f. and i.f. stages can be analysed and the output from local oscillators and mixers viewed without disturbing the circuit under test. TK 2374 series may also be used in conjunction with the Spectrum Analyser tracking generator for such applications as the measurement of i.f. crystal filters which are designed to operate into a high impedance load.



*Zero Loss Probe Kit* *14882*

Voltage dividers of 10:1 and 100:1 ratio are supplied with the probe so that a wide range of input levels can be accepted. The probe itself can safely withstand four volts peak a.c. input, extended to 80 volts by use of the voltage dividers. Thus the risk of damage to the probe by accidental overload is minimized.

Power to the probe is provided from a d.c. outlet on the Spectrum Analyser front panel, or from an independent supply as required.

TK 2374 is supplied complete with all accessories in an accessory case.

| | |
|---|---|
| **FREQUENCY RESPONSE** | |
| (From 50 Ω or 75 Ω source) | ±0·5 dB from 500 Hz to 110 MHz<br>−3 dB at 50 Hz and 200 MHz. |
| **INSERTION LOSS AT 10 MHz** | 0 dB ±1 dB. |
| **INPUT IMPEDANCE** | |
| Probe alone, Power ON | Nominally 100 kΩ at d.c., shunt capacitance not greater than 5 pF at 10 MHz. |
| Probe alone, Power OFF | Shunt capacitance not greater than 14 pF at 10 MHz. |
| Probe with voltage divider | Nominally 1 MΩ at d.c., shunt capacitance not greater than 2·5 pF at 10 MHz for 100:1 divider; not greater than 3·0 pF at 10 MHz for 10:1 divider. |
| **OUTPUT IMPEDANCE** | TK 2374: suitable for operation at 50 Ω.<br>TK 2374/1: suitable for operation at 75 Ω. |
| **INTERMODULATION CAPABILITY** | Does not degrade the specified performance of Spectrum Analyser provided that the signal level at the probe tip is less than −30 dBm into 50 Ω or 75 Ω. |
| **MAXIMUM SAFE INPUT** | |
| Probe alone | 4 V peak a.c. ±100 V d.c. |
| Probe with voltage dividers | 40 V peak a.c. ±200 V d.c. with 10:1 divider.<br>80 V peak a.c. ±200 V d.c. with 100:1 divider. |

| | |
|---|---|
| **AVERAGE NOISE LEVEL** | From 100 kHz to 110 MHz when used with Spectrum Analyser: less than −105 dBm with 5 kHz filter, manual sweep and counter off. |
| **PROBE SUPPLY** | Available at the spectrum analyser front panel or −7·5 V regulated at 60 mA d.c. |
| **TERMINATIONS** | Signal lead: BNC.<br>Supply lead: Subminiature 3 pin. |

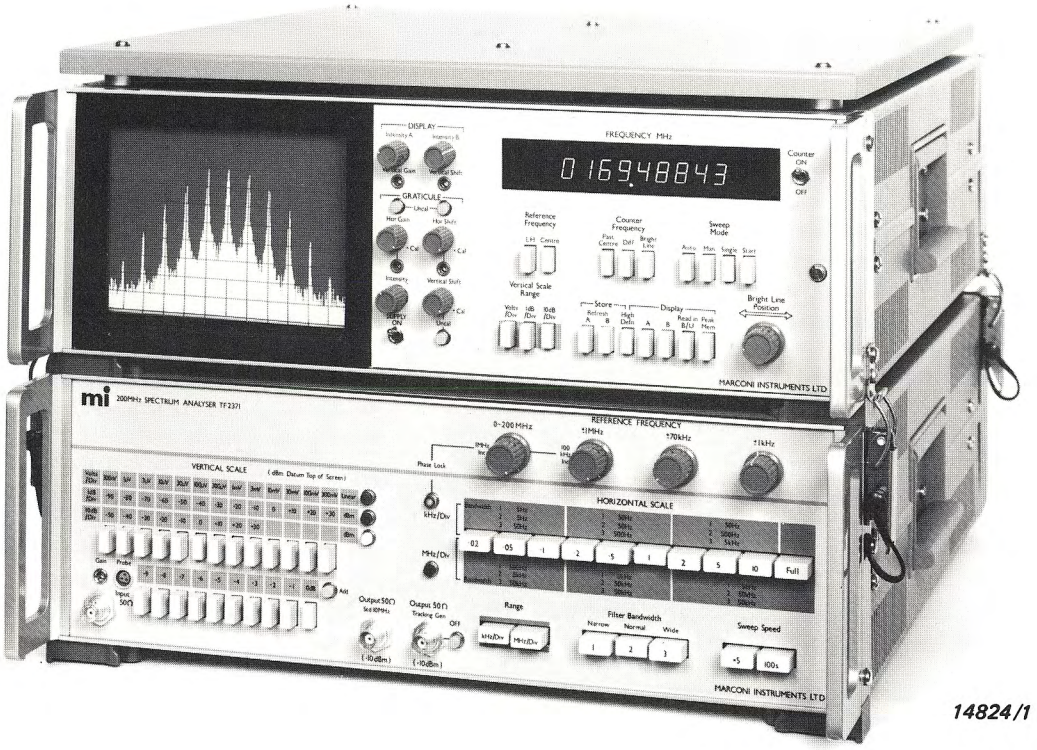
| **DIMENSIONS AND WEIGHT** (Accessory case with probe and all accessories) | Height | Width | Depth | Weight |
|---|---|---|---|---|
| | 56 mm | 233 mm | 142 mm | 480 gm |
| | 2·2 in | 9·2 in | 5·6 in | 1·1 lb |

**VERSIONS AND ACCESSORIES**

*When ordering please quote eight-digit code numbers*

| Ordering numbers | |
|---|---|
| | **Versions** |
| **52374–900C** | Zero Loss Probe TK 2374, for 50 Ω use. |
| **52374–901R** | Zero Loss Probe TK 2374/1, for 75 Ω use. |
| | **Supplied Accessories** |
| | Accessory Case.<br>Voltage Divider 10:1.<br>Voltage Divider 100:1.<br>BNC probe input adapter.<br>Probe hook tip.<br>Earth lead.<br>Sprung earthing clip.<br>50 Ω or 75 Ω Through termination.<br>Spare probe tips (3 off).<br>Instruction Manual. |

# 200 MHz Spectrum Analyser TF 2371 series




14824/1

- ☐ 100 dB displayed dynamic range
- ☐ 0·1 dB and 5 Hz resolution
- ☐ 30 Hz to 200 MHz frequency range
- ☐ Frequency measurement to 1 Hz resolution
- ☐ Phase lock tuning
- ☐ Digital storage of spectral information
- ☐ Split store mode gives dual display
- ☐ Built-in tracking generator

TF 2371 is a comprehensive Spectrum Analyser covering the frequency range 30 Hz to 200 MHz. Outstanding features of this instrument include 100 dB displayed dynamic range, resolution of 0·1 dB and 5 Hz, and a very advanced data presentation system employing electronic storage.

Thus the TF 2371 has important advantages over all previous spectrum analysers for measurements of communications signals including broadcast, f.d.m., p.c.m., s.s.b. and f.s.k.

Swept selective measurements for the frequency response characterisation of active and passive networks over wide dynamic ranges are made possible by the inclusion of a tracking generator. A dual display mode and the 9-digit frequency counter together enhance the precision measurement capability.

Simplicity of operation is achieved by a logic programme which automatically selects the best r.f./i.f. gain ratio, sweep rate and filter bandwidth, eliminating the possibility of measurement error resulting from incorrect setting of the controls.

The standard model of TF 2371 has input and output impedances of 50 Ω. An alternative version, TF 2371/1. is available for 75 Ω use. In this model the RF input, Tracking Generator output and Calibrator output are all at 75 Ω impedance. TF 2371/1 is particularly suitable for measurements on i.f.s. and basebands of f.d.m. systems where the normal impedance is 75 Ω.

## Data Store and Display

The detected output from the receiver section of the analyser is converted to digital form giving a 256 level by 512 ordinate representation which is stored in a m.o.s.f.e.t. recirculatory digital store. The stored information is continuously scanned and displayed on a bright 130×100 mm television camera monitor tube as a brightness modulated picture on a vertically scanned raster.

Superimposed on this display is an electronically produced graticule which may be shifted vertically or horizontally and scaled horizontally against the internal counter to give an exact frequency calibration.

A bright line cursor coupled to the counter can also be superimposed on the display after any single sweep recording and it can be positioned to enable the frequency of any point on the screen to be measured. In the MANUAL mode this electronic cursor becomes an edit pointer indicating the manual tune position and enabling the display to be selectively updated around points of interest and the frequency to be measured to a resolution of 1 Hz.

A split-store mode permits the store to be used in two halves, each of 256 ordinates, to superimpose two recorded displays with the facility for updating one store while retaining the other for comparison purposes. One image can be dimmed relative to the other for easy identification.

## Frequency Measurement

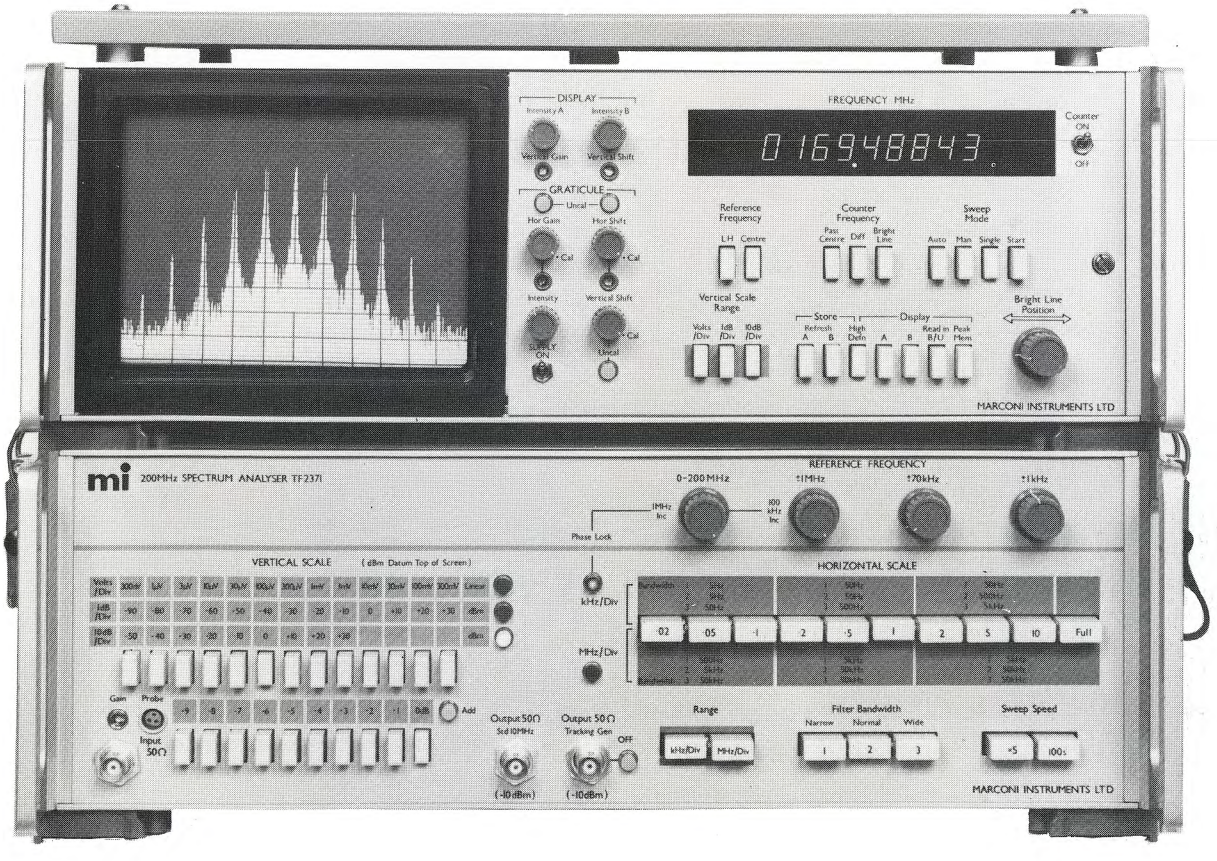
The 9-digit electronic counter gives readout in MHz with automatic positioning of the decimal point. Three modes of operation are available: in the PAST CENTRE mode the centre frequency is measured and displayed each time the data is renewed. In the BRIGHT LINE mode the counter displays the frequency corresponding to the position of the bright line, and in the DIFF mode the counter displays the difference between these two values. This is useful, for example, in measuring sideband frequencies relative to a carrier.

## X-Y Output

X, Y and pen-lift outputs suitable for driving most pen recorders are available at a socket on the rear panel of the display unit.

## Optional Accessories

A number of optional accessories are available to increase the usefulness of TF 2371. Among these are two Zero Loss Probes TK 2374 series which provide a high input impedance for the Spectrum Analyser, and a camera hood for mounting a camera for photographic recording of the display. Frequency Extender TK 2373 cannot be used with TF 2371.




14824/2

## FREQUENCY MEASUREMENT

**Range** 30 Hz to 200 MHz.

**Tuning** Four REFERENCE FREQUENCY controls provide frequency cover of 0 to 200 MHz, ±1 MHz. ±70 kHz and ± 1 kHz respectively.

**Reference** The reference frequency for scan width expansion can be selected by front panel push-button to be either the centre or the left hand side of the display.

**Frequency reading** By calibrated electronic graticule and 9-digit electronic counter. The counter resolution is automatically switched to suit the combination of filter/scan width selected.

**Resolution** 1 Hz using the MANUAL MODE, 5 Hz filter and 200 Hz scan width.

## AMPLITUDE MEASUREMENT

There are two logarithmic and one linear vertical scales.

**Vertical scale range** +30 to −159 dBm using 10 dB/div scale.
+30 to −109 dBm using 1 dB/div scale.
(1 div = approx. 1 cm).

**Vertical scale display** *Log:* 10 dB/div for a 100 dB full screen display.
1 dB/div for a 10 dB full screen display.
*Linear:* 300 mV/div to 300 nV/div in a 1, 3, 10 sequence on a 10 division display.
GAIN control allows for pre-set adjustment of the vertical scale display.

**Vertical scale range accuracy** *10 dB steps:* ±0·3 dB/10 dB; cumulative error less than ±1·5 dB.
*1 dB steps:* ±0·1 dB/1 dB; cumulative error less than ±0·3 dB.

**Vertical scale display accuracy** *Log:* 10 dB/div ±1 db (0 to −80 dB), ±1·5 dB (−80 to −100 dB)
1 dB/div ±0·1 dB.
*Quantization error:* ±0·25% of full scale for 5 Hz to 5 kHz filter bandwidths.
*Volts/div linearity* ±1·5% of full-scale range.

**Frequency response (relative to 10 MHz level)** ±1 dB from 100 Hz to 170 MHz −3 dB at less than 30 Hz and greater than 200 MHz.

**Bandwidth/scan width switching accuracy** Maximum error when switching between bandwidths and Hz/div settings (15 to 25°C);
*Log:* ±1dB ±1% f.s.d.
*Linear:* ±10%.

**Overall accuracy** Accuracy when set against internal calibrator ±0·3 dB at 10 MHz.

**Amplitude stability** ±0·1 dB per °C.

**Maximum input level** +25 dBm continuous (4 V r.m.s.)
+30 dBm for five minutes (7·1 V r.m.s.)

**Input impedance** TF 2371: 50 Ω.
TF 2371/1: 75 Ω
(BNC socket).

**Input v.s.w.r.** Less than 1·25:1.

## SWEEP AND FILTER CHARACTERISTICS

**Sweep modes** AUTO: Analyser sweep free runs.
MANUAL: Tuning point indicated by position of electronic BRIGHT LINE cursor. In this mode the instrument may be used as a selective level measuring set, a 1·5 Hz bandwidth video filter for noise averaging being automatically selected.
SINGLE: A single sweep may be initiated by the START control.
START: Initiates a new sweep on either AUTO or SINGLE.

**Frequency scan width (dispersion)** 200 Hz to 200 MHz, 19 calibrated ranges 10 MHz/div to 20 Hz/div in a 1, 2, 5 sequence and in two bands. kHz/div and MHz/div, and Full Sweep. In the kHz/div position the 0 to 200 MHz and ±1 MHz REFERENCE FREQUENCY controls are phase locked in frequency increments of 1 MHz and 100 kHz respectively.

**Scan width accuracy** ±10% of full-scale-scale ±20 Hz against electronic graticule. May be set to within ±1% ±20 Hz using internal counter.

**Sweep speed** Automatically selected to match the dispersion and filter bandwidth chosen.
100 ms to 100 s in 1, 2, 5 sequence.
×5 speed up over the optimum is available by press-button operation.
A fixed 100 s sweep can be selected for use with an X-Y recorder.

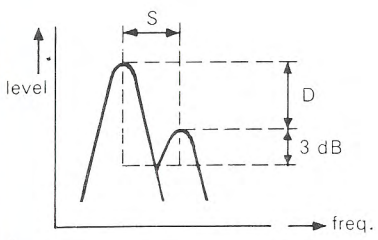
**Filter bandwidth** 5 Hz, 50 Hz, 500 Hz, 5 kHz and 50 kHz at the −3 dB point. Up to three (NARROW, NORMAL and WIDE) are automatically selected from the above five to match the selected dispersion.

**Bandwidth accuracy** ±20% of stated 3 dB bandwidth.

**Bandwidth selectivity** Better than 10:1 from 60 dB to 3 dB.

**Resolution** Using the 5 Hz filter, signals 100 Hz away from a response at 0 dB can be measured to −70 dB.

**Skirt resolution** (The frequency separation of two responses which merge with a 3 dB notch).




D dB is the level difference and S Hz frequency separation for a 3 dB notch between the signals.
Typical skirt resolution for close-in signals:

| D (dB) | S (Hz) |
|---|---|
| >10 dB | 8 Hz |
| >20 dB | 10 Hz |
| >30 dB | 12 Hz |

**Frequency stability** 100 Hz per 10 min after 2 hours warm up and with the RANGE switch in kHz/div position.

**Temperature drift** 100 Hz per °C with RANGE switch in kHz/div position.

**COUNTER** The nine digit counter enables frequency measurement to be made on any part of the spectral display. Modes of operation:
PAST CENTRE: Displays the centre frequency of the last sweep.
BRIGHT LINE: Displays the frequency corresponding to the position of the electronic cursor.
DIFF: Displays the frequency difference between the above two measurements.

**Frequency measurement accuracy** Using the counter, after 60 minutes warm up and using the internal frequency standard:
AUTO SWEEP: ±20 Hz ±1% of scan width ± counter accuracy.
MANUAL: ±2 Hz ± counter accuracy.
Counter accuracy:
±1 count
$\pm 2 \times 10^{-7}$ (accuracy of setting internal standard)
$\pm 1 \times 10^{-6}$ per year (ageing rate)
$\pm 2 \times 10^{-6}$ (maximum error due to temperature variation).

**DISPLAY** A digital storage system giving infinite persistence with 100 ms minimum data renewal time provides the following STORE/DISPLAY modes.

HIGH DEFN: Full capacity of electronic store (500 × 200 elements) is used to display the spectrum.

DISPLAY 'A': Half capacity of electronic store (250 × 200 elements) is used to display the spectrum.

DISPLAY 'B': Remaining half capacity of electronic store (250 × 200 elements) is used to display the spectrum.

REFRESH 'A': In this mode, DISPLAY 'A' is continuously refreshed as in HIGH DEFN; DISPLAY 'B' is permanently stored.

REFRESH 'B': In this mode, DISPLAY 'B' is continuously refreshed as in HIGH DEFN; DISPLAY 'A' is permanently stored.

READ IN B/U: Display 'Bright-up' indicates the data renewal point on the display.

PEAK MEMORY: The peak signal level of a spectrum (whose level may be changing) is stored and displayed.

**Display tube** Television camera viewfinder tube with 100 × 130 mm viewing area.

**Intensity 'A'** Controls brightness of the HIGH DEFN and 'A' DISPLAY.

**Intensity 'B'** Controls brightness of the 'B' DISPLAY.

**Vertical gain** This control allows for pre-set adjustment of the display amplitude.

**Vertical shift** This control allows for pre-set adjustment of the vertical display position.

**ELECTRONIC GRATICULE** Generates nominal 1 cm vertical and horizontal lines sub-divided horizontally to 2 mm.

**Vertical shift** Positions the graticule over greater than 1 major division.

**Horizontal shift** Positions the graticule over greater than 1·5 major divisions.

**Horizontal gain** Expands the graticule. Cover greater than ±15%.

Indicator lamps show when the above controls are being operated in the uncalibrated position.

**Intensity** Controls background brightness of the graticule.

**SPECTRAL PURITY**

**Intermodulation capability (measured on manual sweep)** Better than −70 dB (two tone test) with signals at −40 dBm at input mixer and 500 Hz apart.

**Residual responses** 30 Hz to 200 MHz: less than −90 dBm.
Measured at the input mixer or input socket, whichever is the greater.

**Spurious responses** Better than 70 dB below a single signal at a level of −40 dBm at input mixer and between 100 kHz and 200 MHz.

**Average noise level (between 100 kHz and 200 MHz measured on manual sweep)** Less than −120 dBm with Counter On.
Less than −130 dBm with 50 Hz filter and Counter Off.

**TRACKING GENERATOR** Enables the transfer characteristics of any network to be measured over a dynamic range of up to 120 dB.

**Frequency** Tracks the input tune frequency within ±2 Hz.

**Amplitude** −10 dBm ±2 dB at 10 MHz.

**Frequency response (relative to 10 MHz level)** ±1 dB from 100 Hz to 170 MHz.
−3 dB at less than 30 Hz and greater than 200 MHz.

**Output impedance** TF 2371: 50 Ω
TF 2371/1 75 Ω.
(BNC socket).

**Output v.s.w.r.** Less than 1·25:1.

**CALIBRATOR**

**Frequency** 10 MHz ±20 Hz.

**Amplitude** −10 dBm ±0·3 dB.

**Output impedance** TF 2371: 50 Ω nominal
TF 2371/1: 75 Ω nominal
(BNC socket)

# TF 2371 series

| | |
|---|---|
| **EXTERNAL STANDARD INPUT** | Rear BNC socket permits internal 10 MHz standard to be locked to external 1 MHz standard. Green light next to socket glows when adequate signal is applied at the correct frequency to achieve satisfactory lock. |
| Input impedance | Approx. 10 kΩ shunted by 100 pF. |
| Signal level required | 0·25 V to 1·0 V r.m.s. |
| Frequency | 1 MHz. |
| Accuracy required | Better than 1 in $10^7$. |
| **DETECTED OUTPUT** | Rear panel BNC socket provides demodulated output. |
| Output impedance | Approx. 600 Ω. |
| Frequency response | −3 dB at less than 30 Hz to greater than 20 kHz using 50 kHz filter relative to the level at 1 kHz. |
| Maximum output level | 0 dBm ± 3 dB into 600 Ω load for 100% a.m. signal. Maximum undistorted output level occurs if the unmodulated carrier is set to the top of the screen on 1 dB/div or 40 dB down from the top of the screen on 10 dB/div. |
| **X-Y RECORDER OUTPUTS** | From 15-way Amphenol socket (type 17-10150), on rear panel of display unit. Enables TF 2371 to be used with X-Y recorder. |
| X output | A ramp of typically 0·8 V/div, 10 V maximum amplitude from source impedance of 1 kΩ. 100 s sweep time. |
| Y output | A detected signal of 0·2 V/div, with typically 2 V corresponding to display at top of screen, from output impedance of 1 kΩ. |
| Pen-lift output | A pair of contacts are closed during the sweep and opened by an internal relay during the flyback period. Enables the pen to be lifted when used with X-Y recorders with automatic pen lift. |
| **PROBE SUPPLY** | Supply available at front panel socket to power Zero Loss Probes TK 2374 and TK 2374/1. |
| **POWER REQUIREMENTS** | |
| AC supply | 200 to 250 V or 100 to 130 V at any frequency between 45 and 440 Hz. *Regulation:* ±10% on the nominal supply voltage. Approximately 130 W (170 VA). |
| **RADIO FREQUENCY INTERFERENCE** | Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference. |
| **SAFETY** | Complies with IEC 348. |
| **LIMIT RANGE OF OPERATION** | |
| Temperature | 0 to 50°C. |
| **CONDITIONS OF STORAGE AND TRANSPORT** | |
| Temperature | −40°C to +70°C. |
| Humidity | Up to 90% relative humidity. |
| Altitude | Up to 2500 m (pressurised freight at 27 kPa differential, i.e. 3·9 lbf/in²). |

| **DIMENSIONS AND WEIGHT (including covers)** | Height | Width | Depth | Weight |
|---|---|---|---|---|
| Display unit | 172 mm<br>$6\frac{3}{4}$ in | 440 mm<br>$17\frac{5}{16}$ in | 516 mm<br>$20\frac{5}{16}$ in | 20 kg<br>44 lb |
| RF unit | 156 mm<br>$6\frac{1}{8}$ in | 453 mm<br>$17\frac{13}{16}$ in | 516 mm<br>$20\frac{5}{16}$ in | 19·5 kg<br>43 lb |

## VERSIONS AND ACCESSORIES

*When ordering please quote eight-digit code numbers*

| Ordering numbers | |
|---|---|
| | **Versions** |
| **52371–900S** | 200 MHz Spectrum Analyser TF 2371, 50 Ω version. |
| **52371–901W** | 200 MHz Spectrum Analyser TF 2371/1, 75 Ω versions. |
| | **Supplied Accessories** |
| | Extender Board 44827–235W, for use when servicing printed boards. |
| | Board Extractor 41700–048A. |
| | Connector Assembly, (umbilical), 170 mm (6·7 in) long, 2-off, 43169–005C. |
| | Protective Cover (2-off) 41690–087N. |
| | Fuse Kit 46883–219V comprising: Fuse, quick acting, 250 mA, 23411–004E. Fuse, quick acting, 3·15A 23411–008L. Fuse, time-lag, 2·0A, 23411–060M. Fuse, (2-off) time-lag, 4·0A, 23411–063B. |
| | Stay Assembly 34900–209W (for use in servicing). |
| | Plug, Amphenol type 17–20150–0, for connection to X-Y recorder output socket. |
| | AC Supply Lead 43123–076Y. |
| | Operating Manual 46881–373H, (H52371-900S, Vol. 1). |
| | **Optional Accessories** |
| **52374–900C** | Zero Loss Probe TK 2374, for 50 Ω use. |
| **52374–901R** | Zero Loss Probe TK 2374/1, for 75 Ω use. |
| **43281–007C** | RF Fuse Unit TM 9884. |
| **54127–211H** | Rack Mounting Kit. |
| **46883–267B** | Camera Hood. For use with Polaroid CR9 or Shackman Models 77 and 7000 cameras for photographic recording of display. |
| **54112–111K** | Carrying Case. (Two required to carry the two halves of TF 2371). |
| **54431–021B** | 20 W, 20 dB, 50 Ω Attenuator. |
| **43169–010B** | Connector Assembly (umbilical), 762 mm (30 in) long. For use during maintenance to enable TF 2371 to be operated while separated into two halves. (Two required). |
| **43129–419M** | Jumper Lead Assembly. (For use with 50Ω model TF 2371 during maintenance to enable RF Unit to be operated while open.) |
| **43129–525C** | Jumper Lead Assembly (For use with 75Ω model TF 2371 during maintenance to enable RF Unit to be operated while open.) |
| **43126–012S** | RF Connecting Cable TM 4969/3, 50 Ω BNC, 1520 mm (60 in) long. |
| **54421–001N** | Telescopic Aerial with BNC Plug. |
| **46881–374E** | Service Manual H52371–900S, Vol. 2. |

marconi instruments

# Counters and Frequency Meters


| | | |
|---|---|---|
| **Selection Guide** | | **112** |
| **Digital Frequency Meters (10 Hz to 80 MHz, 10 Hz to 200 MHz, 10 Hz to 500 MHz)** | **2430A series** | **114** |
| **Digital Frequency Meter (10 Hz to 2 GHz)** | **2435** | **121** |
| **GPIB Unit** | **2436** | **125** |
| **Universal Counter Timers (d.c. to 100 MHz, d.c. to 520 MHz)** | **2437 and 2438** | **127** |
| **20 GHz Microwave Counter** | **2440** | **134** |

*For further Frequency Meters see the Microwave Products Section:*

**Wavemeter Grade 2 type 6017/2** **258**

# Counters and Frequency Meters

## DIGITAL FREQUENCY METERS
## 2430A series & 2435

## UNIVERSAL COUNTER/TIMERS
## 2437 & 2438

## GPIB INTERFACE UNIT
## 2436

*– and to be introduced shortly* ***MICROWAVE COUNTER 2440***

These digital frequency meters and universal counter/timers are high quality, high reliability instruments that provide various ranges of frequency measurement within the wide overall coverage of DC to 2 GHz – with new additions to the range (see Advance Information on page 134) soon to extend this up towards 20 GHz.

Models 2430A, 2431A, 2432A and 2435 are general-purpose digital frequency meters offering direct measurement of frequencies in various ranges within the overall coverage of 10 Hz to 2 GHz. Frequency resolution is 0·1 Hz, with certain models also providing 0·01 Hz maximum resolution for inputs up to 5 kHz by means of an integral LF multiplier. Model 2432A also has a facility for 'burst mode' measurements on short-duration r.f. signals.

Models 2437 and 2438 are universal counter/timers providing measurement of frequency, frequency ratio, period, multi-period, time interval, time interval averaging and counting. Frequency measurement is within various ranges from DC to 520 MHz, the timing range is from 100 ns to 1000 s, and the count capability is up to $10^7$ events per second.

All instruments offer readout by bright l.e.d. displays (7-digit for 2430A, 8-digit for all other models), the displays featuring memory, automatic positioning of decimal point, overflow indication and leading-zero suppression.

All models are available in different versions according to the type of internal frequency standard fitted, and will also accept inputs from external frequency standards.

### DATA INTERFACE/GPIB OPERATION

All models offer an optional data interface allowing the instruments to be used with a printer or as part of an instrumentation system. The data interface allows the instruments to be connected to external equipment either directly or via the Model 2436 GPIB Interface Unit, which then provides full listener/talker programmability via a standard GPIB interface.

### SENSITIVITY

All models have input sensitivities in the 10 – 50 mV sinewave range depending on frequency, and the frequency meter models also have automatic gain control to provide a wide dynamic range for simpler operation.

### INPUT IMPEDANCE

Input impedances are 1 M on ranges extending up to 200 MHz, 50 Ω on ranges extending beyond this limit. The frequency meter models also include a switchable low-pass 10 kHz input filter for use when measuring audio signals bearing high frequency noise.

### TEMPERATURE STABILITY

Temperature stabilities are from ±0·1 p.p.m. to ±5 p.p.m., depending on the version selected, over the operating temperature range of 0 to 40°C.

# Frequency Meters
# Selection Guide

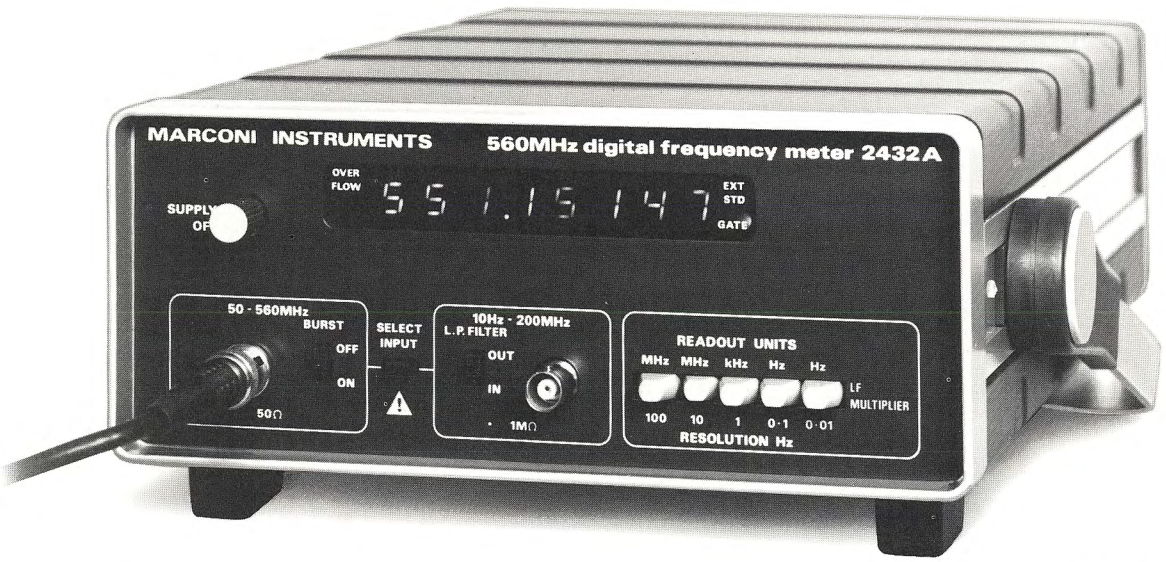
| | FREQUENCY METERS | | | | COUNTER/TIMERS | |
|---|---|---|---|---|---|---|
| | 2430A | 2431A | 2432A | 2435 | 2437 | 2438 |
| Frequency range | 10 Hz–80 MHz | 10 Hz–200 MHz | 10 Hz–560 MHz | 10 Hz–2 GHz* | DC–100 MHz | DC–520 MHz |
| Input sensitivity | 25 mV | 10 mV | 10 mV | 10 mV/–10 dBm | 10–5 mW | 10–50 mW |
| Overload protection | 250 V r.m.s. | 250 V r.m.s. | 250 V r.m.s./50 V r.m.s. | 250 V r.m.s./10 W | 250 V r.m.s. | 250 V r.m.s. |
| Input impedance | 1 MΩ | 1 MΩ | 1 MΩ/50 Ω | 1 MΩ/50 Ω | 1 MΩ | 1 MΩ/50 Ω |
| Low pass filter | Yes | Yes | Yes | Yes | | |
| LF multiplier | | | Yes | Yes | | |
| Burst mode | | | Yes | | | |
| A G C | Yes | Yes | Yes | Yes | | |

*New additions to the range will shortly extend this up towards 20 GHz (see page 134).*



# Digital Frequency Meter

# 2430A series




*Model 2432A*

*14741/12*

- ☐ **2430A; 10 Hz to 80 MHz**
- ☐ **2431A; 10 Hz to 200 MHz**
- ☐ **2432A; 10 Hz to 560 MHz**
- ☐ **Direct frequency measurement—resolution to 0·01 Hz**
- ☐ **Automatic gain control—wide dynamic range**
- ☐ **Choice of three internal frequency standards or external standard**
- ☐ **Burst mode of operation on 2432A**
- ☐ **Data interface option**
- ☐ **Excellent reliability and servicing accessibility—2 year guarantee**

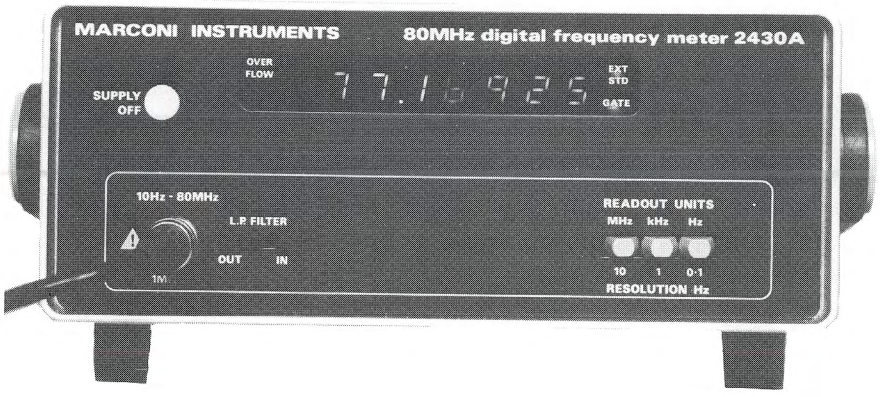
Digital frequency meters types 2430A, 2431A and 2432A are high quality, high reliability, general purpose instruments providing direct frequency measurement over the range 10 Hz to 560 MHz.

Much of the circuitry is contained in a custom-designed MOS-LSI chip. CMOS and low power Shottky devices are also extensively used resulting in operational simplicity, reliability and low power consumption.

Features common to the range include a bright l.e.d. display with memory, automatic positioning of decimal point, overflow indication, leading zero suppression and a digit check facility. The instruments all have provision for operating with internal or external frequency standard.

### Input channels

Models 2430A and 2431A both have single, high impedance inputs with frequency cover from 10 Hz to 80 MHz and 10 Hz to 200 MHz respectively. 2432A has




*Model 2430A* *14741/7*

two separate inputs, selected by a front-panel switch. A high impedance input covers the frequency range 10 Hz to 200 MHz and a 50 Ω input covers the range 50 MHz to 560 MHz.

Automatic gain control on all inputs enables a wide range of signal levels to be accommodated without the need for a sensitivity control or manual attenuator. Sensitivity of 2430A is 25 mV r.m.s. and of the two higher frequency models is 10 mV r.m.s. The maximum signal input with which the frequency meters will operate satisfactorily is not less than 260 V r.m.s. at 50 Hz, reducing to 5 V r.m.s. at the highest frequencies. The 50 Ω high frequency input channel of 2432A is protected by a built-in r.f. fuse. Application of overload voltages up to 50 volts to this channel will result only in a blown fuse.

All models include a switchable low-pass input filter which reduces the sensitivity of the instruments at frequencies above 10 kHz. This is valuable when measuring audio frequencies in the presence of high frequency noise.

Model 2432A includes a frequency multiplier circuit to enhance further the low frequency performance. The multiplier produces an output frequency equal to 100 times the input frequency. This gives a resolution of 0·01 Hz in one second measurement time for input frequencies between 10 Hz and 5 kHz. This facility is very useful for fast and accurate measurements of audio frequencies such as amplifier response characteristics and calling tone measurements in paging instruments.

A useful 'burst' measurement mode is also incorporated in 2432A, permitting frequency measurements on any r.f. signals existing for only a short period of time. Normally the counter display is updated at the end of each measurement cycle and if the signal is removed the next display will be zero. In the burst mode, if the signal is removed the display will retain the previous reading indefinitely or until a signal is re-applied. This mode is useful for measuring transmitter carrier frequencies by brief operation of the 'transmit' switch.

## Display

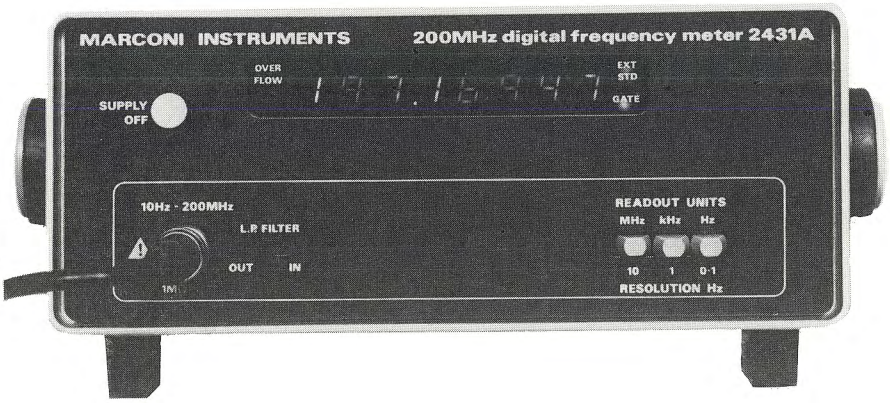
Frequency readout is by bright light emitting diode displays with memory – a seven-digit display in 2430A and an eight-digit display in the two higher frequency models. Characters are seven-segment and have a minimum height of 8 mm.

Readout units – MHz, kHz or Hz as appropriate – are indicated by front-panel markings adjacent to the gate-time push-buttons, and resolution in Hz is also indicated for each range. Decimal point positioning, overflow indication and leading zero suppression are all automatic. A digit check facility is also included whereby all the l.e.d. segments and all decimal points are displayed when all the gate-time buttons are simultaneously released.

## Frequency standard

Options of the various instruments are available with three different frequency standards and there is provision on all models for operation with an external frequency. Two versions of 2430A offer either a standard crystal oscillator with a stability of ±5 in $10^6$ over the operating temperature range, or a temperature compensated crystal oscillator with a stability of ±1·5 in $10^6$. Model 2432A has a choice of the temperature compensated crystal oscillator or an oven-controlled crystal oscillator giving a stability of ±0·1 in $10^6$ over the range. Model 2431A is available in all three versions. A control accessible through the rear panel of all models permits adjustment of the internal standard to compensate for crystal ageing.

There is provision on all models for operation with a 1 MHz external standard frequency applied via a rear-panel socket. Application of an external signal automatically overrides the internal oscillator and a front-panel lamp indicates when the external standard is in use. If the external standard fails or is removed, the instrument switches automatically to operation from the internal oscillator. This feature is valuable in automatic or remote set-ups where there is no access to the rear




*Model 2431A* *14741/10*

panel. The sensitivity and bandwidth versatility of the external input offer the possibility of ratio measurements by connecting one signal to the front panel input socket and the other signal to the external standard socket.

## Data interface

All models can be fitted with an optional data output and programming interface, allowing the frequency meter to be used in conjunction with a printer or as part of an instrumentation system.

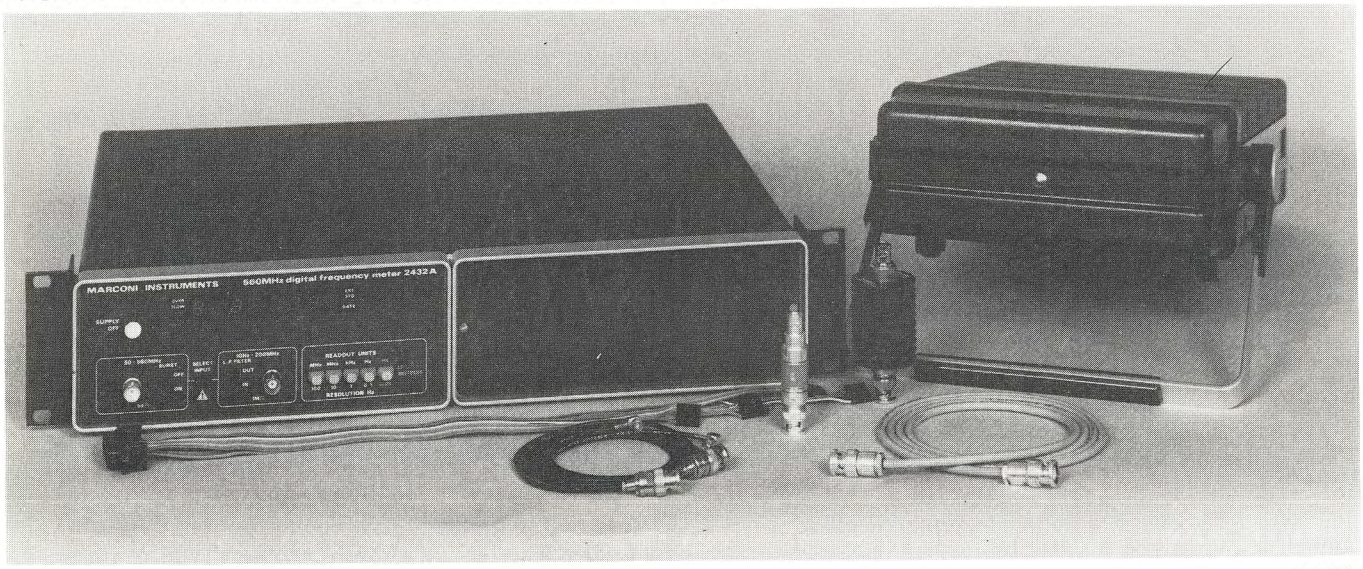
External control signals can set the frequency meter to remote, set the counter range, clear and trigger the count sequence and enable or disable the display.

The resulting frequency reading is available as serial b.c.d. data multiplexed into the interface by external synchronizing signals. Decimal point indication and suppressed leading zeros data are multiplexed simultaneously. Provision is included for single measurements by giving direct access to the main gate control circuitry.

The data interface kit consists of a 24 way connector which is fitted to the rear panel and a ribbon cable which links this connector to miniature sockets in the instrument. This kit can readily be fitted by the user.

## Battery power unit

A version of 2432A is available with an attached rechargeable nickel cadmium battery pack providing a useful operation time of greater than 3 hours when fully charged. When the instrument is operated on mains supply it will switch automatically to battery operation if the mains supply fails. This ensures continuous operation where mains drop-out is a possibility. The battery unit includes a current-limited battery charger driven from the 2432A mainframe and this charger can be used when the frequency meter is fully operational. There is also facility for charging from an external 12 volt car battery. Recharging time to full capacity is approximately 15 hours at 700 mA. The battery pack cannot be damaged by indefinite overcharging.




*Model 2432A in Rack Mounting Kit with some optional accessories* *14756*

## Specification for the series

| TYPE NUMBER | 2430A | 2431A | 2432A |
|---|---|---|---|
| INPUT CHANNELS | Single Channel | | Two channels, switch selected. |
| Frequency range | 10 Hz to 80 MHz. | 10 Hz to 200 MHz. | *LF INPUT:* 10 Hz to 200 MHz.<br>*HF INPUT:* 50 MHz to 560 MHz. |
| Sensitivity | 25 mV r.m.s. (sinewave). | 10 mV r.m.s. (sinewave). | *LF INPUT:* 10 mV r.m.s. (sinewave) from 10 Hz to 70 MHz<br>25 mV r.m.s. (sinewave) from 70 MHz to 200 MHz.<br>*HF INPUT* −27 dBm (10 mV r.m.s. sinewave p.d. into 50 Ω). |
| | Built-in a.g.c. provides capability for handling signals automatically over a wide dynamic range. | | |
| Dynamic range | 80 dB. | 90 dB. | *LF INPUT:* 90 dB.<br>*HF INPUT:* 54 dB. |
| Maximum sinewave input | 260 V r.m.s. at 50 Hz<br>5 V r.m.s. at 80 MHz<br>Degradation from 50 Hz to 80 MHz is approximately $3 \times 10^{-6}$ V/Hz. | 260 V r.m.s. at 50 Hz<br>5 V r.m.s. at 200 MHz<br>Degradation from 50 Hz to 200 MHz is approximately $1{\cdot}3 \times 10^{-6}$ V/Hz. | *LF INPUT:* 260 V r.m.s. at 50 Hz<br>5 V r.m.s. at 200 MHz.<br>Degradation from 50 Hz to 200 MHz is approximately $1{\cdot}3 \times 10^{-6}$ V/Hz.<br>*HF INPUT:* +27 dBm (5 V r.m.s. p.d. into 50 Ω). from 50 MHz to 560 MHz. |
| Maximum d.c. | 250 V. | | *LF INPUT:* 250 V.<br>*HF INPUT:* 5 V. |
| .a.c. +d.c. | 250 V r.m.s. at 50 Hz. | | *LF INPUT:* 250 V r.m.s. at 50 Hz.<br>*HF INPUT:* 5 V. |
| Input impedance | Approximately 1 MΩ in parallel with less than 25 pF AC coupled via 0·1 μF. | | *LF INPUT:* Approximately 1 MΩ in parallel with less than 25 pF. AC coupled via 0·1 μF.<br>*HF INPUT:* 50 Ω nominal. |
| Input filter | Switchable low pass filter reduces sensitivity above 10 kHz to improve noise immunity when counting LF signals (attenuation at least 20 dB above 100 kHz). | | |
| MODES OF OPERATION | | | |
| Range selection | Three push-buttons select the following ranges and indicate the resolution and readout units.<br><br>100 ms gate time providing 10 Hz resolution<br>1 s gate time providing 1 Hz resolution<br>10 s gate time providing 0·1 Hz resolution<br><br>All ranges operate over the full frequency range. | | Five push-buttons select the following ranges and indicate the resolution and readout units.<br><br>10 ms gate time providing 100 Hz resolution<br>100 ms gate time providing 10 Hz resolution<br>1 s gate time providing 1 Hz resolution<br>10 s gate time providing 0·1 Hz resolution<br>1 s gate time providing 0·01 Hz resolution<br><br>The first four ranges operate on both channels over the full frequency range. The last range operates only on the LF channel up to 5 kHz. |
| Burst mode | | | A push-button selects a burst mode on the HF channel only. The display then retains the reading indefinitely after the input signal is removed. The signal must be present for at least twice the gate time plus 200 ms. |
| DISPLAY | Seven digit with memory | Eight digit with memory | |
| | Seven segment LEDs of 8 mm height | | |
| Features | Decimal point automatically selected.<br>Overflow indication. Leading zeros suppressed.<br>Digit check facility—releasing all range buttons displays all l.e.d. segments and decimal points. | | |
| Display time | Readout retained during gating period. | | |
| Gate indication | Lamp indicates gating period. | | |

| | | | |
|---|---|---|---|
| **ACCURACY** | ±1 count ± stability of frequency standard. | | |
| **FREQUENCY STANDARD** | Internal crystal oscillator or external input automatically selected.<br>Application of external signal overrides the internal oscillator.<br>A front panel lamp indicates when the external standard is in operation.<br>A control accessible through the rear panel allows adjustment of the internal standard to compensate for ageing. | | |
| **INTERNAL CRYSTAL OSCILLATOR** | Model 52430–311H | Model 52431–311S | |
| **Temperature stability** | Better than ±5 p.p.m. over the operating temperature range of 0° to 40°C. | | |
| **Ageing rate** | Better than ±0·8 p.p.m. nominal per month after 1 month continuous use. | | |
| **TEMPERATURE COMPENSATED CRYSTAL OSCILLATOR** | Model 52430–312E | Model 52431–312W | Model 52432–312A |
| **Temperature stability** | Better than ±1·5 p.p.m. over the operating temperature range of 0° to 40°C. | | |
| **Ageing rate** | Better than ±0·4 p.p.m. nominal per month after 1 month continuous use. | | |
| **OVEN CONTROLLED CRYSTAL OSCILLATOR** | | Model 52431–313D | Model 52432–313Z |
| **Temperature stability** | | Better than ±0·1 p.p.m. over the operating temperature range of 0° to 40°C | |
| **Ageing rate** | | Better than ±0·4 p.p.m. nominal per month after 1 month continuous use. | |
| **Warm-up time** | | Within 0·5 p.p.m. of final frequency within 5 min from switch-on at 20°C ambient. | |
| **AUXILIARY OUTPUT** | | | |
| **Frequency** | Internal standard 1 MHz available from rear panel socket. | | |
| **Level** | Greater than 100 mV p-p into 50 Ω (approximately 4 V p-p e.m.f.). | | |
| **Impedance** | Approximately 2 kΩ. | | |
| **EXTERNAL FREQUENCY STANDARD** | | | |
| **Frequency** | 1 MHz sinewave or squarewave. Usable from 10 kHz to 1 MHz for ratio measurements. | | |
| **Input level** | 2·5 V to 5·5 V p.p. | | 150 mV r.m.s. minimum up to approximately 10 V r.m.s. maximum. |
| **Input impedance** | Approximately 300 Ω a.c. coupled. | | Approximately 100 kΩ a.c. coupled. |

**DATA INTERFACE**

BCD data output and remote range selection are available using the optional data output lead. This lead, which can be installed by the user, provides the following connexions.

| Mnemonic | Function |
|---|---|
| ABCD, BBCD, CBCD, DBCD | BCD data output, bit parallel, byte serial. |
| DEN | Display enable input. |
| OFL | Overflow indication output. |
| NCLR | Counter and display clear input. |
| NINH | Counter gate control – may be used as an output to monitor gate or as an input to control gate. |
| SCX | External display scan input – also controls data output multiplexing. |
| SCR | External display scan enable input. |
| DPT | Decimal point output. |
| LZS | Leading zeros suppression output. |
| ATB, BTB, CTB, DTB | 1 of 4 range selection input. (1 of 3 for 2430A and 2431A) |
| NREM | Not remote (i.e. local). |
| FREQ | Selects l.f. multiplier |
| FUNC | Selects burst mode |

Note: DTB, FREQ and FUNC apply to 2432A only.

| TYPE NUMBER | 2430A | 2431A | 2432A |
|---|---|---|---|
| RADIO FREQUENCY INTERFERENCE | Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference. | | |
| SAFETY | Complies with IEC 348. | | |
| OPERATING TEMPERATURE RANGE<br>Rated range of use | 0° to 40°C | | |
| Limit range of operation | 0° to 55°C | | 0° to 55°C<br>0° to 50°C (with battery unit) |
| CONDITIONS OF STORAGE AND TRANSPORT<br>Temperature | −40° to +70°C | | −40°C to +70°C<br>−40°C to +50°C (with battery unit) |
| Humidity | Up to 90% relative humidity. | | |
| Altitude | Up to 2500 m (pressurised freight at 27 kPa differential, i.e. 3·9 lbf/in²). | | |
| POWER REQUIREMENTS<br>AC supply | Switchable voltage ranges: 105 to 110 V, 115 to 120 V, 210 to 220 V, 230 to 240 V, all ±10%, 50 to 400 Hz ±10%. | | |
| | 10 VA approximately | | 15 VA approximately |
| Battery | | | (Model 52432–314H only)<br>**Type**: Fully sealed NiCd battery pack.<br>**Voltage**: 6 V nominal.<br>**Capacity**: Sufficient for minimum of three hours (typically five hours) of continuous operation at a charging and operating temperature of 20°C. A front panel lamp indicates when the battery is approximately 90% discharged.<br>**Recharging time**: Approximately fifteen hours to charge fully a discharged battery when in the 'charge' mode.<br>**External charge**: Rear panel switch and terminals allow the battery to be charged from an external d.c. source in the range 10 to 14 V. The maximum current required is 700 mA. |
| Modes of operation | | | Three modes are selected by front panel push-buttons.<br>**Off**: If the a.c. supply is connected the frequency meter operates normally and the battery receives a trickle charge.<br>**On/standby**: If the a.c. supply is connected the frequency meter operates normally and the battery receives a trickle charge. If the a.c. supply is removed the battery supplies power. A front panel lamp indicates when the instrument is operating on battery power.<br>**Charge**: If the a.c. supply is connected the frequency meter operates normally and the battery receives a fast charge. A front panel lamp indicates when the charge mode is selected. |

| | | | |
|---|---|---|---|
| **DIMENSIONS** | | | |
| **Height** | 108 mm 4·25 in | | 108 mm 4·25 in<br>153 mm 6·0 in (with battery unit) |
| **Width** | 256 mm 10·1 in | | 256 mm 10·1 in |
| **Depth** | 338 mm 13·3 in | | 338 mm 13·3 in |
| **Weight** | 2·2 kg 4·85 lb | | 4·0 kg 8·8 lb<br>7·0 kg 15·4 lb (with battery unit) |
| **VERSIONS** | | | |
| **Ordering number and description** | **52430–311H**<br>80 MHz Digital Frequency Meter 2430A with standard crystal oscillator.<br>**52430–312E**<br>80 MHz Digital Frequency Meter 2430A with temperature compensated crystal oscillator. | **52431–311S**<br>200 MHz Digital Frequency Meter 2431A with standard crystal oscillator.<br>**52431–312W**<br>200 MHz Digital Frequency Meter 2431A with temperature compensated crystal oscillator.<br>**52431–313D**<br>200 MHz Digital Frequency Meter 2431A with oven controlled crystal oscillator. | **52432–312A**<br>560 MHz Digital Frequency Meter 2432A with temperature compensated crystal oscillator.<br>**52432–313Z**<br>560 MHz Digital Frequency Meter 2432A with oven controlled crystal oscillator.<br>**52432–314H**<br>560 MHz Digital Frequency Meter 2432A with temperature compensated crystal oscillator and with battery unit. |
| **SUPPLIED ACCESSORIES** | Mains Lead 43123–076Y<br>Operating Manual | | |
| **OPTIONAL ACCESSORIES** | 46883–401T<br>46883–405C<br>43126–012S<br>54124–022L<br>54124–023J<br>54431–021B<br>54421–001N<br>46881–351F<br>46881–353V<br>46881–355W | Rack Mounting Kit (for all models except 52432–314H)<br>Data Interface Kit<br>BNC to BNC Lead, 1·5 m, 50 Ω<br>Cover Assembly (storage)<br>Cover Assembly (storage). For use with model 52432–314H only<br>20 dB, 20 W Attenuator (for 2432A only)<br>Telescopic Aerial with BNC Plug<br>Service Manual for 2430A series<br>Service Manual for 2431A series<br>Service Manual for 2432A series | |

# 2GHz Digital Frequency Meter 2435




14741/15

- ☐ **Wide frequency range –10 Hz to 2 GHz**
- ☐ **Resolution to 0·01 Hz**
- ☐ **Automatic gain control – wide dynamic range**
- ☐ **Choice of two internal frequency standards or external standard**
- ☐ **Data interface option**
- ☐ **Excellent reliability and servicing accessibility – 2 year guarantee**

2 GHz Digital Frequency Meter 2435 is a high quality instrument providing frequency measurement over the wide band of 10 Hz to 2 GHz in two switched ranges. Two versions are available with a choice of internal frequency standards with differing stabilities. The instruments can also be operated with an external frequency standard.

### Input channels

2435 has two input channels, selected by a front panel switch. The lower frequency channnel (channel B) covers the range 10 Hz to 200 MHz, and has a sensitivity of 10 mV r.m.s. up to 70 MHz and 25 mV r.m.s. from 70 MHz to 200 MHz. The input impedance on this range is 1 MΩ. A switchable low pass filter can be used to reduce the sensitivity above 10 kHz to improve noise immunity when measuring audio signals.

To enhance further the low frequency performance, a frequency multiplier circuit is included which gives a resolution of 0·01 Hz in one second measurement time for input frequencies between 10 Hz and 5 kHz. This facility is very useful for fast and accurate measurements of audio frequencies such as amplifier response characteristics and calling tone measurements in paging instruments.

Channel A employs a transfer oscillator technique to cover the frequency range 200 MHz to 2 GHz, with a sensitivity of –12 dBm. PIN diode limiting protects the channel from high incident power up to 10 W c.w.

### Display

Frequency readout is by an eight-digit light emitting diode display with memory. Characters are seven-segment and have a minimum height of 8 mm.

Readout units – GHz, MHz, kHz or Hz as appropriate – are indicated by front-panel markings adjacent to the gate-time push-buttons, and resolution is also indicated for each range. Decimal point positioning, overflow indication and leading zero suppression are all automatic. A digit check facility is also included whereby all the l.e.d. segments and all decimal points are displayed when all the gate-time buttons are simultaneously released.

## Frequency standard

Two versions of the instrument are available with different frequency standards – a temperature compensated crystal oscillator with a stability better than ±1·5 p.p.m. over the operating temperature range, and an oven-controlled crystal oscillator with a stability of ±0·1 p.p.m. A control accessible through the rear panel permits adjustment of the internal standard to compensate for crystal ageing.

There is provision for operation with a 1 MHz external standard frequency applied via a rear-panel socket. Application of an external signal automatically overrides the internal oscillator, and a front-panel lamp indicates when the external standard is in use. If this external standard fails or is removed, the instrument switches automatically to operation from the internal oscillator. This feature is valuable in automatic or remote set-ups where there is no access to the rear panel. The sensitivity and bandwidth versatility of the external input offer the possibility of ratio measurements by connecting one signal to the front-panel input socket and the other signal to the external standard socket.

## Data interface

The frequency meter can be fitted with an optional data output and programming interface, allowing it to be used with a printer or as part of an instrumentation system.

External control signals can set the frequency meter to remote, set the counter range, clear and trigger the count sequence and enable or disable the display.

The resulting frequency reading is available as serial b.c.d. data multiplexed into the interface by external synchronizing signals. Decimal point indication and suppressed leading zeros data are multiplexed simultaneously. Provision is included for single measurements by giving direct access to the main gate control circuitry.

The data interface kit consists of a 24-way conector which is fitted to the rear panel, and a ribbon cable which links this connector to miniature sockets in the instrument. This kit can readily be fitted by the user.

## Battery power unit

A version of 2435 is available with an attached rechargeable nickel cadmium battery pack providing a useful operation time of greater than 2 hours when fully charged. When the instrument is operated on mains supply it will switch automatically to battery operation if the mains supply fails. This ensures continuous operation where mains drop-out is a possibility. The battery unit includes a current-limited battery charger driven from the 2435 mainframe and this charger can be used when the frequency meter is fully operational. There is also facility for charging from an external 12 volt car battery. Recharging time to full capacity is approximately 15 hours at 700 mA. The battery pack cannot be damaged by indefinite overcharging.




*2435 in Rack Mounting Kit with some optional accessories.* 14741/1

# 2435

**INPUT CHANNELS**

Two channels, switch selected, covering the frequency range 10 Hz to 2 GHz.

**INPUT CHANNEL A**

**Frequency range**
200 MHz to 2 GHz.

**Dynamic range**
Built-in a.g.c. provides the capability for handling signals over a dynamic range of at least 25 dB.

**Sensitivity**
−12 dBm (56 mV r.m.s. p.d. into 50 Ω).

**Maximum sinewave input**
+13 dBm (1 V r.m.s. p.d. into 50 Ω).

**Maximum d.c.**
100 V.

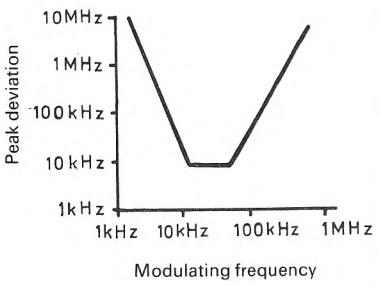
**Overload limit**
10 W continuous incident power.
100 W pulse (maximum pulse length 1 μs; duty cycle ⩽10%).

**Input impedance**
50 Ω.

**Input v.s.w.r.**
Better than 2:1.

**AM tolerance**
Up to 50% modulation depth at signal levels between −7 dBm and +7 dBm at modulating frequencies of 1 kHz or less

**FM tolerance**
*Worst case:* At least 5 kHz peak deviation at any modulating frequency (single tone) at any carrier frequency within the frequency range and any level from −7 dBm to +7 dBm.
*Typical:* At any carrier frequency within the frequency range the performance is typically better than the graph at any level from −7 dBm to +7 dBm.




**INPUT CHANNEL B**

**Frequency range**
10 Hz to 200 MHz.

**Dynamic range**
Built-in a.g.c. provides capability for handling signals over a dynamic range of up to 90 dB.

**Sensitivity**
10 mV r.m.s. sinewave from 10 Hz to 70 MHz.
25 mV r.m.s. sinewave from 70 MHz to 200 MHz.

**Maximum sinewave input**
260 V r.m.s. at 50 Hz.
5 V r.m.s. at 200 MHz approximately.
Degradation from 50 Hz to 200 MHz is approximately $1{\cdot}3\times10^{-6}$ V/Hz.

**Maximum d.c.**
250 V.

**Maximum pk. a.c. +d.c.**
250 V r.m.s. at 50 Hz.

**Input impedance**
Greater than 1 MΩ in parallel with less than 25 pF. AC coupled via 0·1 μF.

**Input filter**
Switchable low pass filter reduces sensitivity above 10 kHz to inprove noise immunity when measuring l.f. signals. Attenuation is at least 20 dB above 100 kHz.

**MODES OF OPERATION**

**Range selection**
Six push-buttons select the following ranges and indicate resolution and readout units.

| Range | Gate time | Resolution |
|---|---|---|
| 1 | 1 ms | 1 kHz |
| 2 | 10 ms | 100 Hz |
| 3 | 100 ms | 10 Hz |
| 4 | 1 s | 1 Hz |
| 5 | 10 s | 0·1 Hz |
| 6 | 1 s | 0·01 Hz |

Notes:
1. Range (6) operates only on channel B up to 5 kHz.
2. Range (5) is specified only on channel B.
3. Ranges (1) to (4) operate on both channels over the full frequency range.
4. Gate times apply directly to channel B only. For channel A the gate times are increased by a factor of approximately (input frequency)/35 MHz.

**DISPLAY**
Eight digit with memory.
Seven segment l.e.d.s. of 8 mm height.

**Features**
Decimal point automatically selected.
Overflow indication.
Leading zeros suppressed.
Digit check facility – releasing all range buttons displays all l.e.d. segments and decimal points.

**Display time**
Readout retained during gating period.

**Gate indication**
Lamp indicates gating period.

**ACCURACY**
±1 count ±frequency standard error (except for ratio measurements which is ±2 counts ±frequency standard error).

**FREQUENCY STANDARD**
Internal crystal oscillator or external input automatically selected. Application of external signal overrides the internal oscillator. A front panel lamp indicates when the external standard is in operation.

**INTERNAL STANDARD**

**Frequency**
10 MHz. A control accessible through the rear panel allows adjustment of the internal standard to compensate for ageing.

**TEMPERATURE COMPENSATED CRYSTAL OSCILLATOR (MODEL 52435-302A)**

**Temperature stability**
Better than ±1·5 p.p.m. over the operating temperature range of 0° to 40°C.

**Ageing rate**
Better than ±0·4 p.p.m. nominal per month after 1 month continuous use.

# 2435

**OVEN CONTROLLED CRYSTAL OSCILLATOR (MODEL 52435-303Z)**

**Temperature stability** — Better than ±0·1 p.p.m. over the operating temperature range of 0° to 40°C.

**Ageing rate** — Better than ±0·4 p.p.m. nominal per month after 1 month continuous use.

**Warm-up time** — Within 0·5 p.p.m. of final frequency within 5 min from switch-on at 20°C ambient.

**AUXILIARY OUTPUT**

**Frequency** — Internal standard at 1 MHz available from rear panel socket.

**Level** — Greater than 100 mV p-p into 50 Ω (approximately 4 V p-p e.m.f.).

**Impedance** — Approximately 2 kΩ.

**EXTERNAL FREQUENCY STANDARD**

**Frequency** — 1 MHz sinewave or squarewave. Usable from 10 kHz to 1 MHz for ratio measurements on Channel B only.

**Input level** — 150 mV r.m.s. minimum up to approximately 10 V r.m.s. maximum.

**Impedance** — 100 kΩ minimum, a.c. coupled.

**DATA INTERFACE**

BCD data output and remote range selection are available using the optional data interface kit. This kit, which can be installed by the user, provides the following connexions.

| Mnemonic | Function |
|---|---|
| ABCD, BBCD, CBCD, DBCD | BCD data output, bit parallel, byte serial. |
| DEN | Display enable input. |
| OFL | Overflow indication output. |
| NCLR | Counter and display clear input. |
| NINH | Counter control – may be used as an output to monitor gate or as an input to control gate. |
| SCX | External display scan unit – also controls data output multiplexing. |
| SCR | External display scan enable input. |
| DPT | Decimal point output. |
| LZS | Leading zeros suppression output. |
| ATB, BTB, CTB, DTB, ETB | 1 of 5 range selection input. |
| NREM | Not remote (i.e. local). |
| FREQ | Selects l.f. multiplier. |

**RADIO FREQUENCY INTERFERENCE**

Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference.

**SAFETY**

Complies with IEC 348.

**OPERATING TEMPERATURE RANGE**

**Rated range of use** — 0° to 40°C.

**Limit range of operation** — 0° to 55°C.

**CONDITIONS OF STORAGE AND TRANSPORT**

**Temperature** — −40°C to +70°C.

**Humidity** — Up to 90% relative humidity.

**Altitude** — Up to 2500 m (pressurized freight at 27 kPa differential, i.e. 3·9 lbf/in²).

**GUARANTEE** — Two years from delivery.

**POWER REQUIREMENTS**

**AC supply** — Switchable voltage ranges:
105 to 110 V, 115 to 120 V, 210 to 220 V, 230 to 240 V, all ±10%.
50 to 400 Hz ±10%.
20 VA approximately.

**BATTERY** (Model 52435-304H).

**Type** — Fully sealed NiCd battery pack.

**Voltage** — 6 V nominal.

**Capacity** — Sufficient for minimum of two hours (typically three hours) of continuous operation at a charging and operating temperature of 20°C. A front panel lamp indicates when the battery is discharged.

**Recharging time** — Approximately fifteen hours to charge fully a discharged battery when in the 'charge' mode.

**External charge** — Rear panel switch and terminals allow the battery to be charged from an external d.c. source in the range 10 to 14 V. The maximum current required is 700 mA.

**Modes of operation** — Three modes are selected by front panel push-buttons.

**Off** — If the a.c. supply is connected the frequency meter operates normally and the battery receives a trickle charge.

**On/standby** — If the a.c. supply is connected the frequency meter operates normally and the battery receives a trickle charge. If the a.c. supply is removed the battery supplies power. A front panel lamp indicates when the instrument is operating on battery power.

**Charge** — If the a.c. supply is connected the frequency meter operates normally and the battery receives a fast charge. A front panel lamp indicates when the charge mode is selected.

**DIMENSIONS AND WEIGHT**

| | Height | Width | Depth | Weight |
|---|---|---|---|---|
| **Models 302A and 303Z** | 108 mm | 256 mm | 338 mm | 4·5 kg |
| | 4·25 in | 10·1 in | 13·3 in | 10 lb |
| **Model 304H** | 153 mm | 256 mm | 338 mm | 7·5 kg |
| | 6·1 in | 10·1 in | 13·3 in | 16·5 lb |

## VERSIONS AND ACCESSORIES

*When ordering please quote eight digit code numbers*

| Ordering numbers | |
|---|---|
| | **Versions** |
| **52435-302A** | 2 GHz Digital Frequency Meter 2435 with temperature compensated crystal oscillator. |
| **52435-303Z** | 2 GHz Digital Frequency Meter 2435 with oven controlled crystal oscillator. |
| **52435-304H** | 2 GHz Digital Frequency Meter 2435 with temperature compensated crystal oscillator and with battery pack. |
| | **Supplied Accessories** |
| | AC Supply Lead 43123-076Y |
| | Operating Manual 46881-357T (H52435-900F Vol. 1). |
| | **Optional Accessories** |
| **54124-022L** | Cover (lid). |
| **43126-012S** | BNC to BNC lead. 50 Ω, 1·5m. |
| **46883-401T** | Rack Mounting Kit. |
| **46883-405C** | Data Interface Kit. |
| **54311-093X** | Coaxial Adapter, Type N male to BNC female. |
| **43126-026A** | RF Connecting Lead, Type N, 50 Ω, 457 mm. |
| **54431-021B** | 20 dB 5 W Attenuator. |
| **54421-001N** | Telescopic Aerial with BNC plug. |
| **46881-358P** | Service Manual (H52435-900F Vol. 2). |

# GPIB Unit 2436




14935/2

- **Provides full GPIB programmability for digital frequency meters and universal counter timers**
- **Suitable for use with all models in the 2430A, 2431A, 2432A, 2435, 2437 and 2438 series**

2436 provides a GPIB interface for Marconi Instruments' current range of digital frequency meters and universal counter timers. It is housed in a similar case and it is intended to be used alongside the associated instrument. The two units are connected by a single cable via multiway connectors and 2436 is independently powered directly from the a.c. supply.

Front panel interlocking push-buttons permit three modes of operation to be selected enabling the associated instrument to send data over the GPIB, to be controlled via the bus or to both send data and receive commands. Further push-buttons can be used to prevent the instrument operating over the GPIB or momentarily to restore control to the instrument's front panel.

The combination of 2436 with any of the digital frequency meters or counter timers forms a fully GPIB programmable instrument suitable for many systems applications.

# 2436

## CONTROLS

**Front panel**

Three interlocked push-buttons select the following modes of operation.

1. Talk only – the instrument front panel controls operate normally, but data is sent over the GPIB at the end of each gate period.
2. Listen only – the main front panel controls are rendered inoperative and the instrument is controlled via the GPIB, but data is not sent over the GPIB.
3. Programmable – the instrument is fully GPIB programmable and may be addressed over the GPIB to listen (to read control settings from the GPIB) or to talk (to output data over the GPIB).

Two independent push-buttons additionally select.

4. SRQ inhibit – when depressed this control prevents the unit from requesting service over the GPIB. (This facility is necessary when the system controller cannot respond to SRQ and it can also be useful in system debugging.
5. Return to local – this control returns the instrument to local operation unless it has been inhibited by the system controller.

**Rear panel**

Five-pole binary switch selects GPIB address.

## GPIB FUNCTIONS

**Bus capabilities**

Complies with the following subsets as defined in IEEE 488–1978.
SH1, AH1, T5, TEØ, L3, LEØ, SR1, RL1, PPØ, DC1, DT1, CØ, E1.

**Data output format**

Data is output in a character string with the following general format:

␣1 2 3 . 4 5 6 7 8 E ± Ø 6 $\begin{matrix}H&Z\\S&\end{matrix}$ ␣ CR LF

Notes:

1. First character is either a space or a * to indicate overflow.
2. Decimal point is positioned as in the instrument display: the exponent (character 13 and 14) is then a multiple of 3.
3. The twelfth character is + or − as appropriate.
4. Fifteenth and sixteenth characters are HZ to indicate Hertz, or S (space) to indicate seconds.
5. End of string is asserted concurrently with LF.

## INTERFACE BUS SPECIFICATIONS

**Driver**

Output voltage in low state is less than +0·5 V at +55 mA sink current.

**Receiver input threshold**

Low to high +1·9 V max.
High to low +0·8 V min.
Hysteresis +0·5 V min.

**Bus loading**

With transceivers set to receive:
With +0·4 V applied current is −1·5 mA to −3·0 mA.
With 0 mA applied, voltage is +2·6 V to +3·6 V.

**Time values**

Refer to IEEE Standard 488–1978. Table 39 for full information.
Response to ATN (t2) ⩽ 200 ns.
Response to IFC or REN false (t4) <100 µs.
Settling time for multiline messages (T1) ⩾ 2 µs.

## GPIB CONNECTOR

Amphenol type 57, 24 way.
Connections as defined in IEEE Standard 488–1978.

## RADIO FREQUENCY INTERFERENCE

Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference.

## SAFETY

Complies with IEC 348.

## OPERATING TEMPERATURE RANGE

**Rated range of use**

0° to 40°C.

**Limit range of operation**

0° to 55°C.

## CONDITIONS OF STORAGE AND TRANSPORT

**Temperature**

−40° to +70°C.

**Humidity**

Up to 90% relative humidity.

**Altitude**

Up to 2500 m (pressurized freight at 27 kPa differential, i.e. 3·9 lbf/in²).

## GUARANTEE

Two years from delivery.

## POWER REQUIREMENTS

**AC Supply**

Switchable voltage ranges:
105 to 110 V, 115 to 120 V, 210 to 220 V, 230 to 240 V, all ±10%.
50 to 400 Hz ±10%.
10 VA approximately.

## DIMENSIONS AND WEIGHT

| Height | Width | Depth | Weight |
|---|---|---|---|
| 100 mm | 220 mm | 310 mm | 2·2 kg |
| 4 in | 8¾ in | 12 in | 4¾ lb |

## VERSIONS AND ACCESSORIES

*When ordering please quote eight-digit code numbers*

| Ordering numbers | |
|---|---|
| **52436–900C** | **Versions**<br>GPIB Unit 2436. |
| | **Supplied Accessories**<br>AC Supply Lead 43123–076Y.<br>Data Link Cable 43129–548W.<br>Instruction Manual 46881–396C. |
| **43129–189U** | **Optional Accessories**<br>GPIB Lead, 1 m. |
| **46883–401T** | Rack Mounting Kit. |
| **46883–405C** | Data Interface Kit. |
| **46883–408K** | IEEE/IEC Adapter Block. |
| **46883–483U** | Diagnostic Kit. |
| **54124–022L** | Cover Assembly (Storage). |

# Universal Counter Timers 2437 and 2438




*Models 2437 and 2438* *14741/3*

- ☐ **2437; d.c. to 100 MHz**
- ☐ **2438; d.c. to 520 MHz**
- ☐ **Period and timing measurement to 100 ns**
- ☐ **Measurement modes include frequency, period, time interval, time interval averaging and count**
- ☐ **Single and dual line timing with independent selection of coupling, attenuation, slope and trigger level**
- ☐ **Extremely simple to use with trigger lights and monitor facility**
- ☐ **Period resolution to 100 ps**
- ☐ **Data interface option**
- ☐ **Excellent reliability and servicing accessibility – 2 year guarantee**

Universal counter timers 2437 and 2438 are very versatile, general purpose instruments providing measurement of frequency, frequency ratio, period, multi-period, time interval, time interval averaging and counting.

Model 2437 offers frequency measurement from d.c. to 100 MHz and model 2438 from d.c. to 520 MHz. They both have period and timing ranges of 100 ns to 1000 seconds and a count capability of up to $10^7$ events per second.

Despite the versatility and the number of functions offered, the instruments have been made simple to operate by attention to panel layout and colour coding of controls and legends. Comprehensive triggering facilities make timing measurements very easy.

The counting section of the models is based around a specially designed MOS-LSI chip, resulting in low cost, small size, low power consumption and excellent reliability.

# 2437/2438




*100 MHz Universal Counter Timer 2437* *14741/20*

## Input channels

Each model has two input channels, A and B. Channel A is used for period measurements, it is the timing 'start' channel and it can be used to control the 'count' gating. Channel B is used for frequency and counting measurements and is the timing 'stop' channel. A SEPARATE/COMMON switch parallels the input sockets so that for most measurements either input can be used.

Push-buttons for each channel provide a.c. or d.c. coupling, a ×10 attenuator and selection of positive or negative trigger slope. Separate controls for each channel also adjust the trigger level and are used in conjunction with trigger lamps. When the trigger level is set below the signal threshold the lamps are off, and when the trigger level is above the signal threshold the lamps are on. Correct triggering is indicated by the lamps flashing. Front panel monitor outputs are provided for displaying the trigger points on an oscilloscope.

When making timing measurements on signals from sources with mechanical contacts, errors can be introduced due to multiple start and stop signals caused by contact bounce. To overcome this difficulty the counter timers incorporate trigger delay controls which allow the instrument to trigger off the first edge presented to it and then disable both start and stop channels for a variable time before allowing triggering to recommence. The length of this delay can be measured on the counter.

## Operating modes

Frequency measurements are made by applying the signal to be measured to channel B. Frequency ratio measurements can be made by applying the higher frequency signal to the channel B input and the lower frequency signal to the rear panel external standard input.

Counting of a number of events, up to $10^7$ per second, can be made by applying the signals to channel B and it continues for a time controlled either by manual operation of a front panel START/STOP push-button, or by applying gating signals to channel A.

Period measurements are made by counting the internal 10 MHz clock for a time determined by the period of the signal applied to channel A. To improve accuracy and resolution a multiple period mode can be used in which the gate is opened for 10, 100 or 1000 periods of the incoming signal.

Time interval measurements are made by applying a 'start' signal to channel A and a 'stop' signal to Channel B. To increase accuracy and resolution, synchronized time interval averaging can be employed, in which 10, 100 or 1000 discrete gate times can be counted. This also enables measurements to be made of intervals less than the fundamental clock period.

## Display

Frequency readout is by eight-digit light emitting diode display with memory. Characters are seven-segment and have a minimum height of 8 mm.

Readout units – for frequency or time – are indicated by front-panel markings adjacent to the range push-buttons. Decimal point positioning, overflow indication and leading zero suppression are all automatic. A digit-check facility is also included whereby all the l.e.d. segments and all decimal points are displayed when all the gate-time buttons are simultaneously released. A front-panel control enables the display time to be varied.

## Frequency standard

Two versions of each instrument are available with different frequency standards. Model 2437 has a choice of a crystal oscillator with a temperature stability better than ±5 p.p.m. over the operating temperature range, or a temperature compensated crystal oscillator with a stability better than ±1·5 p.p.m. Model 2438 has a choice of the temperature compensated crystal oscillator or an oven-controlled crystal oscillator with a stability better than ±0·1 p.p.m. A control accessible through the rear panel permits adjustment of the internal standard to compensate for crystal ageing.

There is provision for operating with an external standard applied via a rear-panel socket. A 10 MHz signal is required for 2438, but 2437 uses a phase-locked




*520 MHz Universal Counter Timer 2438* *14741/24*

loop acting as a ×10 multiplier to enable the more readily available 1 MHz standard to be used. Application of an external signal automatically overrides the internal oscillator, and a front panel lamp indicates when the external standard is in use. If this external standard fails or is removed, the instrument switches automatically to operation from the internal oscillator. This feature is valuable in automatic or remote set-ups where there is no access to the rear panel. The sensitivity and bandwidth versatility of the external input offer the possibility of ratio measurements by connecting one signal to the front panel input socket and the other signal to the external standard socket.

## Data interface

The counter timers can be fitted with an optional data output and programming interface, allowing them to be used with a printer or as part of an instrumentation system.

External control signals can set the instruments to remote, set the required function and the range, clear and trigger the count sequence and enable or disable the display.

The resulting frequency or time reading is available as serial b.c.d. data multiplexed into the interface by external synchronizing signals. Decimal point indication and suppressed leading zeros data are multiplexed simultaneously. Provision is included for single measurements by giving direct access to the main gate control circuitry.

The data interface kit consists of a 24-way connector which is fitted to the rear panel and a ribbon cable which links this connector to miniature sockets in the instrument. This kit can readily be fitted by the user.




*2437 in Rack Mounting Kit with some optional accessories* *14756/1*

# 2437/2438

## Specification for the series

| TYPE NUMBER | 2437 | 2438 |
|---|---|---|
| INPUT CHANNELS | Two channels, A and B. | |
| INPUT CHANNEL A<br>Frequency range | *DC coupled:* DC to 10 MHz<br>*AC coupled:* 10 Hz to 10 MHz | |
| Sensitivity | 30 mV r.m.s. sinewave from d.c. to 1 MHz<br>50 mV r.m.s. sinewave from 1 MHz to 10 MHz | |
| INPUT CHANNEL B<br>Frequency range | *DC coupled:* DC to 10 MHz<br>*AC coupled:* 10 Hz to 10 MHz<br>*AC coupled, VHF mode:* 10 MHz to 100 MHz. | *DC coupled:* DC to 10 MHz<br>*AC coupled:* 10 Hz to 10 MHz<br>*AC coupled, frequency mode:* 10 Hz to 50 MHz<br>*AC coupled, UHF frequency mode:* 50 MHz to 520 MHz. |
| Sensitivity | 30 mV r.m.s. sinewave from d.c. to 1 MHz.<br>50 mV r.m.s. sinewave from 1 MHz to 10 MHz.<br>*VHF mode:* 10 mV r.m.s. sinewave from 10 MHz to 50 MHz. 25 mV r.m.s. sinewave from 50 MHz to 100 MHz. | 30 mV r.m.s. sinewave from d.c. to 1 MHz.<br>50 mV r.m.s. sinewave from 1 MHz to 10 MHz.<br>*Frequency mode:* 10 mV r.m.s. sinewave from 10 Hz to 20 MHz. 15 mV r.m.s. sinewave from 20 MHz to 50 MHz.<br>*UHF frequency mode:* −19 dBm (25 mV r.m.s. p.d. into 50 Ω) from 50 MHz to 520 MHz. |
| CHANNELS A AND B<br>Input impedance | Approximately 1 MΩ in parallel with less than 45 pF. | Approximately 1 MΩ in parallel with less than 45 pF. Channel B, UHF frequency mode: 50 Ω nominal. |
| Maximum input | *DC coupled:* 250 V d.c.<br>*AC coupled:* 250 V r.m.s. sinewave at 50 Hz, decreasing to 5 V r.m.s. sinewave at 100 MHz. | *DC coupled:* 250 V d.c.<br>*AC coupled:* 250 V r.m.s. sinewave at 50 Hz, decreasing to 10 V r.m.s. sinewave at 50 MHz, except Channel B, UHF frequency mode: +21 dBm (2·5 V r.m.s. p.d. into 50 Ω) from 50 MHz to 520 MHz.<br>**Note: These levels will not cause damage whether or not the attenuators are used, but the attenuators should be selected at high signal levels for correct operation.** |
| Controls | Separate push-buttons for each channel provide:<br>*Coupling:* a.c. or d.c.<br>*Attenuator:* attenuates input by ×10 nominal,<br>*Slope:* selects +ve or −ve trigger.<br>A single push-button commons both channels. | Separate push-buttons for each channel provide:<br>*Coupling:* a.c. or d.c.<br>*Attenuator:* attenuates input by ×10 nominal. Channel B, UHF frequency mode: 10 dB nominal.<br>*Slope:* selects +ve or −ve trigger.<br>A single push-button commons both channels |
| Trigger level | Separate controls adjust trigger level from:<br>0 V to ± 2·5 V (attenuator ×1)<br>0 V to ±25 V (attenuator ×10)<br>A switched position on the trigger level controls selects 0 V nominal. | |
| Monitor outputs | Front panel outputs allow monitoring of trigger points.<br>Positive edge of output waveform corresponds to trigger point. | |
| Trigger indication | Separate lamps indicate trigger level:<br>*Lamp on:* trigger level above signal threshold.<br>*Lamp off:* trigger level below signal threshold.<br>*Lamp flashing:* triggering in range. | |
| Ratio input | Rear panel switch enables external standard input to be used for ratio measurements.<br>**Frequency range:** 10 kHz to 10 MHz.<br>**Sensitivity:** 180 mV r.m.s. sinewave.<br>**Maximum input:** 1·8 V r.m.s. sinewave.<br>**Input impedance:** 10 kΩ nominal. | |
| MODES OF OPERATION<br>Functions | Seven push-buttons select the following functions:<br>(i) Freq. B: Channel B is used for frequency measurements.<br>(ii) VHF/UHF: selects v.h.f./u.h.f. mode on Channel B for frequency measurement only.<br>(iii) Per. A: Channel A is used for period measurements.<br>(iv) Count B: Channel B input is counted.<br>(v) Start/Stop: momentary action button used to start and stop count function. The count function is also started and stopped by an input to Channel A.<br>(vi) Reset: resets memory and display (for use mainly in 'count' mode.)<br>(vii) T. Int A–B: a time interval measurement is started by a pulse on Channel A and stopped by a pulse on Channel B. The number of intervals averaged depends on the range selected.<br>Simultaneous selection of Per. A and VHF/UHF functions causes the delay time to be displayed. | |

| TYPE NUMBER | 2437 | 2438 |
|---|---|---|

**Range of operation**

**Frequency:** d.c. to 100 MHz (see Channel B specification)

**Frequency:** d.c. to 520 MHz (see Channel B specification)

**Period and time:** 100 ns minimum to 1000 s maximum without overflow.

**Count:** up to $10^7$ events per second.

**Range selection**

Five push-buttons select the following ranges and indicate readout units:

| | | Frequency Mode | | Period or Time Interval Mode | | |
|---|---|---|---|---|---|---|
| Range | Readout Units | Gate Time† | Resolution | No. of Periods Averaged | Resolution | |
| | | | | | Period | T.I.* |
| (i) | MHz/s | 1 ms | 1 kHz | 1 | 10 µs | |
| (ii) | MHz/ms | 10 ms | 100 Hz | 1 | 100 ns | |
| (iii) | kHz/µs | 100 ms | 10 Hz | 10 | 10 ns | 33 ns |
| (iv) | kHz/µs | 1 s | 1 Hz | 100 | 1 ns | 10 ns |
| (v) | Hz/ns | 10 s | 0·1 Hz | 1000 | 100 ps | 3·3 ns |

*In T.I. averaging mode:

$$\text{Resolution} = \frac{100\text{ ns}}{\sqrt{\text{No. Intervals averaged}}} \pm 100\text{ ps}$$

†For Channel B, UHF frequency mode, multiply gate times by 10.

**Ratio mode**

Rear panel switch selects ratio mode. Selection of Freq. B then measures the ratio between Channel B input and the rear panel input.

| Range | n |
|---|---|
| (i) | $10^4$ |
| (ii) | $10^5$ |
| (iii) | $10^6$ |
| (iv) | $10^7$ |
| (v) | $10^8$ |

$$\text{Displayed ratio} = \frac{nB}{R}$$

**Delay control**

A rear panel control provides a variable delay for use in Time Interval, Count B and Period A modes to eliminate false triggering due to contact bounce. Both channels are disabled for a pre-determined period following receipt of a start signal.

The decimal point flashes when the delay is switched on.

**Range:** 150 µs to 8 ms continuous adjustment.

**Dead time:** typically 100 ns (time between delay trigger pulse and delay becoming operative).

**DISPLAY**

**Features**

Eight digits with memory.
Seven segment l.e.d. of 8 mm height.
Decimal point automatically selected.
Lamp indicates overflow.
Leading zeros suppressed.
Digit check facility releasing all range buttons displays all segments and decimal points.

**Display time**

Front panel control varies display time typically from 100 ms to 10 s in addition to gate time.

**Gate indication**

Lamp indicates gating period.

**ACCURACY**

**Frequency measurement**

±1 count ±frequency standard error.

**Period measurement**

± 1 count ± frequency standard error ± trigger error/number of periods averaged.

**Time interval measurement**

*Single interval:* ± 1 count ± frequency standard error ± trigger error.

*Interval averaging:* ± systematic error ± frequency standard error

$$\pm \frac{100\text{ ns} \pm \text{triggering error}}{\sqrt{\text{number of periods averaged}}}$$

Notes: 1. Minimum pulse width for period or time measurement is 50 ns.

2. Minimum dead time from each stop event to the next start event is 100 ns.

3. Trigger error is less than 0·3% of one period for sinewave of 40 dB S/N or better and amplitude equal to sensitivity of instrument. For any waveshape the trigger error is less than:

$$\frac{\pm 2 \times \text{peak noise voltage}}{\text{signal slope}}$$

or $\pm \frac{0{\cdot}85\text{ ns}}{\text{signal slope}}$ for 40 dB S/N. (Signal slope has the units of V/µs)

4. Systematic error is the difference in delays between the start and stop channels which can be minimised by external matching. Without matching the error is 10 ns maximum per input.

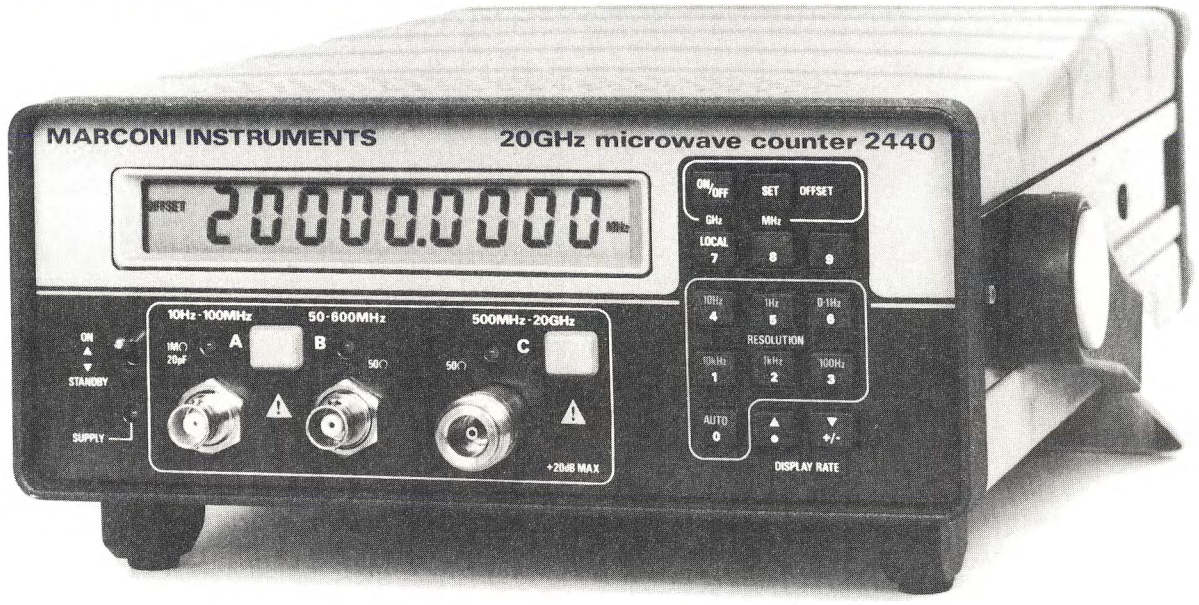
# 2437/2438

| TYPE NUMBER | 2437 | 2438 |
|---|---|---|
| **FREQUENCY STANDARD** | Internal oscillator or external input automatically selected. Application of the external signal overrides the internal oscillator.<br>A front panel lamp indicates when the external standard is accepted. | |
| **INTERNAL STANDARD**<br>**Frequency** | 10 MHz. A control accessible through the rear panel allows adjustment of the internal standard to compensate for ageing. | |
| **CRYSTAL OSCILLATOR** | Model 52437–301C | |
| **Temperature stability** | Better than ±5 p.p.m. over the operating temperature range of 0° to 40°C. | |
| **Ageing rate** | Better than ±0·8 p.p.m. nominal per month after 1 month continuous use. | |
| **TEMPERATURE COMPENSATED CRYSTAL OSCILLATOR** | Model 52437–302R | Model 52438–302L |
| **Temperature stability** | Better than ±1·5 p.p.m. over the operating temperature range of 0° to 40°C. | |
| **Ageing rate** | Better than ±0·4 p.p.m. nominal per month after 1 month continuous use. | |
| **OVEN CONTROLLED CRYSTAL OSCILLATOR** | | Model 52438–303J |
| **Temperature stability** | | Better than ±0·1 p.p.m. over the operating temperature range of 0° to 40°C. |
| **Ageing rate** | | Better than ±0·4 p.p.m. nominal per month after 1 month continuous use. |
| **Warm-up time** | | Within 0·5 p.p.m. of final frequency within 5 min from switch-on at 20°C ambient. |
| **AUXILIARY OUTPUT** | Internal standard at 1 MHz available from rear panel socket. | Internal standard at 10 MHz available from rear panel socket. |
| **Level** | Greater than 100 mV p-p into 50 Ω (approximately 4 V e.m.f.). | |
| **Impedance** | Approximately 2 kΩ. | |
| **EXTERNAL STANDARD INPUT** | | |
| **Frequency** | 1 MHz sinewave or squarewave. | 10 MHz sinewave or square wave. |
| **Input level** | 500 mV to 5 V p-p. | |
| **Input impedance** | Approximately 10 kΩ a.c. coupled. | |
| **DATA INTERFACE** | BCD data output and remote range selection is available using the data interface kit (see accessories list). This kit, which can be installed by the user, provides the following connections:<br>Mnemonic — Function<br>ABCD, BBCD, CBCD, DBCD — BCD data output, bit parallel, byte serial<br>DEN — Display enable input<br>OFL — Overflow indication output<br>NCLR — Counter and display clear input<br>NINH — Counter gate control – may be used as an output to monitor the gate or as an input to control the gate.<br>SCX — External display scan input – also controls data output multiplexing.<br>SCR — External display scan enable input<br>DPT — Decimal point output<br>LZS — Leading zero suppression output.<br>ATB, BTB, CTB, DTB, ETB — 1 of 5 range selection input<br>FUNC — Select VHF/UHF mode input<br>TIME — Time interval<br>PER — Period<br>FREQ — Frequency<br>CNTB — Count<br>NREM — Not remote (i.e. Local)<br>Select 1 of 5 function input | |

# 2437/2438

| TYPE NUMBER | 2437 | 2438 |
|---|---|---|
| RADIO FREQUENCY INTERFERENCE | Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference. | |
| SAFETY | Complies with IEC 348. | |
| OPERATING TEMPERATURE RANGE | | |
| Rated range of use | 0° to 40°C. | |
| Limit range of operation | 0° to 55°C. | |
| CONDITIONS OF STORAGE AND TRANSPORT | | |
| Temperature | −40° to +70°C. | |
| Humidity | Up to 90% relative humidity. | |
| Altitude | Up to 2500m (pressurized freight at 27 kPa differential i.e. 3·9 lbf/in²). | |
| POWER REQUIREMENTS | | |
| AC supply | Switchable voltage ranges: 105 to 110 V, 115 to 120 V, 210 to 220 V, 230 to 240 V, all ±10%, 50 to 400 Hz ±10%. 20 VA approximately. | |
| DIMENSIONS AND WEIGHT | Height: 108 mm / 4·25 in; Width: 256 mm / 10·1 in; Depth: 338 mm / 13·3 in; Weight: 4·0 kg / 8·8 lb | |
| VERSIONS | | |
| Ordering number and description | **52437–301C**<br>100 MHz Universal Counter Timer 2437 with standard crystal oscillator.<br>**52437–302R**<br>100 MHz Universal Counter Timer 2437 with temperature compensated crystal oscillator. | **52438–302L**<br>520 MHz Universal Counter Timer 2438 with temperature compensated crystal oscillator.<br>**52438–303J**<br>520 MHz Universal Counter Timer 2438 with oven controlled crystal oscillator. |
| SUPPLIED ACCESSORIES | | Mains Lead 43123–076Y<br>Operating Manual Vol. 1. |
| OPTIONAL ACCESSORIES | 54124–022L<br>43126–012S<br>46883–401T<br>46883–405C<br>43129–399L<br>54431–011D<br>54431–021B<br>54421–001N<br>46881–360T<br><br>46881–362X | Cover (Lid)<br>BNC to BNC lead, 50 Ω, 1·5 m.<br>Rack Mounting Kit<br>Data Interface Kit<br>Monitor Output Lead, Conhex (SMS) to BNC<br>20 dB, 1 W, 50 Ω Attenuator (for 2438)<br>20 dB, 20 W, 50 Ω Attenuator (for 2438)<br>Telescopic Aerial with BNC Plug.<br>Service Manual for 2437 (H 52437–900N Vol. 2)<br>Service Manual for 2438 (H 52438–900P Vol. 2) |

# MICROWAVE COUNTER 2440




- ☐ **Extends frequency measurement into high microwave (J-band) region.**
- ☐ **High sensitivity even at microwave frequencies.**
- ☐ **Fast acquisition.**
- ☐ **Compact and portable.**
- ☐ **Fully GPIB programmable.**
- ☐ **High f.m. and a.m. tolerance.**

With a measurement range extending from 10 Hz up towards the top of the J-band (10 GHz – 20 GHz), the new 2440 Microwave Counter offers the added user convenience of small physical size and portable operation. Other advantages include high sensitivity (–20 dBm at frequencies above 12 GHz), high f.m. and a.m. tolerance, and fast acquisition time. The instrument's new-generation microprocessor-based design offers enhanced ease of use and the option of full GPIB-based operation. A choice of internal frequency standards, as well as operation with external standards, is also available.

## MEASUREMENT CAPABILITIES

**Frequency coverage**
3 input channels covering the entire frequency range:
Channel A 10 Hz – 100 MHz
B 50 MHz – 600 MHz
C 600 MHz up

**Sensitivity**
25 mV r.m.s. sinewave 10 Hz – 10 MHz
50 mV r.m.s. sinewave 10 MHz – 50 MHz
75 mV r.m.s. sinewave 50 MHz – 100 MHz
–20 dBm 50 MHz – 560 MHz
–25 dBm 600 MHz – 12 GHz
–20 dBm 12 GHz up

**Low-pass filter**
Channel A is fitted with a switchable low-pass filter to improve noise immunity when measuring l.f. signals.

**Frequency Offset Function**
Keyboard entry and display of reference frequency for subsequent selection as offset datum for frequency readings.

**Resolution**
Resolution in 6 ranges from 0·1 Hz to 10 kHz, with eigher manual range selection or full autoranging operation.

## OUTPUT

**Display**
9-digit LCD with annunciators.

**Display rate**
Can be incremented/decremented from keyboard.

**Analogue**
Optional digital-to-analogue convertor gives analogue voltage output.

**Auxiliary Frequency Ouput**
Provides rear-panel access to internal frequency standard.

## FREQUENCY STANDARDS

**Internal/External**
Internal 10 MHz standard selected as default, overriden by external signal applied to reference input.

**Internal Standard**
Different versions employ:
- temperature compensated crystal oscillator
- oven controlled crystal oscillator
- double oven controlled crystal oscillator

**Internal Frequency Adjustment**
Control allows adjustment to compensate for ageing of internal crystal oscillator.

**GPIB**
Option supports full GPIB operation.

marconi instruments

# Power Meters


| | | |
|---|---|---|
| AF Power Meter (10 watts) | 893B | 136 |
| RF Power Meter (3 watts) | TF 2501 | 138 |
| RF Power Meter (10 watts) | TF 2502 | 139 |
| RF Power Meter (100 watts) | TF 2503 | 140 |
| 75/50 Ω RF Transformer | TF 2509 | 141 |


*For further Power Meters see the Microwave Products Section:*


| | | |
|---|---|---|
| tft Power Heads (10 MHz to 40 GHz) | 6440/6420 series | 232 |
| Military tft Power Meter Systems | 6460S/CT596 | 235 |
| Power Meter *(Advance Data)* | 6900 series | 252 |

# AF Power Meter 893B




*Model 50893-321J with SINAD filter* *14715/5*

- ☐ **Ten power ranges: 300 µW to 10 W full scale**
- ☐ **Frequency range: 20 Hz to 35 kHz**
- ☐ **Impedance: 2·5 Ω to 20 kΩ in 48 steps**
- ☐ **Balanced or unbalanced inputs**
- ☐ **Direct calibration in watts and dBm**
- ☐ **Version available with SINAD filter**

AF Power Meter 893B covers the wide power range of 300 µW to 10 W full scale in ten ranges, and operates over the frequency range of 20 Hz to 35 kHz.

Power delivered by the source into a load provided by the power meter is measured by a temperature-compensated multi-range detector circuit feeding a voltmeter. Ten power range push-buttons are marked in voltage and in dBm, and the meter is calibrated with voltage scales marked from 0 to 3 and from 1 to 10, providing good resolution, and also with a dBm scale.

The required input impedance is obtained by means of a tapped transformer and switched resistive matching pads, providing 48 impedances between 2·5 Ω and 20 kΩ. Unbalanced inputs are provided by connecting across the two input terminals, and balanced inputs by connecting the centre tap of the source to the CT terminal. Impedance of one quarter of the marked value (i.e. down to 0·625 Ω) can be obtained by connecting the source between one input terminal and the CT terminal. Impedance is selected by means of two controls with colour coded panel markings, a six position IMPEDANCE SELECTOR and an eight-position IMPEDANCE RANGE MULTIPLIER.

A SINAD version of the power meter incorporates a switchable 1 kHz filter for making signal-to-noise measurements by comparison of two power level readings. An initial reading is taken with the filter switched out and a second reading with it switched in to remove the 1 kHz fundamental. The difference between readings on the dBm scale gives the SINAD ratio. The standard version of 893B can be converted for SINAD measurement by fitting a filter kit which is available as an optional accessory.

## MODEL 50893–920M

**RANGE**

**Power**
Ten power ranges with full scale deflections from 300 μW to 10 W in a 1–3–10 sequence.
Decibel ranges are provided with a 0 dB reference at 1 mW.

**Impedance**
48 impedance settings between 2·5 Ω and 20 kΩ, with an impedance selector of 2·5, 3, 4, 5, 6, 8, 6·25, 7·5, 10, 12·5, 15, 20 and with multipliers X1, X10, X100, X1000.
Impedances of one quarter of the above settings (extending the range down to 0·625 Ω) may be obtained using the input centre tap, but at reduced accuracy.
The impedance of the power meter falls when it is connected into a circuit carrying d.c.
At 50 Hz a drop of approximately 5% is produced by 60 mA d.c. at the 100 Ω setting, and by 4 mA at the 20 kΩ setting.

**ACCURACY**

**Power**
±7% of f.s.d. ±10 μW, from 100 Hz to 10 kHz and from 5° to 35°C.

**Impedance**
±7% at 1 kHz.

**FREQUENCY CHARACTERISTICS**
Power level is less than 3 dB down (typically 0·7 dB down) at 20 kHz relative to level at 1 kHz.
Power level is less than 1 dB down at 50 Hz relative to 1 kHz level.
The instrument can be used over the extended frequency range 20 Hz to 35 kHz with reduced accuracy.

**TERMINALS**
The high and low terminals are isolated from the case earth.
A separate terminal is provided for linking to the case.
The terminals will accept:
Bare wires.
Crocodile clips.
4 mm plugs (and pin type AVO leads).
Spade type AVO leads.

**SAFETY**
Complies with IEC 348.

**LIMIT RANGE OF OPERATION**

**Temperature**
0° to 55°C.

**CONDITIONS OF STORAGE AND TRANSPORT**

**Temperature**
−40° to +70°C.

**Humidity**
Up to 90% relative humidity.

**Altitude**
Up to 2500 m (pressurized freight at 27 kPa differential, i.e. 3·9 lbf/in²).

**DIMENSIONS AND WEIGHT**

| Height | Width | Depth | Weight |
|---|---|---|---|
| 153 mm | 246 mm | 338 mm | 4 kg |
| 6 in | 9·7 in | 13·3 in | 8·8 lb |

## MODEL 50893–321J

The specification for this model is the same as that given above with the following additions.

**SINAD FILTER**

**Centre frequency**
1 kHz with the SINAD FILTER switch in.

**Rejection at 1 kHz**
At least 20 dB at 1 W input power.
At least 30 dB at 300 mW or less. input power.

**3 dB bandwidth**
Not greater than 480 Hz.

**20 dB bandwidth**
At least 150 Hz.

**Power**
Maximum total input power with SINAD filter in circuit is 1 W.

### VERSIONS AND ACCESSORIES

*When ordering please quote eight-digit code numbers*

| Ordering numbers | |
|---|---|
| | **Versions** |
| **50893–920M** | AF Power Meter 893B. |
| **50893–321J** | AF Power Meter 893B with SINAD filter. |
| **50893–322F** | AF Power Meter 893B. NATO version. Cat. No. 6625–99–541–2891. |
| | **Supplied Accessories** |
| | Instruction Manual 46881–349G. |
| | **Optional Accessories** |
| **54499–041N** | SINAD Filter Kit to convert model 50893–920M to model 50893–321J. |
| **54124–024F** | Stowage Cover Assembly. |

# RF Power Meter TF 2501




112.36

- ☐ **DC to 1 GHz**
- ☐ **3 W f.s.d.**
- ☐ **VSWR 1·1:1**
- ☐ **Thermocouple for true mean power**
- ☐ **Uncalibrated fast-response diode meter for peaking**

TF 2501 is an r.f. absorption power meter of very advanced design, intended for use with low power transmitters at frequencies up to 1 GHz.

True mean power is indicated by means of a thermocouple meter, with switch-selected sensitivity of 1 watt or 3 watts f.s.d. As range selection is effected by changing the sensitivity of the d.c. side of the measuring circuit, it is impossible to damage the thermocouple by inadvertently switching to the wrong power range. A fast-response diode meter is also incorporated as a convenient indicator for transmitter tuning adjustments.

The sensitivity of this second indicator is continuously variable for ease of operation; and the diode also functions as a demodulator for a.m. signals, the a.f. output being available from a telephone jack on the front panel.

The instrument is fully demountable; the thermocouple/load unit may be separated from the main body of the instrument for remote indication of output power when the r.f. connection is not easily accessible; or the r.f. load (TM 8587) can be removed from the power meter altogether and used independently.

| | |
|---|---|
| **POWER MEASUREMENT** | (Calibrated thermocouple meter.) |
| **Range** | 1 and 3 W f.s.d. |
| **Accuracy** | ±5% of f.s.d. (true mean power). |
| **Frequency range** | DC to 1 GHz for stated accuracy. |
| **Input impedance** | 50 Ω. |
| **VSWR** | 1·1:1. |
| **Overload capacity** | 20% continuously.<br>50% for periods of up to 30 s. |
| **DIODE DETECTOR** | (Uncalibrated.) |
| **Frequency range** | From below 5 MHz to at least 1 GHz. |
| **SAFETY** | Complies with IEC 348. |
| **LIMIT RANGE OF OPERATION** | |
| **Temperature** | 0 to 55°C. |

| | |
|---|---|
| **CONDITIONS OF STORAGE AND TRANSPORT** | |
| **Temperature** | −40°C to +70°C. |
| **Humidity** | Up to 90% relative humidity. |
| **Altitude** | Up to 2500 m (pressurized freight at 27 kPa differential, i.e. 3·9 lbf/in²). |

**DIMENSIONS AND WEIGHT**

| Height | Width | Depth | Weight |
|---|---|---|---|
| 130 mm | 220 mm | 120 mm | 1·4 kg |
| $5\frac{1}{8}$ | $8\frac{5}{8}$ in | $4\frac{3}{4}$ in | 3 lb |

**VERSIONS**

*When ordering please quote eight-digit code numbers*

| Ordering numbers | Versions |
|---|---|
| 52501-015E | RF Power Meter TF 2501. |
| 52509-015D | **Optional Accessories**<br>75/50 Ω RF Transformer TK 2509.<br>For details see page 141 |

# RF Power Meter TF 2502




11237/1

- ☐ **DC to 1 GHz**
- ☐ **10 W f.s.d.**
- ☐ **VSWR 1·1:1**
- ☐ **Thermocouple meter for true mean power**
- ☐ **Uncalibrated fast-response diode meter for peaking**

TF 2502 is an r.f. absorption power meter of very advanced design, intended for use with low power transmitters at frequencies up to 1 GHz.

True mean power is indicated by means of a thermocouple meter, with switch-selected sensitivity of 3 watts or 10 watts f.s.d. As range selection is effected by changing the sensitivity of the d.c. side of the measuring circuit, it is impossible to damage the thermocouple by inadvertently switching to the wrong power range. A fast-response diode meter is also incorporated as a convenient indicator for transmitter tuning adjustments. The sensitivity of this second indicator is continuously variable for ease of operation; and the diode also functions as a demodulator for a.m. signals, the a.f. output being available from a telephone jack on the front panel.

The instrument is fully demountable; the thermocouple/load unit may be separated from the main body of the instrument for remote indication of output power when the r.f. connection is not easily accessible; or the r.f. load (TM 8544) can be removed from the power meter altogether and used independently.

| | |
|---|---|
| **POWER MEASUREMENT** | (Calibrated thermocouple meter.) |
| **Ranges** | 3 and 10 W f.s.d. |
| **Accuracy** | ±5% of f.s.d. (true mean power). |
| **Frequency range** | DC to 1 GHz for stated accuracy. |
| **Input impedance** | 50 Ω. |
| **VSWR** | 1·1:1. |
| **DIODE DETECTOR** | (Uncalibrated.) |
| **Frequency range** | From below 5 MHz to at least 1 GHz. |

**DIMENSIONS AND WEIGHT**

| Height | Width | Depth | Weight |
|---|---|---|---|
| 130 mm | 220 mm | 120 mm | 1·4 kg |
| 5⅛ in | 8⅝ in | 4¾ in | 3 lb |

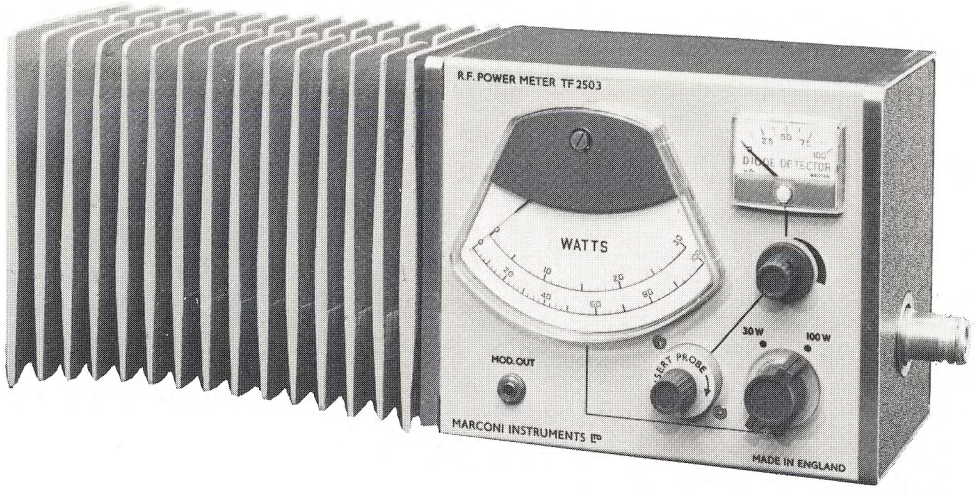
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|---|---|
| **SAFETY** | Complies with IEC 348. |
| **LIMIT RANGE OF OPERATION** | |
| **Temperature** | 0 to 55°C. |
| **CONDITIONS OF STORAGE AND TRANSPORT** | |
| **Temperature** | −40°C to +70°C. |
| **Humidity** | Up to 90% relative humidity. |
| **Altitude** | Up to 2500 m (pressurised freight at 27 kPa differential, i.e. 3·9 lbf/in²). |

**VERSIONS**

*When ordering please quote eight-digit code numbers.*

| Ordering numbers | Versions |
|---|---|
| **52502–015W** | RF Power Meter TF 2502. |
| **52509–015D** | **Optional Accessories** 75/50 Ω RF Transformer TK 2509. |

# RF Power Meter TF 2503




*11238/1*

- ☐ **DC to 1 GHz**
- ☐ **100 W f.s.d.**
- ☐ **VSWR 1·1 : 1**
- ☐ **Thermocouple for true mean power**
- ☐ **Uncalibrated fast-response diode meter for peaking**

TF 2503 is an r.f. absorption power meter of very advanced design, intended for use with medium and low power transmitters at frequencies up to 1 GHz. It is one of a range of power meters, in which the small size and unusually low v.s.w.r. have been achieved by the use of a high-vacuum evaporation technique.

True mean power is indicated by means of a thermocouple meter, with switch-selected sensitivities of 30 watts and 100 watts full scale. A Marconi patented thermocouple is employed, with its heater element forming part of the inner conductor of the coaxial line. This arrangement has the advantage that the load remains independent of the indicator, but the correct characteristic impedance is maintained throughout the link between the input socket and the load.

A fast-response diode meter is also incorporated as a convenient indicator for transmitter tuning adjustments. The sensitivity of this second indicator is continuously variable for ease of operation; and the diode also functions as an a.m. demodulator, the a.f. output being available from a telephone jack on the front panel.

The instrument is fully demountable; the thermocouple unit, with the load attached, may be separated from the main body of the instrument for remote indication of output power when the r.f. connection is not readily accessible or the r.f. load can be removed from the power meter and used independently.

| | |
|---|---|
| **POWER MEASUREMENT** | (Calibrated thermocouple meter.) |
| Ranges | 0 to 30 W and 0 to 100 W. |
| Accuracy | ±5% of f.s.d. (true mean power.) |
| Frequency range | DC to 1 GHz for stated accuracy. |
| Imput impedance | 50 Ω. |
| VSWR | Not greater than 1·1:1. |
| Overload capacity | 20% continuously.<br>50% for periods of up to 30 s. |
| **DIODE DETECTOR** | (Uncalibrated.) |
| Frequency range | From below 5 MHz to at least 1 GHz. |
| **SAFETY** | Complies with IEC 348. |
| **LIMIT RANGE OF OPERATION** | |
| Temperature | 0 to 55°C. |
| **CONDITIONS OF STORAGE AND TRANSPORT** | |
| Temperature | −40°C to +70°C. |
| Humidity | Up to 90% relative humidity. |
| Altitude | Up to 2500 m (pressurized freight at 27 kPa differential, i.e. 3·9 lbf/in².) |

**DIMENSIONS AND WEIGHT**

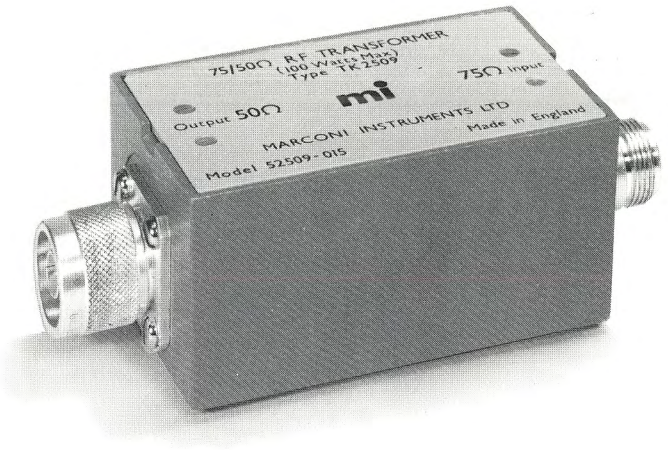
| Height | Width | Depth | Weight |
|---|---|---|---|
| 160 mm | 280 mm | 110 mm | 4 kg |
| 6¼ in | 11 in | 4½ in | 10 lb |

**VERSIONS**

*When ordering please quote eight-digit code numbers*

| Ordering numbers | Versions |
|---|---|
| 52503-015A | RF Power Meter TF 2503. |

# 75/50 Ω RF Transformer TK 2509




126 75

- ☐ **Matches 75 Ω sources to 50 Ω power meters**
- ☐ **Power rating: 100 W continuous**
- ☐ **Frequency range: 1·4 MHz to 200 MHz**
- ☐ **VSWR: 1·1:1 up to 100 MHz; 1·2:1 up to 200 MHz**
- ☐ **Can be operated in reverse mode**

TK 2509 is an impedance matching transformer which enables 50 Ω power meters to be used for measurements on 75 Ω sources. It is primarily intended for use with the Marconi Instruments RF Power Meters TF 2501, TF 2502 and TF 2503, but it is suitable for use with any equivalent 50 Ω absorption power meter. When used in this way the power meter will give a direct indication of power from a 75 Ω source.

The transformer has a continuous power rating of 100 watts when terminated in a 50 Ω load. It covers the frequency range 1·4 MHz to 200 MHz with good v.s.w.r. when terminated in 50 Ω.

For matching a 75 Ω power meter to a 50 Ω source the transformer can be operated in the reverse mode with a small deterioration in v.s.w.r.

The transformer is enclosed in a small box with type N input and output connectors, and can be plugged directly onto the input socket of the TF 2501, TF 2502 or TF 2503, without requiring a connecting cable.

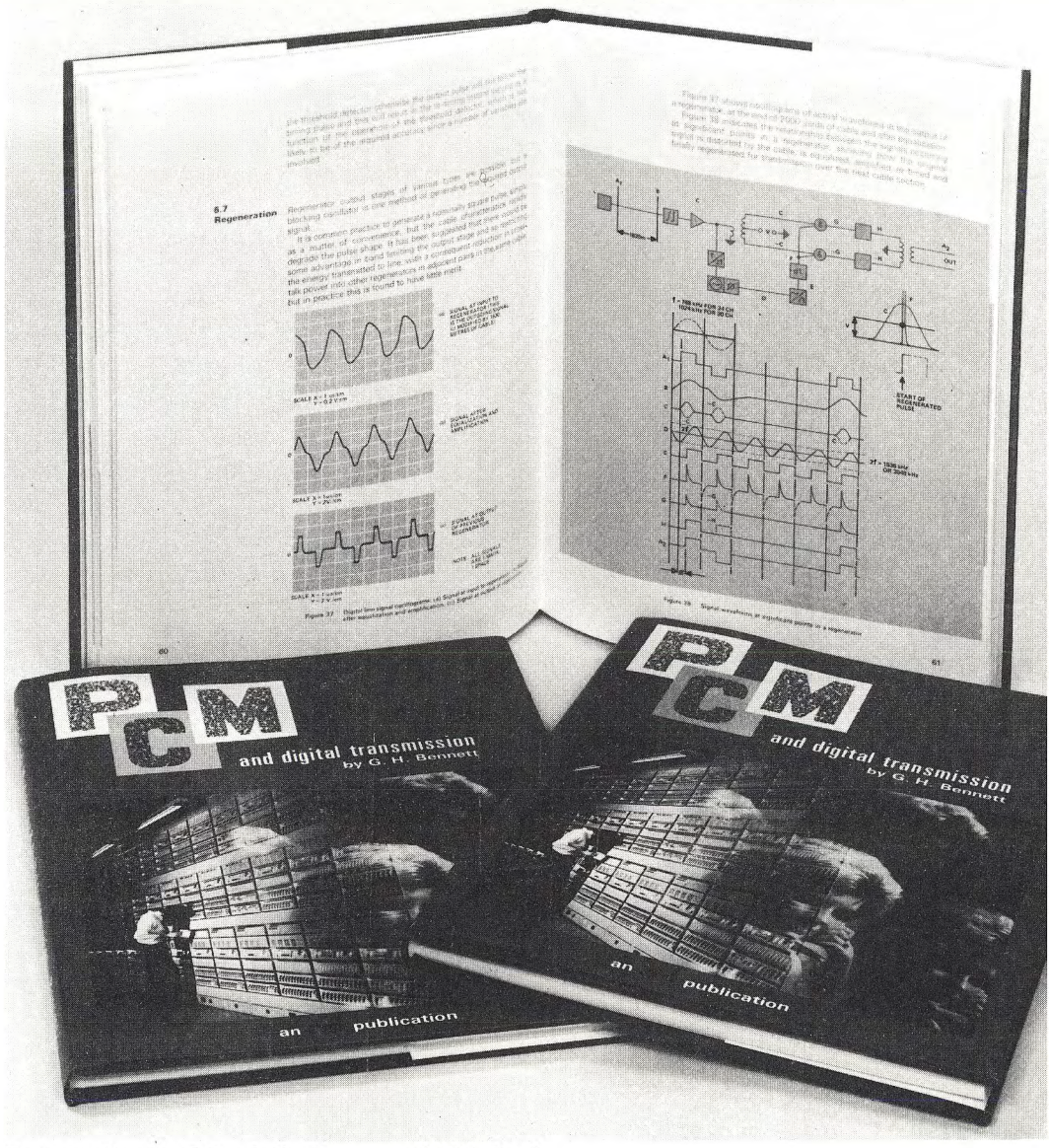
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|---|---|
| **POWER RATING** | When terminated in a 50 Ω load the transformer will transmit 100 W continuously. |
| **FREQUENCY RANGE** | 1·4 MHz to 200 MHz. |
| **INPUT IMPEDANCE** | 75 Ω. |
| **OUTPUT IMPEDANCE** | 50 Ω. |
| **INPUT VSWR** | When terminated in a 50 Ω load:<br>Better than 1·1:1 from 1·4 MHz to 100 MHz.<br>Better than 1·2:1 from 100 MHz to 200 MHz. |
| **DISSIPATION LOSS** | When terminated in a 50 Ω load:<br>Not greater than 0·25 dB at 200 MHz.<br>Typically less than 0·25 dB down to 1·4 MHz. |
| **REVERSE MODE** | When used as a 50/75 Ω transformer the v.s.w.r. is typically 1·1:1 up to 100 MHz and 1·25:1 up to 200 MHz. |

| | |
|---|---|
| **CONNECTORS** | |
| **Input** | Type N, 75 Ω socket. |
| **Output** | Type N, 50 Ω plug. |
| **SAFETY** | Complies with IEC 348. |
| **DIMENSIONS AND WEIGHT** | Height 42 mm (1¾ in), Width 124 mm (5 in), Depth 51 mm (2 in), Weight 0·275 kg (10 oz) (includes connectors). |

**VERSIONS AND ACCESSORIES**

*When ordering please quote eight-digit code numbers*

| Ordering numbers | Versions |
|---|---|
| **52509-015D** | 75/50 Ω RF Transformer TK 2509. |
| | **Associated Equipment** |
| **52501-015E** | RF Power Meter, 3 W TF 2501 |
| **52502-015W** | RF Power Meter, 10 W TF 2502 |
| **52503-015A** | RF Power Meter, 100 W TF 2503 |




## Pulse Code Modulation and Digital Transmission

**By G. H. Bennett**

A book for the engineer and student who has a grounding in telephone communications systems – but requires an introduction to the practical aspect of PCM. The fundamentals of digital transmission are examined particularly in the context of symmetric pair cables, leading to the concept of a regenerative repeater and its composite elements. The author then describes how progression to higher rate systems is achieved by means of digital multiplexing and highlights the future possibility of integral digital transmission switching.

G. H. Bennett is the Head of Digital Systems Development in the Telecommunications Development Department of the British Post Office. He represents the B.P.O. on digital matters at meetings of the International Telegraph and Telephone Consultative Committee (CCITT) and the Conference of European Posts and Telegraphs (CEPT).

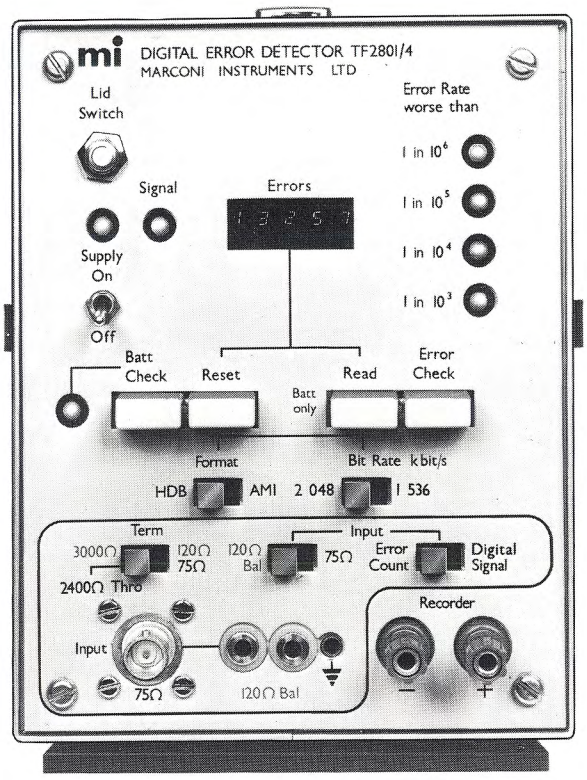
marconi instruments

# PCM Test Equipment


| | | |
|---|---|---|
| Digital Error Detector | TF 2801/4 | 144 |
| Pattern Generator and SLMS | TF 2802/2 | 146 |
| PCM Regenerator Test Set | OA 2805A | 148 |
| PCM Multiplex Tester | TF 2807A | 150 |
| PCM Regenerator Tester | TF 2823 | 154 |
| PCM Digital Simulator | TF 2828A | 157 |
| PCM Digital Analyser | TF 2829 | 162 |
| PCM Multiplex Tester | 2830 | 165 |
| PCM Channel Access Switch | 2831 | 169 |
| Digital Line Monitor | 2833 | 171 |

# Digital Error Detector TF 2801/4

- For use with p.c.m. bipolar 1·536 and 2·048 Mbit/s signals
- AMI and HDB3 formats
- Detects pulse omissions or additions in a pulse train
- Built-in five digit electronic counter
- Solid-state lamps indicate error rates in excess of 1 in $10^3$, 1 in $10^4$, 1 in $10^5$ and 1 in $10^6$
- AC mains or battery operation




14035/1

The Digital Error Detector TF 2801/4 detects the errors in a p.c.m. signal consisting of a train of bipolar pulses, and caters for AMI and HDB3 input signals. If a pulse is omitted from a signal, or if an extra pulse is added, an error will occur in the form of a bipolar violation; i.e. two consecutive pulses of the same polarity. The instrument detects this violation and produces a pulse for every error that occurs, these pulses being totalised on a built-in five digit electronic counter, with a solid state readout. The HDB3 system involves the deliberate introduction of bipolar violations, and in this system an error is defined as two consecutive violations of the same polarity. To monitor these errors a double detection system is used with two a.m.i. detectors in tandem.

Error rates are displayed in a statistical manner by four l.e.d. lamps indicating error rates exceeding 1 in $10^3$, 1 in $10^4$, 1 in $10^5$, and 1 in $10^6$. An analogue output is available for pen recorder drive, with discrete current levels indicating the error rate.

The instrument operates at two bit rates, 1·536 Mbit/s and 2·048 Mbit/s switch selected, the input signal being regenerated internally to ensure that the instrument functions correctly under conditions of high near-end cross-talk interference. The presence of a signal is indicated by an l.e.d. lamp.

The counter normally 'locks' when the maximum count of 99999 is reached, but can be reset to zero at any time. This locking facility can be removed if required by altering an internal link. To reduce power requirements the three left-hand digits of the display have leading zero suppression on them.

TF 2801/4 can be powered either from a.c. mains or by internal dry datteries. The digital readout is normally off during battery operation to reduce current drain and the error count total is displayed by pressing the READ button. Two self check facilities are included. The ERROR CHECK introduces pulses into the counter circuits at a rate of 600 per second which enables the counter, display and recorder output current to be tested. On BATT CHECK an l.e.d. lamp is lit if the battery is serviceable.

| | |
|---|---|
| **INPUT SIGNAL** | A p.c.m. signal of alternate mark inversion (AMI) or high density bipolar (HDB) coded. |
| **Bit rate** | a) 1·536 Mbit/s ±75 bit/s.<br>b) 2·048 Mbit/s ±100 bit/s. |
| **Pulse amplitudes** | a) 75 Ω TERM: 1·29 V to 3·0 V. (2·37 V nominal).<br>b) 2400 Ω THRO: 37 mV to 100 mV. (72 mV nominal).<br>c) 120 Ω BAL: 1·7 V to 3·8 V. (3·0 V nominal).<br>d) 3000 Ω: 1·7 V to 3·8 V. (3·0 V nominal). |
| **Duty cycle** | 50% nominal. |

| | |
|---|---|
| **INPUT IMPEDANCE** | |
| **75 Ω INPUT** | BNC socket. 75 Ω unbalanced with two input conditions, 75 Ω TERM and 2400 Ω THRO, switch selected.<br>*75 Ω TERM:* for use when the instrument is used to terminate a 75 Ω source.<br>*2400 Ω THRO:* for use when the instrument is fed from a 2400 Ω source. |
| **120 Ω BAL input** | Siemens socket. Balanced input with two input conditions, 120 Ω and 3000 Ω, switch selected.<br>*120 Ω:* for use when the instrument is used to terminate a 120 Ω source.<br>*3000 Ω:* for use when the 120 Ω source is terminated other than by the instrument. |

# TF 2801/4

**Return loss**
On 75 Ω TERM, 2400 Ω THRO and 120 Ω BAL, the return loss is not less than 20 dB over the range 100 kHz to 2·2 MHz.

**INPUT FILTERS**
Selected by BIT RATE switch.

**Response**
a) 1·536 Mbit/s.
Relative to level at 100 kHz:
Not greater than −2 dB at 768 kHz.
Not greater than −6 dB at 1·5 MHz.
Greater than −13 dB at 2 MHz.
b) 2·048 Mbit/s.
Relative to the level at 100 kHz:
Not greater than −2 dB at 1 MHz.
Not greater than −6 dB at 2 MHz.
Greater than −13 dB at 2·5 MHz.

**SIGNAL INDICATION**

**Signal**
A red lamp will be lit if the signal level is greater than 1·29 V (75 Ω TERM) or 37 mV (2400 Ω THRO) or 1·7 V (120 Ω and 3000 Ω) and does not contain more than 16 consecutive spaces.

**No signal**
The lamp will be extinguished if the signal level is less than 0·84 V (75 Ω TERM) or 27 mV (2400 Ω THRO) or 1·0 V (120 Ω and 3000 Ω), or if the pulse is absent for more than 32 digit time slots.

**ERROR INDICATION**
*AMI:* The presence of a violation, defined as two consecutive pulses of the same polarity, will be indicated as an error.
*HDB:* Two consecutive violations of the same polarity will be indicated as an error.

**Counter**
The detected errors are totalized and displayed on an electronic counter.
*Display:* Five-digit solid state readout displaying detected errors.
Display locks when 99999 count is reached and only resets when RESET switch is operated.
*Read:* To conserve battery life, the display section of the counter is normally unlit when internal battery operation is selected. The totalized error count can be displayed by operating the biased READ switch. On a.c. mains operation the display is always lit.
*Reset:* RESET switch sets display to zero.

**Error rate indication**
Four solid state lamps indicate error rate exceeding 1 in $10^3$, 1 in $10^4$, 1 in $10^5$, and 1 in $10^6$.

**ERROR COUNT**

**Input impedance**
BNC socket. 75 Ω unbalanced.
Return loss: not less than 24 dB over the range 40 kHz to 3·0 MHz.

**Pulse amplitude**
+2·0 V to 5·0 V peak.

**Pulse width**
200 ns to 600 ns.

**Repetition period**
From single shot pulse to pulses with 250 µs interval.

**RECORDER OUTPUT**
Unbalanced output. Constant current source for load resistance of 0 to 4 kΩ.
Damping normally preset at 40 kΩ.
Suitable for a pen recorder of 1 mA f.s.d.

**Error rate**
Discrete current levels indicate:
No signal (375 µA approx. or less).
1 in $10^3$ errors (397 µA approx.).
1 in $10^4$ errors (446 µA approx.).
1 in $10^5$ errors (500 µA approx.).
1 in $10^6$ errors (562 µA approx.).
No errors (667 µA approx.).

**ERRORS CHECK**
A biased push button switch provides a self check of the error counting and display circuits and of the recorder output. Injected error rate approximately 5 kHz.

**REGENERATOR**

**Gating**
The signal is regenerated by gating during a short period near the mid-point of each time slot. The timing clock circuit is locked to the frequency at the input socket.

**Clock extraction circuit Q**
Set to enable jitter test as in BPO specification No. RC5450B to be met. Drift less than 0·4%.

**NOISE IMMUNITY**
With an error-free pseudo-random signal ($2^{15}$-1 bits) and an interfering signal simulating n.e.x.t. interference added together, such that a signal-to-noise ratio of 20 dB is obtained, the error rate is less than 1 in $10^7$ bits, i.e. not more than an average of 9 errors per minute for 1·536 Mbit/s or 12 errors per minute for 2·048 Mbit/s.

**SAFETY**
Complies with IEC 348.

**RADIO FREQUENCY INTERFERENCE**
Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference.

**LIMIT RANGE OF OPERATION**

**Temperature**
0 to 55°C.

**CONDITIONS OF STORAGE AND TRANSPORT**

**Temperature**
−40°C to +70°C.

**Humidity**
Up to 90% relative humidity.

**Altitude**
Up to 2500 m (pressurized freight at 27 kPa differential, i.e. 3·9 lbf/in²).

**POWER REQUIREMENTS**
Internal batteries or external mains supply, switch selected.

**Internal battery**
2 × 9 V batteries (type PP9, DT9 or equivalent). Recommended for intermittent use only.
*Battery check:* When BATT CHECK switch is operated, the battery lamp will be lit if the voltage is above a satisfactory level.
*Lid switch:* The internal battery supply will be switched off when the clip-on front cover is fitted.

**AC supply**
95 V to 130 V and 190 V to 264 V.
45 to 500 Hz. 2 VA maximum.

**DIMENSIONS AND WEIGHT**

| Height | Width | Depth | Weight |
|---|---|---|---|
| 190 mm | 146 mm | 375 mm | 4·1 kg |
| 7½ in | 5¾ in | 14¾ in | 9 lb |

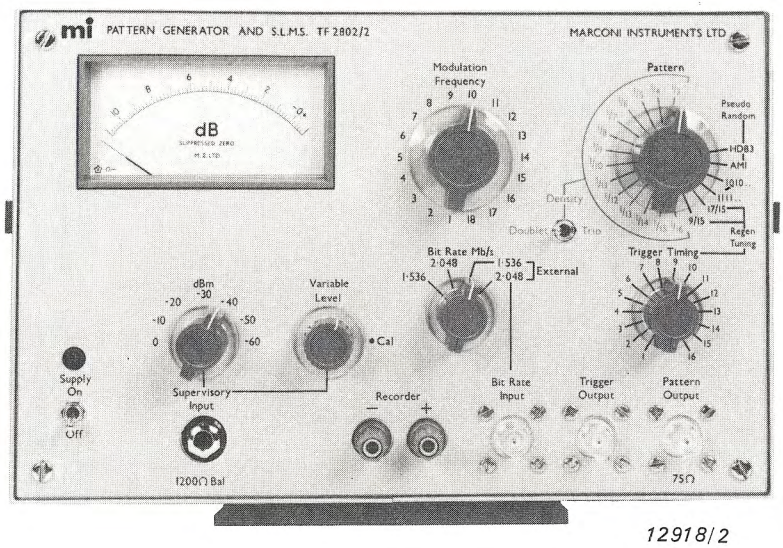
## VERSIONS AND ACCESSORIES

*When ordering please quote eight-digit code numbers*

| Ordering numbers | |
|---|---|
| | **Versions** |
| **52801-904B** | TF 2801/4. Version with BNC connectors and 75/120 Ω input. |
| **52801-309T** | TF 2801/4. Version with BNC connectors, 75/120 Ω input, and bit rates of 1·544 and 2·048 Mbit/s. |
| **52801-311D** | TF 2801/4. Version with P.O. No. 1B connectors and 75/120 Ω input. |
| | **Supplied Accessories** |
| | Clip-on Front Panel Cover, holding power supply lead. |
| | Instruction Manual. |

# Pattern Generator and SLMS

# TF 2802/2




12918/2

- For use with p.c.m. systems at 1·536 and 2·048 Mbit/s
- AMI or HDB3 formats
- External bit rate facility
- Recorder output for long term SLMS monitoring

The Pattern Generator and Selective Level Measuring Set TF 2802/2 is a combined pulse pattern generator and selective level measuring set used for testing and fault finding on p.c.m. links consisting of up to 18 regenerators. When used with, or as part of, a regenerator test set the clock tuning patterns of the TF 2802/2 enable the regenerators to be set up accurately.

The instrument produces general purpose test signals, regenerator clock tuning patterns and a signal of bipolar doublet and triple pulse trains at any one of fourteen pattern densities, the trio pulse train being modulated at any of 18 audio frequencies by reversal of the pattern polarity.

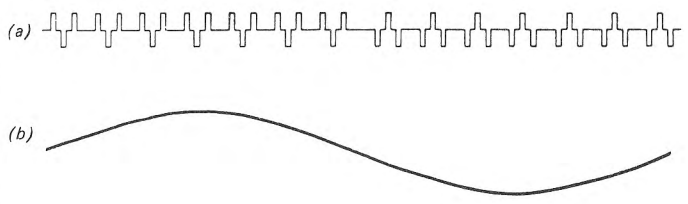
The bipolar triple pulse (trio) pattern differs from a normal p.c.m. pattern in that bipolar violations (consisting of two consecutive pulses of like polarity) are introduced causing a shift in mean d.c. level of the signal. The shift in mean d.c. level is alternated positively and negatively by the modulating frequency giving an audio component to the test waveform.

Each regenerator location in a p.c.m. link has a band-pass filter (b.p.f.) associated with it of which the centre frequency is one of the audio modulation frequencies. When the appropriate modulation frequency is present in the p.c.m. signal then an output from the b.p.f. is returned to the test location on a supervisory line or is used to switch the test pattern onto a return p.c.m. line.

The Selective Level Measuring Set and the Pattern Generator are synchronously tuned and a level meter enables the level of the returned a.f. component from any selected regenerator to be observed as the pattern density is increased.

A 20 volt d.c. supply is fed from the instrument via the supervisory line to activate the b.p.f's. A second pulse train (digital drive) is provided to drive unused p.c.m. lines, particularly the second set of regenerators in systems having two regenerators per regenerator unit.

The instrument will operate at 1·536 Mbits/s and 2·048 Mbits/s from internal clocks or from 1·25 to 2·25 Mbits/s using an external clock.




(a) *Transmitted pattern signal of modulated trios.*

(b) *AF component through band-pass filter of selected regenerator, returned to SLMS*

***Trios test transmitted and received test signals.***

## PATTERN GENERATOR

### PATTERN OUTPUT

| | |
|---|---|
| **Bit rate** | Internal clock or external input, switch selected.<br>*Internal clock:*<br>a) 1·536 Mbit/s ± 60 bit/s.<br>b) 2·048 Mbit/s ± 80 bit/s.<br>*External input:*<br>a) Pattern output driven from external clock, digital drive (2nd regenerator) from an internal 1·536 Mbit/s clock.<br>b) Pattern output driven from an external clock, digital drive (2nd regenerator) from an internal 2·048 Mbit/s clock. |
| **Pulse characteristic** | *Duty cycle:* 50% corresponding to h.a.d. of 326 ns ±30 ns at 1·536 Mbit/s; and 244 ns ±25 ns at 2·048 Mbit/s.<br>*Pulse amplitude:* 2·37 V ±0·24 V across 75 Ω.<br>Difference between positive and negative pulse amplitude not greater than 5%.<br>*Overshoot:* Not greater than 5%.<br>*Mean pulse level:* Nominally 0 V. |
| **Output impedance** | 75 Ω unbalanced ±10% (BNC plug). |
| **Return loss** | Better than 30 dB between 100 kHz and 2·2 MHz. |

**EXTERNAL CLOCK INPUT**

| | |
|---|---|
| Frequency range | Input of 2·5 MHz to 5 MHz sine or square wave producing a bit rate at half input frequency. |
| Input level | Between 500 mV and 3 V p-p from 75 Ω source. |
| Impedance | 200 Ω approximately. |

**FORMAT**

PCM signal of alternate mark inversion (AMI) or high density bipolar (HDB3) coded pseudo-random pattern.

**Pulse groups (switch selected)**

a) Pseudo-random HDB3: HDB3 coded pseudo-random sequence of length $2^{15}-1$ bits, 15 consecutive 'zeros' included. Feedback connected from 14th and 15th stages.
b) Pseudo-random AMI: Pulses of alternate polarity in a pseudo-random sequence as for HDB3.
c) 1010: Pulses of alternate polarity separated by empty time slots.
d) 1111: A continuous series of pulses of alternate polarity.
e) 17/15: Pulses of alternate polarity in a sequence of 17 consecutive 'ones' and 15 consecutive 'zeros'. Regenerator clock tuning pattern, high density.
f) 9/15: Nine pulses of alternate polarity separated by empty time slots, followed by 15 consecutive 'zeros'. Regenerator clock tuning pattern, low density.
g) Trio or doublet: Three pulses of alternate polarity in consecutive digit time slots (trio) or two pulses of alternate polarity in consecutive digit time slots (doublet), switch selected.

**Pulse pattern**

PATTERN switch selects trio or doublet pulse group densities from one group per three digit time slots to one group per sixteen digit time slots in fourteen steps.

**Modulation frequency**

Trio polarity inverted at selected frequencies from 1185 Hz to 3100 Hz in 18 steps as follows:
1185, 1260, 1340, 1420, 1500, 1585, 1675, 1770, 1870, 1980, 2095, 2215, 2345, 2480, 2620, 2770, 2930, and 3100 Hz.
*Accuracy:* ±10 Hz on nominal frequency.
*Modulation mark/space:* 1:1 nominal.

**TRIGGER OUTPUT (BNC)**

One of four trigger output waveforms automatically selected.
a) Psuedo-random: negative going pulse occurring once per pseudo-random sequence. Approximately 1 bit width.
b) 1010, 1111: Negative going pulse occurring at bit rate. Approximately 100 ns width.
c) 17/15, 9/15: Negative going pulse occurring twice per 32 bit pulse group, the second pulse occurring 17 digit time slots after the first. Approximately 1 bit width TRIGGER switch selects one of 16 timing points. At position 1 the trigger pulse occurs immediately before the 1st and 17th slot. Each successive position selects trigger occurrence 1 digit time slot later, culminating at position 16 immediately before the 16th and 32nd time slot.
d) Trio: Squarewave at modulation frequency.
*Pulse amplitude:* Greater than 1 V p-p into 75 Ω.
*Rise time:* Not greater than 25 ns
*Overshoot:* Not greater than 10%.

**DIGITAL DRIVE**

BNC plug on rear panel.
Output switched by biased toggle switch normally on.

| | |
|---|---|
| Format | Pulses of alternate polarity in consecutive time slots. Duty cycle nominally 50%. |
| Bit rates | BIT RATE switch ganged with digital output, selects one of two rates from internal clock independent of internal or external bit rate selection.<br>Switch selects digital drive phase locked to digital output or not locked.<br>1·536 Mbit/s ±60 bit/s.<br>2·048 Mbit/s ±80 bit/s. |
| Pulse amplitude | 2·37 V ±0·24 V across 75 Ω. |
| Mean pulse level | Nominally 0 V. |
| Output impedance | 75 Ω ±10% unbalanced. |

## SELECTIVE LEVEL MEASURING SET

| | |
|---|---|
| Supervisory input | *Level range:* −71 dBm to +1 dBm in 7 ranges, using the dBm switch and meter. |
| dBm switch | 0 dBm to −60 dBm in 10 dB steps. |
| Level meter | Calibrated from +1 dB to −11 dB. |
| Variable level | *Control range:* At least 10 dB with CAL position. |
| Overall level | *Accuracy:* ±1 dB ±15 Hz of centre frequency. |
| Tuning | Synchronous with pattern modulation frequency 1185 Hz to 3100 Hz. |
| Locking range | Will lock to an incoming frequency within ±30 Hz of selected modulation frequency with reduced accuracy. |
| Input impedance | 1200 Ω ±10% balanced. (PO jack No. 99A).<br>*Balance:* Better than 50 dB at 1·5 kHz. |
| Power feed | To energise the filter amplifier whilst simultaneously measuring the audio frequency.<br>20 V ±0·5 V.<br>1 kΩ nominal source impedance, short circuit protected. |
| Recorder output | Output current corresponds to SLMS level. Current at 0 dB nominally 500 μA into 1·9 kΩ.<br>Nominal range +3 dB to −11 dB. |
| Rear panel connector | Provides supervisory input and power feed from TF 2823 and digital drive to TF 2823. (7-way socket, Painton 159 series, type No. 74/10/0755/10). |
| **SAFETY** | Complies with IEC 348. |
| **LIMIT RANGE OF OPERATION** | |
| Temperature | 0 to 55°C. |
| **CONDITIONS OF STORAGE AND TRANSPORT** | |
| Temperature | −40°C to +70°C. |
| Humidity | Up to 90% relative humidity. |
| Altitude | Up to 2500 m (pressurized freight at 27 kPa differential, i.e. 3·9 lbf/in²). |
| **POWER REQUIREMENTS** | |
| AC supply | 190 to 264 V and 95 to 130 V 45 to 500 Hz. 20 VA nominal. |

**DIMENSIONS AND WEIGHT**

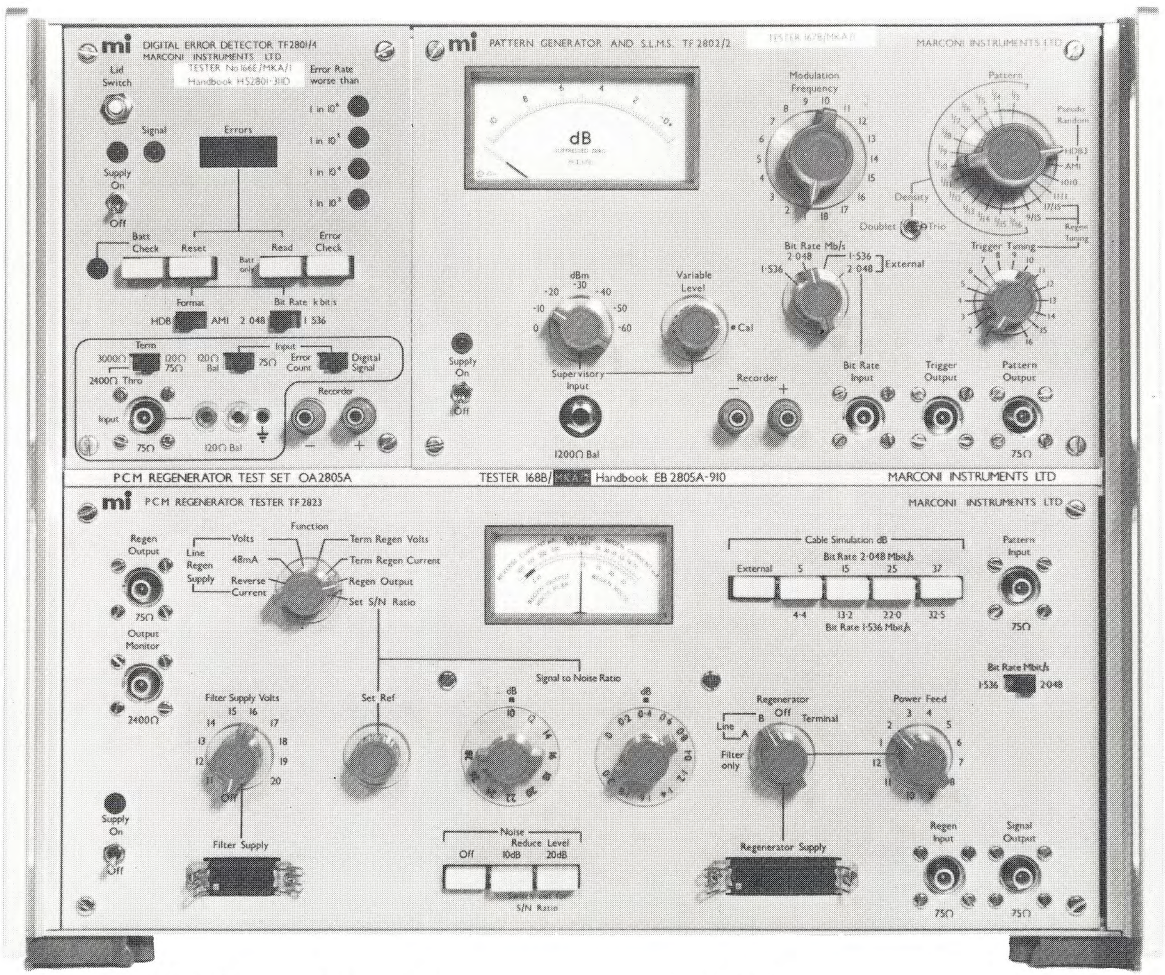
| Height | Width | Depth | Weight |
|---|---|---|---|
| 190 mm | 280 mm | 405 mm | 7·25 kg |
| 7·5 in | 11 in | 16 in | 16 lb |

## VERSIONS AND ACCESSORIES

*When ordering please quote eight-digit code numbers*

| Ordering numbers | |
|---|---|
| | **Versions** |
| 52802–302M | TF 2802/2 Version with BNC connectors. |
| 52802–301X | TF 2802/2 Version with PO No. 1B connectors. |
| 52802–303C | TF 2802/2 Version with bit rates of 1·544 and 2·048 Mbit/s. |
| | **Supplied Accessories** |
| | Clip-on Front Cover, holding a.c. supply and signal input leads.<br>Signal Input Lead 1·8 m long.<br>PO Plug (No. 316) 43125–070C.<br>Board Extractor 41148–605K (TM 8089).<br>AC Supply Lead.<br>Instruction Manual 46881–224P. |
| | **Optional Accessories** |
| 44836–104L | Extender Board. |
| 54411–011S | Matching Unit, 75 Ω unbalanced to 120 Ω balanced. |

# PCM Regenerator Test Set OA 2805A




*Model 52805–315S with P.O. connectors* *14598/2*

- ☐ **Performs complete checks on p.c.m. regenerators prior to installation**
- ☐ **For use with p.c.m. systems at 1·536 and 2·048 Mbit/s**
- ☐ **AMI and HDB3 formats**
- ☐ **Improved signal-to-noise measurement accuracy**

OA 2805A comprises three separate instruments combined in one case, and performs all the tests necessary for the complete checking of p.c.m. regenerators prior to their installation in a line system. It simulates the conditions which a regenerator will encounter in operation and it is suitable for use with p.c.m. systems operating at 1·536 and 2·048 Mbit/s and for both AMI and HDB3 formats. Tests which can be carried out include measurements on the clock tuning and output levels of regenerators, and checks on noise immunity and the functioning of supervisory test signals and filters.

# OA 2805A

The three instruments incorporated in OA 2805A are Digital Error Detector TF 2801/4, Pattern Generator and SLMS TF 2802/2, and PCM Regenerator Tester TF 2823. The TF 2823 included in this latest model of OA 2805A features an improved signal-to-noise measurement accuracy of $\pm\frac{1}{2}$ dB.

The Pattern Generator produces a variety of p.c.m. signals including pseudo-random sequences in both AMI and HDB3 form, and also regenerator clock tuning patterns. PCM Regenerator Tester TF 2823 provides a noise signal to simulate near-end crosstalk (n.e.x.t) and combines this with the signal from the pattern generator. It also includes cable simulators equivalent to various lengths of cable for insertion in the signal path. Four cable simulators are built-in, with provision for connecting external simulators if required. Power signals for the regenerators under test and for the supervisory test filters are also provided by TF 2823. The output from the regenerator under test is monitored by the Error Detector which totalises errors on a five-digit electronic counter.

Among tests which can be carried out with the OA 2805A are:

1. Tuning of regenerators using test signals produced by the Pattern Generator.
2. Checks on the performance of regenerators in the presence of noise.
3. Checking of the regenerator performance when using the supervisory test signal.
4. Monitoring of the output level of regenerators on a peak reading voltmeter.
5. Measurement of the d.c. current and voltage powering the regenerators.
6. Separate testing of the supervisory test filters.

These tests carried out on a regenerator prior to its installation ensure that it is optimized to give its best performance and life capability in operation.

| | |
|---|---|
| **FUNCTION** | Provides comprehensive test facilities, appropriate power supplies and interface for p.c.m. regenerators. |
| **FORMAT** | AMI and HDB3. |
| **RADIO FREQUENCY INTERFERENCE** | Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference. |
| **SAFETY** | Complies with IEC 348. |
| **LIMIT RANGE OF OPERATION** | |
| **Temperature** | 0 to 55°C. |

| | |
|---|---|
| **CONDITIONS OF STORAGE AND TRANSPORT** | |
| **Temperature** | −40°C to +70°C. |
| **Humidity** | Up to 90% relative humidity. |
| **Altitude** | Up to 2500 m (pressurized freight at 27 kPa differential, i.e., 3·9 lbf/in²). |
| **POWER REQUIREMENTS** | |
| **AC supply** | 95 to 130 V or 190 to 264 V.<br>45 to 500 Hz. 30 VA nominally. |
| **DIMENSIONS AND WEIGHT** | |

| Height | Width | Depth | Weight |
|---|---|---|---|
| 370 mm | 430 mm | 380 mm | 25 kg |
| 14½ in | 17 in | 15 in | 55 lb |

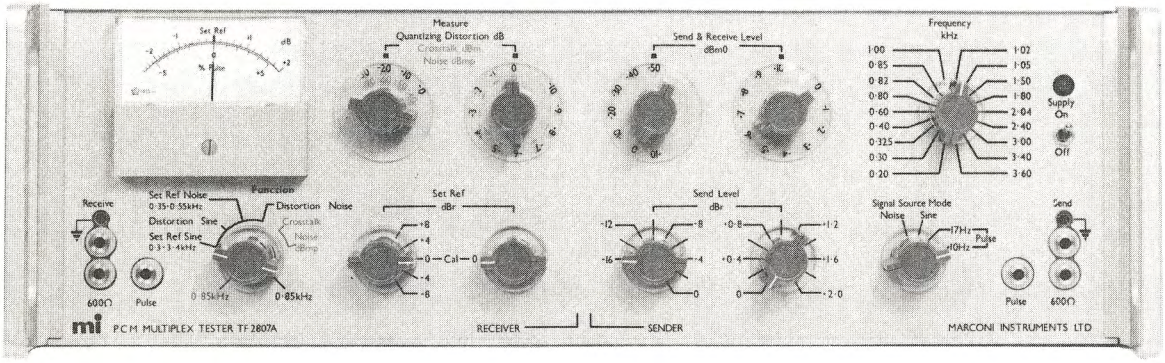
For full specifications of the three instruments incorporated in OA 2805A refer to the appropriate pages in this section.

## VERSIONS AND ACCESSORIES

*When ordering please quote eight-digit code numbers*

| Ordering numbers | |
|---|---|
| | **Version** |
| **52805-314V** | OA 2805A. Version with bit rates 1·536 and 2·048 Mbit/s;<br>BNC connectors.<br>Comprises:<br>TF 2801/4 (52801-904B)<br>TF 2802/2 (52802-302M)<br>TF 2823 (52823-312D)<br>The following versions may be available to special order. |
| **52805-316W** | OA 2805A. Version with bit rates 1·544 and 2·048 Mbit/s;<br>BNC connectors.<br>Comprises:<br>TF 2801/4 (52801-309T)<br>TF 2802/2 (52802-303C)<br>TF 2823 (52823-315X) |
| **52805-315S** | OA 2805A. Version with bit rates 1·536 and 2·048 Mbit/s;<br>P.O. connectors.<br>Comprises:<br>TF 2801/4 (52801-311D)<br>TF 2802/2 (52802-301X)<br>TF 2823 (52823-311W) |
| | **Supplied Accessories**<br>(For 52805-314V version).<br>Supply Lead 43129-071D.<br>Terminal Regenerator Supply Lead 43129-050K.<br>Filter Supply Lead 43129-051A.<br>Line Regenerator Supply Lead 43129-052Z.<br>Interface Lead 43129-056Y (TF 2802/2 to TF 2823 rear panels).<br>Flexible 'U' Link 43125-050Y (BNC to BNC plugs: 3 supplied).<br>Supply Distribution Unit 44990-094H.<br>Board Extractor 41148-605K.<br>Instruction Manual. |
| **44836-104L** | **Optional Accessories**<br>Extender Board. |

# PCM Multiplex Tester TF 2807A




14263

- ☐ **Measures all major primary PCM multiplex parameters**
- ☐ **Sender and receiver in one portable instrument**
- ☐ **Quantizing distortion measured with noise or sinewave stimulus**
- ☐ **All major measurements to CCITT recommendations**
- ☐ **Fast and simple operation**
- ☐ **Versions available for five crosstalk frequencies**

TF 2807A consists of a composite sender and receiver and can be used to check the overall performance of a p.c.m. multiplex system from audio input to audio output, measuring impairments in performance introduced during multiplexing and analogue to digital conversion. The performance of digital systems may be assessed either end to end or looped at the digital output/input of the multiplexer. This model is an improved version of PCM Multiplex Tester TF 2807 with better stability, distortion and accuracy and also with improved mechanical construction and switches. Switched audio output frequencies replace the previous analogue output giving increased ease of operation. Filters are included conforming to CCITT recommendations.

The tester covers all the main tests necessary for commissioning and servicing a p.c.m. multiplex system. It includes two signal sources and a variety of measurement functions including:

Quantizing distortion
Signalling distortion
Channel gain or loss
Linearity
Channel frequency response
Interchannel crosstalk
Idle channel noise

The receiver section of the instrument performs as a level meter with filters giving a variety of passband characteristics. True r.m.s. value of the input signal is displayed on the meter which has a short settling time allowing high speed measurement.

## Quantizing distortion

Two signal sources are included in TF 2807A, pseudo random noise and sinewave, offering two CCITT approved methods of measuring quantizing distortion. The noise output has a probability distribution of amplitude approximating to Gaussian form and band limited to conform with the latest CCITT recommendations. This measurement produces results similar to those obtained using white noise, but with a greatly reduced test time. The test signal is applied to the multiplex input and transmitted over the p.c.m. link. Distortion components together with the stimulating signal, appear at the analogue output of the multiplex and are separated in TF 2807A by high pass filtering. The ratio of distortion components to stimulation signal is measured by a combination of precision attenuators and an r.m.s. voltmeter, both included in the tester.

Quantizing distortion may also be measured using sinewave stimulus. The measurement procedure is similar to that using noise, except that the original signal

is rejected by a band stop filter with sufficient rejection to prevent summation of the residual signal with the distortion components. These components are measured with CCITT psophometric weighting.

### Linearity

Variation of channel gain with input level can be measured using either the noise or sinewave source at the channel input. To give improved noise immunity at low signal levels the band limited input of TF 2807A may be used to measure the audio output of the channel over the dynamic range of the system. Measurement of channel linearity is simplified when making loopback measurements by the ganging together of the send and receive attenuators so that a decrease in signal input to the channel automatically gives a corresponding increase in input sensitivity. Deviation of the centre zero meter indicates the non-linearity of the channel at the set input level.

### Crosstalk

Interchannel crosstalk requires the measurement of low level signals, and to provide sufficient noise rejection TF 2807A has a high selectivity input which is brought into circuit when the CROSSTALK function is selected. For making these measurements a sinewave stimulus is applied to one channel and the resultant output from other channels is observed. To cater for various national standards different versions of TF 2807A are available with different crosstalk frequencies.

### Idle channel noise

TF 2807A may be used to measure quiescent noise in a channel psophometrically to CCITT weighting characteristics and time constants for telephone measurements.

### Channel frequency response

This may be determined by applying a sinusoidal input of varying frequency over the band 200 Hz to 3600 Hz, provided by TF 2807A at 18 switched frequencies. A wide band input is available for use in conjunction with the sinewave output for measurement of channel frequency response.

### Signalling distortion

A PULSE input is provided which, used in conjunction with the centre zero meter, displays the percentage distortion of received signalling impulses. A corresponding PULSE output consisting of alternately high and low impedance connections at 17 Hz or 10 Hz, switch selected, is available for the provision of simulated dialling impulses.

## SENDER

| | |
|---|---|
| **NOISE SIGNAL** | Pseudo random band limited noise conforming with CCITT recommendations. Near Gaussian probability distribution. The noise signal is derived by bandpass filtering the output of a 17-stage shift register. |
| **Spectral density** | 1 spectral line per 2·6 Hz approximately. |
| **Noise bandwidth (Bandpass filter response)** | 3 dB bandwidth nominally 130 Hz (at least 100 Hz with reference to the maximum level). 3 dB down at not less than 370 Hz and not greater than 550 Hz.<br>Greater than 55 dB down at 250 Hz and below.<br>Greater than 20 dB down at 300 Hz.<br>Greater than 6 dB down at 580 Hz.<br>Greater than 20 dB down at 650 Hz.<br>Greater than 40 dB down at 700 Hz.<br>Greater than 50 dB down at 750 Hz.<br>Greater than 60 dB down at 800 Hz and above. |
| **Peak: r.m.s. ratio** | 10·5 dB nominal. |
| **Amplitude accuracy** | *Overall accuracy:* ±0·35 dB for total range of levels.<br>±0·15 dB at 0 dBm0, 0 dBr.<br>±0·1 dB at 0 dBm0, 0 dBr at +20°C ±5°C. |
| **SINE WAVE OUPUT** | |
| **Frequency range** | 200 Hz to 3600 Hz.<br>18 switched positions as follows: 200, 300, 325, 400, 600, 800, 820, 850, 1000, 1020, 1050, 1500, 1800, 2040, 2400, 3000, 3400, 3600 Hz. |
| **Accuracy** | ±1%. |
| **Total harmonic distortion** | Less than 0·1% from 300 Hz to 3·6 kHz.<br>Less than 0·2% at 200 Hz. |
| **Amplitude accuracy** | *Overall accuracy:* ±0·35 dB for total range of levels.<br>±0·1 dB at 0 dBm0, 0 dBr and 1 kHz at +20°C ±5°C.<br>±0·15 dB at 0 dBm0, 0 dBr and 1 kHz. |
| **Frequency response** | ±0·1 dB at 0 dBm relative to 1 kHz. |
| **SEND LEVEL** | |
| **Send range** | −76 to +12 dBm0. |
| **Coarse attenuator (send and receive level)** | −50 to +10 dBm0 in 10 dB steps. |
| **Fine attenuator (send and receive level)** | −10 to 0 dBm0 in 1 dB steps. |
| **Coarse attenuator (send level)** | −16 to 0 dBr in 2 dB steps. |
| **Fine attenuator (send level)** | 0 to +2 dBr in 0·2 dB steps. |
| **OUTPUT IMPEDANCE** | 600 Ω BALANCED. |
| **Return loss** | Better than 36 dB from 300 to 3600 Hz. |
| **Balance** | Greater than 60 dB from 300 to 3600 Hz. |

# TF 2807A

## RECEIVER

**MEASUREMENT ACCURACIES**

Accuracies include meter, level, attenuators and frequency response errors as applicable.

**Set ref sine 300 to 3400 Hz**

Gain/level and frequency/level measurements with sinusoidal test signal.
*Total input range:* −70 dBm to +20 dBm (−60 dBm0 to +10 dBm0 and −10 dBr to +10 dBr).
*Level accuracy:* ±0·35 dB for all receive levels. ±0·2 dB at 0 dBm0, 0 dBr and 1 kHz.

**Distortion sine 850 Hz**

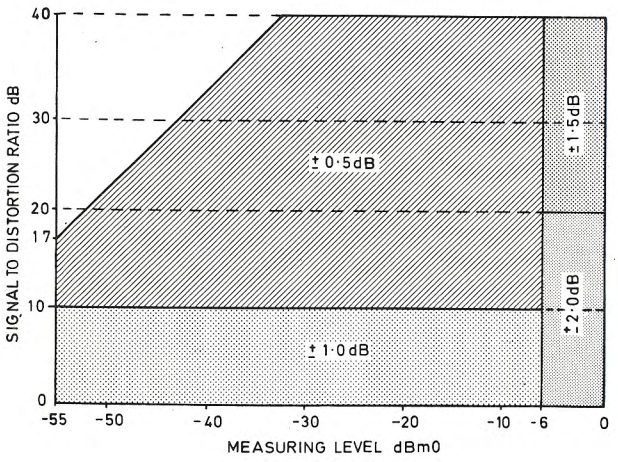
Total distortion (including quantizing distortion) measured using an 850 Hz sinusoidal test signal.
Distortion measured using an 850 Hz band stop filter and psophometer (telephone weighted filter). Correction added to allow for noise power lost in 850 Hz notch.
*Measurement range:* −42 dB to 0 dB signal to distortion ratio within level ranges −60 dBm0 to +10 dBm0 and absolute distortion level not less than −72 dBm0.
*Accuracy:* ±0·5 dB.

**Set ref noise 35 to 550 Hz**

Gain/level measurement using band limited pseudo random noise to CCITT recommendation. Input filter 350 Hz to 550 Hz.
*Total input range:* −70 dBm to +20 dBm.
*Level accuracy:* ±0·35 dB for all levels. ±0·25 dB at 0 dBm0 and 0 dBr.

**Distortion noise**

Total distortion (including quantizing distortion) measured, using band limited pseudo random noise to CCITT recommendations. Distortion is measured in a bandwidth of 850 to 3400 Hz and a correction added to relate measurement to telephone channel bandwidth 300 to 3400 Hz.
*Measurement range: −42 dB to 0 dB.*
*Level accuracy:* ±0·5 dB.




*Limits of distortion measurement accuracy (noise stimulus) using any combination of sender and receiver manufactured to CCITT recommendations.*

**Crosstalk dBm**

*Frequency:* 850 Hz.
*Measurement range:* −82 dBm to −38 dBm.
*Accuracy:* ±0·75 dB at 850 Hz ±1%.

**Noise dBmp**

Measurement of idle channel noise using psophometer (telephone weighted filter).
*Measurement range:* −82 dBm to −38 dBm.
*Accuracy:* ±0·3 dB at 800 Hz at −40 dBm. ±1·0 dB with noise signal.

**RECEIVE ATTENUATORS**

**Send and receive**

Controls ganged with SEND LEVEL attenuator and covering the same range.

**Set ref attenuator**

*Switched:* +8 dBr to −8 dBr in 4 dB steps.
*Variable:* −2·2 dBr to +2·2 dBr with switch position for 0 dBr.

**Measure attenuator (Quantization distortion)**

*Coarse:* 0 to −30 dB in 10 dB steps.
*Fine:* 0 to −10 dB in 1 dB steps.

**Measure attenuator (Crosstalk)**

*Coarse:* −40 to −70 dBm in 10 dB steps.
*Fine:* 0 to −10 dBr in 1 dB steps.

**Measure attenuator (Noise)**

*Coarse:* −40 to −70 dBmp in 10 dB steps.
*Fine:* 0 to −10 dBmp in 1 dB steps.

**INPUT IMPEDANCE**

600 Ω BALANCED.

**Return loss**

Better than 40 dB from 300 to 3600 Hz.

**Balance**

Greater than 60 dB from 300 to 3600 Hz.

**METER SCALE**

−2 dB to +2 dB in 1 dB divisions with 0·2 dB sub-divisions.

**dB scale accuracy**

±0·15 at −2 dB and +2 dB w.r.t. 0 dB.

**Pulse scale accuracy**

See PULSE section.

**MEASUREMENT**

True r.m.s. (effective value).

**Meter settling time**

Approximately 2 s.
Distortion sine, Crosstalk and Noise 300 ms approximately.

**RECEIVE FREQUENCY RESPONSE**

**300 to 3400 Hz**

Response with reference to the 0 dBm level at 1 kHz:
±0·15 dB from 300 to 3400 Hz.
Less than 3 dB down at 15 kHz.

**Distortion sine**

Below 600 Hz and above 1200 Hz: psophometric telephone circuit to CCITT 1972 Green Book Vol. V. Recommendation P.53.
From 835 to 865 Hz:
greater than 60 dB down with reference to the 800 Hz level on Noise Function.

**350 to 550 Hz**

Band limited. Does not diminish the power of noise band between 350 and 550 Hz by more than 0·25 dB.

**Distortion (noise)**

Filter response: with reference to the maximum output level 2 dB bandwidth at least 2·4 kHz.
Greater than 60 dB down, 150 Hz and below.
Greater than 55 dB down at 650 Hz.
Greater than 35 dB down at 700 Hz.
Greater than 20 dB down at 750 Hz.
3 dB or greater at 800 Hz.
3 dB or greater at 3·4 kHz.
Greater than 10 dB down at 3·5 kHz.
Greater than 20 dB down at 3·6 kHz.
Greater than 40 dB down at 3·7 kHz.

# TF 2807A

| | |
|---|---|
| | Greater than 50 dB down at 3·75 kHz. Greater than 60 dB down at 5·0 kHz and above. Measurement is related to distortion present in the full p.c.m. channel bandwidth of 300 to 3400 Hz by a built-in correction factor. |
| **Crosstalk** | 850 Hz ±10 Hz (0·3 dB points). Filter response with reference to the maximum output level: Less than −0·6 dB at 840 and 860 Hz. Greater than −3·0 dB at 810 and 890 Hz. Greater than −30·0 dB at 690 and 1010 Hz. |
| **Noise** | Psophometric telephone circuit to CCITT 1972 Green Book Vol. V. Recommendation P.53. |
| **PULSE** | |
| **Send pulse output** | When switched to PULSE all switch controls on the instrument are disabled. Signal source mode switch selects one of two pulse frequencies, 10 Hz or 17 Hz ±1 Hz. *Mark/space ratio:* 1:1 to 1:1·01. *Output impedance: Mark* – high, Space – low |
| **Receive pulse input** | When switched to PULSE all instrument controls are disabled. The meter provides a direct reading of difference between actual mark duration and the correct duration. *Meter scale:* −5% to +5% of pulse period (−5 ms to +5 ms at 10 Hz). *Accuracy:* ±5% of reading, ±0·3% pulse period. |
| **INTERFACE** | |
| **Normal mode** | 4 mm sockets with centres at 12 mm and an additional chassis socket in line at 9 mm. |
| **Pulse** | 4 mm socket. |

## GENERAL

| | |
|---|---|
| **SAFETY** | Complies with IEC 348. |
| **RADIO FREQUENCY INTERFERENCE** | Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference. |
| **LIMIT RANGE OF OPERATION** | |
| **Temperature** | 0 to 55°C. |

| | |
|---|---|
| **CONDITIONS OF STORAGE AND TRANSPORT** | |
| **Temperature** | −40°C to +70°C. |
| **Humidity** | Up to 90% relative humidity. |
| **Altitude** | Up to 2500 m (pressurized freight at 27 kPa differential, i.e. 3·9 lbf/in²). |
| **POWER REQUIREMENTS** | |
| **AC supply** | 95 to 130 V and 190 to 264 V 45 to 500 Hz. 15 VA approx. |

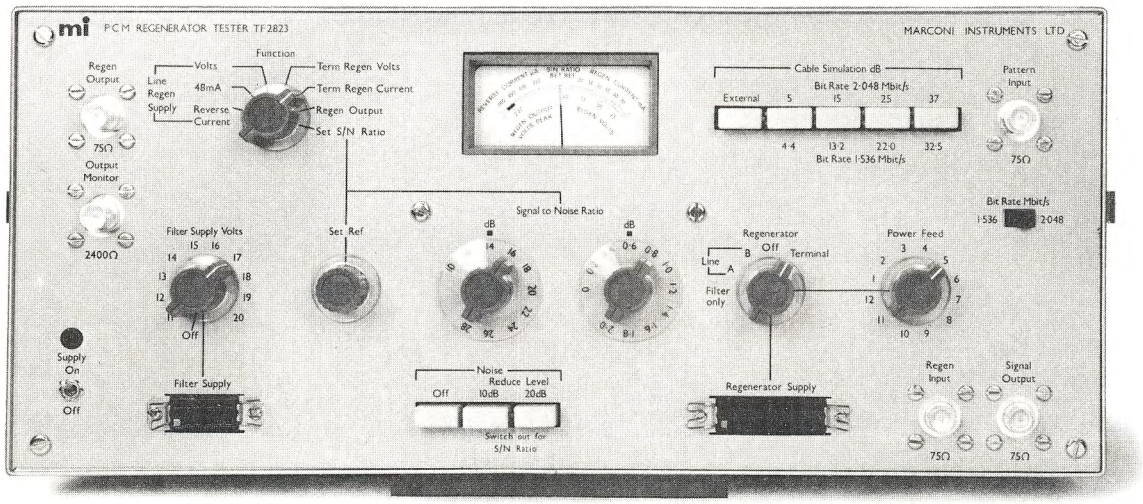
| **DIMENSIONS AND WEIGHT** | Height | Width | Depth | Weight |
|---|---|---|---|---|
| | 148 mm | 430 mm | 370 mm | 11·0 kg |
| | 5¾ in | 17 in | 14½ in | 24 lb |

### VERSIONS AND ACCESSORIES

*When ordering please quote eight-digit code numbers*

| Ordering numbers | |
|---|---|
| | **Versions** |
| **52807-910T** | TF 2807A Standard version with 850 Hz crosstalk. |
| **52807-311Y** | TF 2807A with 325 Hz crosstalk. |
| **52807-312N** | TF 2807A with 820 Hz crosstalk. |
| **52807-313L** | TF 2807A with 1020 Hz crosstalk. |
| **52807-314J** | TF 2807A with 1050 Hz crosstalk. |
| **52807-315F** | TF 2807A with 820 Hz crosstalk and French text front panel. |
| **52807-316G** | TF 2807A. P.O. Measuring Set No. 53A. |
| **52807-317V** | TF 2807A with 1020 Hz crosstalk and "C" message filter. |
| **52807-319W** | TF 2807A with 850 Hz crosstalk and 60%/40% pulse. |
| | **Supplied Accessories** |
| | Signal Lead 43125-074A (Two supplied). |
| | Extender Board and Extractor 44827-735E. |
| | Front Cover Assembly 41690-160N, with operating summary. |
| | AC Supply Lead. |
| | Instruction Manual. |
| | **Optional Accessories** |
| **54127-071H** | Rack Mounting Kit. |

# PCM Regenerator Tester TF 2823




*12924/3*

- ☐ **Provides composite test signal for p.c.m. regenerators at 1·536 and 2·048 Mbit/s**
- ☐ **Includes cable simulators and near-end crosstalk generator**
- ☐ **Tests clock tuning, output levels and noise immunity of line and terminal regenerators**
- ☐ **Provides power feeds for regenerators and supervisory test filters**

The TF 2823 provides facilities for testing line and terminal regenerators for 24 and 30 channel p.c.m. systems at 1·536 and 2·048 Mbit/s respectively. It provides a noise signal to simulate near-end crosstalk (n.e.x.t.) and combines this with a p.c.m. test signal from an external pattern generator. It also includes cable simulators equivalent to various lengths of cable for insertion in the signal path and provides power supplies for the regenerators under test and for supervisory test filters.

When used in conjunction with a pattern generator and an error detector the p.c.m. regenerator tester enables the following tests to be carried out:

1. Regenerator tuning.
2. Checking regenerator performance in the presence of noise and cable distortion.
3. Monitoring regenerator output level.
4. Monitoring the d.c. voltage and current supply to the regenerator, including a reverse current check by which correct operation of the fault location components can be ascertained.

## Cable simulators

There are four cable simulators for use in the signal path with attenuation values of 5, 15, 25 and 37 dB at 1 MHz, which is half the bit rate frequency for 2·048 Mbit/s 30 channel systems. The simulators have responses derived from phase/frequency and attenuation/frequency characteristics of 28-pair 0·63 mm (10 lb) p.c.q.t. cable of 1000 m length. Alternatively, connection can be made to external simulators, if required.

## NEXT generator

The interference simulator is a white noise generator with a flat frequency response from 30 kHz to 6 MHz, the output of which is shaped by either of two filters for 2·048 or 1·536 Mbit/s systems so as to simulate n.e.x.t. interference. Before the noise is combined with the signal from the cable simulators the signal-to-noise ratio is set up by comparing levels in the signal and noise channels using the internal r.m.s. voltmeter.

The composite signal and noise is applied to the regenerator under test together with the appropriate power supply. Provision is also made for driving the second regenerator housed in the line regenerator unit with a signal derived from the associated pattern generator. The regenerator output is returned to the TF 2823 from which it may be monitored by an external error detector.

TF 2823 is available as a separate unit or complete with Pattern Generator and SLMS TF 2802/2 and Digital Error Detector TF 2801/4 in an assembly designated PCM Regenerator Test Set OA 2805A.

# TF 2823

**PATTERN INPUT**

A p.c.m. signal of alternate mark inversion (AMI) or high density bipolar (HDB3) coded.

| | |
|---|---|
| **Bit rates** | 1·536 Mbit/s or 2·048 Mbit/s. |
| **Pulse amplitude** | 2·37 V ±0·24 V. |
| **Duty cycle** | 50% nominal. |
| **Input impedance** | Nominal 75 Ω unbalanced (BNC socket). |

**DIGITAL DRIVE (for 2nd regenerator)**

A continuous series of pulses of alternate polarity.

| | |
|---|---|
| **Bit rate** | 1·536 Mbit/s or 2·048 Mbit/s nominal. |
| **Pulse amplitude** | 2·37 V ±0·24 V. |
| **Duty cycle** | 50% nominal. |
| **Input impedance** | Nominal 75 Ω unbalanced. (Rear panel 7-way Plessey (Painton) 159 series socket type No. 74/10/0756/10.) |

**CABLE SIMULATION**

4 cable simulator networks. Selected by push button switches, simulating various lengths and weighting of telephone lines referred to by the insertion loss. The simulators are inserted between PATTERN INPUT and SIGNAL OUTPUT. Connection may also be made to an external simulator.

| | |
|---|---|
| **Insertion loss** | At 1 MHz (for 2·048 Mbit/s): 5, 15, 25 and 37 dB nominal. At 800 kHz (for 1·536 Mbit/s): 4·4; 13·2; 22 and 32·5 dB nominal. |

**WHITE NOISE GENERATOR**

A white noise signal of gaussian distribution is filtered to simulate near-end crosstalk (n.e.x.t.). The noise level is variable or can be switched off.

| | |
|---|---|
| **Frequency band** | 10 kHz to 6 MHz. |
| **Response** | Nominal flatness: 10 kHz to 2 MHz within 0·4 dB. 2 MHz to 6 MHz within 2·0 dB. |

**NOISE CHARACTERISTICS**

| | |
|---|---|
| **NEXT Filters** | Selected by BIT RATE switch. 1·536 Mbit/s: Response shaped to simulate n.e.x.t. on 1·536 Mbit/s system (conforming to BPO filter for 24 channel p.c.m.). 2·048 Mbit/s: Response shaped to simulate n.e.x.t. on 2·048 Mbit/s system (conforming to BPO filter for 30 channel p.c.m.). |
| **Output level (with pseudo-random signal)** | Adjustable so that any signal to noise ratio between 10 dB and 30 dB may be selected by switched attenuators, calibrated as signal to noise ratio in dB. |
| **Coarse attenuator** | 10 dB to 28 dB in 2 dB steps. |
| **Fine attenuator** | 0 dB to 2 dB in 0·2 dB steps. |

**SIGNAL TO NOISE MEASUREMENT**

A null reading r.m.s. differential voltmeter, used with the SET REF control calibrates the white noise level relative to the pattern signal level fed to the regenerator under test. The white noise output level attenuators indicate the selected signal to noise ratio in dB.

| | |
|---|---|
| **Accuracy** | ±0·5 dB at 2048 kbit/s. ±0·6 dB at 1536 kbit/s. |

**REGENERATOR SUPPLY**

Interface for line or terminal regenerators, comprising pattern and noise test signal outputs, return signals for measurement and power supplies (Front panel 19-way Plessey (Painton) 159 series socket, type No. 74/10/1956/10).

| | |
|---|---|
| **Signal and noise level** | Test pattern level determined by CABLE SIMULATION selected. Noise may be added at a level set by SIGNAL TO NOISE RATIO and NOISE LEVEL controls or switched off. The signal is fed via SIGNAL OUTPUT and REGEN. INPUT externally linked for access. |
| **Noise reduce level attenuators** | 10 and 20 dB. Accuracy: ±1 dB. Impedance: 120 Ω balanced for feeding into regenerator under test. |
| **Digital drive level** | Maximum of 3 V peak ±10% into 120 Ω attenuated by the nominal value of CABLE SIMULATION selected. Impedance: 120 Ω balanced for feeding into section of line regenerator not being tested. |
| **Pattern** | The regenerated pattern signal from the regenerator under test is fed to MONITOR and REGEN. OUTPUT sockets (for connection to an error detector) and may be monitored by the meter. |
| **Filter** | The supervisory filter test signal from the regenerator is fed to the FILTER SUPPLY socket. |

**REGENERATOR POWER SUPPLIES**

| | |
|---|---|
| **Line regenerator current** | 48 mA ±1 mA, isolated from earth. |
| **Feed** | POWER FEED switch selects one of twelve power feeds as follows: One way working: 1. Intermediate regenerator – input feed. 2. Intermediate regenerator – input feed (reversed). 3. Intermediate regenerator – output feed. 4. Intermediate regenerator – output feed (reversed). 5. Power turn-round regenerator – input feed. 6. Power turn-round regenerator – output feed. Two way working: 7 to 12 as 1 to 6 respectively. |
| **Terminal regenerator voltage** | 24 V d.c. nominal, isolated from earth. |

**FILTER SUPPLY**

Interface for supervisory filter, comprising test signal, return signal for measurement and power supplies. (Front panel socket 11-way Plessey (Painton) 159 series socket, type No. 74/10/1156/10.)

| | |
|---|---|
| **Signal output** | The TRIO test signal from a pattern generator is fed directly to the supervisory frequency filter or after passing through the regenerator under test, as selected by the front panel REGENERATOR switch. |
| **Signal input** | The audio signal from the supervisory frequency filter is fed via the FILTER SUPPLY socket to the 7-way socket on the rear panel (for connection to an s.l.m.s.). |

# TF 2823

| | |
|---|---|
| **Filter power supply voltage** | From 20 V ±0·3 V to 11 V ±0·6 V selected in steps of 1 V ±0·3 V. |
| **Impedance** | Nominal 1 kΩ source impedance. |
| **METER** | Meter FUNCTION switch selects one of seven functions. |
| **1) Line regenerator supply** | Indicates supply current to regenerator on reverse current check. Calibrated 200 µA to 500 µA. |
| **2) 48 mA** | Indicates supply current to line regenerator. Calibrated 20 mA to 70 mA. |
| **3) Line regenerator voltage** | Monitors voltage drop across line regenerator. Calibrated 10 V to 25 V. |
| **4) Terminal regenerator voltage** | Monitors terminal regenerator supply voltage. Calibrated 10 V to 25 V. |
| **5) Terminal regenerator current** | Indicates terminal regenerator supply current. Calibrated 20 mA to 70 mA. |
| **6) Regenerator output** | Monitors regenerator output signal peak level. Calibrated 2·37 V with ±10% band. |
| **7) Set S/N ratio** | Indicates correct setting of signal to noise ratio. |
| **Measurement accuracy** | DC current and voltage: ±10%. Regenerator output peak voltage: ±5%. |
| **CONNECTORS** | |
| **Signal output** | Carries test pattern with added noise as selected. (BNC socket.) |
| **Regen. input** | Provides access to the regenerator under test. (BNC socket.) The SIGNAL OUTPUT and REGEN. INPUT are externally linked for normal regenerator testing. (BNC sockets.) |
| **Regen. output** | Provides access to the regenerator under test, connected to an error detector for normal regenerator testing. (BNC socket.) *Output impedance:* 75 Ω. |
| **Output monitor** | Provides monitoring facility of the output of the regenerator under test. (BNC socket.) *Output impedance:* 2·4 kΩ nominal. |
| **External simulators** | Provides connection to external cable simulators. (19-way Plessey, Painton 159 series socket type No. 74/10/1956/10.) |
| **RADIO FREQUENCY INTERFERENCE** | Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference. |
| **SAFETY** | Complies with IEC 348. |
| **LIMIT RANGE OF OPERATION** | |
| **Temperature** | 0 to 55°C. |
| **CONDITIONS OF STORAGE AND TRANSPORT** | |
| **Temperature** | −40°C to +70°C. |
| **Humidity** | Up to 90% relative humidity. |
| **Altitude** | Up to 2500 m (pressurized freight at 27 kPa differential, ie., 3·9 lbf/in²). |

| | |
|---|---|
| **POWER REQUIREMENTS** | |
| **AC supply** | 190 to 264 V and 95 to 130 V. 45 to 500 Hz. 15 VA nominal. |
| **DIMENSIONS AND WEIGHT** | |

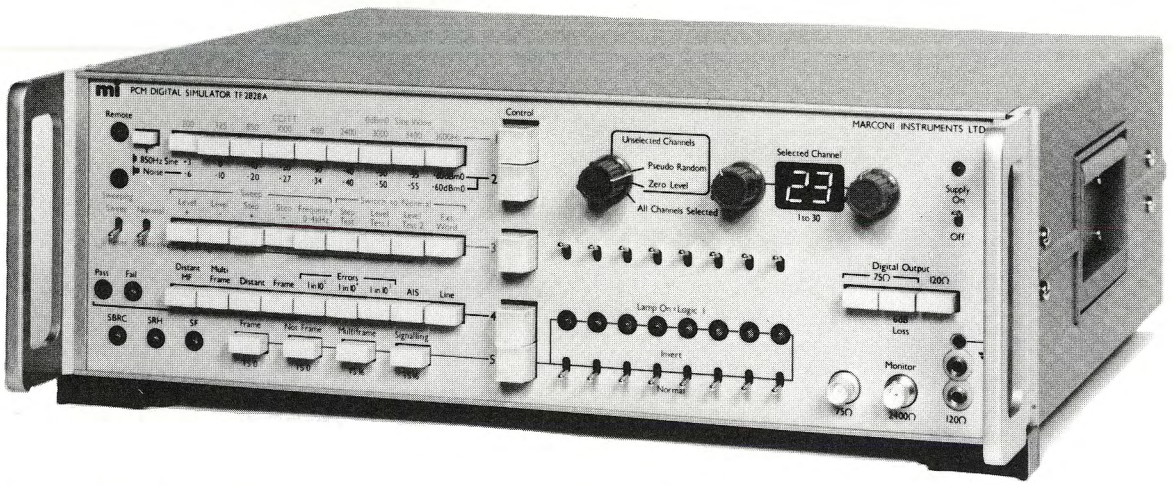
| Height | Width | Depth | Weight |
|---|---|---|---|
| 186 mm | 420 mm | 410 mm | 10·9 kg |
| 7·3 in | 16·5 in | 16·2 in | 24 lb |

## VERSIONS AND ACCESSORIES

*When ordering please quote eight-digit code numbers*

| Ordering numbers | |
|---|---|
| | **Versions** |
| **52823–311W** | TF 2823 Version in OA 2805A case, with P.O. connectors. |
| **52823–312D** | TF 2823 Version in OA 2805A case, with BNC connectors. |
| **52823–313T** | TF 2823 Version in single bench case with BNC connectors. |
| **52823–314P** | TF 2823 Version in single bench case with P.O. connectors. |
| **52823–315X** | TF 2823 Version in OA 2805A case, with BNC connectors. Bit-rates: 1·544 and 2·048 Mbit/s. |
| | **Supplied Accessories** |
| | Board Extractor 41148–605K (supplied with all versions). |
| | Interface Lead 43129–056Y (supplied with all versions). 7-way lead with Plessey (Painton) connectors for second regenerator drive and connection to TF 2802/2. |
| | Accessory Kit 46883–169H (supplied with all versions). Comprising Terminal Regenerator Supply Lead 43129–050K, Filter Supply Lead 43129–051A and Line Regenerator Supply Lead 43129–052Z. |
| | Accessory Kit 46883–255S (supplied with version 52823–315X). Comprising Filter Supply Lead 43129–110T and Line Regenerator Supply Lead 43129–111P. |
| | Lead 43125–050Y (TM 4726/164) BNC. (three supplied with versions 52823–311W, 52823–313T and 52823–315X). For connection from TF 2823 to TF 2801/4 and TF 2802/2. |
| | Cord Assembly 43129–057N (supplied with version 52823–311W). For connection from TF 2823 to TF 2801/4 and TF 2802/2. |
| | U-Link 23441–098U P.O. No. 1 (supplied with version 52823–311W). To link SIGNAL OUTPUT and REGEN. INPUT sockets. |
| | AC Supply Lead 43129–071D. |
| | Supply Distribution 44990–094H. |
| | Instruction Manual. |
| | **Optional Accessories** |
| **44836–104L** | Extender Board; for use when servicing printed boards. |

# PCM Digital Simulator TF 2828A




- ☐ **Simulation of 2048 kbit/s HDB 3 encoded line signal to CCITT Recommendation G732**
- ☐ **Range of frequencies from 200 to 3600 Hz**
- ☐ **Range of levels at 850 Hz from +3 to −60 dBm0**
- ☐ **Simulation of alarm conditions**
- ☐ **Remote control of essential functions through TTL interface**
- ☐ **Optional GPIB interface**

PCM Digital Simulator TF 2828A generates a digital stream incorporating a 2048 kbit/s frame structure to CCITT Recommendation G732. The simulator is used for testing the receive section of a p.c.m. multiplex and it has five basic control modes selected by the front panel CONTROL push-button switches.

Control modes 1, 2 and 3 are used for audio channel tests and they enable selected eight-bit digital words to be inserted either on to all 30 speech channel time slots or on to any one chosen time slot, selected by front panel rotary switches with digital read-out. In the latter case the remaining speech channels can either be loaded with a code equivalent to a zero-level signal or they can be loaded with a pseudo-random bit stream representative of traffic. These options permit measurements to be made of both quiescent noise and crosstalk.

Control modes 4 and 5 are used for alignment and alarm tests and permit modifications to be made to the contents of time slots 0 and 16. The speech channels then carry a digital representation of a 1 kHz sine wave at a level of 0 dBm0, enabling the action of multiplex alarms upon audio channels to be determined.

## Control modes

**Control mode 1** uses a bank of nine push-button switches to select a 0 dBm0 sine wave at a range of frequencies from 200 Hz to 3600 Hz for measurements of frequency response at the audio output of the multiplex.

**Control mode 2** uses the same bank of push-buttons to give digital representations of an 850 Hz sine wave or a band-limited pseudo-random noise frequency at nine levels, enabling the linearity of the multiplex decoder circuits to be tested.

**Control mode 3** uses a second bank of nine push-button switches to select various sequences of words which can be used for level testing, and it also provides a facility for incrementing the words automatically through 128 levels for sweep testing. The required words are set up using a bank of eight toggle switches. It is also possible to generate increments of frequency at 0 dBm0 in 30 Hz steps from 15 Hz to 4000 Hz at a stepping rate of about 1 increment per quarter second. This low stepping rate allows for the response time of 'x-y' plotters which can be used to plot individual channel frequency response.

# TF 2828A

**Control mode 4** uses a third bank of nine push-buttons to select various words for testing the detailed operation of the majority of alarms displayed on the alarm panel of the multiplex equipment. The reaction of the multiplex equipment is established by comparing the signal on the alarm lines from the multiplex with logic states stored in the memory of TF 2828A. The response of the multiplex is indicated by PASS and FAIL lamps on TF 2828A front panel. Errors at three specified rates can be imposed on the frame alignment words.

**Control mode 5** uses a bank of four push-buttons and allows each bit of the alignment and signalling words to be modified by means of 8 NORMAL/INVERT toggle switches and the words are displayed on an array of eight l.e.d. lamps.

All essential functions of TF 2828A are remotely programmable when the simulator is fitted with the optional GPIB conversion kit, or they can be remotely controlled via a socket on the rear panel.

TF 2828A together with the PCM Digital Analyser TF 2829 and PCM Multiplex Tester 2830 provides the facility for complete testing of p.c.m. multiplexes.

**OUTPUT**

PCM frame structure to CCITT Recommendation G732.

**Format**

HDB 3 code.

**Bit rate**

Internal clock generator 2048 kbit/s ±100 bit/s.

**Output impedance and amplitude**

*75 Ω unbalanced:*
Return loss greater than 26 dB.
Pulse amplitude (terminated in 75 Ω) 2·37 V ±10%.
6 dB loss network simulating 6 dB of cable loss at 1 MHz inserted in output path.
*120 Ω balanced:*
Return loss greater than 26 dB.
Pulse amplitude (terminated in 120 Ω) 3·0 V ±10%.
*2400 Ω monitor:*
Pulse amplitude into 75 Ω (with selected output terminated) 72 mV nominal.

**EXTERNAL CLOCK INPUT**

2048 kbit/s ±200 bit/s.
*Impedance:* 75 Ω unbalanced.
*Level:* Greater than 1 V p-p sine or square wave.

**CONTROL MODES**

An illuminated control switch permits selection of five operating modes.
Modes 1, 2 and 3 select test signals for loading selected channel time slots in an error-free frame structure (see AUDIO CHANNEL TESTS).
Modes 4 and 5 allow modifications to the standard frame structure with the channel time slots loaded with a standard test signal (see ALIGNMENT TESTS).

## AUDIO CHANNEL TESTS

**CHANNEL SELECTION**

In control modes 1, 2 and 3 selected test signals may be loaded into any one or all audio channel time slots as selected by the channel switches and indicated on the seven segment displays. When a single channel is selected, the unselected channels may be loaded with either a zero level or pseudo-random signal.

**CONTROL MODE 1 (0 dBm0 sine wave)**

Generates digital sequences representing sine waves at nine selected frequencies at a level of 0 dBm0. The frequencies generated are listed below. They are not sub-harmonics of the 8 kHz sampling rate except for the CCITT recommended 1 kHz.

| Nominal frequency (Hz) | Clock derived frequency (Hz) |
|---|---|
| 200 | 203 |
| 325 | 328 |
| 850 | 859 |
| 1000 | 1000 |
| 1800 | 1797 |
| 2400 | 2390 |
| 3000 | 2984 |
| 3400 | 3391 |
| 3600 | 3609 |

*Frequency accuracy:* derived from the clock source.
*Level accuracy:* theoretical error of fundamental due to quantizing error no greater than ±0·01 dB.
Signal to quantizing noise ratio greater than 35 dB.
Signal to quantizing noise ratio is the ratio of the fundamental frequency to the harmonic and sub-harmonic frequency components of the fundamental in the frequency range 300 Hz to 3·4 kHz.

**CONTROL MODE 2 (850 Hz sine wave or band limited noise)**

Generates digital sequences representing a sine wave of nominally 850 Hz (859 Hz), or a band limited pseudo-random noise sequence (415 to 540 Hz), at nine levels. Selection of sine or noise is controlled by a switch.

**Sine**

The following nine levels are generated as measured in a 300 Hz to 3·4 kHz bandwidth.

| Level (dBm0) | Theoretical quantizing level error (dB) | Theoretical signal to quantizing noise ratio (dB) |
|---|---|---|
| +3 | <0·01 | >35 |
| 0 | <0·01 | >35 |
| −10 | <0·01 | >35 |
| −20 | <0·01 | >35 |
| −30 | <0·01 | >35 |
| −40 | <0·01 | >30 |
| −50 | <0·05 | >20 |
| −55 | <0·05 | >15 |
| −60 | <0·05 | >10 |

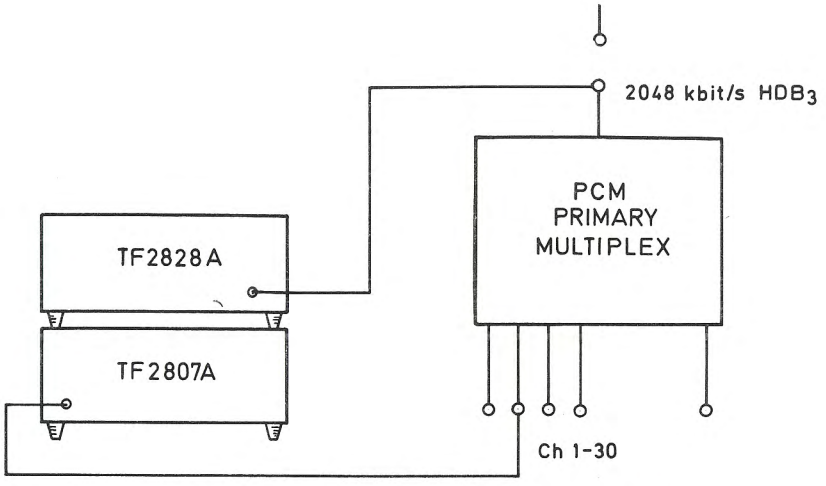
**Noise**

The following nine levels are generated as measured in a 350 to 550 Hz bandwidth.

| Noise (dBm0) | Level error (dB) | Quantizing distortion (dB) | Quantizing distortion error (dB) |
|---|---|---|---|
| −6 | ±0·01 | 38·70 | ±0·06 |
| −10 | ±0·01 | 38·52 | ±0·06 |
| −20 | ±0·01 | 38·56 | ±0·06 |
| −27 | ±0·01 | 38·54 | ±0·06 |
| −34 | ±0·01 | 36·78 | ±0·06 |
| −40 | ±0·01 | 32·11 | ±0·06 |
| −50 | ±0·01 | 21·94 | ±0·06 |
| −55·03 | ±0·01 | 17·01 | ±0·06 |
| −60 | ±0·01 | 11·99 | ±0·06 |

The repeat time of the pseudo-random function is 384 ms ±0·05 ms.
Peak to r.m.s. ratio is 10·5 dB nominal.
Bandwidth (3 dB) is 415 to 540 Hz. The noise source is compatible with the requirements of CCITT Recommendation 0·131 and with the PCM Multiplex Tester 2830.

# PCM Test Equipment
# TF 2828A




*TF 2828A used with TF 2807A for testing a PCM Primary Multiplex*

**CONTROL MODE 3 (Decoder tests)**

The following definitions apply.

**Word** — Set by means of eight two-position switches on the front panel. Switches indicate the state of the word prior to alternate digit inversion. Left hand switch gives polarity: 1=positive, 0=negative. Of the seven remaining switches the first (left hand) switch gives the most significant bit and the last (right hand) switch the least significant bit.

**Positive word** — As 'Word' but with the first (polarity) bit permanently set at '1' (first switch inoperative).

**Negative word** — As 'Word' but with first (polarity) bit permanently set at '0' (first switch inoperative).

**Zero** — Generates word X0000000 where X is a '1' or '0' as set by 'Word' in same test sequence.

**Word+1** — Generates word advanced by one code level, e.g. if 'Word'=binary number −106 then 'Word+1'=binary number −107. The following test patterns may be inserted into any or all audio channel time slots, as indicated on the display.

**Level test 1** — Generates a continuous sequence of eight positive words followed by eight negative words.

**Level test 2** — Generates a continuous sequence of eight words and eight zeros.

**Step test** — Generates a continuous sequence of eight words and eight word+1's.

**Sweep level+** — Level test 2 is automatically sequenced from +0 through to +127.

**Sweep level−** — Level test 2 is automatically sequenced from −0 through to −127.

**Sweep step+** — Step test is automatically sequenced starting at +0 through to +126.

**Sweep step−** — Step test is automatically sequenced starting at −0 through to −126. For the preceding four tests the word changes after 1024 multiframes (approximately 2 s).

**Decoder test stimulus switch (500 Hz/pseudo-random)** — With this switch set to '500 Hz' the preceding seven tests occur as detailed above. With 'pseudo-random' selected the transition between the two words will occur at a pseudo-random rate.

**Sweep frequency (0 to 4 kHz)** — 0 dBm0 sine wave is automatically sequenced through 128 frequencies (approximately 15 Hz to 4 kHz in 30 Hz steps). The frequency changes every 256 multiframes (approximately 0·5 s). All sweep tests are single shot and are controlled by a sweep/reset switch. A green lamp is illuminated when a sweep is in progress.

**Recorder output** — A positive going staircase for sweep tests available at a rear panel socket. *Sweep rate:* controlled by test function. *Amplitude:* 0 to 3·5 V nominal. *Output impedance:* 10 k Ω approximately.

**Sweep/Reset switch** — Initiates sweep and sets RECORDER OUTPUT to zero.

**Set output high** — Biased rear panel switch sets RECORDER OUTPUT to full scale irrespective of setting of reset control.

**External word** — Accepts input to EXT WORD INPUT socket on rear panel of instrument. Output of clocks are provided at 2048 kbit/s and 8 kHz.

*Connector:* 15 way Plessey 159 series socket.

| Function | Pin |
|---|---|
| Bit 1 | 1 |
| Bit 2 | 2 |
| Bit 3 | 3 |
| Bit 4 | 4 |
| Bit 5 | 5 |
| Bit 6 | 6 |
| Bit 7 | 7 |
| Bit 8 | 8 |
| 2048 kHz output | 10 |
| 8 kHz output | 12 |
| Earth | 15 |

*Input logic level:* positive logic Logic 1=+5 V, Logic 0=−5 V.
*Input impedance:* greater than 10 kΩ.
*Output clocks level:* +5 V to −5 V.
*Output impedance:* less than 10 kΩ.
The above levels are CMOS compatible.

**Selective signalling/ normal switch** — Set to NORMAL the instrument functions as described. Set to SELECTIVE SIGNALLING the operation of 'Step Test', 'Level Test 1' and 'Level Test 2' is overridden.
Set to SELECTIVE signalling with 'Level Test 2' selected the signal associated with the selected channel can be modified by the WORD control switches. The switches acting as 0 for normal and 1 for invert. Normal word is 0101. for channels 1 to 15 the first four word switches are used and for channels 16 to 30 the last four switches are used. The digital signal in the selected channel is the CCITT 1000 Hz.

# TF 2828A

## ALIGNMENT TESTS

A standard 2048 kbit/s frame structure is generated to CCITT G732 and errors/alarm conditions are inserted. Switches/internal straps allow for change in frame strategy. Audio channel time slots are loaded with a digital pattern of peak code 116 representing a sine wave at 1 kHz and 0 dBm0.
The logic associated with the alarm outputs can be checked to ensure correct functioning of the multiplex. Rear panel socket TO MULTIPLEX allows access to alarm lines.

**CONTROL MODE 4**

Error conditions are activated by depressing the Control Mode 4 switch which illuminates while the error condition is present.

**Line**

Signal removed from output sockets.

**AIS (Alarm indication signal)**

Generates a 2048 kbit/s stream of all '1's.

**Errors 1 in $10^3$**

Injects errors into the frame alignment word at a rate of 1 in $10^3$.

**Errors 1 in $10^4$**

Injects errors into the frame alignment word at a rate of 1 in $10^4$.

**Errors 1 in $10^5$**

Injects errors into the frame alignment word at a rate of 1 in $10^5$.

**Start and stop pulses for counter-timer**

For the preceding three tests negative-going pulses (+5 to −5 V, 20 µs nominal) are available from TO COUNTER/TIMER START and STOP outputs on the rear panel, which in conjunction with alarm signals generated by the multiplex may be used to measure time taken to action the alarm.

**Frame**

A sequence is generated which exercises the multiplex for loss and recovery of frame alignment in accordance with CCITT Recommendation G732.

**Distant**

A sequence is generated which exercises the multiplex for correct indication of 'Distant' alarm.

**Multiframe**

A sequence is generated which exercises the multiplex for loss and recovery of multiframe alignment in accordance with CCITT Recommendation G732.

**Distant multiframe**

A sequence is generated which exercises the multiplex for correct indication of Distant Multiframe alarm.

For the preceding four tests PASS and FAIL lamps indicate the functioning of the multiplex alarms. These four tests are normally single-shot sequences. However, the rear panel switch REPEATED ALARM SEQUENCES allows the above sequences to run continuously.

**Trigger output**

A trigger output at the start of each sequence is available from TRIGGER OUTPUT on the rear panel for synchronization when viewing multiplex alarm logic. Trigger consists of a 5 V squarewave, positive going edge coincident with start of sequence.

**Test lead to TF 2829**

Rear panel terminal provides for connection to PCM Digital Analyser TF 2829 for back-to-back testing of instrument alignment structure.

**CONTROL MODE 5**

As a further aid to alarm testing the following words may be monitored by eight l.e.d.s and their logic states may be inverted by eight associated switches denoted NORMAL/INVERT.

**Frame TSO**

Frame alignment word normally 10011011.

**Not frame TSO**

Not frame word normally 11011111.

**Multiframe TS16**

Multiframe alignment word normally 00001011.

**Signalling TS16**

Signalling words normally 01010101. See 'Selective signalling'.

**MULTIPLEX ALARM AND SIGNALLING HIGHWAY MONITOR**

The conditions monitored are SBRC, SRH and SF which are alarm conditions monitored by the BPO.
However, if only a single alarm is available on the multiplex this can be applied to both SBRC and SRH inputs allowing alarm functioning to be assessed while sequence testing in Control Mode 4.

Alarm lamps ON condition are as follows (TTL +ve logic).

**SBRC (System busy receive common)**

Logic 1 (normally logic 0).

**SRH (secondary receive highway)**

Continuously high (normally varying data).

**SF (System fail)**

Line connected to earth (normally open circuit).

**REMOTE**

All essential functions are remotely programmable when the simulator is fitted with the GPIB kit or they can be remotely controlled via a socket on the rear panel (50 way Amp connector). A lamp indicates REMOTE operation.

**Via GPIB**

GPIB subset reference list:
SH1, AH1, SR1, RL1, T5, L3, DC1, E1.

**Via rear panel REMOTE socket**

The following table indicates the functions and modes controlled. (Inputs TTL −ve logic. Outputs TTL +ve logic).

**Control lines and functions**

Remote enable
Data valid (held high while changing functions and control modes).
Channel select (5 lines).
Loading of unselected channels (2 lines):
  All channels selected.
  Pseudo random signal in unselected channels.
  Zero level signal in unselected channels.
Control mode select (5 lines):
  Control modes 1 and 2. Nine levels sine (at a frequency set by Test

| | |
|---|---|
| | word/frequency lines) or noise (Test word/frequency lines set to 0) and CCITT 0 dBm0 at 1 kHz.<br>Control mode 3. Channel word, level tests 1 and 2, step test. (Channel word set by Test word/frequency lines).<br>Control mode 4. Alarm tests (except LINE).<br>Control mode 5. Set frame or not frame or multiframe or signalling words. (Word set by Test word/frequency lines).<br>Test word/frequency select (8 lines):<br>Sets frequency in control modes 1 and 2 (noise if all 0).<br>Sets channel word in control mode 3.<br>Sets word in control mode 5.<br>Line off.<br>Sine or Pseudo random on level tests.<br>SBRC (output).<br>SRH (output).<br>SF (output).<br>Alarm sequence test pass/fail (output).<br>Alarm sequence test pass/inhibit (output).<br>Ground. |
| **SAFETY** | Complies with IEC 348. |
| **LIMIT RANGE OF OPERATION** | |
| **Temperature** | 0 to 55°C. |
| **CONDITIONS OF STORAGE AND TRANSPORT** | |
| **Temperature** | −40° to +70°C. |
| **Humidity** | Up to 90% relative humidity. |
| **Altitude** | Up to 2500 m (pressurized freight at 27 kPa differential, i.e. 3·9 lbf/in²). |
| **POWER REQUIREMENTS** | |
| **AC supply** | 115 V and 230 V nominal.<br>45 to 65 Hz. 20VA nominal. |
| **Supply outlet** | 2A maximum outlet for PCM Digital Analyser TF 2829. |

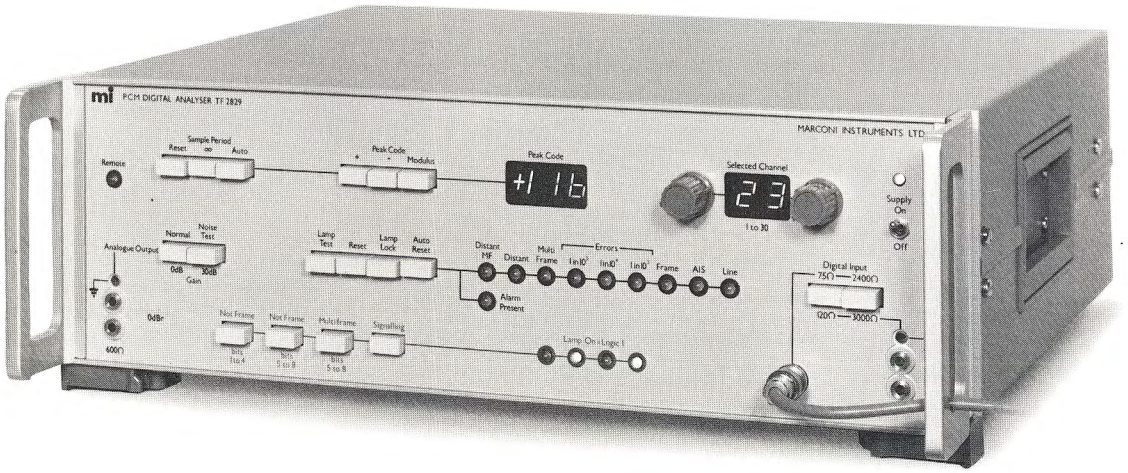
| **DIMENSIONS AND WEIGHT** | Height | Width | Depth | Weight |
|---|---|---|---|---|
| | 148 mm | 430 mm | 444 mm | 10 kg |
| | 5·75 in | 17·0 in | 17·5 in | 22 lb |

## VERSIONS AND ACCESSORIES

*When ordering please quote eight digit code numbers*

| **Ordering numbers** | |
|---|---|
| | **Versions** |
| **52828–910U** | TF 2828A Standard version. |
| **52828–311X** | TF 2828A fitted with GPIB conversion kit. |
| | **Supplied Accessories** |
| | Accessory Pack 46883–366M, including Board Extractor, Lamp Extractor, Push-Button Lamps and Fuse Links.<br>AC Supply Lead (side entry) 43129–003W.<br>Interconnecting Lead 43129–288Z.<br>Instruction Manual 46881–325T. |
| | **Optional Accessories** |
| **54127–071H** | Rack Mounting Kit. |
| **54347–013Z** | Lead Assembly (Multiplex). Lead to connect TF 2828A to a Multiplex. |
| **54511–012R** | Extender Board. |
| **54712–041M** | Multiway Plug (7 way) Multiplex. |
| **54712–051H** | Multiway Plug (15 way) Ext. Word. |
| **46883–368R** | 50 way Plug Kit (Remote). |
| **43129–189U** | GPIB Lead, 1 metre. |
| **46883–449Y** | GPIB Conversion Kit. (To convert version –910U to version –311X). |

# PCM Digital Analyser TF 2829




14591/1

- ☐ **In-service or out-of-service monitoring of audio channels and digital display of peak code**
- ☐ **Detection and display of alarm conditions**
- ☐ **Digital to analogue conversion of selected channel**
- ☐ **Remote control of essential functions through TTL interface**
- ☐ **Optional GPIB interface**

PCM Digital Analyser TF 2829 provides for 'in-service' or 'out-of-service' monitoring and testing of 2048 kbit/s HDB3 encoded digital line signals conforming to CCITT Recommendation G732. The analyser is used for testing the transmit section of a p.c.m. multiplex.

The analyser has four operational functions. An alignment section provides indication of faults on the transmitted frame structure. A second section extends the use of the alignment monitor to include a display of either the current state of bits not directly concerned with alignment in time slots 0 and 16 or the state of the signalling bits on a selected channel. The third function uses a peak code detector to display the peak digital code that appears in a selected speech channel. In the fourth function the selected speech channel binary words are processed in a digital to analogue converter, the resulting analogue output being available for further measurement of the transmitter performance.

The input will accept signal levels over a 40 dB range allowing either direct or bridging connection to the digital stream. A clock signal is recovered from the amplified input signal from which are derived timing signals corresponding to channel and alignment time slots for use throughout the instrument.

All essential functions of TF 2829 are remotely programmable when the simulator is fitted with the optional GPIB* conversion kit, or they can be remotely controlled via a socket on the rear panel.

TF 2829 together with the PCM Digital Simulator TF 2828A and the PCM Multiplex Tester 2830 provides the facility for complete testing of p.c.m. multiplexes.

| | |
|---|---|
| **INPUT** | PCM frame structure to CCITT Recommendation G732. |
| **Format** | HBD 3 code. |
| **Bit rate** | 2048 kbit/s ±200 bit/s. Synchronization will be maintained with up to 1·5 bits p-p jitter at 4 kHz. |
| **Input impedance and amplitude** | *75 Ω unbalanced:* Return loss greater than 30 dB between 100 kHz and 3·0 MHz. Input pulse amplitude range 32 mV to 2·7 V. *2400 Ω unbalanced:* Input pulse amplitude range 1·0 V to 2·7 V. *120 Ω balanced:* Return loss greater than 20 dB. Input pulse amplitude range 40 mV to 3·3 V. *3000 Ω balanced:* Input pulse amplitude range 1·0 V to 3·3 V. |

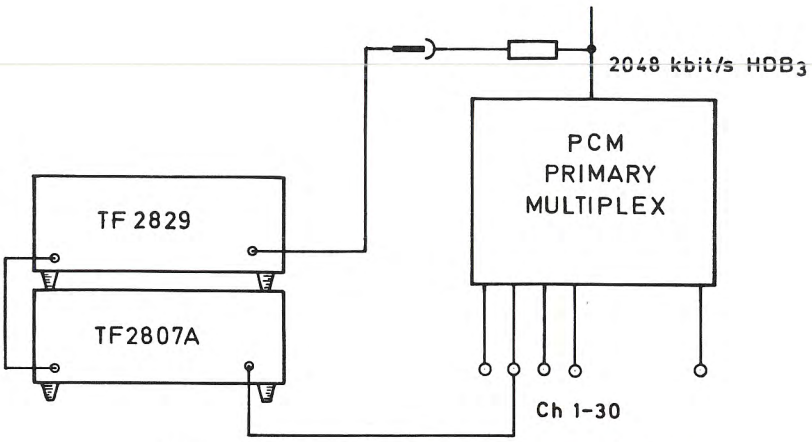
## FRAME STRUCTURE MONITORING

| | |
|---|---|
| **ALARM MONITORING** | Lamps indicate the frame structure alarm conditions and are graded in order of priority. When several alarm conditions are simultaneously presented the highest priority alarm only is indicated. Two display modes are available, AUTO RESET and LAMP LOCK. |
| **Auto reset** | Lamp extinguishes when alarm condition clears. |
| **Lamp lock** | Lamp remains on after alarm clears. However until the line is alarm free further alarm conditions will be recorded and held. Lamps remain on until manually RESET. This condition does not apply to ALARM PRESENT Lamp. |
| **Alarm present** | Lamp lights when an alarm condition is present and extinguishes when alarm condition clears. This facilty is useful after frame errors have been removed from the input signal as the error rate circuit takes up to 60 s to clear. |
| | Alarm conditions in order of priority are: |
| **Line** | A lamp will light when the signal is all '0' s. |
| **AIS (Alarm indication signal)** | A lamp will light when the signal is all '1' s. |
| **Frame** | A lamp will light when 3* consecutive Frame words or Not Frame words have been received each with one or more errors. **The number of consecutive Frame words or Not Frame words to be monitored during the above sequence can be varied by adjustment of internal strapping.* The lamp will extinguish when a sequence of Correct Frame, Not Frame and Frame words has been detected. |
| **1 in $10^3$ errors** | A lamp will light if the error rate on the incoming frame alignment word is greater than 1 part in $10^3$. Errors averaged over a 300 ms period. |
| **1 in $10^4$ errors** | A lamp will light if the error rate on the incoming frame alignment word is greater than 1 part in $10^4$. Errors averaged over a 3 s period. |
| **1 in $10^5$ errors** | A lamp will light if the error rate on the incoming frame alignment word is greater than 1 part in $10^5$. Errors averaged over a 30 s period. Recovery of error alarms is checked over a 30 s period, so up to about 60 s may elapse before alarm clears on removal of errors. |
| **Multiframe** | A lamp will light when two consecutive multiframe alignment words have been received, each with one or more errors. The lamp will extinguish when one correct multiframe alignment word has been received. |
| **Distant** | A lamp will light when the distant frame alarm is received on at least two consecutive occasions. The lamp will extinguish when non-alarm condition is detected. |
| **Distant multiframe** | A lamp will light when the distant multiframe alarm is received on two consecutive occasions. The lamp will extinguish when the non-alarm condition is detected. |
| **Test lead to TF 2828A** | Rear panel terminal provides for connection to PCM Digital Simulator TF 2828A for back-to-back testing of instrument alignment structure. |
| **WORD MONITORING** | In addition to the above alarm monitoring the state of other parts of the frame structure may be monitored on four lamps. Switch selection allows access to: |
| **Not frame bits 1 to 4** | The four lamps indicate the logic state of bits 1 to 4 of the Not Frame word. |
| **Not frame bits 5 to 8** | The four lamps indicate the logic state of bits 5 to 8 of the Not Frame word. |
| **Multiframe bits 5 to 8** | The four lamps will indicate the logic state of bits 5 to 8 of the Multiframe alignment word. |
| **Signalling** | The four lamps will indicate the logic state of the signalling word in any channel selected. |

## AUDIO CHANNEL TESTS

| | |
|---|---|
| **Selected channel** | Any one of the 30 channels may be switch selected. The channel number is indicated on two seven-segment displays. The display is blanked out on loss of frame lock. |
| **PEAK CODE** | Indication of peak code in selected channel on seven segment numerical display is either: |
| **Positive** | Peak most positive code. |
| **Negative** | Peak most negative code. |
| **Modulus** | Maximum code. Positive or negative. |
| **Sample period** | In AUTO the peak code is continuously monitored using a sampling period of about 0·15 s. In INFINITY the highest code is continuously monitored and is displayed until manually reset. On RESET returns to current code. |
| **ANALOGUE OUTPUT** | The digital information on the selected channel is converted to an analogue output signal. |
| **Frequency response** | 300 Hz to 3·4 kHz ±0·1 dB w.r.t. 850 Hz. 200 Hz to 3·5 kHz ±0·2 dB w.r.t. 850 Hz. |
| **Linearity** | Maximum variation of gain with input level at −10 dBm0, measured selectively at 850 Hz. ±0·15 dB from +3 dBm0 to −50 dBm0. ±0·3 dB from −50 dBm0 to −55 dBm0. ±0·5 dB from −55 dBm0 to −60 dBm0. With 30·1 dB digital gain (ANALOGUE OUTPUT switched to NOISE TEST). ±0·15 dB from −50 dBm0 to −55 dBm0. ±0·25 dB from −55 dBm0 to −60 dBm0. |
| **Distortion** | Additional distortion added to the decoded output is negligible, and is of the order of 0·05 dB theoretical error on the signal to distortion ratio. |

# TF 2829




*TF 2829 used with TF 2807A for testing a PCM Primary Multiplex*

| | |
|---|---|
| **Output level** | 0 dBm0 ±0·1 dB into 600 Ω at a transmission level of 0 dBr (when digital signal on selected channel is equivalent to 0 dBm0 signal at 850 Hz).<br>The dBr level may be adjusted internally over a range of levels up to +10 dBr. |
| **600 Ω output impedance** | Return loss better than 36 dB from 200 Hz to 3·6 kHz.<br>Balance greater than 60 dB from 200 Hz to 3·6 kHz. |
| **Noise test** | For low level output signal not exceeding code levels ±31 (idle channel noise, cross-talk etc.) a digital gain may be switch selected. This effectively increases the gain by a factor of 32 (30·1 dB). |
| **LAMP TEST** | A non-locking switch will illuminate all front panel lamps and displays excluding REMOTE lamp. |
| **REMOTE** | All essential functions can be remotely controlled via a socket on the rear panel (50 way AMP connector). A lamp indicates REMOTE operation.<br>Output of alarm states and peak code detector are available. |
| **Via GPIB** | GPIB subset reference list:<br>SH1, AH1, SR1, RL1, T5, L3, DC1, E1. |
| **Via rear panel REMOTE socket** | The following table indicates the functions and modes controlled. (Inputs TTL −ve logic. Outputs TTL +ve logic). |
| **Control lines and functions** | Remote enable<br>Control lines (8 lines) select<br>Peak code (2 lines) +ve,<br>−ve, modulus.<br>Reset peak code.<br>Noise test (+30 dB gain).<br>Reset alarms.<br>Frame structure monitor (3 lines).<br>Multiframe word bits 5 to 8,<br>not-frame word bits 5 to 8,<br>not-frame word bits 1 to 4,<br>signalling word in selected channel.<br>Channel select (5 lines).<br>Peak code outputs (8 lines) +ve logic.<br>TS(n) selected channel timing signal.<br>Alarm lamp outputs (10 lines) +ve logic:<br>Alarm present<br>Line<br>AIS<br>Frame<br>Error rate 1 in $10^3$, 1 in $10^4$, 1 in $10^5$.<br>Multiframe<br>Distant<br>Distant Multiframe<br>Frame structure monitor lamp (4 lines) +ve logic<br>Ground. |

| | |
|---|---|
| **AUXILIARY OUTPUTS** | Auxiliary outputs (t.t.l.) on 7-way Painton socket:<br>Data NRZ.<br>Clock.<br>TS(n) selected channel timing signal.<br>Frame errors.<br>Ground. |
| **SAFETY** | Complies with IEC 348. |
| **LIMIT RANGE OF OPERATION** | |
| **Temperature** | 0 to 55°C. |
| **CONDITIONS OF STORAGE AND TRANSPORT** | |
| **Temperature** | −40° to +70°C. |
| **Humidity** | Up to 90% relative humidity. |
| **Altitude** | Up to 2500 m (pressurized freight at 27 kPa differential, i.e. 3·9 lbf/in²). |
| **POWER REQUIREMENTS** | |
| **AC supply** | 115 V and 230 V nominal.<br>95 to 130 V and 190 to 264 V.<br>45 to 65 Hz. 18 VA nominal. |
| **DIMENSIONS AND WEIGHT** | |

| Height | Width | Depth | Weight |
|---|---|---|---|
| 148 mm | 430 mm | 444 mm | 10 kg |
| 5·75 in | 17·0 in | 17·5 in | 22 lb |

## VERSIONS AND ACCESSORIES

*When ordering please quote eight digit code numbers*

| Ordering numbers | |
|---|---|
| | **Versions** |
| **52829-901J** | TF 2829 standard version. |
| **52829-304A** | TF 2829 fitted with GPIB conversion kit. |
| | **Supplied Accessories** |
| | Accessory Pack 46883-367C, including Board Extractor and Fuse Links. |
| | AC Supply Lead (side entry) 43129-003W. |
| | Instruction Manual 46881-326P. |
| | Interconnecting Lead 43129-288Z. |
| | **Optional Accessories** |
| **54127-071H** | Rack Mounting Kit. |
| **54511-012R** | Extender Board. |
| **46883-368R** | 50 way Plug Kit (Remote). |
| **54712-041M** | Multiway Plug (7 way) Multiplex. |
| **43129-189U** | GPIB Lead, 1 metre. |
| **46883-449Y** | GPIB Conversion Kit. (To convert version -901J to version -304A.) |

# PCM Multiplex Tester 2830




15208/1

- ☐ **High accuracy**
- ☐ **High speed**
- ☐ **Fully automatic and manual operation**
- ☐ **Programmable measurement sequences**
- ☐ **Analogue and digital modes**
- ☐ **Output for printer via GPIB**

The 2830 is a simple to operate tester for PCM primary multiplexes, providing high standards of measurement accuracy and speed of measurement, and great flexibility of application.

Tests which can be made to CCITT recommendations include:

- Frequency response
- Gain
- Linearity
- Quantizing distortion
- Idle channel noise
- Crosstalk
- ★ Impedance balance
- ★ Return loss
- ★ Signalling distortion
- End to end measurements by modem control.

★ *These measurements can be made only when 2830 is used in conjunction with Channel Access Switch 2831.*

### High accuracy for improved stand-off

The 2830 provides standards of measurement accuracy in most parameters, previously unobtainable with other instruments. The most important improvements are in LEVEL and DISTORTION measurements, so that PCM multiplex manufacturers can achieve significant stand-off for production measurements of channel gain, linearity, frequency response and distortion.

### Speed of measurement

Measurement techniques have been developed to minimise parameter measurement times, thereby reducing overall testing time for a multiplex equipment. In some parameters, reduction of measurement time has been dramatic, and a significant increase in multiplex throughput can result in a production environment.

### Automatic and manual operation

The 2830 has been designed primarily for fully automatic testing, but can just as easily be used in the manual mode for laboratory use or where more detailed investigatory measurements are required.

### Programmability

Automatic test sequences with tolerance masks can be programmed by Marconi Instruments to suit customers'

particular requirements. Since up to four sequences are available, different stages of measurement can be allowed for very easily, for example in multiplex production testing. In addition, if measurement of all parameters is not required in any sequence, the parameters measured can be selected in any chosen combination.

So that measurement sequences can be performed on all channels of a multiplex automatically, the 2830 will normally be used in conjunction with the 2831 Channel Access Switch, which is GPIB controlled from the 2830. A sequence of tests can thus be stepped through each channel in turn.

## Analogue and digital modes

When 2830 is used as a standalone instrument, or in conjunction with the Channel Access Switch 2831, all the usual primary multiplex parameters can be measured on an analogue-to-analogue basis.

Where digital-to-analogue and analogue-to-digital measurements are required, 2830 and 2831 can be combined with 2828A PCM Digital Simulator and 2829 PCM Digital Analyser to form an automatic test set, the latter instruments being controlled via the GPIB by 2830.

Furthermore, 2830 itself is capable of being controlled by an external controller, in applications where measurements beyond the scope of 2830 are required.

## Printer output

A 20 or 80 column printer can be connected via the GPIB, and either all results printed out, or just those which fall outside of limits.

## Other features

- ☐ Test sequences can be channel limited to a sequential group down to one channel.
- ☐ Test sequences can be recycled repeatedly.
- ☐ Quantizing Distortion can be measured on one selected channel only in an AUTO sequence.
- ☐ Failed tests in an AUTO sequence can be verified after repair before continuing.
- ☐ AUTO sequences can be manually stepped, one test at a time.
- ☐ Peak code tests (A to D) can be performed.
- ☐ Transmitter d.c. offset tests (A to D) can be performed.
- ☐ An automatic calibration sequence when 2829 is used extends the high inherent accuracy of 2830.

*Note: Items below marked * are dependent upon the 'personality' module fitted to the instrument and may be altered, within the indicated ranges where appropriate, according to the customers' needs.*
*Please contact Marconi Instruments for further details.*

## TRANSMIT SECTION

Generates either a sine or a band limited noise signal.

### SINE

**Frequency range**
Any number of discrete frequencies between 200 Hz and 4·0 kHz up to a maximum of 20 can be programmed as required.*
Normally:–

| | |
|---|---|
| 202 Hz | 1·50 kHz |
| 300 Hz | 1·80 kHz |
| 402 Hz | 2·10 kHz |
| 502 Hz | 2·40 kHz |
| 600 Hz | 2·70 kHz |
| 802 Hz | 3·00 kHz |
| 850 Hz | 3·40 kHz |
| 1·002 kHz | 3·60 kHz |
| 1·200 kHz | |

**Frequency accuracy**
±0·1%.

**Distortion**
Less than 0·1% (total distortion.)

**Amplitude range**
+12 dBm to –78 dBm in 0·1 dB steps. This includes +2 dBr to –18 dBr and +10 dBmO to –60 dBmO.

**Amplitude accuracy**
At 850 Hz after self calibration:
±0·030 dB from +12 dBm to –60 dBm
±0·075 dB from –60 dBm to –78 dBm.

**Frequency response**
±0·05 dB relative to 850 Hz.

### NOISE

Pseudo-random band limited noise conforming with CCITT Recommendation 0·131. The noise signal is derived by band-pass filtering the output of a 17 stage shift register.

**Probability distribution**
Near Gaussian.

**Spectral density**
One spectral line per 2·6 Hz approx.

**Noise bandwidth**
3 dB bandwidth nominally 130 Hz centred on 460 Hz.

**Peak to r.m.s. ratio**
10·5 dB nominal.

**Amplitude range**
+12 dBm to –78 dBm in 0·1 dB steps. This includes +2 dBr to –18 dBr and +10 dBmO to –60 dBmO.

**Amplitude accuracy**
After self calibration:
±0·035 dB from +12 dBm to –60 dBm
±0·075 dB from –60 dBm to –78 dBm.

### OUTPUT IMPEDANCE

600 Ω balanced.

**Return loss**
Greater than 40 dB, 200 Hz to 4·0 kHz.

**Balance**
Greater than 60 dB, 200 Hz to 4·0 kHz.

### IDLE CHANNEL NOISE MODE

When idle channel noise mode is selected the transmitter output is switched off. The 600 Ω termination will remain connected.

## RECEIVE SECTION

### MEASUREMENTS

Eight measurement modes are available:–
Level sine
Gain sine
Quantizing distortion sine (QD sine)
Level noise
Gain noise
Quantizing distortion noise (QD noise)
Crosstalk (Xtalk)
Idle channel noise (ICN)

**Initialization**
The sender output signal and displays are set to suit the measurement mode selected.*

**Measuring circuit**
True r.m.s. with a measurement period of 384 ms, approximately 2·5 readings per second.

**Settling time**
The time taken to reach a settled reading varies according to the type of stimulus used, and the size and direction of level changes. Typical times are given where appropriate.

**Reference levels**
For level and gain modes the measurement may be absolute or relative to a previous stored reading.

**Averaging**
The measured quantity may be averaged or instantaneous reading.

**Input levels**
The range of received levels is +20 dBm to –90 dBm including ±10·0 dBr.

**CALIBRATION**
A calibration routine allows the instrument to be calibrated against an internal reference source.

**INPUT IMPEDANCE**
600 Ω balanced.

**Return loss**
Greater than 40 dB, 200 Hz to 4·0 kHz.

**Balance**
Greater than 60 dB, 200 Hz to 4·0 kHz.

**LEVEL SINE**
Wideband measurement of receive level. The transmitter is set to sine output at a selectable frequency and level.

**Display resolution**
0·01 dB.

**Amplitude accuracy**
At 850 Hz after self calibration
±0·03 dB from +20 to –60 dMm
±0·06 dB from –60 to –70 dBm
±0·15 dB from –70 to –75 dBm.
±0·30 dB from –75 to –80 dBm

**Frequency response**
Relative to 850 Hz at 0 dBm
±0·05 dB from 200 Hz to 3·6 kHz less than 3 dB down at 15 kHz.

**Settling Time**
Typically 0·75s.

**LEVEL NOISE**
Wideband measurement of the receive level. The transmitter is set to noise output at a selectable level.

**Display resolution**
0·01 dB.

**Amplitude accuracy**
At 850 Hz after self calibration
±0·035 dB from +20 to –60 dBm
±0·060 dB from –60 to –70 dBm
±0·15 dB from –70 to –75 dBm
±0·30 dB from –75 to –80 dBm

**Frequency response**
As level sine.

**Settling time**
Typically less than 0·75s.

**GAIN SINE**
Narrowband measurement of the receive level at the crosstalk frequency. The transmitter is set to sine output at crosstalk frequency and a selectable level. The displayed parameter is the received level relative to the displayed send level thus giving a direct reading of linearity error.

**Display resolution**
0·01 dB.

**Amplitude accuracy**
±0·03 dB from +20 to –60 dBm
±0·05 dB from –60 to –70 dBm
±0·15 dB from –70 to –80 dBm
±0·30 dB from –80 to –90 dBm
In addition errors in transmitted level affect accuracy.

**Frequency response**
850 Hz selective filter (standard).*
Flat bandwidth ±10 Hz.

**Settling time**
Typically 0·75s.

**GAIN NOISE**
Narrowband measurement of receive level (350 Hz to 550 Hz). The transmitter is set to noise output at a selectable level. The displayed parameter is the received level relative to the displayed send level thus giving a direct reading of linearity error.

**Display resolution**
0·01 dB.

**Amplitude accuracy**
±0·035 dB from +20 to –60 dBm
±0·05 dB from –60 to –70 dBm
±0·15 dB from –70 to –80 dBm
±0·30 dB from –80 to –90 dBm
In addition errors in transmitted level affect accuracy.

**Frequency response**
350 Hz to 550 Hz band pass filter to CCITT Recommendation 0·131.

**Settling time**
Typically less than 0·75s.

**QD SINE**
Total distortion (including quantizing distortion). The transmitter is set to sine output at 850 Hz at a selectable level. Simultaneous display of wideband receive level and distortion. Distortion is measured using an 850 Hz band stop filter and psophometer. A correction is added for noise power lost in the 850 Hz notch.

**Display resolution**
*Receive level:* 0·01 dB.
*Distortion:* 0·1 dB.

**QD measurement range**
0 dB to 40 dB signal to distortion ratio within the level range +10 to –60 dBm, with the absolute distortion level not less than –90 dBm.

**QD accuracy**
±0·2 dB from 0 to 40 dB.
±0·4 dB from 40 to 48 dB.

**Frequency response receive level**
As level sine.

**QD**
Below 600 Hz and above 1·5 kHz:
Psophometric telephone circuit to CCITT Recommendation P53.
835 to 865 Hz.
Greater than 60 dB down with reference to 800 Hz, 0 dBmO, level on ICN function.

**QD settling time**
Typically less than 2s.

**QD NOISE**
Total distortion (including quantizing distortion). The transmitter is set to noise output at a selectable level. Simultaneous display of receive level measured narrowband (350 Hz to 550 Hz), and distortion. Distortion is measured in a bandwidth 850 Hz to 3·4 kHz, and a correction is added to relate the measurement to the telephone channel bandwidth 300 Hz to 3·4 kHz.

**Display resolution**
*Receive level:* 0·01 dB.
*Distortion:* 0·1 dB.

**QD measurement range**
As QD sine.

**QD accuracy**
As QD sine.

**Frequency response receive level**
350 Hz to 550 Hz band pass to CCITT Recommendation 0·131.

**QD**
Flat response 850 Hz to 3·4 kHz to CCITT Recommendation 0·131.

**QD settling time**
Typically less than 2s.

**CROSSTALK**
Narrowband measurement of receive level at crosstalk frequency. Transmitter is set to sine output at crosstalk frequency (normally 850 Hz) and a level of 0 dBmO*. The input signal may contain a dither signal.

**Display resolution**
0·1 dB.

**Accuracy**
±0·2 dB from +20 to –80 dBm.
±0·3 dB from –80 to –90 dB.
±0·2 dB at transmitted crosstalk frequency.

**Frequency response**
850 Hz standard (325 Hz, 820 Hz, 1·02 kHz and 1·05 kHz optional alternatives).
For 850 Hz with reference to maximum output level:–
Less than 0·6 dB at 840 Hz and 860 Hz
Greater than 3·0 dB at 810 Hz and 890 Hz
Greater than 30·0 dB at 690 Hz and 1·01 kHz.

**Maximum level of out of band dither signal**
40 dB greater than crosstalk level.

**Settling time**
Typically less than 2s.

**IDLE CHANNEL NOISE (ICN)**
Psophometrically weighted measurement of receive level. The transmitter signal is disconnected but the output remains correctly terminated.

**Display resolution**
0·1 dB.

**Accuracy**
±0·2 dB from +20 to –80 dBmp
±0·4 dB from –80 to –90 dBmp with white noise input.

**Frequency response**
Psophometric circuit to CCITT Recommendation P53.

**Settling time**
Typically less than 2s.

# 2830

## MANUAL/AUTO OPERATING MODES

**MANUAL**

Eight basic functions as described in previous sections.

**Transmitter display**

Transmit level in dBmO and output frequency if appropriate.

**Receiver display**

Receive level in dB, dBmO or dBmOp as appropriate and quantizing distortion in dB.

**AUTO**

Auto function provides automatic measurement routines, the results of which are compared with stored limits to give a pass/fail response.

The 2830 will control a 2828A PCM Digital Simulator, a 2829 PCM Digital Analyser, one or two 2831 PCM Channel Access Switches and a printer via the GPIB to enable analogue and digital tests to be made.

Full or partial sequence for Analogue to Anologue (A to A) and/or Anologue to Digital (A to D) and/or Digital to Analogue (D to A) are selectable. Tests not configured will be ignored.

Where appropriate tests will include

Frequency response–All (A/A, A/D and D/A)
Gain Linearity – All
QD – All
ICN – All
Xtalk – All

A calibration test to eliminate errors in the

Digital Analyser – A/D
Peak code v gain – A/D

For Xtalk measurements a channel access switch must be present. All channels can be tested when the access switch is connected.

**DISPLAYS**

**Test number**

Cross reference to test in progress.*

**Error code**

Indicate type of error or failure.

**Limits**

Upper and lower limits for acceptable measurement.

**Alarm**

When a printer is not connected or selected, the measurement sequence is interrupted when an out of limits measurement is made and a buzzer gives an audible alarm if selected.

**Reveal**

On alarm, operating the REVEAL button will cause the measurement to be displayed.

**STOP**

Indicates sequence has finished.

**FAIL**

Fail along with error code indicates test terminated due to system fault or error count exceeded.*

**Printer**

A 20 or 80 column GPIB controlled printer can be connected. Printout of all results or failures only may be selected.

**GPIB**

Control of 2830 via GPIB gives full control over the instrument including AUTO mode. Independent control over set up registers enables additionally:–

Full range of transmitter frequencies from 200 Hz to 4·0 kHz set to 1 Hz resolution.
0·01 dB resolution on transmit level.
Different filter combinations in receiver.
Computation of results externally.
Diagnostic facilities.

**GPIB subset**

SH1, AH1, T6, L4, SR1, RL2, PP$\phi$, DC1, DT$\phi$, C1, C2, C3, C11, E1.

**MODEM**

Integral modem allows interconnection of two 2830s over an audio link. The receive 2830 controls the transmit section of the remote 2830. A front panel lamp indicates stored condition.

## GENERAL

**RADIO FREQUENCY INTERFERENCE**

Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference.

**SAFETY**

Complies with IEC 348.

**OPERATING TEMPERATURE RANGE**

**Rated range of use**

10° to 35°C.

**Limit range of operation**

0° to 55°C.

**CONDITIONS OF STORAGE AND TRANSPORT**

**Temperature**

–40° to +70°C.

**Humidity**

Up to 90% r.h.

**Altitude**

Up to 2500 m (pressurized freight at 27 kPa differential i.e. 3·9 lbf/in$^2$).

**POWER REQUIREMENTS**

**AC supply**

115 V or 230 V nominal.
95 to 130 V, 190 to 264 V.
50 to 60 Hz, 50 VA

**DIMENSIONS AND WEIGHT**

| Height | Width | Depth | Weight |
|---|---|---|---|
| 145 mm | 450 mm | 400 mm* | 10 kg |
| 5·7 in | 17·7 in | 15·7 in | 22 kg |

*435 mm (17·1 in) with front panel cover.

### VERSIONS AND ACCESSORIES

*When ordering please quote eight digit code numbers.*

| Ordering numbers | Versions |
|---|---|
| **52830-901V** | PCM Multiplex Tester, standard version. |
| **52830-303H** | PCM Multiplex Tester, USA Version (900/600 Ω, C-Message). |
| **52830-304B** | PCM Multiplex Tester, French Version, (French Text, 820 Hz X-talk). |
| **52830-305U** | PCM Multiplex Tester, Swedish Version, (Swedish Text). |
| | **Supplied Accessories** |
| | AC Supply Lead, (side entry) 43129-163L |
| | Interconnecting Lead (AC Supply) 43129-288Z. |
| | Operating Manual 46881-459T (H52830-901V, Vol 1). |
| | Pullout Instruction Cards. |
| | **Optional Accessories** |
| **54511-012R** | Extender Board. |
| **41700-328F** | Board Extractor. |
| **43129-189U** | GPIB Lead (1 m). |
| **46883-506M** | Rack Mounting Kit. |
| **46881-425W** | Service Manual, H 52830-900G, Vol. 2. |
| **43125-074A** | Lead, B.T. Test Cord, 2-72G. |
| **46883-408K** | IEEE/IEC Adaptor Block. |

# Channel Access Switch 2831




15137

- ☐ **Switches up to 32 channels**
- ☐ **Full manual control**
- ☐ **Full automatic control via the GPIB**
- ☐ **Return loss, balance and signalling distortion measurements**

The 2831 provides individual channel access for p.c.m. and f.d.m. telecommunications systems. It may be controlled both manually and via the GPIB and is therefore particularly suited to automated production and maintenance testing.

When it is used for testing p.c.m. systems, test signals may be controlled to and from the inputs and outputs of up to thirty speech channels. The return loss and balance of these interfaces may also be measured.

The 2831 will switch the digital input and output of the system to a PCM Digital Simulator 2828A or PCM Digital Analyser 2829. A suitable controller for GPIB use is the PCM Multiplex Tester 2830 which when used in conjunction with the Channel Access Switch and the Digital Analyser and Simulator, forms an automatic test system capable of measuring all primary multiplex parameters on all channels in A to A, A or D and D to A modes.

The 2830 can control two 2831 s allowing up to sixty channels to be switched if required. In addition the 2831 may be used to switch f.d.m. voice channels or groups and voice frequency telegraph circuits for production, installation and maintenance testing.

| LF CHANNEL SWITCHES | |
|---|---|
| **Insertion loss** | Less than 0·03 dB at 20 kHz.<br>Less than 0·05 dB at 110 kHz. |
| **Return loss** | Greater than 36 dB when terminated in 600Ω (d.c. to 110 kHz). |
| **Balance** | Greater than 70 dB (d.c. to 4 kHz).<br>Greater than 50 dB (d.c. to 110 kHz). |
| **Crosstalk (isolation from any) other l.f. input or output)** | Greater than 100 dB (d.c. to 4 kHz).<br>Greater than 70 dB (d.c. to 110 kHz). |
| **Changeover time** | Less than 20 ms (including bounce). |
| **DC isolation from ground** | 150V maximum. |

| | |
|---|---|
| **Maximum d.c. current capability** | 100 mA through.<br>20 mA terminated. |
| **LF switching capability** | Selects one of thirty two inputs and routes signal to a test signal output port.<br>Selects one of thirty two outputs and routes signal to a test set input port.<br>An extra output channel port is available for connecting an l.f. output signal from a digital analyser to the test set input port.<br>All unselected inputs and outputs are terminated. |
| **Connectors** | *Channel inputs and outputs* are wired to six 37-way. D-type connectors.<br>*Test set ports:* balanced audio connectors. |

# 2831

## DIGITAL CHANNEL SWITCHES

**Insertion loss** Less than 0·5 dB (d.c. to 5 MHz).

**Return loss** 30 dB (d.c. to 3 MHz).
26 dB (d.c. to 5 MHz).

**Digital Switching Capability: Inputs/Outputs**

1. Tx MUX A: Digital signal from 1st multiplex transmitter.
2. Rx MUX A: Digital signal from 1st multiplex receiver
3. Tx MUX B: Digital signal from 2nd multiplex transmitter
4. Rx MUX B: Digital signal from 2nd multiplex receiver
5. 2828A: Digital Generator (test equipment)
6. 2829: Digital Analyser (test equipment)

**Connection Modes: Single Multiplex Testing:**

Multiplex connected to MUX A Tx and Rx ports

1. Analogue to Analogue:
   MUX Tx looped back to MUX Rx
   2829 Digital Analyser connected to MUX Tx as monitor
2. Analogue to Digital:
   MUX Tx connected to 2829 Digital Analyser
3. Digital to Analogue:
   MUX Rx connected to 2828A Digital Generator
   2829 Digital Analyser connected to MUX Rx as monitor

**Connection Modes: Two Multiplex Testing:**

1. Analogue to Analogue:

1.1 Tests from MUX A to MUX B (MUX A-B selected)
MUX A Tx connected to MUX B Rx
2829 connected to MUX A Tx as monitor

1.2 Tests from MUX B to MUX A (MUX B-A selected)
MUX B Tx connected to MUX A Rx
2829 connected to MUX B Tx as monitor

2. Analogue to Digital:

2.1 For MUX A (MUX A-B selected)
MUX A Tx connected to 2829 Digital Analyser

2.2 For MUX B (MUX B-A selected)
MUX B Tx connected to 2829 Digital Analyser

3. Digital to Analogue:

3.1 For MUX A (MUX A-B selected)
MUX A Rx is connected to 2828A Digital Generator
2829 Digital Analyser connected to MUX A Rx as monitor.

3.2 For MUX B (MUX B-A selected)
MUX B Rx is connected to 2828A Digital Generator.
2829 Digital. Analyser connected to MUX B Rx as monitor.

**Connectors** BNC 75 Ω unbalanced
BNC balanced
Others to order.

## RETURN LOSS MEASUREMENT

**Measurement range** 10 to 40 dB

**Accuracy:**
**Within range 10 to 30 dB** 0·5 dB from 200 Hz to 4 kHz
1·5 dB from 4 kHz to 20 kHz
**Within range 30 to 40 dB** 1·0 dB from 200 Hz to 4 kHz
2·0 dB from 4 kHz to 20 kHz

## BALANCE MEASUREMENT

**Measurement range** 26 to 60 dB

**Accuracy:**
**Within range 26 to 50 dB** 0·8 dB from 200 Hz to 4 kHz
2·0 dB from 4 kHz to 20 kHz
**Within range 50 to 60 dB** 3·0 dB from 200 Hz to 20 kHz

## DIALLING PULSE DISTORTION MEASUREMENT

**Transmitter** *Send Frequency:* 6 to 25 Hz in 0·1 Hz steps
*Mark to Space Ratio range (% mark):* 10 to 90% in 1% steps.

**Receiver** *Range (% Mark):* 0 to 99%
*Accuracy:* ±1 digit
*Display:* Receive pulse measurement relative to transmit pulse.

## GPIB CONTROL

**Listener** Operates as a listener to set l.f. and digital connections.

**Talker** Gives status of l.f. and digital connections.

## MANUAL CONTROL

**Transmit and receive channel** 1 to 32 set by keyboard switches controlling increase or decrease in selected channel number. In addition, the receive channel can be switched to an input from the audio output of 2829 Digital Analyser (A-D measurements).

**Digital connectors** Set by keyboard switch A-A, A-D, or D-A and 2 MUX as indicated above.

**Input/output ports** Set by keyboard switch as required.

## RADIO FREQUENCY INTERFERENCE

Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference.

## SAFETY

Complies with IEC 348.

## LIMIT RANGE OF OPERATION

Temperature 0° to 55°C.

## CONDITIONS OF STORAGE AND TRANSPORT

**Temperature** –40° to +70°C.

**Humidity** Up to 90% r.h.

**Altitude** Up to 2500m (pressurized freight at 27 kPa differential i.e. 3·9 lbf/in$^2$).

## POWER REQUIREMENTS

**AC supply** 240/115 V with 2 A outlet socket.

## DIMENSIONS AND WEIGHT

| Height | Width | Depth | Weight |
|---|---|---|---|
| 150 mm | 452 mm | 403 mm | 10 kg |
| 5·9 in | 17·8 in | 15·9 in | 22 lb |

## VERSIONS AND ACCESSORIES

*When ordering please quote eight digit code numbers.*

| Ordering numbers | Version |
|---|---|
| **52831-900R** | Channel Access Switch 2831. |
| | **Supplied Accessories**<br>AC Supply Lead (side entry) 43129-163L.<br>Interconnecting Lead 43129-288Z.<br>Protective Lid/cover.<br>Operating Manual 46881-450N. (H52831-900R, Vol. 1). |
| | **Optional Accessories** |
| **43129-189U** | GPIB Lead (1 m). |
| **46883-408K** | IEEE/IEC Adaptor Block. |
| **54511-012R** | Extender Board. |
| **41700-328E** | Board Extractor. |
| **46883-506M** | Rack Mounting Kit. |
| **46883-608M** | 37 way D-type Connector. (6 required for 32 channels). |
| **46881-451L** | Service Manual (H52831-900R, Vol. 2). |

# Digital Line Monitor 2833




15067/1

- ☐ **For use as an error detector with p.c.m. systems at 2048 and 8448 kbit/s**
- ☐ **Displays totalised errors or error ratio**
- ☐ **Monitors the frame structure of 2048 kbit/s systems to CCITT Recommendation G732**
- ☐ **Indication of alarm states including loss of frame and multiframe**
- ☐ **Display of selected channel signalling code and last digit dialled**
- ☐ **64 kbit/s co-directional digital output for any selected channel time-slot**
- ☐ **External count facility for measurement of multiplex alarms**

Digital Line Monitor 2833 is a new instrument providing very comprehensive facilities for in-service measurement and analysis of 2048 and 8448 kbit/s p.c.m. transmission systems which conform to CCITT Recommendations G732 and G742. Extensive use is made of new advances in technology such as microprocessors and custom designed LSI integrated circuits in order to provide a capability previously unobtainable. The design incorporates many features contributing to ease of use and operational convenience, in particular the size has been kept to an absolute minimum. A self test mode can be switch selected to check the input circuitry and display to ensure user confidence.

Input impedance is 75 Ω unbalanced or 120 Ω balanced. Switch selected sensitivity adjusts the input circuit to accept signals from 75 Ω or 120 Ω sources direct or from monitor points with 2400 Ω, 75 Ω input, or 3000 Ω, 120 Ω input source impedances.

The instrument can be powered either from the a.c. mains supply or from a 12 volt d.c. supply such as a car battery, enabling the instrument to be used at remote regenerator locations.

### Error measurement

The p.c.m. bit stream is monitored and code violations of the HDB3 format are detected. The errors are either totalised and displayed on a six digit counter or displayed as an error ratio in the form of a mantissa and exponent from 1 in $10^6$ to 1 in 10. Errors are therefore displayed in the mode required for any application.

An important feature is that the totalisation of errors continues when the mode is switched to error ratio enabling error ratio to be measured without interfering with a long-term monitoring sequence.

A buzzer can be enabled such that audible indication of an error is given to the operator thus facilitating the location and rectification of faults. The buzzer can also be set to sound when a signal is present.

### Frame alignment signal

The frame alignment signal in the 2048 kbit/s bit stream is monitored and errors are determined. Display of errors is similar to the error measurement mode in that totalisation and error ratio facilities can be switch selected and totalisation continues when error ratio is selected.

Measurement of the frame alignment signal has been found to be a most powerful means of assessing the true errors in a p.c.m. bit stream. Monitoring of bipolar errors does not always give a realistic indication of errors especially when a digital exhange forms a part of a transmission path, since the exchange will remove errors (violations of AMI or HDB3 codes) before re-transmission. The 2833 enables the user to make in-service error measurements with complete confidence. Previously it has been necessary to make measurements out of service to ensure valid results.

### Alarm state indication

LED lamps illuminate corresponding with the following error conditions; Line, AIS, Frame, Errors, Multiframe, Distant Frame, Distant Multiframe. If more than one error condition exists then only the highest priority lamp is lit. Lamps are self-extinguishing when an error-free situation is re-established unless the Lamp Lock mode is selected. Multiplex alarms can be assessed to ensure their integrity both during commissioning and in traffic.

### Channel signalling

The 4 bit channel signalling code in time slot 16 can be selected for any desired channel and decoded and displayed as a decimal equivalent from 0 to 15. A simple 'look-up' table enables the operator to decode this information and give a signalling state equivalent. This facility enables the operator to diagnose fully the state of the p.c.m. signal under investigation. A buzzer in the instrument can be enabled which can give the operator audible warning of a change in signalling state.

The last digit dialled can also be displayed; this is another facility enabling further detailed analysis of the p.c.m. system. For use on particular PTT systems contact Marconi Instruments Ltd.

### 64 kbit/s co-directional output

Any time slot from 0 to 31 can be selected by front panel control such that the data in the selected time slot appears at a rear panel output socket as a 64 kbit/s co-directional signal (CCITT Rec. G732). This signal is provided so that associated test equipment can be interfaced with the 2833 enabling further analysis of the p.c.m. signal at the 64 kbit/s level.

### External count

An external count input socket is provided to totalise the error pulses from a multiplex alarm monitor thus obviating the need for an additional counter for this task.

### Pen recorder

Rear panel output sockets enable a current drive pen recorder to be interfaced with the 2833 allowing for the long-term monitoring of signal, alarm and error conditions.

| | |
|---|---|
| **MEASUREMENT MODES** | One of five measurement modes can be set as follows:<br>HDB3 line code error detector at 2048 kbit/s<br>HDB3 line code error detector at 8448 kbit/s<br>Frame alignment monitor at 2048 kbit/s<br>Signalling monitor at 2048 kbit/s<br>External count input. |
| **HDB3 LINE CODE ERROR DETECTOR 2048 kbit/s** | Detects HDB3 line code errors in a 2048 kbit/s digital stream and displays the totalised errors or the error ratio. AMI strap selectable. |
| **HDB3 LINE CODE ERROR DETECTOR 8448 kbit/s** | As 2048 kbit/s but for an 8448 kbit/s digital stream. |
| **FRAME ALIGNMENT MONITOR AT 2048 kbit/s** | Checks the frame structure of a 2048 kbit/s digital stream to CCITT Recommendation G732. Displays any frame or multiframe alarms found and monitors the frame word for errors which are displayed as a totalised count or error ratio. The tester automatically aligns itself to the incoming signal. |

| | |
|---|---|
| **Alarm indications** | Lamps will light if the following alignment errors are detected. |
| **Line** | No signal present. |
| **AIS** | Alarm indication signal present. (All ones signal.) |
| **Frame** | Loss of frame alignment. |
| **Errors (Frame Word)** | Error ratio in the frame alignment word is greater than, or equal to, 1 in $10^5$. |
| **Multiframe** | Loss of multiframe alignment. |
| **Distant frame** | Detection of the distant frame alarm. |
| **Distant multiframe** | Detection of the distant multiframe alarm. |
| **Alarm priority** | When alarm conditions are detected only the highest priority alarm condition is lit, the priorities being in descending order as above. |
| **Indication mode** | Switch selected to Auto Reset or Lamp Lock. |
| **Auto-reset** | Indication is present for the length of time an alarm condition exists with a minimum of 300 ms. |
| **Lamp Lock** | Once set the alarm indication remains on until auto-reset mode is selected. |

*Notes:*
(1) Lamp Lock Mode:
(a) When more than one alarm of a different type has been detected

and cleared then more than one alarm may be indicated until reset.

(b) When an alarm condition has been 'set' a later higher priority alarm will be ignored until the original alarm is cleared.

(2) Multiframe and distant multiframe alarms may be inhibited by internal links.

**Frame word errors** The frame word is monitored bit by bit for errors and displayed as a totalised count of frame words with error or as frame word error ratio.

**Channel select** The output of a selected time slot may be accessed on the rear panel as a 64 kbit/s co-directional output.

*Note:* A full description of the alarm functioning is given in Appendix A.

## SIGNALLING MONITOR

Displays the signalling code present for a selected channel in a 2048 kbit/s digital stream to CCITT Recommendation G732.

**Signalling code** The present signalling code is displayed as its decimal equivalent. The previous code may be recalled.

**Last number dialled** When a Circuit Seized signalling condition is present the signalling code is monitored for dial breaks and the last number dialled is displayed.

The unit will detect errors listed in the following table and display them as the corresponding error code. Links may be specified for use on various PTT systems.

| *Code* | *Error* | |
|---|---|---|
| 1 | Detected signalling code not circuit seized or dial break. | |
| 2 | Dial break pulse | out of limits. |
| 3 | Dial break pulse | |
| 4 | Inter dial break | out of limits. |
| 5 | Inter dial break | |
| 6 | 11 or more dial break pulses. | |

**Channel select** Push button selection of channel required.

**Alarm indications** Alarm indications function as in the Frame Alignment Monitor mode.

**Frame errors** When switched to signalling mode from frame alignment mode the unit continues to count frame alignment errors, which can be displayed as error ratio or total errors on switching directly back to frame alignment mode.

## EXTERNAL ERROR COUNTER

Accepts error pulses from a multiplex alarm monitor and totalises the number received.

## SIGNAL INPUT

**Bit rate** 2048 kbit/s ± 50 p.p.m. or 8448 kbit/s ± 30 p.p.m.

**Format** HDB3 to CCITT Recommendation G703 with or without frame structures to G732 (2048 kbit/s) and G742 (8448 kbit/s).

**Amplitude** Switch selected sensitivity for terminating a 75 Ω or 120 Ω source directly or from monitor points with source impedances of 2400 Ω (75 Ω input) or 3000 Ω (120 Ω input).

The nominal attenuation of the signal from a monitor point is 33 to 1 (≙ 30 dB).

| *Source Impedance* | *Nominal peak amplitude* |
|---|---|
| 75 Ω | 2·37 V |
| 120 Ω | 3·00 V |
| 2400 Ω | 72 mV |
| 3000 Ω | 91 mV |

The input sensitivity also allows for further loss from a feed cable having a 6 dB attenuation at the half bit rate.

**Impedance**

**75 ohms unbal.** 75 Ω unbalanced, BNC connector. (BT No. 1 connector optional).

**Return loss** Greater than 20 dB, 100 kHz to 12 MHz. Greater than 15 dB, 50 kHz to 100 kHz.

**120 ohms bal.** 120 Ω balanced, Siemens type connectors.

**Return loss** Greater than 20 dB at 1 MHz.

**Jitter** Jitter tolerance to CCITT Recommendation G703.

**Signal lamp** A valid signal level is indicated by a signal lamp. The tester will discriminate against a wrong bit rate being applied.

**External count input**

**Rate** 0 to 4 kHz.

**Format** Positive t.t.l. pulses 2 to 5 V peak amplitude 200 to 600 ns duration.

**Impedance** 75 Ω unbalanced. BNC connector (BT No. 1 connector optional).

## DISPLAYS

Display format is 6 digit l.e.d. with an exponent digit and overflow lamp.

**Line code error detector at 2048 kbit/s or 8448 kbit/s**

**Totalise** Errors are totalised on a six digit counter with overflow indication and stop, continue and reset to zero facilities.

Display format:–

```
      – –
XXXXXX
```

**Error ratio** Error ratio (X in $10^y$) is displayed in the form of a mantissa and exponent from 1 in $10^6$ to 1 in 10.

Display format:–

```
          in 10^y
-----X
```

**Frame alignment monitor**

**Totalise** As for line code errors, (pressing time slot select button will temporarily switch to error rate display as below to allow access to change time slot selected for output).

**Error ratio** Error ratios (X in $10^y$) of 0 in $10^5$, 1 in $10^5$, 1 in $10^4$, and 1 in $10^3$ are indicated on the display and time slot (TS) selected for output as 64 kbit/s co-directional output on rear panel sockets. Time slot select button is used to change to required output.

```
          in 10^y
-TS--X
```

**Signalling monitor** The six digit display shows the selected channel (CH), the present signalling code (SS) and the last digit dialled (D) or flashing error code (D flashing).

```
        – D
CH--SS
```

By momentarily pressing channel select button the signalling code (PP) previous to present code is displayed – PP is blank if no change of code has occurred.

```
        – D
CH–PP–
```

By holding channel select button on the display changes to channel only and selected channel can be varied.

```
      – –
CH----
```

**External count** Counts input pulses as a total with display format as for line code errors totalise.

# 2833

**AUDIBLE ALARM**

An internal buzzer may be switched into circuit to give audible indications of the state of the input signal.

**Code error mode** — Alarm may be set to give an indication of signal present or error detected.

**Alignment monitor mode** — Alarm may be set to give an indication of signal present or alignment error detected.

**Signalling monitor mode** — Alarm may be set to give an indication of signal present or change of signalling code.

**External count** — Alarm may be set to give indications of input pulses.

**PEN RECORDER OUTPUT**

A recorder output is available for monitoring frame structure alarms or code error rates. The output is available on two terminals on the rear panel. Maximum output current may be set to 1 mA or 5 mA by internal links (normally set to 1 mA).

| *MODE* | | *Output Current mA (5 mA max)* | *Output Current mA (1 mA max)* |
|---|---|---|---|
| *Line Code Errors* | *Frame Alignment* | | |
| No Signal | Line | 0 | 0 |
| — | AIS | 1 | 0·2 |
| — | Frame | 1·5 | 0·3 |
| Error Rate 1 in $10^3$ | Error Rate 1 in $10^3$ | 2·0 | 0·4 |
| Error Rate 1 in $10^4$ | Error Rate 1 in $10^4$ | 2·5 | 0·5 |
| Error Rate 1 in $10^5$ | Error Rate 1 in $10^5$ | 3·0 | 0·6 |
| Error Rate 1 in $10^6$ | Multiframe | 3·5 | 0·7 |
| — | Distant | 4·0 | 0·8 |
| — | Distant MF | 4·5 | 0·9 |
| Signal no errors | | 5·0 | 1·0 |

For line code errors mode, error rates less than 1 in $10^6$ cause a 1 in $10^6$ output current to be generated for a short period of time.

The pen recorder output is automatically set to 'auto-reset' mode, with priorities as in the alignment mode.

Maximum current is produced when Lamp Test is selected.

**Accuracy (1 mA)** ± 0·03 mA (+ 0·03 mA, –0 at 0 mA)
**(5 mA)** ± 0·1 mA (+ 0·1 mA, –0 at 0 mA)

**OUTPUTS**

**64 kbit/s co-directional** — The eight bit data word of a selected time slot is converted to a 64 kbit/s co-directional output conforming to CCITT Recommendation G732. Available from the rear panel on Siemens type connectors.

**15-way output socket** — The following outputs are available as TTL levels from a 15-way D type connector on the rear panel.

**'Not Frame' word** — Unassigned bits 1, 4, 5, 6, 7, 8, in TSO (Not Frame word), bit 3 (distant alarm) also available.

**'Frame' word** — Unassigned bit 1 in TSO (Frame word).

**'Multiframe' word** — Unassigned bits 5, 7, 8, in Frame 0, TS16.

**Alarm present** — An output signal is given when an alarm is detected in the alignment monitor or signalling monitor mode. It is not affected by the 'lamp lock' control.

This may be used in conjunction with the digital simulator TF 2828A to test receive multiplex frame alignment sequences (going into and out of frame alignment).

**SELF CHECKS**

**Self Check** — An internally generated signal of 2048 kbit/s with a known error ratio of 1 in $10^5$ checks the input and error detector circuits.

**Lamp Check** — A lamp check button will illuminate all panel lamps and displays.

**POWER REQUIREMENTS**

**AC supply** — AC supply 115 and 230 V nominal.
95 to 130 V, 190 to 264 V.
50 to 400 Hz. 18 VA.

**External d.c.** — 12 V d.c. supply may be connected to terminals on rear panel.

**DIMENSIONS AND WEIGHT**

| Height | Width | Depth | Weight |
|---|---|---|---|
| 110 mm | 260 mm | 340 mm* | 3·2 kg |
| 4·3 in | 10·25 in | 13·4 in | 7·1 lb |

*410 mm (16·1 in) with cover.

**SAFETY** — Complies with IEC 348.

**LIMIT RANGE OF OPERATION**

**Temperature** — 0 to 55°C.

**CONDITIONS OF STORAGE AND TRANSPORT**

**Temperature** — –40°C to + 70°C.

**Humidity** — Up to 90% relative humidity.

**Altitude** — Up to 2500 m (pressurized freight at 27 kPa differential, i.e. 3·9 lbf/in$^2$).

**RADIO FREQUENCY INTERFERENCE**

Conforms with the requirements of E.E.C. Directive 76/889 as to limits of r.f. interference.

## VERSIONS AND ACCESSORIES

*When ordering please quote eight digit code numbers.*

| **Ordering numbers** | **Versions** |
|---|---|
| **52833 – 900X** | Digital Line Monitor 2833, standard version. |
| **52833 – 301L** | Digital Line Monitor 2833, with BT No. 1 connectors. |
| | **Supplied Accessories** |
| | Front Panel Cover (– 301L version only) 41690 – 224E. |
| | Lead Assembly (side entry) for a.c. power supplies (3 m) 43129 – 163L. |
| | Instruction Manual 46881 – 411 H. |
| | **Optional Accessories** |
| **44419 – 001N** | 75Ω Unbalanced HiZ Probe (BNC to BNC). |
| **46883 – 513K** | Flexible Extender Board (for servicing). |
| **46883 – 514A** | 15 way D-type connector. |
| **54124 – 022L** | Front panel cover (– 900T version only). |

## APPENDIX A

## ALIGNMENT MONITOR STRATEGY

The alarms are set and reset in the alignment monitor as detailed below.

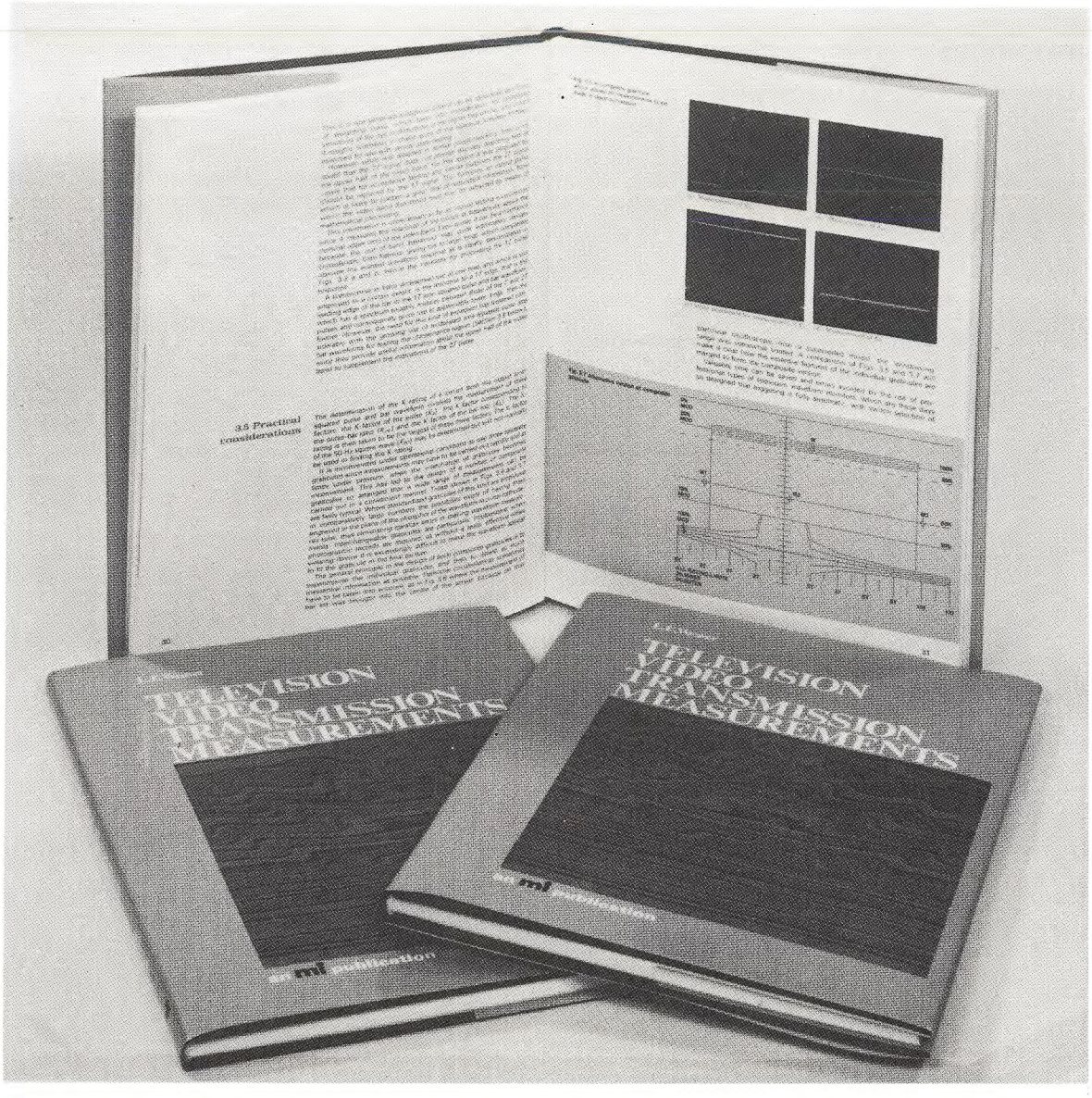
**Alarm conditions in order of priority**

| | |
|---|---|
| **Line** | A lamp will light when no signal is present (defined as at least 11 or more consecutive zeros) or a wrong bit rate is present. |
| **AIS (Alarm indication signal)** | A lamp will light when the signal is all '1's; (all '1's is defined as a signal with less than 3 zeros in 512 bits). |
| **Frame** | A lamp will light when three consecutive frame words have been received each with one or more errors. The lamp will extinguish when a sequence of correct frame, correct not-frame, and correct frame words has been detected. |
| **Errors (1 in $10^5$)** | A lamp will light if the error ratio on the incoming frame alignment word is greater than 1 part in $10^5$.<br>Recovery of error alarms is checked over 30 s period, so up to about 60 s may elapse before alarm clears on removal of errors. |
| **Multiframe** | A lamp will light when two consecutive multiframe alignment words have been received each with one or more errors. The lamp will extinguish when one correct multiframe alignment word has been received. |
| **Distant** | A lamp will light when the distant frame alarm is received on at least two consecutive occasions. The lamp will extinguish when the non-alarm condition is detected. |
| **Distant multiframe** | A lamp will light when the distant multiframe alarm is received on two consecutive occasions. The lamp will extinguish when the non-alarm condition is detected. |

## APPENDIX B

The error rate for the frame alignment word is calculated statistically on the assumption that the digital input signal contains errors which have a Poisson distribution. The operation of the error rate display is summarised below.

| *Error Ratio Indication* | *Average Error Ratio in Input Signal* | *Probability (%) of indication illuminating or extinguishing within the periods (secs) stated below* | |
|---|---|---|---|
| | | *Illuminate* | *Extinguish* |
| 1 in $10^3$ | 1 in $10^3$<br>5 in $10^4$<br>1 in $10^4$ | > 50% within 0·3s<br>< 5% within 0·3s<br>— | < 5% within 0·3s<br>—<br>> 95% within 0·3s |
| 1 in $10^4$ | 1 in $10^4$<br>5 in $10^5$<br>1 in $10^5$ | > 50% within 3s<br>< 5% within 3s<br>— | < 5% within 3s<br>—<br>> 95% within 3s |
| 1 in $10^5$ | 1 in $10^5$<br>5 in $10^6$<br>1 in $10^6$ | > 50% within 30s<br>< 5% within 30s<br>— | < 5% within 30s<br>—<br>> 95% within 30s |




## Television Video Transmission Measurements
**By L. E. Weaver**

This book has been produced to advise practising television engineers of some of the techniques which have been found operationally satisfactory for the measurement of the various distortions of the video signal, as a result of the authors long experience in the field of television broadcasting. Attention has been focused on the most basic measurements, with particular reference to the handling of colour signals.
To assist engineers in the understanding of the ways in which they are derived, the subject of working tolerances has been dealt with in some detail, together with values suitable for use in a high-quality television service.
Until he became an international TV engineering consultant L. E. Weaver was head of the British Broadcasting Corporation's measurement laboratory and has made many important contributions to the techniques of TV measurements.

# TV Measuring Equipment


| | | |
|---|---|---|
| Non-Linear Distortion Analyser | TF 2910/4 | 178 |
| Television Test Line Generator and Inserter | TF 2913 | 182 |
| Insertion Signal Analyser | TF 2914A | 188 |
| Data Monitor | TF 2915 | 192 |
| Data Selector | TK 2917 | 196 |
| Television Interval Timer | TF 2920 series | 200 |
| On-line Monitoring Systems | | 202 |

# Non-Linear Distortion Analyser TF 2910/4




14634/1

- ☐ **Differential gain measurement: resolution to 0·02%**
- ☐ **Differential phase measurement: resolution to 0·02°**
- ☐ **Luminance non-linearity: staircase or sawtooth**
- ☐ **Full field or line selected ITS waveforms**
- ☐ **Burst or black level phase reference**
- ☐ **Built-in noise sampler with bright line repetitive read out**
- ☐ **0·1% or 0·1° measurements with 25 dB signal/noise ratio**
- ☐ **Simultaneous analysis of all three parameters**
- ☐ **SECAM operation in chroma-lock mode**

TF 2910/4, working in conjunction with an oscilloscope, provides for the measurement of non-linear distortion from various test signals consisting of video line waveforms containing a staircase or sawtooth with superimposed sub-carrier. This signal can be present during the full field or it can be inserted on one line in the field blanking time, allowing standard national or international insertion test signals to be used; provision is made for the selection of any one of 12 lines in the field suppression period. A built-in sampling circuit, suitable for use on a five-step staircase, provides an improvement in discrimination when measuring differential gain and phase of signals with low signal-to-noise ratios. Demodulated outputs of differential phase and gain are routed to circuits which determine the mean level of each step of the demodulated waveform, considerably reducing the effects of random noise. The sampler also enables an insertion test signal display to be read out at line rate, giving a bright display on the oscilloscope.

### Differential phase

The sub-carrier component of the input waveform is extracted, amplified and limited before being applied to a phase comparator. This comparator is also fed from a local oscillator locked to either the reference colour burst or to the black level chrominance on the waveform. The output of the phase comparator is filtered and clamped, and a calibrated comparison pulse whose amplitude is adjustable on the front panel is inserted into the line blanking interval. A SET TO REF control enables any part of the measurement waveform to be set against the calibration pulse base line when viewed on an oscilloscope. Calibrated measurements of differential phase can be made up to 11° in 1° or 0·1° steps using the calibrated pulse.

*Extended range* By interpolation of the calibration pulse, measurements can be taken down to 0·02° for readings up to 11° or 2% of extrapolated reading for readings above 11°, and up to 35° differential phase.

### Differential gain

The sub-carrier component is extracted from the input waveform, amplified and detected, and a calibrated pulse whose amplitude is adjustable on the front panel is

inserted into the line blanking interval. A SET TO REF control enables the demodulated waveform to be moved to align the reference point of measurement against the base of the calibration pulse; two ranges of sensitivity allow for sub-carrier levels of 80 to 160 mV and 160 to 420 mV.

This combined waveform, after further amplification, is provided for assessment on an oscilloscope. Measurements of differential gain can be made up to 11% in 0·1% steps using the calibrated pulse.

*Extended range* By interpolation of the calibration pulse, measurements can be taken down to 0·02% for readings up to 11% or 2% of extrapolated reading for readings above 11%, and up to 15% differential gain. Greater levels of differential gain distortion can be measured by direct oscilloscope examination of the amplified sub-carrier, which is made available as an output.

### Line time non-linearity (Luminance non-linearity)

The staircase component of the input waveform is differentiated to produce pulses proportional to the amplitude of the risers. These pulses are amplified and shaped before being routed to the output for amplitude comparison on an oscilloscope. A d.c. level control enables the pulse tips or the base-line of the output waveform to be set at earth potential, augmenting the oscilloscope's vertical shift control.

### Sawtooth waveforms

When using a sawtooth waveform to replace the full line staircase, the oscilloscope display appears as a continuous line waveform rather than as a histogram. When used in conjunction with the sampler the sawtooth is sampled at five points.

### Operation on noisy signals

When taking measurements on signals having a signal-to-noise ratio in the region of 25 dB using the sampler it will be found that the demodulated waveforms exhibit a random vertical movement. It is possible using the PRESS TO HOLD button to 'freeze' the display at a desired point within the range of measurement in order to fix the base reference level in relation to the calibration pulse.

### Simultaneous monitoring of all three parameters

The measurement waveforms are fed independently to the sockets on the rear panel of the instrument for simultaneous monitoring. Any of the measurement waveforms or the test signal as selected by the push-button switches is fed to the front panel output socket.

| | |
|---|---|
| **TELEVISION SYSTEM** | 625 lines colour with sub-carrier frequency of 4.43361875 MHz. 50 fields per second. Standard negative – going sync pulses. |
| **TEST SIGNAL INPUT** | CCIR ITS signal line 330, British National test line signal A or full line staircase. Selection of appropriate button automatically adjusts internal blanking to blank out unwanted part of test signal. |
| **Luminance component** | 0.7 V ±3 dB video line waveform. For non-linearity measurement a 5, 7 or 10 step staircase. For differential phase and differential gain measurements a 5, 7 or 10 step staircase with superimposed sub-carrier (5 step only with sampler). |
| **Sub-carrier component** | 80 to 420 mV p-p. |
| **Input impedance** | 75 Ω (BNC). Return loss ratio greater than 30 dB up to 5 MHz. |
| **SYNC LOCK** | Internal or external, selected by front panel push-button switch. |
| **Internal** | Sync lock obtained from composite video input. |
| **External** | For use with non-composite signals. |
| **Amplitude** | 2 to 4 V p-p from 75 Ω source. |
| **Impedance** | 75 Ω (BNC) termination provided: can be switched out to loop through into external load. Return loss ratio greater than 40 dB up to 5 MHz with internal termination or 75 Ω ±1% external termination. |
| **DIFFERENTIAL PHASE** | Display measurement made by calibration pulse gated into line blanking interval with amplitude proportional to setting of calibration controls. |
| **Measurement range** | 0 to 11° in 1° and 0.1° steps. |
| **Accuracy** | ±5% of the scale reading. |
| **Extended range** | Up to 35° by extrapolation of calibration pulse. |

| | |
|---|---|
| **Set to reference control** | Enables lowest tread of measurement waveform to be aligned with calibration pulse base line. |
| **Sensitivity** | Output amplitude control enables display amplitude to be adjusted to suit oscilloscope sensitivity. Measurement waveform amplitude is greater than 50 mV per 0.1° unterminated or 25 mV per 0.1° into 75 Ω. |
| **DIFFERENTIAL GAIN** | Display measurement made by calibration pulse gated into line blanking interval with amplitude proportional to setting of calibration controls. |
| **Measurement range** | 0 to 11% in 1% and 0.1% steps. |
| **Accuracy** | ±5% of the scale reading. |
| **Extended range** | Up to 15% by extrapolation of calibration pulse. |
| **Set to reference control** | Enables black level tread of measurement waveform to be aligned with calibration pulse base line. Coverage of 80 to 420 mV in two continuously variable steps of 80 to 160 mV and 160 to 420 mV. |
| **Output amplitude control** | Enables display amplitude to be adjusted to suit oscilloscope sensitivity. Measurement waveform amplitude is greater than 50 mV per 0.1% unterminated or 25 mV per 0.1% into 75 Ω. |
| **Output noise** | Not greater than 0.06% when working with a test signal where the signal to noise ratio is better than 65 dB. |
| **CHROMINANCE OUTPUT** | Displays chrominance envelope amplified approximately five times enabling measurement of up to 100%. |
| **SAMPLER** | For use on a five-step staircase when measuring differential gain and phase of signals with low signal-to-noise ratio. |
| **Integration time constant** | Approximately 35 s. |

# TF 2910/4

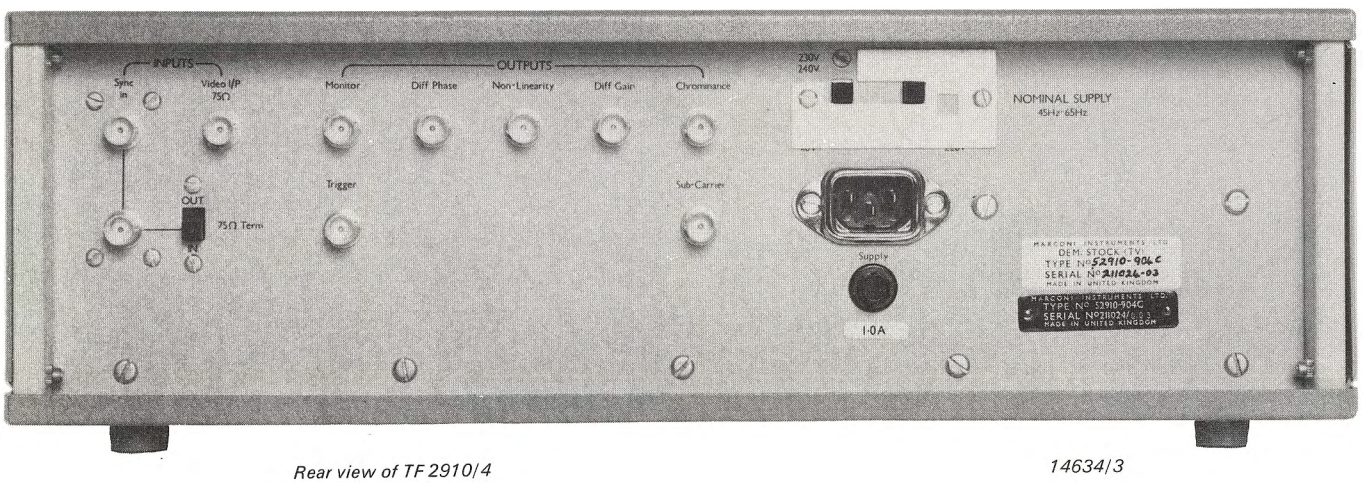
| | |
|---|---|
| **Noise reduction** | Sampler allows measurement to a discrimination of within 0.1° and 0.1% nominal for a signal to noise ratio of 25 dB with signals of low distortion. |
| **Hold button** | Allows sampling sequence to be stopped and display held for up to 30 s. |
| **Display readout rate** | Line repetitive when measuring either ITS or full field signals. |
| **Check** | Sampled steps within 0.1% or 0.1°. Improved measurement uncertainty obtained by comparison of measurement result with the check condition. |
| **LUMINANCE NON-LINEARITY** | |
| **Measurement pulse amplitude** | Adjustable up to 2 V p-p into high impedance or 1 V p-p into 75 Ω for staircase step amplitude down to 70 mV. |
| **Pulse duration** | 1 µs approx. H.A.D. |
| **Output noise** | Not greater than 0.3% Non-Linearity with measurement pulse set to 1 V p-p from staircase step of 70 mV p-p, when working with a test signal where the signal to noise ratio is better than 65 dB. |
| **Output d.c. level control** | Enables tips or baselines of pulses to be viewed when using oscilloscope on high sensitivity setting. |
| **ITS MODE** | |
| **Line selector** | Any appropriate insertion test line from lines 16 to 21 or 329 to 334 can be selected for measurement by setting front panel switch. Only one line per field or picture is required to measure differential phase, differential gain or line time non-linearity. |
| **INTERNAL SUB-CARRIER OSCILLATOR** | |
| **Free running frequency** | 4.43361875 MHz ±12 Hz. |
| **Lock-in mode** | Can be phase locked to colour burst or to sub-carrier on black level tread of staircase as selected by front panel push-button. |
| **Lock-in range** | 4.433619 MHz ±100 Hz. |
| **OUTPUT** | |
| **Front panel** | Push-button switches select one of the measurement waveforms, differential phase, differential gain, non-linearity or chrominance, or the input test signal for monitoring. Trigger output is permanently connected to its own socket. |
| **Rear panel** | Independent, permanently – connected sockets are provided for each of the measurement waveforms, differential phase, differential gain, non-linearity, chrominance and for trigger, input monitor and sub-carrier. |
| **Trigger output** | Negative going. Amplitude between 2.4 V and 4 V p-p into high impedance. In ITS mode the leading edge of the trigger pulse coincides with the leading edge of the sync pulse on the line selected. In full field mode the trigger pulse is line repetitive and up to 4 µs in advance of the sync pulse. Both are line repetitive when the sampler is switched in. |
| **Impedance** | All except trigger 75 Ω nominal. Trigger approximately 100 Ω. |
| **POWER REQUIREMENTS** | |
| **AC supply** | 95 to 130 V and 190 to 264 V, 45 to 65 Hz. 60 VA approx. |
| **SAFETY** | Complies with IEC 348. |
| **DIMENSIONS AND WEIGHT** | |

| Height | Width | Depth | Weight |
|---|---|---|---|
| 133 mm | 425 mm | 380 mm | 9.8 kg |
| 5¼ in | 16¾ in | 15 in | 21½ lb |

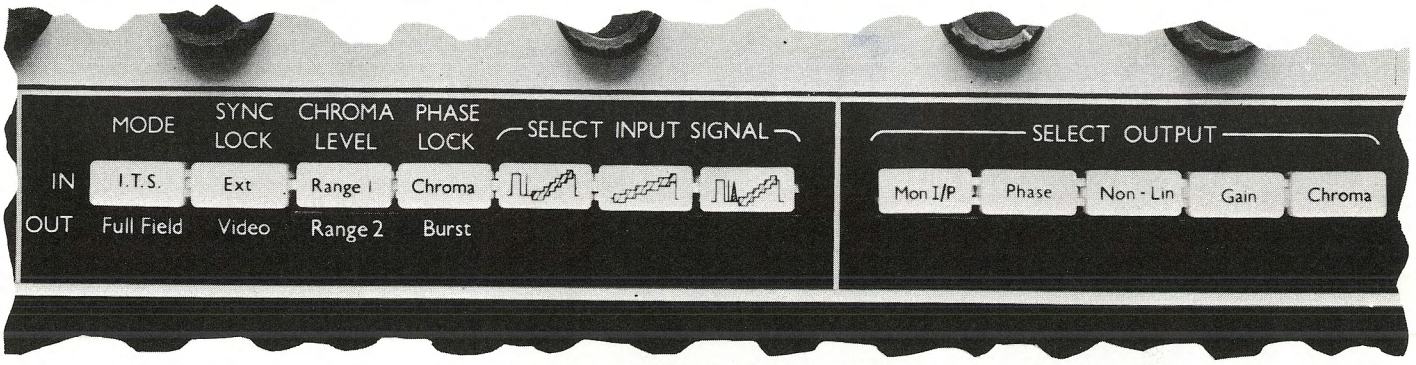
## VERSIONS AND ACCESSORIES

*When ordering please quote eight-digit code numbers*

| Ordering numbers | |
|---|---|
| **52910–904C** | **Versions**<br>TF 2910/4. |
| | **Supplied Accessories**<br>Accessory Kit 46883–244U comprising:<br>Extender Board 44836–106F.<br>Board Extractor 41700–048A.<br>Rack Mounting Kit 46883–175Y.<br>Instruction Manual 46881–237E.<br>AC Supply Lead 43129–003W. |
| **23443–398M**<br>**54127–191D**<br>**46883–358W** | **Optional Accessories**<br>"U" Link 75 Ω.<br>Rack Slide Kit.<br>Grill and Deflector Plate Kit. |

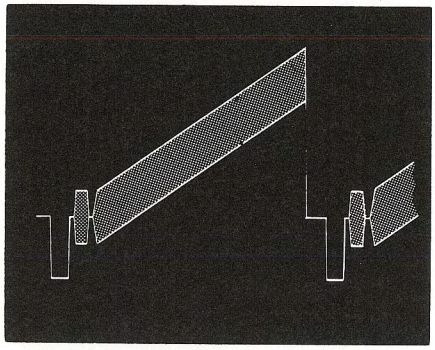



*Rear view of TF 2910/4* *14634/3*

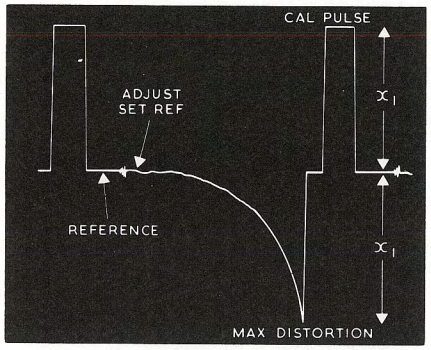



*Part of front panel of TF 2910/4* *14634/4*

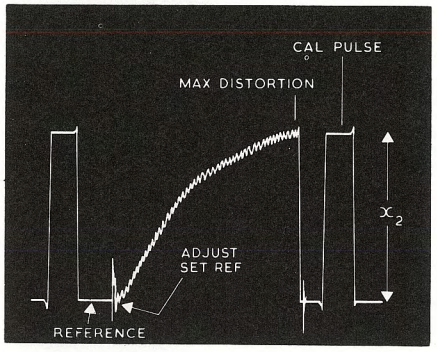
## FULL LINE SAWTOOTH



*Input Signal (monitor output)*

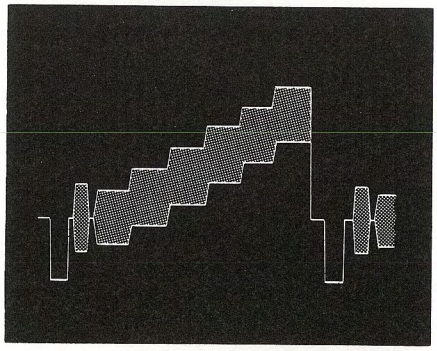



*Differential gain e.g. $x_1 = 0{\cdot}8\%$*

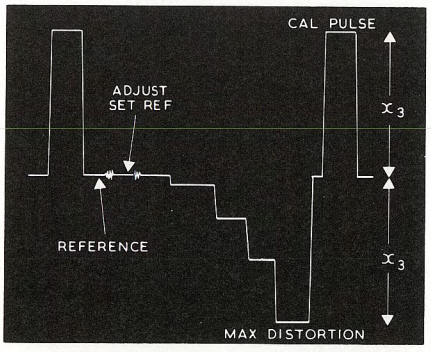



*Differential phase e.g. $x_2 = 0{\cdot}6°$*

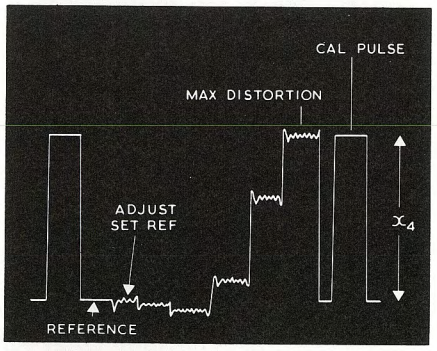
## FULL LINE STAIRCASE



*Input signal (monitor output)*

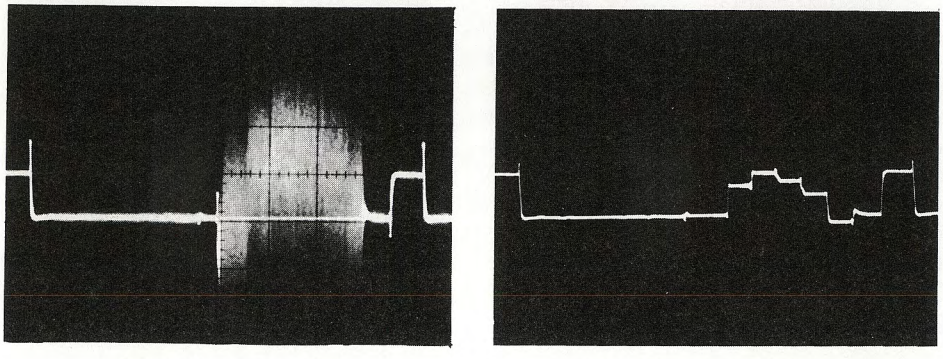



*Differential gain e.g. $x_3 = 2\%$*




*Differential phase e.g. $x_4 = 1°$*

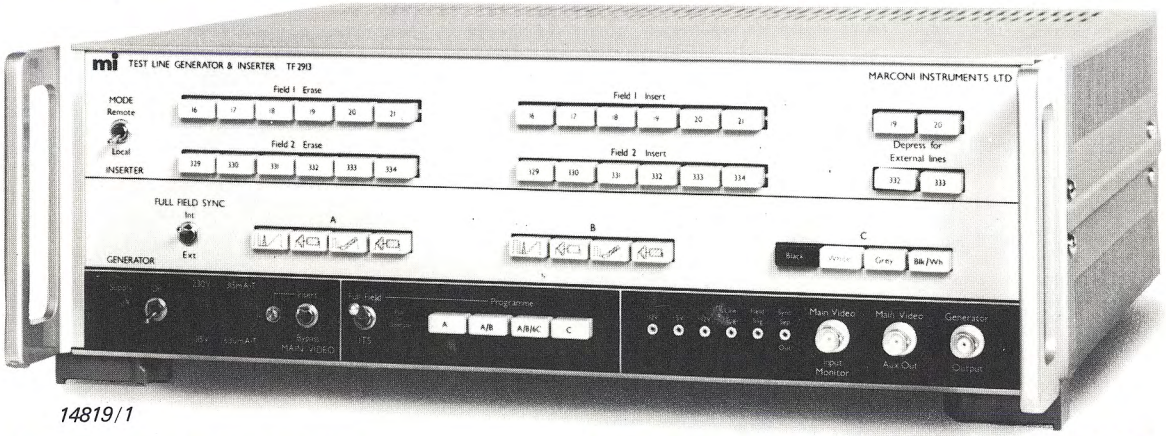
## SAMPLING THROUGH NOISE



*(a) before sampling* *(b) after sampling*

Waveform of International Test Signal 5 step staircase with 0·2° differential phase and 38 dB signal to noise ratio.

# Television Test Line Generator & Inserter TF 2913




14819/1

## ITS ERASURE AND INSERTION

- ☐ **Erasure and insertion for six lines in each field**
- ☐ **Inserts internally or externally generated waveforms**
- ☐ **Digital data insertion capability**
- ☐ **Pre-erasure and post-insertion monitoring**

## FULL FIELD WAVEFORM GENERATOR

- ☐ **International CCIR or UK National test signals**
- ☐ **Eight basic TV waveforms**
- ☐ **Programmable in various waveform combinations**
- ☐ **Rigorous average picture level testing**
- ☐ **External synchronizing from video or s.p.g.**

TF 2913 can be considered as two instruments, an Inserter and a Waveform Generator, which work independently with the exception of the common synchronizing pulse timing.

### OPERATION OF INSERTER

The Test Line Inserter is essentially a feed-through device with its input and output connections situated on the rear panel, and with front panel video monitoring provided for the input signals. By a combination of internal and front panel switching it is possible to individually erase existing signals and/or insert new signals, either analogue or digital, on to any of the 12 lines, 16–21 in field 1 and 329–334 in field 2. These new insertion signals can be obtained either from the generator unit or from an external source fed into each line position through BNC connectors on the rear panel. Signal routeing from the generator or from the BNC inputs is normally provided by internal switching, but additional front panel buttons carry out this function on lines 19, 20, 332 and 333.

**ITS Operation**

In the ITS operating mode, an "On-Air" programme signal is fed to the video input, and by suitable erasure and/or insertion the original programme with new insertion signals appears at the video output socket. An isolated main video auxiliary output is also available on the front panel. In this mode of operation, the synchronizing signals are taken from the incoming video by looping this signal through the MIXED SYNC input and output sockets on the rear panel.

**Full Field Mode**

The full field signal derived from the generator now replaces the "On-Air" programme signal at the video output socket. Synchronizing can be either from an external sync pulse generator, or by triggering from the "On-Air" programme video. Change-over from ITS to full field operation is made by a mechanically protected toggle switch.

**Bypass**

A fail-safe relay can be mounted on the rear panel to route the input video directly to the output socket in the event of power failure or should any of the circuit boards in the signal path be removed. This condition can be manually selected on the front panel by operating the BYPASS switch.

### OPERATION OF WAVEFORM GENERATOR

The following full field test signal programmes can be selected on the generator front panel. These programmes are made up from a maximum of eight waveforms comprising either four international or national insertion test signal waveforms, peak white, black, grey or black/white bounce.

## PROGRAMME

**A** — Any one of the four test signals generated line repetitively.

**A/B** — Any two of the four test signals generated line alternately.

**A/B/6C** — Any two of the four test signals repeated every eight lines with the intervening six lines being either black, grey or white level or an alternation from black to white level.

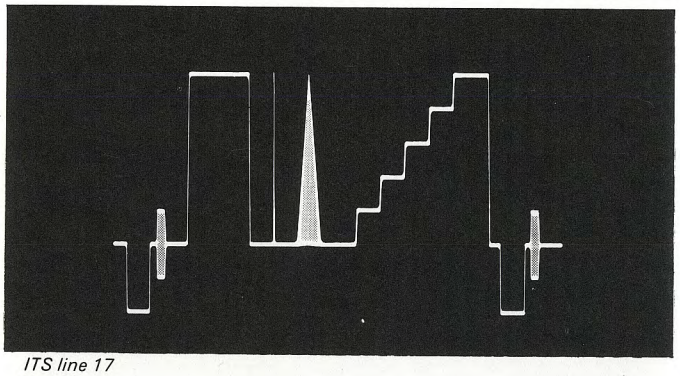
**C** — A continuous level either black, grey or white, or the alternation from black to white level, the static duration of which is internally adjustable from 1 to 5 seconds approximately.
(This programme is intended for noise assessment and v.l.f. measurement.)

In the internal or free running mode all these signal programmes have a fixed reference burst and cycle at line repetition rate automatically line synchronising to any incoming video, but they possess no field component. The line sync output pulse is only available when incoming video or sync is applied.

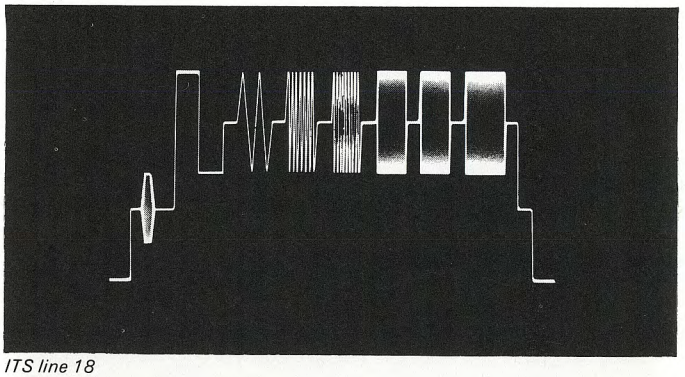
If the signal programmes are required as a fully composite TV signal then the internal generator can be driven by an external television sync pulse generator via the input sockets on the rear panel. The resultant signal is fully line and field blanked and contains a phase alternating reference burst and, moreover, the international test signals can be inserted into the field suppression period.

## INSERTION TEST SIGNALS

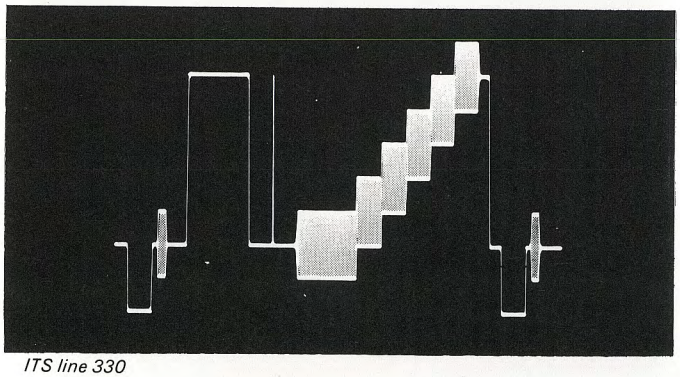
The four international test waveforms available for the CCIR Insertion Test Signal Lines 17, 18, 330 and 331 are shown below. These waveforms can also be switched independently into any of the line positions 19, 20, 21 on field 1, and 332, 333 and 334 on field 2, by internal switching. The waveform appearing on lines 16 and 329 will be the selected programme A or C waveform.



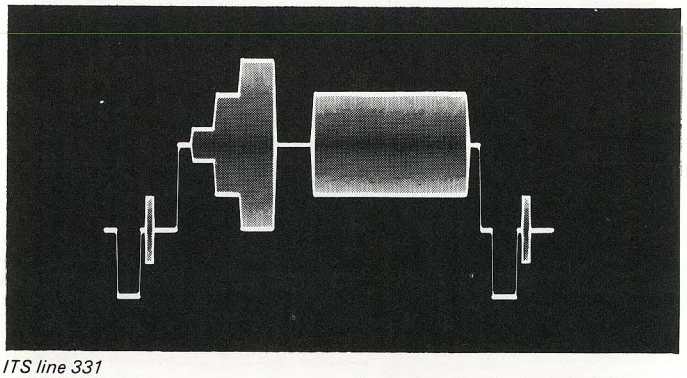
*ITS line 17*



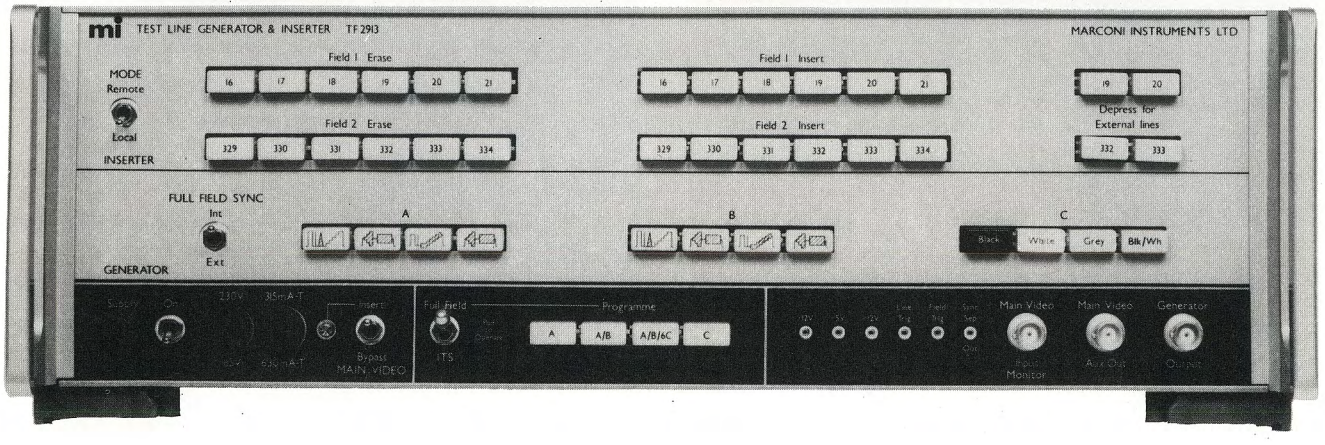
*ITS line 18*



*ITS line 330*



*ITS line 331*



# 2913

## FRONT PANEL OUTPUTS

**1. Auxiliary output** This is a duplicate of the inserter output for monitoring the programme video and inserted signals.

**2. Test generator output** This provides an output of the full field test programmes whilst insertion signals are being added to the outgoing programme video. This is primarily a studio facility supplying a local test signal distribution with a selection of synchronous waveforms.

**3. Main video input monitor** This is a feed of the input signal prior to erasure for the analysis of incoming ITS signals.

**4. Field trigger** This is a 25 Hz squarewave for triggering an oscilloscope, field change being effected by switching the oscilloscope trigger polarity.

**5. Line trigger** An oscilloscope trigger derived from line sync.

**6. Sync separator** A check point to determine that the separator is functioning.

**7. +12v, −12v and +5v** The supply rail monitor points.

(4, 5, 6 and 7 are resistively isolated, and brought out on pin sockets to allow for open-wire connection).

## REAR PANEL CONNECTIONS

1. External connections for sync pulse generator with loop-through facility.
2. Socket for connection of remote switching facilities of inserter section.
3. By-pass relay.
4. Main Video In and Out.
5. Sockets for externally inserted lines.
6. Outputs for internally generated sync and blanking.

## INSERTER SECTION

### GENERAL

**Selection of insertion lines (internal)**

Selection of insertion lines is by numbered push button. Erasure of previous information on selected lines is automatic. Signals may be inserted in lines 16 to 21 of one field and 329 to 334 of the other field.

Signals inserted in lines 19 to 21 and 332 to 334 are determined by internal switches.

Signals inserted in lines 16 and 329 are as selected by Programme buttons.

**Selection of insertion lines (external)**

External signals may be inserted in place of the internally generated signals in up to four lines in any one of three combinations selected as follows:

a) Lines 19, 20, 332 and 333 selected by numbered push buttons.
b) Lines 17, 18, 330 and 331 selected by internal adjustment.
c) Lines 16, 21, 329 and 334 selected by internal adjustment. (The appropriate numbered buttons must also be pressed as for internally generated signals.)

**Selection of line erase**

Selection is made by numbered push buttons. Erasure may be selected on lines 16 to 21 of one field and 329 to 334 of the other field. (The cover of lines can be shifted by internal adjustment).

**Remote control**

Insertion and erasure may be controlled remotely via the Remote Control socket by connecting the appropriate pins to a common pin which is earthed in the Remote mode.

### BLACK LEVEL STABILITY

Over a temperature range of 0 to +45°C, the deviation in black level of an inserted/erased line, from the black level of the main signal, does not exceed 5 mV.

### MAIN VIDEO SIGNAL

**Normal input**

Standard level (IV p-p) 625 line monochrome or colour video signal, i.e.

*Picture:* +0·7 V, w.r.t. black level.
*Sync pulses:* −0·3 V, w.r.t. black level.

**Main video in input impedance**

75 Ω.
*Return loss ratio:* better than 30 dB up to 7 MHz.

**Main video out output impedance**

75 Ω.
*Return loss ratio:* better than 30 dB up to 7 MHz.

**Gain**

0 dB ±0·1 dB.

**Frequency response**

±0·1 dB from 100 kHz to 6 MHz.
+0·1 dB −0·6 dB from 6 to 10 MHz.

### MAIN VIDEO INPUT MONITOR

**Output impedance**

75 Ω.
*Return loss ratio:* better than 30 dB up to 5 MHz.

**Output level**

Standard level 1 V p-p.

### MAIN VIDEO AUXILIARY OUTPUT

**Output impedance**

75 Ω.
*Return less ratio:* better than 30 dB up to 7 MHz.

**Output level:**

*Standard level:* 1 V p-p.

### INFLUENCE ON MAIN VIDEO SIGNAL

Influences of the inserter main video path on the parameters of the video signal fed through it are within the limits stated below.

### INFLUENCE ON MAIN VIDEO SIGNAL

**Chrominance/luminance inequalities**

*Gain:* Less than ±0·05 dB.
*Delay:* Less than ±5 ns.

**2T pulse/bar ratio**

100% ±0·25% if incoming signal ratio is unity.

**2T pulse overshoot**

Output signal does not differ from input signal by more than 0·5% of the luminance bar amplitude.

**50 Hz square wave tilt**

Less than 0·5%.

**15 kHz line tilt**

Less than 0·25%.

**Differential phase**

At standard level: less than 0·15°.
At +3 dB: less than 0·3°.

**Differential gain**

At standard level: less than 0·2%.
At +3 dB: less than 0·4%.

**Line-time non linearity**

Less than 0·2%.

**Random HF noise (weighted)**

Better than −80 dB r.m.s. w.r.t. pk-pk picture amplitude, (using CCIR

| | |
|---|---|
| | recommended filters as in Rec. 451 section 4.3., Oslo 1966). |
| **Residual sub-carrier** | On lines other than insertion line: better than –60 dB pk-pk w.r.t. picture amplitude. Using CCIR filter as above. |
| **Hum and lower order harmonics** | Better than –60 dB pk-pk w.r.t. picture amplitude. |
| **Spurious transients induced in the signal path during picture time and during the active part of the insertion lines** | Better than –60 dB pk-pk w.r.t. picture amplitude up to 5 MHz. |
| **Spurious transients induced in signal path at other times** | Better than –40 dB pk-pk w.r.t. picture amplitude up to 5 MHz. |
| **Signal attenuation in "erase" mode** | 2T pulse: greater than 70 dB.<br>Sub-carrier: greater than 60 dB. |
| **Cross-talk into main signal path from insertion signals measured with identical signals at all insertion channel inputs** | 2T pulse: less than –70 dB pk-pk.<br>Sub-carrier: less than –60 dB pk-pk. |
| **Non useful d.c. components of the output** | Not exceeding ±1 V when terminated in 75 Ω. |
| **Effect of coded pulses (sound in sync)** | Instrument will operate satisfactorily in presence of coded pulses which may be superimposed on the sync pulses. (e.g. for transmitting and accompanying sound signal), and the inserter will not affect any such signals. |
| **By-pass relay** | System protected against failure by a by-pass relay operating on the main signal path which operates in the following events:<br>a) Failure of mains supply.<br>b) Failure of power supply.<br>c) Removal of instruments from rack.<br>d) Removal of any printed circuit board in the video path.<br>e) By-pass switch on front panel operated in local mode.<br>f) Remote by-pass switch operated in remote mode.<br>Operation of relay does not cause any significant disturbance to the picture.<br>*Insertion loss:* Not greater than ±0·15 dB. |
| **ISOLATION BETWEEN MAIN & AUXILIARY OUTPUTS** | Better than 46 dB up to 1 MHz.<br>Better than 36 dB up to 4·43 MHz. |
| **EXTERNAL TEST LINE INPUTS** | |
| **Lines** | The unit is supplied with one external line insertion card providing inputs on lines 19 and 20 in field 1 and lines 332 and 333 in field 2. By repositioning this card, lines 17, 18, 330 and 331 can be selected or, alternatively, lines 16, 21, 329 and 334 can be used. |
| **Amplitude** | Standard level 1 V pk-pk. |
| **Impedance** | 75 Ω. |
| **Return loss ratio** | Better than 30 dB up to 7 MHz. |

## GENERATOR SECTION

| | |
|---|---|
| **OPERATING MODES** | Generator may be used in ITS mode or full field mode, external or internal sync mode. |
| **ITS mode** | Generator can be locked to the sync pulses (and colour burst, if present) of the incoming video signal. Test signals can then be inserted on selected lines of the incoming video signal. |
| **Full field/ext. sync mode** | Generator can be locked to sync. pulses of an incoming video or composite sync signal.<br>The generated signal contains:<br>a) Mixed sync pulses.<br>b) Insertion test signals on selected lines.<br>c) During active picture time a programme containing a choice of APL or repetition of selected insertion signals.<br>d) Sub-carrier burst with phase alternation and Bruch blanking (provided that required external drive signals are connected).<br>e) Field blanking (provided external mixed blanking signal is connected). |
| **Choice of APL** | The choice of APL during active picture time is by front panel push-buttons as follows:<br>a) Black (internally adjustable over range of nominally 0 to 15% of luminance bar amplitude).<br>b) White (internally adjustable between 85 and 100% of luminance bar amplitude).<br>c) Grey (50% ±2% of luminance bar amplitude).<br>d) Black and white switched alternately to constitute a square wave of unity mark/space ratio and with a period internally adjustable over a nominal range of 1 to 10 s. |
| **Insertion signals** | The normal insertion signals selected by push buttons as required can be provided during field blanking when used in a normal fully composite mode. |
| **Selection of programme** | By pressing the appropriate push-buttons the following signal combinations are available:<br>a) Any one of the three available insertion signals repeated every line.<br>b) Any two of the three available insertion signals repeated line alternately.<br>c) Any two of the three available insertion signals repeated every eight lines, the intervening 6 lines being at: white, black, grey or black/white, described under choice of APL as required.<br>d) Black, white or grey or bump test continuously. |
| **Full field/int. sync mode** | *Free running (no incoming sync pulses):* As 'full field/ext. sync' mode except that generator is free running at approximately line repetition rate. The generated signal contains line sync pulses and a single phase colour burst. No field information is provided.<br>*Locked:* As 'full field/int. sync' mode except generator is locked to line sync pulses contained by any incoming signal. Locking occurs automatically when incoming line sync pulses are present. |
| **LINE SYNC PULSES** | |
| **Repetition frequency** | 1 MHz oscillator divided by 64 to give line repetition frequency of 15·625 kHz ±0·05%. |
| **Amplitude** | 0·3 V pk-pk ±3%. |
| **Duration (half amplitude)** | Int. sync mode: 4·7 ±0·2 μs.<br>Ext. sync mode: within ±0·2 μs of incoming sync duration. |
| **Rise and decay time** | 200 ±100 ns. |

# 2913

**COLOUR BURST**

| | |
|---|---|
| **Duration** | 10 cycles ±1 cycle of sub-carrier at 4·43 MHz. |
| **Amplitude** | 0·3 V pk-pk ±5%. |
| **Rise time** | 300 ns ±100 ns. |
| **Phase** | Alternates between +135° and −135° to the B-Y axis (in Ext. sync mode only, provided also that the required external drive signals are connected). |

**TIMING**

Line duration is divided into 32 equal time periods.

| | |
|---|---|
| **Time periods** | Time periods within ±20 ns of each other. |
| **Luminance timing** | Sync pulse to luminance waveform transition timing is within ±250 ns. |
| **Chrominance timing** | Sync pulse to chrominance waveform transition timing, is within ±500 ns except for the 20T pulse and reference chroma bar which are within ±700 ns. |
| **Colour burst timing** | Timing of sync pulse to first transition of burst is within ±100 ns. |
| **Timing adjustment (w.r.t. sync pulse)** | A preset control is provided to adjust the overall timing w.r.t. the mid-amplitude point of the leading edge of the Line Sync pulses over a range of ±1·0 μs. |
| **Resetting of timing** | It is possible by internal alteration to reset the individual timing of any of the luminance or chrominance elements in increments of 2μs. |

**INSERTION TEST SIGNAL ELEMENTS**

Specifications are for CCIR test signals.

**LUMINANCE BAR**

| | |
|---|---|
| **Amplitude** | 0·7 V pk-pk ±1%. |
| **Shape** | Determined by a Thompson filter with a transfer-function modulus having its first zero at 4·43 MHz. |
| **Rise and decay time** | 200 ±100 ns. |
| **Tilt (10 μs period)** | Less than 0·5%. |

**STAIRCASE**

Level of the uppermost tread of staircase within ±0·25% of luminance-bar amplitude.

| | |
|---|---|
| **Number of risers** | Five. |
| **Shape of risers** | Shape determined by a Thompson filter with a transfer-function modulus having its first zero at 4·43 MHz (Rise time 200 ±100 ns). |
| **Line time non linearity** | The difference in amplitude between the largest and smallest risers is less than 0·5% of the largest amplitude. |
| **Superimposed sub-carrier frequency and phase** | *Frequency:* 4·43361875 MHz ±10 Hz. *Phase:* 60° ±5° to the B-Y axis, referred to burst in ITS mode, sub-carrier in full field mode (provided incoming reference is present). |
| **Rise and fall times of sub carrier superimposed on staircase** | 1 μs approximately. |
| **Inherent differential gain** | Not greater than 0·5%. |
| **Inherent differential phase** | Not greater than 0·2°. |
| **Amplitude of superimposed sub-carrier** | 0·28 V pk-pk ±1%. |

**2T PULSE**

| | |
|---|---|
| **Amplitude** | Within ±0·5% of luminance bar amplitude. |
| **Half-amplitude duration** | 200 ±6 ns. |
| **Ripple after pulse** | 1st overshoot: (0·9 ±0·5)% of pulse amplitude.<br>2nd overshoot: (0·4 ±0·2)% of pulse amplitude. |

**20T COMPOSITE PULSE**

| | |
|---|---|
| **Amplitude** | Within ±1% of luminance bar amplitude. |
| **Half-amplitude duration** | 2 ±0·06 μs. |
| **Ripple after pulse** | 1st overshoot: (0·9 ±0·5)% of pulse amplitude.<br>2nd overshoot: (0·4 ±0·2)% of pulse amplitude. |
| **Inherent chrominance/luminance delay and gain inequality** | Perturbation of base line less than 0·5% of the pulse amplitude. |

**CHROMINANCE BAR**

Either single level or three level selected by internal patching.

**THREE-LEVEL CHROMINANCE BAR**

| | |
|---|---|
| **Position of transitions** | 7H/32, 9H/32, 11H/32 and 14H/32. |
| **Amplitudes** | *1st section:* Within ±1% of 1/5 of luminance bar amplitude (nominal value 0·14 V).<br>*2nd section:* Within ±1% of 3/5 of luminance bar amplitude (nominal value 0·42 V).<br>*3rd section:* Within ±1% of luminance bar amplitude (nominal value 0·7 V). |
| **Pedestal** | +0·35 V ±1%. |
| **Inherent chrominance/luminance intermod.** | Within ±0·5% of pedestal amplitude. |
| **Envelope rise time** | 1 μs approximately. |

**SINGLE LEVEL CHROMINANCE BAR**

Alternative to three level chrominance bar.

| | |
|---|---|
| **Pk-pk amplitude** | Within ±1% of luminance bar amplitude (nominal value 0·7 V pk-pk). |
| **Pedestal** | +0·35 V ±1%. |
| **Inherent chrominance/luminance intermod.** | Within ±0·5% of pedestal amplitude. |
| **Envelope rise time** | 1 μs approximately. |

**CHROMINANCE REFERENCE**

| | |
|---|---|
| **Amplitude** | 0·42 V pk-pk ±1%. |
| **Pedestal** | +0·35 V ±1%. |
| **Envelope rise time** | 1 μs approximately. |

**PHASE STABILITY**

Phase difference of chrominance signal elements in adjacent lines does not exceed 2°.

**MULTIBURST ITS LINE 18**

**(Model 52913–304T only)**

The Multiburst signal consists of six frequency bursts preceded by a reference bar. Each burst has a duration of 4 to 5·6 μs, and contains a discrete number of complete cycles, starting at zero phase.
N.B. – For customers who have no requirement for the Multiburst waveform, the signal on line 331 is repeated on line 18.

**BURST FREQUENCIES AND STARTING POSITIONS**

(1) 0·5 MHz. 12H/32.
(2) 1·0 MHz. 15H/32.
(3) 2·0 MHz. 18H/32.
(4) 4·0 MHz. 21H/32.
(5) 4·8 MHz. 24H/32.
(6) 5·8 MHz. 27H/32.

| | |
|---|---|
| **Reference bar amplitude** | First section within 1% of 4/5 of luminance bar amplitude (0·56 V nominal) measured from blanking level.<br>Second section within 1% of 1/5 of luminance bar amplitude (0·14 V nominal) measured from blanking level. |
| **Burst amplitude** | Within ±1% of the reference bar amplitude over a range of ambient temperatures from 13° to 33°C. |

| | |
|---|---|
| **Pedestal** | Within ±1% of 50% of the luminance bar amplitude. |
| **GENERATOR OUTPUT** | |
| **Amplitude** | Standard level 1 V pk-pk. Signal component accuracy as specified above when output terminated with 75 Ω ±0·1%. |
| **Impedance** | 75 Ω. |
| **Return loss ratio** | Better than 30 dB up to 7 MHz. |
| **Sub-carrier leak** | Less than 2 mV pk-pk on insertion lines. |
| **Harmonic content of sub-carrier** | Less than –40 dB w.r.t. fundamental. |
| **EXTERNAL TRIGGER REQUIREMENTS** | Instrument may be externally triggered to give composite video outputs provided that input signals are to 625 line CCIR standards: "System I, B, G or H, CCIR Report 308–1 for Luminance" and "PAL System I or G, Oslo 1966, Report 407 for colour". |
| **SYNC PULSE INPUT** | |
| **Requirement** | 2 to 4 V pk-pk nominal, mixed sync signal or standard IV video signal containing sync pluse of nominal 300 mV pk-pk amplitude. |
| **Impedance** | *Return loss ratio:* greater than 30 dB up to 7 MHz when looped through into 75 Ω ±1% load. |
| **BLANKING PULSE INPUT** | |
| **Requirement** | 2 to 4 V pk-pk nominal, mixed blanking signal. |
| **Impedance** | *Return loss ratio:* greater than 30 dB up to 5 MHz when looped through into 75 Ω ±1% load. |
| **SUB-CARRIER INPUT** | |
| **Requirement** | 1 to 2 V pk-pk at 4·4336 MHz sinewave. |
| **Impedance** | *Return loss ratio:* greater than 30 dB up to 5 MHz when looped through into 75 Ω ±1% load. |
| **BURST GATE INPUT** | |
| **Requirement** | 2 to 4 V pk-pk noominal burst gate signal. |
| **Impedance** | *Return loss ratio:* greater than 30 dB up to 5 MHz when looped through into 75 Ω ±1% load. |
| **PAL SQUAREWAVE SIGNAL INPUT** | |
| **Requirement** | 2 to 4 V p-p nominal PAL squarewave signal. |
| **Impedance** | *Return loss ratio:* greater than 30 dB up to 5 MHz when looped through into 75 Ω ±1% load. |
| **Sub-carrier burst when externally triggered** | Burst will only be present when incoming sub-carrier, burst gate and PAL squarewave signals are present. |
| **AUXILIARY OUTPUTS** | |
| **Supply rail monitor points** | +12 V, –12 V and +5 V. |
| **LINE TRIG** | |
| **Waveform** | Positive going pulses at line repetition rate derived from the incoming video or composite sync signal. |
| **Pulse width** | 4·7 μs. |
| **Level** | TTL. |
| **Output impedance** | 600 Ω nominal. |
| **FIELD TRIG** | |
| **Waveform** | 25 Hz squarewave derived from the incoming video or composite sync signal. |
| **Level** | TTL. |
| **Impedance** | 600 Ω nominal. |
| **SYNC SEP OUT** | |
| **Waveform** | Composite signal containing negative going line and field sync pulses derived from the incoming video or composite sync signal. |
| **Level** | TTL. |
| **Impedance** | 600 Ω nominal. |
| **SYNC OUT** | |
| **Waveform** | Composite signal negative going line and field sync pulse derived from the incoming video or composite sync signal. |
| **Level** | TTL compatible. |
| **Output impedance** | 1·2 k Ω nominal. |
| **BLANKING OUT** | |
| **Waveform** | Composite signal containing line and field blanking pulses derived from incoming Ext Mixed Blanking when switched to Full Field/Ext mode. |
| **Level** | TTL compatible. |
| **Output impedance** | 600 Ω nominal. |
| **RADIO FREQUENCY INTERFERENCE** | Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference. |
| **SAFETY** | Complies with IEC 348. |
| **TEMPERATURE STABILITY** | Instrument remains within specification between 0 and 45°C. |
| **POWER REQUIREMENTS** | |
| **AC supply** | 105 to 110 V, 115 to 120 V, 210 to 220 V, 230 to 240 V, all ±10%. 45 to 65 Hz. Approximately 60 VA. |
| **DIMENSIONS AND WEIGHT** | |

| Height | Width | Depth | Weight |
|---|---|---|---|
| 133 mm | 425 mm | 380 mm | 11·4 kg |
| 5¼ in | 16¾ in | 15 in | 25·1 lb |

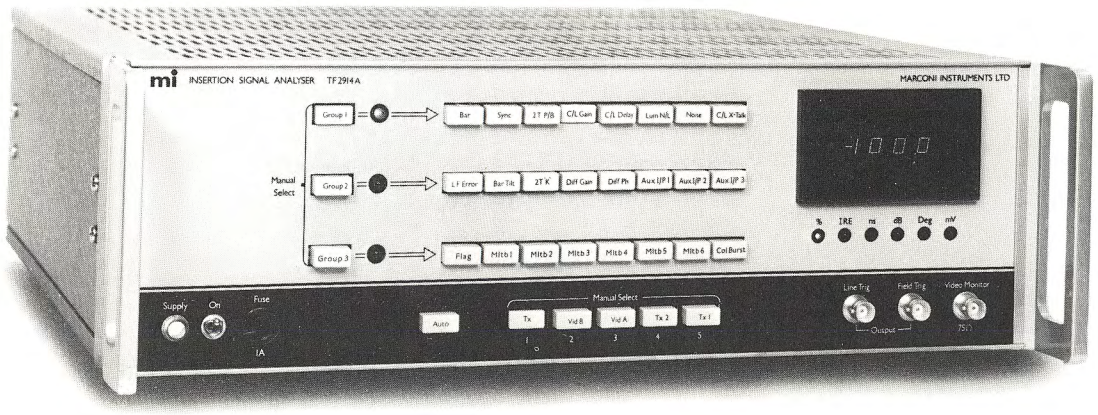
## VERSIONS AND ACCESSORIES

*When ordering please quote eight digit code numbers.*

| Ordering numbers | |
|---|---|
| | **Versions** |
| **52913–015N** | TF 2913. Standard version. |
| **52913–304T** | TF 2913. With multiburst. |
| **52913–311C** | TF 2913. Standard UK National version. |
| **52913–302W** | TF 2913. With one additional external line card. |
| **52913–303D** | TF 2913. With two additional external line cards. |
| | **Supplied Accessories**<br>Board Extractor 41148–605K<br>AC Supply Lead, side entry 43129–003W<br>Extender Board 44836–106F<br>Rack Mounting Kit (basic) 46883–175Y<br>Waveform button (4 supplied) 37565–922Y<br>Miniature Plug, black (2 supplied) 23421–031K<br>50 way Plug 23435–420Z<br>Plug, Cable entry pack (5 supplied) 23443–371R<br>Plug, Body pack (5 supplied) 23443–374A<br>Fuse Link, 630mA–T (2 supplied) 23411–057M. |
| **54127–191D** | **Optional Accessories**<br>Rack Slide Kit. |

# Insertion Signal Analyser

# TF 2914A




14387

- ☐ **Automatic television waveform measurements**
- ☐ **Objective high-resolution readings from digital panel meter**
- ☐ **Measures up to a total of 24 separate parameters**
- ☐ **Manual and automatic modes of operation**
- ☐ **600 series: 625 line operation – PAL or SECAM, National or CCIR International waveforms**
- ☐ **500 series: 525 line operation – NTSC, NTC-7 or CBC 1 and CBC 2 VITS waveforms**

The Insertion Signal Analyser TF 2914A measures a variety of video parameters in the TV system, using waveforms inserted into the vertical interval of the programme signal.

Five video inputs are provided on TF 2914A, each input being individually selected by front panel push-button. The parameter chosen for measurement is also selected by manual push-buttons specifying the group to which it belongs and the identity of the parameter itself. Measured results are presented on a digital panel meter which provides automatic indication of decimal point and sign, the units being indicated below the meter by a light emitting diode.

Parameters which can be measured include:

- Luminance bar amplitude
- Sync amplitude
- 2T pulse to bar ratio
- Chrominance to luminance gain inequality
- Chrominance to luminance delay
- Luminance non-linearity
- Signal-to-noise ratio
- Chrominance to luminance crosstalk (intermodulation)
- Low frequency error
- Bar tilt
- 2T 'K' factor
- Differential gain
- Differential phase
- Multiburst (six separate burst amplitudes)
- Colour reference burst amplitude
- Flag amplitude
- Three auxiliary d.c. inputs

Variants of the basic unit provide five or six-level staircase modulation measurements and the ability to extract digital information on the International data line. The latter feature replaces the auxiliary input facility.

### Automatic operation

In conjunction with the Data Monitor TF 2915 or the Data Selector TK 2917 the instrument can also be used in an automatic mode by operation of the front panel AUTO button. Both the video inputs and the parameters to be measured are sequentially selected through automatic switching, the measured values being processed digitally for limits comparison and off-line data processing.

# TF 2914A

## Specification for 625 line models

**INPUT SIGNAL**

Various models of TF 2914A are available, suitable for use on 625 line TV systems (PAL and SECAM) using international insertion test signals as defined by CCIR Recommendation 475, or test signals defined by national authorities.

**Reading settling time**

Not greater than 30 s (15 s on UK National test signal).

**FUNCTION MODES**

**Manual**

The video input channel and parameter to be measured are selected by front panel push-buttons, the measurement being displayed on a digital panel meter.

**Auto**

Output signals in both b.c.d. and analogue form together with control logic are available via rear panel connections. (This mode of operation is used in conjunction with the Data Monitor TF 2915 and/or the Data Selector TK 2917.)

**MEASUREMENT PARAMETERS**

**Standard model**

Parameters 00 to 12 can be measured with the standard model of TF 2914A.

**Variants**

Parameters 13 to 15 can be supplied with the standard model or they can be added at a later date as an optional facility. Parameters 16 to 23 can be added to the standard model if specified at the time of ordering.
The following parameter definitions apply to the TF 2914A (600 series), 625 line units for use with International CCIR and European National Waveforms.

**00 LUMINANCE BAR AMPLITUDE**

The difference in amplitude between the mid-point of the luminance bar and 700 mV. The measured difference displayed as a percentage of 700 mV.

**Measurement range**

–50 to +50%. (nominal output 0%).

**Reading uncertainty**

±0·5% from –20 to +20%.
±1·0% from –50 to +50%.

**Resolution**

±0·1%.

**01 SYNC PULSE AMPLITUDE**

The difference in amplitude between the peak amplitude of sync and 300 mV. The measurement difference displayed as a percentage of 300 mV.

**Measurement range**

–50 to +50%.

**Reading uncertainty**

±1·0% from –20 to +20%.
±1·5% from –50 to +50%.

**Resolution**

±0·1%.

**02 2T PULSE TO BAR RATIO**

The difference in amplitude between the peak amplitude of the 2T pulse and the mid-point of the luminance bar. Measurement displayed as a percentage of the luminance bar amplitude.

**Measurement range**

–50 to +50%.

**Reading uncertainty**

±0·7% from –20 to +20%.
±1·0% from –50 to +50%.

**Resolution**

±0·1%.

**03 CHROMINANCE TO LUMINANCE GAIN INEQUALITY**

The difference in amplitude between the peak of the chrominance component of the chrominance bar and the mid-point of the luminance bar. Measurement displayed as a percentage of the luminance bar.

**Measurement range**

–50 to +50%

**Reading uncertainty**

±0·7% from –20 to +20%.
±1·0% from –50 to +50%.

**Resolution**

±0·1%.

*Parameters 00 to 03 may be patched for an error-free reading of either 100% or 0 (normally patched for 100%).*

**04 CHROMINANCE TO LUMINANCE DELAY**

The time difference between the chrominance and luminance components of the composite sine squared pulse. Positive reading indicates chrominance components delayed relative to the luminance.

**Measurement range**

−150 ns to +150 ns.

**Reading uncertainty**

± 5 ns from −100 to +100 ns.
±10 ns from −150 to +150 ns.

**Resolution**

±0·1 ns.

**05 LUMINANCE NON-LINEARITY**

Measured as the difference between the largest and smallest step amplitudes of the luminance staircase. Displayed as a percentage of the largest step.

**Measurement range**

0 to 50%.

**Reading uncertainty**

±1% from 0 to 20%.
±2% from 20 to 50%.

**Resolution**

±0·1%.

**06 SIGNAL/NOISE RATIO**

The signal-to-noise measurement expressed in dB referred to the amplitude of the mid-point of the luminance bar. Filter options available.

**Measurement range**

*Weighted:* 76 dB to 28 dB signal-to-noise ratio.
*Unweighted:* 70 dB to 28 dB signal-to-noise ratio.

**Reading uncertainty**

±2 dB from 70 to 28 dB.

**Resolution**

±0·1 dB.

**07 CHROMINANCE TO LUMINANCE CROSSTALK (INTERMODULATION)**

Measured as the change in amplitude of the luminance pedestal during the three level chrominance signal. Measurement displayed as a percentage of the mid-point of the luminance bar.

**Measurement range**

−40 to +40%.

**Reading uncertainty**

±1·0% from −20 to +20%.
±2·0% from −40 to +40%.

**Resolution**

±0·1%.

**08 LOW FREQUENCY ERROR**

The weighted measurement of the peak to peak amplitude of low frequency signals superimposed on the full field signal. Weighting network approximately −6 dB at 50 Hz and 550 Hz relative to 300 Hz.

**Measurement range**

0 to 150 mV.

**Reading uncertainty**

±3 mV at 50 Hz.

**Resolution**

±0·1 mV.

**09 BAR TILT**

The difference in amplitude of the luminance bar at two points approximately 1 µs and 9 µs after leading edge of bar. Measurement displayed as a percentage of the bar amplitude.

**Measurement range**

−50 to +50%.

**Reading uncertainty**

±1% from −20 to +20%.
±2% from −50 to 50%.

# TF 2914A

| | |
|---|---|
| **Resolution** | ±0·1%. |
| **10 2T PULSE 'K' FACTOR** | Time weighted measurement of the pre-pulse and post-pulse ringing amplitudes by comparison with an electronically generated mask of the form defined in CCIR Geneva 1974 Rep. 486–1, Ref. 3·5·1·4 within the measurement time interval. Displayed as percentage K. |
| **Measurement range** | 0% to 10% K. |
| **Time interval** | With reference to middle of 2T pulse −8T to −2T and +2T to +12T for 625 line systems, where T is 100 ns. |
| **Reading uncertainty** | ±1% with a signal-to-noise ratio of better than 50dB.<br>±2% with a signal-to-noise ratio between 40 and 50dB. |
| **Resolution** | ±0·1% K. |
| **11 DIFFERENTIAL GAIN** | The modulus of maximum amplitude deviation of the sub-carrier superimposed on the staircase expressed as a percentage of its amplitude at black level. |
| **Measurement range** | −50 to +50%. |
| **Reading uncertainty** | ±0·5% from 0 to 10%.<br>±2% from 10 to 20%.<br>±3% from 20 to 30%.<br>±5% from 30 to 50%. |
| **Resolution** | ±0·1%. |
| **12 DIFFERENTIAL PHASE** | The modulus of maximum phase deviation of the sub-carrier superimposed on the staircase relative to its phase at black level. |
| **Measurement range** | −45 to +45°. |
| **Reading uncertainty** | ±1° from 0 to 10°.<br>±2° from 10 to 20°.<br>±3° from 20 to 30°.<br>±5° from 30 to 45°. |
| **Resolution** | ±0·1°. |
| **13-15 AUXILIARY DC INPUTS** | These are available as an optional facility. Access obtained via rear panel Automatic State socket. |
| **Measurement range** | Two of the inputs to be patched to give error-free readings of either 0 or 100. The third input can be preset to any value between 0 and 100. −1·999 V to +1·999 V when used with Data Selector TK 2917 only. −1·599 V to +1·599 V when used with Data Monitor TF 2915.<br>+1 V = +100·0 d.p.m. reading.<br>−1 V = −100·0 d.p.m. reading. |
| **Input impedance** | 110 kΩ ±1%. |
| **Accuracy** | ±2%. |
| **Resolution** | ±0·1%. |
| **16 REFERENCE BAR (FLAG)** | Amplitude of the reference bar relative to the amplitude of the luminance bar. |
| **Measurement range** | 50 to 150%. |
| **Reading uncertainty** | ±0·5% from 80 to 120%.<br>±1% from 50 to 150%. |
| **Resolution** | ±0·1%. |
| **17-22 MULTIBURST** | |
| **Gain-frequency Response** | Amplitude of each frequency burst relative to the amplitude of the luminance bar. |
| **Measurement range** | 50 to 150%. |
| **Reading uncertainty** | ±1% from 90 to 110%.<br>±2% from 80 to 120%.<br>±3% from 50 to 150%. |
| **Resolution** | ±0·1%. |
| **23 COLOUR REFERENCE BURST** | The amplitude of the colour reference burst relative to the amplitude of the luminance bar. |
| **Measurement range** | 50 to 150%. |
| **Reading uncertainty** | ±1% from 90 to 110%.<br>±3% from 80 to 120%.<br>±4% from 50 to 150%. |
| **Resolution** | ±0·1%. |
| **DATA LINE EXTRACTION** | This facility is available as an alternative to the auxiliary d.c. input measurement capability.<br>No measurements are carried out on the Data Line, but the information carried by it is gated out and routed to a rear panel BNC socket. |
| **Line selection** | Selected internally by the programme links. The standard version is normally programmed for line 16 and line 329. |
| **Output impedance** | 75 Ω. |
| **Return loss** | >28 dB up to 7 MHz. |
| **Output level** | Within ±4% of the input signal level. |
| **VIDEO INPUTS** | Rear panel BNC socket. |
| **Input selection** | Five video inputs with loop-through facility selected by front panel push-buttons, or automatically by the use of either the Data Monitor TF 2915 or the Data Selector TK 2917. |
| **Isolation between inputs** | Greater than 55 dB. |
| **Impedance** | 75 Ω. |
| **Return loss** | Greater than 30 dB up to 7 MHz. |
| **Operating modes** | Transmitter or five-input mode selected by two-position switch located on rear panel.<br>*Five input:* each of the five video inputs may be selected.<br>*Transmitter:* three of the five video inputs may be selected, the remaining two switch positions select input one, or as programmed by Data Monitor TF 2915 when used. |
| **INTERFACING FOR AUTOMATIC OPERATION** | |
| **Digital signal plug** | Rear panel mounted.<br>*Parameter reading:* 14 bits.<br>*Control:* 5 bits.<br>*Video input select:* 3 bits.<br>*Levels:* TTL. |
| **Analogue signal socket** | Rear panel mounted.<br>*Parameter outputs:* Analogue voltage output of each parameter measurement. Analogue voltage levels in the range −1·5 to +1·5 V d.c. |
| **VIDEO MONITOR OUTPUT** | Front panel BNC socket. |
| **Source impedance** | 75 Ω. |
| **Gain** | 1 ±5% into 75 Ω. |
| **LINE TRIGGER OUTPUT** | Front panel BNC socket. |
| **Source impedance** | 500 Ω nominal. |
| **Level** | TTL logic. |
| **FIELD TRIGGER OUTPUT** | Front panel BNC socket. |
| **Source impedance** | 500 Ω nominal. |
| **Level** | TTL logic. |
| **DISPLAY** | Digital panel meter.<br>$3\frac{1}{2}$ digit l.e.d. display with decimal point and automatic polarity indication. |

# TF 2914A

| | |
|---|---|
| **DPM uncertainty** | ±1 digit should be added to all reading uncertainties. |
| **CONTROLS** | |
| **Parameter selection buttons** | Interlocking push-buttons with 3 banks for manual selection. |
| **Video input buttons** | Five interlocking push-buttons permit manual selection of up to five video inputs. |
| **Auto button** | Cancels manual mode, the analyser is then controlled by either the Data Monitor TF 2915 or the Data Selector TK 2917. |
| **RADIO FREQUENCY INTERFERENCE** | Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference. |
| **POWER REQUIREMENTS** | |
| **AC supply** | 95 to 132 V and 190 to 264 V. 45 to 65 Hz. 100 VA. |
| **SAFETY** | Complies with IEC 348. |
| **DIMENSIONS AND WEIGHT** | Height 133 mm (5¼ in), Width 425 mm (16¾ in), Depth 457 mm (18 in), Weight 11·4 kg (25 lb) |

## ACCESSORIES

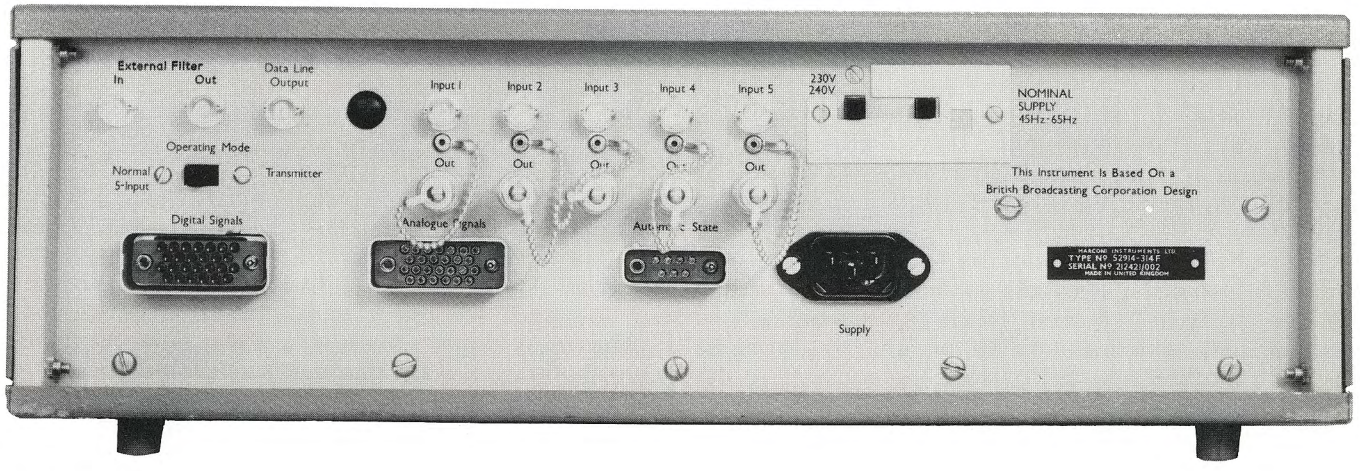
*When ordering please quote eight digit code numbers*

| | |
|---|---|
| | **Supplied Accessories**<br>Accessory Kit 46883–339A.<br>Comprises:<br>Extender Board 44827–235W.<br>Mains Lead, side-entry 43129–003W.<br>Free Plug 23443–328T, 75 Ω, (4 supplied).<br>Seven-way Plug 23435–416A.<br>Board Extractor 41700–048A.<br>Rack Mounting Kit (basic) 46883–175Y.<br>Coaxial Lead Assembly 43129–209T. |
| **Ordering Numbers** | **Optional Accessories** |
| **46883–193X** | Data Line Extraction. |
| **54541–091F** | Auxiliary Inputs. |
| **54499–001Z** | Luminance Noise Weighting Filter CCIR. |
| **54499–010L** | Unified Noise Weighting Filter CCIR. |
| **54127–171A** | Rack Slide Kit. |
| **46883–231X** | Plug Socket Kit 26-way. |
| **46883–358W** | Ventilation Kit. |
| **46881–323W** | Service Manual. |

## VERSIONS

| MODEL 52914– | 600T | 601P | 602X | 603M | 610K | 611A | 612Z | 613H | 614E | 620N | 630W | 631D | 632T | 640R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| System | PAL | PAL | PAL | PAL | PAL | PAL | PAL | PAL | PAL | SECAM | SECAM | SECAM | SECAM | PAL UK |
| Differential phase and gain (6 level modulation) | ✲ | ✲ | ✲ | | ✲ | ✲ | ✲ | | | ✲ | ✲ | ✲ | ✲ | ✲ |
| Differential phase and gain (5 level modulation) | | | | ✲ | | | | ✲ | ✲ | | | | | |
| LF error, 20 to 700 Hz (3 dB) | | | | ✲ | | | | ✲ | ✲ | | | | | |
| LF error, 50 to 550 Hz (6 db w.r.t. 300 Hz) | ✲ | ✲ | ✲ | | ✲ | ✲ | ✲ | | | ✲ | ✲ | ✲ | ✲ | ✲ |
| Multiburst and colourburst | | | | | ✲ | ✲ | ✲ | ✲ | ✲ | | ✲ | ✲ | ✲ | |
| Auxiliary inputs | | ✲ | | | | ✲ | | | ✲ | | | ✲ | | |
| Data line extraction | | | ✲ | | | | ✲ | | | | | | ✲ | |

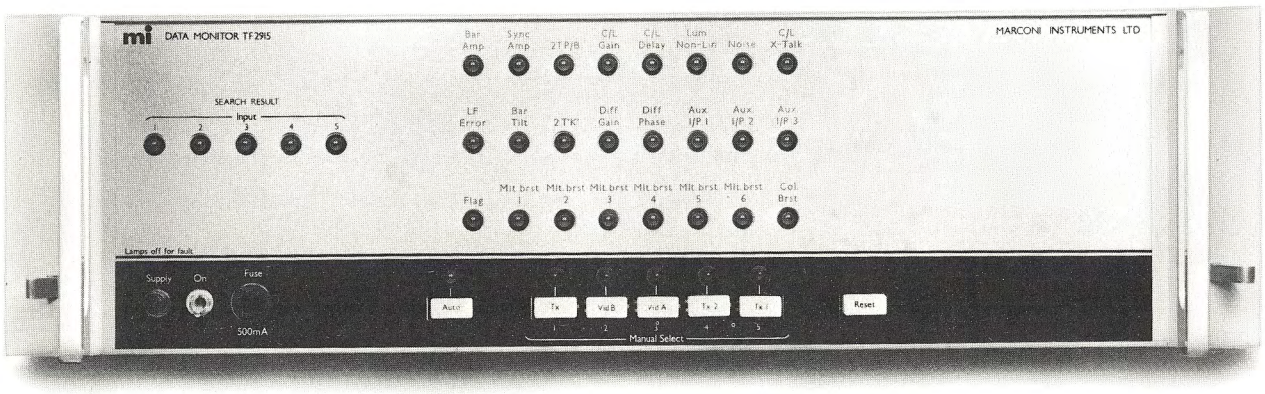
Variants of these models can be supplied on request.
Versions are also available for 525 line operation.




*Rear view of TF 2914A*

*14374/4*

# Data Monitor TF 2915




14260/1

- ☐ **Television studio and transmission monitoring**
- ☐ **Individual or sequential scanning of up to five video inputs**
- ☐ **Four-limit comparison on each parameter measurement**
- ☐ **Immediate and individual limit changing for each parameter**
- ☐ **Front panel indication of each parameter and of video input status**
- ☐ **Automatic external switching and status reporting**

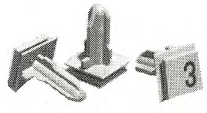
Data Monitor TF 2915 compares parameter measurements with pre-determined limits providing instantaneous and time-weighted analysis. As a result of this averaging process automatic switching action can be taken.

The analogue outputs from the TF 2914A, representing the measured values of the parameters, are taken to a Parameter Switch in the TF 2915. This switch is automatically cycled around the parameters and feeds back the measured value for each in sequence to the TF 2914A where it is converted to b.c.d. form by an analogue to digital converter. This b.c.d. signal is returned to a Limits Comparator in the TF 2915 where it is compared with the pre-set limits. Four limits can be set up for each parameter, consisting of high and low values of two grades – 'urgent' and 'caution', executive control switching being initiated by exceeding either the urgent or the caution limits, depending on the video input selected. These limits can be changed easily and quickly for each individual parameter by altering the plug-in buttons which are accessible via a hinged panel as shown in the two photographs on the following page.

The front panel contains a light emitting diode corresponding to each parameter measured and to the search result status for each video input the latter indicating the time-averaged analysis. These lamps are normally illuminated, but are extinguished by an out-of-limits result for the corresponding parameter or video input.

## Time-weighted averaging

When an out-of-limits result is obtained a signal is supplied to a faults counter. A pre-selected number of scans takes place, covering all the parameters on one video input, and a fault/scan comparator determines the fault incidence rate. When the number of faults occurring in a given number of scans exceeds the pre-set limit an output signal is obtained. Both the number of scans and the fault incidence can be independently set. The data outputs provide a '1' state TTL off in the event of a fault occurring, while the executive relays give a contact closure in the event of a failure.




*Preset limit buttons*



14388

*Interior view of TF 2915 showing individual parameter limit switches*

## Transmitter applications

Normally, in the automatic mode of operation, the instrument monitors the output of the main transmitter of a television system, or the combined transmitter output where parallel transmitters are employed. When a fault condition is found the instrument is automatically cycled to monitor first the reserve video input, then the main video input. It then returns to the transmitter output, or to the two separate transmitter outputs in the case of parallel operation. A separate store is provided in the TF 2915 for each of these monitoring points and any faults found are recorded in these stores. Each store has associated with it a front panel lamp which is normally illuminated but is extinguished if a fault condition occurs e.g. transmitter failure.

When this happens the instrument evaluates each video input signal in turn in order to initiate the optimum system switching configuration for transmitters and video inputs in order to maintain transmission quality. Data output is also provided to indicate the condition of the various stores and to report on the switching status.

## Studio applications

By appropriate internal linkages, from one to five video inputs can be scanned sequentially, providing a continuously sampled status condition on each video line. The transition time when switching from one video input to the next is 30 seconds, allowing all the measurements to stabilize under the worst operational conditions. The total time to monitor all five video inputs varies from nominally 2 min 30 sec to 5 min 30 sec depending on whether the scan count is set to 1 or 30.

## Semi-automatic mode

A semi-automatic mode of operation of the TF 2915 is available in which the monitoring position is selected by a series of front panel push-buttons. Automatic scanning of the parameters occurs as in the fully automatic mode, but the stores are inhibited from accepting information.

*Reset*–A push-button is provided which removes all fault indications stored and returns the complete system to its initial condition.

*Inhibit*–An inhibit facility prevents the equipment from indicating fault conditions during the warm-up period of a transmitter.

*Rack mounting*–TF 2915 can be supplied with rack-mounting slides and quick release catches.

| OPERATING MODES | |
|---|---|
| **Automatic** | Fully automatic scanning of system parameters, selection of monitoring positions and executive action. External overrides apply. Alternative modes available by internal patching give monitoring of:<br>(a) One or more video inputs sequentially.<br>(b) Main or cold-standby transmitters.<br>(c) Parallel transmitters. |
| **Semi-automatic** | Manual selection of monitoring positions by front panel push-buttons or remote selection by inputs on a rear panel socket. Automatic scanning of parameters with parameter 'out-of-limits' display operating normally but with fault counters and failure stores inhibited from accepting information. |

# TF 2915

## MEASUREMENT DATA

**Parameter measurement accuracy**
Parameter measurement accuracy is determined by the Insertion Signal Analyser TF 2914A.

**Parameter limits**
The limits to which parameters are compared can have the magnitude −1599 < limit < +1599. The limits are stored as a mixed binary/b.c.d. number in the limits store, and may be visually read as a decimal number.

**Maximum number of parameters**
Instruments can be supplied to scan 14, 16 or 24 parameters as required.

**Limit store capacity**
Up to a maximum of 96 limit values are provided, depending on the model supplied.

## PARAMETER MEASUREMENT INPUTS

**Parameter analogue signals**
Up to 24 lines (one line for each available Parameter) from the Insertion Signal Analyser TF 2914A. The analogue voltage is set to a suitable range for the $3\frac{1}{2}$ digit panel meter in TF 2914A.

**Parameter b.c.d.**
24 lines (three decades of b.c.d. plus a '1000' digit and sign) from the analogue to digital converter in TF 2914A.

## PARAMETER INPUT FROM TF 2914A

**Model 52915-301F** Parameters 00 to 13.

**Model 52915-302G** Parameters 00 to 23.

| Parameter number | Name | Units of measurement |
|---|---|---|
| 00 | Bar amplitude | % |
| 01 | Sync amplitude | % |
| 02 | 2T pulse/bar ratio | % |
| 03 | Chrominance/luminance gain | % |
| 04 | Chrominance/luminance delay | ns |
| 05 | Luminance non-linearity | % |
| 06 | Noise | dB |
| 07 | Chrominance/luminance cross talk | % |
| 08 | LF error | mV |
| 09 | Bar tilt | % |
| 10 | 2T 'K' factor | % |
| 11 | Differential gain | % |
| 12 | Differential phase | degrees (angle) |
| 13–15 | Auxiliary d.c. inputs | V |
| 16 | Multiburst bar | % |
| 17 | Multiburst | % |
| 18 | Multiburst | % |
| 19 | Multiburst | % |
| 20 | Multiburst | % |
| 21 | Multiburst | % |
| 22 | Multiburst | % |
| 23 | Colour reference burst | % |

*The units of measurement shown in this table are determined by the programming in the associated TK 2917 and will vary for different applications.*

## DISPLAY

**Out-of-limits**
LED lamps; one lamp per parameter.
In limits: lamp illuminated.
Out-of-limits: lamp extinguished.

**Fault condition**
5 LED lamps: one lamp per fault store.
No fault condition: lamp illuminated.
Fault condition: lamp extinguished.

## DATA OUTPUTS

Open collector TTL outputs 'On' state: less than 0·4 V at I (sink) = 40 mA.
'Off' state: 30 V max.

| | |
|---|---|
| Parameter number | 8 bits |
| Video source selected | 3 bits |
| Parameter reading | 14 bits |
| Urgent limit comparison | 1 bit |
| Caution limit comparison | 1 bit |
| End of measurement | 1 bit |
| Parameter store results | 14 bits |
| End of scan | 1 bit |
| Search store results | 6 bits |
| End of search | 1 bit |
| Transmitter fail | 1 bit |
| Station fail | 1 bit |

## CONTROL INPUT

HLL input.
'0' state: 0 to +5 V short circuit to common sinking 3 mA.
'1' state: +9 V to 25 V or open circuit.

| | |
|---|---|
| Zero Reset | 1 bit |
| Inhibit | 1 bit |
| Video Feed Selected | 1 bit |
| Remote Video Input Select | 3 bits |

Inputs compatible with TF 2914A outputs.
Control signals from TF 2914A to TF 2915 when video input is manually selected from TF 2914A.

## CONTROL OUTPUT

**Transmitter 1 or 2 selector**
**Two relays**
Contact closure for selection. Rating 42 V; 0·25 A; 10 VA.
Outputs compatible with TF 2914A inputs. Control signals from TF 2915 to TF 2914A while operating in automatic or semi-automatic mode.

## EXECUTIVE OUTPUT

| | |
|---|---|
| Video A failed | 1 Relay |
| TX 1 failed | 1 Relay |
| TX 2 failed | 1 Relay |

Contact closure for failure
Rating 42 V; 1 A; 50 VA.

Storage of Executive Control Information on Mains Supply failure.

## POWER REQUIREMENTS

**AC supply**
95 to 132 V and 190 to 264 V.
45 to 65 Hz, 90 VA.

## SAFETY

Complies with IEC 348.

## RADIO FREQUENCY INTERFERENCE

Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference.

## DIMENSIONS AND WEIGHT

| Height | Width | Depth | Weight |
|---|---|---|---|
| 133 mm | 483 mm | 533 mm | 10·7 kg |
| 5·2 in | 19 in | 21 in | 23·5 lb |

## VERSIONS AND ACCESSORIES

*When ordering please quote eight digit code numbers*

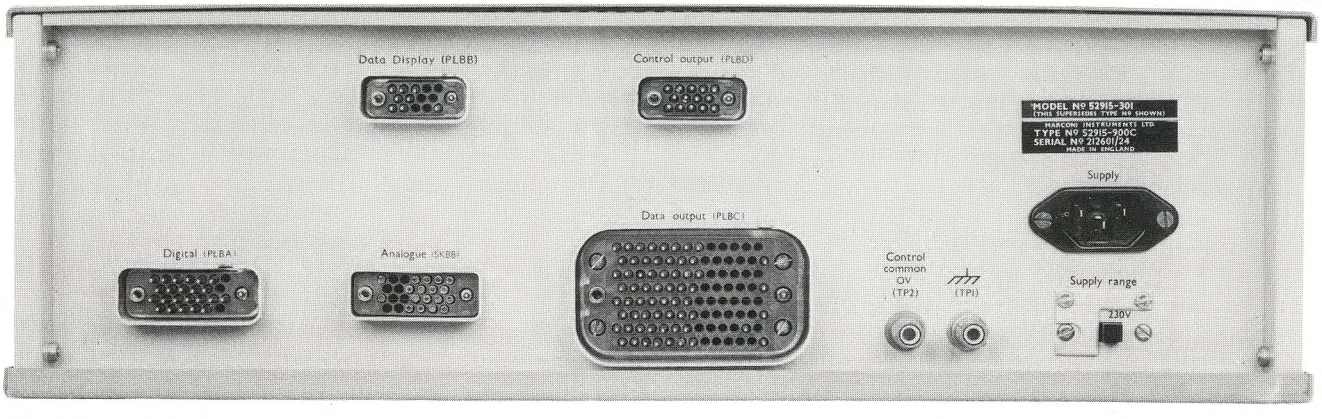
| Ordering numbers | |
|---|---|
| | **Versions** |
| 52915-301F | TF 2915 with 14 monitored parameters. |
| 52915-302G | TF 2915 with 24 monitored parameters. (For transmitter applications.) |
| | **Supplied Accessories** |
| | Accessory Kit 46883-247L. Comprises: 14 way Socket 23435-435W. 104 way socket 23435-499W. Blank Button 23435-599D (5 supplied). Tx button 37590-072V. Digital Cable 46883-212U. Analogue Cable 46883-316N. Plug Extractor 22951-399D. Plug Tops (586 supplied). Instruction Manual 46881-233K. AC Supply Lead 43123-076Y. |
| | **Optional Accessories** |
| 54127-181L | Rack Slide Kit. |

## TRANSMITTER SWITCHING APPLICATIONS

**EXECUTIVE ACTION TRUTH TABLE**

Shows the executive status number associated with the various search results. The first half of the table only is used in a main/standby transmitter station. When the data monitor is used in a parallel transmitter station the whole truth table will apply.
Video feed switch reads:
'0' in position VID A
'1' in position VID B
'1' indicates a fault for video feed B, video feed A, Tx 2 and Tx 1.

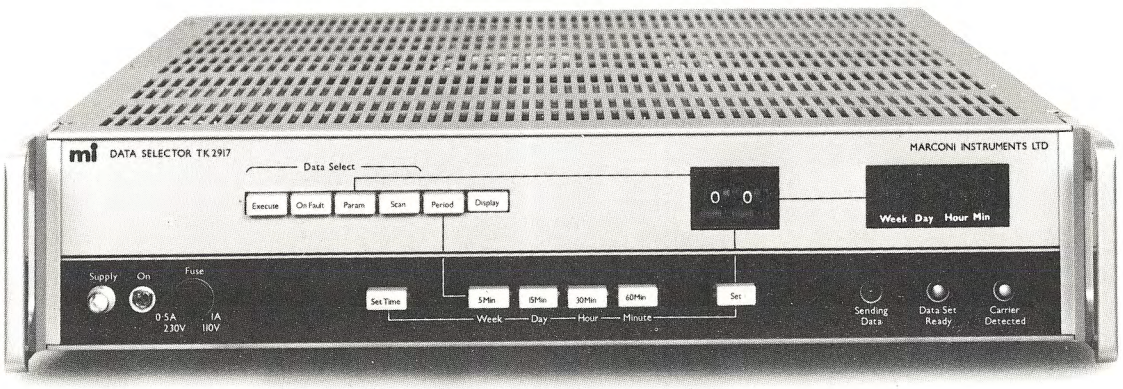
| Executive number | Video feed switch | Video feed B | Video feed A | $Tx_2$ | $Tx_1$ | Search result | Excutive action |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | No failure | |
| 1 | 1 | 0 | 0 | 0 | 0 | No failure | |
| 2 | 0 | 1 | 0 | 0 | 0 | VID B fail | |
| 3 | 1 | 1 | 0 | 0 | 0 | VID B fail | Change to VID A |
| 4 | 0 | 0 | 1 | 0 | 0 | VID A fail | Change to VID B |
| 5 | 1 | 0 | 1 | 0 | 0 | VID A fail | |
| 6 | 0 | 1 | 1 | 0 | 0 | Both video feeds fail | |
| 7 | 1 | 1 | 1 | 0 | 0 | Both video feeds fail | |
| 8 | 0 | 0 | 0 | 1 | 0 | $Tx_2$ fail | Turn $Tx_2$ off or to stand-by |
| 9 | 1 | 0 | 0 | 1 | 0 | $Tx_2$ fail | Turn $Tx_2$ off or to stand-by |
| 10 | 0 | 1 | 0 | 1 | 0 | $Tx_2$ fail | Turn $Tx_2$ off or to stand-by |
| 11 | 1 | 1 | 0 | 1 | 0 | $Tx_2$ fail, VID B fail | Change to VID A |
| 12 | 0 | 0 | 1 | 1 | 0 | $Tx_2$ fail, VID A fail | Change to VID B |
| 13 | 1 | 0 | 1 | 1 | 0 | $Tx_2$ fail | Turn $Tx_2$ off or to stand-by |
| 14 | 0 | 1 | 1 | 1 | 0 | Both video feeds fail | Station fail |
| 15 | 1 | 1 | 1 | 1 | 0 | Both video feeds fail | Station fail |
| 16 | 0 | 0 | 0 | 0 | 1 | $Tx_1$ fail | Turn $Tx_1$ off |
| 17 | 1 | 0 | 0 | 0 | 1 | $Tx_1$ fail | Turn $Tx_1$ off |
| 18 | 0 | 1 | 0 | 0 | 1 | $Tx_1$ fail | Turn $Tx_1$ off |
| 19 | 1 | 1 | 0 | 0 | 1 | $Tx_1$ fail, VID B fail | Change to VID A |
| 20 | 0 | 0 | 1 | 0 | 1 | $Tx_1$ fail, VID A fail | Change to VID B |
| 21 | 1 | 0 | 1 | 0 | 1 | $Tx_1$ fail | Turn $Tx_1$ off |
| 22 | 0 | 1 | 1 | 0 | 1 | Both video feeds fail | Station fail |
| 23 | 1 | 1 | 1 | 0 | 1 | Both video feeds fail | Station fail |
| 24 | 0 | 0 | 0 | 1 | 1 | Both Tx fail | Tx fail |
| 25 | 1 | 0 | 0 | 1 | 1 | Both Tx fail | Tx fail |
| 26 | 0 | 1 | 0 | 1 | 1 | Both Tx fail | Tx fail |
| 27 | 1 | 1 | 0 | 1 | 1 | Both Tx fail, VID B fail | Change to VID A |
| 28 | 0 | 0 | 1 | 1 | 1 | Both Tx fail, VID A fail | Change to VID B |
| 29 | 1 | 0 | 1 | 1 | 1 | Both Tx fail | Tx fail |
| 30 | 0 | 1 | 1 | 1 | 1 | Both Tx and video feeds fail | Station fail |
| 31 | 1 | 1 | 1 | 1 | 1 | Both Tx and video feeds fail | Station fail |




*Rear panel view of TF 2915*

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# Data Selector TK 2917




14552

- ☐ **Television and Telemetry data interface**
- ☐ **Manual and automatic operating modes**
- ☐ **Individual parameter selection**
- ☐ **Full parameter scanning**
- ☐ **Fault analysis and switching status reporting**
- ☐ **Data supplied to on-site printers or remote terminals using modems**
- ☐ **Control by local or remote keyboards**
- ☐ **Digital annual clock providing timed recordings and periodic automatic operation**
- ☐ **Each record identified with location, date and time to within one minute in one year**

Data Selector TK 2917 is an interface between data collection and measurement equipments and a data storage or transmission system. Although the unit can act in conjunction with many configurations of data system it was specifically designed for use with the Marconi Instruments' TF 2914A and TF 2915 television measurement, comparison and executive control equipments for use in studio or transmitter applications. It permits the operator to select the required information from the automatic measuring equipment for recording at the equipment site or for transmission to a remote site, and it also provides a buffer storage facility in order that the monitoring function continues without interruption from the data storage system.

Information is available from the Data Selector in either b.c.d. bit parallel with numeric printouts or in ASCII bit serial with various language options.

The following data may be selected from the Television Automatic Measuring Equipment using the Data Selector.

Any one parameter reading on any one of five video inputs.

Any faulty parameter reading on any one of five video inputs.

The readings of all the parameters monitored on any one of five video inputs.

The result of the last valid fault search carried out by the AME.

This information may be demanded from the Data Selector through the bit serial input in ASCII code, or in binary coded decimal through the bit parallel input. Alternatively, the Data Selector may be programmed using the front panel switches to produce the information at 5, 15, 30 or 60 minute intervals, or every 3, 6, 12 or 24 hours.

The Data Selector contains a 24 hour digital clock giving a time readout in week number, day number, hours and minutes, with every set of data selected. The clock may be set and displayed on the front panel.

# TK 2917

## GENERAL

**Parameter reading store size**
24 parameters of 8 digits each parameter.

**Annual digital clock**
Reading in week number, day number, hours and minutes up to 52 7 23:59.
Settable from the front panel.
Operates from internal oscillator or external 1 Hz drive.

**Accuracy: internal crystal oscillator**
±5 minutes per year (1 in $10^5$).

**External 1 Hz clock drive levels**
'0' less than +0·8 V.
'1' within the limits +3·6 V and +5·0 V.

**Time intervals**
Time intervals for automatic information request, selectable at the front panel: 5, 15, 30 or 60 minutes or 3, 6, 12 or 24 hours.

## DATA SELECTION CONTROLS (Front panel)

| | |
|---|---|
| *Executive number | push-button |
| Parameter | push-button |
| Parameter number | leverwheel switch |
| Parameter scan | push-button |
| *Faulty parameter | push-button |
| Period select 5, 15, 30, 60 minutes or 3, 6, 12, 24 hours | push-button interlocking push-buttons |
| set time | push-button |
| set | non-latching push-button |
| Week, day, hour, minute | interlocking push-button |
| Time | leverwheel switch |
| Display | push-button |

**Available only when used with TF 2915.*

## DISPLAYS

7 digit LED readout of annual clock.
LED lamps: Sending data.
Ready to send.
Carrier detected.

## INTERFACE INPUT/OUTPUT

Options provide interface with either Data Monitor TF 2915 or Insertion Signal Analyser TF 2914A.

## TF 2914A INTERFACE OPTION

**Data input**

| | |
|---|---|
| Parameter reading | 32 bits |
| Video source selected | 4 bits |
| End of measurement | 1 bit |
| Inhibit | 1 bit |

**Levels**
TTL single load input.
ON state less than 0·8 V.
OFF state greater than 2·0 V.
(Maximum +5·5 V.)

**Analogue interface**
*Inputs:* 24.
*Outputs:* 1, selected from the 24 inputs by the Parameter number selection.
*Level range:* ±2 V nominal, from TF 2914A.

**Control outputs**
DPM trigger, 1 bit—TTL totem pole
Video input select 4 bits—3 state totem pole.
*Levels:* TTL totem pole
ON state less than 0·4 V
OFF state greater than 2·4 V.

## TF 2915 INTERFACE OPTION

**Data input**

| | |
|---|---|
| Parameter number | 6 bits |
| Parameter reading | 32 bits |
| Search store results | 5 bits |
| Video source selected | 8 bits |
| Urgent limit comparison | 1 bit |
| Caution limit comparison | 1 bit |
| End of measurement | 1 bit |
| Execute | 1 bit |
| End of scan | 1 bit |

**Levels**
TTL single load input.
ON state less than 0·8 V.
OFF state greater than 2·0 V.
(Maximum +5·5 V.)

**Control output**

| | |
|---|---|
| Zero reset | 1 bit |
| Inhibit | 1 bit |
| Video input select | 8 bits |

**Levels**
Open collector TTL output.
ON state less than 0·4 V at $I_{sink}$ = 40 mA.
OFF state 30 V max.

## BIT PARALLEL INPUT/OUTPUT OPTION

Parallel BCD to a strip printer.

**Data available**
*Executive number.
*Any faulty parameter readings on any one video input.
Any one parameter reading on any one video input.
One parameter scan on any one video input.
Parameter number.
Video input number.
Time in weeks, days, hours, minutes.
Station identification, from station numbers 00 to 99.
Print command.

**Interrogation input**

| | |
|---|---|
| Parameter number | 6 bits |
| Information demand | 4 bits |
| Video input number demand | 8 bits |
| Inhibit | 1 bit |
| Zero reset | 1 bit |
| Demand valid | 1 bit |
| Video input number select | 1 bit |

*Levels:*
HLL input
ON state 0 to +5 V
OFF state +9 to +25 V.

**Data output**

| | |
|---|---|
| *Urgent limit alarm | 1 bit |
| *Caution limit alarm | 1 bit |
| Data bits (13 b.c.d. characters) | 52 bits |
| Data valid (print command) | 1 bit |
| TK 2917 busy | 1 bit |

*Levels:* TTL output five logic true
'1' state greater than 2·4 V.
'0' state less than 0·4 V.

## BIT SERIAL INPUT/OUTPUT OPTION

Serial ASCII No. 7. code to a data terminal.

**Data available**
*Executive number.
*Any faulty parameter reading on any one video input.
Any one parameter reading on any one video input.
One parameter scan on any one video input.
Parameter description.
Video input number.
Time in weeks, days, hours, minutes.
Station identification from station numbers 00 to 99.

# TK 2917

| | |
|---|---|
| | AME operating description (delay, inhibit).<br>Spaces, carriage return, line feeds. |
| **Input/output port** | To CCITT V 24 specification.<br>*Input:* Serial data.<br>Line signal detected.<br>Calling indicator.<br>Data set ready.<br>*Levels:* Logic '1' greater than +3 V.<br>Logic '0' less than −3 V.<br>(Maximum ±25 V.)<br>*Output:* Serial data.<br>Connect data set to line.<br>Request to send.<br>Signal ground.<br>*Levels:* Logic '1' greater than +6 V.<br>Logic '0' less than −6 V<br>into 3 kΩ, maximum ±12 V<br>into open circuit. |
| **Baud rate** | 110, 300, 600, 1200 or 2400 internal switch selected.<br>Serial input and output with even parity. |
| **Input/output port for local recording** | Serial output levels:<br>Logic '1' +6 V nominal.<br>Logic '0' −6 V nominal<br>into 3 kΩ maximum ±12 V into open circuit. |
| **Byte serial output** | 8 bits. |

| | |
|---|---|
| **Punch command** | 1 bit.<br>*Levels:* TTL open collector output with 1 kΩ pull up resistors (to less than 30 V).<br>Logic '0' less than 0·7 V at 40 mA. |
| **Punch busy** | 1 bit.<br>*Input levels:*<br>Logic '0' less than 0·8 V.<br>Logic '1' greater than 2·0 V, not greater than 5·5 V. |
| **Pull up power rails** | +12 V nominal.<br>+5 V nominal.<br>Signal ground. |
| **Information demand** | In words comprising station address and data/control required. |
| **POWER REQUIREMENTS** | |
| **AC supply** | 95 to 130 V and 190 to 264 V.<br>45 to 65 Hz, 60 VA approx. |
| **RADIO FREQUENCY INTERFERENCE** | Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference. |
| **SAFETY** | Complies with IEC 348. |
| **DIMENSIONS AND WEIGHT** | |

| Height | Width | Depth | Weight |
|---|---|---|---|
| 89 mm | 483 mm | 533 mm | 10·4 kg |
| 3½ in | 19 in | 21 in | 23 lb |

**EXAMPLE OF A PRINT OF THE INFORMATION FROM THE AME**

A print of a parameter scan on input 3 at station number 02 at 02·48 hours on day 1 (Monday), week number 01.
Information provided at the bit serial output in ASCII code, V24 interface.

```
AME02 WK01 D1 02:48
     3 BAR AMP      +101.7  %
     3 2T P/B       +101.0  %
     3 C/L DELAY    -020.6 NS
UC   3 SIG./NOISE   +045.4 DB
     3 LF ERROR     +005.6 MV
     3 2T 'K'       +001.2  %
UC   3 DIFF PHASE   +009.9DEG
     3 AUX I/P  2   +005.2
     3 MLT BAR      +101.4  %
     3 MLT BRST 2   +098.8  %
     3 MLT BRST 4   +097.7  %
UC   3 MLT BRST 6   +116.9  %
     3 SYNC AMP     +099.1  %
C    3 C/L GAIN     +105.4  %
     3 LUM N-LIN    +001.3  %
     3 C/L X-TALK   -000.5  %
     3 BAR TILT     -001.4  %
UC   3 DIFF GAIN    +004.0  %
     3 AUX I/P  1   +005.2
     3 AUX I/P  3   +005.2
     3 MLT BRST 1   +100.2  %
     3 MLT BRST 3   +096.0  %
     3 MLT BRST 5   +106.2  %
     3 COL. BRST    +104.5  %
```

*Note: UC indication denotes parameter measurements exceeding both urgent and caution limits.*

# TK 2917

*VERSIONS*

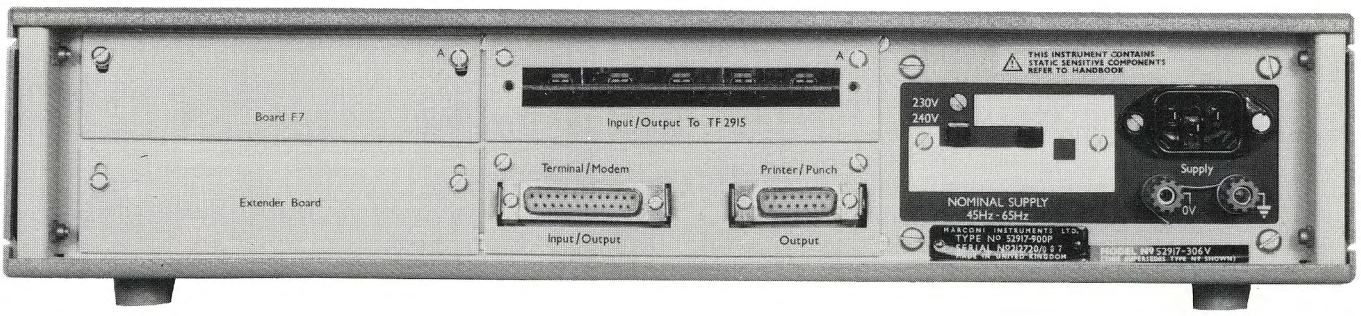
| MODEL 52917 – | 301N | 302L | 303J | 304F | 305G | 306V |
|---|---|---|---|---|---|---|
| For use with TF 2914A only | ✲ | ✲ | | | ✲ | |
| For use with TF 2914A in conjunction with TF 2915 | | | ✲ | ✲ | | ✲ |
| ASCII Bit serial V24 interface E.I.A. Port to RS 232C | ✲ | | ✲ | | ✲ | ✲ |
| BCD Bit parallel output Numerical print out | | ✲ | | ✲ | | |
| International units English Language print out | ✲ | | ✲ | | | |
| NTC/CBC Insertion test signals Print out with IRE units | | | | | ✲ | ✲ |

*Note: Various language printouts are available, e.g. French and Cyrillic.*

## ACCESSORIES

*When ordering please quote eight digit code numbers*

| Ordering numbers | |
|---|---|
| | **Supplied Accessories**<br>Accessory Kit 46883–287S comprising Board Extractor, Supply Lead, Rack Mounting Kit and 3, 6, 12, 24 hour buttons.<br>AME Interface Lead. (Either lead 43129–164J for TF 2914A or lead 43129–165F for TF 2915 supplied.)<br>Modem Interface Cable 43129–161Y for serial input/output option.<br>38-way socket and shroud 43169–012A for parallel input/output option.<br>*(Either of the above two items are supplied, depending on the input/output option.)* |
| **44319–004H**<br>**46883–298R**<br><br>**54127–251L** | **Optional Accessories**<br>Battery Back-up for digital clock.<br>Kit of parts for external 1 Hz digital clock drive.<br>Rack Slider Kit. |
| | Various interface cable accessories are available to suit different printers, terminals, punches, etc. |

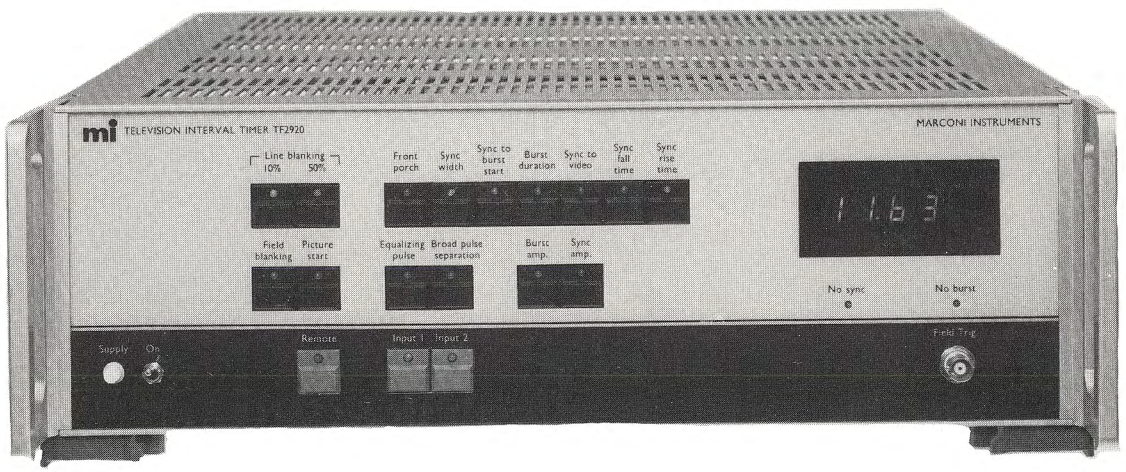



*Rear panel view of TK 2917*

*14552/1*

# Television Interval Timer

# TF 2920 series




- ☐ **Automatic measurement of line and field blanking intervals**
- ☐ **Objective high resolution readings from digital display**
- ☐ **Measures intervals to CCIR Recommendation 624 PAL 1 specifications**

The Television Interval Timer TF 2920 automatically performs line and field interval time measurements on composite television signals.

The parameter chosen for measurement is selected by front panel push-button. The instrument automatically performs the measurement and displays the result as a digital reading on the front panel. The measurement is constantly updated allowing for the evaluation of different material sources during programme preparation or transmission.

Line blanking measurements are performed on every line during the active field providing the instrument with the ability to measure active programme material. The field blanking measurements are unaffected by the presence of Insertion Test Signals, "Teletext" or source code identification.

Two loop-through video inputs are provided on the TF 2920, and may be selected by front panel push-buttons. Control of all the front panel functions and the output of the measurement reading, are available through a rear panel connector.

## Input signal

Composite Video, PAL 625 lines, 0·5 to 1·5 Volts peak to peak.ITS not required.

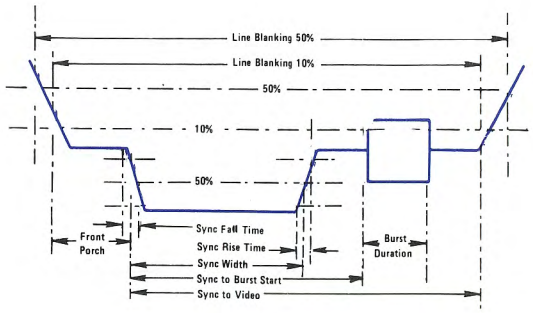
## Operating modes

*Manual:* Parameter and Video input to be measured may be selected by front panel push-buttons. The measured value of the selected parameter is automatically shown on the digital display with the units of measurement. The display is constantly updated with repeated measurements.

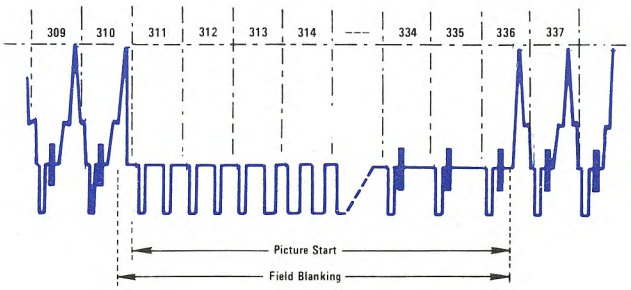
*Automatic:* Mode selected by "Remote" front panel switch. All parameter and video input selection can be made from the rear panel connector. Alternatively, internal parameter sequencing may be used to cycle through all measurements with the reading fed to an external printer on a handshake cycle.

*Automatic subroutine:* Mode selected by pressing the "Remote" button twice in rapid succession. Two or more parameters may be sequenced, parameters chosen for the subroutine are programmed in PROM.

# TV Measuring Equipment
# TF 2920 series




## HORIZONTAL BLANKING INTERVAL




## VERTICAL BLANKING INTERVAL

| Parameters Measured | Measurement Range | Detecting Levels* (Normalised to Sync and Burst Amplitudes) | Sample Size and Readout Basis | Reading uncertainty (For Signal/Noise >46 dB Unweighted) | Resolution | CCIR Nominal Values for PAL System 1 |
|---|---|---|---|---|---|---|
| Line Blanking 10% | 9·80 — 18·00 µs | 10% of White | Min. of 1000 | ±35 ns | ±10 ns | 11·7±0·3 µs |
| Line Blanking 50% | 9·80 — 18·00 µs | 50% of White | Min. of 1000 | ±35 ns | ±10 ns | 12·0±0·3 µs |
| Front Porch | 0·10 — 4·00 µs | 10% white to 50% sync | Min. of 1000 | ±35 ns | ±10 ns | 1·35±0·3 µs |
| Sync Width | 3·00 — 5·50 µs | 50% sync | Avg. of 100 | ±35 ns | ±10 ns | 4·7 ±0·2 µs |
| Sync to Burst Start | 4·70 — 7·00 µs | 50% sync to burst start† | Min. of 1000 | ±35 ns | ±10 ns | 5·6 ±0·1 µs |
| Burst Duration | 5·5 — 13·0 cycles | ±50% burst amplitude | Direct | detecting level uncertainty ±2% | ±0·5 cycles | 10±1 cycle |
| Sync to Video | 9·00 — 14·00 µs | 50% sync to 10% White | Min. of 1000 | ±35 ns | ±10 ns | 10·5 µs |
| Sync Fall Time | 0·06 — 0·40 µs | 10% to 90% sync amp. | Direct | ±35 ns | ±10 ns | 0·2±0·1 µs |
| Sync Rise Time | 0·06 — 0·40 µs | 90% to 10% sync amp. | Direct | ±35 ns | ±10 ns | 0·2±0·1 µs |
| Field Blanking | 20·0 — 100·0 lines | 10% White | Min. of 10, then 100 | ±0·3 lines | ±0·1 line | 25·0 lines |
| Picture Start | 20·0 — 40·0 lines | 10% White | Min. of 10, then 100 | ±0·2 lines | ±0·1 line | 25·0 lines |
| Equalising Pulse Width | 1·50 — 3·50 µs | 50% Sync | Avg. of 100 | ±35 ns | ±10 ns | 2·35±0·1 µs |
| Broad Pulse Separation | 3·30 — 6·00 µs | 50% Sync | Avg. of 100 | ±35 ns | ±10 ns | 4·7 ±0·2 µs |
| Burst Amplitude | 50 — 150% | pk to pk compared to 0·3 V | Direct analogue | ±2% | ±1% | 100±3% |
| Sync Amplitude | 50 — 150% | pk to pk compared to 0·3 V | Direct analogue | ±2% | ±1% | 100±3% |

*Alternate detecting levels may be selected internally.
†Burst start defined as first transition through ±50% burst amplitude.

**VIDEO INPUTS** — Rear panel BNC socket.

**Input selection** — Two video inputs with loop-through facility, selected by front panel push-button or from rear panel connector when "Remote" button is selected.

**Isolation between inputs** — Greater than 55 dB.

**Return loss** — Greater than 30 dB up to 7 MHz.

**Impedance** — 75 Ω.

**FIELD TRIGGER OUTPUT** — Front panel BNC socket.

**Source impedance** — 500 Ω nominal.

**Level** — TTL logic.

**INTERFACING FOR AUTOMATIC OPERATION** — Rear mounted 50 way Amphenol connector. All inputs and outputs at TTL levels.

**Parameter select** — Parallel b.c.d. control.

**Video input select** — Parallel b.c.d. control.

**Output data** — Parallel b.c.d. output of measurement and units plus parameter number and channel selected.

**Data ready** — 1 bit output.

**Hold data** — 1 bit input.

**Remote control request** — 1 bit input.

**POWER REQUIREMENTS** — 95 to 132 V and 190 to 264 V. 45 to 65 Hz to 100 VA.

**DIMENSIONS AND WEIGHT**

| Height | Width | Depth | Weight |
|---|---|---|---|
| 133 mm | 425 mm | 457 mm | 11·4 kg |
| 5¼ in | 17 in | 18 in | 25 lb |

### VERSIONS AND ACCESSORIES

*When ordering please quote eight digit code numbers*

| Ordering numbers | |
|---|---|
| | **Versions** |
| **52920–600K** | **TF 2920 Television Interval Timer** 625 line PAL Version. |
| **52920–500Z** | TF 2920 525 line, measures to RS 170A specification. |
| **52920–501H** | TF 2920 525 line, measures picture front porch, sync to picture. |
| **52920–502E** | TF 2920 525 line, measures to ABC TQ2/TQ3 specification. |
| | **Supplied Accessories** AC Supply Lead 43123–076Y. Extender Board 44828–307. |
| | **Optional Accessories** |
| **54127–171A** | Rack Slide Kit. |
| **54127–071H** | Rack Mounting Kit. |

# ON-LINE MONITORING SYSTEMS

## Broadcast transmitters and PTT links

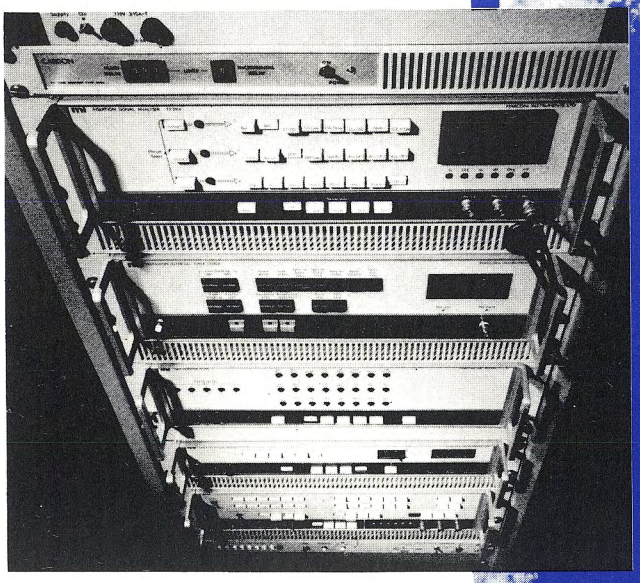
Marconi television monitoring equipment is now in use in over thirty countries world wide. For many years it has been monitoring unattended TV transmissions in the United Kingdom and elsewhere, providing daily systems performance checks. Its use has also spread to satellite ground stations, microwave bearer installations and PTT cable circuits.

Continuously in operation during daily programmes, the equipment gives instantaneous fault diagnosis with hard-copy print-out over wide limits of operation. Having made the sort of measurements which cannot be made as accurately, in the same time or with the same repeatability by any other means, these equipments remove much uncertainty and provide measuring confirmation that the network is not introducing unacceptable picture defects.

## Studio paths, outside broadcasts and VTR

Mobile racks within the studio complex can be used for checking individual equipments in situ or for providing master control facilities for monitoring internal video signal paths or input signals from outside venues. Additional incremental delay of up to 99 lines between the signal generator and analyser permits the checking of more complex video paths. Confirmation of VTR and ancillary equipment performance can be made quickly while at the same time providing a precision reference standard of measurement throughout the station. The equipment is equally suitable for use with 2 inch quadruplex and 1 inch helical machines the test signals being positioned at any point through the picture period. Horizontal and vertical blanking timing checks during tape editing ensure consistent frame size throughout the programme with a hard copy record if required.

Press button simplicity of operation, coupled with high resolution and accuracy, enable precision measurements to be made even by relatively unskilled engineers in everything from complete route paths down to individual video distribution amplifiers.



## Manufacturing quality control

Manufacturers of video and radio frequency link equipment monitor their production test facilities automatically using Marconi systems. Continuous unattended surveillance ensures quality control standards are maintained, particularly during soak-testing, and that no intermittent faults are present.

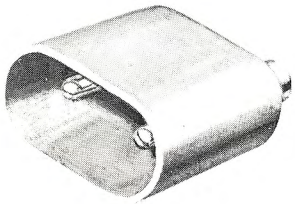
Video tape and cassette duplicating facilities achieve consistent output quality by continuous tape monitoring using the vertical interval test signals, hence removing the requirement for 100% viewing checks on the finished product.

# Optional Accessories

# Optional Accessories

*A selection of the range of Marconi Instruments accessories.*

## Adapters



| TYPE No. | DESCRIPTION |
|---|---|
| **43168-008S**<br>TB 39868 | Mates with output terminals of oscillators and signal sources to provide a BNC socket connection. |
| **43168-009W**<br>TB 39867 | Mates with output terminals of oscillators and signal sources to provide a Type 83 socket connection. |

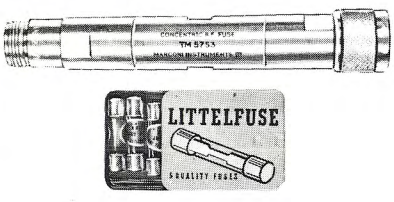
## Attenuator Pads




| TYPE No. | ATTENUATION | IMPEDANCE | CONNECTORS | REMARKS |
|---|---|---|---|---|
| **44425-501E**<br>TM 5573 | 20 dB | 50 Ω | BNC | Frequencies up to 500 MHz |
| **44425-002D**<br>TM 5573/1 | 6 dB | 50 Ω | BNC | |
| **54431-011D**<br>**54431-021B** | 20 dB<br>20 dB | 50 Ω<br>50 Ω | BNC<br>BNC | 1 W<br>20 W |

## Coaxial Fuses

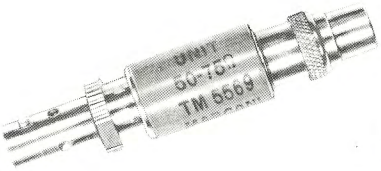
For use with Signal Generators, Modulation Meters, Counters, etc., to prevent damage to inputs or outputs.

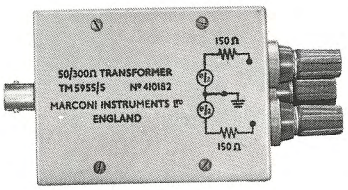


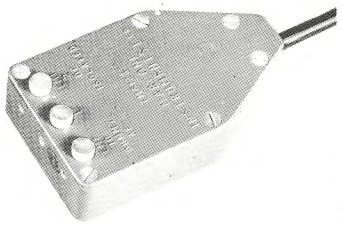

| TYPE No. | DESCRIPTION | REMARKS |
|---|---|---|
| **43281-001W**<br>TM 5753 | *Rating:* 0·4 W.<br>*Insertion loss:* Nominally 0·5 dB.<br>*VSWR:* Not greater than 1·35 at 400 MHz; not greater than 1·5 at 470 MHz, when terminated with a matched 50 Ω load.<br>*Connectors:* Type N.<br>*Fuse:* 1/16 Amp Littlefuse, Cat. No. 316.062 10 spares are provided. | For use with 50 Ω equipment |
| **43281-007C**<br>TM 9884 | *Rating:* 0·4 W.<br>*Insertion loss:* Less than 0·6 dB at 400 MHz. Less than 0·1 dB at 470 MHz.<br>*VSWR:* Not greater than 1·5 at 470 MHz, when terminated with a matched 50 Ω load.<br>*Connections:* Type BNC.<br>*Fuse:* 1/16 Amp Littlefuse, Cat. No. 316.062 10 spares are provided. | For use with 50 Ω equipment |

# Matching Units

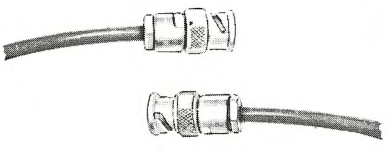
*Note: When using matching units with signal generators it is recommended that the matching unit is connected directly to the receiver under test (i.e. at the remote end of the coaxial cable connected to the signal generator).*



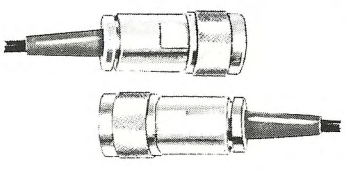



| TYPE No. | DESCRIPTION | REMARKS |
|---|---|---|
| **44411-001M**<br>TM 5569 | **50 Ω to 75 Ω Matching Pad.** Comprises a single 25 Ω series resistor to convert the 50 Ω source resistance to 75 Ω.<br>*Input connector:* BNC socket.<br>*Outer connector:* Belling Lee L734P plug. | For use up to 72 MHz |
| **44411-018F**<br>TM 6599 | Similar to TM 5569 but with Burndept type PR4E output plug. | For use up to 72 MHz |
| **44412-021C**<br>TM 5955/5 | **Matching Transformer.** 50 Ω unbalanced to 300 Ω balanced. Comprises toroidal auto-transformer.<br>*Input connector:* BNC socket.<br>*Output connector:* Miniature terminals. | For use up to 100 MHz |
| **54481-011C**<br>TM 5955 | **Matching Transformer.** 75 Ω to 150 Ω balanced.<br>*Input connector:* BNC.<br>*Output connector:* Miniature terminals. | For use from 12 kHz to 550 kHz |
| **44412-023B**<br>TM 6123 | **Composite Dummy Aerial and DC Isolating Unit.** Includes connecting cable with BNC plug; spring-clip output terminals. For general receiver testing or for use on circuits with d.c. potentials up to 350 V. | For use up to 72 MHz with 50 Ω signal generators |
| **44411-019G**<br>TM 5573/3 | **50 Ω to 75 Ω Matching Pad.** Matches 50 Ω generator to 75 Ω load. 6 dB insertion loss.<br>*Input connector:* BNC socket.<br>*Output connector:* BNC plug. | For use up to 100 MHz |
| **43535-009J**<br>TM 7120 | **Isolating Transformer.** Designed for use with bridges to isolate external sources.<br>*Connectors:* Spring terminals. | For use from 50 Hz to 50 kHz |
| **54422-011A** | 12 W, 50 Ω Termination.<br>BNC connector. | Non-radiating termination |
| **54452-011E** | **Signal Sniffer.** T connector for insertion between transmitter and load with small signal from T branch. | For use up to 1000 MHz |



# RF Connecting Cables



| TYPE No. | $R_0$ | LENGTH | CONNECTORS INPUT | CONNECTORS OUTPUT | REMARKS |
|---|---|---|---|---|---|
| **43126-012S**<br>TM 4969/3 | 50 Ω | 1524 mm | BNC Plug | BNC Plug | Frequencies up to 500 MHz |
| **43126-026A**<br>TM 4726/286 | 50 Ω | 457 mm | N Plug | N Plug | Solid coaxial lead<br>For use up to 1 GHz |
| **54351-011F**<br>TM 4726/260 | 75 Ω | 1830 mm | BNC Plug | BNC Plug | Frequencies up to 500 MHz |

# Marconi Instruments' ATE/CAE – solving the daunting test problems of modern electronics manufacturing

For well over a decade, Marconi Instruments has lead the development of advanced automatic test equipment and related Computer Aided Engineering (CAE) systems. Its highly successful System 80 series of in-circuit testers has already made the company the largest manufacturer of such equipment in Europe – and this European success is now being matched by equal success in the USA and, more recently, Japan. In functional testing, too, Marconi Instruments also leads, in this case with its highly versatile Graduate System 8060, the commercial version of the well established Graduate series of high performance ATE originally developed for specialist defence applications. Now integrated into Marconi Instruments' standard ATE range, the System 8060 complements the System 80 series by offering a very advanced functional test capability that is especially effective in the real-time functional testing of high speed highly complex digital p.c.b.s.

As well as these advanced ATE systems from its standard range, Marconi Instruments also offers users with specialist requirements – whether in the commercial or military sectors – a complete ATE design and manufacturing service based on the specialist facilities of its Scottish-based ATE Projects Division. Associated with this specialist ATE division is the Marconi Instruments Trainers and Simulators Division*, which designs and manufactures a wide range of advanced computer-based operational trainers and simulators, also for both commercial and military applications.

To promote the efficient application of its ATE systems, Marconi Instruments also produces a range of related equipment that not only allows the provision of comprehensive test-support facilities in traditional ATE applications but also paves the way to the integration of the user's ATE into wider-ranging CAE systems for advanced 'factory of the future' applications. Typical of this ATE-associated equipment is Marconi Instruments' innovative Computer Aided Repair (CAR) system, an advanced productivity aid that bridges the gap between ATE and Computer Aided Manufacturing (CAM) by using the test-results output by the ATE to guide the actions of repair technicians engaged in repairing the tested p.c.b.s. Advanced CAE aids such as these allow the user to realise to the full the important productivity gains that the use of advanced ATE systems can provide.

As a result of this wide-ranging commitment to ATE/CAE, Marconi Instruments is now able to fulfill every user's ATE/CAE requirements – whether these are for a standalone test system to fit into an existing electronics production line or for a comprehensive automatic test and repair network to form part of a whole new 'factory of the future'. In any case, the user will benefit in particular both from the systems' ease of use – in terms of both ease of test set-up and ease of test operation – and from their high reliability, as evidenced in the System 80 series' unique 2-year warranty. In addition, each Marconi Instruments' ATE user has access to the company's unrivalled back-up and support services, ranging from detailed product training and full applications advice to the unique 'FixtureFast' rapid-turnaround fixture customisation service. Perhaps most of all, the user also has the assurance that, no matter how rapidly his ATE/CAE requirements grow, and no matter how rapidly the ATE/CAE technologies continue to develop, Marconi Instruments will go on offering the most cost-effective solution to all the testing problems of modern electronics manufacturing.

*See page 280 for more details.

marconi instruments

# Automatic Test Equipment


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**A complete range of high-performance ATE, plus comprehensive test-support and networking facilities, designed to cover between them all your present and future PCB-testing requirements.**

# IN-CIRCUIT TESTING

## System 80 series



Marconi Instruments' System 80 series is a complete range of advanced in-circuit automatic test systems and associated equipment that together represents the culmination of over 12 years experience gained as Europe's leading manufacturer of in-circuit test systems.

During these 12 years, in-circuit testing has developed from a pioneering new technique, regarding as suitable only for specialist high-volume or high-value applications, to become a completely accepted and indeed practically indispensable part of every modern electronics manufacturing operation. During this time, too, Marconi Instruments' in-circuit ATE products have developed at an equally impressive rate, so that its current in-circuit ATE range, the System 80 series, now offers a complete range of high-performance ATE, plus comprehensive test-support and networking facilities, designed to cover between them all your present and future PCB-testing requirements.

### Overview

The System 80 series currently includes 3 fully compatible automatic test systems – System 80, System 80X and System 80R – backed up by a wide range of associated and ancilliary equipment, including an advanced distributed processing test-support facility, the Multiterminal Workstation. All models in the series use Marconi Instruments' sophisticated INCITE test programming system, and are consequently fully software compatible, and all use the well proven Fixture 80/80X test fixtures, which provide full upwards compatibility throughout the range. By selecting the appropriate models and options within the System 80 series, the user can configure a high-performance test system directly tailored to his needs – from a basic 128 test points up to the very high maximum of 2048; with a choice of analog only testing, digital only, enhanced synchronous digital, or fully universal analog/digital; with either single or dual fixturing; with either floppy disk or Winchester disk storage; with either integral programming facilities or independent programming stations; and for either conventional manual or fully automatic ('robot') operation. In addition, the user may operate the System 80 series testers as standalone systems; or in conjunction with the Multiterminal Workstation to support program preparation and distribution, results analysis and computer-aided p.c.b. repair; or, again via the Multiuser Workstation System, as fully integrated components of complete user-defined computing networks and automated production facilities. The System 80 series covers all in-circuit testing needs.

### Capabilities

All System 80 series test systems provide for the complete in-circuit testing of analog, digital and hybrid analog/digital p.c.b.s up to the highest board densities. With their high testing speed, they rapidly and reliably detect p.c.b. assembly defects such as solder bridges, dry joints, and damaged and incorrectly mounted components, as well as carrying out detailed tests on all components on the board, including passives, discretes, analog ICs and digital ICs up to VLSI levels of complexity.

### Ease of use

System 80 series test systems are all designed specifically for ease of use. This includes not only ease of test operation, ensuring that the test system fits into the user's production flow as smoothly as possible so as to achieve maximum throughput, but also ease of test set up in terms of both fixturing and programming, ensuring that test overheads are kept to a minimum. Ease of test operation is supported by System 80 series features such as ergonomic design and simple push-button operator controls. Ease of test set-up is achieved through System 80 series features such as the specially designed Fixture 80/80X range of easily assembled and economical test fixtures and through the use of Marconi Instruments' sophisticated test programming system, INCITE.

### Ease of Integration

System 80 series test systems are also designed for ease of integration with other modern electronics production equipment, allowing them to play their full part in the kind of integrated Computer Aided Engineering (CAE) /Computer Aided Design Manufacture and Test (CADMAT) facilities that are now being developed, and which will become increasingly important in the future. Integration of System 80 series test equipment into such CAE/CADMAT facilities is supported by a number of hardware and software features already incorporated into the System 80 series design approach and due to be increasingly exploited as the drive towards fully integrated CAE/CADMAT systems develops.

The power of these System 80 series CAE/CADMAT features can already be seen in the capabilities of the unique Marconi Instruments' Computer Aided Repair (CAR) terminal system, an advanced productivity aid that bridges the gap between automatic testing and the computer aided manufacturing (CAM) of p.c.bs. Similarly, the gap between automatic testing and computer aided design (CAD) is bridged by fully software supported links between System 80 series testers and widely used CAD systems. In terms of hardware interconnections these CAD and CAM links are supported by the facilities of the System 80 series Multiterminal Workstation, an advanced distributed-processing terminal system that not only allows programming of System 80 series test systems simultaneously with their test operations, but also provides a wide range of other test-support and CAE/CADMAT facilities. Fully utilised, the Multiterminal Workstation can act as a complete test node in a complete 'Factory of the Future' CAE network, which, if the pioneering System 80R model tester is used in conjunction with automatic board-handling equipment, may even provide for completely unmanned board assembly and test.

### Reliability

Whether used alone or integrated with other equipment, automatic test systems must achieve very high levels of reliability in order to support continuous production-line work flows. System 80 series test systems offer extremely high levels of reliability as a result of both their intrinsically high-reliability design and their comprehensive built-in self checking facilities that monitor all aspects of their operation. In addition, when occasional failures do, as is inevitable, occur, downtime is kept to a minimum as a result of the highly serviceable modular design, which allows straightforward field replacement of failed modules for subsequent factory repair. So reliable have System 80 series test systems already proved in actual use that Marconi Instruments is now able to offer a warranty period of no less than 2 years, a remarkable bonus for users of a system that has been found in practice to offer user pay-back periods of as little as 6 months.

## System 80 series

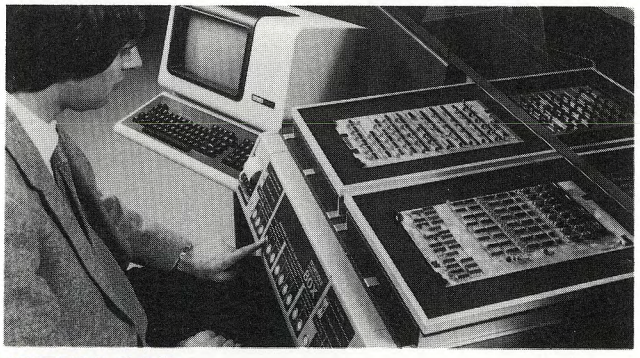
Currently the System 80 series includes three advanced automatic test systems and the Multiterminal Workstation range:–

### SYSTEM 80 –

the well-proven original model in the System 80 series, featuring a practical yet attractive desk-top styling and providing optimum test facilities for boards requiring up to 640 test points.

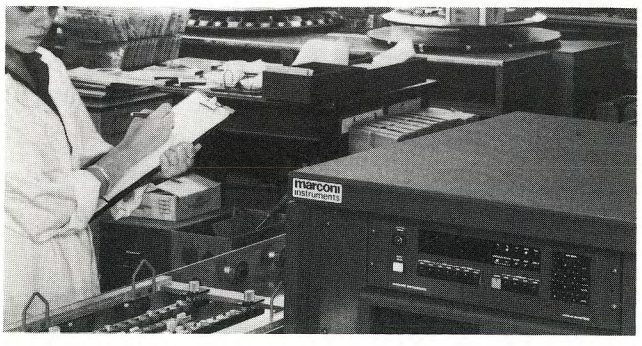
### SYSTEM 80X –

a new model at the top of the System 80 series offering greatly increased test-point capacity for boards with up to 2048 test points, and featuring a unique approach to dual fixturing that enables optimum use to be made of this exceptionally high test capacity.



### SYSTEM 80R –

a pioneering new System 80 series model specifically designed for straightforward and cost-effective integration into highly automated high-volume automatic manufacturing facilities, particularly those using automatic manipulation ('robot') equipment for handling pcbs.



### MULTITERMINAL WORKSTATION –

a range of advanced distributed processing terminal systems providing a wide variety of test-support and CAE/CADMAT networking facilities. Terminals supported by a Multiuser Workstation System may be used for test programming (simultaneously with test operation), for computer aided repair (CAR) of tested boards, and for user-defined functions (e.g. statistical analysis, production control etc.).

Also included within the System 80 series are:–

### Synchronous Logic Tester (SLT) –

a new add-on enhancement for System 80 and System 80X test systems, supporting even more effective testing of complex digital ICs by offering parallel stimulus and advanced timing capabilities in conjunction with unique 'on-the-fly' high-speed program branching.

### Programmer's Terminals –

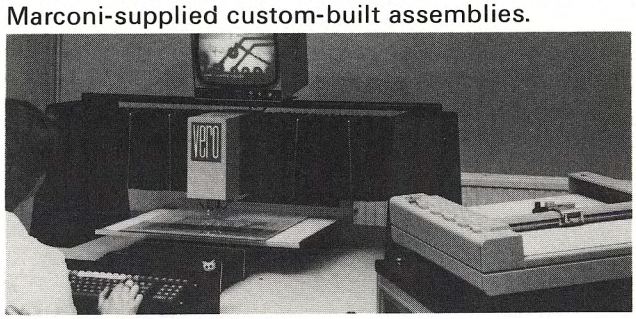
for attachment to a Multiterminal Workstation, providing complete hardware and software facilities (including local disk storage and printing where required) for the efficient development of System 80 series test programs completely independently of the test systems themselves.

### Computer Aided Repair (CAR) Terminals –

also for attachment to a Multiterminal Workstation, these advanced productivity aids greatly simplify the physical location and repair of board faults – both in components and tracking – previously detected by System 80 series or other test systems. Using a CAR terminal, the repair technician works directly from a colour-graphics image of the particular board, on which all the detected faults are made instantly locatable by the use of strongly contrasting colours.

### Fixture 80/80X –

a range of economical and easily assembled 'bed of nails' test fixtures for use with System 80 series test systems, offering versatile and highly reliable fixturing based on either user-assembled kits of parts or Marconi-supplied custom-built assemblies.



### Fixture Fast Service

a unique fast-turnaround fixturing service employing the most advanced computer-aided design and manufacturing facilities and offering extremely rapid and economical assembly of fully customised System 80 series test fixtures, with despatch usually being within 14 days of receipt of order.

# System 80 series – range features

- ☐ **Fast and comprehensive in-circuit testing of boards with up to 2048 test points.**
- ☐ **Full testing of:– connectivity, passive components, discretes, analog ICs, and digital ICs from SSI to VLSI.**
- ☐ **Optional enhanced high-speed synchronous testing for LSI/VLSI.**
- ☐ **Fault location to component level with results logging, statistics generation etc.**
- ☐ **Fast, easy programming and operation using well proven System 80 series software systems, including the advanced INCITE language.**
- ☐ **Simultaneous programming and testing, and comprehensive test-support and networking facilities, supported by distributed-processing Multiterminal Workstation.**
- ☐ **Reliable low cost fixturing – available in kit form or ready assembled via fast-turnaround Fixturefast service.**
- ☐ **Dual fixturing for high throughput – available on all models either as standard or option.**
- ☐ **Range includes models optimised for both traditional manual production facilities and automated production using automatic board handling.**
- ☐ **Manual operation supported by ergonomically designed operator positions for simple operation.**
- ☐ **GPIB Interface for add-on functional testing.**
- ☐ **Highly reliable, with full self-check facilties.**
- ☐ **Extended 2-year warranty.**

## Test capabilities

All System 80 series test systems carry out rapid and detailed testing of p.c.bs contacted by a bed-of-nails fixture. Each component, track and wiring link on the p.c.b. can be subjected to a full range of tests, including:–

***connectivity***
high speed connectivity testing detects solder shorts, broken tracks, missing wiring links etc.

***passive components***
full impedance testing of all passive components, using 2, 3 or 4 – terminal measurements as required.

***discretes, analog ICs***
full testing to establish correct location, orientation, functioning etc.

***digital ICs***
full node-forcing testing at burst-mode speeds for all TTL and CMOS devices up to VLSI levels of complexity, with special facilities for tristate outputs and ROM/PROM checking.

In addition, the optional Synchronous Logic Tester (SLT) add-on provides for enhanced high-speed synchronous testing of LSI and VLSI devices.

Also, in situations where additional functional testing and/or adjustments are required, a built-in GPIB interface and associated software functions support the use of customer-specified instruments.

### Test Capacities

All System 80 series test systems have a test capacity expandable from a basic 128 test points up to a maximum of 640 for System 80, a maximum of 768 for the System 80R, and a greatly expanded total of 248 for System 80X. Each test point may be connected to an analog switch channel or to a digital swich channel or to both, providing for analog only, digital only or combined analog/digital testing at that particular test point.

### Dual Fixturing

In situations where board-handling times become significant, optimum use of a system's test capacity can be promoted by dual fixturing, allowing one board to be loaded/unloaded at one test fixture while a second board is being actively tested at the other fixture. For System 80, dual fixturing is optional and is provided by means of an additional plug-in fixture unit. For System 80X, dual fixturing is standard, with two complete operator stations – including full operator controls and independent output printers – being located side-by-side on the convenient working surface. To make optimum use of System 80X's greatly expanded test capacity, these two operator stations can be simply switch selected to run either independently, allowing for simultaneous testing of two boards each with up to 1024 test points, or in special combined mode, providing a single extra-high-capacity test facility for boards requiring up to the full 2048 test points.

### Test Results

All System 80 series test systems produce detailed test results for each board tested, diagnosing, right down to component level, all faults discovered during the test. Test results are directly printed out on a 'fault ticket' produced by a printer located immediately next to the operator controls. Results may also be logged on the system's disk store for subsequent analysis, either by using the system's own computer or by using the facilities of the Multiterminal Workstation, allowing a wide range of production reports and reliability statistics to be compiled. By adding user-specified functions to the software of the Multiterminal Workstation, or by downloading to other linked computers, fault statistics and even complete production-control data may be produced.

In addition, test results can also be transmitted from System 80 series test systems to the Multiterminal Workstation for display on Computer Aided Repair (CAR) Terminals. These innovative new productivity aids allow even simpler location and repair of faulty components by presenting the repair technicians with detailed colour graphics images of the boards under repair, with the actual physical positions of all the previously identified faults being precisely located by means of instantly recognisable contrasting colours.

### Ease of use

All models in the System 80 series are designed to offer maximum ease of use, in terms of both test operation and test set-up.

Ease of test operation is ensured by careful attention to physical layout and the design of control functions. In terms of physical layout, System 80 uses a desk-like styling with equipment cabinets located under the working surface, while System 80X is based on a high-capacity upright system cabinet with a projecting-shelf working surface. Both these layouts provide ample working surface area and ergonomically designed operator positions so as to streamline workflow. As an alternative, for situations where the user wishes to build the test system directly into his automated production-line installation, System 80R employs a simple and rugged equipment cabinet that can readily be integrated into almost any highly automated production facility.

In terms of design of control functions, all System 80 series models provide three different sets of controls for three different modes of use – routine test operation, system set-up and supervision, and interactive program development. Dividing up the overall control functions in this way promotes maximum flexibility of use while keeping each separate set of controls as simple as possible. This is particularly important for routine test operation, where using the simplest possible form of operator control ensures fast and efficient handling of even the highest test throughputs.

The three sets of controls provided on each System 80 series test system are:–

**TEST OPERATION –**
basic operator controls providing simple push-button 'start/stop/continue' operation.

**SUPERVISORY OPERATION –**
separate supervisory console with both duplicate

operator controls and additional control functions (including keypad and alphanumeric display) for system set-up and supervision.

**PROGRAMMING –**
separate v.d.u. – based interactive programming facilities using the INCITE high level programming language and associated PPP program preparation package.

As well as the on-line programming facilities provided with each System 80 series test system, System 80 series Programmer's Terminals, linked to a Multiterminal Workstation, also support simultaneous programming and testing. Based on an advanced distributed-processing approach, the use of separate Programmer's Terminals not only keeps the test system fully available for production testing but also imposes no additional processing load on the test system's computer.

## Ease of programming

Whether programmed directly, via their own on-line programming facilities, or indirectly, via Programmer's Terminals linked to a Multiterminal Workstation, all System 80 series test systems make use of Marconi Instruments' well-proven INCITE software system, which is based on the INCITE programming language, a sophisticated high-level language directly geared to the needs of in-circuit testing. The ease of INCITE programming contributes significantly to the ease of test set-up and low test overheads provided by all the System 80 series test systems.

Using INCITE, the System 80 series programmer simply inputs to the system what is effectively a list of components on the board, identifying their type, position and interconnections. This information will certainly be obtainable directly from standard design documentation, and where Computer Aided Design (CAD) facilities have been used to design the board, may be fed directly from the CAD system to the test system via software running on the Multiuser Workstation System. Given this information, the INCITE software system then consults its library of device models to determine the tests required for each component and automatically incorporates them into the finished test program.

As a semi-compiled language, INCITE provides the programmer with the best of both worlds – the efficiency of program execution associated with compiled code and the ease of program preparation and modification associated with interpreted languages.

The INCITE software system provides a complete programmer interface, avoiding the need for the programmer to work in any other language or with any lower-level form of code. As well as the language-handling software itself, the system also includes a number of their software utilities to further ease the programming task. Notable among these utilities are the INCITE Program Preparation Package (PPP), which provides comprehensive menu-driven facilities for the interactive entry and modification of complete test programs, and INCITE Autoguard, which automatically augments the basic INCITE test programs to provide for the electrical guarding of components and for other important test-support functions.

Enhancements to the INCITE software system are continually being developed in order to add new and improved test facilities to the System 80 series.

## Fixturing

The ease of test set-up on System 80 series test systems is also promoted by the ease of fixturing provided by the specially designed Fixture 80/80X range of fixtures. As well as being easily assembled and highly economical, these fixtures are also highly reliable in practice – an important point because, like all in-circuit test systems, those in the System 80 series ultimately rely for their successful operation on the quality of the electrical contact achieved between the test fixture and the board under test. With this in mind, not only has the Fixture 80/80X range been specifically designed for reliability, but the System 80 series test systems themselves have been specifically designed to include both hardware and software facilities for carefully monitoring the quality of the contacts achieved in practice.

Fixture 80/80X test fixtures are used on all test systems in the System 80 series:– for use with System 80, the original Fixture 80 units provide up to 640 test points; while for use with the much higher capacity System 80X, the new Fixture 80X units provide up to 2048 test points. Existing Fixture 80 test fixtures can also be used directly on System 80X test systems by means of an optionally available adaptor.

All Fixture 80/80X range test fixtures are high quality versatile units that can be adapted to accommodate virtually any board size and shape. They can be readily configured by the user from the easily assembled kits of parts supplied, but in practice many users will prefer instead to take advantage of Marconi Instruments' fast-turnaround FixtureFast service, which offers a rapid and extremely economical fixture assembly service using highly automated in-house facilities. The highly automated nature of the FixtureFast service normally allows fully customised fixtures to be despatched within only 14 days of receipt of order.

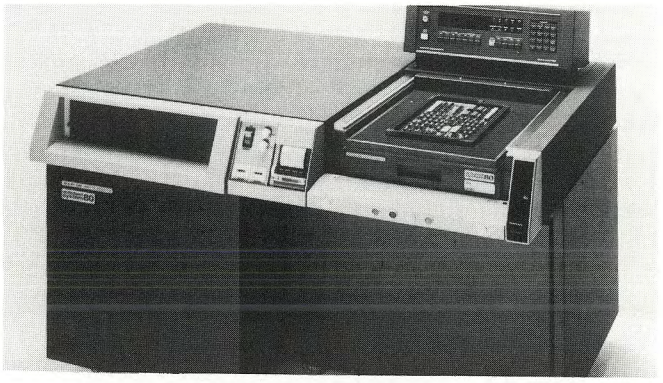
The high reliability of the Fixture 80/80X range test fixtures is backed up in practice by the built-in facilities provided on each System 80 series test system to monitor the quality of the contacts actually achieved. These facilities carefully scrutinise all the contacts between the test fixture and the board under test, producing a warning output whenever a suspect contact is detected. Extended contact analysis can also be carried out before each separate test run, and a special hand-held BUGPROBE attachment can be used to enable the operator to confirm the quality of test contacts under program control.

Special facilities are also provided to aid contact analysis during programming and fixture assembly.

*Individual model details*

## System 80

- ☐ **Optimum test facilities for boards with up to 640 test points.**
- ☐ **Compact desk-like layout.**
- ☐ **Dual fixturing option for high throughputs.**
- ☐ **Built-in facilities support optional pneumatic operation.**



The original model in the System 80 series, System 80 has already achieved widespread market acceptance and proved highly effective and reliable in practice. With a test capacity of up to 640 test points, System 80 provides optimum test facilities for users with boards in the intermediate size range, with the benefit of also providing a clear upgrade path via the higher capacity but fully upwards-compatible System 80X.

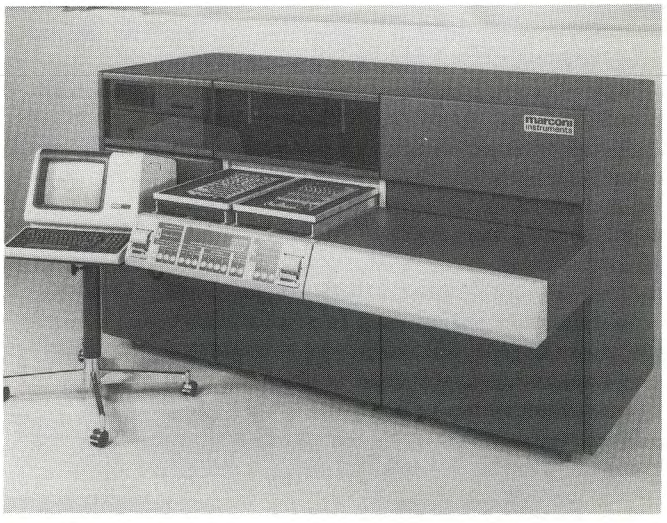
In its full configuration, System 80 uses the standard 7·5 MByte Winchester disk unit provided as standard on all System 80 range test systems. However, an entry-level configuration using twin floppy disks is also available for lower cost applications.

In terms of physical layout, System 80 employs compact desk-style units providing ample working surfaces and convenient operator access. The System 80 supervisor's console is an independent desk-top unit movable to any position, while the programmer's console is a matching desk-style unit fitted not only with v.d.u. and line printer but also with convenient copyholder and storage locker. Dual fixturing is supported by an add-on second test bay that is also contained in a matching desk-style unit.

As in all System 80 series test systems, vacuum actuation of test fixtures is standard. However, System 80 also provides built-in facilities to support the optional use of pneumatic actuation where this is preferred by the user. Even where vacuum actuation is used, the System 80 can optionally work directly off standard air lines as a result of its built-in venturi convertor.

## System 80X

- ☐ **Greatly expanded test capacity — up to 2048 test points.**
- ☐ **Unique dual-operation arrangement provides dual fixturing as standard.**
- ☐ **Dual operator stations usable either independently for high throughput or in combined mode for extra-high test capacity.**
- ☐ **Optimised signal conditioning for high-speed digital testing.**
- ☐ **Attractive new styling accommodates greatly expanded system hardware while retaining System 80 ergonomic design features.**



A recent addition at the top of the System 80 range, the new System 80X offers not only a greatly expanded test capacity of up to 2048 points, but also a unique approach to dual fixturing that enables optimum use to be made of this very high capacity. As a result, with System 80X – which provides a fully upwards-compatible growth path for users of System 80 – the new high test capacity is fully designed in, not just added on.

Included as standard on System 80X are two complete operator stations, located side-by-side on the spacious working surface. For use in testing extra-large boards that demand over 1024 test points each, the two operator stations can be simply switch selected to operate in a combined mode in which they share a single double-sized test fixture that will accommodate boards requiring up to the very high total of 2048 test points. Alternatively, for use with boards each requiring no more than the still very substantial total of 1024 test points, the two operator stations can be simply switch selected to operate independently in a dual mode, in which each uses a single-sized test fixture to accommodate its own board, which can then be tested com-

pletely independently of the board accommodated on the other test fixture.

As a result of this uniquely versatile arrangement, users are able to simply and rapidly switch between two ways of using System 80X's greatly expanded capacity – using the combined mode when the requirement is for testing extra large boards, and using the dual mode when the requirement is for the high throughput testing of more conventionally sized boards.

To support this built-in dual fixturing facility, each operator station on the System 80X has not only its own complete set of operator controls but also its own fault-ticket printer, so that truly independent operation is achieved while imposing no additional complications on the operator. Inside the system, too, complete independence is maintained between co-resident test programs without the need for any special programming techniques – system software automatically interleaves test programs as required and can switch instantly between different programs simply by making use of memory remapping. The system software also automatically remaps test point addresses within programs to allow them to be switched transparently so as to operate with either operator station, as desired.

As a result of these special design features, the greatly expanded test capacity of System 80X is supported with no reduction in flexibility of operation – and also with no reduction in either operating speed or system reliability, which have been maintained by design features such as using memory-backed driver/sensors for all digital test points, avoiding the many disadvantages of signal multiplexing, and also carefully ensuring the high transmission quality of all signal paths.

The greatly expanded test capacity of System 80X, with all the additional test hardware required, has also been accommodated without sacrificing the proven ergonomic advantages of the orginal System 80 styling. In System 80X, all the test hardware is contained in a single high-capacity low-profile system cabinet fitted with a large projecting-shelf working surface that duplicates the ample work-surface area provided by the System 80's desk-like styling. As on System 80, the System 80X operator controls are ergonomically positioned in order to streamline work flow, and separate supervisory controls and programming terminals are provided to support simple but effective operation in any of the three operating modes – routine test operation, system set-up and supervision and interactive program development.

All the additional features of System 80X have been provided while retaining full upwards compatability from the System 80, using the same well proven INCITE software and accommodating the same Fixture 80 test fixtures (via an optionally supplied adaptor) for boards with up to System 80 limit of 640 test points. For boards requiring up to the full 2048 test points available on the System 80X, the new Fixture 80X range of test fixtures provides the same well proven economy and reliability as the original Fixture 80 range.

## System 80R

- ☐ **Logically and physically optimised for integration into fully automated manufacturing facilities.**
- ☐ **Readily configurable to the user's specific requirements.**
- ☐ **Highly cost effective.**
- ☐ **Fully software compatible with other System 80 series models.**

In response to the rapidly growing interest in the use of advanced automation and CAE/CADMAT facilities for electronics manufacture, Marconi Instruments has introduced the System 80R. Fully compatible with both System 80 and System 80X, System 80R differs from them in being optimised not for manual operation as part of traditional manual production lines, but for fully automatic operation as part of advanced highly automated manufacturing facilities, particularly those using automatic manipulation ('robot') equipment for handling p.c.bs.

In terms of physical layout, this change of orientation has meant the replacement of the distinctly ergonomic and operator-oriented styling of the other System 80 series models by a new machine-oriented design based on a single vertical rack that can easily be built directly into the user's overall automation system.




In terms of system functions, the change of orientation has meant the slimming down of the full range of standalone operating and programming facilities offered on the other models so as to provide the user with just the functions he needs to configure the test system as a built-in component of a wider-ranging automatic installation.

The result of these changes is a very compact and readily configurable test system that is also optimally cost effective for use in automatic manufacturing. Used as a component of an overall automatic manufacturing facility, System 80R is typically located next to an automated board-handling line and connected to it by cable. Boards moving down the line are placed on the test fixture, built into the line itself, by an automatic board handler, and the line's controlling computer then triggers the System 80R to begin testing. After testing,

the test results obtained are then passed from the System 80R to subsequent stages of the production process, which is optimally based on System 80 series Computer Aidered Repair (CAR) Terminals. An overall installation may well contain several System 80R testers and a number of CAR Terminals, all linked together through the facilities of a Multiterminal Workstation.

Although specifically designed for use as part of highly integrated high-volume automatic production facilities of this type, the System 80R also provides an extremely cost-effective solution to certain other specialised testing requirements. In particular the 'slimmed down' nature of System 80R design can provide specialist low-volume users (e.g. those engaged in prototype or small-batch production) with all the features of a high-performance automatic test system at an attractively low cost. To support this type of low-cost application, System 80R is optionally available fitted with a dual floppy-disk unit in place of the Winchester storage unit that is standard on all System 80 series models.

## Synchronous Logic Tester (SLT)

- ☐ **More effective yet easier programmed high-speed testing of LSI/VLSI digital devices.**
- ☐ **Tests wide range of logic families, including ECL.**
- ☐ **Unique distributed-memory architecture provides advanced test capabilites including fully synchronous operation and high speed 'on the fly' program branching.**
- ☐ **Removes need for the special 'fixture circuitry' often required to support high-speed LSI/VLSI testing using other approaches.**
- ☐ **Fits to either System 80 or System 80X.**
- ☐ **Directly supported by extensions to INCITE and PPP test programming software.**

An optional modular enhancement to the System 80 or System 80X, the Synchronous Logic Tester (SLT) extends the already comprehensive digital test capabilities of these systems to provide even greater fault coverage for complex LSI/VLSI devices, as well as making test generation for such devices easier than ever before.

With its sophisticated distributed-memory architecture, the SLT adds a range of advanced stimulus and measurement capabilities to up to 128 of the host system's test points. These advanced capabilities include the ability of the test logic at each pin to loop and branch within a test pattern sequence stored in a local 4 kbit memory, thus allowing complex 'on the fly' program branching and subroutining according to the test results obtained at the individual pin. This sophisticated hardware, supported by equally advanced system software, results in unmatched flexibility in the setting up and execution of intricate test sequences for modern highly complex LSI/VLSI devices.

Another important feature of the SLT is its ability to synchronise its stimulus and measurement operations with a device's own free-running clock, or alternatively to drive the device at up to 16 MHz in full synchronisation with the test system. Supporting this high-speed synchronous testing capability, and adding high precision to all the SLT's operations, is the unit's ability to selectively and precisely program stimulus-pulse edges and measurement strobes to the high accuracy of 62·5 ns. As well as this high timing accuracy, the SLT's specially designed output circuitry also offers precisely controlled slewing rates over an especially extended range of output voltages, enabling it to support, among other extended test facilities, the testing of a wider range of logic families, including ECL.

The advanced test facilities of the SLT hardware are fully supported by associated enhancements to the INCITE test language and PPP program preparation package. Among the enhancements to PPP are facilities to support a special SLT library of device modules that allows the straightforward generation of efficient test code for even highly complex software-reconfigurable LSI/VLSI devices. Included in the enhancements to INCITE are new facilities to simplify the testing of bus-controlled devices and associated circuitry. These software enhancements directly support the programming and operation of the SLT as an integral part of the host test system, and maintain the ease of programming and efficiency of test operation associated with the System 80 series as a whole.

## Multiterminal Workstation

To provide System 80 series users with fully networked access to a wide range of programming, test-support and CAE/CADMAT facilities, Marconi Instruments has developed the Multiterminal Workstation range. Through an advanced distributed-processing architecture, the Multiterminal Workstation provides the user with an expandable network of multi-function terminals which access a wide range of both standard and user-defined support facilities, while reserving the full power of the System 80 series test systems for uncompromised test efficiency.

To exploit the facilities of the Multiterminal Workstation, the user first of all connects the central unit of the workstation system to each of his System 80 series test systems, and then builds up the exact test-support system he requires by adding the appropriate workstation terminals to the network thus formed. To provide additional programming facilities, for example, the user will add the required number of Programmer's Terminals, convenient v.d.u.-based workstations with optional

local floppy disk storage and output printers, the use of which allows test programming to proceed simultaneously with production line testing and without in any way affecting the testers' throughput. Similarly, to provide for the efficient computer-aided repair of tested boards, the user will add the required number of Computer Aided Repair (CAR) Terminals, which will greatly increase the productivity of the overall manufacturing process, again without imposing any additional load on the test systems themselves. Other support facilities, including results analysis, test management etc., and also those developed by the user himself, can be accessed through these and any other industry-standard type of terminal, providing the user with the freedom to configure his test-support network to exactly the specification he requires.

To provide this flexibility of configuration, Marconi Instruments has based the Multiterminal Workstation range on the industry-standard PDP-11/LSI-11 family of computers, as used internally in the System 80 series test systems themselves. To meet the exact requirements of users, Marconi Instruments also offers Multiterminal Workstation models ranging from a compact desktop unit typically supporting two terminals to a high-powered 'super-minicomputer' system capable of supporting large numbers of user terminals simultaneously. A common software suite covers the whole Multiterminal Workstation range, allowing users to move straightforwardly upwards from one model to another as their test-support requirements grow.

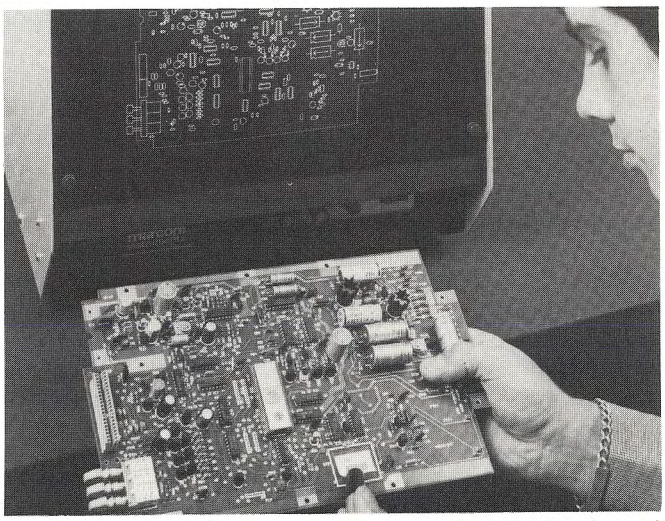
Within any given user's factory installation, System 80 series test systems and Multiterminal Workstation terminals can be located wherever the user finds it convenient. Moreover, the workstation system itself can be linked directly into other factory-floor systems, acting as the test-support node of the user's wider-ranging production control and automation system. With the Multiterminal Workstation as well as the unique Computer Aided Repair System and System 80R, the System 80 series is thus paving the way towards the complete integration of ATE into the comprehensively automated facilities of the coming 'Factory of the Future'.

## Programmer's Terminals

Connected to a Multiterminal Workstation, Programmer's Terminals support fully interactive test programming simultaneously with, and without in any way detracting from, the full-power operation of the System 80 series test systems. In addition, the Programmer's Terminals, which provide full workstation facilities optionally including local disc storage and printing facilities, also provide access to the other standard and user-specified support functions of the Multiterminal Workstation.

## Computer Aided Repair Terminals

- ☐ **Direct colour graphics display of board faults to simplify and speed repair process.**
- ☐ **On-line collection and real-time display of test data from any System 80 series or other test system.**
- ☐ **Optional bar code input of board numbers.**
- ☐ **Automatic identification of 'rogue' boards, persistent failures etc.**



An aid to the efficient repair of tested boards, Marconi Instruments' Computer Aided Repair (CAR) Terminals provide immediate visual identification of the actual physical positions of all faults detected on a given board as a result of its earlier testing by a System 80 series or other test system.

All System 80 series test systems produce detailed 'fault ticket' print-outs of test results that identify all faulty components and interconnections by means of user-defined designations – component number, track number etc. For repair technicians familiar with the board's layout, these fault tickets provide all the information required for the rapid location and repair of all faults on the boards. Where repair technicians are less familiar with the particular board layout, however, working from such a fault ticket can involve time consuming references to layout diagrams and other board documentation. There is also the problem of such fault tickets becoming detached from the boards to which they relate, and the general difficulty of integrating this form of fault reporting into the busy and increasingly automated manufacturing environments now found in industry.

Marconi Instruments' Computer Aided Repair (CAR) Terminals solve these problems by maintaining on-line links to the user's System 80 series test systems via a Multiterminal Workstation. As each board is tested, the test results are transferred to a special disk file on the Multiterminal Workstation for real time display. When the board is presented at a CAR terminal for repair, inputting the board's serial number results in the repair technician being presented with a full colour-graphics

image of the board on the CAR Terminal's colour monitor, with the actual physical positions of each fault—whether component or tracking – being clearly identified by instantly recognisable contrasting colours. The repair technician can then immediately locate the faults by sight and go on to repair the board with the minimum delay.

The CAR Terminal provides a number of special display facilities to even further simplify fault location and repair. Typical of these are the 'zoom' capability, for clear inspection of even the densest regions of the board, and the 'flipover' facility that allows tracks to be directly traced from one side of the board to the other.

Board serial numbers can be input into the CAR Terminal by means of the integral v.d.u., but increased efficiency can be achieved by using the optional bar code reader that can directly interpret standard bar code markings printed on the board.

The CAR Terminal also provides facilities for the automatic identification and flagging of 'rogue' boards—the inherently fault-prone boards produced by any manufacturing operation, which repeatedly fail retest even after careful repair. To detect such rogue boards, the CAR Terminal monitors all boards presented for repair after retest and immediately alerts the repair technician when presented with any board that has already been submitted for repair more than a preset number of times.

Using the logged data and real-time analysis functions of the the Multiterminal Workstation, the CAR Terminal can also offer full colour graphics display of fault distributions, production statistics etc. which can be provided in addition to the alpha-numeric statistics displays available at Programmers' Terminals connected to the Multiterminal Workstation.

## FixtureFast service

- ☐ **Fast-turnaround production of fully customised test features—despatch usually within 14 days of order.**
- ☐ **Economical and reliable fixtures for every application.**
- ☐ **Highly efficient automated plant.**
- ☐ **Kits for user assembly still available.**



Although the Fixture 80/80X range of test fixtures used by all System 80 test systems can readily be assembled by the user using the appropriate easily obtainable kit of parts, many users will prefer instead to have their fixtures assembled for them. Recognising this, Marconi Instruments has invested heavily in a special automated facility so as to be able to offer all System 80 range users an extremely fast, economical and reliable fixture assembly service.

Using the Marconi Instruments' FixtureFast service, the user submits a special order form containing details of the board to be tested, backed up by standard board-design data. Using a fully integrated Computer Aided Engineering (CAE) facility, the FixtureFast service then designs, assembles, and tests the required fixture to the highest engineering standards. The completed test fixtures are then despatched to the user, normally within only 14 days of receipt of order. This very rapid turnaround is coupled with the greatly reduced costs and increased reliability that also result from the high degree of automation used in the FixtureFast service.

# FUNCTIONAL TESTING

To complement its System 80 series of in-circuit test systems, Marconi Instruments offers the Graduate System 8060, an advanced functional test system forming part of the well established Graduate series of high performance ATE orginally developed for specialist defence applications. Now integrated into Marconi Instruments' standard ATE range, Graduate System 8060 is an extremely versatile functional test system that is especially effective for the real-time functional testing of high speed high complexity digital p.c.b.s.

### Graduate Capabilities

Graduate System 8060 has the full capability to functionally test digital, analog and hybrid (digital/analog) circuitry up to any level of complexity and at any level of system assembly – from p.c.b.s to fully integrated systems.

An extremely versatile ATE system, Graduate is itself assembled from a comprehensive range of test modules and system components, which are accommodated in a correspondingly modular physical layout based on the

Graduate kernel unit and one or more 19-inch racks. When required, the latter units can also accommodate user-specified test instruments, and a unique feature of the Graduate design allows such instruments to be fully integrated into the ATE's operation in a way that is completely transparent to the user.

## Graduate Digital Test Unit (DTU)

One especially important Graduate system component is the advanced Digital Test Unit (DTU). Among the many speical features of this high-performance digital test facility is its fully software-controlled variable architecture, which allows the Graduate user to implement any of the 3 basic digital test strategies:–

- Auto stimulus generation: pass/fail testing via 'pattern spraying' inputs and CRC signature checking.
- Circuit Simulation exercising: stimulus v. stored response comparison using simulator-generated responses.
- Functional exercising: stimulus v. stored response comparison using programmer-generated responses.

Because the architecture of the DTU is fully software controlled, the user can actually switch between these different test strategies within a single test program.

## Graduate Software

Through the unique Graduate software system, Climate, the full versatility of the Graduate test facilities can be exploited without the need for correspondingly advanced programming techniques. Indeed, Climate is specifically designed to allow engineers without traditional programming skills to produce complete test programs by responding to high-level menu-like screen formats, formats that simulate the operation of the conventional test equipment with which the engineer is naturally more familiar. Existing test programs written in conventional test programming languages can be straightforwardly accommodated via special interface facilities.

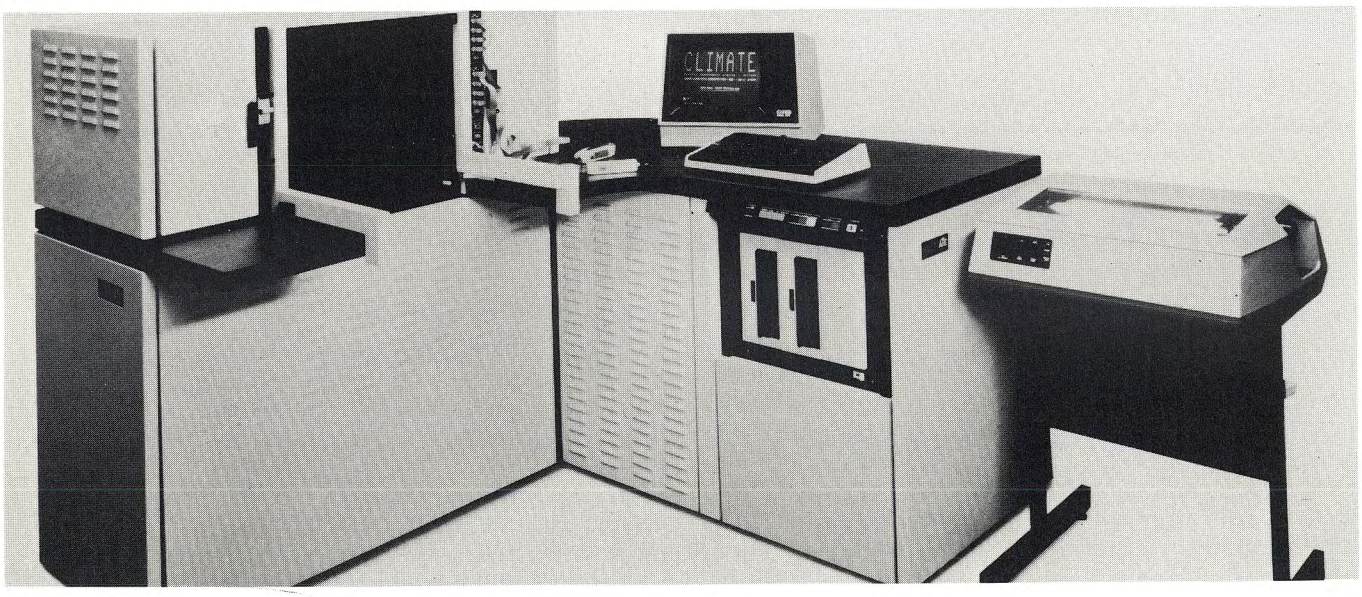
A separate program development workstation is also available for the optional development of test software away from the main test system.

## Graduate versatility

As a result of all these special facilities, Graduate System 8060 can be relied upon to meet the exact specification of almost any functional test requirement.

## Graduate features:–

- ☐ **High performance functional testing of digital, analog or hybrid (digital/analog) circuitry at any level of assembly from pcbs to fully integrated systems.**
- ☐ **Digital testing allowing flexible choice of 3 separate test strategies for high-speed (10 MHz) test execution.**
- ☐ **Analog testing fully integrated using standard Graduate modules or user-specified instruments transparently incorporated into the system's operation.**
- ☐ **Comprehensive fault diagnosis to component level without the need for complex probing.**
- ☐ **User-friendly software allows programming by existing engineering staff and minimises programming costs.**
- ☐ **Fully modular system architecture allows flexible future expansion.**
- ☐ **Comprehensive self-checking facility provides high-confidence test results.**
- ☐ **Full hardware/software support service proven by extensive military use.**



marconi instruments

# Microwave Products


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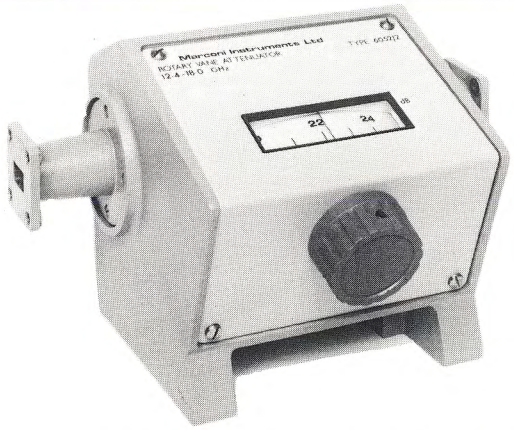
*Advance Data:*

| | | |
|---|---|---|
| Power Meter | 6950 | 252-253 |
| Power Sensor | 6910 | |
| Automatic Power Meter | 6960 | |

# Rotary Vane Attenuators

# 6052 series

- ☐ Frequency ranges up to 40 GHz
- ☐ Calibrated range 60 dB
- ☐ Low insertion loss
- ☐ Low phase shift
- ☐ Excellent resettability




The Type 6052 series of Rotary Vane Attenuators operate over a series of full waveguide bandwidths up to a maximum frequency of 40 GHz. Each instrument covers a range of attenuation from 0 to 60 dB and all units have a maximum insertion loss of 0·75 dB and VSWR better than 1·15:1.

The achievement of high attenuation accuracy combined with small overall size and light weight has been the result of using Tchebyscheff quarter-wavelength stepped transitions (Gaussian tapers on higher frequency models).

Considerable care has been taken to simplify the mechanical system such that high accuracy and a clear attenuation readout system is achieved. A directly calibrated attenuation scale consists of a self-reeling tape driven by a sprocket wheel on the main drive shaft. The gearing is arranged such that a 45 inch scale is fitted for the total attenuation range 0 to 60 dB. This offers a high order of setting accuracy and discrimination such that the attenuation may be reset to 0·02 dB at the 10 dB point.

The design of the Type 6052 series has been produced to give the best possible electrical performance so that insertion loss and VSWR are kept to a minimum. The phase-shift characteristics are such that the specification offered is 2° maximum.

These Rotary Vane Attenuators offer a sensibly flat attenuation response over the whole of each waveguide band for all values of attenuation setting which, coupled with the low phase-shift characteristics, make them ideal for use in swept frequency systems.

For applications where certification of the performance of these attenuators is required, calibration certificates can be supplied at a small extra cost.

| Type No. | 6052/1 | 6052/2 | 6052/3 |
|---|---|---|---|
| **RF PERFORMANCE** | | | |
| Frequency range | 26·5–40 GHz | 12·4–18·0 GHz | 8·2–12·4 GHz |
| Waveguide size | R320, WG22 | R140, WG18 | R100, WG16 |
| CW Power rating | 1 Watt | 5 Watts | 7 Watts |
| VSWR | 1·15 max | 1·15 max | 1·15 max |
| Insertion loss | 0·75 dB max | 0·75 dB max | 0·75 dB max |
| Phase shift | 2° max | 2° max | 2° max |
| **ATTENUATION CHARACTERISTICS** | | | |
| Calibration range | 0 to 60 dB | | |
| Absolute accuracy (% of reading) | 0 to 10 dB: ±0·1 dB<br>10 to 40 dB: ±1% | | 40 to 50 dB: ±2%<br>50 to 60 dB: ±3% |
| Scale increments | 0 to 0·1 dB: 0·01 dB<br>0·1 to 2·0 dB: 0·02 dB<br>2·0 to 10·0 dB: 0·1 dB<br>10·0 to 30·0 dB: 0·2 dB | | 30·0 to 40·0 dB: 0·5 dB<br>40·0 to 50·0 dB: 1·0 dB<br>50·0 to 60·0 dB: 2·0 dB |
| Resettability | 0·005 dB at 1 dB | | 0·02 dB at 10 dB |
| **TEMPERATURE RANGE** | 0 to 50°C | | |
| **FLANGE COMPATIBILITY** | Square Flange<br>Mates with UG 599/U | Square Flange<br>Mates with UG 419/U<br>and 5985–99–083–0030 | Square Flange<br>Mates with UG 39/U<br>and 5985–99–083–0052 |
| **MECHANICAL** | | | |
| Length | 190 mm, 7½ in | 206 mm, 8½ in | 270 mm, 10¾ in |
| Weight | 2·04 kg, 4 lb 8 oz | 2·04 kg, 4 lb 8 oz | 2·94 kg, 6 lb 8 oz |

# Solid State Signal Sources

# 6055 series




12840

- ☐ **850 MHz to 18 GHz**
- ☐ **Digital frequency readout**
- ☐ **1 kHz internal amplitude modulation**
- ☐ **External levelling capability**
- ☐ **Manual sweep facility**
- ☐ **Small size and low weight**

This range of all solid state microwave signal sources operates within the frequency range 850 MHz to 18 GHz. Two types of oscillators are used to achieve the wide frequency coverage. The 6055C and 6056B (850 MHz to 4 GHz), use a high frequency transistor oscillator while the 6057B/1, 6058B and the 6059A (4·0–18·0 GHz) use a Gunn diode operating in fundamental mode coaxial cavities.

RF power is adjusted by means of an electrically variable PIN diode attenuator. Internal facilities include CW operation and 1 kHz (or 3 kHz option) square wave modulation. There is also access to the PIN diode attenuator via a front panel mounted BNC socket. The excellent modulation sensivity of the PIN device enables a diverse range of amplitude modulation conditions to be achieved including r.f. levelling. This latter possibility coupled with the d.c. output voltage proportional to frequency, available on the rear panel, enables manual swept frequency measurements to be carried out. The 6587 levelling amplifier is fully compatible with all models.

A miniature ferrite isolator is fitted to all models above 2 GHz which minimises the effect of load variations and prevents damage being caused by external mismatches. Models below 2 GHz have built-in protection by means of the coupling factor between the cavity and the r.f. output probe.

Also included in the r.f. output line is a low pass filter to reduce the second harmonic component to a low level. In-band harmonics are minimised by ensuring that the cavity design excludes spurious modes of operation.

A mains selector switch enables the units to be operated from a 230 volt or 115 volt supply.

# 6055 series

## SPECIFICATIONS

| | TRANSISTOR FUNDAMENTAL OSCILLATORS | | GUNN FUNDAMENTAL OSCILLATORS | | | |
|---|---|---|---|---|---|---|
| **MODEL** | 6055C | 6056B | 6057B/1 | 6058B | 6058B/1 | 6059A |
| **FREQUENCY RANGE** | 850 to 2000 MHz | 2·0 to 4·0 GHz | 4·0 to 8·0 GHz | 8·0 to 12·5 GHz | 8·0 to 12·5 GHz | 12·0 to 18·0 GHz |
| **R.F. POWER OUTPUT** | | | | | | |
| Minimum | 20 mW | 10 mW | 5 mW | 20 mW | 10 mW | 5 mW |
| Typical | 50 mW | 30 mW | 10 mW | 40 mW | | 20 mW |
| **FREQUENCY ACCURACY AT 22 C AND MAXIMUM R.F. POWER** | ±1%[10] | ±1% | ±1% | ±1% | ±1%[9] | ±1% |
| **FREQUENCY PULLING** | Effect of[11] R.F. Level control of −15 dB 1·5 % | Effect of[1] V.S.W.R. of 3:1 0·1% at 2 GHz 0·05% at 3 GHz 0·1% at 4 GHz | Effect of[1] V.S.W.R. of 3:1 0·1% at 4·0 GHz 0·08% at 6·0 GHz 0·1% at 8·0 GHz | Effect of[1] V.S.W.R. of 3:1 0·09% at 8·0 GHz 0·06% at 10·0 GHz 0·09% at 12·0 GHz | Effect of[1] V.S.W.R. of 3:1 0·09% at 8·0 GHz 0·06% at 10·0 GHz 0·09% at 12·0 GHz | Effect of[1] V.S.W.R. of 3:1 0·2% at 12·0 GHz 0·1% at 15·0 GHz 0·2% at 18·0 GHz |
| **R.F. LEVEL CONTROL (Internal and External)** | 20 dB | 20 dB | 20 dB | 15 dB | 15 dB | 10 dB |
| **HARMONIC LEVEL** | | | | | | |
| Minimum | −17 dB | −20 dB[2] −30 dB[1] | −20 dB −30 dB[1] | −20 dB −30 dB[1] | −20 dB −30 dB[1] | −20 dB −30 dB[1] |
| **AMPLITUDE MODULATION** | | | | | | |
| Internal depth (1 kHz ±100 Hz min) | 20 dB | 20 dB | 20 dB | 15 dB | 15 dB | 10 dB |
| External Depth | 20 dB For 20 volts Input | 20 dB For 20 volts Input | 20 dB For 100 mA Input | 17 dB For 100 mA Input | 17 dB For 100 mA Input | 14 dB For 100 mA Input |
| Rise Time | <5 µsec | <5 µsec | <5 µsec | <5 µsec | <5 µsec | <5 µsec |
| **FREQUENCY STABILITY** | | | | | | |
| Typical[3] | | | | | | |
| Short Term[4] | 0·0015% | 0·0015% | 0·004% | 0·003% | 0·003% | 0·002% |
| Long Term[5] | 0·006% | 0·005% | 0·007% | 0·008% | 0·008% | 0·009% |
| With Temperature[6] | 0·006% | 0·006% | 0·007% | 0·006% | 0·006% | 0·007% |
| **With Line Voltage** | 0·001% per 10 volt change in the range 220 to 250 volts. | | | | | |
| **RESIDUAL FM** | 3 p.p.m.[8] | | 10 p.p.m. | | | |
| **OUTPUT LEVELLING USING AMPLIFIER TYPE 6587** | Within ±0·1 dB (Plus Coupler and Detector Variation) | | Within ±0·1 dB (Plus Coupler and Detector Variation) | | | |
| **OUTPUT CONNECTOR** | 'N' Type Female 50 Ω | | Precision Stainless Steel 'N' Type Female 50 Ω | | | |
| **POWER REQUIREMENTS** | 100–120 or 200–250 volts, 50–60 Hz, 12 VA | | 100–120[7] or 200–250 volts, 50–60 Hz, 20 VA | | | |
| **DIMENSIONS AND WEIGHT** | Height 98 mm 3⅞ in; Width 203 mm 8 in; Depth 298·5 mm 11¾ in; Weight 3·4 kg 8 lb | | Height 98 mm 3⅞ in; Width 203 mm 8 in; Depth 298·5 mm 11¾ in; Weight 4·0 kg 8¾ lb | | | |

1 Typical performance.
2 −15 dB below 2150 MHz.
3 After 1 hour warm-up in a constant environment.
4 Over a 5 minute period and with a settling time of 15 minutes, after the frequency change.
5 Over a 1 hour period.
6 Change per °C in the range +10°C to +50°%C.
7 Except 6057B/1 where lower limit is 110 V a.c.
8 Except for 6055C where maximum residual f.m. is 10 p.p.m. between 850 and 1000 MHz.
9 Overall ±2·5%. Calibrated at 8·5, 9·0, 9·5, 10·0, 10·5 GHz to ±1%.
10 Interpolated below 1000 MHz.
11 PIN modulator mismatch effect.



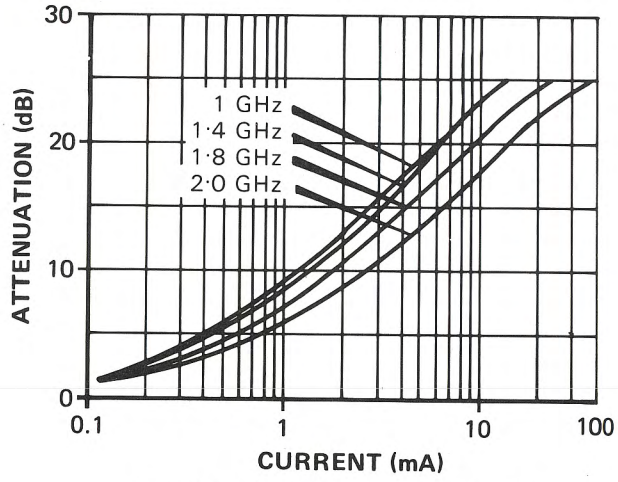

**REAR PANEL FACILITIES**
BNC connector providing output voltage directly proportional to frequency.
European type mains connector.
Battery connections. (See table opposite).
Mains voltage selector switch.
Fuse.

**BATTERY CONNECTIONS TO SIGNAL SOURCES**

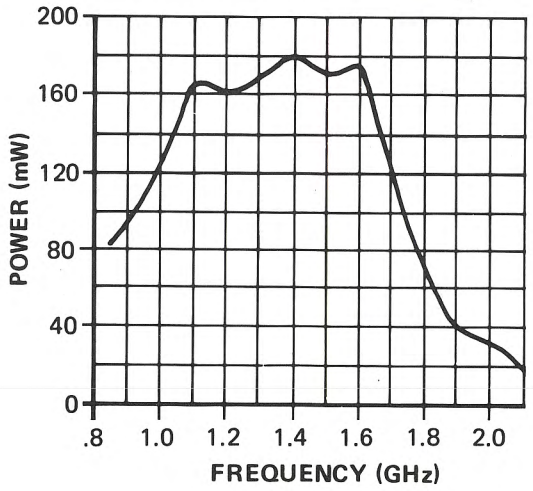
| Signal Source | Battery Voltages | Current Ratings | Suggested Battery Capacities | Socket Connections to Battery |
|---|---|---|---|---|
| **6055C** | 36 Volts | 150 mA | 36 Volts at 1·5 AH | +VE to E, −VE to D |
| **6056B** | 30 Volts and 22 Volts | 100 mA and 100 mA | 30 Volts at 1·0 AH and 22 Volts at 1·0 AH | +VE to A −VE to D and +VE to C −VE to H |
| **6057B/1 6058B 6059A 6058B/1** | 30 Volts and 22 Volts | 400 mA and 50 mA | 30 Volts at 4·0 AH and 22 Volts at 0·5 AH | +VE to A −VE to D and +VE to C −VE to H |

# PERFORMANCE CHARACTERISTICS

## 6055C

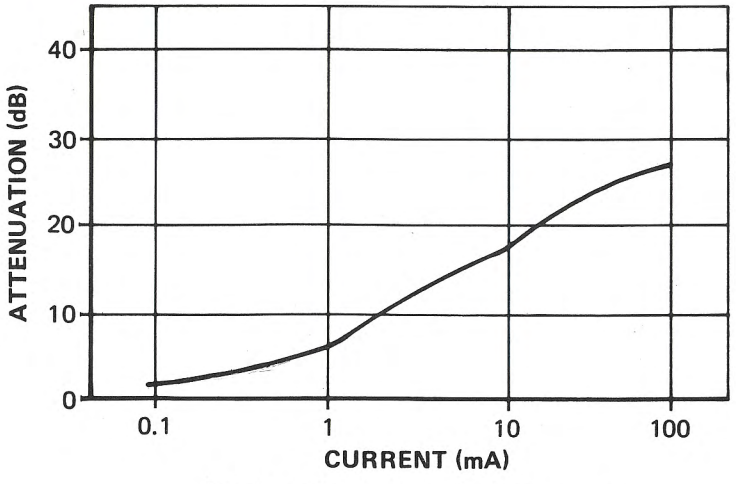



*Typical Modulator Performance*

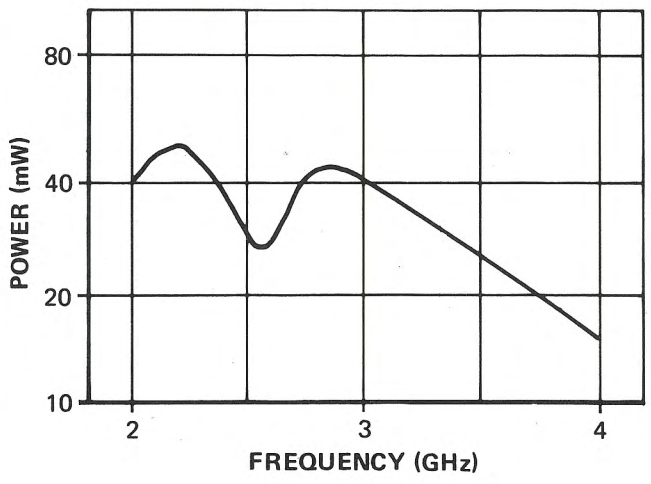



*Typical Power Output*

## 6056B

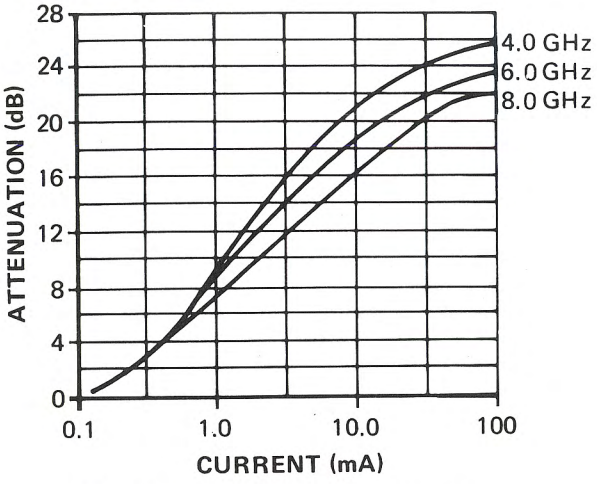



*Typical Modulator Performance*

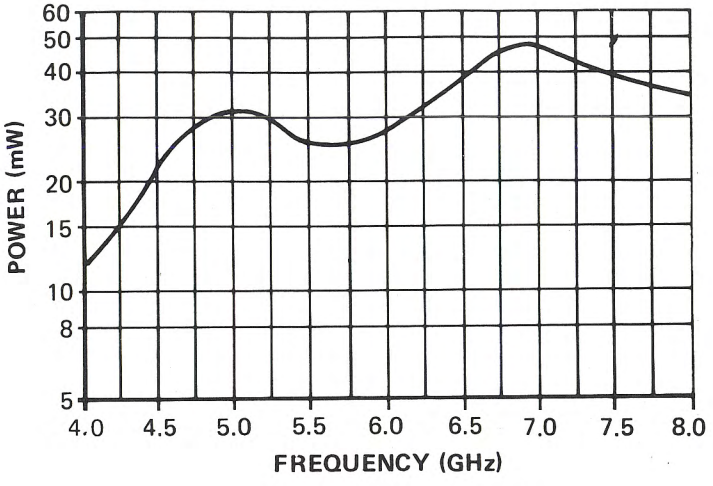



*Typical Power Output*

## 6057B/1

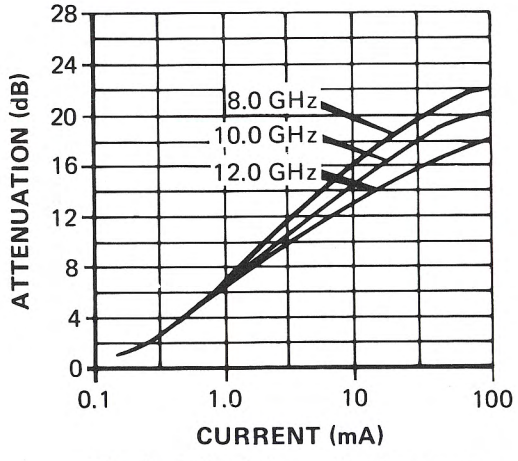



*Typical Modulator Performance*

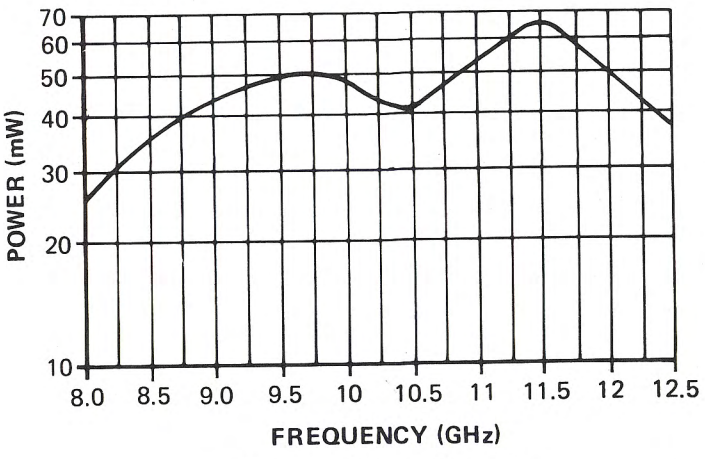



*Typical Power Output*

## 6058B

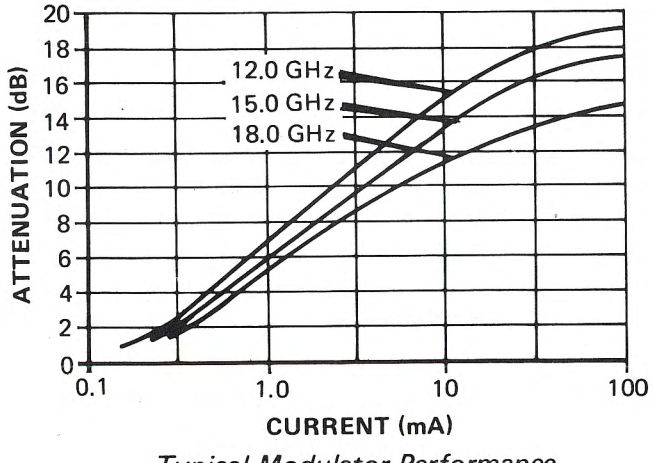



*Typical Modulator Performance*

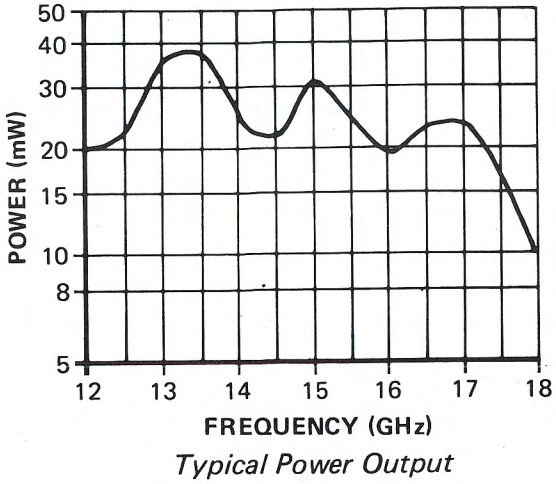



*Typical Power Output*

## 6059A

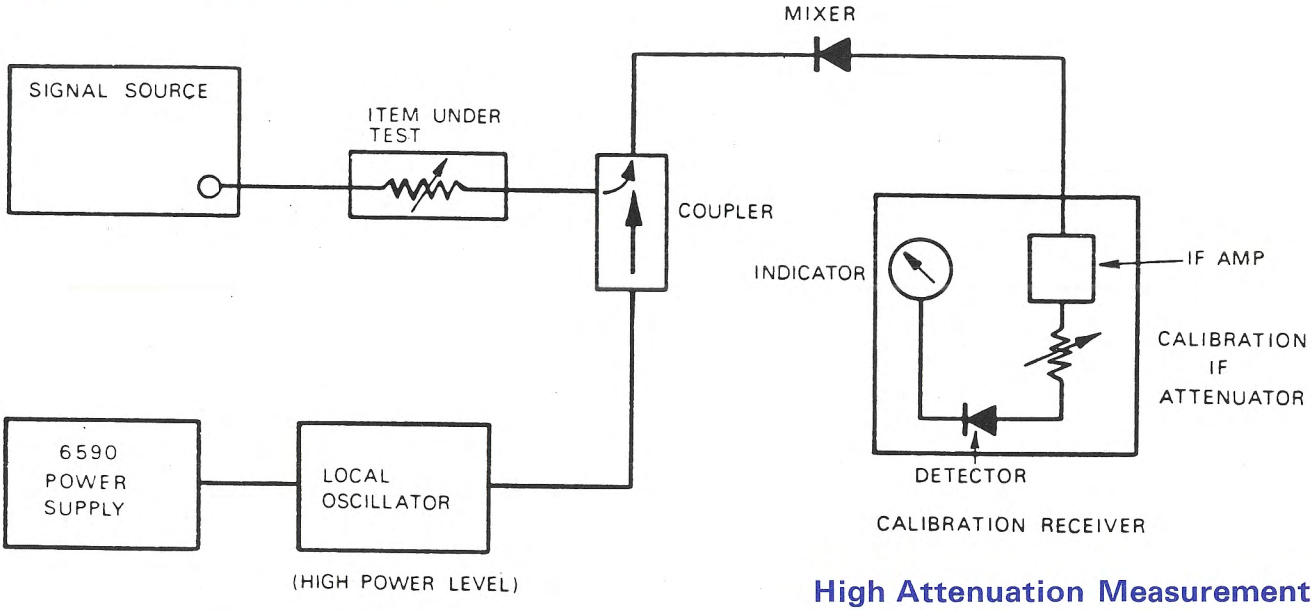



*Typical Modulator Performance*

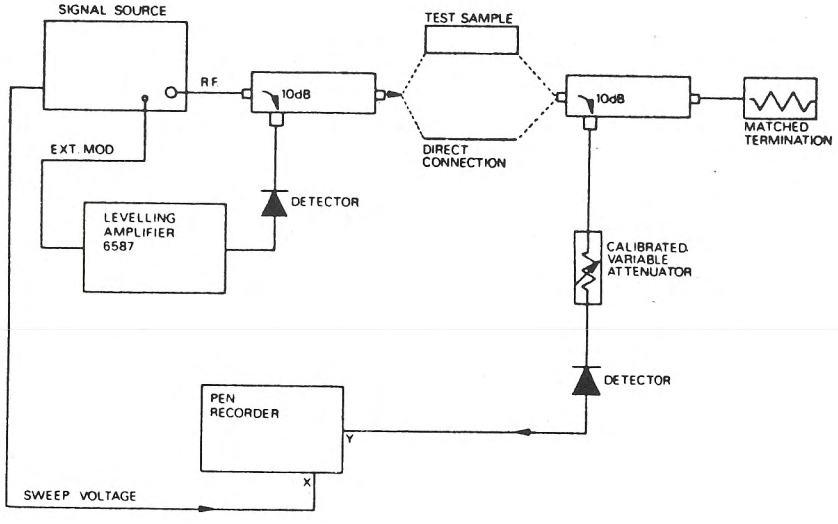



*Typical Power Output*

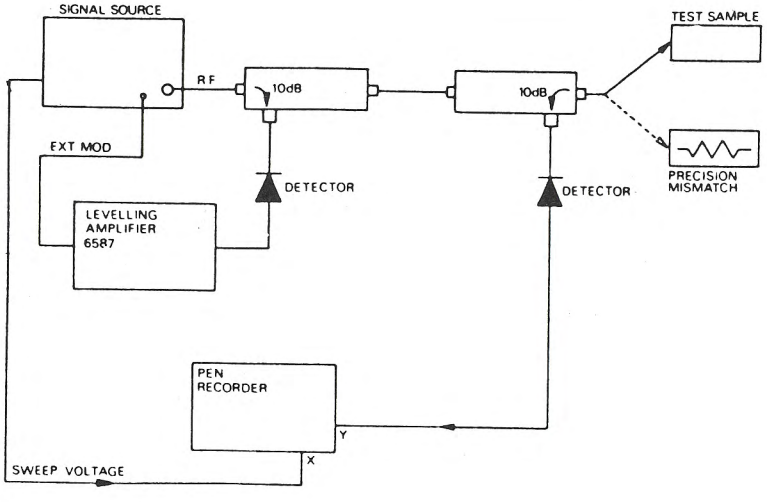
## Typical applications




High Attenuation Measurement




Transmission Loss Measurements




VSWR Measurements

# GPIB Adaptor 6140




- ☐ **Converts IEEE 488 Bus to Analogue Voltage and Current**
- ☐ **Enables IEEE 488 Bus control of BCD programmable devices**
- ☐ **High resolution for accurate measurements**
- ☐ **20 Digital Control Lines**
- ☐ **IEEE 488 Bus Control of Test Stations, Plotters and Sweepers**
- ☐ **Versatile for wide range of applications**
- ☐ **Fast Slew rate for use with Fast Handshake**
- ☐ **Simulate analogue waveforms via IEEE 488 Bus**

The GPIB Adaptor 6140 will interface between an Instrument Bus and non-Bus programmable instruments which have some remote control facilities. The 6140 is compatible with IEEE Standard 488-1978, HP-IB and IEC Publication 625-1 (First Edition) with optional adaptor.

By providing a series of analogue and digital outputs, instruments and components can be remotely computer controlled by analogue voltage, current, BCD or TTL signals.

Five separate outputs are simultaneously available from the 6140. A 10,000 point programmable voltage varying from 0 to either plus or minus 10 V (or up to +20 V by internal selection) gives a high resolution drive. Both offset and range may be adjusted via the front panel and this output is duplicated on the front panel via a BNC socket for ease of direct connection. A 1000 point programmable voltage to plus or minus 10 V or up to 50 mA is available for secondary control. By combining these outputs a $10^7$ resolution can be generated. The 1000 point output is derived from a 3 digit, 12 line BCD output. An independent 4 line digital BCD output is available. A further output provides 4 programmable floating changeover relays rated up to 3 W, and interface power supplies at ±15 V and +5 V are provided.

The 6140 can interface commands from the Bus to an instrument i.e. "listen". It comes complete with 50 way output connector, and mains lead. Optional accessories include GPIB Bus cables, IEEE/IEC adaptor and rack mounting kit.

Applications for the 6140 include:

* GPIB control of the BCD programmable instruments.
* GPIB control of signal generators and sweepers for both power and frequency (e.g. Marconi Instruments 6700, 6600 and 6150 series).
* GPIB control of XY plotters, temperature control chambers, test jigs etc.
* GPIB control of components such as attenuators, switches, YIG oscillators, servo systems, transducers.
* GPIB control of fine tune items such as YIG Filters using high resolution mode.

**GPIB**

Full Bus compatibility with HP-IB, IEEE 488 and IEC 625-1 instrument bus.
Address set by rear panel switches.
Front panel lamp indicates when unit is addressed. Standard Marconi Instrument command format. All output values are stored internally.
Functions: AH1, L1, RL1, DC1, SHφ, Tφ, LEφ, SRφ, PPφ, DTφ, Cφ.

**Command Format**

ASCII characters, "X N N N CR"
where X = Output identifier letter.
N = Numeric data.
CR = CR, Comma.

**Output F+**

Programmable analogue voltage 0 – N volts in 10,000 steps, where the value N may be selected by an internal resistor, N may be any value up to +20 volts.
OFFSET & RANGE are screwdriver adjustable calibration controls on the 6140 front panel.
Offset: front panel adjustable from –1 volt to +1 volt.
Range: front panel adjustable by ±10%.
Linearity: ±0·1. of range.
Resolution: ±0·01% of range.
This output is available at front panel BNC connector as well as at rear panel main output connector.
*N.B.:* This output is semi-floating from ground to reduce ground noise.

**Output F–**

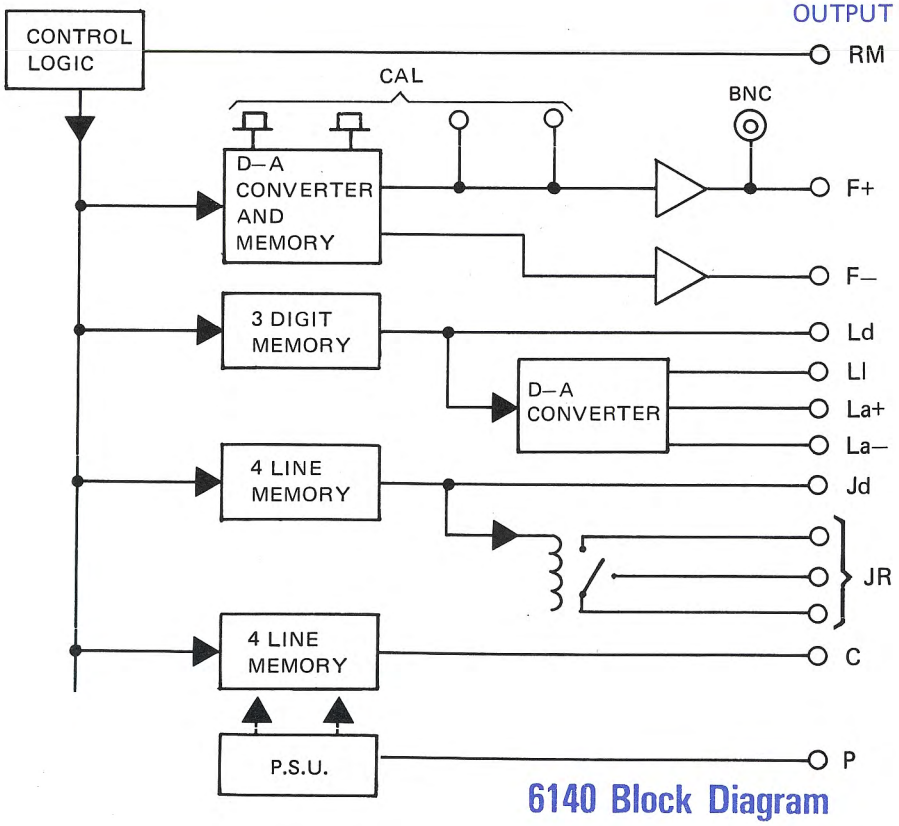
As F+, 0 to –10 V fixed range and offset.

**Output Ld**

3 digit BCD (12 lines) fully buffered.
Output: 0 = 0 Volt
1 = +5 Volt
Positive true logic. Maximum load = 2TTL (CMOS compatible).
These output lines are also used to set output +La, –La and LI.

# GPIB Adaptor
# 6140

| | |
|---|---|
| **Output +La** | Programmable analog voltage in 1000 steps.<br>Range = 0 to +10 V ±1%. |
| **Output –La** | As +La but 0 to –10 Volt. |
| **Output LI** | Programmable analogue current 0 – 50 mA nominal derived from +La. The data for +La, –La and LI is derived from output Ld. |
| **Slew rate** | Typically 20 $\mu$s for 0 – 10 V on F and L outputs. |
| **Output C** | 4 line digital control output fully buffered, BCD Format.<br>Output 0 = 0 Volt.<br>1 = +5 Volts.<br>Positive true Logic. Max. load = 2TTL. |
| **Output JR** | 4 off change-over relays, fully floating.<br>Each relay independently controllable.<br>Contact Rating: 28 volts, 0·5 A limited to maximum 3 watt dissipation. |
| **Output Jd** | 4 off digital lines, fully buffered. These are used internally to drive the relays of output JR, but may be used as general digital outputs when output JR is not required.<br>0 = 0 Volt.<br>1 = +5 Volts.<br>Positive True Logic: Maximum load = 2TTL (CMOS Compatible). |
| **Output Jd** | 4 off digital lines, fully buffered. These are used internally to drive the relays of output JR, but may be used as general digital outputs when output JR is not required.<br>0 = 0 Volt.<br>1 = +5 Volts.<br>Positive True Logic: Maximum load = 2TTL (CMOS Compatible). |
| **Output P** | Power output for interface circuits.<br>+15 volts 150 mA<br>–15 volts 150 mA<br>+ 5 volts 300 mA<br>All outputs protected. |
| **Output RM** | Local/remote line controlled by GPIB and front panel control. Allows remote switching in BCD controlled instruments. Logical operation as HP-IB, IEEE Bus systems. |
| **Output Handshake** | NDAC, stops acceptance of Bus data.<br>DELIM, pulse signifying acceptance of new data. |
| **Connectors** | Rear panel: 24 way GPIB input connector for IEEE-488. 50 way output connector.<br>Front panel: F+ duplicated on front panel BNC. |
| **Safety** | Meets IEC 348. |
| **Dimensions** | 420 wide; 340 deep; 40 high (mm), 3 KG weight. |
| **Power requirements** | 115 V/230 V, 50 Hz, 20 W. |
| **Accessories supplied** | 50 way Connector.<br>Mains Supply lead (1 m).<br>Instruction Manual. |
| **Optional** | GPIB lead (1 m) (Amphenol 57, 24 way connector). Ordering Code 43129-189U.<br>IEC/IEEE Adaptor. Ordering Code 46883-408K.<br>Racking Mounting Kit. Ordering Code 3963-029.<br>GPIB Manual. Ordering Code H54811-010P. |




6140 Block Diagram

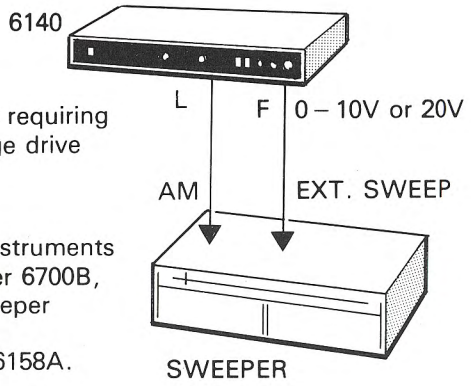
| OUTPUT | FUNCTION |
|---|---|
| RM | LOCAL REMOTE RM AND HANDSHAKE |
| F+ | 0 TO + 10 OR + 20 V PROGRAMMABLE IN 10,000 STEPS |
| F– | 0 TO –10 V |
| Ld | 3 DIGIT BCD (12 LINES) |
| LI | 0 TO + 50 mA } PROGRAMMABLE IN 1,000 STEPS |
| La+ | 0 TO + 10 V } PROGRAMMABLE IN 1,000 STEPS |
| La– | 0 TO – 10 V } PROGRAMMABLE IN 1,000 STEPS |
| Jd | 4 DIGITAL CONTROL LINES |
| JR | 4 CHANGE-OVER RELAYS |
| C | 4 DIGITAL CONTROL LINES |
| P | LOW CURRENT POWER SUPPLY |

# 6140

## Application Information

Drive existing analogue or BCD controlled instruments from IEEE-488 Bus with the 6140. Some typical applications are shown below.

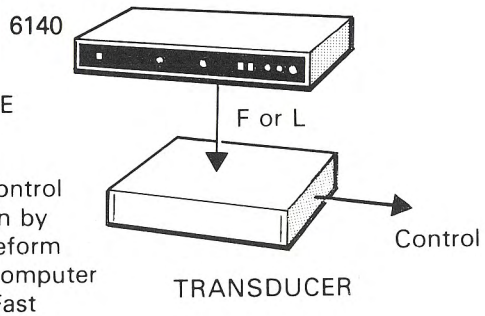
### FREQUENCY/POWER




Any instrument requiring analogue voltage drive 0 – 10 or 20 V.

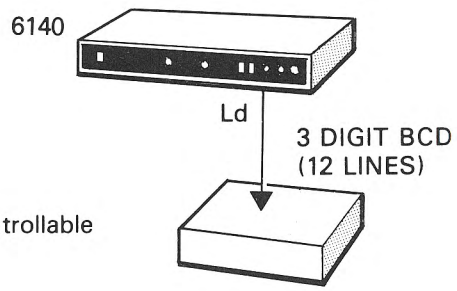
e.g. Marconi Instruments 18 GHz Sweeper 6700B, Millimetric Sweeper 6600A/1. Signal Source 6158A.

### ANALOGUE WAVEFORM



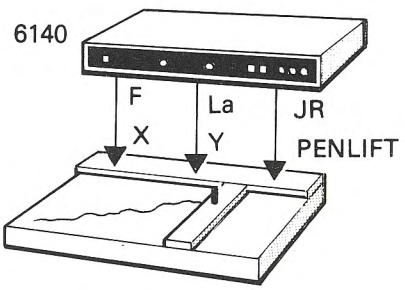

e.g. Servo control system driven by stepped wareform using microcomputer buffer with Fast Handshake facility.

### BCD CONTROL



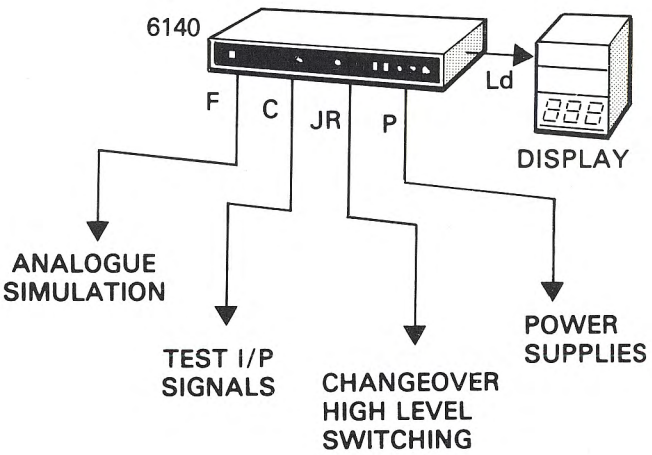

Any BCD controllable unit.

### PLOTTER

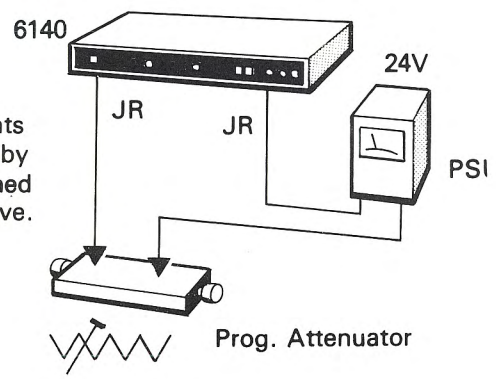



X-Y Plotter

### CONTROLLER FOR TEST JIGS




### RF POWER – EXTERNAL




Components controlled by ext. switched voltage drive.

# AM-FM Signal Source 6158A




- ☐ **Versatile Modulation**
- ☐ **Low harmonics**
- ☐ **High Stability**
- ☐ **IEEE-488 or IEC control using GPIB Adaptor 6140**

The 6158A microwave AM-FM Signal Source is a tunable solid state oscillator using a GaAs FET as the active element with a YIG resonator.

The output frequency with low harmonic and spurious content may be varied manually via the front panel potentiometer or via remote control using rear panel sockets. The LED display indicates frequency to ± 0·75% accuracy and offers excellent resetability and speed of operation.

A wide range of modulation facilities are provided and the 6158A may be operated in several modes by selecting the appropriate front panel push button switches and providing the necessary drive inputs.

CW – Single frequency tuned using front panel knob. Low residual f.m. mode.

SWP – Enables swept frequency when a 0 to + 10V drive is applied (for full range) to the rear panel auxilliary or BNC sockets.

CW + SWP Enables slow sweeps (<1 Hz) or steps between frequencies with low residual f.m. using rear panel sockets and external drive.

FM – Fast frequency modulation up to ±20 MHz deviation for ±10 V input to front panel BNC socket at up to 100 kHz rate for -3 dB response. This enables fine tuning or external locking about a centre frequency.

RF OFF – RF output disabled.

INT AM ON– Internal modulator switches RF amplitude at 1 kHz rate adjustable ±200 Hz with depth up to 18 dB.

All AM functions are performed using a PIN modulator and so total AM depth is 18 dB which is the summation of internal AM, external AM (if any) and front panel RF Level control. This is a 10 turn potentiometer allowing fine control of output power. An external levelling circuit may be used for swept frequency testing by incorporating a coupler, detector and the 6587 Levelling Amplifier. AM and FM functions are independent allowing full control of the 6158A, in both CW and SWP modes.

# 6158A

The rear panel auxilliary socket enables remote control of

* centre frequency
* output power
* 1 kHz internal modulation
* RF on/off
* display blanking

These may be conveniently controlled via the IEEE-488 or IEC Interfaces by the 6140 GPIB Adaptor. A pin on the auxilliary socket also provides a dc output voltage (0 to 10V) proportional to centre frequency. This may be used to drive external recording devices such as X-Y pen recorders or display oscilloscopes.

The 6158A operates from either 110 V or 240 V mains supply via a changeover switch. The internal temperature rise is kept low for short warm up time and good stability. However should the instrument be inadvertently operated in an excessive ambient temperature a thermal trip operates in the power supply circuitry.

Typical uses of the 6158A include testing microwave components, antennas, radar receivers and systems. Used with the 6140 it provides a compact, economical and versatile GPIB controlled microwave oscillator with the ability to generate both swept power and frequency. As a low harmonic oscillator it provides a convenient RF source for X Band measurements with the 6500 Automatic Amplitude Analyser.

Supplied Accessories: Mains Lead
Handbook
Mating Connector 'D' 15 way for Auxilliary socket.

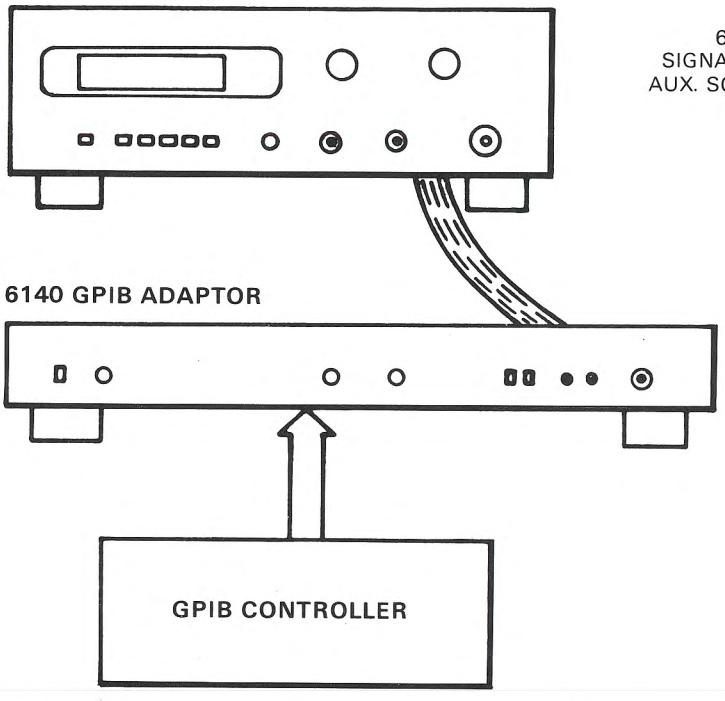
Optional Accessories: GPIB Adaptor 6140
IEC/GPIB Adaptor Part No. 46883-408K
GPIB lead Part No. 43129-18911
Levelling Amplifier 6587
Detector 6165/2
Coupler 6177/10

## Specification

| | |
|---|---|
| **FREQUENCY RANGE** | 8·0–12·4 GHz |
| **RF POWER OUTPUT** | |
| Minimum | 10 mW |
| **FREQUENCY ACCURACY AT 20°C AND MAXIMUM RF POWER** | ±0·75% |
| **FREQUENCY PULLING** | |
| External | ±2 MHz DUE TO 2:1 VSWR |
| Internal | ±2 MHz DUE TO 10 dB CHANGE IN LEVEL CONTROL |
| **FREQUENCY STABILITY** | |
| Warm up time (1) (2) | <15 min |
| Temperature Coefficient (1) | ±0·01%/°C (calibrated at 22°C nominal) |
| **SPECIAL PURITY (1) (3) AT MAXIMUM RF POWER** | |
| Residual f.m. | <35 kHz rms |
| Harmonic Content | –40 dBc |
| Spurious Output | –60 dBc |
| **RF LEVEL CONTROL** | |
| (Internal & External (4) | 18 dB |
| **AMPLITUDE MODULATION** | |
| Internal Depth (4) (1 kHz ±200 Hz min) | 18 dB |
| External Depth (4) | 18 dB For +10 V or +50 mA Input |
| Rise and Fall Time | <600 ns |
| **FM CAPABILITY** | |
| Deviation | ±20 MHz for ±10 V Input |
| Maximum Rate (–3 dB) | 100 kHz |
| **SWEEP CAPABILITY** | |
| Input | 0 to +10 V |
| –3 dB Bandwidth (1) | 100 Hz |
| Tuning Voltage Output | 0 to +10 V for full sweep, reduced for narrow band |
| **OUTPUT CONNECTOR** | Precision Stainless Steel 'N' Type, Female 50 ohm |
| **POWER REQUIREMENTS** | 100–125 or 200–250 V, 50–60 Hz, 60 VA |
| **DIMENSIONS AND WEIGHT** | Height 98 mm (3⅞ in.), Width 270 mm (10½ in.), Depth 254 mm (10 in.), Weight 6·1 kg (13½ lb) |
| **ENVIRONMENTAL: TEMPERATURE** | 10 to +35°C meets specification, 0 to +50°C operating, –40 to +70°C storage, |
| **SAFETY** | Meets IEC 348. |

(1) Typical values
(2) To be within frequency accuracy
(3) In CW and FM modes
(4) AM depth is dependent on r.f. level control settings and external modulation input. As only one modulator is used for all AM functions it therefore has a summation capability.

# Control of 6158A via 6140




## CONNECTIONS DETAILS

| 6158A SIGNAL SOURCE AUX. SOCKET PINS | 6140 GPIB ADAPTOR OUTPUTS (SK3) PINS | | CONTROL FUNCTION |
|---|---|---|---|
| 15 | 41 | F+ | FREQUENCY |
| 7 | 43 | F COMMON | GROUND (ANALOGUE) |
| 4 | 29 | LI | AMPLITUDE |
| 10 | 18 | L COMMON | GROUND (DIGITAL) |
| 5 | 38 | Jd (B1) | INTERNAL AM ON/OFF |
| 14 | 37 | Jd (A1) | RF ON/OFF |
| 6 | 33 | C (A1) | DISPLAY BLANK |

The GPIB Adaptor 6140 will interface between an Instrument BUS (IEEE-488, HP-IB or IEC 625-1 †) and non-BUS programmable instruments, which have some remote control facilities. The 6140 provides a series of analogue and digital outputs and hence instruments remotely controllable by analogue voltage, current or BCD signals can now be made fully IEEE-BUS compatible.

The 6140 can interface commands from the BUS to an instrument, i.e. listen. It will not transmit information back onto the BUS i.e. talk.

### IEE-BUS CONTROLLED OUTPUTS

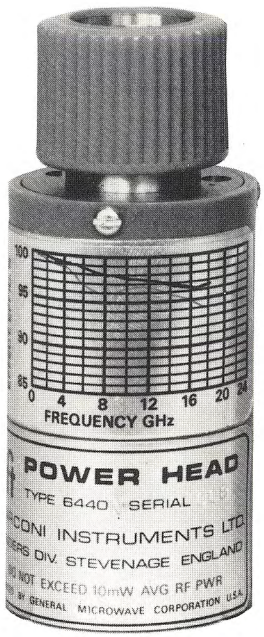
The following outputs are independently available from 6140.

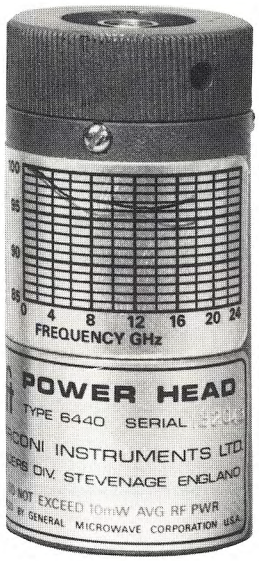
* VOLTAGE (F) 0 to ±10 V (or up to +20 V) programmable in 10,000 steps. Ultra-high resolution of 10,000,000 steps by combining 'F' and 'L'.
* CURRENT OR VOLTAGE (L) 0 to +50 mA or 0 to ±10 V programmable in 1000 steps.
* BCD LOGIC (LD) Programmable 3 digit BCD logic output (12 lines)
* RELAYS (JR) 4 programmable, floating change-over, relays
* POWER SUPPLY (P) ±15 V 150 mA, +5 V, 300 mA, non-programmable, available for external use.

*For full details and other applications see 6140 Data.

† using IEC/GPIB Adaptor. Part No. 46883-408K.

# tft Power Heads 6440/6420 series




14194/12

- ☐ **Frequency range 10 MHz—40 GHz**
- ☐ **Type N and SMA connectors**
- ☐ **Power range 30 nano watts—3 watts**
- ☐ **Field replaceable tft elements**
- ☐ **Waveguide heads**
- ☐ **High overload rating—300%**
- ☐ **Compatible with all tft power meters**

Measurement of power levels as low as 0·03 µW (−45 dBm) can be made with the Type 6422. Direct reading power measurements as high as 3 watts (+35 dBm) can be made with the Type 6423. Power Heads with intermediate power ranges are available.

Coaxial **tft** Power Heads are available that cover the frequency range from 10 MHz to 18 GHz.

A series of waveguide **tft** Power Heads are available from 8·2 to 40 GHz with a mean power rating of up to 10 mW.

### 18 GHz Coaxial tft Power Heads

The 6440 series is a range of coaxial **tft** Power Heads which extends the operating frequency of the **tft** Powermeters to 18 GHz. Low VSWR and compensated efficiency combine to provide precision power measurements at levels from 10 mW to as low as 0·3 µW.

Type N, and SMA connectors are available on the 6440 series Heads.

### High power Coaxial tft Power Heads

Four coaxial Power Heads with precision Type N input connectors are available. The Type 6422 covers the measurement range 0·01 µW to 1 mW and the Type 6423 covers the range 0·1 mW to 3 watts, so that only these two coaxial Heads are required to cover the complete 80 dB dynamic range. For many applications, however, it is more convenient to use a Power Head covering one of these intermediate sub-ranges; two further **tft** Power Heads are available; Type 6420 covers 0·1 µW to 10 mW and Type 6421 covers 1 µW to 100 mW.

All these coaxial Power Heads are suitable for frequencies ranging from 10 MHz to 12·4 GHz.

# Power Heads
# 6440/6420 series

## Waveguide tft Power Heads

Waveguide **tft** Power Heads covering the power range 0·3 μW to 10 mW are available in standard waveguide sizes for use over the frequency range 8·2 GHz to 40 GHz. These heads are fitted with square mating flanges. Details of performance, waveguide size, and frequency range of each of these Power Heads are given in the table 6420 series.

## Long Cable operation

By use of extension cables the **tft** Power Head may be operated at distances up to 120 metres (400 ft) from the Powermeter.

## Field Replacement

In the event of failure of the **tft** Power Heads the **tft** element may be replaced in the field and a simple audio frequency calibration procedure used to set up the basic **tft** Power Head sensitivity. This calibration holds for frequencies up to about 2 GHz. Above this frequency the original Eff.Eff. or Cal. Factor calibration points may be used as good approximation, unless the best accuracy is required, when a recalibration against an RF Standard is necessary.

## Tool Kit TK-1

This Kit contains all the special tools necessary for field replacement of any type of **tft** power element.

## Power measurement accuracy

Every **tft** Power Head is individually calibrated using standards traceable to the most accurate available, and which have British Calibration Service (BCS) approval.

The permanent calibration graph on the power heads shows CALIBRATION FACTOR and EFFECTIVE EFFICIENCY information and a calibrated variable control on the rear of each power head can be used to compensate for either parameter.

(i) EFFECTIVE EFFICIENCY is the ratio of audio reference power to RF power dissipated within the **tft** Head for the same d.c. output voltage.

(ii) CALIBRATION FACTOR is the ratio of audio reference power to RF power incident on the **tft** Head for the same d.c. output voltage.

*tft® Thin Film Thermoelectric




14194/5




14194/10

# 6440/6420 series

## 6440 SERIES OF TFT POWER HEADS

The Type 6440 Series are coaxial thermoelectric Power Heads with coaxial connectors in type N, ultra precision APC7 and miniature SMA. These Power Heads extend the operating frequencies to 18 GHz.

| Type | Freq. Range (GHz) | Average Power Range(1) From | To | Max. peak pulse power at +25°C | Max. Energy Per Pulse at +25°C W – µsec. | Pulse Duration at +25°C µs (max) | Max. VSWR | Field Replacement tft element | RF Connector |
|---|---|---|---|---|---|---|---|---|---|
| 6440<br>6440N | 0·01–18<br>0·01–18 | 0·3 µW<br>–35 dBm | 10 mW<br>+10 dBm | 1W | 5 | 5 | 1·5:1 from 0·01 to 0·015 GHz<br>1·35:1 from 0·015 to 10 GHz<br>1·6:1 from 10 to 18 GHz | TL–4A | SMA-male<br>Type N male(2) |

*Temperature Coefficient:* Less than 0·1% per deg. C. when used with any tft Powermeter

*Dimensions* 6440 2·66"L × 1·28" Dia. (67,6 × 32,5 mm) (3)

6440N 3·42"L × 1·28" Dia. (86,9 × 32,5 mm) (3)

Nett Weight: Approx. 3 oz. (35,1 gm)

(1) Overload Rating 300%. While the heads will take overloads for short periods of time, extended periods of operation at overload levels may result in permanent change in the element characteristics or even burn out. Maximum care should be exercised to avoid such an occurrence.

(2) Precision type N 50 Ω male to MIL-C-39012

(3) Maximum, including r.f. connector but excluding cable and multi-pin connector.

## 6420 SERIES OF TFT POWER HEADS

in coaxial and waveguide.

| Type | Freq. Range (GHz) | Average Power Range From | To | Max. Peak Pulse Power | Max. Energy Per Pulse W – µsec | Pulse Duration µS (max) | Max. VSWR | Field Replacement tft Element | Connector |
|---|---|---|---|---|---|---|---|---|---|
| 6420 | 0·01–12·4 | 0·3 µW<br>–35 dBm | 10 mW<br>+10 dBm | 3W | 34 | 11 | | TL-OA | Precision Type N 50 Ω male to MIL-C-39012 |
| 6421 | | 3 µW<br>–25 dBm | 100 mW<br>+20 dBm | 30W | 180 | 6 | 10 MHz – 15 MHz 1·4:1<br>15 MHz – 50 MHz 1·35:1<br>50 MHz – 2 GHz 1·25:1 | TL-1A | |
| 6422 | | 0·03 µW<br>–45 dBm | 1 mW<br>0 dBm | 0·3W | 2 | 7 | 2 GHz to 12·4 GHz 1·4:1 | TL-2A | |
| 6423 | | 0·3 mW<br>–5 dBm | 3 W<br>+35 dBm | 60W | 500 | 8 | (I) | TL-3 | |
| 6425 | 8·2–12·4 | | | 2·5W | 25 | 10 | 1·5 | TL-XO-A | R100, WR90 UG39/U |
| 6426 | 12·4–18·0 | | | 2·5W | 25 | 10 | 1·5 | TL-UO-A | R140, WR62 UG419/U |
| 6427 | 18·0–26·5 | 0·3 µW<br>–35 dBm | 10 mW<br>+10 dBm | 1·6W | 10 | 6 | 1·5 | TL-KO-A | R220, WR42 UG595/U |
| 6428 | 26·5–40·0 | | | 1·6W | 10 | 6 | 1·65 | TL-AO-A | R320, WR28, UG599/U |

(I) Except 6423 where VSWR from 11 to 12·4 GHz may rise to 2·0:1

Nett Weights: 6420, 6421, 6422: 1lb 2oz 505g
6423 2lb 2oz 975g
6425, 6426, 6427, 6428 1lb 10oz 800g

# Military tft Power Meter Systems 6460S CT596




14431

- ☐ **Wide frequency range**
- ☐ **Wide power range**
- ☐ **Internal 50 MHz calibrator**
- ☐ **Automatic scales selection**
- ☐ **Storage for accessories**
- ☐ **Ruggedized case**

The Powermeter System 6460S and Wattmeter Absorption CT596 comprise two specific collections of instruments and accessories, as detailed, and are selected and tested for military applications. These equipments measure power in the range 300 nW to 1W in a frequency range of 10 MHz to 18 GHz and meet the environmental requirements of Joint-Services Specification REMC/20/FR (Iss. 6) Cat. III.

They are based on the 6460/1 (Powermeter type 3888-001, fitted with a standard commercial case) which, in conjunction with a series of **tft**®*. Power Heads, can provide a total measuring range of 30 nW to 3 W from 10 MHz to 40 GHz.

*® Thin film thermoelectric device made under licence from General Microwave Corp., USA.

# 6460S and CT596

## COMPOSITION OF EQUIPMENT

The complete Powermeter System 6460S consists of:–

| | | *NATO ref. no.* |
|---|---|---|
| (1) | Powermeter type 3888-001 complete with case and storage covers 3888-002 | 6625–99–637–9583 |
| | (including mains lead, 3 m long, part no. 2400–035) | 5995–99–637–9586 |
| (2) | **tft** Power Head type 6440N/1 | 6625–99–643–8693 |
| (3) | 20 dB Attenuator type 6534/4 | 5905–99–520–8780 |
| (4) | Coaxial-to-waveguide Transformer type 6237/1, 12·4 to 18 GHz | 5985–99–637–9587 |
| (5) | Battery Pack, part no. 2200–186 | |

The complete Wattmeter Absorption CT596 consists of:–

| | | |
|---|---|---|
| (1) | Powermeter type 3888–001 complete with case and storage covers 3888–002 | 6625–99–637–9583 |
| | (including mains lead, 3 m long, part no. 2400–035) | 5995–99–637–9586 |
| (2) | **tft** Power Head type 6440N | 6625–99–637–9584 |
| (3) | 20 dB Attenuator type 6534/4 | 5905–99–520–8780 |
| (4) | Coaxial-to-waveguide Transformer type 6237/3, 8 to 12·4 GHz | 5985–99–637–9585 |
| (5) | (Optional extra) Battery Pack, part no. 2200–186 | |

## FEATURES

Type 6460/1 Powermeter in conjunction with the 6420 and 6440 series of **tft** Power Heads, is a highly accurate instrument which measures radio frequency power over an extremely wide frequency and power range. It measures and indicates the average power absorbed by the power head in use, and accepts amplitude and frequency modulated, pulsed and c.w. signals. Tables listing the **tft** power head characteristics are on page 234

The powermeter features automatic scales selection, which ensures that only the scale corresponding to the sensitivity of the power head in use is activated. Other features include a switch which enables the selection of either normal or fast amplifier response time, output terminals for measurement systems using external recorders or digital voltmeters, and two paralleled input connectors which permit power head connection at the front or rear of the 6460/1.

An internal 50 MHz r.f. calibrator is fitted. This produces three pre-set power levels of 1 mW, 10 mW or 100 mW depending on the power rating of the power head being used. The calibrator automatically supplies the correct output to the power head.

The 6460/1 is suitable for use in a wide variety of applications, including portable and field use (when used with the optional rechargeable battery pack) fixed stations and laboratory bench set-ups. Since all **tft** power heads will operate with the 6460/1 a single instrument with different power heads can be applied to a wide variety of measurement applications.

By using the proper rack adapter the 6460/1 can be rapidly rack-mounted by itself, with any other Marconi unit packaged in this half-rack configuration or with 198 mm (7 25/32 in) wide half-rack units of other manufacturers.

## Specifications

| | |
|---|---|
| **FREQUENCY RANGE** | |
| **Type 6460S and CT596** | 10 MHz to 18 GHz. |
| **Type 6460/1** | 10 MHz to 40 GHz depending on **tft** power head in use. |
| **POWER RANGE** | |
| **Type 6460S and CT596** | 0·3 μW to 10 mW (−35 dBm to +10 dBm) in 1-3-10 range steps. With 20 dB Attenuator 6534/4, range is extended to 1 W (+30 dBm). |
| **Type 6460/1** | 0·03 μW to 3 mW (−45 dBm to +35 dBm), depending on **tft** power head in use, in 1-3-10 range steps. |
| **Accuracy** | ±1·5% of f.s.d. on all ranges from 0°C to +55°C. (When CAL ADJ control standardized). |
| **Noise and drift** | Less than ±1% of f.s.d. on lowest range, and correspondingly less on higher ranges, (except for the highest sensitivity position where it may rise to 2% peak) at constant ambient temperature. |
| **Temperature coefficient** | Less than ±0·1% per °C using any **tft** power head. |
| **Response time** | 100 ms approx. or less than 1 s. |
| **Recorder output** | Proportional to input power.<br>*1-10-100 ranges:*<br>The output at full scale is −1 V, or adjustable from 0 to −1 V.<br>*3-30-300 ranges:*<br>The output at full scale is −0·3 V, or adjustable from 0 to −0·3 V. |
| **Recorder output accuracy** | ±0·5%. |
| **RF calibrator** | Internal 50 MHz oscillator with type N female connector on front panel. Power level corresponding to **tft** power head automatically preset. |
| **Power output** | 1 mW, 10 mW or 100 mW depending on **tft** power head connected to powermeter.<br>Power level factory set to ±0·7%; traceable to national standards. |
| **Temperature coefficient** | ±0·1%/°C worst case (0 to 55°C); ±0·05%/°C typical. |
| **Input connectors** | Two provided, one on front panel and one at the rear. |
| **Meter** | 115 mm (4½ in) mirror scale, sprung-jewel suspension. |
| **Power requirement** | 115/230 V a.c. ±10%, 50 to 400 Hz, 5 W. Mains connector to CEE 22 (BS 4491). |
| **DIMENSIONS AND WEIGHT** | |
| **Type 6460S and CT596** | Height: 200 mm (8 in)<br>Width: 222 mm (8¾ in)<br>Depth: 358 mm (14 in) over controls<br>480 mm (18⅞ in) with covers<br>Weight: 8·3 kg (18 lb)<br>Battery: 1·3 kg (2¾ lb) |
| **Type 6460/1** | Height: 185 mm (7¼ in)<br>Width: 200 mm (8 in)<br>Depth: 350 mm (13¾ in)<br>Weight: 4 kg (9 lb) |

## tft POWER HEAD CHARACTERISTICS

Powermeter System CT596 uses Power Head 6440N only. The 6460S uses the 6440N/1 only; this head is identical to the 6440N except for its connecting cable which has a low temperature (−40°C) operating capability.

Powermeter 6460/1 can use any of the power heads listed, but only the 6440N and N/1 will fit in the storage compartments of the powermeter systems.

In order to extend the maximum power measuring capability of the system, a 20 dB attenuator type 6534/4 is included as standard. This item covers a frequency range DC to 18 GHz and its inclusion raises the maximum power limit from 10 mW up to 1 W c.w. The system can therefore measure powers up to this level over the specified frequency range for any co-axial system fitted with 'N' type connectors, as required.

In order to extend the capability into waveguide, alternative waveguide to co-axial transformers are included in the two systems covering the 12·4 to 18 GHz and 8 to 12·4 GHz frequency ranges respectively.

Specification details of all three items are described below.

### 20 dB Attenuator 6534/4 (NATO No. 5905-99-520-8780)

| SPECIFICATION | |
|---|---|
| Frequency range | DC-18 GHz. |
| Attenuation | 20 dB ±1 dB up to 12·4 GHz, ±2 dB up to 18 GHz. |
| Power input | 5 W Av., 1 kW peak. |
| Connectors | Precision type 'N male/female. |

### WG-Coaxial. Transformer 6237/1 (NATO No. 5985-99-637-9587)

| SPECIFICATION | |
|---|---|
| Adaptor Type | WG 18 to Type 'N female precision (50 Ω). |
| Freq. range | 12·4–18 GHz. |
| V.S.W.R. | Less than 1·25:1. |
| Flange type | Square 5985–99–083–0030. |
| WG Size | R140 (WG 18). |

### WG-Coaxial. Transformer 6237/3 (NATO No. 5985-99-637-9585)

| SPECIFICATION | |
|---|---|
| Adaptor Type | WG 16 to Type 'N female precision (50 Ω). |
| Freq. range | 8–12·4 GHz. |
| V.S.W.R. | Less than 1·25:1. |
| Flange type | Square UG39/U |
| WG Size | R 100 (WG 16) |

## ACCESSORIES

**Supplied accessories**

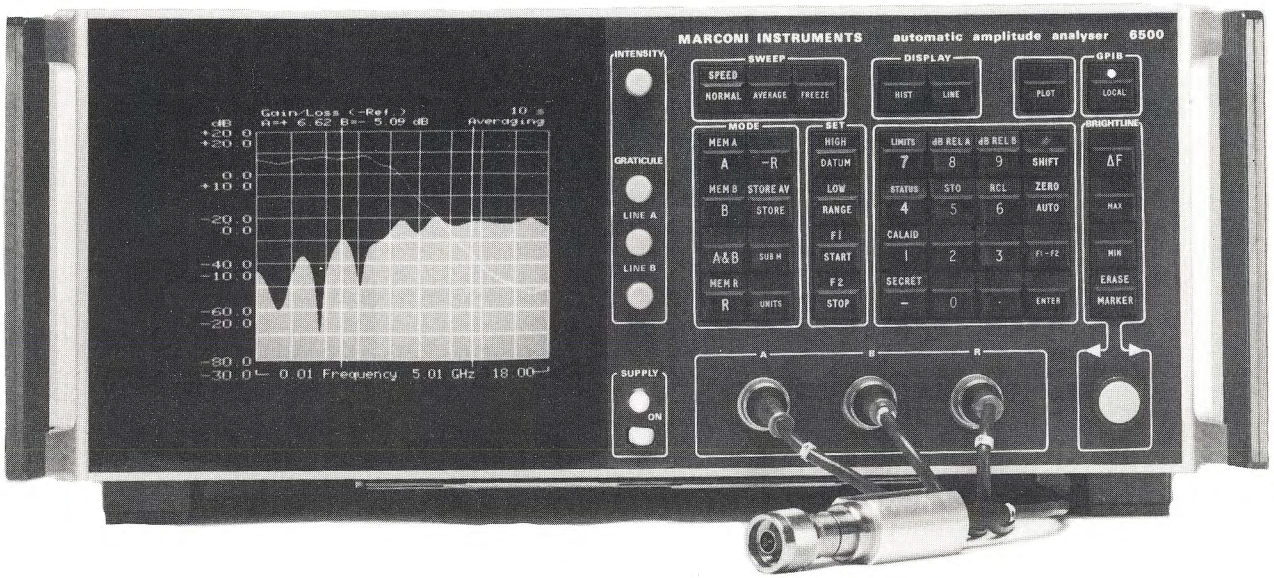
Mains leads, 3 m (10 ft) long — *Code no.* 2400–035

**Optional accessories**

Rechargeable Battery Pack 2200–186 – Permits portable or field use of type 6460/1. Provides up to 16 hours operation

Rack Adaptor (19 in) 3850–001 – Permits rack mounting of the type 6460/1 by itself, or with any other Marconi unit packaged in the half-rack configuration.

# Amplitude Analyser 6500




- ☐ On Screen alpha-numerics
- ☐ Full scaling information on C.R.T.
- ☐ 66dB Dynamic Range(+16dBm to –50dBm for All channels. (Selectable noise reduction to –55dBm)
- ☐ Full Frequency control of any sweeper
- ☐ High accuracy power measurements, all channels
- ☐ Movable 'Brightline' gives amplitude and frequency display on screen to 0.01dB and 10MHz resolution
- ☐ 10MHz to 18GHz with 6511 and 6512 detectors
- ☐ Comprehensive memory system
- ☐ Intelligent Interface to standard X-Y Plotter
- ☐ Full IEEE-488 programmability of all Keyboard functions
- ☐ 'AUTO' Function places trace(s) on optimum range for screen
- ☐ Intelligent Frequency Scaling
- ☐ Store up to 9 Display Settings

The 6500 Automatic Amplitude Analyser features new innovative design with powerful microprocessor control and represents a major step forward in accurate scalar measurements of transmission loss or gain, return loss, and power. It provides versatile and intelligent control of a swept frequency source by outputting a 12 bit (4096 step) ramp voltage into the external sweep facility. This gives the user the advantage of eliminating the need for purchasing a desk top computer and additional sweepers.

Full IEEE 488 data bus compatibility is available as an optional, field installable module. The 6500 is fully compatible with all existing sweeper systems and is offered in a standard 19" rack mounting configuration, with integral display.

The 6500 has 3 independent channels, to which are connected detectors. There are 3 channel data stores and 3 associated memories. Each memory and data

store can hold a complete sweep of 422 measurement points across the selected frequency range. The 3 input channels are multiplexed and before a sweep is commenced the required channel is switched on. At each measurement point the microprocessor accesses from an EPROM a log converted value of the signal and stores it in the channel data store. This data is converted into a displayed value using the screen parameters of Datum level and Range.

By simple use of the keyboard, considerable manipulation of the display is possible. This can show A, B or A and B channels with their associated memories over any frequency range within the limits of the sweeper and with a minimum resolution of 10MHz. The AUTO key enables the optimum screen display of the amplitude of the required channel(s) to be shown. The frequency scaling on the X axis is always spaced at meaningful intervals. RANGE and DATUM keys enable the amplitude display to be varied to the users requirements. LIMITS may be set for amplitude max or min and if exceeded an error message is flashed on-screen or an SRQ sent via the GPIB (if option fitted).

After initial switch-on the microprocessor does a self test routine and an AUTO ZERO operation is carried out on the 3 channels. The sweeper limits of F1 and F2 are entered via the keyboard and the 6500 is ready for use. Channels may be displayed as either a LINE or HISTOGRAM for ease of viewing. The display may be frozen for photography or output to hard copy via the PLOT facility.

A brightline is shown vertically on the display giving a readout of amplitude and frequency to .01dB and 10MHz resolution. The brightline may be set to MAX or MIN values or used to set up frequency bands for measurement or to zoom-in on an item of interest on screen. The Brightline is also used for displaying up to 8 on-screen MARKERS and has a △F function, particulary useful for filter analysis.

The hard copy output is via a PLOT FACILITY. This will drive a standard X-Y recorder for any size paper and provides the amplitude and frequency shown on screen. A menu allows the user to draw axes annotated for frequency and amplitude scales, A and B channels and select the speed of plotting for accurate results to be recorded without the use of a separate calculator and printer.

The high accuracy of the 6500 System is maintained by using Marconi Instruments Ltd., low noise detectors 6510 series. True square law and temperature correction is provided up to +16 dBm for high power measurements without compression. The 6500 provides 66dB dynamic range in normal operation. By using an averaging process this can reduce the noise level to –55dBm.

Complete front panel control is possible using IEEE-488 (or IEE 625 via connector adapter) Interface Bus as there are no manual offset keys to be adjusted. Due to the ease of use and programmability via keypad of the 6500 this GPIB operation is an option using a field installable module.

The 6500 displays on screen error and prompt messages for user convenience. The amplitude scaling may be in dB, dBm, mW or VSWR. Operator selected limits (High, Low, Channels A and B) may be programmed via the keyboard and stored. Flashing error messages appear on-screen when the limits are exceeded. The STATUS function displays on-screen the current limits, whether they are enabled, current GPIB address, frequency range and dB relative values. Up to 9 such front panel settings may be stored and recalled. The frequency scaling on the X axis and brightline may be removed for photography by using the SECRET key. Calibration aid is provided and the 6500 has many self diagnostic routines for fault finding.

## 6500 AUTOMATIC AMPLITUDE ANALYSER

| | |
|---|---|
| **FREQUENCY RANGE** | 0–126GHz (Dependent on Detector) |
| **DYNAMIC RANGE** | 66dB; +16 dBm to –50dBm<br>71dB; +16 dBm to –55dBm (average mode)<br>All channels |
| **RESOLUTION (BRIGHTLINE)** | |
| **Frequency** | Digital readout to 10MHz |
| **Amplitude** | Digital readout to 0·01dB(m) |
| **FREQUENCY LINEARITY** | Dependent on Linearity of sweeper.<br>See Ramp output linearity. |
| **MARKERS** | Up to 8 on-screen markers with 10MHz resolution. |

| | |
|---|---|
| **FRONT PANEL SELECTABLE PARAMETERS** | |
| **Range** | 0·1 to 10·9dB(m)/division;<br>0·1dB(m) increments |
| **Datum** | ±99·9dB(m)<br>0·1dB(m) increments |
| | Above parameters individually selectable on A, B and R channels. |
| **High/Low Limits** | ±99·99dB(m) individually selectable on A and B channels. |
| **F1, F2 (Sweeper Range)** | Selectable in Range 0 to 126GHz; 10MHz Resolution. |
| **△F** | Selectable Symmetrical within range F1-F2; Centre Frequency is Brightline position. 10MHz Resolution. |

# 6500

| | |
|---|---|
| **Start, Stop (Selected Range)** | Selectable within Range F1-F2; 10MHz Resolution. |
| **Display Format** | Line or histogram |
| **Sweep Speed** | 70ms to 20s nominal (10 Alternative Speeds) |
| **X-Y Plotter Output** | Set Pen bottom left<br>Set Pen top right<br>Set Pen to origin<br>Draw axes<br>Label axes<br>Plot<br>Set Pen lift<br>Set Plot Speed (9 alternatives) |

**RAMP OUTPUT**

| | |
|---|---|
| **Fixed** | 0–10V ±10mV |
| **Linearity** | ±5mV |
| **Resolution** | 4096 points |
| **Variable** | Adjustable from 1–20V (approx) using Coarse and Fine rear panel controls. |
| **Offset** | Bottom of range = 0V ±10% of Range |
| **Linearity** | ±0·25% |
| **Resolution** | 4096 points |

**CHANNEL MEMORIES**

At any time when valid data is available on the screens, the trace may be stored in any of the three memories. New data may be averaged with data already present. When invoked:-
A memory is subtracted from A trace,
B memory is subtracted from B trace,
R memory is subtracted from A and/or B trace, as selected. Recall is available on all memories.

**PLOTTER OUTPUT**

| | |
|---|---|
| **X output** | See Ramp Output 1 BNC socket |
| **Y output** | 0–10V ±50mV BNC socket |
| **Z output** | Open collector drive; selectable high/low impedance for pen up/down. BNC socket |

**C.R.T.**

| | |
|---|---|
| **Dimensions** | 105mm x 135mm used screen area |
| **Phosphor** | P31 green |

**REMOTE PROGRAMMING**

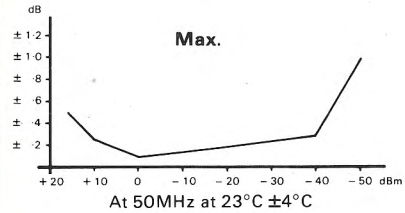
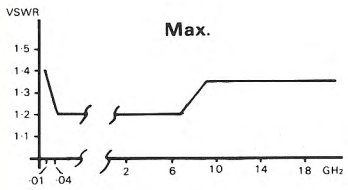
Compatible with IEEE 488-78 (Option 001)

**GENERAL**

| | |
|---|---|
| **Temperature Range** | |
| **Storage** | –40 to +70°C |
| **Operational (full Specification)** | 0°C to 50°C<br>10°C to 35°C |
| **Humidity** | 95% relative at 35°C |
| **Power Consumption** | 120VA Max. |
| **Weight** | 15·7kg |
| **Dimensions Max.** | 533L 427W 192H(mm) including carrying handles and feet |
| **Safety** | Meets IEC 348 |

| | |
|---|---|
| **OPTIONS** | -001 GPIB Compatibility Module, 3964-300 |
| **ACCESSORIES** | Supplied: Mains Cable<br>Operating Handbook<br>Optional: Detectors 6511 or 6512<br>Other 6510 Series Detectors<br>Camera Mount, 3964-239<br>Rack Mounting Kit, 3964-400<br>Service Manual, H6500-2<br>50 MHz Calibrator, 6540<br>Connector for HP8620C<br>Sweeper 3964-005 |

## 6511 DETECTOR

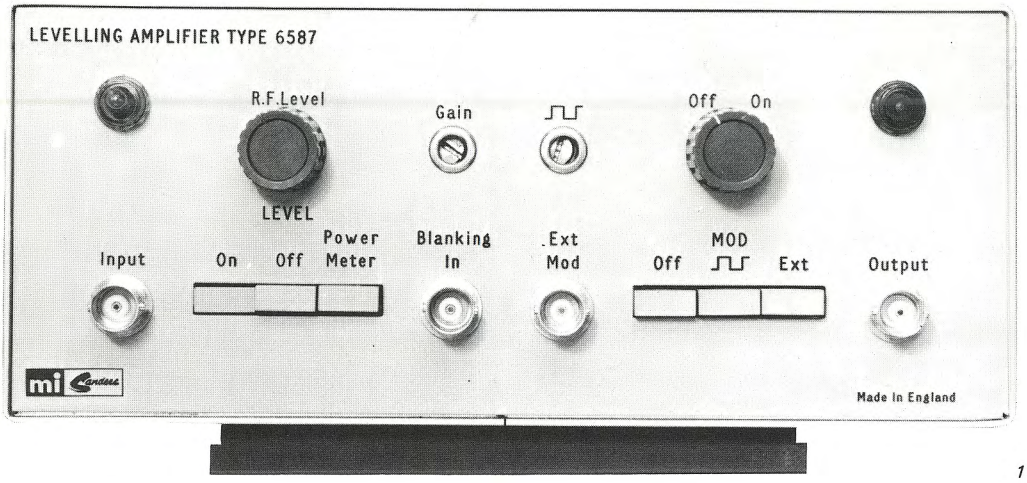
| | |
|---|---|
| **FREQUENCY RANGE** | 0·01 to 18GHz |
| **DYNAMIC RANGE** | +16 dBm to –55 dBm |
| **POWER ACCURACY**[1] | <br>At 50MHz at 23°C ±4°C |
| **Maximum Input Power** | +26dBm |
| **V.S.W.R.** |  |
| **FREQUENCY RESPONSE** | ±0·5dB Variation 0·01 to 18·0GHz |
| **CONNECTOR** | Precision Type N (m) 50 Ω |

[1]Excluding errors due to Return Loss, Flatness and Source Harmonics.

## 6512 DETECTOR

Specifications as above fitted with APC-7 connector.

# Levelling Amplifier 6587




11939/2

- ☐ **Reduces signal level variations of 20 dB to ± 0·1 dB**
- ☐ **May be used with any oscillator**
- ☐ **Amplitude modulation facility**
- ☐ **Straightforward operation**

The Levelling Amplifier is basically a variable-gain, stable d.c. amplifier to be used with a directional coupler, crystal detector and PIN diode modulator to form a control feedback loop in the r.f. output channel of a signal source. The r.f. sample from the directional coupler is rectified by the crystal detector and fed to the Levelling Amplifier. After comparison with a d.c. voltage, preset by the RF LEVEL control, the sample is appropriately amplified and fed to the PIN diode whose insertion loss varies with applied current. So, the r.f. level at the "output" end of the diode modulator is held constant for any given setting of the RF LEVEL control.

Amplitude modulation is provided either internally from a 1 kHz square-wave oscillator or externally via a front panel BNC socket. Full levelling capabilities are maintained while modulation is being applied since the modulating signal is applied as a change to a reference level within the closed loop. If a true square-law detector is used for levelling, power level modulation is linearly related to the applied voltage.

The instrument has a single RF LEVEL control, and an indicator lamp shows when the r.f. power is "levelled". Provision is made for the insertion of a blanking waveform for such applications as suppression of the r.f. signal during the retrace period when levelling a sweep oscillator output. A LEVEL ON/OFF switch allows the levelling function to be dispensed with if the levelling amplifier is to be used only as a PIN modulator driver. The RF LEVEL control remains effective in this mode.

A front panel push-button allows selection of a thermistor-type power meter as the d.c. sample source in place of the crystal detector. The power meter must provide a suitable d.c. signal, proportional to its r.f. input. Such a signal is available from the recorder output of most microwave power meters.

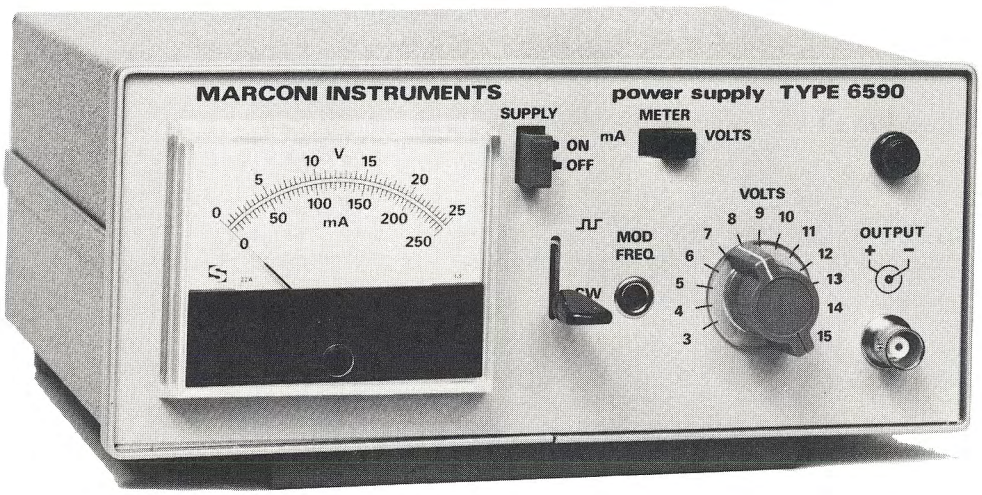
The power handling capacity and frequency range of the levelling system depend upon the characteristics of the PIN diode modulator and directional coupler used. In general, any suitable components may be used, although best results are obtained with PIN diodes having a wide dynamic range.

Signal Sources, type 6055B series and type 6150 series incorporate internal PIN diode modulators in their r.f. output circuits obviating the need for an external modulator when used with the Levelling Amplifier.

| | |
|---|---|
| **OUTPUT POWER LEVELLING** | ±0·1 dB output variation for an input power variation of 20 dB (excluding coupler and detector variation) providing the PIN diode requires not more than 1 mA bias current for 20 dB attenuation. Suitable for grounded cathode or grounded anode PIN diode modulators. |
| **AMPLITUDE MODULATION** | |
| Internal | 0·8 to 1·2 kHz Rise and fall time 15 µsec (approx.). |
| External | 15 volts negative to raise output from minimum to maximum: rise and fall time <1 µsec. |
| **BLANKING INPUT** | 15 volts negative. |

| | |
|---|---|
| **DETECTOR INPUT** | Suitable for either positive or negative signal from a crystal detector or power meter. |
| **MODULATOR CURRENT** | 0 to 35 mA, positive or negative. |
| **POWER REQUIREMENTS** | |
| A.C. mains | 200 to 250 volts or 100 to 125 volts: 45 to 60 Hz. |
| **DIMENSIONS AND WEIGHT** | Height 85 mm (3¼ in), Width 200 mm (8 in), Depth 255 mm (10 in), Weight 1·8 kg (4 lb) |
| **RECOMMENDED ANCILLARY EQUIPMENT** | |
| Solid state signal sources | 6150 series and 6055B series. |
| Detectors | 6160 series |

# Power Supply 6590




- ☐ **Designed for Gunn-diode oscillators**
- ☐ **Suitable for general applications**
- ☐ **Up to 15 volts, 250 mA**
- ☐ **Internal squarewave modulation**

Designed primarily as a power source for the Gunn Diode Oscillator 6061A, this power supply unit is capable of delivering a voltage stabilised supply variable up to 15 volts d.c. at load currents up to 250 mA. It is also suitable for use with a wide variety of solid state microwave devices and other electronic circuits.

A single panel meter monitors both output current and voltage, the monitoring function being selected by means of a two-position slider switch. For convenience, a nominal calibration associated with the output voltage control gives an indication of the voltage setting when the current monitoring meter function is being used.

Provision is made for 100% squarewave modulation of the d.c. supply. The modulating waveform is generated internally, and a preset frequency control – accessible at the front panel – facilitates frequency adjustment from 800 to 1200 Hz. With squarewave modulation the panel meter indicates peak voltage or average current. A three-position panel switch selects continuous d.c. output (c.w. from Gunn-diode oscillator), modulated output, or power-off.

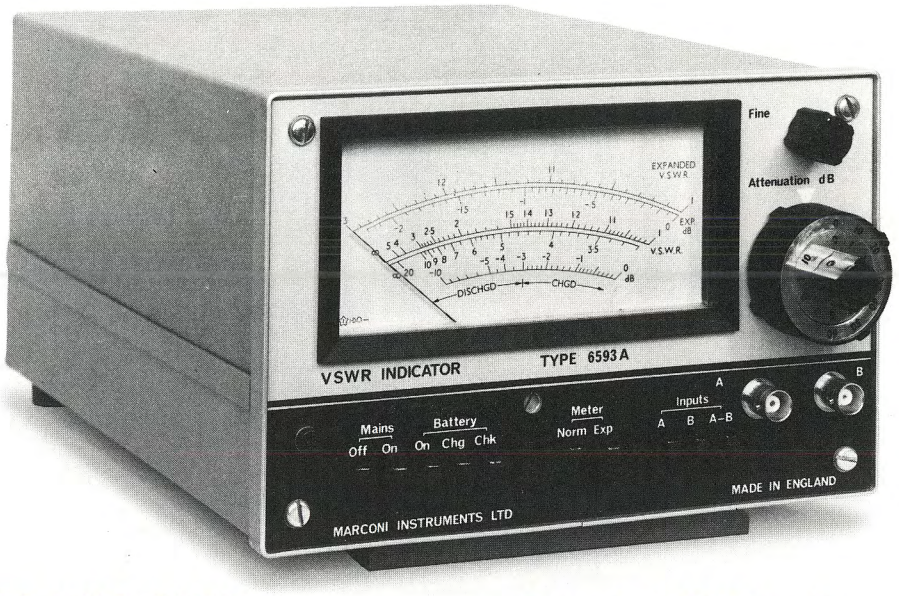
The unit is compact, light and robust, special attention having been given to convenience and ease of handling and servicing.

| | |
|---|---|
| **OUTPUT** | |
| **Voltage range** | −3 to −15 volts d.c. |
| **Current range** | 250 mA maximum |
| **Ripple** | Less than 1 mV p-p. |
| **Stability** | 10 mV maximum change in output voltage for ±10% mains voltage variation. |
| **MODULATION (Squarewave on/off)** | |
| **Frequency** | 1 kHz ±20% continuously variable. |
| **Amplitude** | 100%. |
| **Rise and fall** | Less than 5 µsec. |

| | |
|---|---|
| **MONITOR** | |
| **Voltage** | 0 to 25 volts (d.c. or peak squarewave). |
| **Current** | 0 to 250 mA (d.c. or squarewave average). |
| **POWER REQUIREMENTS** | |
| **A.C. mains** | 240 or 115 volts ±10% 50 to 60 Hz. |

| Height | Width | Depth | Weight |
|---|---|---|---|
| 98 mm ($3\frac{7}{8}$ in) | 203 mm (8 in) | 203 mm (8 in) | 2·15 kg ($4\frac{3}{4}$ lb) |

# VSWR Indicator 6593A




- ☐ **High sensitivity: 0·5 μV FSD**
- ☐ **Dual channel inputs**
- ☐ **Expanded VSWR scale**
- ☐ **70 dB attenuator**

The 6593A is a highly sensitive, tuned amplifier and metering system with a built-in 70 dB precision attenuator. The amplifier can be tuned to 1000 Hz ±200 Hz with a band width variable between 20 Hz and 100 Hz. The meter scales are calibrated for use with square law detectors and a rear-panel analogue output is provided.

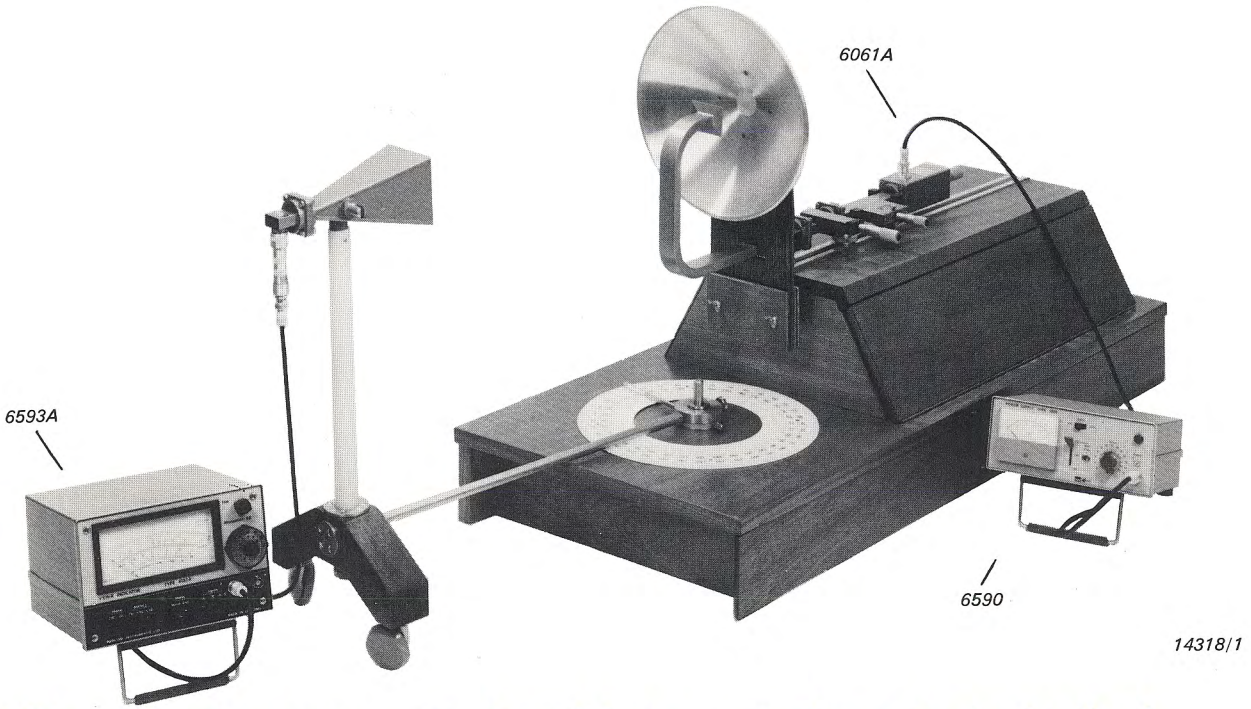
Two high impedance inputs A and B are provided to enable bridge measurements and accurate comparisons to be made. The input sensitivity of both channels is 0·5 μV RMS, FSD. A rear-panel bolometer input is also provided which has an input sensitivity of 0·15 μV RMS, FSD.

The EXPANDED VSWR scale is included to enable VSWR's between 1·01 and 1·3 to be measured with high resolution and an additional scale is provided to measure VSWR's up to 20:1.

The 6593A is an easily portable instrument lending itself to applications in the field and can be operated from an optional internal rechargeable battery pack which provides for 20 hours operation. A trickle charge on the batteries is supplied when the instrument is operating from the mains supply and the batteries can be fully recharged in 10 hours.

| | |
|---|---|
| **AMPLIFIER** | |
| **Inputs** | 2 channels, A and B. High impedance. 200 Ω Bolometer input, bias current 4·5 mA. |
| **Functions** | A, B, A-B, Bolometer. |
| **Frequency range** | 800 Hz-1200 Hz variable. |
| **Selectivity** | 20 Hz-100 Hz variable. |
| **Sensitivity** | 0·5 μV RMS for FSD on channels A and B. 0·15 μV RMS for FSD on Bolometer input. |
| **Noise level** | Below −10 dB level on meter at maximum sensitivity and bandwidth with high impedance input terminated in 50 Ω. |
| **Output** | Proportional to meter indication. 1 volt corresponding to f.s.d. Output impedance, 100 kΩ. |
| **ATTENUATORS** | |
| **Coarse** | 0 to 60 dB in steps of 10 dB ±0·1 dB/10 dB. From 0-10 dB ±0·5 dB. |
| **Medium** | 0 to 10 dB in steps of 1 dB ±0·05 dB/dB. |
| **Fine** | 0 to 1 dB continuously variable. |
| **METER SCALES** | |
| **VSWR** | 1·0 to ∞. 3·16 to ∞. |
| **Expanded** | 1·0 to 1·3. |
| **dB range** | 0 to −10 dB. |
| **Battery check** | Discharged/Charged. |
| **Meter calibration** | For square law detector. |
| **POWER REQUIREMENTS** | |
| **AC mains** | 115 or 230 V a.c. ±10% 50 to 60 Hz. |
| **DIMENSIONS AND WEIGHT** | Height Width Depth Weight<br>140·5 mm 202 mm 284 mm 2·64 kg<br>5·53 in 7·95 in 11·2 in 5lb 13oz |
| **OPTIONAL ACCESSORY** | |
| **2200186** | Internal rechargeable battery pack. Permits use up to 20 hours continuous operation. |

# Educational
# Antenna Test Bench 6452A/2




☐ **Wide variety of antennae** ☐ **Rugged design** ☐ **Comprehensive handbook**

The 6452A/2 is a unique equipment for the demonstration and evaluation of a range of typical microwave antennae. It enables the primary characteristics of the antennae, including gain and polar plots, to be determined with speed and accuracy. Seven different types of antennae are supplied as standard and have been selected to be representative of those found in practise. These include waveguide horns, dipole feed, horn feed, paraboloid antenna, narrow wall shunt slot linear array, broad wall shunt slot linear array and a dielectric end-fire antenna.

A complete set of mechanical parts is included so that each experiment can be constructed with ease.

Antenna gains are measured by comparing the gain of the unknown antenna with the gain of a standard horn for varying angles, measured by the protractor on the cabinet assembly.

Polar plots are measured by mounting the antenna under test on the cabinet assembly and the receiving horn at the end of the constant radius arm. Signal strength is monitored for varying angles of the receiving antenna.

The antennae are designed to operate at a frequency of 9·0 GHz with the exception of the linear arrays which operate at 9·375 GHz. All components are constructed in WG16 (R100), WR90 and are fitted with the internationally standardized square flanges.

In order to complete the Test Bench a microwave signal source, a power supply and an indicating instrument are required. For most applications the Gunn Diode Oscillator Type 6061A together with its Power Supply Type 6590 and VSWR indicator Type 6593A are recommended.

Further equipment from the wide catalogue range offered can be added to this Test Bench as the need arises and popular choices have been the Solid State Signal Source Type 6058B and the **tft** Power Meter Type 6555 with one of the range of 6440-6420 series **tft** Power Heads.

**A typical working system consists of the following items:**

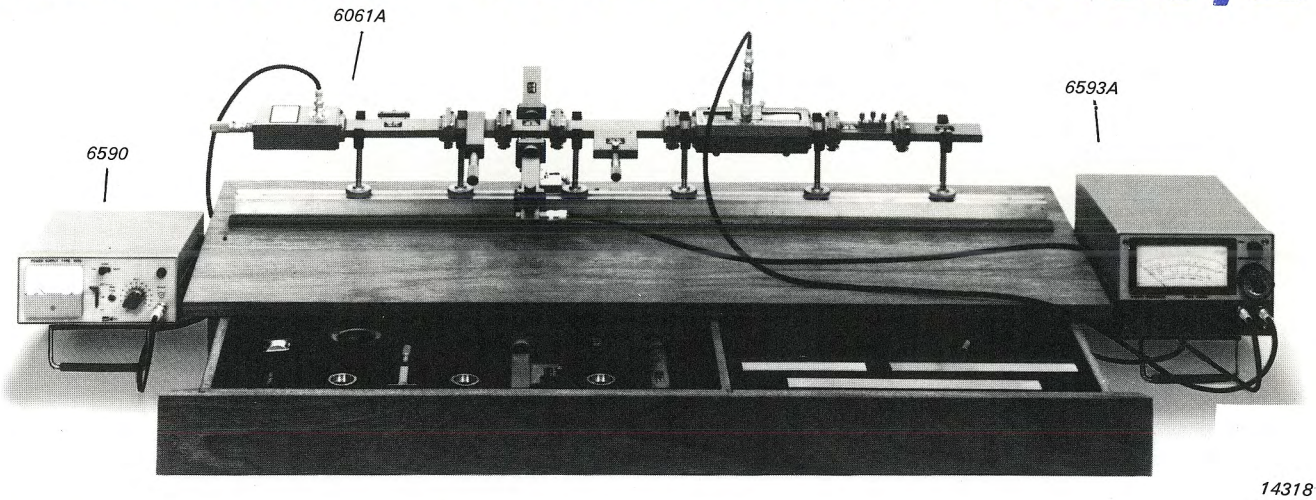
| | | |
|---|---|---|
| **Educational Antenna Test Bench** | **Type 6452A/2** | **Qty. 1** |
| **Gunn Diode Oscillator*** | **Type 6061A** | **Qty. 1** |
| **Power Supply*** | **Type 6590** | **Qty. 1** |
| **VSWR Indicator** | **Type 6593A** | **Qty. 1** |
| ***or Solid State Signal Source** | **Type 6058B/1** | **Qty. 1** |

The 6452A/2 consists of the following items:

| Designation | No. off | Description |
|---|---|---|
| Type 6042/3 | 3 | Waveguide Support Clip |
| Type 6036/4 | 1 | Waveguide Horn |
| Type 6027/3 | 1 | Waveguide Twist |
| Type 6005/4 | 1 | Variable Short Circuit |
| Type 6037/3 | 1 | Waveguide-to-Coaxial Transformer |
| Type 6017/2 | 1 | Wavemeter |
| Type 6020/4 | 1 | Variable Attenuator |
| Type 6019/4 | 1 | Calibrated Attenuator |
| Type 6002/1 | 1 | Coaxial Crystal Detector |
| — | 1 | Manual of Experiments |
| Part No. 2139024A | 1 | Coaxial Cable 1·22 m (4') (BNC/BNC Connectors) |
| Part No. 2452001 | 1 | Cabinet Assembly |
| Part No. 2452021 | 1 | Antenna Support |
| Part No. 2452048 | 1 | Slot Antenna Support Rod |
| Part No. 2452004 | 1 | Carriage |
| Part No. 2452011 | 1 | Horn Support Rod |
| Part No. 2452012 | 4 | Extension Rod |
| Part No. 2452042 | 3 | Waveguide Support |
| Part No. 2452043 | 3 | Waveguide Support Extension |
| Part No. 2452010 | 1 | Paraboloid Dish |
| Part No. 2452007 | 1 | Dish Adaptor |
| Part No. 2558006 | 1 | Dipole Feed |
| Part No. 2558005 | 1 | Horn Feed |
| Part No. 2452016 | 1 | Dielectric Antenna |
| Part No. 2558007 | 1 | Broad Wall Slot Antenna |
| Part No. 2558004 | 1 | Narrow Wall Slot Antenna |
| Part No. 2558002 | 1 | Pick-up Horn Antenna |
| Part No. 2558003 | 1 | Flanged Waveguide |
| Part No. 2558001 | 1 | Waveguide |
| Part No. 2558009 | 1 | WG Round to square flange adaptor |

Nett weight: 28 kg.

# Microwave Educational Test Bench 6599/2




14318

☐ **10 different experiments** ☐ **Comprehensive handbook—"Experimental Microwaves"**

☐ **Rugged design** ☐ **Audiotype cassette course "Understanding Microwave Equipment"**

The 6599/2 is a general purpose laboratory Test Bench incorporating WG16 (R100) microwave components and accessories. It is widely used for exhibiting basic microwave parameters and techniques.

Ten different experiments are suggested in a comprehensive handbook supplied and the equipment has been designed so that each component may be readily detached and substituted by suitable ancillary equipment housed in the drawer beneath the case.

A full description of each kind of component is included in the Instruction Manual and the experiments carried out include the study of attenuation, impedance, frequency and phase-shift.

A pair of horn antennae is included to enable students to study the basic characteristics of microwave radiation as well as being able to compare free-space wavelength with waveguide wavelength.

The large number of components included in this equipment leads to extreme versatility and other experiments may be devised in addition to those suggested in the Instruction Manual. The components selected are typical of those widely used in development and test departments throughout the microwave industry.

The 6599/2 is supplied with the internationally standardised square flanges.

In order to complete the Test Bench a microwave signal source, a power supply and an indicating instrument are required. For most applications the Gunn Diode Oscillator Type 6061A together with its Power Supply Type 6590 and VSWR Indicator Type 6593A are recommended.

Further equipment from the wide catalogue range offered can be added to this Test Bench as the need arises and popular choices have been the Solid State Signal Source Type 6058B and the **tft** Power Meter Type 6555 with one of the range of 6420 series **tft** Power Heads.

**A typical working system consists of the following items:**

| | | |
|---|---|---|
| **Microwave Educational Test Bench** | **Type 6599/2** | **Qty. 1** |
| **Gunn Diode Oscillator*** | **Type 6061A** | **Qty. 1** |
| **Power Supply*** | **Type 6590** | **Qty. 1** |
| **VSWR Indicator** | **Type 6593A** | **Qty. 1** |
| ***or Solid State Signal Source** | **Type 6058B/1** | **Qty. 1** |

The 6599/2 consists of the following items:

| Designation | No. off | Description |
|---|---|---|
| Type 6021/5 | 1 | Glass Vane Preset Attenuator |
| Type 6029/2 | 1 | Double Cruciform Directional Coupler |
| Type 6032/2 | 2 | Low Power Matched Load |
| Type 6017/2 | 1 | Direct Reading Guide-Wavelength Wavemeter |
| Type 6003/3 | 2 | Waveguide Detectors, including the necessary diodes, cables and connectors. |
| Type 6020/4 | 1 | Card Vane Variable Attenuator 0-20 dB. |
| Type 6019/4 | 1 | Glass Vane Precision Calibrated Attenuator 0-40 dB including calibration certificate. |
| Type 6009/2 | 1 | Standing Wave meter (slotted section) |
| Type 6002/1 | 1 | Coaxial Detector complete with necessary diode, cable and connectors. |
| Type 6006/2 | 1 | Variable 3-Stub Tuner |
| Type 6036/4 | 2 | Waveguide Horns |
| Type 6005/4 | 1 | Variable Short Circuit |
| Type FG16-6" | 1 | 6-inch Section Flexible Waveguide |
| Type 6478 | 1 | Square-to-round Flange Adaptor |
| Type 6022/4 | 1 | Variable Phase Shifter |
| Type 6025/3 | 1 | E-Plane Bend |
| Type 6026/4 | 1 | H-Plane Bend |
| Part No. 2415001 | 1 | 17.1/2° Waveguide Twist |
| Part No. 2139014-6" | 1 | Sections of straight waveguide |
| Part No. 2139013-9" | 1 | |
| Part No. 2139012-12" | 1 | |
| Part No. 2139004 | | Waveguide Support Assemblies comprised from Part Numbers quoted |
| Part No. 2139005 | 6 | |
| Part No. 2139006 | | |
| Part No. 2139007 | | |
| Part No. 2139003 | 1 | 3' 6" Extruded Waveguide Support Rail |
| — | 1 | "Experimental Microwaves"—a detailed instruction book, listing microwave theory and suggested experiments. |
| | 1 | "Understanding Microwave Equipment" – a clear audio tape course giving details of microwave systems. |
| Part No. 2139001 | 1 | Polished Wood Storage Base |

Nett weight: 27 kg.

# Microwave Sweep Oscillator 6600A/1




11504/3

- ☐ **Frequency range 200 MHz to 110 GHz**
- ☐ **Low residual f.m.**
- ☐ **Front entry plug-in oscillator units**
- ☐ **Diode levelling to 18 GHz**
- ☐ **Comprehensive modulating and programming facilities**
- ☐ **Calibrated 100% symmetrical sweep**
- ☐ **IEEE-488 or IEC control using GPIB Adaptor type 6140**

The 6600A/1 is a versatile microwave sweeper which utilises plug-in oscillator units to achieve the very wide total frequency range of 200 MHz to 110 GHz. Each oscillator unit has its own directly calibrated frequency scale, easily fitted to the instrument front panel, giving a clear indication of end limit and marker frequency settings. Two pairs of controls adjacent to the frequency dial set, respectively, the sweep limit frequencies and the positions of two frequency markers, the setting of each of these four controls being indicated clearly by a sliding cursor type pointer. The respective roles of the pairs of controls are interchangeable and are determined by the position of the Function Selector switch.

All plug-in RF units incorporate a levelling amplifier which is connected either to the appropriate grid of the BWO tube or to a Pin Diode Modulator, where fitted. Thus, with a suitable wideband coupler and detector to complete a negative feedback loop, RF power may be levelled across the operating frequency range. External couplers and detectors may be used with all units but some types have these items internally. (See Table).

Provision is also made for operation in the levelled mode using an external directional coupler and thermistor power meter, the DC output from the thermistor bridge being fed back to the detector input socket. When the system is set for use with a power meter, the time constants in the feedback amplifier are adjusted to accommodate the slower system response to prevent instability.

The 6600A/1 offers excellent frequency stability since the power supplies have been designed so that the ripple, noise and line regulation components are so low that minimal residual FM is produced.

For the plug-in units operating between 1 and 40 GHz the instrument offers a 'blanket' residual FM specification of 2 p.p.m. peak. In addition, the line regulation is kept to ±5 p.p.m. maximum for ±10% change in line voltage.

For applications where minimal frequency pulling during the levelling mode is required many plug-ins are offered with a Pin Diode Modulator. When the unit is being operated under the internal levelling mode the RF output power is levelled at the front panel output connector. The minimum power output specifications quoted in the table of plug-in oscillator units refer to power available at the front panel socket or waveguide flange over the whole of the frequency range concerned.

In applications where the ultimate frequency stability is required, it is desirable to be able to phase lock the sweeper to a crystal oscillator. Commercially available frequency synchronisers can be used in this way to develop the correction signal as a function of the phase difference between the sweeper output and a harmonic of a crystal oscillator.

This correction signal may be applied to the FM input socket which is DC coupled to the BWO helix. Input bandwidth of the external F.M. input is in excess of 5 MHz for BWO units operating between 1 and 40 GHz. Holding the frequency stability of the microwave source to that of the crystal oscillator may be achieved using phase lock techniques.

The 6600A/1 sweep oscillator is compatible with commercially available pen recorders, display oscilloscopes and network analysers. High accuracy measurements can be made using the inherent stability and frequency accuracy available from the 6600 series.

## Millimetre Wave Sweeper System




Plug-ins operating in frequency bands between 33 – 110 GHz are available using a specialised millimetric BWO and all the important features of the sweep oscillators are retained.

Since the BWO tubes will not fit into the normal plug-in a separate RF head unit is supplied which contains the tube and a blower unit. The appropriate electrical supplies to the tube are carried on a multi-core cable which is connected to a front panel socket of the plug-in.

Millimetric Sweep Oscillators have many applications including long haul circular waveguide transmission systems and microwave spectroscopy.

All specifications for the 6600A/1 apply with the following minor exceptions:

| | |
|---|---|
| **FREQUENCY STABILITY** | |
| **Residual FM** | 20 ppm typical. |
| **MODULATION** | |
| **External AM** | Rise time 1 millisecond max.<br>Fall time 0·2 microsecond max. |
| **External FM** | Direct coupled input limited to 300 kHz bandwidth by cable. |

| | |
|---|---|
| **RESIDUAL AM** | Typically 20 dB below rated output. |

**DIMENSIONS AND WEIGHT**

| | Height | Width | Depth | Weight |
|---|---|---|---|---|
| **RF Head** | 230 mm<br>9 in | 280 mm<br>11 in | 340 mm<br>13½ in | 12 kg<br>26 lb |

# 6600A/1

## Specification for 6600A/1

| | |
|---|---|
| **FREQUENCY** | |
| Frequency range | Determined by r.f. unit installed. |
| Frequency accuracy | BWO units ±1%; others ±1·5%. |
| Frequency linearity | Same as Frequency Accuracy. |
| **SWEEP PRESENTATION** | |
| End limit | Between any two frequencies in band. |
| Marker end limit | Between any two frequencies in band. |
| Symmetrical | Calibrated and adjustable from 0-100% of the total frequency band. Calibrated width accuracy ±10%. Centre frequency can be centred on the position of the M1 indicator or on a frequency set by a remote potentiometer. |
| External | Direct coupled 20 volts for full sweep, positive voltage increasing r.f. frequency. Response time: 200 microseconds for full sweep with increasing frequency and 2 milliseconds for full sweep with decreasing frequency. Provision for external resistance programming. |
| CW operation | Four independent single frequencies, calibrated and continuously variable. |
| **MARKER** | Two independent adjustable markers displayed either as dips in r.f. output or externally as video markers. |
| Accuracy | BWO units ±1%; others ±1·5%. |
| Resolution | Less than 0·05% of sweep range. |
| Amplitude | Continuously variable. |
| Output | Auxiliary video marker, amplitude 5 volts. |
| **SWEEP RATE** | |
| Automatic | Decade from 10 seconds/sweep to ·01 seconds/sweep with vernier 10 to 1 continuously variable prolongation. |
| Manual | The r.f. output frequency can be manually swept between the limits set in the end limit of symmetrical sweep mode. |
| **TRIGGERED SWEEP** | |
| Internal | Recurrent. |
| Line | At supply frequency. |
| External | 10 volts input with 1 microsecond minimum duration. |
| Manual | Front panel push-button. |
| **SWEEP DWELL TIME** | Delay in the start of sweep long enough to allow the r.f. power level to stabilise. |
| **SWEEP OUTPUT** | Direct coupled, adjustable from 0 to 15 volts peak. |
| Sweep-On indicator | An indicator is lit during the forward direction of sweep and is off at all other times. |

| | |
|---|---|
| **PROPORTIONAL OUTPUT** | Direct coupled voltage proportional to instanteous frequency; 0 volts at low end and +18 to +42 volts (pre-settable) at high end. |
| **BLANKING OUTPUT** | 5 volts negative |
| **PEN LIFT OUTPUT** | Relay contact closure during forward trace portion of sweep. |
| **BASE LINE** | Switch selects r.f. ON or OFF during retrace. |
| **FREQUENCY STABILITY** | |
| Residual FM | BWO Units: 2 ppm peak. Others: 10 ppm typical. |
| Line regulation | ±5 ppm maximum for a ±10% change in line voltage. |
| **LEVELLED RF OUTPUT** | Internal feedback amplifier maintains output power variation to within 0·1 dB plus coupler and detector variation. When operated with internal directional detector, total power variation is as indicated in the table opposite. Optional use with external directional coupler and r.f. crystal detector or r.f. power meter. |
| **MODULATION** | |
| Internal AM | Square wave modulation adjustable from 950 to 1050 Hz. |
| External AM | 20 volt positive signal increases r.f. output to maximum. Rise and fall times are 0·1 microsecond unlevelled and approximately 10 microseconds levelled. |
| External FM (BWO units only) | Direct coupled input provides frequency response in excess of 5 MHz. |
| **RESIDUAL AM** | 40 dB below rated r.f. output. |
| **SPURIOUS SIGNALS** | Non-harmonics 40 dB below rated r.f. output; harmonics 20 dB below rated r.f. output. |
| **DIMENSIONS AND WEIGHT** | |
| Basic unit | Height 222 mm (8¾ in) Width 438 mm (17¼ in) Depth 534 mm (21 in) Weight 20·4 kg (45 lb) |
| Plug-in oscillators | 130 mm (5⅛ in) 178 mm (7 in) 457 mm (18 in) 5·4 to 8·1 kg (12 to 18 lb) |
| **POWER REQUIREMENTS** | |
| A.C. mains | 210 to 250 volts or 105 to 125 volts 50 to 65 Hz, approx. 150 VA. |
| **ACCESSORIES** Optional | A wide range of waveguide and coaxial instruments and components is available for use in swept test systems. Please enquire for further details specifying frequency ranges of interest. |
| 6652 | Storage Unit for plug-in oscillators. |

# Plug-in Oscillator Units

| | | GRID LEVELLED Internal directional detector | | | | DIODE LEVELLED Internal directional detector | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Without | With | | | Without | With | | | |
| Frequency Range (GHz) | Min.[1] Power Output (mW) | Type | Type | Levelled Power Variation (dB) | Min.[1] Power Output (mW) | Type | Type | Levelled Power Variation (dB) | Tube | Output Connector |
| 0·2–0·4 | — | — | — | — | 20 | 6601 | — | — | VTM | 50 Ω Type N Female |
| 0·25–0·5 | — | — | — | — | 50 | 6602 | — | — | VTM | 50 Ω Type N Female |
| 0·35–0·7 | — | — | — | — | 100 | 6603 | — | — | VTM | 50 Ω Type N Female |
| 0·4–1·2 | — | — | — | — | 20 | 6604 | — | — | VTM | 50 Ω Type N Female |
| 0·5–1·0 | — | — | — | — | 100 | 6605 | — | — | VTM | 50 Ω Type N Female |
| 1–2 | 100 | 6608 | 6609 | ±0·3 | 60 | 6610 | 6611 | ±0·3 | BWO | 50 Ω Type N Female |
| 1·4–2·5 | 100 | 6612 | 6613 | ±0·3 | 60 | 6614 | 6615 | ±0·3 | BWO | 50 Ω Type N Female |
| 1·7–4·2 | — | — | — | — | 15 | 6618 | 6619 | ±0·5 | BWO | 50 Ω Type N Female |
| 2–4 | 80 | 6620 | 6621 | ±0·2 | 40 | 6622 | 6623 | ±0·5 | BWO | 50 Ω Type N Female |
| 3·5–6·75 | 40 | 6624 | 6625 | ±0·5 | 25 | 6626 | 6627 | ±0·5 | BWO | 50 Ω Type N Female |
| 3·7–8·3 | — | — | — | — | 8 | 6630 | 6631 | ±0·5 | BWO | 50 Ω Type N Female |
| 4–8 | 30 | 6632 | 6633 | ±0·5 | 20 | 6634 | 6635 | ±0·5 | BWO | 50 Ω Type N Female |
| 7–11 | 25 | 6636 | 6637 | ±0·5 | 10 | 6638 | 6639 | ±0·5 | BWO | 50 Ω Type N Female |
| 7–12·4 | 25 | 6640 | 6641 | ±1·0 | 10 | 6642 | 6643 | ±1·0 | BWO | 50 Ω Type N Female |
| 8–12·4 | 50 | 6644 | 6645 | ±0·75 | 25 | 6646 | 6647 | ±0·75 | BWO | 50 Ω Type N Female |
| 10–15·5 | 20 | 6648 | — | — | 10 | 6657 | — | — | BWO | Square flange |
| 12·4–18 | 40 | 6649 | — | — | 15 | 6653 | — | — | BWO | Square flange |
| 18–26·5 | 20 | 6650 | — | — | — | — | — | — | BWO | Square flange |
| 26·5–40 | 10 | 6651 | — | — | — | — | — | — | BWO | Square flange |
| 4·8–9·7 | 20 | 6658 | — | — | — | — | — | — | BWO | 50 Ω Type N Female |
| 8–16 | 12 | 6666 | — | — | — | — | — | — | BWO | 50 Ω Type N Female |
| 8–18 | 8 | 6667 | — | — | — | — | — | — | BWO | 50 Ω Type N Female |
| 10–20 | 4 | 6668 | — | — | — | — | — | — | BWO | 50 Ω SMA Female |
| 15–22 | 5 | 6670 | — | — | — | — | — | — | BWO | Square flange |
| 2–4·5 | — | — | — | — | 30 | 6673 | 6674 | ±0·5 | BWO | 50 Ω Type N Female |
| 7–13 | 12 | 6676 | — | — | — | — | — | — | BWO | 50 Ω Type N Female |
| 7–16 | 12 | 6677 | — | — | — | — | — | — | BWO | 50 Ω Type N Female |

OTHER BANDS CAN BE OFFERED AS BWO BECOME AVAILABLE.

**MILLIMETRIC OSCILLATOR UNITS**

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 40–60 | 12 | 6654 | — | — | — | — | — | — | BWO | Round flange |
| 60–90 | 6 | 6655 | — | — | — | — | — | — | BWO | Round flange |
| 33–50 | 25 | 6659 | — | — | — | — | — | — | BWO | Found flange |
| 50–75 | 8 | 6671 | — | — | — | — | — | — | BWO | Round flange |
| 75–110 | 3 | 6672 | — | — | — | — | — | — | BWO | Round flange |

1. Minimum Power Output refers to that available at the front panel socket or waveguide flange over the whole of the frequency range concerned. Power is 1 dB less when an internal directional coupler is fitted.

# Microwave Signal Generator 6812




- ☐ **Fast frequency switching**
- ☐ **Internal/external am/fm modulation**
- ☐ **Fast pulse capability**
- ☐ **IEEE-488 Data Bus Programming**
- ☐ **Good harmonic and noise performance**
- ☐ **Wide range attenuator**

The 6812 microwave synthesized solid state signal generator covers the 8·0 to 12·4 GHz band in a compact, standard 19" size.

This new generator provides one of the most versatile, calibrated, fully screened microwave X-Band sources available today.

The main features of this generator are the fast frequency switching speed (less than 15 millisecond for full X-Band frequency step) and the wide range of internal and external amplitude and frequency modulation together with full band sweeping facility. These can be controlled via the front panel and also via the GPIB Bus interface for in-house ATE requirements.

## Operation

The 6812 synthesizer range uses a YIG tuned oscillator and filter to provide a stable pure microwave signal which is referenced back to an internal oven controlled crystal oscillator. The microwave signal is mixed with a comb line selected by the YIG filter, the video signal being down converted and locked to the low frequency synthesizer. In the FM and sweep modes, both narrow band and wide band, the low frequency synthesizer output is locked and the microwave start or centre frequency is referenced to this signal, modulation can then be applied to allow up to full band frequency deviation at up to 100 Hz rate; or for operation at up to 1 MHz rate lower deviations are possible.

## RFI screening

Each block within the instrument is fully screened on all power and signal lines as well as r.f. screened from one another. Although full screening has been used within the instrument, clever design allows the instrument to hinge into two areas for extremely easy maintenance. The power supplies feature full protection which give front panel indication of fault conditions as well as instrumentation switch off in the unlikely event of a fault occurring.

## RF output

Output power is controllable from +3 dBm to −119 dBm using a step attenuator and fine vernier, power level being displayed on a $2\frac{1}{2}$ digit LED display, resulting in excellent resettability. The higher power output achieved is the direct result of careful r.f. output line design which allows +3 dBm minimum power at the front panel whilst still providing 75 dB modulation as a standard feature built into the instrument. In the unlevelled mode up to 8 mW is available.

## Modulation

All the AM and FM features are independent, allowing full control of the signal in any mode. Internal AM provides both square wave and pulse over 10 Hz to 100 kHz with 10 ns rise and fall, with widths from 0·1 µs to 100 ms.

External AM is available for both external detector input on the front panel and external pulse input on the rear panel. Internal sweep is provided to give deviations from 100 kHz to full band in six ranges at sweep rates from 0·01 s to 100 s. External FM and sweep use the same six ranges and allow modulation in the non-synthesized, but locked, mode. Deviation which is linear with input voltage, is displayed on the front panel analogue meter.

## Readouts

In addition to the 7 digit LED display of frequency, the 2½ digit LED display of power level and the analogue meter for power calibration FM or sweep deviation, the instrument contains indicators to inform the user of the status of the generator. On plugging the instrument into the power socket, the OVEN light is illuminated to indicate the standby condition, as well as indication of the crystal oven warm up.

Once the main switch is closed then the following status are indicated:

(i) ALC – levelled state
(ii) SYNTH – lock – unlocked state
(iii) SWEEP – non-synthesized mode for wide deviation
(iv) FM – non-synthesized mode for narrow deviation
(v) TRIP – fault condition – instrument automatically shutdown.

## Programming

The instrument is compatible with standard bus control equipment (GPIB Bus) to give programming of frequency and power level together with r.f. on/off, external pulse AM enable, external FM enable, FM deviation.

### FREQUENCY

| | |
|---|---|
| Range | 8·0 to 12·4 GHz. Overrange is possible in programming mode to reduced specification in range 7·95 to 12·45 GHz. |
| Indicator | 7 digit LED. |
| Resolution | 10 kHz. |
| Time base (Internal) | 10 MHz. |
| Ageing Rate | $1\times10^{-8}$/day. $5\times10^{-8}$ after 5 minutes from switch on. |
| (External) | 10 MHz TTL input on rear panel. |
| Switching Time | <15 ms to be within 10 kHz of final frequency for 5 GHz step. |

### SPECTRAL PURITY

| | |
|---|---|
| Harmonic | Better than −45 dBc. |
| Spurii | Better than −60 dBc at greater than 10 kHz from carrier. |
| Phase Noise | −55 dBc at 100 Hz.<br>−65 dBc at 1 kHz.<br>−70 dBc at 10 kHz.<br>−90 dBc at 100 kHz in the SSB in 1 Hz, CW mode. |

### OUTPUT

| | |
|---|---|
| Power | Up to +9 dBm unlevelled.<br>+3 to −119 dBm levelled & calibrated. |
| Indicator | 2½ digit LED display, analogue meter for calibration position for external detector. |
| Levelled Accuracy | At 0 dBm ±2·0 dB. |
| 10 dB switch | At −10 dBm ±2·5 dB.<br>At −20 dBm ±2·7 dB.<br>Below −30 dBm ±2·0 dB ±0·3 dB/10 dB. |
| 1 dB switch | ±0·5 dB incremental worst error ±1 dB/10 dB. |
| Switching Time | 10 dB increment 20 ms.<br>1 dB increment 10 µs. |

### AMPLITUDE MODULATION – INTERNAL PULSE

| | |
|---|---|
| Prepulse | TTL output 200 ns advance approx. |
| Pulse Repetition Frequencies | 10– 100 Hz.<br>100–1000 Hz.<br>1– 10 kHz.<br>10– 100 kHz. |
| Pulse Rise and Fall | 10 ns. |
| Pulse Depth | 75 dB min. |
| Pulse Widths | ·1– 10 µs<br>10– 100 µs 1– 10 ms<br>100–1000 µs 10–100 ms |

### AMPLITUDE MODULATION – INTERNAL SQUAREWAVE

| | |
|---|---|
| Squarewave | 1 kHz ± 10% variation. |
| Rise and Fall | 10 ns. |
| Pulse Depth | 75 dB min. |

### AMPLITUDE MODULATION – EXTERNAL SQUAREWAVE

| | |
|---|---|
| Input | Squarewave or pulse. |
| Drive | TTL. |
| Range | 10 Hz to 100 kHz. |
| Rise and Fall | 10 ns. |
| Depth | 75 dB min. |

### AMPLITUDE MODULATION – EXTERNAL LINEAR

| | |
|---|---|
| Linear Depth | Up to ± 10 dB. |
| Drive | 10 mW per V. |
| Rise and Fall | 5 µs. |

### FREQUENCY MODULATION – INTERNAL FM OR SWEEP MODE

| | |
|---|---|
| Indicator | Meter (indicated accuracy ±5%). |
| Sensitivity | Range 1 MHz to 500 MHz/V (internal sweep). 6 Ranges ±100 kHz/V to ±5 GHz/V continuously variable (external FM/Sweep). |
| FM/Sweep 3 dB Bandwidth | 100 kHz up to ±100 MHz/V deviation. |
| FM Drift | 5 MHz/hour. |
| FM Residual | 25 kHz rms. |

### POWER REQUIREMENTS

| | |
|---|---|
| AC Supply | 375 VA (240 V 50 Hz or 115 V 60 Hz nominal, internal switch). |

### DIMENSIONS AND WEIGHTS

| Height | Width | Depth | Weight |
|---|---|---|---|
| 161 mm | 427 mm | 567 mm | 30 kg |

### ENVIRONMENTAL

| | |
|---|---|
| Temperature Range | storage −40 to +70°C.<br>operating 0 to +50°C.<br>full specification 10 to +35°C. |
| | Meets IEC 348 Safety. |
| | Meets MIC 1070 General: |
| | Vibration 3 axes 1 g 10 hrs. |
| | Shock 6 axes 200 bumps. |
| | Humidity 35°C 95% RH Full Spec.<br>40°C 95% RH 14 day storage. |

### PROGRAMMING

Via IEEE −488 Interface BUS Control:
Frequency 10 kHz steps.
Output level 10 dB and 1 dB steps.
Carrier on, await lock.
Modulation AM, 1 kHz pulse, FM Sweep.
ALC internal or external.
FM/Sweep deviation 1 MHz–5 GHz.

# Power Sensor 6910

- ☐ Semiconductor thermocouple element
- ☐ 10 MHz – 18 GHz coverage
- ☐ High overload capability
- ☐ Wide Dynamic Range –30 to +20 dBm
- ☐ Field Replaceable element
- ☐ Low VSWR



This new Sensor using the resources of the GEC Group is designed for RF and microwave measurements. Combining a robust, reliable thermocouple element with high overload capability in a field replaceable module, with an FET chopper and amplifier, the 6910 provides a stable, accurate power sensor suitable for use with the 6950 and 6960 range of Power Meters.

The 6910 has a low VSWR (typically 1·18:1 over 2 to 12·4 GHz) and is fitted with a precision N (m) type 50 ohm connector for RF connection and a multiway socket for cable connection to the power meter. The sensor has a robust mechanical construction with an overload level up to 300 mW average, 15 W peak.

*Sensors for other power and frequency ranges are being investigated for the 6910 series.*

# Power Meter 6950

- ☐ Power Calibrator
- ☐ Unique Sensor/Scale arrangement
- ☐ 1·5% instrumentation accuracy
- ☐ Low cost and portable with battery option




The 6950 is a new analogue power meter designed to work with the 6910 series of Power Sensors. Initially 10 MHz – 18 GHz coverage is available with sensitivity range –30 to +20 dBm.

The power meter displays in dBm, 0 – 10 or 0 – 3 ranges the true mean power absorbed by the head. Signals may be AM, FM, pulse or CW. The meter has a mirror scale for anti parallax viewing.

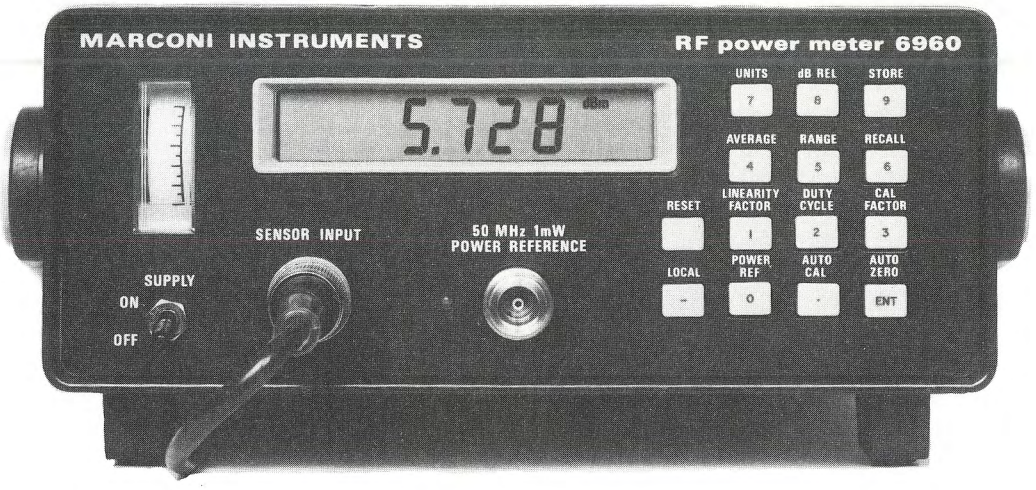
Power sensors are supplied with a magnetic scale which locates on the range selection switch to give unambiguous full scale values in both mW and dBm. Cable length between sensor and meter can be up to 200 foot. Drift and noise are ±0·5% on most sensitive scale.

Zero and calibration are manually adjusted from the front panel using a screwdriver. Response time is adjustable using a rear panel control.

The internal calibrator provides 1 mW at 50 MHz factory set to ±0·7% traceable to NPL via a precision 50 ohm type N connector.

The Optional rechargeable Battery pack fits inside the case making the power meter completely portable and can be recharged via the 6950 or can be easily removed via the top cover.

# Automatic Power Meter 6960




- ☐ Auto Range
- ☐ Auto Calibration
- ☐ 3 modes: dBREL, dBm, mW
- ☐ Power Accuracy linearity correction
- ☐ Non Volatile Memory
- ☐ Instrument Setting Storage
- ☐ Full GPIB Compatability
- ☐ Averaging Time Selection
- ☐ Auto zero
- ☐ Long lead Operation
- ☐ Duty Cycle correction

The new 6960 microprocessor controlled power meter offers several advantages over existing designs. Modern technology offers calibration factors to be automatically entered via the front panel keyboard or via the GPIB. The unique auto zero control offers infinite hold and elimination of zero carryover errors and by being able to vary the time averaging, faster operator controlled response times can be obtained. The meter will send error messages (SRQ) via the GPIB and has a unique linearity correction for power accuracy. Up to 9 Instrument settings can be stored via the front panel and are held in non-volatile memory. Peak power measurements can be made by entering the duty cycle via the keyboard.

The 6960 automatically monitors which head in the 6910 series is being used. A 50 MHz, 1 mW calibrator is provided on the front panel, factory preset to ±0·7% traceable to NPL. The instrumentation accuracy is ±0·5% with negligible zero carryover. Noise is 0·5% full scale on most sensitive range. The response time may be operator adjusted from 2 ms to 10 sec.

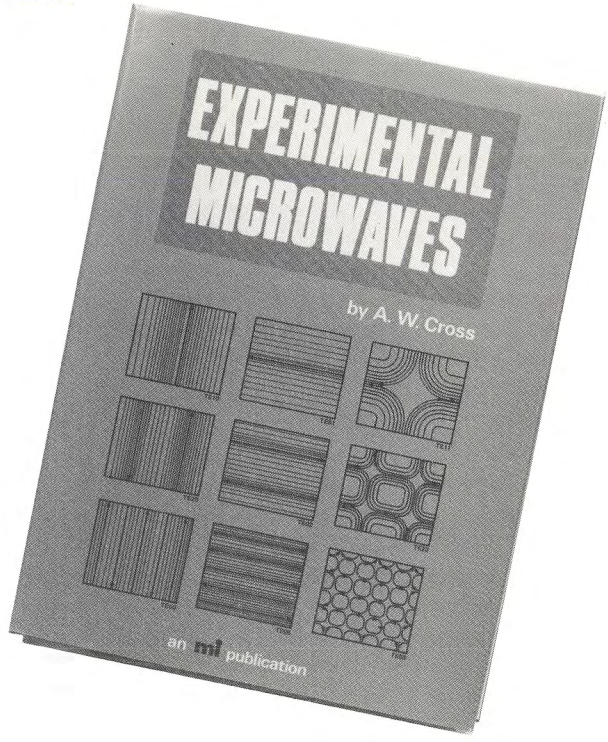
The LCD display shows power, mode, GPIB status and ranging information. A peaking meter is included for trimming use. GPIB operation or battery pack are optional fittings. Standard sensor cable length is 5 feet but can be up to 200 feet whilst still meeting full specification.

A rear panel socket provides a dc level proportional to input power and has the microprocessor controlled functions of autozero, auto calibration and linearity correction.

The 6960 offers sensitivity, speed, accuracy as well as flexibility and ease of use for modern microwave engineering.

# Microwave Educational Publications

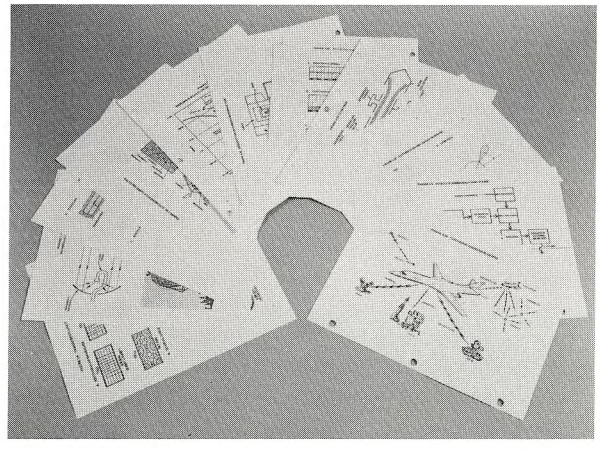
## EXPERIMENTAL MICROWAVES




The author deliberately avoids the use of pages and pages of theoretical mathematics in order to minimise confusion. The only equations used, and explained, are those considered necessary for the understanding of propagation problems in waveguides. Instead, the book concentrates on the physical aspects of microwaves – what actually happens rather than what should happen. In this way the book reinforces the theoretical knowledge gained in training centres with a practical knowledge of the subject.
The first half of the book describes in fundamental terms what is happening as a signal propagates down a waveguide. The second part consists of a series of experiments designed to illustrate measurement techniques and give practical explanations of the formulae used. The final section contains tables useful to microwave engineers.

## UNDERSTANDING MICROWAVE EQUIPMENT

This audio tape course comes complete with six cassette tapes and binder of notes and drawings. The course covers microwave principles, devices, components and systems and is complementary to Marconi Instruments Educational Test Benches. The combination is of use in teaching students in colleges and universities as well as updating or retraining technicians and apprentices in Industry. The six sessions cover:-



* Survey – e.m. spectrum and uses.
* Transmission lines – matching, ferrites, multiplexers.
* Solid State Sources – 2 and 3 terminal devices including FETs, Gunn, Impatt and Trapatt diodes.
* Tubes – Gridded devices, klystrons, TWT's, CFA's, gyrotrons, BWO's and magnetrons.
* Low Noise Receivers – Noise consideration, paramp, FET amp.
* Systems – Radio relay, ECM, CW, Pulsed and Doppler radars. MTI pulse compression techniques.

# Microwave Components

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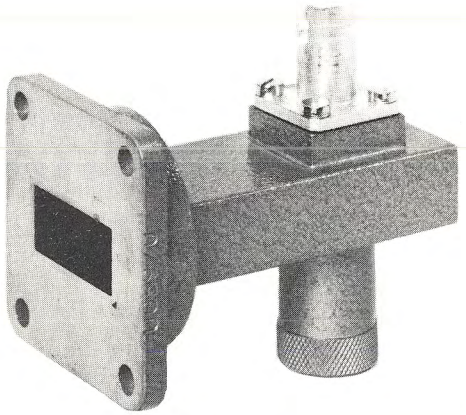

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# Microwave Components

## Broad Band Detector 6000/3

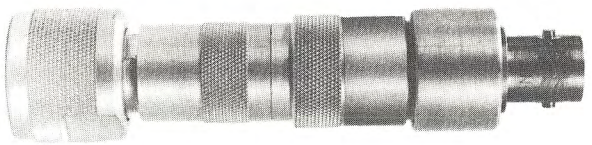


The 6000/3 is fitted with a BNC video output connector. A ridge insert is employed to flatten the impedance change normally experienced over the waveguide frequency band, thus improving the VSWR to better than 2:1 over the band.

| Type No. | Frequency range in GHz | Flange fitted | Diode | Length | Height | Weight | Waveguide size |
|---|---|---|---|---|---|---|---|
| 6000/3 | 8·2 to 12·4 | Square UG39/U | CV2154 CV2155 | 63·5 mm (2·50 in) | 57·9 mm (2·28 in) | 0·17 kg (6 oz) | R100 (WG16) |

*NOTE: Detector, 6000/3 is supplied less diode, but those specified are availbale at extra cost.*

## Coaxial Detector 6002/1



The 6002/1 is a low priced general purpose coaxial diode detector for use at frequencies from 200 MHz to 12 GHz. It is fitted with a Type N connector and the output socket is BNC, 50 ohms.

The performance of this detector unit is largely a function of the characteristics of the diode fitted; type numbers of suitable diodes are given in the specification. Owing to the very wide frequency cover, certain limitations are imposed on the detector units' operating characteristics. These take the form of variations in the r.f. input impedance – nominally 50 ohms – and restrictions of the video output bandwidth by the 25 pF shunt capacitance of the r.f. filter.

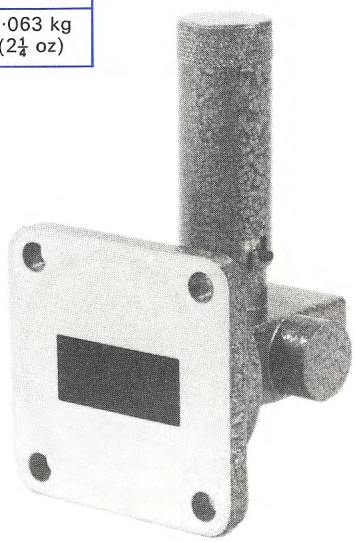
Reflected power does not, however, normally exceed −5 dB, the matching being assisted by a 50 ohms disc resistor at the input end. This resistor also provides a d.c. return circuit for the diode current should this not be present in the associated equipment.

For precision measurements in the band 10 MHz to 18 GHz Wideband Detectors 6160 series are also available.

| Type No. | RF input connector | Frequency range | Internal DC return | Type of diode required | Length | Width | Weight |
|---|---|---|---|---|---|---|---|
| 6002/1 | N Male | 200 MHz to 12 GHz | Yes | CV2154 CS9B CV2155 | 81·8 mm (3·22 in) | 19·0 mm (0·75 in) | 0·063 kg (2¼ oz) |

*NOTE: Detector 6002/1 is supplied less diode, but those specified are available at extra cost.*

## Waveguide Detector 6003/3



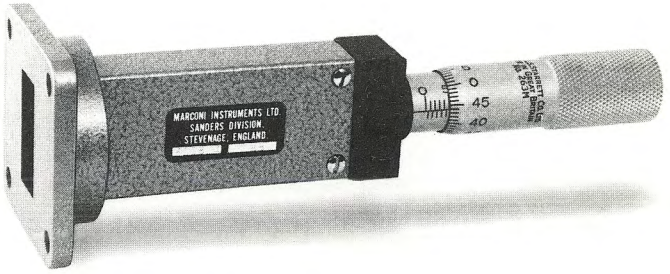
The 6003/3 detector is available with a modified Belling-Lee coaxial terminal on the video output port.

The detector, in waveguide size R100 (WG16), is fixed tuned, and has a VSWR of better than 2:1 over a 10% band centred on 10 GHz with the majority of CV2154 and CV2155 diodes.

| Type No. | Frequency range in GHz | Flange fitted | Diode | Length | Height | Weight | Waveguide size |
|---|---|---|---|---|---|---|---|
| 6003/3 | 8·5 to 12·4 | Square UG39/U | CV2154 CV2155 | 39·4 mm (1·55 in) | 50·0 mm (1·97 in) | 0·17 kg (6 oz) | R100 (WG16) |

*NOTE: Detector, 6003/3 is supplied less diode, but those specified are availbale at extra cost.*

## Short Circuit 6005/4



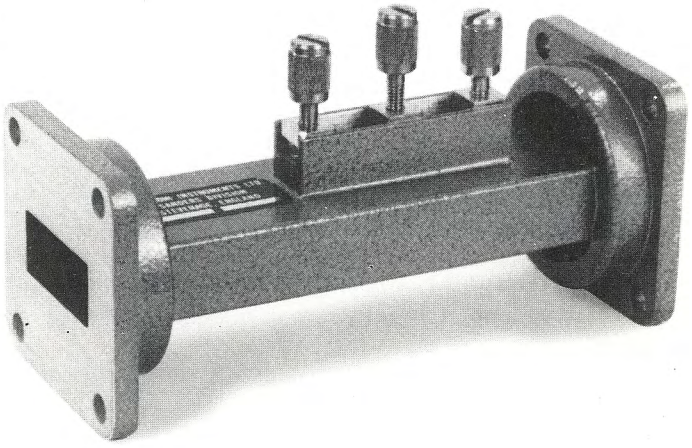

The variable short circuit has been designed to provide an extremely high standing wave ratio, typically greater than 50 dB (i.e. reflection coefficient greater than 0·994) over the entire waveguide frequency range.

The plunger is of the non-contacting type and employs low-high-low impedance sections. The back cavity is heavily damped with lossy material.

Adjustment of the short circuit is made with a micrometer head, enabling the plunger position to be determined to within 0·005 cm.

| Type No. | Frequency range in GHz | S.W.R. | Flange fitted | Height | Weight | Waveguide size |
|---|---|---|---|---|---|---|
| **6005/4** | 8·2 to 12·4 | 50 dB | Square UG39/U | 15·32 mm (6·03 in) Max. | 226·8 g (8 oz) | R100 (WG16) |

## Waveguide Stub Tuner 6006/2



This tuner consists of a standard rectangular waveguide on to which is mounted a block carrying three spring-loaded and choked screws spaced about three-eights of a waveguide wavelength apart at the band centre. Knurled knobs enable the screws to be moved easily. The whole block is mounted nearer one flange than the other, so that when the tuner is reversed the screw positions are changed. There are occasions when moving the screws to another point in the waveguide enables the adjustments required to be made with greater ease.

The tuner is suitable for general laboratory use where matches of up to about 10:1 are required to be reduced to a reasonable value. It is widely used in education for experiments on matching techniques or for producing arbitrary mismatches. It can also be used to minimize the VSWR of a waveguide system in order to reduce the uncertainties, thereby improving the accuracy of attenuation measurements.

| Type No. | Frequency range in GHz | Flange fitted | Length | Height | Width | Weight | Waveguide size |
|---|---|---|---|---|---|---|---|
| **6006/2** | 8·2 to 12·4 | Square UG39/U | 95·25 mm (3·75 in) | 50·8 mm (2 in) | 41·2 mm (1·625 in) | 226·8 g (8 oz) | R100 (WG16) |

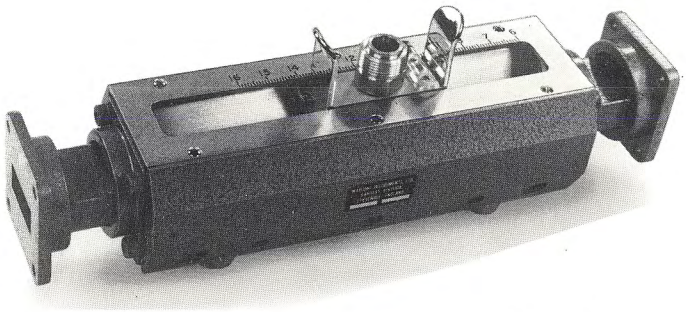
# Microwave Components

## Grade 2 Waveguide Standing Wave Detector 6009/2

This instrument has been specially designed for use in educational and production establishments.

The waveguide section is fabricated from two identical U-shaped channels accurately pinned and bolted together. The dimensional accuracy and rigidity of the resulting waveguide is of a high order. A large V-shaped groove is incorporated which forms, with a top plate bearing the engraved centimetre scale, the necessary bearing surfaces for the sliding probe carriage.

The output of the probe, which protrudes into the waveguide, is fed into a broadband cavity, and thence to a Type N socket which normally is connected to a separate coaxial crystal detector (Type 6002/1). The omission of any form of probe tuning makes quick measurements at large numbers of different frequencies a simple matter, and the constancy of coupling (about 23 dB) over the whole of the WG16 frequency range makes the 6009/2 very suitable for building into semi-automatic testing systems. A magnifying lens allows scale readings to 0·1 mm.



Phase measurements made with the 6009/2 are normally better than ±1% and can be half of this figure if very carefully undertaken. Movement of the carriage is made by pressure of the operator's fingers on one or both of the specially shaped chromed levers, and it is due to the lack of a mechanically driven carriage that the 6009/3 is so attractively priced. It is quite adequate for a large percentage of normal microwave measurements, and has found wide use in industry as well as education.

| Type No. | Frequency range in GHz | Flange fitted | Length | Height | Width | Weight | Waveguide size |
|---|---|---|---|---|---|---|---|
| **6009/2** | 8·2 to 12·4 | Square UG39/U | 219·1 mm (8·62 in) | 74·6 mm (2·94 in) | 55·5 mm (2·20 in) | 2·6 kg (5 lb 12 oz) | R100 (WG16) |

## Grade 2 Wavemeter 6017/2

This broadband absorption wavemeter has been so designed that the micrometer is calibrated directly in guide wavelength. This has been achieved by using a $TE_{011}$ resonator of rectangular cross section having a cut-off wavelength equal to that of the waveguide. The Q factor is generally better than 1000 throughout the range, and, when the wavemeter is tuned to resonance, a decrease in signal strength of approximately 2 dB is obtained.

A further feature of the design is that the quantities capable of determining the resolution of the instrument, namely the cavity Q and the micrometer discrimination, are very similar. Limiting conditions are given in the specification.

Where the waveguide wavelength range exceeds a ratio of 2:1 it is inevitable that the $TE_{012}$ mode will be excited, but since this ambiguity exists between two frequencies separated by approximately the waveguide range, it is unlikely to cause confusion.

Wavemeter 6017/2 is included in the Educational Test Benches, 6599/2 and 6452A/2.



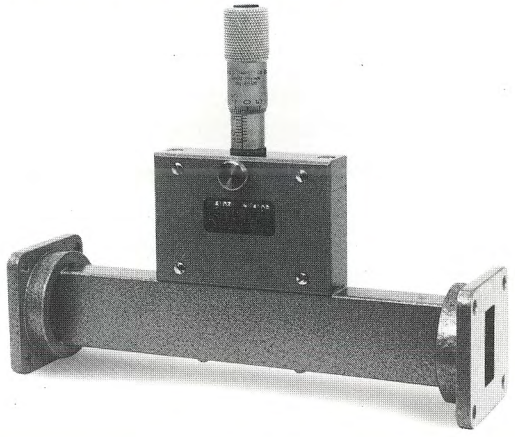
| Type No. | Frequency range in GHz | Flange fitted | Mode used | Resolution | Height | Width | Weight | Waveguide size |
|---|---|---|---|---|---|---|---|---|
| **6017/2** | 8·2 to 12·4 | Square UG39/U | $TE_{011}$ | 2·1 MHz at 12·4 GHz<br>1 MHz at 8·2 GHz | 154·9 mm (6·10 in) | 76·2 mm (3·00 in) | 0·34 kg (12 oz) | R100 (WG16) |

# Grade 2 Calibrated Variable Attenuators 6019 series

The 6019 series variable attenuators are general purpose components. They are fabricated from selected sections of standard waveguide tubing and find wide use in microwave technology.

The high quality, 0 to 40 dB, glass vane is driven by a simplified, but precise anti-backlash system, which gives absolute accuracies better than 0·1 dB at settings of 20 dB. A 20 dB maximum vane can be fitted, should this be required.

The attenuator is supplied calibrated at a minimum of two frequencies in the waveguide band. It can be supplied calibrated at other frequencies for a small charge.

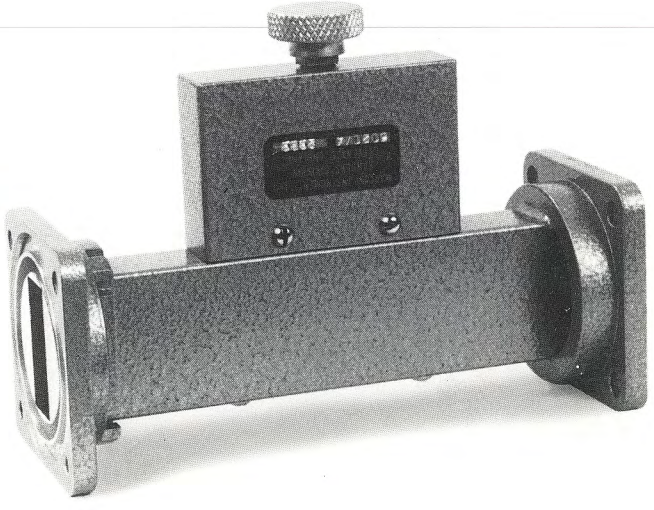


| Type No. | Frequency range in GHz | Flange fitted | Calibration Frequencies | Insertion Loss | Length | Width | Height | Weight | Waveguide size |
|---|---|---|---|---|---|---|---|---|---|
| **6019/2** | 12·4 to 18·0 | Square 5985–99–083–0030 | 12·4, 15·5, 17·0 | 0·2 dB | 139·7 mm (5·50 in) | 33·3 mm (1·31 in) | 118·1 mm (4·65 in) | 283 g (10 oz) | R140 (WG18) |
| **6019/4** | 8·2 to 10·5 | Square UG39/U | 8·5, 10·5 | 0·1 dB | 152·4 mm (6·00 in) | 41·2 mm (1·62 in) | 127·0 mm (5·00 in) | 462 g (15 oz) | R100 (WG16) |
| **6019/6** | 5·85 to 7·5 | Round 5985–99–083–0042 | 5·85, 6·5, 7·0, 7·5 | 0·1 dB | 254·0 mm (10·00 in) | 79·21 mm (3·12 in) | 156·9 mm (6·18 in) | 1248 g (2¾ lb) | R70 (WG14) |

# Variable Attenuators 6020 series

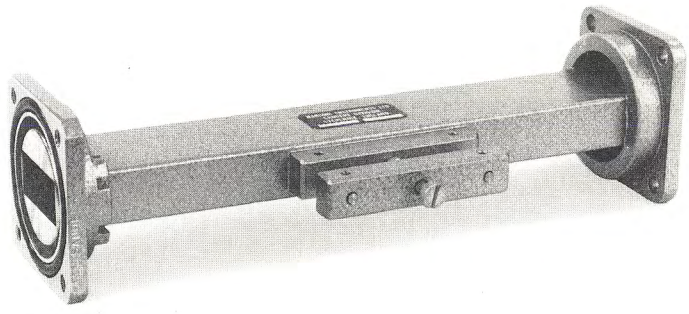
The attenuator is shorter than the other types in the range, and is normally useful up to 20 dB. The 6020 series of attenuators have many uses in the microwave field, where an approximate, or easily variable value of attenuation is required.

The position of the vane is controlled by means of a simple drive, fitted with a knurled knob.



| Type No. | Frequency range in GHz | Flange fitted | Input V.S.W.R. | Insertion Loss | Length | Width | Height | Weight | Waveguide size |
|---|---|---|---|---|---|---|---|---|---|
| **6020/3** | 8·2 to 12·4 | Round 5985–99–083–0004 5985–99–083–0003 | 1·1:1 | 0·15 dB | 101·6 mm (4·00 in) | 41·1 mm (1·62 in) | 76·2 mm (3·00 in) | 283 g (10 oz) | R100 (WG16) |
| **6020/4** | 8·2 to 12·4 | Square UG39/U and UG40B/U | 1·1:1 | 0·15 dB | 101·6 mm (4·00 in) | 41·1 mm (1·62 in) | 76·2 mm (3·00 in) | 283 g (10 oz) | R100 (WG16) |

## Pre-set Attenuator 6021/5

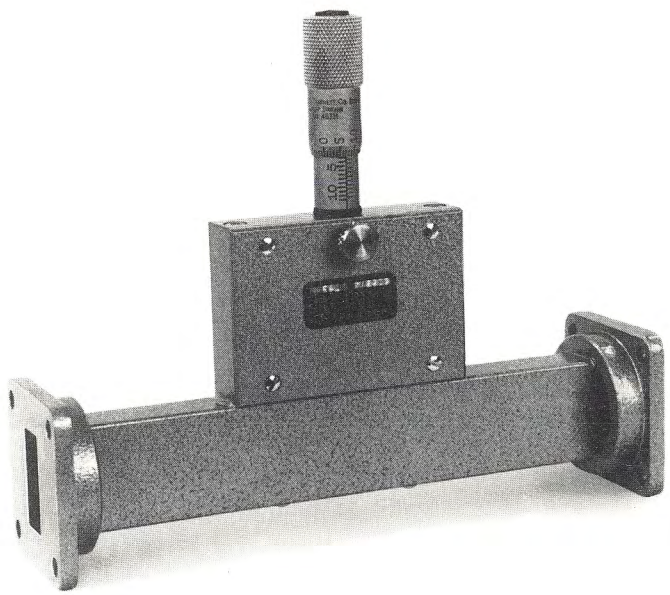


Using the same high quality glass vane as the 6019 variable attenuator the pre-set type offers a simple, but reliable, means of providing a fixed value of attenuation up to 40 dB.

Typical uses for this type of attenuator are: As a pad to prevent interaction between the various components of a microwave test bench: range extension of the 6019 variable attenuator: high stability transfer standard or fixed attenuator.

| Type | Frequency range in GHz | Flange fitted | Input V.S.W.R. | Max. attenuation | Insertion Loss | Length | Width | Height | Weight | Waveguide size |
|---|---|---|---|---|---|---|---|---|---|---|
| **6021/5** | 8·2 to 10·5 | Square UG39/U +UG40B/U | 1·075:1 | 40 dB | 0·1 dB | 152·4 mm (6·00 in) | 41·2 mm (1·62 in) | 59·4 mm (2·34 in) | 311 g (11 oz) | R100 (WG16) |

## Phase Shifter 6022/4



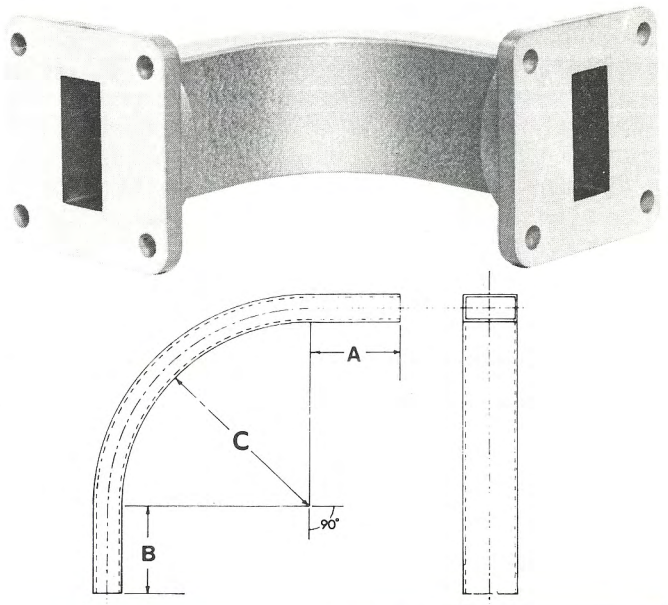
Simplicity and low cost have been the main aims in designing this instrument consistent with good accuracy and a reasonable match in the medium power range.

This is achieved by moving a dielectric vane, supported on two rods across the waveguide. The position of the vane is controlled by a micrometer.

The relationship between micrometer movement and phase shift is necessarily a function of frequency. It is not difficult to recalibrate the phase shifter using a good slotted line and calibrated variable short circuit.

| Type No. | Frequency range in GHz | Flange fitted | Minimum total phase Shift | V.S.W.R. | Length | Height | Weight | Waveguide size |
|---|---|---|---|---|---|---|---|---|
| **6022/4** | 8·2 to 12·4 | Square UG39/U | 180° | 1·20:1 | 152·7 mm (6·00 in) | 107·9 mm (4·25 in) | 425 g (15 oz) | R100 (WG16) |

## E Plane Bends 6025 series



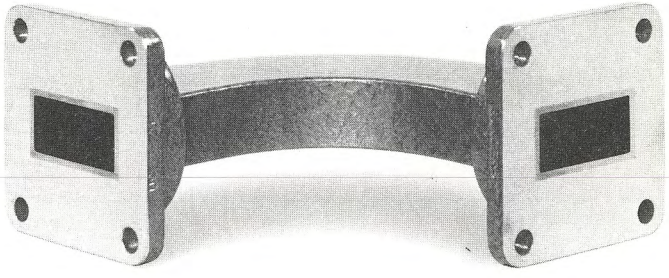

These E plane bends are widely used where a 90° angle is required with negligible reflection of the microwave signal. The maximum VSWR is 1·05:1 plain to plain flange assembly and 1·075:1 for plain to choke arrangement.

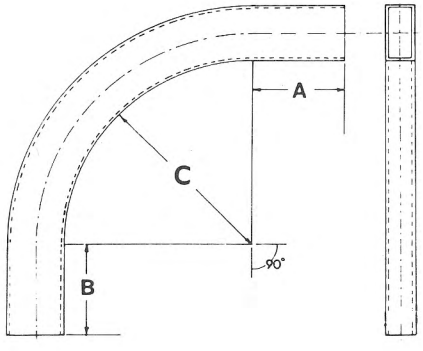
The bends are fabricated from copper waveguide. The inner cross-sectional dimensions are maintained within the standard waveguide tolerances.

Standard E plane bends are fitted with plain flanges on both ends. Other radii, flanges, materials and dimensions are available to special order.

| Type No. | Frequency range in GHz | Flange fitted | Dimensions A | B | C | Weight | Waveguide size |
|---|---|---|---|---|---|---|---|
| **6025/2** | 12·4 to 18·0 | Square 5985–99–083–0030 | 19·05 mm (0·75 in) | 19·05 mm (0·75 in) | 29·36 mm (1·156 in) | 113·4 g (4 oz) | R140 (WG 18) |
| **6025/3** | 8·2 to 12·4 | Square UG39/U | 33·32 mm (1·31 in) | 33·32 mm (1·31 in) | 23·65 mm (0·94 in) | 212·6 g (7½ oz) | R100 (WG 16) |
| **6025/5** | 7·05 to 10·0 | Square 5985–99–083–0034 | 31·75 mm (1·25 in) | 31·75 mm (1·25 in) | 38·10 mm (1·50 in) | 340·2 g (12 oz) | R84 (WG15) |

## H Plane Bends 6026 series






These H plane bends are widely used where a 90° angle is required with negligible reflection of the microwave signal. The maximum VSWR is 1·05:1 for plain to plain flange assembly, and 1·075:1 for plain to choke arrangement.

The bends are fabricated from copper waveguide. The inner cross-sectional dimensions are maintained within the standard waveguide tolerances.

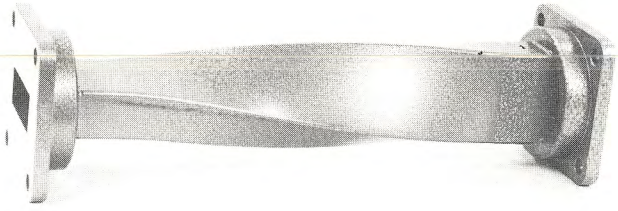
Standard H plane bends are fitted with plain flanges on both ends. Other radii, flanges, materials and dimensions are available to special order.

| Type No. | Frequency range in GHz | Flange fitted | Dimensions A | B | C | Weight | Waveguide size |
|---|---|---|---|---|---|---|---|
| **6026/2** | 12·4 to 18·0 | Square 5985–99–083–0030 | 19·05 mm (0·75 in) | 19·05 mm (0·75 in) | 24·50 mm (1·00 in) | 113·4 g (4 oz) | R140 (WG18) |
| **6026/4** | 8·2 to 12·4 | Square UG39/U | 25·40 mm (1·00 in) | 25·40 mm (1·00 in) | 25·40 mm (1·00 in) | 212·6 g (7½ oz) | R100 (WG16). |

# Microwave Components

## Waveguide Twist 6027/3

The continuous twist consists of a straight length of waveguide with a constant angular rate of twist over its length. The method of manufacture ensures that the cross section of the waveguide is closely maintained. This produces a VSWR which is about 1·05:1. The advantage of this type of twist is that it can readily be made in different lengths and different angles of overall twist. The standard angle of twist is 90°.



| Type No. | Frequency range in GHz | Flange fitted | V.S.W.R. | Length | Weight | Waveguide size |
|---|---|---|---|---|---|---|
| 6027/3 | 8·2 to 12·4 | Square UG39/U | 1·05:1 | 152·4 mm (6·00 in) | 225 g (9 oz) | R100 (WG16) |

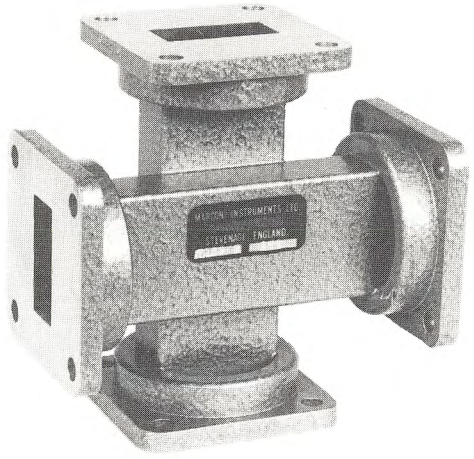
## Directional Coupler 6029/2

For applications where space is at a premium and where a moderate performance is required, the 6029/2 cross-guide coupler will solve many problems.

The coupler is formed of two waveguide sections joined at right angles across the broad dimensions. Coupling elements are of the double cruciform type, a configuration which has been found to be superior to other layouts.

Directivity has in general been held to the high figure of 27 dB but this drops to 22 dB at the extremes of the waveguide frequency band. The input VSWR is less than 1·05 over the frequency range quoted, but will exceed this beyond the upper frequency limit.

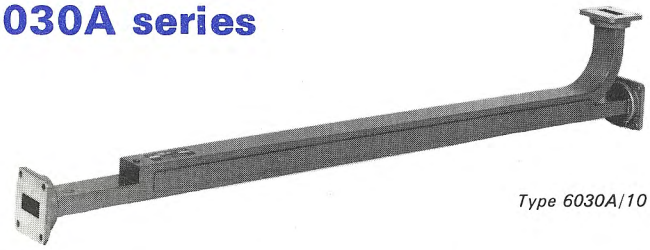
The main applications of this coupler are in power and frequency monitoring both in systems and on test benches.



| Type No. | Frequency range in GHz | Flange fitted | Coupling in dB | Length | Height | Width | Weight | Waveguide size |
|---|---|---|---|---|---|---|---|---|
| 6029/2 | 8·5 to 10·5 | Square UG39/U | 20 | 76·2 mm (3·00 in) | 76·2 mm (3·00 in) | 59·1 mm (2·33 in) | 340·2 g (12 oz) | R100 (WG16) |

## Multi-Hole Directional Couplers 6030A series

The directional coupler is used for power monitoring, reflection measurements, isolation of wavemeters or signal sources and levelling of swept sources. This range of directional couplers employ circular holes as coupling elements between the broad walls of the two waveguides. The coupling factors are arranged as a Tshebyshef series having a reverse radiation spectrum which oscillates with equal ripple amplitude about a given value. The chief advantage lies in the fact that the directivity is extremely broadband without deterioration near the band extremities as in the case of the binomial array. Directivity is better than 40 dB over the complete waveguide frequency range.



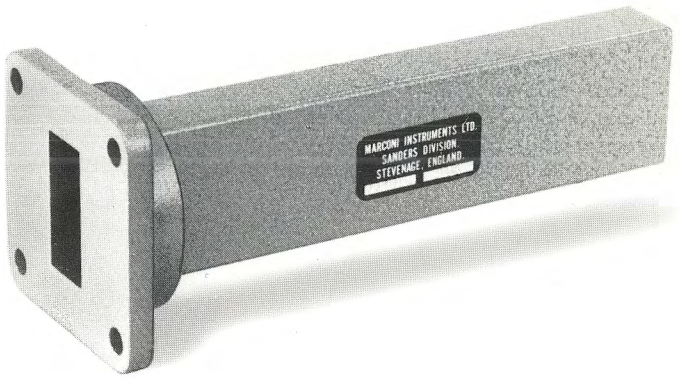
*Type 6030A/10*

| Type No. | Frequency Range in GHz | COUPLING Nominal | Nominal Coupling Accuracy | Spread | VSWR Main-line | Side-arm | Flange fitted | Length | Height | Weight | Waveguide size |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6030A/8 | 8·2–12·4 | 3 dB | ±0·4 dB | ±0·5 dB | 1·1 | 1·1 | Square UG39/U | 581·0 mm 22·86 in | 99·6 mm 3·92 in | 1·135 kg 2lb 8oz | R110 (WG16) |
| 6030A/10 | 8·2–12·4 | 10 dB | ±0·4 dB | ±0·5 dB | 1·04 | 1·1 | Square UG39/U | 492·1 mm 19·38 in | 99·6 mm 3·92 in | 0·851 kg 1lb 14oz | R100 (WG16) |

# Short Matched Terminations 6032 series

These components are the result of a requirement to provide a termination of compact dimensions with high performance. They have a maximum VSWR of 1·02 over the full waveguide bandwidth with a length of less than 2·5 λg at mid-band frequency.

To obtain this performance great care has been taken in design to ensure that the iron loaded dissipative elements are of the optimal geometric configuration to ensure virtually complete absorption of the incident wave, whilst the composition of the elements is such that this takes place in the minimum number of guide wavelengths.

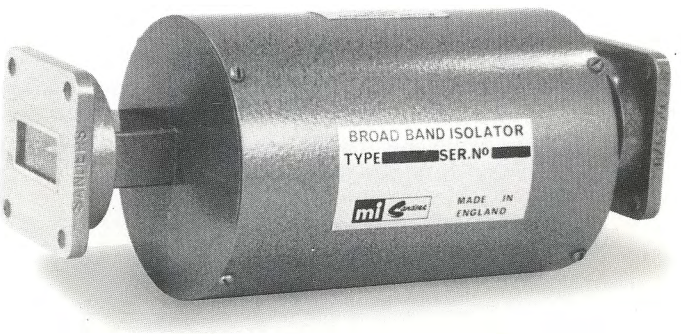



*Type 6032/2*

| Type No. | Frequency range in GHz | Flange fitted | V.S.W.R. | Power handling capacity | Height | Weight | Waveguide size |
|---|---|---|---|---|---|---|---|
| **6032/1** | 12·4 to 18·0 | Square 5985–99–083–0030 | 1·02:1 | 2W mean | 71·4 mm (2·81 in) | 67·5 g (2 oz) | R140 (WG18) |
| **6032/2** | 8·2 to 12·4 | Square UG39 U | 1·02:1 | 2W mean | 109·5 mm (4·31 in) | 150 g (5¼ oz) | R100 (WG16) |
| **6032/4** | 7·0 to 10·00 | Square 5985–99–083–0034 | 1·02:1 | 3W mean | 125·8 mm (4·95 in) | 264 g (8¼ oz) | R84 (WG15) |
| **6032/5** | 5·85 to 8·2 | Round 5985–99–083–0038 | 1·02:1 | 10W mean | 151·2 mm (5·95 in) | 502 g (1 lb 1¾ oz) | R70 (WG14) |

# Broad Band Isolator 6033/3

This ferrite isolator has been designed especially for test equipment applications and has a high performance over the entire frequency range. The unit may take the place of the usual buffer attenuator between r.f. oscillator and waveguide bench. The isolator combines a good match over the whole of its operating range with low forward loss and high attenuation of energy reflected from subsequent mismatches. Thus, frequency pulling of the r.f. source is avoided whilst full advantage is taken of the power available. It is ideal for use in wideband swept frequency systems.



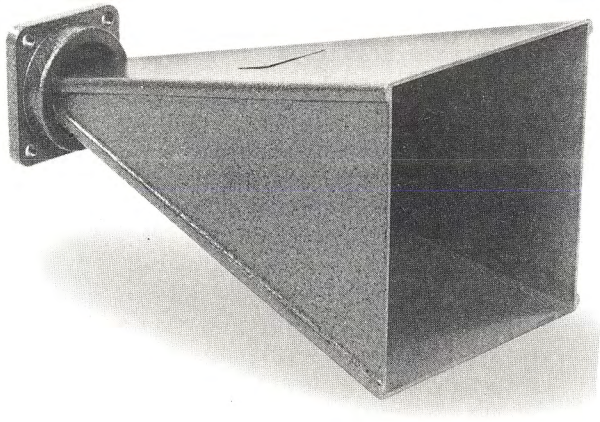

| Type | Frequency range in GHz | Flange fitted | Average power | Isolation minimum | Insertion Loss | Length | Width | Weight | Waveguide size |
|---|---|---|---|---|---|---|---|---|---|
| **6033/3** | 8·2 to 12·4 | Square *see NOTE 3 | 15W | 30 dB | 2·0 dB max. 1·5 dB typical | 152·4 mm (6·00 in) | 63·5 mm (2·50 in) | 1·70 kg (2 lb 10 oz) | R100 (WG16) |

NOTE 1: Power rating applies to any load mismatch.
NOTE 2: VSWR = 1·2 under matched load conditions.
NOTE 3: Flange mates with UG39/U OR 5985 – 99-083-0052.

# Microwave Components

## Waveguide Horn 6036/4

The close agreement between theoretical and measured gain of a pyramidal horn makes it convenient for use as a gain standard when calibrating more complex aerial systems. They may also find an application in the plotting of polar patterns and as feeds for large reflectors.



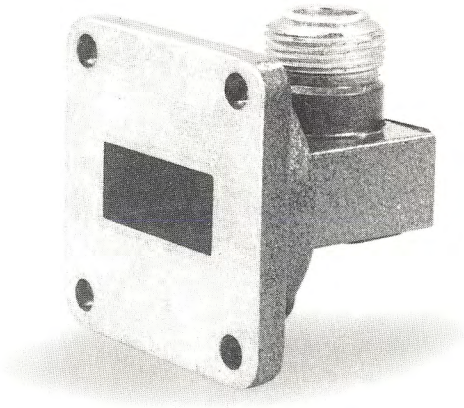
| Type No. | Design frequency GHz | Flange fitted | Gain dB | Length | Width | Height | Weight | Waveguide size |
|---|---|---|---|---|---|---|---|---|
| **6036/4** | 9·375 | Square UG39/U | 17·2 | 152·4 mm (6·00 in) | 81·3 mm (3·2 in) | 78·7 mm (3·1 in) | 396·89 g (14 oz) | R100 (WG16) |

## Coaxial to Waveguide Transformers 6037 series

These Coaxial to Waveguide Transformers have been designed for broadband applications and have particular use in swept frequency applications. They provide a simple means of converting from waveguide to 50Ω coaxial line. Type 'N' female connectors and plain flanges are fitted as standard. When used in conjunction with the 6030 series Directional Couplers and 6160 Wideband Detector a levelling loop for swept applications is completed.

The transformers are constructed using the 'rod and crossbar' principle, which automatically provides a d.c. return, and gives excellent electrical characteristics.

Also available are the 6237 and 6238 series of precision coaxial to waveguide transformers.



*Type 6037/3*

| Type No. | Frequency range in GHz | Maximum V.S.W.R. | Flange fitted | Length | Weight | Waveguide size |
|---|---|---|---|---|---|---|
| **6037/1** | 12·0 to 18·0 | 1·5:1 | Square 5985–99–083–0030 | 33·3 mm (1·31 in) | 99·219 g (3½ oz) | R140 (WG18) |
| **6037/2** | 8·5 to 12·0 | 1·5:1 | Round 5985–99–083–0004 | 34·9 mm (1·37 in) | 113·40 g (4 oz) | R100 (WG16) |
| **6037/3** | 8·5 to 12·0 | 1·5:1 | Square UG39/U | 34·9 mm (1·38 in) | 113·40 g (4 oz) | R100 (WG16) |
| **6037/4** | 7·0 to 10·0 | 1·55:1 | Square 5985–99–083–0034 | 43·3 mm (1·70 in) | 170·1 g (6 oz) | R84 (WG15) |
| **6037/5** | 5·85 to 8·2 | 2·0:1 | Round 5985–99–083–0038 | 40·1 mm (1·58 in) | 340·2 g (12 oz) | R70 (WG14) |
| **6037/6** | 4·2 to 5·85 | 1·5:1 | Round 5985–99–083–0042 | 55·2 mm (2·17 in) | 0·533 kg (1 lb 3½ oz) | R48 (WG12) |

# Waveguide Support Bench 6039/3 and 6040 series




### Waveguide Support Bench, 6039/3

| Type No. | Length | Features and Composition |
|---|---|---|
| 6039/3 | 3ft (914) | The bench consists of:<br>2 end plates<br>2 stainless steel rails |

### Carriage 6040 For use with 6039/3 bench

The Carriage will traverse the length of the bench and may be locked in any desired position. The vertical support position is automatically locked when the support rod is raised to the desired height, release is obtained by actuating a simple lever. The support rod can be rotated about its vertical axis and be fitted with any of the 6042 clips or 6043 table.

### Free Standing Support, 6041

A specially designed base casting permits close proximity support. This casting houses the same mechanism as the 6040 carriage and can be fitted with 6042 series clips or 6043 table.

### Support Clips, 6042 series
### For use with 6040 and 6041 supports

| Type No. | Waveguide Size |
|---|---|
| 6042/1 | R320 (WG22) |
| 6042/2 | R140 (WG18) |
| 6042/3 | R100 (WG16) |
| 6042/4 | R84 (WG15) |
| 6042/5 | R70 (WG14) |
| 6042/7 | R32 (WG10) |

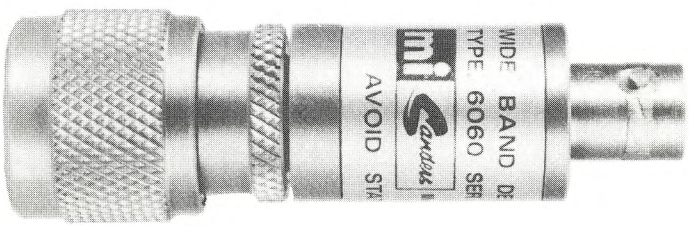
### Instrument Table, 6043
### For use with 6040 and 6041 supports

Suitable for supporting the large microwave instruments.

# Wide Band Detector 6060

Wideband Detector Type 6060 is intended for use in coaxial systems operating in the frequency range 10 MHz to 12·4 GHz. Its flat frequency response, high sensitivity, and excellent square-law characteristics make this detector ideally suitable for a number of measurement applications.

Optimum Square-law Response. When loaded with a high impedance the detector maintains its square-law characteristic (i.e. output voltage is directly proportional to input power) to within ±0·5 dB up to 30 mV output, the sensitivity in this condition being at least 150 µV output per µW input. The range of the square-law response can be extended – with reduced sensitivity – by using the detector in conjunction with Load Resistor Part No. 2200154, which is available as an optional accessory. Each resistor is matched to a particular detector and provides square-law response to within




±0·5 dB for output voltages up to 100 mV. The combination is designated Type 6060/2.

Diode Replacement. The output polarity of the detector is normally negative, but positive polarity is obtainable by simply reversing the diode.

*NOTE: Great care should be taken when handling the diode element to avoid discharging any static electricity through it. Cables to the detector should be connected to the ancillary equipment and discharged before connecting to the detector.*

| Type No. | RF input connector | Frequency Range | Sensitivity with load | Sensitivity without load | Diode Part No. | Load Part No. | Weight |
|---|---|---|---|---|---|---|---|
| 6060 | N male | 10 MHz to 12·4 GHz | 50 µV/µW to 100 mV | 150 µV/µW to 30 mV | 2561001 | 2200154 | 0·065 kg (3 oz) |

# Microwave Components

## Gunn Diode Oscillator 6061A




This Gunn diode oscillator has been designed as a source of microwave power which is stable, harmonically pure and easy to operate.

The unit is a pure waveguide cavity with the inherent advantage of excellent frequency stability compared to other types of cavities as well as having an effective fine frequency control by the position of a non-contacting RF short circuit.

The oscillator has been designed to be tolerant to different Gunn diode characteristics which results in a unit which will accept virually any X band diode making diode replacement economic, should the need arise.

The unit is particularly suitable for use with the educational test benches, 6599/2 and 6452A/2.

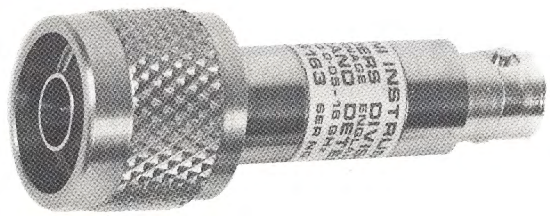
| | |
|---|---|
| **FREQUENCY** | |
| Range | 8·5 to 10·5 GHz min.<br>8·0 to 11·5 GHz typical. |
| Tuning | Micrometer controlled plunger. |
| **OUTPUT** | |
| Waveguide | R100 (WG16, WR90) plain face flange with four 8/32 UNC screw-holes. |
| Power | 6 mW min. Typically 20 mW. |

| | |
|---|---|
| **POWER REQUIREMENTS** | |
| External d.c. | −13 V. 200 mA typically detailed calibration data provided with each unit. |
| **NETT WEIGHT** | 580 g (1 lb 6 oz). |
| **RECOMMENDED POWER UNIT** | Gunn Diode Power Supply, Type 6590B |
| Optional extra | Spare Gunn Diode P/N 2569/020. |

## Wideband Coaxial Detectors 6160 series

This new range of coaxial detectors covers the frequency range 50 MHz to 12·4 GHz or 50 MHz to 18 GHz.

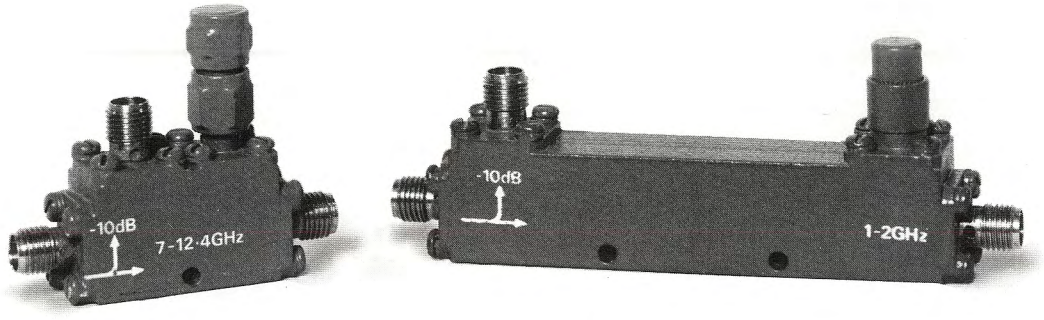
These components utilize Low-Barrier Schottky diodes and microchip components in a sealed r.f. module. This results in significant improvement in broadband flatness, v.s.w.r., burn-out protection and environmental specification compared with point contact detectors.



| MODEL | 6162/1 | 6163 | 6162/2 | 6165/1 | 6166 | 6165/2 |
|---|---|---|---|---|---|---|
| FREQUENCY RANGE | 0·05 to 18 GHz. | | | 0·05 to 12·4 GHz. | | |
| FREQUENCY RESPONSE | ±1 dB up to 18 GHz. | | | ±1 dB up to 12·4 GHz. | | |
| VSWR | 1·4 from 0·05 to 4 GHz.<br>2·0 from 4 to 18 GHz. | | | 1·4 from 0·05 to 4 GHz.<br>1·5 from 4 to 12·4 GHz. | | |
| MAXIMUM OPERATING INPUT | 1 W peak. 200 mW average. | | | | | |
| SENSITIVITY (low level) | 0·5 mV/μW. | | | | | |
| TEMPERATURE COEFFICIENT | 0·05 °C typical. (1 MΩ video load.) | | | | | |
| TANGENTIAL SENSITIVITY | −54 dBm in 100 kHz B.W. typical. | | | | | |
| VIDEO IMPEDANCE | 1 KΩ typical. | | | | | |
| OPERATING RANGE | −10 °C to +70 °C. | | | | | |
| STORAGE | −40 °C to +100 °C. | | | | | |
| OUTPUT POLARITY | Negative. | | | | | |
| INPUT CONNECTOR | Type SMA male. | Precision Type N male. | Type SMA male. | Type SMA male. | Precision Type N male. | Type SMA male. |
| OUTPUT CONNECTOR | Type SMC male. | BNC female | BNC female. | Type SMC male. | BNC female. | BNC female. |
| LENGTH | 35·5 | 56·0 | 44·0 | 35·5 | 56·0 | 44·0 |
| MAX. DIAMETER | 11·0 | 21·0 | 12·7 | 11·0 | 21·0 | 12·7 |

*NOTE: Great care should be taken when handling the diode element to avoid discharging any static electricity through it. Cables to the detector should be connected to the ancillary equipment and discharge before connecting to the detector.*

# Subminiature Broadband Directional Couplers, 6170 series




The 6170 series of subminiature directional couplers offer small size, light weight, rugged units which will withstand stringent environmental conditions. Each model is rated to cover the standard octave band but by using 2 sections, the bandwidths are inherently wider.

The couplers are available as 10 dB versions, all couplers having the standard through line configuration with the fourth port terminated.

The assembly is RF screened and finished in a high quality durable paint. Fixing holes are provided on all units, two holes on the low frequency units and one on the high frequency ones.

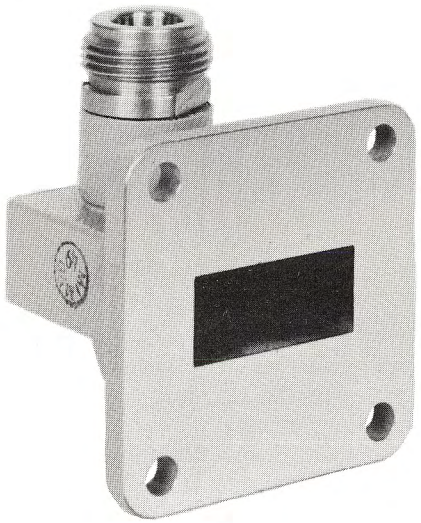
Input and output connectors are stainless steel SMA (female) which conform to MIL-C-39012.

| Type No. | 6171/10 | 6173/10 | 6175/10 | 6177/10 |
|---|---|---|---|---|
| Coupling +dB | 10 ±1·25 | 10 ±1·25 | 10 ±1·25 | 10 ±1·25 |
| Nominal bandwidth GHz | 1–2 | 1·7–4·3 | 3·7–8·3 | 7–12·5 |
| Average power W | 5 | 5 | 5 | 5 |
| Frequency sensitivity dB | ±0·5 | ±0·5 | ±0·5 | ±0·5 |
| Insertion loss *dB | 0·2 | 0·2 | 0·2 | 0·4 |
| Directivity dB | 22 | 22 | 18 | 17 |
| VSWR main arm | 1·15 | 1·20 | 1·30 | 1·35 |
| VSWR secondary arm | 1·15 | 1·20 | 1·30 | 1·40 |
| Length ins/cm | 2·75/6·5 | 1·7/4·3 | 1·1/3 | 1·0/2·5 |
| Width ins/cm | 0·6/1·5 | 0·6/1·5 | 0·6/1·5 | 0·6/1·5 |
| Thickness ins/cm | 0·5/1·25 | 0·5/1·25 | 0·5/1·25 | 0·5/1·25 |
| Weight gm | 45 | 35 | 28 | 28 |

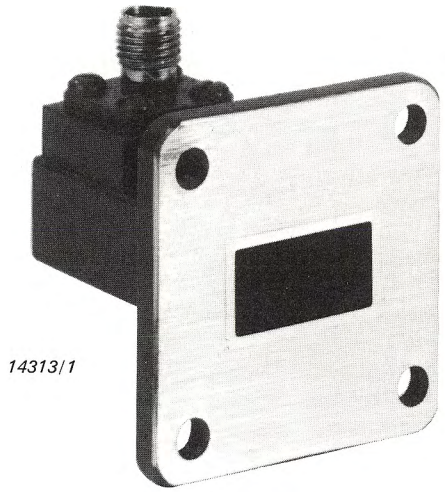
+Coupling includes frequency sensitivity.
*Excluding power coupled out in the secondary line.

## Precision Coaxial to Waveguide Transformers, 6237 and 6238 series

These Coaxial to Waveguide Transformers provide a convenient means of converting from waveguide to coaxial line or vice versa. The transformers cover the full waveguide frequency range with a maximum VSWR of 1·25:1. The units are ideal for swept frequency applications where low VSWR is essential and can easily be used in systems applications. Each transformer is fitted with a Stainless Steel 'N' type or SMA connector and will handle a maximum mean power of 50 watts.

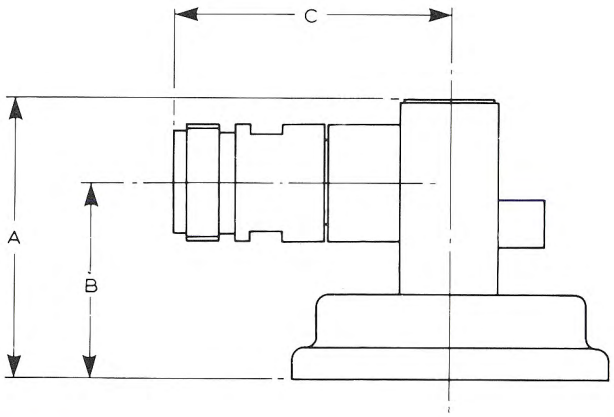


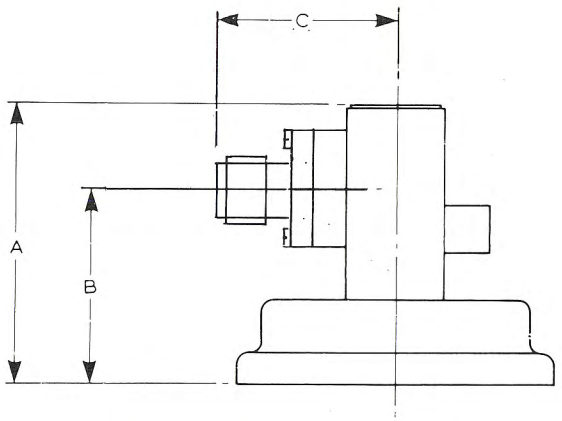
*Type 6237/3*



*14313/1*

*Type 6238/3*




| Type | Frequency Range (GHz) | Waveguide Size | Maximum VSWR | Coaxial Connector | Flange Fitted | A inches (mm) | B inches (mm) | C inches (mm) | Weight |
|---|---|---|---|---|---|---|---|---|---|
| **6237/1** | 12·4 to 18·0 | R140 (WG18) WR-62 | 1·25:1 | Type 'N' 50 Ω female | Square 5985–99–083–0030 | 1·36 (34·5) | 1·05 (26·55) | 1·3 (33·1) | 80 g 4 oz |
| **6237/3** | 8 to 12·4 | R100 (WG16) WR-90 | 1·25:1 | Type 'N' 50 Ω female | Square UG39/U | 1·44 (36·6) | 1·02 (25·9) | 1·36 (34·5) | 135 g 5 oz |
| **6238/1** | 12·4 to 18·0 | R140 (WG18) WR-62 | 1·25:1 | Type SMA 50 Ω female | Square 5985–99–083–0030 | 1·36 (34·5) | 1·05 (26·55) | 0·91 (23·2) | 80 g 4 oz |
| **6238/3** | 8 to 12·4 | R100 (WG16) WR-90 | 1·25:1 | Type SMA 50 Ω female | Square UG39/U | 1·44 (36·6) | 1·02 (25·9) | 0·97 (24·7) | 135 g 5 oz |

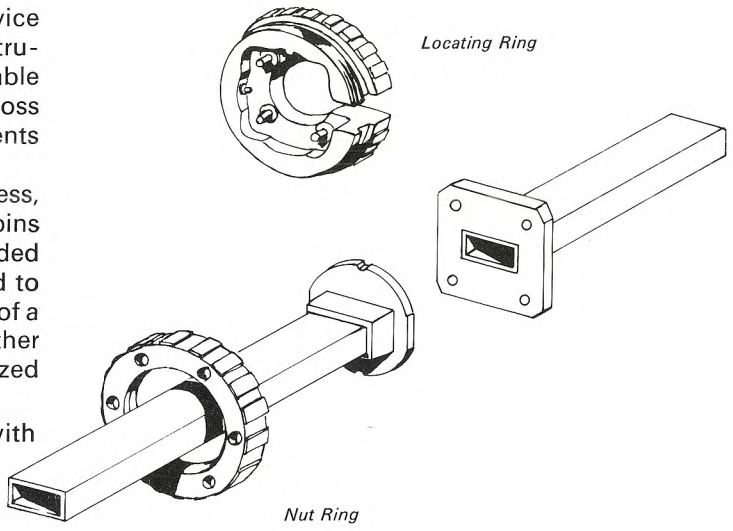
NATO Stock Numbers
6237/1 5985–99–637–9587
6237/3 5985–99–637–9585

## Square to Round Flange Adapter 6478

The Square to Round Flange Adapter is a unique device designed for coupling together waveguide 16 instruments carrying dissimilar flanges. The Adapter is suitable for either plain or choke flanges and offers no greater loss in performance than the normal coupling arrangements between compatible flanges.

The locating ring is slotted to allow waveguide access, and the square flange is accurately positioned by four pins locating the flange screw clearance holes. The threaded nut ring is passed over the round flange and screwed to the locating ring. Provision is made for the application of a series 20 peg spanner (5·70 mm centres) should other than finger tightness be required, as in pressurized systems.

The standard adapter has been designed for use with square flanges carrying clearance holes.




Material: Brass, nickel plated.

Weight: ½ lb (0·23 kg).

Dimensions: Diameter (max): 2·71 in, (68·8 mm).
Width including flanges (max): 0·77 in. (19·6 mm).

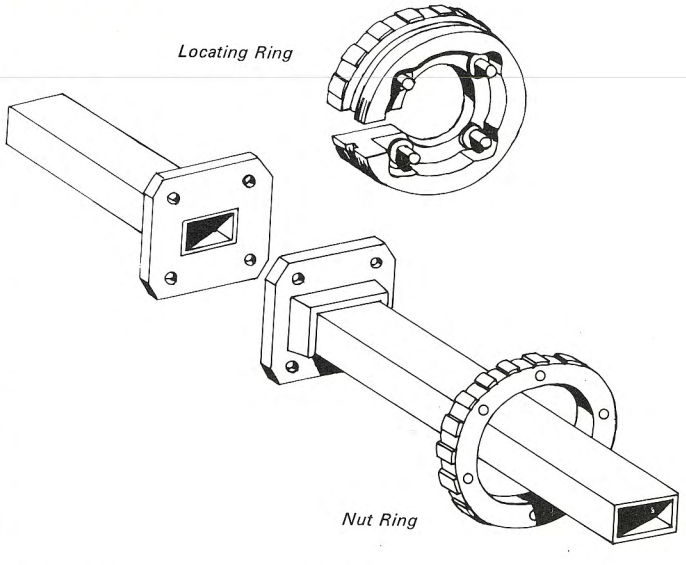
## Square to Square Rapid Coupler 6478/1

The square to square rapid coupler, 6478/1 is a unique device designed for coupling together X band instruments or components terminated with square flanges containing 4·29 mm diameter (min.) clearance holes. The coupler is suitable for either plain or choke flanges and offers equal or lower insertion loss than the conventional bolted coupling.

The absence of loose parts such as nuts, bolts, etc. facilitates rapid assembly of waveguide runs in adverse conditions, or a change of components during production testing. It also facilitates the assembly of waveguides in environments in which the presence of loose small parts could constitute a safety hazard.

Rubber seating rings take up tolerances on flange thicknesses to ensure a good mating of the flange faces. Provision is made for the application of a series 20 peg spanner (2·24 in (5·70 mm) centres) to British Standard 2090, should other than finger tightness be required, as in pressurised systems.

The locating ring is slotted to allow waveguide access, and both flanges are accurately positioned by four pins which locate the flange clearance holes. .The threaded nut ring is passed over the flange and screwed to the locating ring.




Material: Brass, nickel plated.

Weight: ½ lb. (0·23 kg).

Dimensions: Dia. (max): 2·71 in (68·8 mm).
Width including flanges (max): 0·77 in. (19·6 mm).

# Microwave Components

## Wideband Coaxial Attenuators and Terminations 6530 series

The 6530 series of attenuators offers a selection of high quality 50Ω units and the 6533 models are wideband terminations.

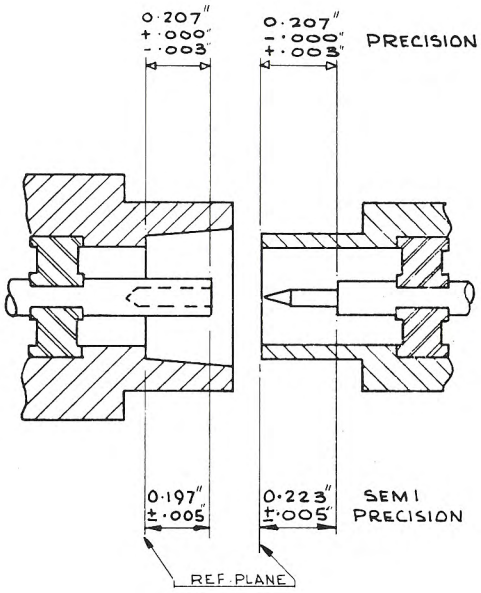
The 18 GHz attenuators use resistive film elements of advanced design giving accurate insertion loss and low VSWR at all frequencies.

Other units utilise resistive networks of rugged design. Close tolerance stainless steel connectors and barrels ensure long life with minimum effects from wear and mechanical deformation. A calibration certificate can be supplied at a small surcharge.




*Type 6534/3*

Connector Dimensions:
Precision Type N (Type 6534).
Semi-Precision Type N (all other models).




WARNING
The precision or semi precision type N connectors fitted to these attenuators may be damaged by mating with general purpose type N connectors which do not conform to the International standard dimensions.

## Terminations 6533 series

| Frequency range | Type No. | Connector | Power input Average | Power input Peak | D.C. Resistance | V.S.W.R. (max.) | Temperature coefficient |
|---|---|---|---|---|---|---|---|
| DC to 12·4 GHz | **6533/1**<br>**6533/2** | Type N male<br>Type N female | 1 w | 1 kW<br>5 µsec. max. pulse length | 50 Ω ±1 Ω at 25°C. | 1·03:1 DC to 1 GHz.<br>1·05:1 1 to 4 GHz.<br>1·15:1 4 to 10 GHz. | Typically less than 0·03%/°C. |

## ATTENUATORS

| Frequency range | Type No. | Attenuation (dB) | Power Input Average (W) | Power Input Peak (kW) | Maximum deviation of Insertion Loss (dB) When properly terminated in 50Ω | | VSWR When properly terminated in 50Ω | Power Sensitivity | Temperature Coefficient |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | AT DC | DC–3·0 GHz | | 6531/1-/4 | |
| | 6531/1 | 3 | 2 | 2 | ±0·02 | ±0·2 | | <·001 dB /dB/W | |
| | 6531/2 | 6 | 2 | 2 | ±0·02 | ±0·2 | | | |
| | 6531/3 | 10 | 1 | 2 | ±0·02 | ±0·2 | 1·02:1 at D.C. | | Typically less |
| | 6531/4 | 20 | 1 | 1 | ±0·05 | ±0·2 | 1·15:1 max. D.C.-1·0 GHz | 6531/5-/7 | than 0·0001 dB |
| DC-3·0 GHz | 6531/5 | 30 | 1 | 1 | ±0·05 | ±0·2 | 1·20:1 max. 1·0-3·0 GHz | <·002 dB /dB/W | /dB/°C |
| | 6531/6 | 40 | 1 | 1 | ±0·05 | ±0·3 | | | |
| | 6531/7 | 50 | 1 | 1 | ±0·05 | ±0·3 | | | |
| | | | | | From Nom. | From 4·0 GHz | | | |
| | | | | | at 4·0 GHz | at 1 GHz at 10 GHz | | | |
| 0·6–12·4 GHz | 6532/1 | 3 | 5 | 10 | ±0·1 | −0·2 +0·2 | 1·25:1 max. 1·0–10·0 GHz | | |
| 1·0–12·4 GHz | 6532/2 | 6 | 3 | 6 | ±0·1 | −0·5 +0·3 | 1·25:1 max. 1·0–10·0 GHz | | |
| 1·0–12·4 GHz | 6532/3 | 10 | 1 | 1 | ±0·1 | −1·1 +0·5 | 1·35:1 max. 1·0–2·0 GHz | | <·0007 dB |
| | | | | | | | 1·30:1 max. 2·0–10·0 GHz | — | /dB/°C |
| 2·0–12·4 GHz | 6532/4 | 20 | 1 | 1 | ±0·2 | −1·3θ +1·0 | 1·35:1 max. 2·0 3·0 GHz | | |
| | | | | | | | 1·30:1 max. 3·0–10·0 GHz | | |
| | | | | | DC–12·4 GHz | 12·4–18·0 GHz | | | |
| | 6534/1 | 3 | 5 | 1 | ±0·3 | ±0·5 | 1·20:1 max. DC–4·0 GHz | Typically | |
| | 6534/2 | 6 | 5 | 1 | ±0·3 | ±0·5 | 1·25:1 max. 4·0–8·0 GHz | less than | Typically less |
| DC–18·0 GHz | 6534/3 | 10 | 5 | 1 | ±0·5 | ±0·6 | 1·35:1 max. 8–12·4 GHz | 0·002 dB | than 0·0001 dB |
| | 6534/4 | 20 | 5 | 1 | ±0·5 | ±0·75 | 1·5:1 max. 12–18 GHz | /dB/watt | /dB/°C |

θ 2 GHz minimum frequency.

## Dimensions and Codings for Attenuators and Terminations

| Type No. | Dimensions (Length & diameter) | Nato Stock No. |
|---|---|---|
| 6531/1 | 80 × 20·6mm (3·15 × 0·81 inches) | 1430–99–522–6443 |
| 6531/2 | 80 × 20·6mm (3·15 × 0·81 inches) | 5840–99–523–1088 |
| 6531/3 | 80 × 20·6mm (3·15 × 0·81 inches) | 5905–99–223–4026 |
| 6531/4 | 103 × 20·6mm (4·06 × 0·81 inches) | 1430–99–522–6445 |
| 6531/5 | 103 × 20·6mm (4·06 × 0·81 inches) | 5905–99–112–8669 |
| 6531/6 | 103 × 20·6mm (4·06 × 0·81 inches) | |
| 6531/7 | 103 × 20·6mm (4·08 × 0·81 inches) | |
| 6532/1 | 209 × 21mm (8·25 × 0·81 inches) | |
| 6532/2 | 209 × 21mm (8·25 × 0·81 inches) | |
| 6532/3 | 209 × 21mm (8·25 × 0·81 inches) | |
| 6532/4 | 209 × 21mm (8·25 × 0·81 inches) | |
| 6533/1 | 44 × 21mm (1·68 × 0·81 inches) | 5935–99–450–6974 OR 5935–99–525–6333 |
| 6533/2 | 45 × 15·7mm (1·8 × 0·62 inches) | 5935–99–450–6975 |
| 6534/1 | 57·9 × 21mm (2·28 × 0·81 inches) | |
| 6534/2 | 57·9 × 21mm (2·28 × 0·81 inches) | |
| 6534/3 | 57·9 × 21mm (2·28 × 0·81 inches) | 5985–99–525–6902 |
| 6534/4 | 57·9 × 21mm (2·28 × 0·81 inches) | 5905–99–520–8780 |

# Flexible Waveguide — 'Flexaguide'

## Marconi Instruments offers these advantages:-

- ☐ Wide frequency range (WG6 to WG18)
- ☐ High power rating
- ☐ High pressure allowed
- ☐ Long lifetime
- ☐ High corrosion resistance
- ☐ Special designs for high pressure, high power applications
- ☐ Design Consultancy Service
- ☐ Range of finishes

'Flexaguide' is an established microwave transmission medium successfully used in a wide range of radar and communications systems.

The bending and flexibility characteristics cater for shock and vibration protection of other components within a system and reduce design problems where component alignment is affected by dimensional and temperature variations.

Various protective coverings are offered to combat all environmental conditions. The construction is designed to give an inherent strength which permits the basic guide to be used without the expensive, mechanical strengthening, "rubber jacket", encountered in the other designs. This "basic" form is suitable for indoor applications such as transmission rooms etc., thereby minimising installation costs. Preformed sections to customer's requirements are also produced and all Flexaguides conform to DEF5353A and MIL-W-287B.

Marconi Instruments Microwave Products Division is registered on the defence contractors registration list, registration number 55660/2/02 to Defence standard 05–21.

### Construction

The construction of Flexaguide begins with strips of beryllium copper which are die-formed into 'U' shaped corrugated half guides. These are joined along the narrow side wall by hard soldering. The bellows thus formed are heat-treated to give longer flexible life. In the case of waveguide 15 and 16 the 'U' shaped corrugated half guides are heat-treated first and then joined along the narrow side wall by soft soldering, which allows greater flexibility in the resultant Flexaguide. Hard seam soldering is used in these two waveguide sizes only where preformed bends or special synthetic jackets are required.

Suitable flanges are attached to the Flexaguide tubing.

### Coverings and finishes available

The basic Flexaguide already described is perfectly satisfactory for indoor applications (e.g. Transmitter rooms) where extremes of environmental conditions are not encountered. This will also have the advantage of keeping the cost to the minimum, particularly when compared with the helically constructed type of flexible waveguide which must have a rubber jacket to provide the mechanical strength. The Flexaguide construction is inherently strong and the rubber jacket is normally only fitted for severe environmental applications, e.g. marine, missiles, oil polluted atmospheres.

If the Flexaguide is required to match into a colour scheme, it can be painted to the appropriate colour, but sometimes a considerable amount of mean power is being transmitted and it is then recommended that the Flexaguide be painted matt black to improve the heat dissipation.

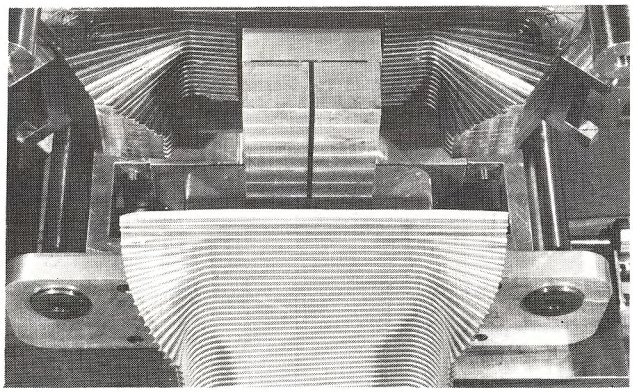
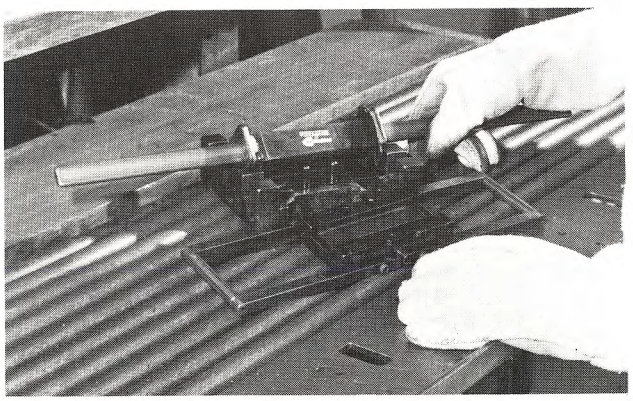
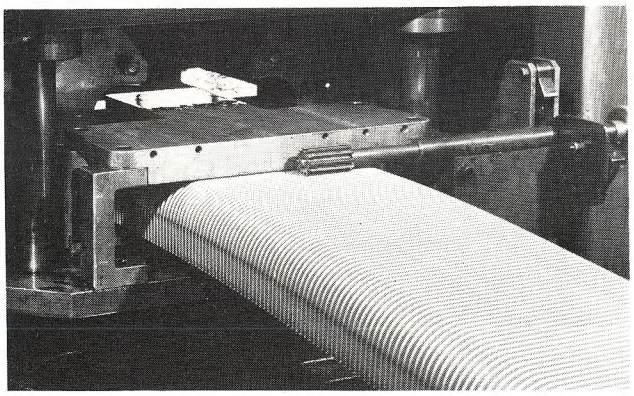


*Illustration showing the extremely complicated and accurate tooling used for the forming of Flexaguide sections. (Section shown WG6).*



*Flexaguide moulding process of protective jacket.*



*Flexaguide WG6 section being formed.*

The standard rubber jacket is moulded polychloroprene conforming to specification MIL-STD-417, and is fitted before the plating process. This provides a rugged pliable cover which protects and supports the convolutions of the waveguide during flexure and reinforces the wall to ensure strength and an air seal for pressurized applications (e.g. high mean and peak power systems–radar). A specially developed rubber lock incorporated in the flanges and the inherently strong mechanical bond between the jacket and the metal makes Flexaguide the ideal product for high power, pressurized systems.

For unusual applications, special rubber compounds other than polychloroprene can be used. Silicone rubber moulded Flexaguide is particularly useful for missile applications where extremely high ambient temperatures cause severe atmospheric operating conditions. The temperature range of this jacket is at least −50°C to +250°C. Silicone rubber is well able to cope with this environment, but is not recommended for use in oil-laden atmospheres. It is more expensive than neoprene.

If extreme temperature and an oil-laden atmosphere are encountered together then a flouro-silicone rubber is recommended which covers the temperature range −100°C to +200°C and is both oil resistant and flame retardant. Flexaguide of this type is being used in the Concorde aircraft. This type of jacket is however much more expensive and is only recommended when absolutely necessary.

## Standard Finishes

(i) External

(A) Polychloroprene Rubber

**The Flexaguide can be moulded in a pliable polychloroprene rubber jacket which protects and supports the convolutions of the waveguide during flexing, and doubly ensures air tightness in pressurized applications. A mechanically strong adherent bond between the jacket and the metal portions of the guide is ensured by special bonding techniques including rubber locks incorporated in the flanges. The flexing life of the assembly is increased by a reinforced tapered section of jacket which extends inwards from the flanges to distribute bending stresses.**

Temperature range −50°C to +120°C.

Shore Hardness BS° 35±5.

(B) Silicone Rubber

As (A) but moulded in silicone rubber. This protective coating is applied in environmental conditions where Skydrol is encountered.

Temperature range −50°C to +250°C.

Shore Hardness 40.

(C) Fluoro Silicone Rubber

As (A) but moulded in fluro-silicone rubber. This protective coating is applied in special environmental conditions which are not met by the previous coatings.

Temperature range −100°C to +200°C.

Shore Hardness 50.

(D) Polysulphide Rubber Paint

This paint is used where a flexible coating is required on Flexaguides which are impractical to rubber mould by method (A) (B) or (C) e.g. very tight preforms and waveguide R14 (preformed or straight).

Temperature range −40°C to +93°C.

Shore Hardness 15–20.

(E) Paint

Flexaguides may be painted, colour to customer order. Matt Black is a standard colour especially with very high mean power applications in mind.

(F) Plated

Silver to DTD 919.

Electro-Tin to DTD 924.

Clean – Bright Dipped.

(ii) Internal

(A) Plated

(i) Silver to DTD 919.
(ii) Electro-tin to DTD 924.
(iii) Clean – Bright Dipped.
(iv) Electro-tin to DTD 924 flanges only. This process is used when the Flexaguide mates with a dissimilar metal component, e.g. Aluminium – to minimise corrosion due to electrolytic action.
(v) Rhodium to DTD 931 used on flange faces only.

## Flexaguide Variations

**Preformed Flexaguide.** Flexaguide can be preformed in both the E and the H planes. The main limitation of this type of product is the minimum bending radius which varies with the waveguide size, and in which plane preform is required. The seams of all preforms are hard soldered.

Clearly, the largest minimum radius will be for the largest waveguide size with a hard soldered seam being preformed in the H plane.

The mechanical tables give a guide to the typical radii which can be achieved, but consultation with the factory is always recommended and full scale drawings of the proposed Flexaguide are appreciated.

**Rigid/Flexible combinations.** For applications where space is at a premium, there is an adaptor piece (in WG.16 only) which allows the Flexaguide to be fixed to a piece of rigid tubing without using flanges. This adaptor is only marginally larger than the outside dimensions of the waveguide and has no derogatory effects upon electrical performance. It can be used in permanent installations such as missiles and boat radars.

**Pressurised Systems.** Many waveguide runs are pressurized to ensure that any leakages there may be are from the inside of the waveguide to the atmosphere. Such systems normally have a dessicator to keep the waveguide dry and a typical application of this type of arrangement would be on board a Naval helicopter.

Secondly, pressurization of the waveguide will allow higher peak powers to be handled as in long range surveillance radars.

All Flexaguides have a pressure test part of the routine production procedure.

**VSWR.** In general all Flexaguides will meet a VSWR specification of better than 1·10 over the normal operating frequency range of the particular waveguide. As with many other types of device, this performance is better at mid-band and an example of this shows the improvement.

Flexaguides operating at 9·375 GHz ±50 MHz will easily meet a VSWR specification of 1·05 (WG16, R100).

Precise electrical specifications are obviously preferred since these are always a help to the test department. Sweep frequency facilities are available and can be offered as part of our production facility.

All flexible waveguides undergo a VSWR test prior to despatch with the exception of M14 ($\frac{1}{2}$ ht 6).

## ELECTRICAL DATA (inch & metric)

| I.E.C. size | W.G. size | E.I.A. | Frequency range GHz | V.S.W.R. | | Attenuation | | Peak power |
|---|---|---|---|---|---|---|---|---|
| | | | | †P/P | ‡P/C | db/ft | db/m | MW* |
| R14 | 6 | WR650 | 1·12 to 1·7 | 1·05 | | ·02 | ·006 | 10 |
| M14 | $\frac{1}{2}$ ht 6 | | 1·12 to 1·7 | 1·05 | | ·04 | ·13 | 2·5 |
| R32 | 10 | WR284 | 2·6 to 3·95 | 1·05 | 1·1 | ·06 | ·197 | 3·5 |
| R40 | 11A | WR229 | 3·22 to 4·9 | 1·05 | | ·06 | ·197 | 2·0 |
| R48 | 12 | WR187 | 3·95 to 5·85 | 1·075 | 1·1 | ·07 | ·23 | 2·0 |
| R70 | 14 | WR137 | 5·85 to 8·2 | 1·075 | 1·1 | ·09 | ·3 | 1·0 |
| R84 | 15 | WR112 | 7·05 to 10 | 1·075 | 1·1 | ·10 | ·33 | ·7 |
| R100 | 16 | WR90 | 8·2 to 12·4 | 1·075 | 1·1 | ·15 | ·49 | ·5 |
| R140 | 18 | WR62 | 12·4 to 18 | 1·1 | 1·12 | ·2 | ·66 | ·35 |

**At Atmospheric pressure*
*†Flanges fitted Plain/Plain*
*‡Flanges fitted Plain/Choke*

## MECHANICAL DATA (inch)

| W.G. size | Equivalent W.G. dims. | Bending radii static E* | Bending radii static H* | MCL Factory preform E | MCL Factory preform H | Max. operating pressure P.S.I.G. | Length† tolerance |
|---|---|---|---|---|---|---|---|
| W.G.6 | 6·5 × 3·25 | 15·5 | 31 | 13·5 | 26 | 10 | ± $\frac{1}{8}$/Ft |
| $\frac{1}{2}$ ht 6 | 6·5 × 1·625 | 15·5 | 31 | 13·5 | 26 | 10 | ± $\frac{1}{8}$/Ft |
| W.G.10 | 2·84 × 1·34 | 7 | 14 | 4·5 | 6·4 | 60 | ± $\frac{1}{8}$/Ft |
| W.G.11A | 2·29 × 1·145 | 6·5 | 13 | 4 | 6 | 45 | ± $\frac{1}{8}$/Ft |
| W.G.12 | 1·872 × ·872 | 6·5 | 13 | 3·5 | 5 | 45 | ± $\frac{1}{8}$/Ft |
| W.G.14 | 1·372 × ·622 | 4 | 8 | 2·5 | 3·5 | 45 | ± $\frac{1}{8}$/Ft |
| W.G.15 | 1·122 × ·497 | 3 | 6 | 1·7 | 2·5 | 45 | ± $\frac{1}{8}$/Ft |
| W.G.16 | ·900 × ·400 | 2·5 | 5 | 1·4 | 2·25 | 60 | ± $\frac{1}{8}$/Ft |
| W.G.18 | ·622 × ·311 | 2 | 4 | 1·3 | 1·75 | 60 | ± $\frac{1}{8}$/Ft |

**Multiply these columns ×4 for continuous bending radii*
*†Minimum length tolerance ± $\frac{1}{16}$*

*MCL = Mean centre line*

## MECHANICAL DATA (metric)

| I.E.C. size | Equivalent W.G. dims. | Bending radii static E* | Bending radii static H* | MCL Factory preform E | MCL Factory preform H | Max. operating pressure P.S.I.G. | Length ‡ tolerance |
|---|---|---|---|---|---|---|---|
| R14 | 165·10 × 82·55 | 393·70 | 787·4 | 347·90 | 660·40 | 10 | 10 mm/m |
| M14 | 165·10 × 41·28 | 393·70 | 787·4 | 347·90 | 660·40 | 10 | 10 mm/m |
| R32 | 72·14 × 34·04 | 177·80 | 355·60 | 114·30 | 162·56 | 60 | 10 mm/m |
| R40 | 58·17 × 29·083 | 165·10 | 330·10 | 101·60 | 152·40 | 45 | 10 mm/m |
| R48 | 47·55 × 22·149 | 165·10 | 330·20 | 88·90 | 127·00 | 45 | 10 mm/m |
| R70 | 34·85 × 15·799 | 101·60 | 203·20 | 63·50 | 88·90 | 45 | 10 mm/m |
| R84 | 28·499 × 12·624 | 76·20 | 152·40 | 43·180 | 63·50 | 45 | 10 mm/m |
| R100 | 22·860 × 10·160 | 63·50 | 127·00 | 35·560 | 57·150 | 60 | 10 mm/m |
| R140 | 15·799 × 7·899 | 50·80 | 101·60 | 33·020 | 44·450 | 60 | 10 mm/m |

**Multiply these columns ×4 for continuous bending radii*
*‡Minimum length tolerance ±1·6 mm*

*MCL = Mean centre line*

### Order Information

All Flexaguide enquiries are handled by a time sharing computer system and when ordering or raising an enquiry the following information is required:

(i) Quantity.
(ii) Flexaguide size.
(iii) Length.
(iv) Type of Flanges.
(v) Flexaguide straight or preformed. If latter then sketch showing required shape.
(vi) Internal finish.
(vii) External finish.
(viii) Conditions of inspection e.g. Ministry, Commercial, etc.
(ix) Frequency range. Improved specification can in some cases be achieved over smaller ranges in the respective waveguide sizes.

### Special Applications

Special applications of Flexaguide are too numerous to list. Basically, however, if you have a problem where waveguide must be used but rigid assemblies are precluded, Flexaguide will provide the answer. Flexaguide can be moulded integral with all rigid straights, bends, twists, etc., and can be supplied in lengths of up to 45' rubbered in special cases. Lengths over 4' are considered special and require confirmation from Flexaguide Design Department before ordering.

Two such examples of special Flexaguide applications are listed below.

(1) We have developed a design principle for flexible waveguides to operate up to 120 p.s.i.g. in waveguide 10 for linear accelerator use where both high peak and mean powers exist.

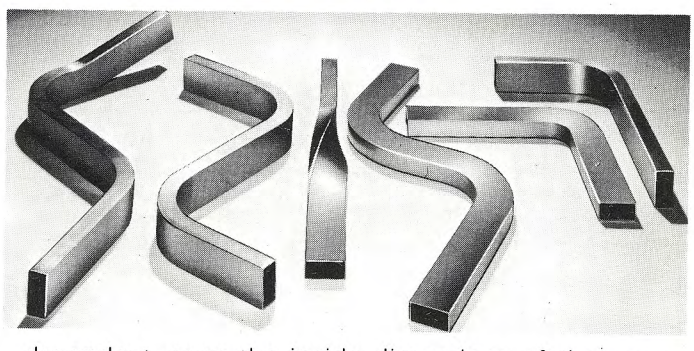
(2) We have developed in waveguide 14 Flexaguides to handle very high CW powers, up to 25 kW-CW. These flexibles incorporate finning to allow for natural or forced air cooling and have also been used in place of rotating joints in limited movement antennas. We have also developed similar lengths in waveguide 11A to replace rotating joints but for this application low loss was the criterion, the Flexaguides being installed in front of a low noise cryogenically cooled parametric amplifier for satellite tracking use.

Please consult our Design Department on any further applications and problems not covered by this catalogue.

# Waveguide Twisting Forming & Bending

### Marconi Instruments offers these advantages:-

- ☐ Wide range of waveguide sizes
- ☐ Tight radii
- ☐ Wide range of finishes
- ☐ Wide range of flanges stocked
- ☐ Design Consultancy Service



A lot of people have tried, without success, to bend Aluminium Waveguide but Microwave Products Division has discovered the secrets; so much so, that a large percentage of our total waveguide fabricated output is for the Aerospace Industry where the highest degree of precision is essential.

The basic bending and fabrication techniques are extremely simple but we keep the "tricks of the trade" to ourselves. Consider the stresses and strains in bending a piece of aluminium tubing and think how easy it is to introduce deformities. High electrical performance is dependent upon the inside dimensions of the waveguide being maintained even round the most tortuous twists and bends.

We have solved these problems and can produce equipments to the highest possible standards as well as being able to electrically test and calibrate the units using the lastest microwave measuring techniques.

If an application exists where close tolerance fabrication or a general waveguide run is required, we have the capacity, the technology, the capability and the microwave expertise.

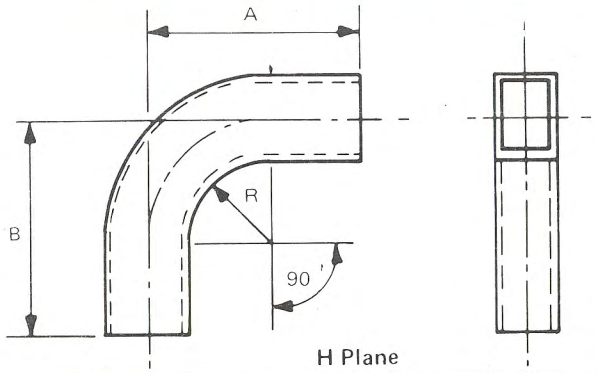
# Waveguide Twists

The overall lengths of the twists shown above are minimum and allow for the fitting of flanges to order.

The company however will be pleased to quote for twists to customer's specifications.

| | MINIMUM OVERALL LENGTHS | | | |
|---|---|---|---|---|
| | FROM 0° | TO 45° | OVER 45° | TO 90° |
| | INCH | MM | INCH | MM |
| WG.22 | 2.55 | 57,15 | 2.50 | 63,50 |
| WG.18 | 3.50 | 88,90 | 4.00 | 101,60 |
| WG.16 | 4.00 | 101,60 | 4.50 | 114,30 |
| WG.15 | 5.50 | 139,70 | 6.50 | 165,10 |
| WG.14 | 5.50 | 139,70 | 7.50 | 190,50 |
| WG.12 | 10.50 | 266,70 | 13.50 | 342,90 |

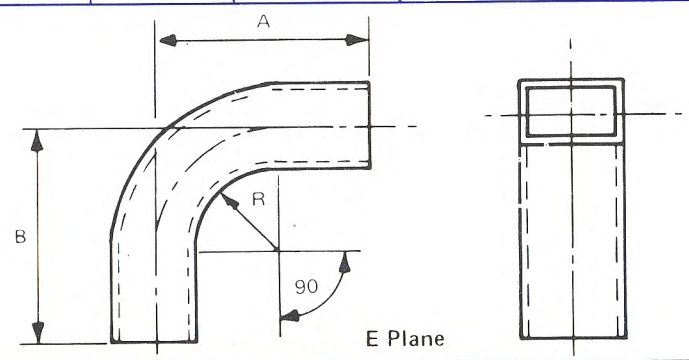
# Press Tool Bends



H Plane

| WG size | R DIM. | | CENTRE-LINE EQUIVALENT | | LEG LENGTH (MAX.) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | A | | B | |
| | Inch | Metric mm | Inch | Metric mm | Inch | Metric mm | Inch | Metric mm |
| 12 | 4·000 | 101,600 | 5·000 | 127,000 | 7·500 | 190,500 | 7,500 | 190,500 |
| 14 | 1·500 | 38,100 | 2·250 | 57,150 | 5·000 | 127,000 | 5·000 | 127,000 |
| 14 | 3·250 | 82,550 | 4·000 | 101,600 | 6·000 | 152,400 | 6·000 | 152,400 |
| 16 | 0·500 | 12,700 | 1·000 | 25,400 | 6·500 | 165,100 | 6.500 | 165,100 |
| 16 | 0·937 | 23,7998 | 1·437 | 36,4998 | 4·000 | 101,600 | 4·000 | 101,600 |
| 16 | 1·000 | 25,400 | 1·500 | 38,100 | 3·000 | 76,200 | 3·000 | 76,200 |
| 16 | 1·500 | 38,100 | 2·000 | 50,800 | 5·250 | 133,350 | 5·250 | 133,350 |
| 16 | 2·437 | 61,8998 | 2·937 | 74,5998 | 7·500 | 190,500 | 7·500 | 190,500 |
| 18 | 1·000 | 25,400 | 1·351 | 34,3154 | 3·500 | 88,900 | 3·500 | 88,900 |
| 18* | 0·375 | 9,525 | 0·726 | 18,4404 | 3·500 | 88,900 | 3·500 | 88,900 |
| 22 | 2·000 | 50,800 | 2·180 | 55,372 | 5·000 | 127,000 | 5·000 | 127,000 |

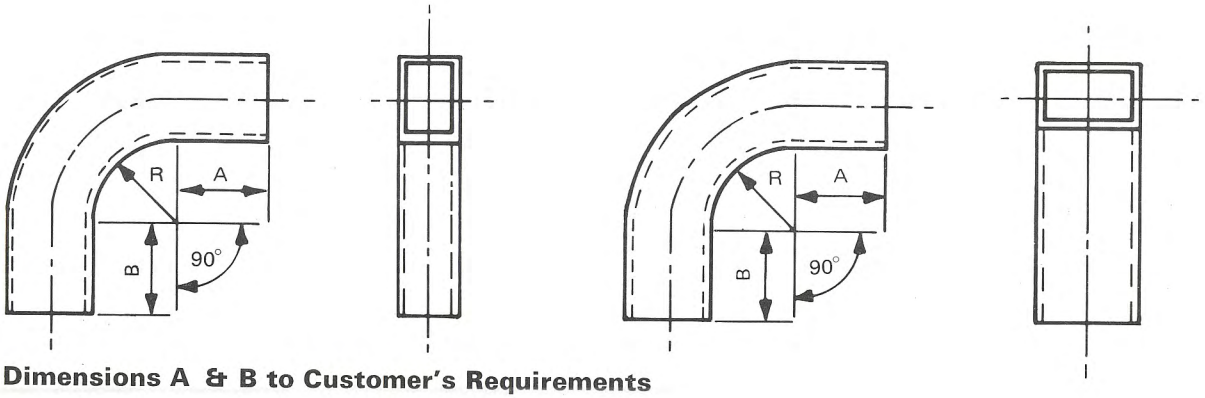
**45° Bend Dimensions from Tangent Point.*



E Plane

| WG size | R DIM. | | CENTRE-LINE EQUIVALENT | | LEG LENGTH (MAX.) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | A | | B | |
| | Inch | Metric mm | Inch | Metric mm | Inch | Metric mm | Inch | Metric mm |
| 12 | 3·500 | 88,900 | 4·000 | 101,600 | 6·500 | 165,100 | 6·500 | 165,100 |
| 14 | 1·843 | 46,8122 | 2·218 | 56,3372 | 3·625 | 92,075 | 3·625 | 92,075 |
| 14 | 1·500 | 38,100 | 1·875 | 47,625 | 3·500 | 88,900 | 3·500 | 88,900 |
| 16 | 0·312 | 7,9248 | 0·562 | 14,2748 | 5·000 | 127,000 | 5·000 | 127,000 |
| 16 | 0·500 | 12,700 | 0·750 | 19,070 | 7·250 | 184,150 | 7·250 | 184,150 |
| 16 | 0·750 | 19,050 | 1·000 | 25,400 | 5·375 | 136,525 | 5·375 | 136,525 |
| 16 | 0·812 | 20,6248 | 1·062 | 26,9748 | 7·450 | 189,230 | 4·500 | 114,300 |
| 16 | 0·937 | 23,7998 | 1·187 | 30,1498 | 6·750 | 171,450 | 6.750 | 171,450 |
| 16 | 1·000 | 25,400 | 1·250 | 31,750 | 6·250 | 158,750 | 4·500 | 114,300 |
| 16 | 1·187 | 30,1498 | 1·437 | 36,4998 | 8·000 | 203,200 | 8·000 | 203,200 |
| 16 | 1·562 | 39,6748 | 1·812 | 46,0248 | 8·500 | 215,900 | 6·000 | 152,400 |
| 16 | 1·687 | 42,8498 | 1·937 | 49,1998 | 5·750 | 146,050 | 4·250 | 107,950 |
| 16 | 1·937 | 49,1996 | 2·187 | 55,5498 | 4·250 | 107,950 | 4·250 | 107,950 |
| 16 | 2·750 | 69,850 | 3·000 | 76,200 | 7·625 | 193,675 | 7·625 | 193,675 |
| 18 | 1·000 | 25,400 | 1·195 | 30,353 | 4·125 | 104,775 | 4·125 | 104,775 |
| 18 | 1·156 | 29,3624 | 1·351 | 34,3154 | 4·500 | 114,300 | 4·500 | 114,390 |
| 22 | 1·000 | 25,400 | 1·110 | 28,194 | 4·000 | 101,600 | 4·000 | 101,600 |

# Machine Bending - Multiple Bends




**Dimensions A & B to Customer's Requirements**

**H Plane**

| WG Size | DIM. R Inch | DIM. R Metric mm | CENTRE-LINE EQUIVALENT Inch | CENTRE-LINE EQUIVALENT Metric mm |
|---|---|---|---|---|
| 12 | 4.000 | 101,600 | 5.000 | 127,000 |
| 14 | 1.250 | 31,750 | 2.000 | 50,800 |
| | 3.250 | 87,550 | 4.000 | 101,600 |
| 15 | 1.562 | 39,6748 | 2.187 | 55,5498 |
| | 3.000 | 76,200 | 3.625 | 92,0750 |
| | 4.936 | 125,3744 | 5.561 | 141,2494 |
| 16 | 0.500 | 12,700 | 1.000 | 25,400 |
| | 0.750 | 19,050 | 1.250 | 31,750 |
| | 0.969 | 24,6126 | 1.469 | 37,3126 |
| | 1.000 | 25,400 | 1.500 | 38,100 |
| | 1.062 | 26,9748 | 1.562 | 39,6748 |
| | 1.469 | 37,3126 | 1.969 | 50,0126 |
| | 1.500 | 38,100 | 2.000 | 50,800 |
| | 1.625 | 41,275 | 2.125 | 53,975 |
| | 1.750 | 44,450 | 2.250 | 57,150 |
| | 2.000 | 50,800 | 2.500 | 63,200 |
| | 2.500 | 63,200 | 3.000 | 76,200 |
| | 3.000 | 76,200 | 3.500 | 88,900 |
| | 3.500 | 88,900 | 4.00 | 101,600 |
| | 3.690 | 93,726 | 4.190 | 106,426 |
| | 4.000 | 101,600 | 4.500 | 114,300 |
| | 6.500 | 165,100 | 7.000 | 177,800 |
| | 12.000 | 304,800 | 12.500 | 317,500 |
| 18 | 0.750 | 19,050 | 1.101 | 27,9654 |
| 22 | 1.420 | 36.068 | 1.600 | 40,640 |
| | 2.000 | 50,800 | 2.180 | 55,372 |

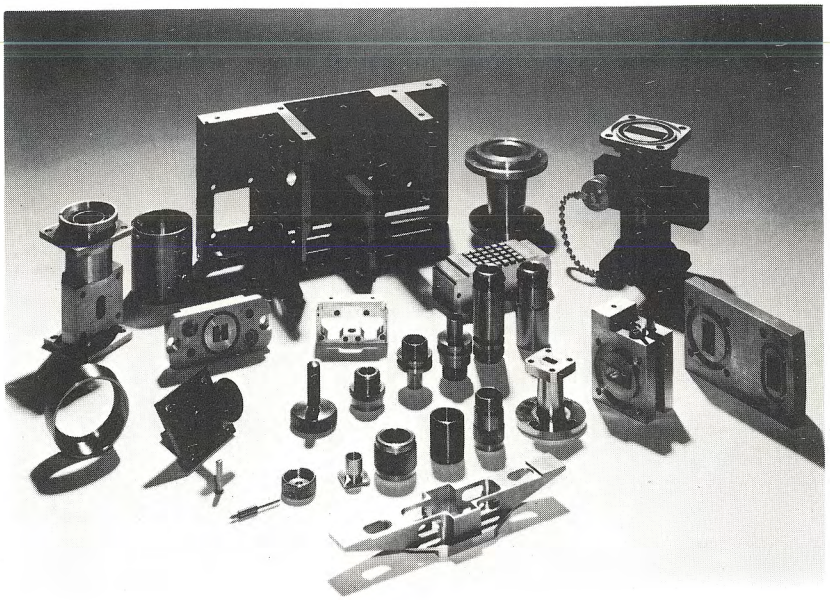
**E Plane**

| WG Size | DIM. R Inch | DIM. R Metric mm | CENTRE-LINE EQUIVALENT Inch | CENTRE-LINE EQUIVALENT Metric mm |
|---|---|---|---|---|
| 11A | 4.655 | 118,237 | 5.292 | 134,4168 |
| 12 | 2.218 | 56,3372 | 2.718 | 69,0372 |
| | 3.500 | 88,900 | 4.000 | 101,600 |
| 14 | 1.343 | 34,1122 | 1.718 | 43,6372 |
| | 1.500 | 38,100 | 1.875 | 47,625 |
| | 1.843 | 46,8122 | 2.218 | 56,3372 |
| 15 | 1.000 | 25,400 | 1.312 | 33,3248 |
| | 1.500 | 38,100 | 1.812 | 46,0248 |
| | 2.140 | 54,356 | 2.452 | 62,2808 |
| | 2.500 | 63,200 | 2.812 | 71,4248 |
| | 2.656 | 67,4624 | 2.968 | 75,3872 |
| 16 | 0.500 | 12,700 | 0.750 | 19,050 |
| | 0.750 | 19,050 | 1.000 | 25,400 |
| | 0.875 | 22,225 | 1.125 | 28,575 |
| | 1.000 | 25,400 | 1.250 | 31,750 |
| | 1.071 | 27,2034 | 1.321 | 33,5534 |
| | 1.125 | 28,575 | 1.375 | 34,925 |
| | 1.500 | 38,100 | 1.750 | 44,450 |
| | 1.562 | 39,6748 | 1.812 | 46,0248 |
| | 1.750 | 44,450 | 2.000 | 50,800 |
| | 2.000 | 50,800 | 2.250 | 57,150 |
| | 2.093 | 53,1622 | 2.343 | 59,5122 |
| | 2.150 | 54,610 | 2.400 | 60,960 |
| | 2.500 | 63,200 | 2.750 | 69,850 |
| | 2.734 | 69,4436 | 2.984 | 75,7936 |
| | 3.000 | 76,200 | 3.250 | 82,550 |
| | 3.250 | 82,550 | 3.500 | 88,900 |
| | 3.671 | 93,2434 | 3.921 | 99,5934 |
| | 4.000 | 101,600 | 4.250 | 107,950 |
| | 4.250 | 107,950 | 4.500 | 114,300 |
| | 4.750 | 120,650 | 5.000 | 127,000 |
| | 5.000 | 127,000 | 5.250 | 133,350 |
| | 6.000 | 152,400 | 6.250 | 158,750 |
| | 6.750 | 171,450 | 7.000 | 177,800 |
| | 12.000 | 304,800 | 12.250 | 311,150 |
| 18 | 1.156 | 29,3624 | 1.351 | 34,3154 |
| 22 | 1.000 | 25,400 | 1.110 | 28,194 |

# Sub-contract Facilities

## Marconi Instruments offers these advantages:-

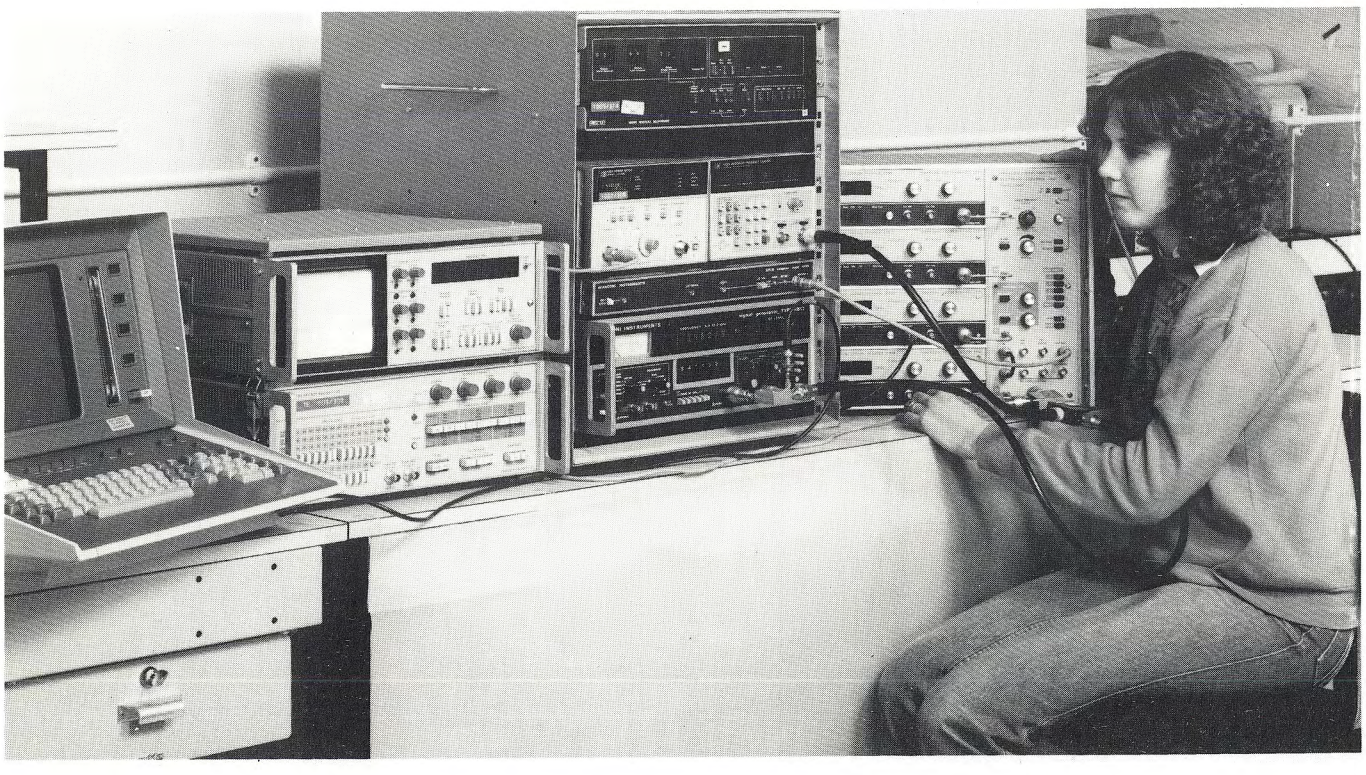
- ☐ Wide experience
- ☐ Complex assemblies
- ☐ Tight tolerances
- ☐ Qualified release
- ☐ Full test facilities



The expertise and techniques required to produce the Marconi Instruments extensive range of catalogue microwave test equipment and components are available to OEM's for sub-contract. Many special-to-type assemblies for high technology Aerospace and Defence Industries are manufactured. A wide range of machining and finishing processes are available using semi-automatic or automatic machine tools.

Printed circuit boards can also be assembled and a fast automatic test system AUTOTEST 80 is available for board checking.

A wide experience of measurements at Marconi Instruments leads to expertise in performing electronic, microwave and mechanical tests using the latest equipment. Qualified release can be provided to the highest standards available. Calibration is performed in-house in the comprehensively equipped laboratory approved by the British Calibration Service.

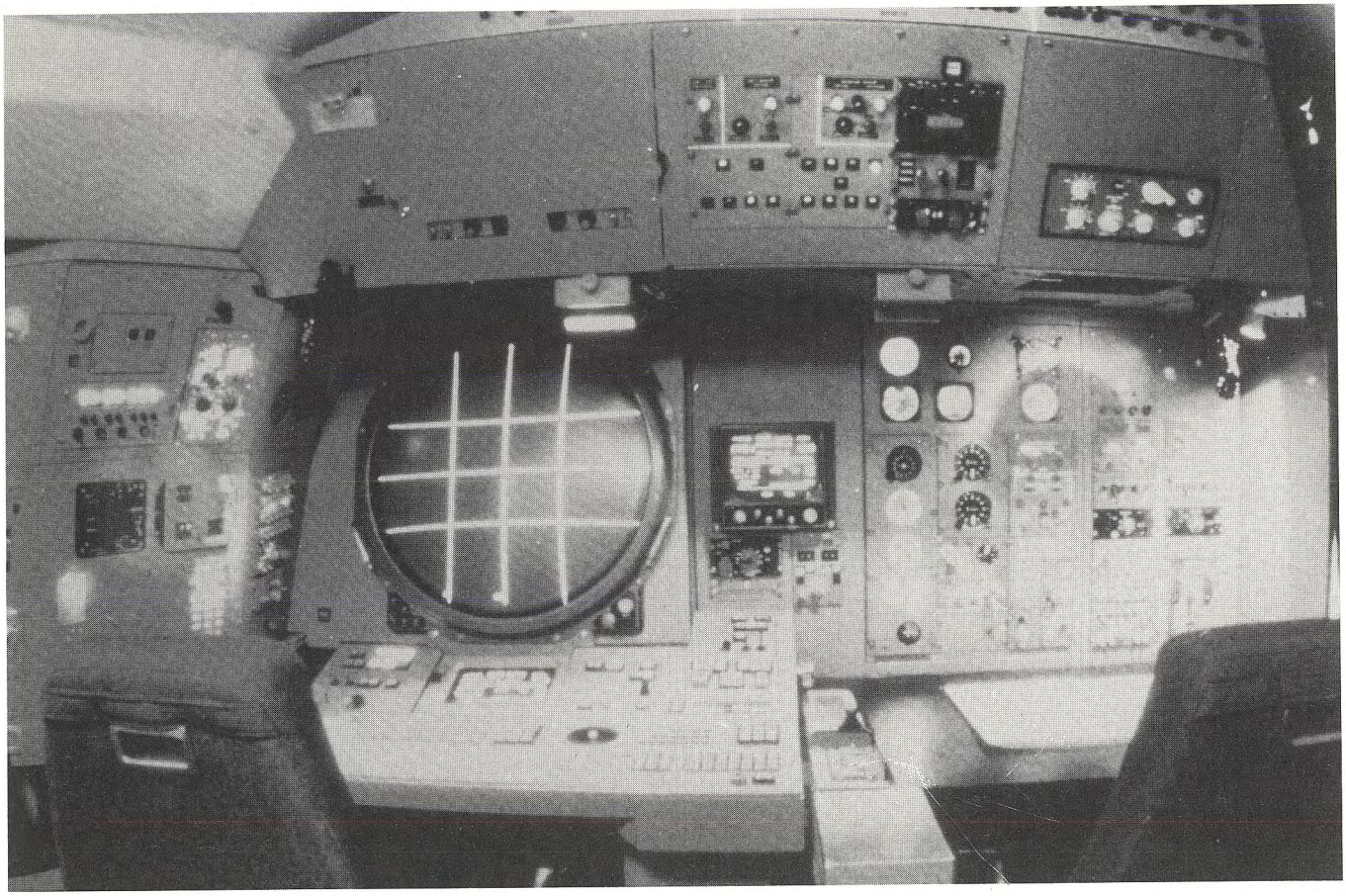


# Waveguide Frequency Ranges, Dimensions and Designations

| FREQUENCY RANGE (GHz) | INTERNAL DIMENSIONS | | OFFICIAL DESIGNATIONS | | | | COMMERCIAL DESIGNATIONS | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (inches) | (mm. approx) | I.E.C. | U.K. (RCSC) | U.S. (EIA) | U.S. (JAN) | U.K. | D-B | H-P | MRI | Narda | Philips | TRG |
| 0.32– 0.49 | 23.0 × 11.0 | 584.0 × 292.0 | | WG00 | WR2300 | | | | | | | | |
| 0.35– 0.53 | 21.0 × 10.5 | 533.0 × 267.0 | | WG0 | WR2100 | | | | | | | | |
| 0.41– 0.625 | 18.0 × 9.0 | 457.0 × 229.0 | | WG1 | WR1800 | RG–201/U | | | | | | | |
| 0.49– 0.75 | 15.0 × 7.5 | 381.0 × 191.0 | | WG2 | WR1500 | RG–202/U | | | | | | | |
| 0.64– 0.96 | 11.5 × 5.75 | 292.0 × 146.0 | | WG3 | WR1150 | RG–203/U | | | | | | | |
| 0.75– 1.12 | 9.75 × 4.875 | 248.0 × 124.0 | | WG4 | WR975 | RG–204/U | | | | P | | | |
| 0.96– 1.45 | 7.7 × 3.85 | 196.0 × 98.0 | | WG5 | WR770 | RG–205/U | | | | | | | |
| 1.12– 1.7 | 6.5 × 3.25 | 165.0 × 83.0 | R14 | WG6 | WR650 | RG–69/U | L | | | L | L | L(25cm) | L |
| 1.45– 2.2 | 5.1 × 2.55 | 131.0 × 65.0 | R18 | WG7 | WR510 | | | | | | | D | |
| 1.7 – 2.6 | 4.3 × 2.15 | 109.0 × 55.0 | R22 | WG8 | WR430 | RG–104/U | | | | M | LS | | |
| 2.2 – 3.3 | 3.4 × 1.7 | 86.0 × 43.0 | R26 | WG9A | WR340 | RG–112/U | | | | | | | |
| 2.6 – 3.95 | 2.84 × 1.34 | 72.0 × 34.0 | R32 | WG10 | WR284 | RG–48/U | S | L | S | S | S | S(10cm) | S |
| 3.3 – 4.9 | 2.29 × 1.145 | 59.0 × 29.0 | R40 | WG11A | WR229 | | | | | | | A(7.5cm) | |
| 3.95– 5.85 | 1.872 × 0.872 | 48.0 × 22.0 | R48 | WG12 | WR187 | RG–49/U | C | K | G | C | C | C(6cm) | C |
| 4.9 – 7.05 | 1.59 × 0.795 | 40·0 × 20·0 | R58 | WG13 | WR159 | | | | C | | | C | |
| 5.85– 8.2 | 1.372 × 0.622 | 35.0 × 16.0 | R70 | WG14 | WR137 | RG–50/U | | J | J | XB | XN | J(4.5cm) | |
| 7.05– 10.0 | 1.122 × 0.497 | 29.0 × 13.0 | R84 | WG15 | WR112 | RG–51/U | | H | H | XL | XB | H(3.5cm) | XL |
| 8.2 – 12.4 | 0.9 × 0.4 | 23.0 × 10.0 | R100 | WG16 | WR90 | RG–52/U | X | G | X | X | X | X(3cm) | X |
| 10.0 – 15.0 | 0.75 × 0.375 | 19.0 × 9.5 | R120 | WG17 | WR75 | | | FA | M | | | | |
| 12.4 – 18.0 | 0.622 × 0.311 | 16.0 × 7.9 | R140 | WG18 | WR62 | RG–91/U | J | F | P | KU | KU | P(2cm) | KU |
| 15.0 – 22.0 | 0.510 × 0.255 | 13.0 × 5.8 | R180 | WG19 | WR51 | | | | N | K | | | |
| 18.0 – 26.5 | 0.420 × 0.170 | 11.0 × 4.3 | R220 | WG20 | WR42 | RG–53/U | | E | K | | K | | K |
| 22.0 – 33.0 | 0.340 × 0.170 | 8.6 × 4.3 | R260 | WG21 | WR34 | | | | | | | | |
| 26.5 – 40·0 | 0.280 × 0.140 | 7.1 × 3.6 | R320 | WG22 | WR28 | RG–96/U | Q | D | R | | V | Q(8mm) | A |
| 33.0 – 50.0 | 0.224 × 0.112 | 5.7 × 2.9 | R400 | WG23 | WR22 | RG–97/U | | C | | | Q | | B |
| 40.0 – 60.0 | 0.188 × 0.094 | 4.8 × 2.4 | R500 | WG24 | WR19 | | | | | | | | U |
| 50.0 – 75.0 | 0.148 × 0.074 | 3.8 × 1.9 | R620 | WG25 | WR15 | TG–98/U | | B | | | M | | V |
| 60.0 – 90.0 | 0.122 × 0.061 | 3.1 × 1.6 | R740 | WG26 | WR12 | RG–99/U | O | A | | | E | E(4mm) | E |
| 75.0 –110.0 | 0.100 × 0.050 | 2.4 × 1.3 | R900 | WG27 | WR10 | | | | | | | | W |
| 90.0 –140.0 | 0.080 × 0.040 | 2.0 × 1.0 | R1200 | WG28 | WR8 | RG–138/U | | W | | | N | | F |
| 110.0 –170.0 | 0.065 × 0.0325 | 1.7 × 0.82 | | WG29 | WR7 | RG–136/U | | | | | | B(2mm) | D |
| 140.0 –220.0 | 0.051 × 0.0255 | 1.3 × 0.65 | | WG30 | WR5 | RG–135/U | | | | | A | | G |
| 170.0 –260.0 | 0.043 × 0.0215 | 1.1 × 0.55 | | WG31 | WR4 | RG–137/U | | | | | | | H |
| 220.0 –325.0 | 0.034 × 0.017 | 0.87 × 0.44 | | WG32 | WR3 | RG–139/U | | | | | R | | J |

*NOTE: Every care has been taken to ensure the information contained in this table is correct, but the company cannot accept any liability for errors.*

# A TOTAL SIMULATION AND TRAINING CAPABILITY



The Trainers and Simulators Division of Marconi Instruments can design, develop and manufacture training devices of wide-ranging complexity and application – from small, portable trainers to full-scale simulators for the very largest projects.

Today, as modern tactical weapons and defence become increasingly sophisticated, the cost of using real equipment for training purposes has become prohibitive – resulting in a high demand for realistic trainers and simulators.

Using the experience gained in custom-building simulation equipment, Marconi Instruments can offer customers an unrivalled level of expertise to solve every type of problem in the field of simulation technology.

Quite apart from its unique experience on defence contracts (from conception right through to implementation) the Division has frequently been commissioned to supply simulation equipment for other Government Departments and numerous major international companies.

## PRODUCT RANGE

The following examples of some of the projects undertaken give only a brief indication of the Division's overall comprehensive experience in the field.

### Nimrod Full Mission Simulator

The Nimrod Maritime Crew Trainer (MCT) meets the conversion and continuation training requirements of the tactical air crew. It provides aircraft environment and tactical scenarios which enable these crews to establish, practice and develop the skills and techniques which are vital to support their real life roles.

The simulator faithfully represents all the aircraft systems: Sonar; Electronic Surveillance Measures (ESM); Radar; Magnetic Anomaly Detector (MAD); Communications; Routine and Tactical Navigation and Weapons Management.

## Nuclear Power Station Control Room

The control room simulator is an exact replica of the plant's control room with all controls and instrumentation fully operable. It meets all training requirements, using design quality mathematical models to represent the plant systems, resulting in a high fidelity simulator which has received the benefits of extensive validation of the design models.

## Aircrew Emergency Procedures Trainers

The emergency procedures trainer is a portable training aid for air crews to practise normal and emergency procedures. The trainer has the appearance of a suitcase when closed and opens to expose a scaled down replica of the aircraft flight console.

## Cockpit Procedural Trainers

The cockpit procedural trainer is used to train flight crews in aircraft systems management, under both normal and emergency or fault conditions, and also to train ground maintenance engineers in fault diagnosis. All aircraft systems are simulated on a complete flight deck to reproduce to a high fidelity the behaviour on the ground and in various in-flight modes of the aircraft systems, including engines.

## Artillery Trainers

An extremely cost effective simulator for the training of Forward Observation Post personnel. All aspects of their training can be covered, including tactics and the production of fire plans. The artillery trainers use computer-generated imagery superimposed on a projected colour panorama of the battlefield area. The superimposed imagery includes synthetic targets, sighted or hidden ground, air and smoke burst – all accompanied by highly realistic audio effects (even the flight of shells).

## Nuclear Submarine Machinery Control Room Simulators

The machinery control room is an exact replica of the ship's control room. All controls, instrumentation and equipments normally visible to, and operated by the crew are fitted. The simulator also contains all necessary instrumentation and controls for the instructor to initiate the training exercise, to monitor trainee operation, act as an out-station operator, override the machinery control room controls and introduce system faults.

## Helicopter Engineering Systems Simulators

The helicopter engineering systems simulators support conversion and continuation training of both ground crew and pilots in normal and emergency procedures, fault diagnosis and engine setting adjustments. Engines, rotors and basic aircraft systems are fully simulated to respond to cockpit control actions and to instructor injected malfunctions. Users of Marconi simulators include the British Army for their Lynx and Gazelle helicopters.

## Railway Driver Trainers

The Marconi Instruments' Railway Driver Trainer covers all aspects of driving, including the use of controls and instrumentation, the recognition and correction of various fault and emergency situations as well as route familiarisation. This latter capability is a result of the highly realistic and dynamic views of the track ahead which are presented to the trainee drivers. Further realism is achieved by the reproduction of audio effects such as track and brake noise.

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# NATO Catalogue Numbers

*(Marconi instruments in this Catalogue which have been allocated NATO Stock Numbers)*

**Note**
*Codification is a continual process, and while every effort has been made to provide a complete list, it may not be exhaustive, since, our products are under continuous consideration for use by the armed services.*

*For further information please contact the:-*
*Military Sales Department,*
*Marconi Instruments Limited, St. Albans.*

| *Marconi Type No.* | *Military Designation* | *NATO Cat. No.* |
|---|---|---|
| 893B | Wattmeter Absorption Audio Frequency (Navy) | 6625-99-541-2891 |
| TF 2000 | Oscillator Audio Frequency (RAF) | 5845-99-923-7246 |
| TF 2005R | Signal Generator Assembly (RAF) | 6625-99-952-0447 |
| TF 2015A | Generator Signal Set CT 584/11 | 6625-99-664-4144 |
| TF 2016A | Signal Generator | (Navy version) 6625-99-541-9092 (RAF version) 6625-99-654-0885 |
| 2018 | Signal Generator | Applied for |
| OA 2090B | White Noise Test Set (Army) | 6625-99-117-6778 |
| TF 2162 | Attenuator Variable CT 532 | 5905-99-972-0856 |
| TF 2163S | Attentuator Variable CT 553 (Navy) | 6625-99-519-9976 |
| TF 2167 | Amplifier, Signal Generator (Army) | 6625-99-634-2805 |
| TF 2169 | Pulse Modulator (RAF) | 6625-99-645-9235 |
| TF 2171 | Synchronizer Digital (Navy & RAF) | 6625-99-647-5594 |
| TF 2173 | Synchronizer Digital (RAF) | 6625-99-645-9552 |
| TF 2300B | Meter Set, Modulation (Army) | 6625-99-631-0502 |
| TF 2300B | Meter Set, Modulation (Triffid) | 6625-99-654-9929 |
| TF 2300BM | Modulation Meter (RAF) | 6625-99-620-9175 |
| TF 2304 | Automatic Modulation Meter (Norwegian Army) | 6625-25-126-7640 |
| 2305 | Modulation Meter | Applied for |
| TF 2331A | Indicator Distortion (Navy & RAF) | 6625-99-537-2004 |
| TF 2370 | Analyser Set Spectrum CT 571/11 (Navy & RAF) | 6625-99-529-1124 |
| TK 2373 | Frequency Extender (Navy) | 6625-99-543-1640 |
| TK 2374 | Probe, Zero Loss (Navy & RAF) | 6625-99-651-6380 |
| 2438 | Universal Counter/Timer | 6625-99-966-3987 |
| TF 2700 | Impedance Bridge | 6625-99-104-3861 |
| TF 2952 | Test Set Radio Telephone (RAF) | 6625-12-173-8093 |

## Microwave Equipment

| *Marconi Type No.* | *Military Designation* | *NATO Cat. No.* |
|---|---|---|
| 6000/3 | Broadband Crystal Detector SF (WG16) | 5840-99-115-5826 |
| 6002/1 | Coaxial Crystal Detector I/P Plug Type N | 4935-99-223-3268 |
| | When fitted with CV 2154 | 5820-99-450-6925 |
| | When fitted with CV 2155 | 5820-99-652-1657 |
| 6003/3 | Crystal Detector SF (WG16) | 5985-99-194-5527 |
| 6005/4 | Short Circuit SF (WG16) | 6625-99-636-0383 |
| 6006/2 | Stub Tuner SF (WG16) | 5840-99-450-6983 |
| 6019/2 | Calibrated Attenuator Grade 2 SF (WG18) | 5985-99-633-1676 |
| 6019/4 | Calibrated Attenuator Grade 2 SF (WG16) | 5985-99-195-6170 |
| 6020/3 | Variable Attenuator RF (WG16) | 5985-99-100-3985 |
| 6020/4 | Variable Attenuator SF (WG16) | 5985-99-537-8152 |
| 6021/5 | Pre-set Attenuator SF (WG16) | 5985-99-144-7577 |
| 6025/2 | 'E' Bend SF (WG18) | 5940-99-195-6148 |
| 6025/5 | 'E' Bend SF (WG15) | 5985-99-450-6921 |
| 6026/2 | WG Bend H Plane 90° SF (WG18) | 5985-99-656-3862 |
| 6030A/8 | Multi-hole Directional Coupler, 3dB, SF (WG16) | 5985-99-654-0820 |
| 6030A/10 | Multi-hole Directional Coupler, 10dB, SF (WG16) | 5985-99-648-6106 |
| 6032/2 | Short Matched Termination SF (WG16) | 5985-99-527-1086 |
| 6032/4 | Short Matched Termination SF (WG15) | 5985-99-450-6939 |
| 6033/3 | Broadband Isolator SF (WG16) | 6625-99-450-6982 |
| 6036/4 | Waveguide Horn SF (WG16) | 5985-99-119-1016 |
| 6037/1 | Coaxial To Waveguide Transformer SF (WG18) | 5950-99-924-3518 |
| 6037/2 | Coaxial to Waveguide Transformer RF (WG16) | 5985-99-914-6933 |
| 6037/3 | Coaxial to Waveguide Transformer SF (WG16) | 5985-99-521-4633 |
| 6037/5 | Coaxial to Waveguide Transformer RF (WG14) | 5985-99-142-7799 or 5985-99-618-0425 |
| 6037/6 | Coaxial to Waveguide Transformer RF (WG12) | 5985-99-195-5487 |
| 6037/7 | Coaxial to Waveguide Transformer RF (WG10) | 5985-99-105-0860 |
| 6039/3 | Waveguide Support Bench 3 feet long | 5985-99-633-1678 |
| 6042/2 | Waveguide Support Clip (WG18) | 5985-99-633-1680 |
| 6042/3 | Waveguide Support Clip (WG16) | 5985-99-633-1681 |
| 6042/4 | Waveguide Support Clip (WG15) | 5985-99-450-6947 |
| 6040 | WG Support Carriage | 5985-99-450-6986 |
| 6041 | WG Free Standing Support | 5985-99-450-6919 |
| 6044/1 | Quick Release Clamp (WG16) | 5985-99-946-9293 |
| 6052/3 | Rotary Vane Attenuator SF (WG16) | 5985-99-111-5210 |
| 6055B | Signal Source Freq. Range 850-2150 MHz | 6625-99-634-7528 |
| 6056B | Signal Source Freq. Range 2·0-4·0 GHz | 6625-99-647-8175 |
| 6060 | Wideband Detector Freq. Range 10 MHz-12·4 GHz | 5820-99-523-6335 |
| 6237/1 | Transformer WG to Coaxial 12·4-18 GHz (WG18) | 5985-99-637-9587 |
| 6237/3 | Transformer WG to Coaxial 8·0-12·4 GHz (WG16) | 5985-99-637-9585 |
| 6420 | Coaxial TFT Head | 6625-99-639-4339 |
| 6422 | Coaxial TFT Head | 6625-99-537-6865 |

# NATO Catalogue Numbers

| *Marconi Type No.* | *Military Designation* | *NATO Cat. No.* |
|---|---|---|
| 6423 | Coaxial TFT Head | 6625-99-642-2903 |
| 6426 | WG TFT Head | 6625-99-639-4338 |
| 6440N | TFT Power Head | 6625-99-637-9584 |
| 6460S | Complete TFT Power Meter system consists of: | |
| | Powermeter Type 3888-001 complete with Case storage covers 3888-002 | 6625-99-637-9583 |
| | (including mains lead, 3m long Part No. 2400-035) | 5995-99-637-9586 |
| | tft Power Head Type 6440N/1 | 6625-99-643-8693 |
| | 20 dB Attenuator Type 6534/4 | 5905-99-520-8780 |
| | Coaxial-to-Waveguide Transformer Type 6237/1 12·4 to 18 GHz | 5985-99-637-9587 |
| | Battery Pack part No. 2200-186 | 6140-99-649-4905 |
| | The complete Wattmeter Absorption CT596 consists of: | |
| | Powermeter Type 3888-001 complete with Case and Storage Covers 3888-002 | 6625-99-637-9583 |
| | (including Mains Lead 3m long part No. 2400-035) | 5995-99-637-9586 |
| | tft Power Head Type 6440N | 6625-99-637-9584 |
| | 20 dB Attenuator Type 6534/4 | 5905-99-520-8780 |
| | Coaxial-to-Waveguide Transformer Type 6237 3·8 to 12·4 GHz | 5985-99-637-9585 |
| | (Optional extra) Battery Pack part No. 2200-186 | 6140-99-649-4905 |
| | Wattmeter Set (Navy version) comprising: Power Meter Type 6460/1 tft Power Head Type 6440N 20 dB Attenuator Type 6534/4 | 6625-99-541-6389 |
| | Coaxial-to-Waveguide Transformer Type 6237/1, 12 to 18 GHz (Optional extra) Battery Pack, part No. 2200-186 | 6140-99-649-4905 |

| *Marconi Type No.* | *Military Designation* | *NATO Cat. No.* |
|---|---|---|
| 6478 | Flange Adaptor Square to Round (WG16) | 5985-99-638-5899 |
| 6478/1 | Flange Adaptor Square to Square (WG16) | 6625-99-636-0384 |
| 6531/1 | Precision Fixed Coaxial Attenuator 3 dB | 1430-99-522-6443 |
| 6531/2 | Precision Fixed Coaxial Attenuator 6 dB | 5840-99-523-1088 |
| 6531/3 | Precision Fixed Coaxial Attenuator 10 dB | 5905-99-223-4026 |
| 6531/4 | Precision Fixed Coaxial Attenuator 20 dB | 1430-99-522-6445 |
| 6531/5 | Precision Fixed Coaxial Attenuator 30 dB | 5905-99-112-8669 |
| 6531/6 | Precision Fixed Coaxial Attenuator 40 dB | 5985-99-119-1980 |
| 6533/1 | Precision Coaxial Termination DC-12·4 GHz | 5935-99-450-6974 or 5935-99-525-6333 |
| 6533/2 | Precision Coaxial Termination DC-12·4 GHz | 5935-99-450-6975 |
| 6534/1 | Precision Fixed Coaxial Attenuator 3 dB | 5905-99-111-3095 |
| 6534/2 | Precision Fixed Coaxial Attenuator 6 dB | 6625-99-111-3096 |
| 6534/3 | Precision Fixed Coaxial Attenuator 10 dB | 5985-99-525-6902 |
| 6534/4 | Precision Fixed Coaxial Attenuator 20 dB | 5905-99-520-8780 |
| 6587 | Levelling Amplifier | 6695-99-636-040 |
| 6599/2 | Educational Test Bench SF (WG16) | 6625-99-111-2592 |
| 6646 | Plug-in Oscillator Unit 8·0-12·4 GHz | 6625-99-119-5795 |

# ASSOCIATED COMPANIES AND SALES OFFICES

Further information can be obtained from any of the following addresses. If it is not available in your locality, please contact the Export Department, Marconi Instruments Limited, St. Albans, Hertfordshire, England.
*(The following information is correct at the time of going to press)*

**ABU DHABI**
Business Communications
UAE (Private) Ltd Abu Dhabi
P.O. Box 2534
ABU DHABI
UAE
*Telephone:* 344294
*Telex:* 22457 BCLAH EM

**ANGOLA, REPUBLICA POPULAR DE**
Tecnidata
Caixa Postal 1619
LUANDA
*Telephone:* 32306
*Telex:* 3019 TECDATA AN

**ARGENTINA**
GEC Marconi Argentina S.A.
Casilla Correo Central 4476
1000 BUENOS AIRES
*Telephone:* 243-8021
*Telex:* 12-2253

**AUSTRALIA**
Amalgamated Wireless (Australasia) Limited
North Ryde Division
422 Lane Cove Road
P.O. Box 96
NORTH RYDE, N.S.W. 2113
*Telephone:* 02-887 7111
*Telex:* 20623 AWARYDE

**AUSTRIA**
L. B. Electronics G.m.b.H.
Rudolf Kassner Gasse 32
A-1190 WIEN
*Telephone:* 222-324151-2-3
*Telex:* 133722 LINDA

**BAHRAIN**
Aeradio Technical Services W.L.L.
P.O. Box 26803
MANAMA
*Telephone:* 243390
*Telex:* 8226 ATS BN

**BANGLADESH**
AEI-English Electric of Bangladesh Ltd.
71 Dilkusha Commercial Area
GPO Box 248
DACCA 2
*Telephone:* 252415
*Telex:* 734 DACCA

**BELGIUM & LUXEMBOURG**
SAIT Electronics S.A.
66 Chaussée de Ruisbroek
B1190 BRUSSELS
*Telephone:* (2) 376 20 30
*Telex:* 21601 SAIT BB

**CANADA**
Canadian Marconi Co.
Electronic Instruments Dept.
Marine & Land Communications Div.
2442 Trenton Avenue
MONTREAL P.Q. H3P 1Y9
*Telephone:* (514) 341-7630
*Telex:* 05-827822

**CHILE**
Gibbs y Cia S.A.C.
Providencia 1050.
Torres De Tajamar
Casilla 16254
SANTIAGO 9
*Telephone:* 231061
*Telex:* 94309 GIBBS KU

**COLOMBIA**
Repro Ltda.
Apartado Aereo 5660
Diagonal 17 No. 28A-90
BOGOTA D.E.
*Telephone:* 2774800
*Telex:* 43175 REPRO CO

**CYPRUS**
S.A. Petrides and Son Ltd.
P.O. Box 4522
NICOSIA
*Telephone:* 42788
*Telex:* 2308 ARMATR CY

**DENMARK**
Instrutek A/S
Christiansholmsgade
DK-8700 HORSENS
*Telephone:* (5) 611100
*Telex:* 61656 INTEK DK

**DUBAI**
Business Communications
UAE (Private) Ltd.
P.O. Box 5444
DUBAI, UAE
*Telephone:* 225135-6-7
*Telex:* 46292 BCLDB EM

**EGYPT, ARAB REPUBLIC OF**
Metra
Middle East Trading & Engineering Co.
P.O. Box 2676
CAIRO
*Telephone:* 729944, 729105
*Telex:* 93719 METRA UN

**EIRE**
Neltronics Ltd.
John F. Kennedy Road
Naas Road
DUBLIN 12
*Telephone:* 01501845
*Telex:*4837 NELT EI

**ETHIOPIA**
Wabashy Electrical Pvt. Ltd. Co.
P.O. Box 5625
ADDIS ABABA
*Telephone:* 443525
*Telex:* 21322 WABASHY ADDIS

**FIJI**
AWA New Zealand Ltd.
P.O. Box 858
SUVA
*Telephone:* 312070-79
*Telex:* FJ 2347 AWA FIJI

**FINLAND**
L. H. Gallen & Co. Ky
P.O. Box 104
00171 HELSINKI 17
*Telephone:* 65 84 24
*Telex:* 121394 (Attn. LEGACO HELSINKI)

**FRANCE**
Marconi Instruments
3 avenue du Maréchal Devaux
91550 PARAY-VIELLE-POSTE
*Telephone:* (1) 687-36-25
*Telex:* 203882F

**GERMANY, FEDERAL REPUBLIC OF**
Marconi Messtechnik G.m.b.H.
Postfach 153
Landsberger Strasse 65
8034 GERMERING
*Telephone:* 89 84 50 85
*Telex:* 05 212 642

**GREECE**
Anco S.A.
44 Syngrou Avenue
ATHENS 403
*Telephone:* 923 6861
*Telex:* 215303

**HONG KONG**
GEC (Hong Kong) Ltd.
1 Hysan Avenue
Causeway Bay
G.P.O. Box 15
HONG KONG
*Telephone:* 5-7902828
*Telex:* 73098 GHONG HX

**ICELAND**
(see NORWAY)

**INDIA**
AIMIL Sales and Agencies Pvt. Limited
Sunlight Building
26/27 Asaf Ali Road
NEW DELHI – 110001
*Telephone:* 273611
*Telex:* 031-2700

**INDONESIA**
Centronix P.T.
36 Jalan Matraman Raya
JAKARTA
*Telephone:* 884187
*Telex:* 48216 CENT JKT

**IRAN**
Irantronics Company Ltd.
20 Salm Road
Avenue Dr. Mofateh
TEHRAN
*Telephone:* 836468, 834459
*Telex:* 212956 BERK IR

**IRAQ**
(see MIDDLE EAST)

**ITALY**
Marconi Italiana S.p.A.
via Palmanova 185
20132 MILANO
*Telephone:* 256 31 41
*Telex:* 311467 MARCON I

**JAPAN**
Rikei Corporation
Shinjuku Nomura Bldg.
1-26-2 Nishishinjuku
Shinjuku-Ku
TOKYO 160
*Telephone:* (03) 345-1411
*Telex:* J24208, J23772

**JORDAN**
Consult-Tel,
P.O. Box 35055
AMMAN
*Telephone:* 36668
*Telex:* 22345 CONS LTJO

**KENYA**
S.A. Pegrume and Co. Ltd.
New Standard Building
Wabera Street
P.O. Box 41093
NAIROBI
*Telephone:* 25873, 331746
*Telex:* 22956 PEGRUME

**KOREA, REPUBLIC OF**
Bando Sangsa Co. Ltd.
2, 3, 5th Floor, The Lucky Building
282 Yang-Dong-Chung-Ku
C.P.O. Box 1899
SEOUL
*Telephone:* 777-8097
*Telex:* Bando K 27266
K 27470

**KUWAIT**
Al-Nawasi Trading Co.
P.O. Box 3204
SAFAT
*Telephone:* 442272, 427340
*Telex:* 22131 AAA KT

**LEBANON**
Mabek Electronics Division
P.O. Box 13-5657
BEIRUT
*Telephone:* 812523, 812538, 292251
*Telex:* 22889 MABEK LE

**MALAWI**
Business Machines Ltd.
P.O. Box 5095
LIMBE
*Telephone:* 652 288
*Telex:* 4218 ERANTHIS

**MALAYSIA**
(Civil Sales)
The General Electric Company of Malaysia Sdn, Bhd.,
Wisma GEC, Jalan 215–Templer,
P.O. Box 225–Jalan Sultan,
PETALING JAYA–SELANGOR
*Telephone:* 571188
*Telex:* 37617 A/B GECMYA MA

(Military Sales)
Straits Industries (M) Sdn, Bhd.,
10B, Lorong Medan Tuanku Satu,
KUALA LUMPUR
*Telephone:* 985588
*Telex:* SRS MA 30226

**MEXICO**
Instrumentacion S.A. de C.V.
Ave Del Parque 42
Colonia Napoles
MEXICO, 18 D.F.
*Telephone:* 687-45-88, 687-47-47
*Telex:* 1772659 INCOME

**MAURITIUS**
Rey & Lenferna Ltd
10 Edith Cavell Street
PORT LOUIS
*Telephone:* 2-0261
*Telex:* 4297 REYFER IW

**MIDDLE EAST**
Middle East Manager
P.O. Box 5518
NICOSIA, CYPRUS
*Telephone:* 49939
*Telex:* 2308 ARMATR CY

**NETHERLANDS**
Vitronic Meetapparatuur b.v.,
Mechelaarstraat 17,
4903 RE OOSTERHOUT (N.BR.)
*Telephone,* 1620-51440
*Telex:* 54617 VITRO NL

**NEW ZEALAND**
AWA New Zealand Ltd.
Wi-Neera Drive
PORIRUA
P.O. Box 50-248
*Telephone:* 75069
*Telex:* AWA NZ 31001

**NIGERIA**
GEC Telecommunications (Nigeria) Ltd.
P.O. Box 2213
APAPA, LAGOS
*Telephone:* 803230/2
*Telex:* 21385

**NORWAY**
Norsk Marconi A.S.
Ryensvingen 5
Post Boks 50 Manglerud
OSLO, 6
*Telephone:* 68-04-80
*Telex:* 76218

**OMAN, SULTANATE OF**
Suhail & Saud Bahwan
P.O. Box 169
MUSCAT
*Telephone:* 734201-2-3-4
*Telex:* 3274 BAHWAN MB

**PAKISTAN**
Intermark Limited,
P.O. Box 6159
Hakimsons Building
19 West Wharf Road
KARACHI 2
*Telephone:* 202122-24
*Telex:* 23649 YAQIN PK

**PAPUA, NEW GUINEA**
Air Programs International Pty Ltd.
P.O. Box 481
SYDNEY SOUTH 2000
Australia
*Telephone:* (02) 264 1498
*Telex:* API AA 68018

**PERU**
Cantec
Compania Andina Tecnica S.A.
Calle Hernan Velarde 179
Casilla 2489
LIMA 1
*Telephone:* 245461
*Telex:* 25231 PE

**PHILIPPINES**
Philippine Electronic Industries Inc.
Rose Industries Bldg,
11 Pioneer Street, Pasig MM
P.O. Box 498, MCC, Makati
Metro MANILA 3116
*Telephone:* 693-1630/1633
*Telex:* 43109 PEI PM

**PORTUGAL**
Socilectra Lda
Avenida 24 de Julho 3, 1°-E
P1200 LISBON
*Telephone:* 67 23 64
*Telex:* 16819 SOCIL P

**QATAR**
Business Communications Qatar
P.O. Box 3656
DOHA
*Telephone:* 325851, 325164
*Telex:* 4454 BCQ DH

**SAUDI ARABIA**
Electronic Equipment Marketing Company
P.O. Box 3750
RIYADH
*Telephone:* 4771650, 4783393
*Telex:* 201120 ZUHAIR SJ

**SINGAPORE**
The General Electric Company of Singapore Pvt. Ltd.
Magnet House
P.O. Box 4046
Bukit Timah
SINGAPORE 21
*Telephone:* 663011
*Telex:* GECSING RS 21508

**SOUTH AFRICA**
Marconi (South Africa) Pvt. Ltd.
P.O. Box 3537
KEMPTON PARK
1620 Transvaal
*Telephone:* 9703620-9
*Telex:* 4-26765

**SPAIN**
Pacisa
Ronda de Atocha, 17
Apartado 7, 023
MADRID 5
*Telephone:* 228 5200
*Telex:* 23014 PACIS EY

**SUDAN**
Abdelmoniem Industrial and Engineering Co. Ltd.
109 Baladia Street
P.O. Box 2413
KHARTOUM
*Telephone:* 70526, 71089
*Telex:* 22422 WAX KM

**SWEDEN**
SRA Communications AB
Agencies Department
Box 1
S-16300 STOCKHOLM
*Telephone:* 46-8 752 10 00
*Telex:* 19270

**SWITZERLAND**
Caltest A.G.
Weiherackerstrasse 15
CH8114 DAENIKON
*Telephone:* 01-844 3274
*Telex:* 59027 CAL CH

**SYRIA**
Recherches et Réalisations Industrielles S.A.R.L.
P.O. Box 2932
DAMASCUS
*Telephone:* 228284, 222633
*Telex:* 419120 ORTEXO SY (Attn. RRI)

**TANZANIA**
Aeradio Tanzania Limited
P.O. Box 861
DAR ES SALAAM
*Telephone:* 30549
*Telex:* 41030 INTAERIO

**THAILAND**
Yip in Tsoi & Jacks Ltd.
P.O. Box 2611
BANGKOK
*Telephone:* 233-1390
*Telex:* 82929 TH

**TURKEY**
Orko Mümessillik
Teknik Cihazlar Ticaret ve Sanayii A.S.
Tunus Caddesi, 85/8
Kavaklidere
ANKARA
*Telephone:* 26 61 80
*Telex:* 42498 OKAS TR

**UNITED ARAB EMIRATES**
(see ABU DHABI and DUBAI)

**URUGUAY**
Pellmar S.A.
Piedras 676-77
MONTEVIDEO
*Telephone:* 901447
*Telex:* BOOTH UY 901, attn. PELLMAR UY 6685

**U.S.A.**
Marconi Instruments
100 Stonehurst Court
Northvale
NEW JERSEY 07647
*Telephone:* (201) 767-7250
*Telex:* 710-991-9752

**YEMEN ARAB REPUBLIC**
(see MIDDLE EAST)

**YEMEN PEOPLE'S DEMOCRATIC REPUBLIC**
(see MIDDLE EAST)

**YUGOSLAVIA**
Jugohemija
Section 620
Gen. Zdanova 31
P.O. Box 441
BEOGRAD
*Telephone:* 341-141 to 9
*Telex:* 11-390 YU YUGHEM

**ZAMBIA**
International Aeradio (Zambia) Ltd.
P.O. Box 31253
LUSAKA
*Telephone:* 73758, 72200
*Telex:* 43260 IALZAM ZA

**ZIMBABWE**
KDB Holdings (Pvt.) Ltd
P.O. Box 2500
HARARE
*Telephone:* 793681
*Telex:* 4-329 ZW