Marconi Instruments

catalogue 1979-80

mi
measuring
equipment

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Marconi Instruments Limited

HEADQUARTERS

for

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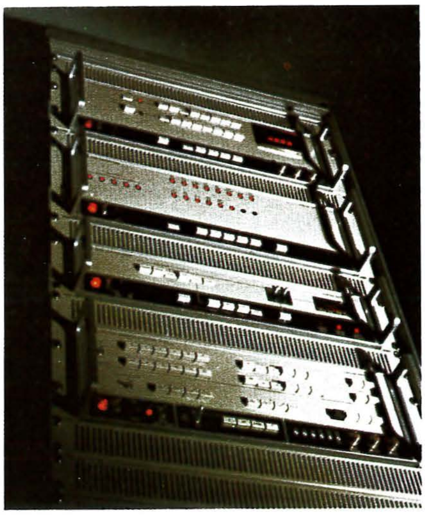
Marconi Instruments Limited is a GEC-Marconi Electronics Company

Microprocessor-controlled, synthesizer-driven Selective Level Measuring Set is one of the recent developments in the Marconi Instruments range. A feature of the equipment is the combination of keyboard operation and traditional, manual tuning with comprehensive a.f.c. control and motor driven search. It is shown here system testing 12 MHz coaxial cable terminals.

(By courtesy of the British Post Office)

A VIEW

Marconi Instruments' Television Automatic Monitoring equipment is being used in the huge new 1980 Olympic Games Television Centre in Moscow. Over 200 systems have now been sold to television organisations throughout the world for local or remote quality assessment. (during programme time) of transmission systems.



Welcome to the Marconi Instruments' catalogue for 1979/80.

The Company's dynamic development programme is one of continuous progress and innovation but, unfortunately, this book cannot progress with it. We can only present here a frozen view, a photograph taken at one moment prior to going to press in 1978.

In order to help overcome this static state we have introduced products within their appropriate chapters, under 'coming soon' headings, see pages 128 and 134, so that you may be aware of new developments and ask for the latest information from your local mi sales engineers.

Full specifications are given in the catalogue for the majority of our test instrumentation. However 'Autotest' systems, flanges and flexible waveguide are only described in outline. A telephone call, telex or letter will bring you full and up-to-date information on these or any other equipment. Addresses are listed inside the back cover of the catalogue.

A chapter of useful data, printed on blue background for quick recognition, is included for your reference.

The Microwave Products Division is able to provide mechanical skills of the very high level required for waveguide and associated specialist manufacture.

Service Division has its own electrical and mechanical manufacturing shops for obsolescent parts, stocks of over 20,000 different parts and specially equipped vans for door-to-door delivery and collection.

Quality and Traceability

Marconi Instruments has been assessed by the UK Ministry of Defence (Directorate General of Quality Assurance) to defence standard 05-21. The assessment applies to all products manufactured, not only to those made especially for the MoD, and is equivalent to the NATO Quality Assurance Document AQAP-1.

The Service Division at Luton Airport is assessed to Defence Standard 05-24 (equivalent to NATO AQAP-4) which covers all forms of quality assurance at the Division.

Whenever you require, Marconi Instruments is able to issue certificates of conformity to these quality standards with each instrument or system supplied.

mi has three standards laboratories: one at headquarters which provides the central Company standards facility for design and production reference; one within the Microwave Products Division to specialize in measurements above 1 GHz; and a third at Service Division to maintain standards of calibration and to specialize in the issue of certificates of conformity-to-specification of recalibrated equipments.

All three laboratories are members of the British Calibration Service, controlled by the UK Government Department of Trade through the National Physical Laboratory. The NPL in turn compares its standards with other national and international measurement standards throughout the world.

The standards laboratory at headquarters is approved under the BCS scheme (number 0006) for more measurement parameters than any other commercial electronics laboratory in the UK. It is able to issue calibration certificates traceable to international standards for almost any electronic measuring instruments.

The Company is also able to accept instruments of **mi** and other manufacture for calibration against 'in-house' Def. Stan. 05-26 or BCS certification.

After sales service

As well as providing customers throughout the world with technical advice through printed materials and personal visits, Marconi Instruments is able to provide, calibration and repair services through its many overseas outlets. This international network is supported by the UK Service Division which is able to supply technical advice and equipment to overseas service establishments, and return-of-post spares service to customers who prefer to maintain their own equipment.

The Division maintains stock of over 20,000 different components and itself manufactures many parts which have now become obsolescent. Maintenance contracts can be offered to UK customers for one, two or hundreds, of equipments after the guarantee period has expired. The Division provides service and repair of electronic measuring equipment of *any* manufacture.

AUTOMATED TESTING

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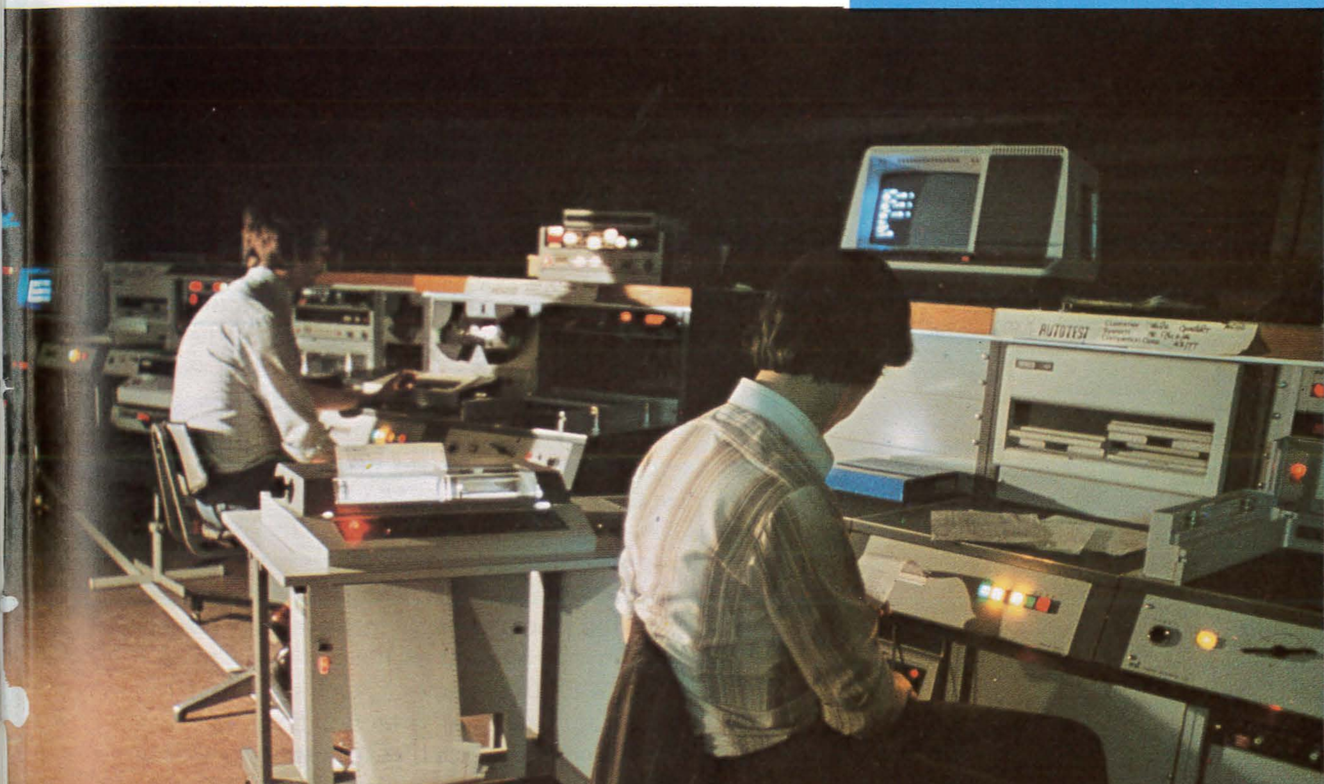

The term 'automatic' has a variety of different interpretations when used in connection with test equipment. Therefore, for clarity, this introduction has been divided into three main classifications:

stand alone instruments;
remotely controlled instruments;
and **fully automatic systems.**

This last classification has been divided into two sections: those which can be used for monitoring on-line equipment and those which cannot.

The Company's well established range of 'Autotest' products is described under the last heading.

Stand alone instruments

This classification encompasses all 'traditional style' instruments where modern design and advances in component technology allow them to perform certain functions automatically. When each new design is engineered the latest techniques are employed wherever appropriate to enable measurements to be made more quickly and to reduce the number of settings needed, thus to make its use more efficient. A simple example is the automatic level control used in signal generators to ensure accurate, calibrated output level across the whole frequency range without the need for an operator to adjust the level setting. Another example can be found in the automatic tuning and levelling in modulation meters where the number of operations of the control knobs, switches etc. needed to make a measurement is reduced from 15 to 4.
Use of automation in 'stand alone' instruments can, through simpler and faster operation, bring what were previously considered as instruments suitable only for the engineering laboratory right into everyday use on the production lines. A relevant example of this is to be found in the 100 MHz Spectrum Analyser, TF 2370, which has recently received three significant technical awards. Hardwired logic circuits automatically set the sweep speed as the operator selects the dispersion range and the filter required. This ensures that the operator has the fastest speed possible without causing 'ringing'. Further logic circuits select a pertinent group of three filters for the operator to choose from and, perhaps most important of all, the balance of attenuation between the r.f. and i.f. amplifiers is made by the instrument automatically when the operator selects a given sensitivity. The user is assured of always receiving the best noise/intermodulation performance.
Instruments in the catalogue incorporating these benefits are not necessarily prefixed with the adjective 'automatic' since this is usually reserved for equipment, like the ***Modulation Meter*** and the ***White Noise Test Set,*** which require minimal setting up and then make the whole measurement automatically. Within this classification,

products are supplied for the following applications

- Modulation measurement
- Multichannel testing
- Television measurement
- Distortion measurement
- Frequency measurement
- Power measurement
- Signal generation

Full details and specifications will be found in the appropriate section of the catalogue.

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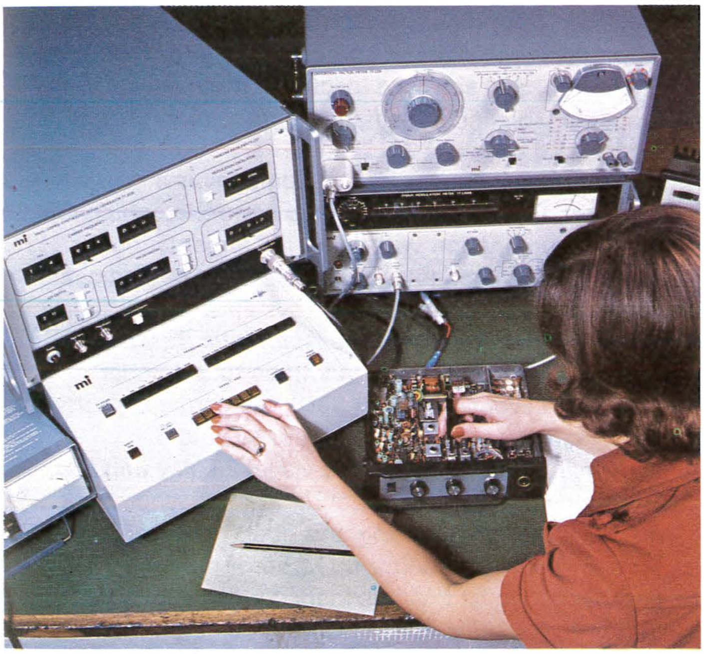
Remotely controlled instruments



Instruments in this classification can be controlled remotely over a data highway and, where applicable, provide measurement results to a remote device. Most of these instruments accept information in parallel b.c.d. form and some can be fitted with an interface to allow operation over the General Purpose Instrument Bus, GPIB*.

Marconi Instruments' policy on new designs is to make available a programmable option on all instruments where appropriate. The increasing use of remote control and reporting systems and rapidly advancing technology is enabling the option to be included in more and more equipment whilst still maintaining a balance in cost/effectiveness.

The White Noise Test Set, OA 2090C, is an example within this classification. The *Noise Receiver* can be operated from its front panel in normal, manual, use. Selection of 'remote control' enables measurements to be carried out from a remote site, by its *Control Unit* or by a suitable computer system. Similarly, the *Noise Generator* can be controlled locally or remotely. Also, provision has been made to control certain of the generator functions from the receiver by a simple cable connection between the two rear panels. Finally, if it is required to operate the White Noise Test Set through the General Purpose Instrument Bus this can be achieved through a suitable b.c.d./GPIB adaptor.

The individual instruments in this classification may be used under the first classification as 'stand alone' equipment or may be controlled and monitored from a remote site or, as it will be seen, form parts of the next classification 'fully automatic systems'.

Products of this type may be found in the catalogue within the following disciplines:

- FDM testing and monitoring
- Power measurement
- Frequency measurement
- Signal generation
- Modulation measurement
- Television measurement
- Microwave equipment

*GPIB – Marconi Instruments' General Purpose Instrument Bus is in accordance with IEEE Standard 488-1975 and IEC *Document 66 (Central Office) 22.*

Fully automatic systems

This classification is further divided into

a) automatic equipment to monitor operational systems (and which may also be used to evaluate the performance of a unit or system during production and maintenance by the addition of further instrumentation to simulate operational traffic) and

b) equipment specifically to evaluate the performance of a system or unit under test during manufacture and/or maintenance but not suitable for manual operational systems.

Both groups within the classification depend upon some central device to control measuring instruments and, where required, equipment to record results. This controller may be punched tape or computer based, as, for example, in the 'Autotest' systems, or may be a simple device where logic circuits are used in conjunction with a clock.

In the case of the ***TV Automatic Monitoring Equipment (TAME)*** and the ***Automatic White Noise Test Set*** the control elements are dedicated to their systems. However, both tape and computer based 'Autotest' controllers are available for customers who wish to buy the control and software 'package' to drive programmable instrumentation particular to their testing needs.

A recent development by the Company is a new, compact, GPIB computer-based controller which will be used in conjunction with other instrumentation, supplied by Marconi Instruments, to create dedicated test systems. The first of these systems (which falls into group (a) monitoring) is the ***Automatic Baseband Monitor*** (a brief description will be found under ***Selective Level Measuring Set***). The hardware/software combination enables the operator to hold a conversational dialogue via a visual display unit for initialising the system, selecting test sequences, choosing methods of fault reporting and other routines. The system is able to monitor up to 56 or more f.d.m. basebands whilst they are loaded with normal traffic and to report at regular intervals and when a fault condition occurs.

As well as the basic controllers for any system, fully automatic test systems can be supplied for the following:–

- Multichannel testing (a)
- Television measurement (a)
- PCM manufacture (b)
- Mobile radio testing (b)
- Automatic electrical inspection of printed circuit boards (b) ('Autotest')

From this brief description it will be evident that there is an overlap between the classifications. In many cases instruments incorporate facilities which allow them to be used alone, in conjunction with companion instruments, or combined under central control for fully automatic test systems.

Marconi Instruments' philosophy is to reduce where possible the extent of manual operations in non-programmable instruments and to build in remote control capability where the instrument functions are considered applicable to automatic test systems. The assembly of such systems is becoming increasingly straightforward as more instruments become available with GPIB interface capability.

mi AUTOTEST SYSTEMS

Marconi Instruments Autotest is a range of fully automatic test systems which can perform the same functions as normal test-rigs of manually operated instruments, but in a fraction of the time taken by conventional methods.

Autotest systems have been designed to offer consistent, reliable testing and are suitable for use by unskilled operators. They feature ease of programming, using either tape or computer control together with flexibility in adapting to different test requirements and allowing for future expansion at minimal cost.

To optimise the performance-to-price ratio of automatic test equipment, Marconi Instruments has designed a range of standard systems covering the main areas of application, thus sharing the design costs over a large number of customers. A high standard of support documentation and excellent spares and "know-how" back-up, all contribute to providing what the major part of the market requires at the most competitive prices.

There is a continuing effort on the part of Marconi Instruments to improve programming techniques. The result has been to achieve faster testing times and an increase in capability of the Autotest Systems.

a

RECENT ADDITIONAL SOFTWARE AIDS

The high level language, INCITE*, is used for preparing the 'test' programs. Various software facilities, briefly described below, are now available with the Autotest Systems. These speed the INCITE program preparations phase and reduce production testing times as well as assisting in fault diagnosis.

AUTOGUARD Automatic program generation to speed test program preparation time. When measuring component values it is necessary to eliminate the effects of adjacent components. This is normally achieved by the addition of guard points and judicious selection of appropriate power supply settings. The Autoguard Program automatically generates optimum test conditions to relieve the engineer from this time consuming task.

AUTOCOMPILE Conversion of INCITE programs to a lower level form for faster testing. This technique typically gives a 2 to 1 improvement, over the direct use of INCITE, in testing times.

AUTOANALYSE Self learning logic (digital) program generation. Using a known good board the user simply designates the input truth table to stimulate the printed circuit board under test and the system will then self learn the corresponding output pattern. The output pattern may be generated for any specified points on the board including both internal circuit nodes and the edge connector.

PRIORITY PRINTOUT Logic fault diagnostic simplified by use of special commands. When a logic test program sets up a pattern of inputs and certain monitor pins are tested, a single faulty device in a logic chain may give rise to misleading fault printouts on test points which depend logically on the true fault. A Priority Statement may be incorporated into the program, to define the 'priority' of the monitor points and in this way misleading fault printouts are suppressed.

** INCITE – Instructional Notation for Computer-controlled Inspection and Test Equipment.*

TIME SHARED VDU Program and editing on a system which is at the same time testing a printed circuit board. Two such v.d.u. stations may be operated whilst a p.c.b. is under test.

INCITE SIMULATOR Program preparation and editing on a separate computer.

AUTOMATIC ELECTRICAL INSPECTION SYSTEMS

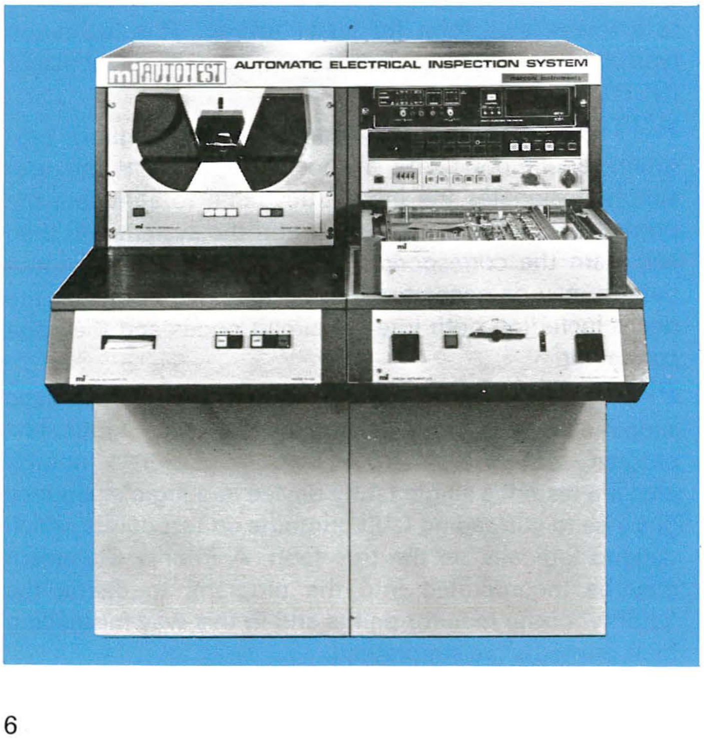
These standard off-the-shelf systems provide very thorough inspection of assembled printed circuit boards allowing every component to be tested in-situ for correct value, mounting and polarity, and also testing the track and soldering.

The equipment is basically an inspection system rather than a functional test system, and it locates 95% of all printed board faults, hence greatly reducing the time spent on fault-finding at the costly functional test stage.

Recent developments in software have further considerably increased the speed of testing components and logic circuitry.

Special measurement techniques (two, three or four terminal as appropriate) inhibit the effect of parallel paths in the circuit, enabling individual components to be identified and their values accurately measured. The full system measures resistance, capacitance and inductance and also scans d.c. voltages around the circuit with power supplies connected.

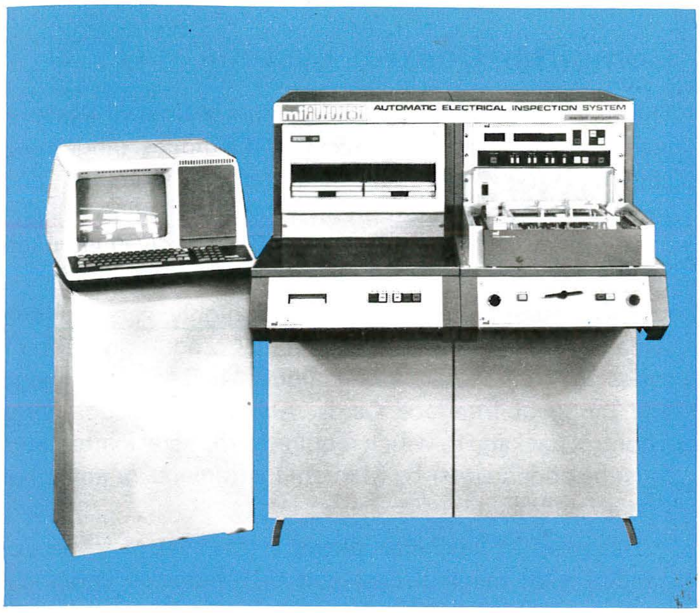
Two systems are available, the tape controlled OE 1760A and the computer controlled OE 1761A. The function of both control systems is to provide executive control for the modes, ranges and settings of the various stimuli, measurement and switching units, and also to process, compare and record test results in the form required. Programmable power supplies, a resistance measurement unit and digital voltmeter are connected to the unit under test via a switching matrix, random access switch and test jig. The only difference between the two systems is the method of control and of providing input information to and obtaining results from the system.



Tape Controlled System OE 1760A

In this system the input is in the form of an alpha-numeric machine code (ASCII) punched onto paper tape. Each controller function and system parameter is allocated a single letter, single digit address code, which is followed by information relating to the setting of the function or parameter. Test results are compared with programmed tolerances and printed out. The printout contains the test number, establishing the area of the fault down to component level, the measured value and the status of the result (high, low or pass). The use of a program store enables high test speeds to be achieved without any appreciable tape wear, and also considerably facilitates test program generation and editing.

If an Autotest OE 1761A (Computer Controlled System) or any PDP 11 computer with appropriate peripherals is available, the paper tape, which uses machine code, may be produced by using the recently developed compiler, from programs prepared in INCITE.



Computer Controlled System OE1761A

The computer system uses the PDP11 computer with a purpose-oriented, high level language INCITE, which is an extension of MI-BASIC and uses accepted engineering terms and symbols. Input to the system can be via tele-typewriter, exchangeable cartridge disc or floppy disc. The programmer specifies the test point location of the component to be checked and writes the component information normally contained in the parts list of the unit under test – the system then does the rest. When a defective component is diagnosed the tele-typewriter will print the appropriate message, for example "Change R17".

Features of the system include the ability to print diagnostic messages for fault clearance, comprehensive mathematical facilities and optional data logging facilities for statistical analysis of faults detected.

CONTROL SYSTEMS

Considering an automatic test system to consist of the Control Unit, Instrumentation and Switching, and Unit Under Test Interface, it is generally found that a major cost area is the interface and any specially-designed instrumentation which have to be produced on a one-off or small quantity basis. Consequently when an intending purchaser considers the system cost breakdown he finds that the section carrying the relatively high price is the only one with which he is already familiar, and this is the part he could produce himself. As a result, an increasing number of a.t.e. users have found the most economical way of acquiring the equipment is by joint co-operation with the supplier who becomes responsible for the control aspects of the system while the user provides the special instrumentation and interface. The standard or proprietary instrumentation could be the responsibility of either party.

Two control systems, one tape controlled and the other computer controlled, are available as packages. They are based on a standard assembly into which can be incorporated a range of plug-in modules to interface with instruments of the customer's choice.

Controller OA 1444B series

OA 1444B series Autotest Controllers are designed to be the executive controllers of a wide range of Automatic Test Systems. Their flexibility, in terms of both internal control facilities and their ability to control most currently available programmable instruments, allows them to handle easily all aspects of a test system, including stimuli control, switching, measurement, and analysis of results.

A simple program language is used which requires very little training, and can be prepared on standard punched tape preparation machines, and although punched tape is the normal medium for program storage, facilities are provided for input of data from external sources, such as a small computer. The use of a program store offers the advantages referred to under the Tape Controlled System OE 1760A.

Typical computer controlled system incorporating the computer package.

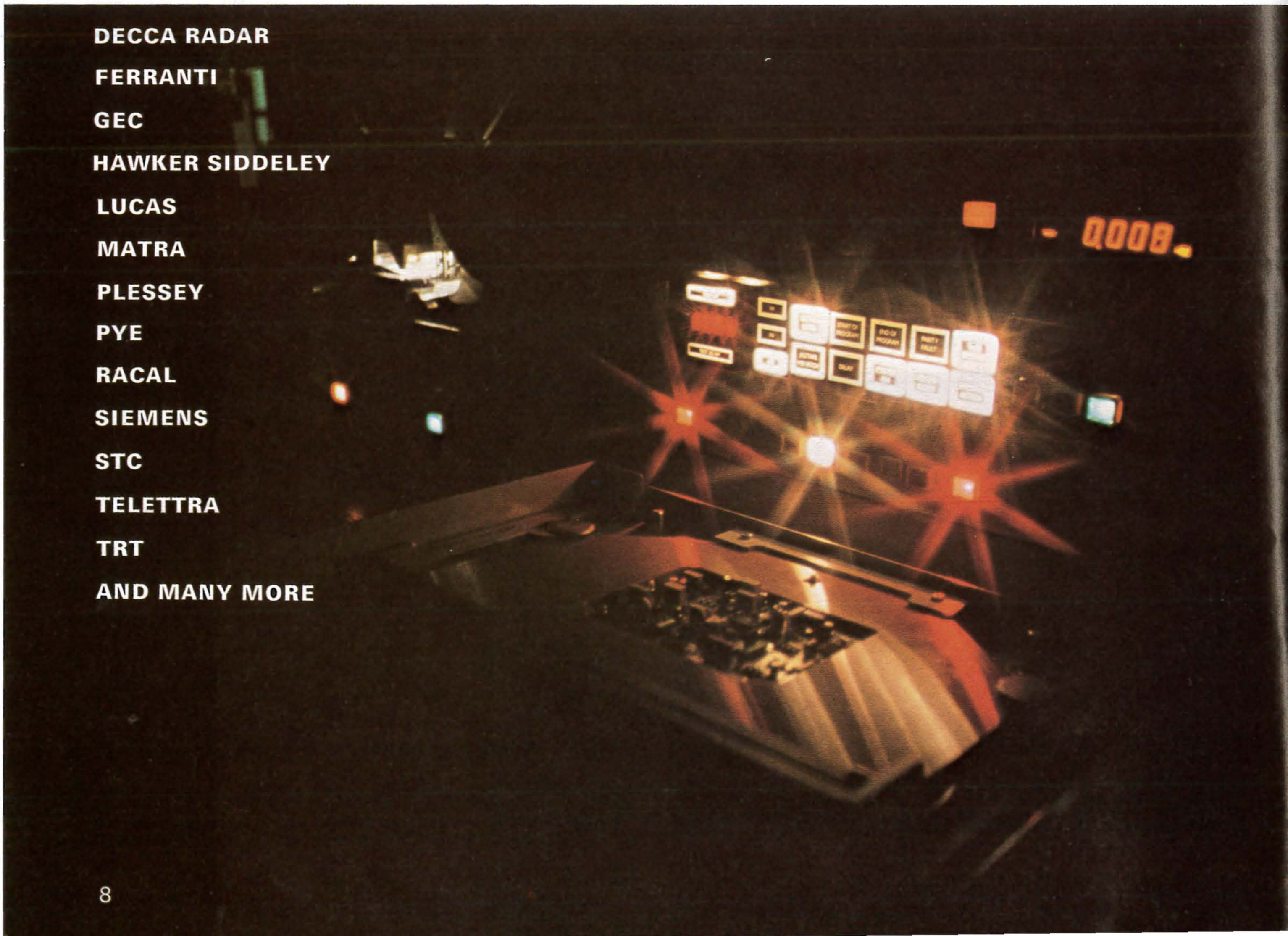
Computer Control System

The functions of the Autotest Computer Control Systems are to provide executive control for the modes, ranges and settings for the various measurement, stimulus and switching units which form an automatic testing system, and to process and record test results in the form required by the System user.

The System is based upon the highly versatile and widely accepted Digital Equipment Corporation PDP 11 series mini-computer, with unique MI-BASIC language and range of Interface Cards. All of which constitutes a control package to which required peripheral instruments must be added either by Marconi Instruments or any other system builder.

Designed-in flexibility allows a test system to be expanded with minimal cost and disruption as additional test capability is required in the future. This is largely attributable to the modular form of construction used in the **mi** Interface Units, and the 'Unibus', single data highway which is a unique feature of the PDP 11 computer.

AUTOTEST inspection, control and functional test systems are already used by more than fifty famous companies throughout the world . . .



DECCA RADAR

FERRANTI

GEC

HAWKER SIDDELEY

LUCAS

MATRA

PLESSEY

PYE

RACAL

SIEMENS

STC

TELETTRA

TRT

AND MANY MORE

SIGNAL GENERATORS

b

MF/HF AM/FM Signal Generator (10 kHz to 88 MHz)	TF 2002B	10
Digital Synchronizer (for use with TF 2002B)	TF 2170B	15
AM/FM Signal Generator (10 kHz to 510 MHz)	TF 2008 series	16
AM/FM Signal Generator (10 to 520 MHz)	TF 2015 series	20
Digital Synchronizer (for use with TF 2015)	TF 2171	24
AM/FM Signal Generator (10 kHz to 120 MHz)	TF 2016	26
Digital Synchronizer (for use with TF 2016)	TF 2173	30
Pulse Modulator	TF 2169	32
Synthesized Signal Generator (50 kHz to 520 MHz)	TF 2020 series	34
Mobile Radio Test Set (23 to 520 MHz)	TF 2950 series	39
AM/FM Radiotelephone Test Set (400 kHz to 520 MHz)	TF 2952	42

For further Signal Generators see the Microwave Products Section:

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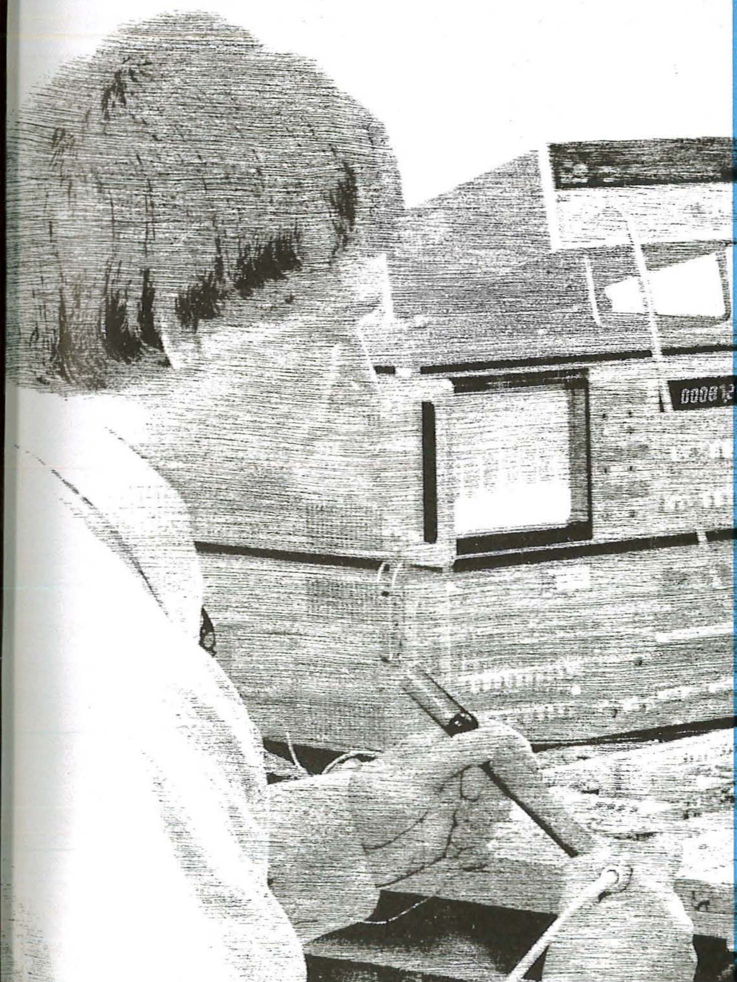
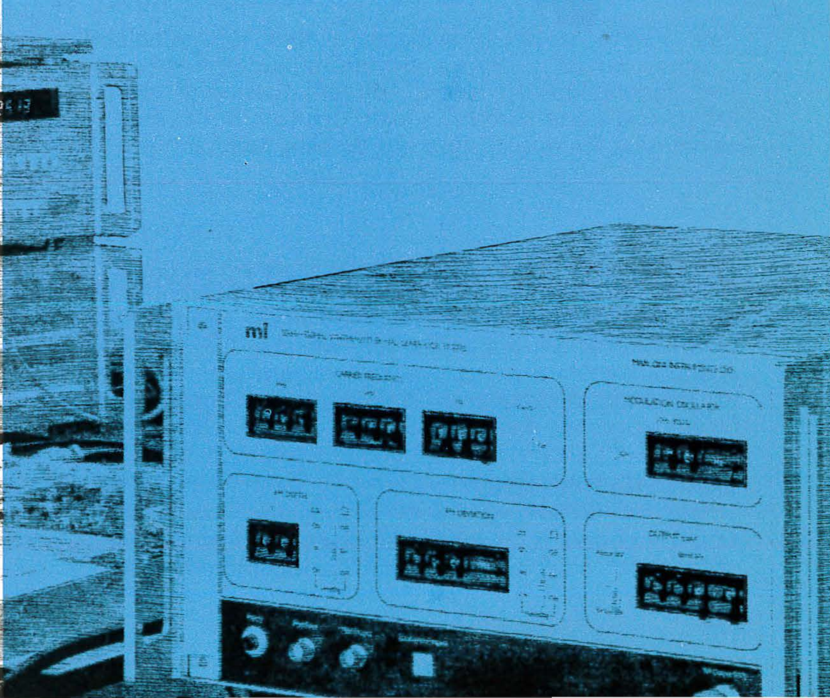
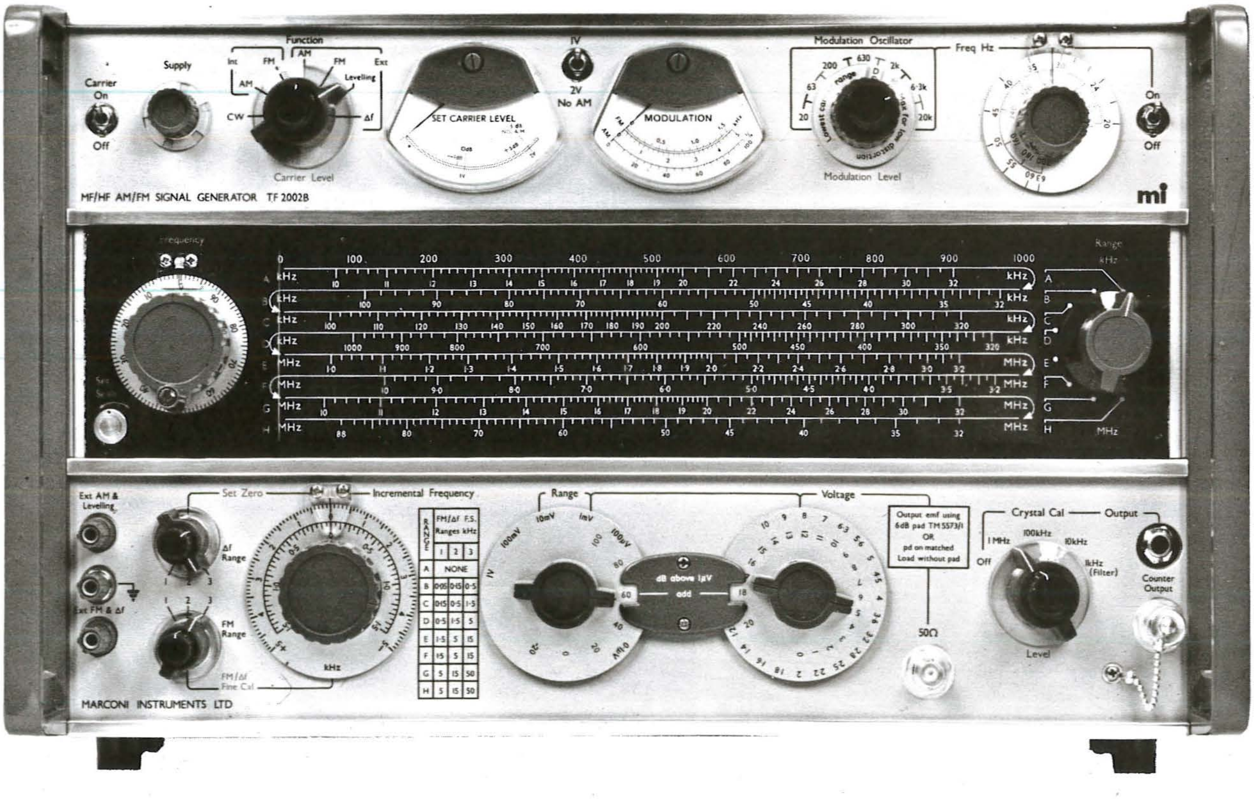
Microwave Sweep Oscillator type 6600A/1 (200 MHz to 110 GHz)	253
Microwave Sweep Oscillator type 6700B (10 MHz to 18 GHz)	257





MF/HF AM/FM Signal Generator

- Frequency range: 10 kHz to 88 MHz
- High discrimination electrical fine tuning calibrated against comprehensive crystal calibrator
- Internal modulating frequency continuously variable from 20 Hz to 20 kHz
- External control of carrier level and incremental frequency sweep
- Low spurious modulation, no non-harmonics



TF 2002B is a high quality, all solid-state signal generator operating over the frequency range of 10 kHz to 88 MHz. It provides internal and external amplitude and frequency modulation and it features a very versatile tuning system. A digital synchronizer is available for use with TF 2002B to give it high frequency stability and a digital setting facility.

CARRIER FREQUENCY

The full 10 kHz to 88 MHz frequency range of the signal generator is covered in eight switch-selected bands, each band having a maximum-to-minimum frequency ratio of approximately 3·16:1 up to 32 MHz. On the highest frequency band, however, the ratio is reduced to approximately 2·75:1.

Main Tuning The main tuning dial has eight hand-calibrated near logarithmic tuning scales – one for each band. These are arranged in a continuous zig-zag, with scales running alternately left and right, so that the main frequency control is rotated clockwise for range A, counter clockwise for range B, clockwise for range C and so on. This feature cuts out much of the tedium which can occur when tuning a signal generator close to the band change frequency.

The signal generator is tuned over the full cover of each band by ten turns of the main frequency control, which also carries a subsidiary dial with a linear logging scale numbered 0 to 100. Corresponding numerals engraved at the top of the main tuning dial show the rotational position of the control. Provision is also made for adjusting the mechanical position of the main tuning dial to correct the calibration, if necessary, when the frequency is set accurately against the internal crystal calibrator.

Crystal Calibrator The internal crystal calibrator provides check points at intervals of 1 MHz, 100 kHz and 10 kHz. The heterodyne beat note is audible from a loudspeaker mounted within the instrument; but, if desired, a pair of headphones may be used via the output jack socket mounted on the front panel.

It is also possible to switch into circuit a 1 kHz band stop filter which gives the effect of a second null when the carrier frequency is 1 kHz away from the 10 kHz check point.

Incremental Frequency The incremental frequency control facilitates high discrimination setting of frequencies above 32 kHz. Below this frequency the discrimination of the main tuning dial is such that incremental control is hardly necessary.

The incremental control is directly calibrated in three ranges, selected by means of a △f RANGE switch, the total cover being dependent on the main frequency range in use as shown in a table on the panel beside the control. Provision is also made for setting up the scale length against the internal crystal calibrator, giving increased accuracy for bandwidth or similar measurements.

External Frequency Shift Incremental frequency shift can also be applied to the carrier by means of a control voltage fed to an appropriate terminal on the front panel. The frequency shift produced is directly proportional to the d.c. level of this voltage, ±1 volt d.c. producing a shift equal to at least the limits shown in the table located beside the incremental frequency control. This facility can be used for manual or automatic frequency control.

It can also be used for narrow band frequency sweep, a particular application being the display of the frequency response characteristic of a tuned amplifier or receiver on an oscilloscope. The sawtooth voltage of the oscilloscope's time base is applied to the frequency shift terminal of the TF 2002B; the r.f. output from the signal generator is fed to the receiver or the amplifier in the normal way; and the output from the unit under test is applied via a suitable detector to the Y input of the oscilloscope.

Stability The frequency stability is typically 30 p.p.m. per 15 minutes after a 3 hour warm-up period, but can be improved by use of the Digital Synchronizer TF 2170B, which gives a stability of 1 p.p.m. after 3 minutes warm-up and an absolute accuracy of 1 p.p.m.

RF OUTPUT

For all carrier frequencies up to 88 MHz a maximum r.f. output of 1 volt p.d. across a 50 Ω load can be obtained with 100% modulation. With no amplitude modulation a maximum of 2 volts p.d. is obtainable. The output can be adjusted by means of two attenuators in cascade, one of which covers 120 dB in 20 dB steps and the other 20 dB in 1 dB steps, giving a total variation of 140 dB. Calibrated output levels down to 0·1 μV are, therefore, available. The attenuators are calibrated in both voltage and decibels.

The output impedance of the signal generator is 50 Ω, and the attenuator voltage calibration is directly in terms of p.d. across a 50 Ω load. Calibration in e.m.f. can be obtained by connecting a 6 dB pad at the end of the cable. A 50 to 75 Ω matching pad is also available.

Carrier Level Monitor The carrier level monitor is calibrated in p.d. at 1 and 2 volts. The instrument is normally used with the meter set to 1 volt but for changes in r.f. output of less than 1 dB, it is necessary to use the CARRIER-LEVEL control instead of the ATTENUATOR controls, the final output level being given by the sum of the meter reading and the attenuator settings. It is a feature of the TF 2002B that the carrier level can be varied without affecting the modulation depth or the carrier frequency.

The converse also applies; for the signal generator is equipped with a very effective automatic level control system, which enables the operator to vary the frequency, change the frequency range, or adjust the modulation depth without affecting the carrier level.

Counter Output It is sometimes desirable to monitor the frequency of a signal generator by means of an electronic counter. But very few counters will operate correctly when the applied signal carries deep modulation; so the TF 2002B is fitted with a separate COUNTER OUTPUT socket so that the carrier is available from a point in the circuit prior to the modulator. This point is, however, subsequent to a buffer amplifier so that connection of the counter does not affect the carrier frequency. The counter output is also used to drive the Digital Synchronizer TF 2170B.

Radiation For highly sensitive receivers which are fitted with internal ferrite-rod aerials it is, of course, extremely important that the signal generator shall be free from stray leakage field. To this end, particular attention has been paid to the high degree of screening needed.

MODULATION

The TF 2002B can be amplitude or frequency modulated internally or externally. Internal a.m. can also be applied simultaneously with external frequency shift, so that dynamic bandwidth measurements can be made using a modulated signal.

Modulation Oscillator The signal generator contains a low distortion modulation oscillator which is continuously variable over the frequency range 20 Hz to 20 kHz. This a.f. range is covered in six sub-ranges, each having a maximum to minimum frequency ratio of approximately 3·16:1.

The output from the modulation oscillator is available for external use from a terminal at the rear, the level remaining constant at about 0·7 volt into 600 Ω irrespective of modulation frequency or depth.

Amplitude Modulation AM, continuously variable up to 100% can be applied from the internal oscillator or from an external source over the frequency range 20 Hz to 20 kHz. At the lower carrier frequencies, however, it is obviously not possible to obtain deep modulation with high modulation frequencies. For guidance of the operator the range switch of the internal modulation oscillator carries markings indicating the lowest carrier frequency for which each a.f. range can be used. These markings also serve to show the approximate limitations when external modulation is used.

External Levelling When the FUNCTION switch is in the LEVELLING position the external a.m. terminal is connected directly to the modulation/level control system. This provides the facility for adjusting the carrier level by application of an external direct voltage. With the instrument in this operating condition a direct voltage of ±6 volts produces ±100% variation in carrier level. This control voltage is, however, relative to a −6·75 volt standing potential, which is present at the terminal when no input is connected. For use with fully floating d.c. sources a −6·75 volt reference is available from a terminal at the rear of the instrument.

Frequency Modulation At carrier frequencies exceeding 1 MHz the signal generator can be frequency modulated from the internal oscillator or an external source over the a.f. range 20 Hz to 20 kHz. Between 100 kHz and 1 MHz the maximum modulating frequency is reduced to 4 kHz.

Deviation is continuously variable in three ranges, the maximum for each being equal to the maximum incremental shift as shown in the table on the signal generator's front panel.

Modulation Monitor The a.m. depth or f.m. deviation is monitored by a panel meter, which is directly calibrated in per-cent a.m. depth and kHz f.m. deviation. When used as an f.m. monitor the sensitivity may be standardised by means of a trimmer control, with the built-in crystal calibrator as an ultimate reference.

POWER SUPPLY

The signal generator is normally intended for operation from an a.c. mains supply and is suitable for use from supplies in both the 110 volt range and 230 volt range. As it can be operated at frequencies up to 500 Hz it is very suitable for operation in aircraft or similar situations. The instrument can also be operated from external batteries, the required input voltage being from 19 to 32 volts, and the current consumption is 400 mA.

CARRIER FREQUENCY

Range Eight bands, with scales graduated in frequency:

A:	10 kHz	to	32 kHz
B:	32 kHz	to	100 kHz
C:	100 kHz	to	320 kHz
D:	320 kHz	to	1000 kHz
E:	1 MHz	to	3·2 MHz
F:	3·2 MHz	to	10 MHz
G:	10 MHz	to	32 MHz
H:	32 MHz	to	88 MHz

Scale accuracy Scale position is adjustable against internal crystal calibrator. Using the index position the accuracy is ±1%.

Mechanical tuning discrimination The frequency scales are near-logarithmic. A linear logging scale, with effectively 1000 divisions, is provided.

Stability At constant ambient temperature between 10° and 35°C, the frequency drift in the 15 minute period commencing 3 hours after switch-on is typically less than 30 p.p.m. +3 Hz and will not exceed 90 p.p.m. +3 Hz. During the period 10 minutes to 3 hours after switch-on, the frequency drift will not exceed three times the amounts stated above. Following a 10°C ambient temperature change (within the range 10° to 35°C) occurring after the above period of operation, the maximum frequency drift rate during the next 3 hours is typically 200 p.p.m. per 15 minutes.
The frequency variation produced by a 10% change in supply voltage about 230 or 115 V is less than 1 p.p.m. +1 Hz, measured after a 2 hour warm-up period. Improvement in stability can be achieved by use of the Digital Synchronizer TF 2170B, which provides a stability of 1 p.p.m.

Attenuator reaction With the output loaded with 50 Ω and with either attenuator at maximum output, the maximum frequency shift between the extremes of the other attenuator control is not greater than 88 Hz at 88 MHz.

Electrical fine tuning Operative above 32 kHz only. Each carrier frequency band is provided with three ranges of electrical fine tuning as shown below.

Frequency	Band	△f range in kHz 1	2	3
32– 100 kHz	B	±0·05	±0·15	±0·5
100– 320 kHz	C	±0·15	±0·5	±1·5
320–1000 kHz	D	±0·5	±1·5	±5·0
1– 3·2 MHz	E	±1·5	±5·0	±15
3·2– 10 MHz	F	±1·5	±5·0	±15
10– 32 MHz	G	±5·0	±15	±50
32– 88 MHz	H	±5·0	±15	±50

Electrical fine tuning up to the maximum in the table may be used as an external frequency shift facility for manual or automatic frequency control, frequency modulation, phase modulation or sweeping.
Sweep widths in excess of the table may be obtained: on Range C up to 5·0 kHz, and on Range D up to 30 kHz.
Incremental frequency accuracy: ±15% of full scale when FM/ △f FINE CAL. control is centralised. For incremental frequency ranges

above ±1 kHz, ±5% of full scale when calibrated using the internal crystal calibrator in the $+\Delta f$ or $-\Delta f$ range.
Discrimination: better than 0·005% of carrier frequency.
Discrimination with Digital Synchronizer TF 2170B: 10 Hz at any carrier frequency above 32 kHz.

Crystal calibrator — Check points at 1 MHz, 100 kHz and 10 kHz intervals.
Crystal accuracy: $\pm 1 \times 10^{-4}$ over range 10°C to 35°C.
Additional check points at ±1 kHz about crystal points.
Accuracy: ±10 Hz.

RF OUTPUT

Level — Between 10 kHz and 88 MHz (c.w. or modulated up to 100%); 0·1 µV to 1 V p.d. across a 50 Ω load. With no a.m. 2 V p.d. is available.

Attenuators — Seven position coarse attenuator with 20 dB steps. Marked −20 dB to +100 dB with respect to 1 µV. Twenty-one position fine attenuator, with 1 dB steps. Marked 0 dB to +20 dB. Both marked with equivalent voltage at each setting. External Attenuator Pad TM 5573/1 provides 6 dB.

Carrier meter — Scale graduated in voltage.
Voltage range: 1 and 2 V with corresponding graduations in dB.

Total output accuracy (with 50 Ω load) — ±1 dB up to 88 MHz. An additional error of ±0·5 dB may occur above 32 MHz at 10°C and 35°C. Automatic level control maintains carrier level meter setting constant within 0·5 dB at all carrier frequencies.

Impedance — Effectively 50 Ω at all level settings. BNC connector.
V.S.W.R.: Better than 1·1:1 for outputs below 200 mV, with or without 6 dB Attenuator Pad TM 5573/1.

Counter output — Greater than 100 mV into 50 Ω.

AMPLITUDE MODULATION

Depth — Continuously variable up to nominally 100%. Trough depth equivalent to at least 90%.

Monitor — Reads equivalent peak modulation.

Accuracy — ±5% modulation from 20 Hz to 20 kHz, not exceeding the maximum usable modulation frequencies shown in the table below.

Envelope distortion — Using internal oscillator, less than 1% distortion factor at modulating frequency of 400 Hz for modulation depth up to 80% at carrier frequencies between 320 kHz and 88 MHz. At carrier frequencies between 100 kHz and 320 kHz, less than 2%. The maximum usable modulation frequencies for a given distortion and modulation depth depend on carrier frequency as shown.

Band	Carrier Frequency	Maximum frequency for 80% modulation depth (5% distortion)
A	10 to 32 kHz	100 Hz
B	32 to 100 kHz	100 Hz
C	100 to 320 kHz	1·5 kHz
D	320 to 1000 kHz	2 kHz
E	1 to 3·2 MHz	20 kHz
F	3·2 to 10 MHz	20 kHz
G	10 to 32 MHz	20 kHz
H	32 to 88 MHz	15 kHz

Internal modulation oscillator — Covers 20 Hz to 20 kHz in six ranges.
Frequency accuracy: ±10%.

Modulation oscillator output — Fixed level signal from rear terminal of approximately 0·7 V r.m.s. into 600 Ω from a 600 Ω source with less than 0·25% distortion.

External AM (a.c.). — Frequency range 20 Hz to 20 kHz subject to depth accuracy and distortion limits as for internal modulation.
Requirements: approximately 1·2 V r.m.s. for nominal 100% a.m. (depth adjustable at panel). Impedance varies between 1 and 2·5 kΩ.

External levelling (d.c.) — An input between −0·75 V and −12·75 V gives control of the carrier level to between approximately 2 and 0 V p.d.
Input impedance: approximately 4 kΩ in series with −6·75 V.

FREQUENCY MODULATION

Deviation — Above 100 kHz carrier frequency continuously variable with three ranges to maximum peak deviations as shown in the table under 'Electrical fine tuning'. When using half f.s.d. on maximum fine tuning and on f.m. ranges the f.m. accuracy is decreased to typically ±20%.

Modulation frequency range — 20 Hz to 4 kHz at carrier frequencies between 100 kHz and 1 MHz. With carriers above 1 MHz the modulation frequency range is extended to 20 kHz with a flatness of ±2·0 dB.

Monitor — Indicates peak deviation.
Accuracy: With modulation frequencies between 20 Hz and 4 kHz, ±15% of full scale when the FM/Δf FINE CAL. control is centralised. ±6% of full scale when the Δf system has been standardised.

Distortion — Less than 3% at maximum deviation with modulation frequencies from 20 Hz to 4 kHz.

Internal oscillator — As for amplitude modulation.

External FM (a.c.) — 20 Hz to 20 kHz, accuracy of deviation and frequency limitations as for internal modulation.
Input: Approximately 1·2 V r.m.s. into 2 to 2·5 kΩ for maximum deviation given under 'Electrical fine tuning'. (Deviation adjustable at panel.)

TF 2002B

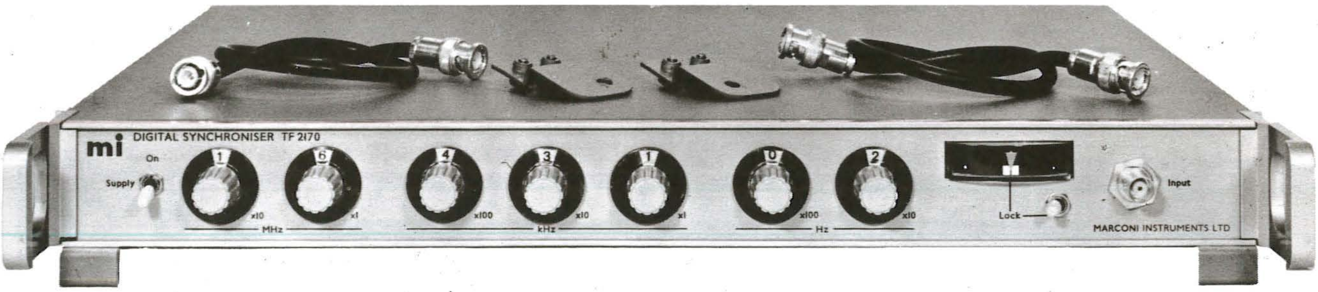
External frequency shift (d.c.)	An input between −5·75 and −7·75 V gives control of the carrier frequency by at least the maximum deviations shown in the table under 'Electrical fine tuning'. *Polarity:* negative going voltage increases frequency. *Input Impedance:* 100 kΩ approx. series with −6·75 V.
Synchronizer input	BNC socket on rear panel for TF 2170B. *Standing voltage:* −6·75 V. *Polarity:* negative going voltage increases frequency. *Sensitivity:* varies between 5% and 0·5% per volt between the lower and higher carrier frequency ranges.
SPURIOUS SIGNALS	
Carrier harmonics	−40 dB from 32 kHz to 20 MHz (ranges B to F) at all levels. −35 dB from 10 MHz to 88 MHz (ranges G and H) at 1 V meter setting. −30 dB from 10 kHz to 88 MHz at 2 V meter setting.
Leakage	Negligible. Allows measurements on sensitive receivers to be made close to the signal generator.
Spurious AM on CW	Below −75 dB relative to the carrier in a 3 dB bandwidth of 650 Hz at carrier frequencies below 450 kHz, and in 20 kHz bandwidth above 450 kHz.
Spurious FM on AM	For 30% a.m. up to 88 MHz at 1 kHz modulation frequency, deviation is less than 250 Hz; and at 10 kHz modulation frequency, deviation is less than 3 kHz.
Spurious FM on CW	Less than 6 Hz in the C.C.I.T.T. 1960 psophometric telephone weighted bandwidth. Less than 25 Hz in a 50 Hz to 20 kHz bandwidth.
Spurious AM on FM	Less than 1% from 320 kHz to 1 MHz. Less than 0·1% above 1 MHz. At 1 kHz modulation frequency and at maximum deviation for the band in use.
Microphony	Less than 1·5 kHz deviation is caused by ½ g acceleration in the range 10 Hz to 100 Hz.
SAFETY	Designed to meet the requirements of IEC 348.
POWER REQUIREMENTS	
AC mains	95 to 130 V, 190 to 264 V, 45 to 500 Hz; 15 VA approx.
External d.c.	19 to 32 V: earthed positive; load 0·4 A approx.
DIMENSIONS AND WEIGHT	Height 284 mm 11¼ in; Width 473 mm 18½ in; Depth 392 mm 15½ in; Weight 26·4 kg 58 lb

VERSIONS AND ACCESSORIES

When ordering please quote eight-digit code numbers

Ordering numbers	
	Versions
52002–035T	TF 2002B. The basic instrument in a case for bench use. The following versions may be available to special order.
52002–301L	TF 2002B. Modified to accept 19·2 kBit/s digital f.m. mod. signal NATO Cat. No. 6625-99-620-9118.
52002–302J	TF 2002B. As 52002–301L plus a kit of parts. NATO Cat. No. 6625-99-628-4711.
	Supplied Accessories
	Output Lead, TM 4969/3 (43126–012S). 50 Ω coaxial cable 1830 mm (6 feet) long fitted with BNC connectors.
	6 dB Attenuator Pad, TM 5573/1 (44425–002D). With pad in use, the TF 2002B is direct reading in output e.m.f. BNC connectors, 50 Ω.
	Matching Pad, TM 5573/3 (44411–019G). 2:1 voltage ratio. 50 to 75 Ω, BNC connectors.
	Jack Plug, 23421–607M. For crystal calibrator a.f. output.
	Trimming Tool, 22951–221Y. To fit cores of r.f. trimming inductors. (Fits into clips inside the instrument.)
	Hexagonal Wrench, 22951–012E. For removing r.f. box cover. (Fits into clips inside the instrument.)
	Optional Accessories
44425–501E	20 dB Attenuator Pad TM 5573. 50 Ω BNC connectors.
44411–001M	Matching Pad TM 5569. Converts from 50 to 75 Ω impedance, with Belling-Lee type L734/P output plug.
44411–018F	Matching Pad TM 6599. Converts from 50 to 75 Ω impedance, with Burndept type PR4E output plug.
44412–023B	Dummy Aerial and D.C. Isolating Unit TM 6123. Provides "dummy" aerial output and also output via d.c. stopper capacitor suitable for direct voltages up to 300 V.
54127–021W	Rack Mounting Kit. Converts bench model, TF 2002B for mounting in a standard 19 in rack.
43281–007C	RF Fuse Unit TM 9884, with spare fuses.
41690–018U	Front Panel Cover. Provides storage for accessories.
43168–008S	Shielded Adapter TB 39868. Converts ¾ in spaced terminals to BNC socket.
44412–021C	Matching Transformer TM 5955/5. Converts from 50 Ω unbalanced to 300 Ω balanced.

- ☐ **Provides synthesizer accuracy for TF 2002 series of signal generators**
- ☐ **Long-term frequency stability: 1 part in 10^6**
- ☐ **Frequency accuracy: 1 part in 10^6**
- ☐ **Digital setting of frequency in 10 Hz increments**



12509

The Digital Synchronizer TF 2170B has been specifically designed for use with MF/HF AM/FM Signal Generators in the TF 2002 family to give a frequency stability and digital setting facility only normally available from a synthesizer. Warm-up drift is eliminated whilst all the signal generator facilities are unimpaired including full a.m. and f.m. capabilities. The synchronizer provides digital setting of frequency down to 10 Hz increments and holds any selected frequency to the accuracy of the internal crystal standard.

In use, the required frequency is first set digitally on the controls of TF 2170B. Then the generator is manually tuned to within approximately 0·5% of this setting. Once within the 0·5% capture range of the synchronizer, the generator will automatically be precisely tuned to the chosen frequency, this condition being indicated by a stable meter reading. False locking points are eliminated by a self-check technique which operates continuously, avoiding any possible ambiguity in operation and obviating the need for an external counter.

The function of the synchronizer is to provide a high stability reference frequency to which the signal generator can be phase locked. Once the lock condition has been achieved, any subsequent drift in the signal generator frequency is automatically corrected by a control voltage which is produced in the TF 2170B and fed back to the f.m. circuitry of the generator.

TF 2170B is mounted in a very slim case which fastens firmly to the top of the signal generator.

CARRIER FREQUENCY	
Range	32 kHz to 88 MHz with TF 2002B. 100 kHz to 72 MHz with TF 2002 and TF 2002AS.
Selection	Seven decade switches provide 10 Hz frequency increments.
Accuracy	Once a lock position has been established, the generator frequency will be held to within 1 part in 10^6 of the digital setting over an ambient temperature range of 10°C to 35°C three minutes after switch on.
Reference crystal ageing	±1 part in 10^6 per year.
RF INPUT LEVEL	Compatible with the counter output voltage of the TF 2002 family of generators.
DC CORRECTION SIGNAL	Two switch selected outputs are available; one for use with either the TF 2002B or TF 2002AS, the other for use with TF 2002, where the output is 2 to 12 V negative.
SAFETY	Designed to meet the requirements of IEC 348.
POWER REQUIREMENTS	
AC mains	95 to 130 V or 190 to 264 V at 45 to 500 Hz. Approximately 20 V

DIMENSIONS AND WEIGHT

Height	Width	Depth	Weight
65 mm	428 mm	390 mm	6 kg
$2\frac{1}{2}$ in	17 in	$15\frac{1}{2}$ in	13 lb

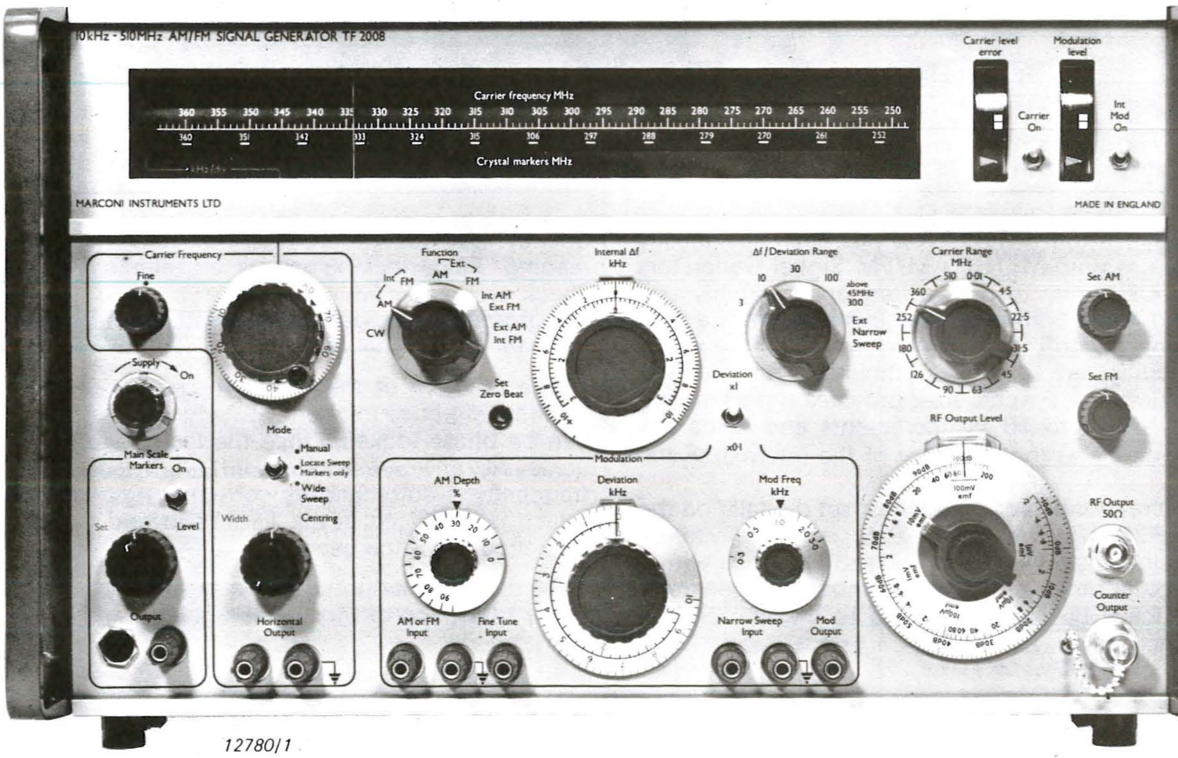
VERSIONS AND ACCESSORIES

When ordering please quote eight-digit code numbers

Ordering numbers	
52170–920H	**Versions** Digital Synchronizer TF 2170B.
	Supplied Accessories Coaxial lead 43122–155Z, 50 Ω BNC (2 supplied). Modification Kit for Signal Generator 46883–137H.

AM/FM Signal Generator

- Frequency range: 10 kHz to 510 MHz; Stability: 5 p.p.m.
- Completely automatic r.f. levelling
- Alternative version provides digital readout of frequency
- Direct reading incremental frequency control
- Built-in frequency sweep with a.m. and f.m. facilities retained
- Crystal calibrator also provides marker outputs



12780/1

TF 2008 is a top grade signal generator which has the added attraction of a built-in frequency sweeper. The very wide frequency cover and unusual range of facilities have been achieved by combining the techniques of the conventional frequency-multiplier type signal generator with those evolving from synthesizer development. In this way an extremely versatile test source has been produced, suitable for measurements on all types of f.m. and a.m. receiver operating at frequencies up to 510 MHz.

In addition to usual signal generator functions, the TF 2008 can be operated in a frequency swept mode, with the sweep width adjustable up to the entire cover of each tuning band. The instrument retains f.m. and a.m. capabilities in the swept mode, and is, therefore, suitable for a number of dynamic measurements on receivers that would be outside the scope of the normal sweep generator.

TF 2008/1 is an alternative version which has all the facilities of the basic instrument and in addition provides digital readout of frequency.

CARRIER FREQUENCY

The carrier frequency is variable over the range 10 kHz to 510 MHz in eleven tuning bands. Nine bands are utilised to cover frequencies from 22·5 to 510 MHz, each having a maximum-to-minimum frequency ratio of only √2:1 to give an open, easily read, tuning scale, with precise control of the main frequency setting. At the low-frequency end of the instrument's range, where the receiver bandwidths are comparatively large in terms of carrier frequency, narrow tuning bands would be inconvenient, and frequencies below 22·5 MHz are, therefore, covered in two tuning bands.

Manual Tuning The main tuning scales are carried on a cylindrical drum which is mechanically coupled to the RANGE switch (Tuning-band selector), so that only the scale corresponding to the selected band is visible, and possible ambiguity is completely obviated. The electrical arrangement of the instrument is such that the direction of the scale is reversed on alternate tuning bands – i.e. frequency increases from left to right on the lowest band, from right to left on the second band, from left to right on the third band and so on. This feature cuts out much of the tedium that can occur when tuning close to the band-change frequency.

Frequency variation over the full cover of each band is effected by twelve turns of the main frequency control, which also carries a subsidiary dial with a 100 division linear logging scale. As the main frequency scale law is linear on all bands, the logging scale forms a convenient means of interpolation between main scale markings, giving effectively 1200 divisions per band, a facility which is further enhanced by the inclusion of a calibration figure on the main dial showing the logging scale gradient in kHz/div for the selected tuning band. The zero mark on the logging scale is adjusted to coincide with the crystal marker frequencies, which are also shown on the main dial.

Fine Tuning Control For fine control of the carrier frequency – e.g., when tuning to a receiver's peak response, etc., – an uncalibrated FINE frequency control is provided. This control varies the bias on a varactor diode coupled to the variable-frequency oscillator, and gives a total frequency variation equivalent to about one division of the logging scale. Electrical access to the fine-frequency-control circuit is available via a FINE TUNE terminal on the front panel, an input of ± 4 volts d.c. centred on approximately –9 volts, producing a frequency variation equal to the range of the panel control. This facility is useful for automatic drift correction.

Crystal Calibrator The internal crystal calibrator provides thirteen check points per tuning band, the crystal check frequencies being indicated on the main tuning dial for easy identification.

For use of the calibrator with manual tuning, the beat note is normally detected aurally by the use of head phones connected via an output jack socket on the front panel. The a.f. output from the calibrator can, however, be drawn via a conveniently placed terminal for use as a marker signal when the instrument is operated in the frequency swept mode.

The audio output level – or marker height – is adjustable by means of a LEVEL control; and an associated SET control, mounted concentrically, enables the user to make small standardising correction to the carrier frequency if necessary.

Incremental Frequency Precise incremental changes in carrier frequency – e.g. for bandwidth measurements – can be made by adjustment of the INT Δ F control. This control is calibrated directly in kHz, with switch-selected full-scale settings of plus or minus 3, 10, 30, or 100 kHz at carrier frequencies below 45 MHz, and plus or minus 3, 10, 30, 100 or 300 kHz at carrier frequencies above 45 MHz. It thus enables the user of the instrument to make very accurate carrier frequency changes ranging from a few hundred Hz to 100 or 300 kHz.

By virtue of the unusual electrical arrangement of the TF 2008 incremental tuning is independent of the main tuning system, so that standardisation of the main tuning calibration is unaffected by adjustment of the incremental control; i.e., when standardised against the internal crystal calibrator, the main tuning scale always indicates the output frequency for zero ΔF setting.

External Frequency Shift (Narrow Sweep) Incremental frequency shift can also be applied to the carrier by means of a control voltage fed to the EXT NARROW SWEEP input terminal. The frequency shift produced is directly proportional to the d.c. level of this control voltage, positive or negative voltages of 5 volts producing, respectively, increase or decrease in frequency of at least 150 kHz at the lowest carrier frequency, and up to 2400 kHz on the highest frequency range.

The facility can be used for remote manual or automatic frequency control and for frequency sweep. As the circuit is d.c. coupled it is capable of operating at very low sweep speeds for such purposes as examination of the response characteristic of narrow band filters. An internally or externally generated amplitude modulating signal can be applied to the carrier with the signal generator operating in the narrow sweep mode, a useful feature when the instrument is used for a.m. receiver alignment.

Wide Sweep By operation of a toggle switch the main tuning system of the signal generator can be converted from normal manual control to the continuously swept mode. This is achieved by bringing into circuit a voltage-controlled oscillator covering the same frequency range as the manually-tuned oscillator; and it is the signal from the voltage-controlled oscillator that is processed to form the final output signal. The manually-tuned oscillator and the voltage-controlled oscillator are both operational in the 'Locate Sweep Markers only' position of the MODE switch, making it possible to identify any one of the 13 markers.

The sweep centre frequency and the sweep width are continuously variable by means of a pair of concentrically mounted controls. The swept display can be accurately calibrated by use of the crystal controlled markers and the variable marker; and the calibrated ΔF control moves the displayed response curve relative to the markers.

Sweep drive is derived from an internal generator, which produces a 1:1 triangular sweep waveform at approximately 18 Hz. This waveform is available from a panel terminal for horizontal drive to a display oscilloscope, such as Marconi Instruments TF 2212A series.

In the wide sweep-mode this instrument retains the modulating facilities that are available with manual tuning. It is, therefore, suitable for a number of measurements on demodulators that would be beyond the scope of a normal sweep generator.

MODULATION

The TF 2008 can be amplitude or frequency modulated internally or externally. Both types of modulation can also be applied simultaneously, either as internal a.m. with external f.m. or vice versa.

Modulating Oscillator The internal modulating oscillator is continuously variable over the frequency range 300 Hz to 3 kHz. This frequency range covers the audio bandwidth of most communications receivers, and includes the modulation frequencies commonly used in performance measurements on receivers of all types.

The output from the modulating oscillator is available for external use from a front panel socket, the level remaining at 0·5 volts regardless of the modulation depth or deviation setting.

Amplitude Modulation The a.m. depth is continuously variable up to 80% at all carrier frequencies by adjustment of a directly calibrated control. Internal modulation is, of course, available over the full range of the built-in a.f. oscillator, or external modulation can be applied at frequencies between 20 Hz and 15 kHz. There is no further restriction on modulation frequency or depth at low carrier frequencies provided that the carrier frequency is at least ten times the modulating frequency.

Frequency Modulation The TF 2008 can be frequency modulated internally over the full range of its built-in a.f. oscillator or from an external source at any frequency from 30 Hz to 125 kHz. The modulation frequency characteristic is flat within 0·6 dB from 30 Hz to 53 kHz with negligible phase shift, so that the instrument is suitable for f.m. stereo applications, giving channel separation better than 35 dB.

Deviation is continuously variable up to 100 kHz at carrier frequencies below 45 MHz and up to 300 kHz at carrier frequencies above 45 MHz. Adjustment is made by means of a directly calibrated control in conjunction with the ΔF switch, the same electrical system being used for frequency modulation as for incremental frequency shift.

For precise setting of low deviation values, operation of a toggle switch reduces the deviation, for any setting of the controls, by a factor of 10. This makes it possible to operate the instrument with large ΔF shifts but with small deviations.

Modulation Monitor For direct indication of a.m. depth or f.m. deviation on the calibrated controls, the input signal (internal or external) to the modulation systems must be set to the reference level indicated by the MODULATION LEVEL meter. Panel controls for this purpose are used for adjusting the levels of both internally and externally generated modulation signals.

Separate controls for SET AM and SET FM are provided for convenience when the signal is frequency and amplitude modulated simultaneously, and a MOD ON/OFF switch enables the user to remove the internally generated modulation – e.g., for signal-to-noise ratio measurements – without disturbing the settings of the modulation level controls.

RF OUTPUT

The r.f. output level is continuously variable from 200 mV down to 0·2 µV e.m.f. from a 50 Ω source impedance. A single OUTPUT LEVEL dial is calibrated directly in voltage and in decibels relative to

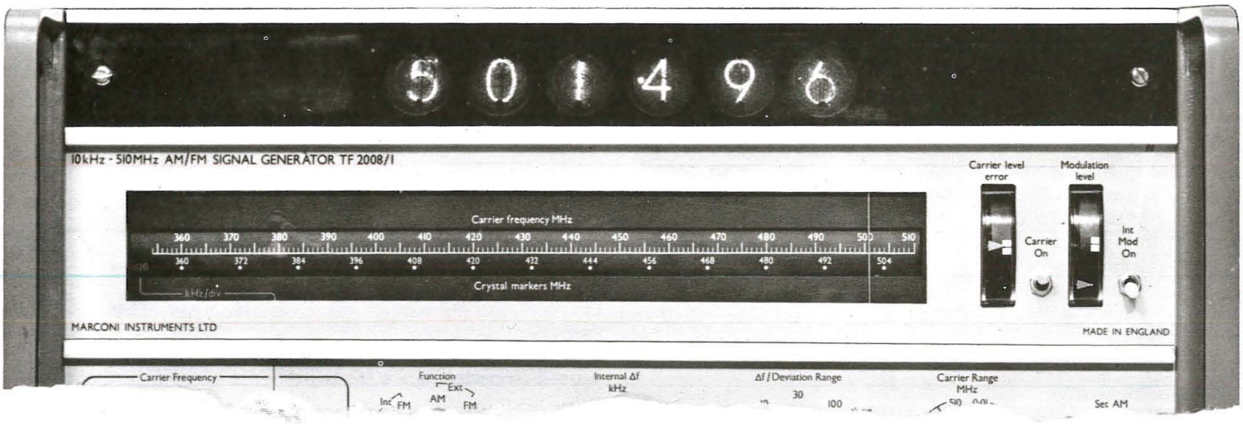
1 μV e.m.f. An alternative attenuation dial calibrated in p.d. is available. Output level adjustment is made by means of two concentric controls associated with the calibrated dial. The coarse control, which carries the dial, covers 110 dB in steps of 10 dB; and the fine control, which moves the cursor via a reduction gear, is continuously variable over 10 dB. The very effective automatic level control system of the TF 2008 obviates the need for the "Set Carrier" control fitted to most signal generators.

Counter Output An auxiliary r.f. outlet is provided in order that the frequency may be monitored while the instrument is in use. The counter output level is independent of the setting of the coarse OUTPUT LEVEL control, and provides at least 100 mV into 50 Ω, variable by the fine OUTPUT LEVEL control.

DIGITAL READOUT VERSION

TF 2008/1 retains all the facilities of the basic instrument, but provides digital readout of carrier frequency in addition to the normal tuning scales. This eliminates the need for an external counter, with its associated leakage, for accurate setting of frequency. The counter output facility is not provided on the TF 2008/1, this output being used to provide the internal digital readout. The readout section is incorporated in the main generator case at the top of the instrument, and the r.f. screening of this section is comparable with that of the main generator so that no deterioration of performance occurs at low output levels.

The six-digit in-line readout shows the frequency in MHz with automatic positioning of the decimal point, the significance of the last digit depending on the carrier range in use. No additional controls are needed and no action is required to bring the readout into use, operation of the signal generator being exactly as for the basic instrument.



Digital readout section of the TF 2008/1

FREQUENCY CONTROL (Manual mode)

Range
10 kHz to 510 MHz in eleven bands. Bands and main scale calibrations as ollows:

	Frequency Band	Scale Division
(1)	0·01 to 4·5 MHz	50 kHz
(2)	4·5 to 22·5 MHz	100 kHz
(3)	22·5 to 31·5 MHz	100 kHz
(4)	31·5 to 45 MHz	100 kHz
(5)	45 to 63 MHz	200 kHz
(6)	63 to 90 MHz	200 kHz
(7)	90 to 126 MHz	500 kHz
(8)	126 to 180 MHz	500 kHz
(9)	180 to 252 MHz	1 MHz
(10)	252 to 360 MHz	1 MHz
(11)	360 to 510 MHz	1 MHz

Calibration accuracy
±0·5% from 22·5 to 510 MHz.

Stability
At constant ambient temperature within the range 10°C to 35°C:
In the 15 minute period commencing 1 hour after switch-on, the frequency variation is typically less than 5 p.p.m. and will not exceed 15 p.p.m. on ranges 3 to 11.
On range 1 the frequency variation is not greater than 350 Hz.
On range 2 the frequency variation is not greater than 900 Hz.
Following a 10 deg. C change in the ambient temperature within the range 10°C to 35°C occurring 3 hours after switch-on, the maximum frequency variation after 1½ hours does not exceed 30 p.p.m. per 15 minutes on ranges 3 to 11.
On ranges 1 and 2 the maximum frequency variation after 1½ hours does not exceed 1·25 kHz per 15 minutes.
After a supply voltage change of +10% or −10%, maximum frequency change is less than 1 p.p.m. +50 Hz.

Microphony
Less than 10 kHz deviation is caused by ½g acceleration at vibration frequencies from 10 Hz to 80 Hz. The instrument is unaffected by acoustic feedback when used with a receiver having a built-in loudspeaker under normal conditions.

Load reaction
With the RF OUTPUT LEVEL controls set for maximum output the frequency shift caused by disconnecting a 50 Ω load does not exceed 100 Hz at carrier frequencies up to 100 MHz, and does not exceed 200 Hz at carrier frequencies up to 510 MHz.

RF level control reaction
The frequency shift caused by varying the RF OUTPUT LEVEL over its entire range does not exceed 100 Hz at carrier frequencies up to 100 MHz, and does not exceed 200 Hz at carrier frequencies up to 510 MHz.

Internal △f control (Incremental tuning)
Directly calibrated, with range full-scale settings as follows:
Bands 1 to 4: 3, 10, 30 and 100 kHz.
Bands 5 to 11: 3, 10, 30, 100 and 300 kHz.
Accuracy: ±5% full-scale ±0·5 kHz.

External narrow sweep
±5 V d.c. or 10 V p-p a.c. to NARROW SWEEP INPUT terminal from source impedance not exceeding 12 kΩ, can be used to sweep the generator as follows:

Carrier frequency	Max. sweep width
0·01 – 45 MHz	± 150 kHz
45 – 90 MHz	± 300 kHz
90 – 180 MHz	± 600 kHz
180 – 360 MHz	±1200 kHz
360 – 510 MHz	±2400 kHz

Drive frequency up to 30 Hz.

FREQUENCY CONTROL (Sweep mode)

Sweep width
Adjustable up to the frequency limits of each tuning band.

Centre frequency
Adjustable over the full cover of each tuning band by means of an uncalibrated control, subject to the sweep width limits above.

Frequency markers
A crystal calibrator provides 13 markers per band. These may also be used to improve the calibration accuracy of the main scale under manual tuning conditions
Crystal oscillator accuracy: ±0·01% at ambient temperatures between 10°C and 35°C.

Sweep drive
From internal triangular-wave generator.
Sweep rate: Approximately 18 Hz.

Horizontal drive output
8 V p-p e.m.f.

AMPLITUDE MODULATION	
Depth	Continuously variable up to 80% by directly calibrated control. The scale is marked up to 95%.
Monitor	Peak reading – reference level.
Calibration accuracy (at 23°C)	±6% mod. depth up to 40%. ±15% of indication from 40 to 80%. An additional error of ±5% of reading may occur at +10° and +35°C.
Envelope distortion	Typically less than 3% at 80% modulation depth using internal modulating oscillator. With external modulation the distortion may rise to 6% at higher modulating frequencies.
Internal frequency range	300 Hz to 3 kHz continuously variable.
External frequency range	20 Hz to 15 kHz.
External input requirement	Approximately 0·5 V to set reference level. *Input impedance:* 600 Ω nominal.
FREQUENCY MODULATION	
Deviation	***Bands 1 to 4:*** 0 to 100 kHz, continuously variable in four ranges with full-scale settings of 3, 10, 30 and 100 kHz. ***Bands 5 to 11:*** 0 to 300 kHz, continuously variable in five ranges with full-scale settings of 3, 10, 30 100 and 300 kHz.
Monitor	Peak reading – reference level.
Calibration accuracy	±5% of range full-scale at 1 kHz.
Envelope distortion	Less than 1% using internal modulating oscillator.
Internal frequency range	300 Hz to 3 kHz continuously variable.
External frequency range	30 Hz to 125 kHz. Suitable for f.m. stereo, giving channel separation better than 35 dB at 1 kHz and 15 kHz.
Response characteristic	30 Hz to 53 kHz: Within ±0·3 dB of the response at 1 kHz. 53 kHz to 125 kHz: Within ±1·0 dB of the response at 1 kHz.
External input requirement	Approximately 0·5 V to set reference level. *Input impedance:* 600 Ω nominal.
MODULATING OSCILLATOR	
Frequency range	300 Hz to 3 kHz continuously variable. *Accuracy:* 10%.
AF output	Available from MOD OUTPUT terminal *Level:* Not less than 0·5 V e.m.f. *Source impedance;* 600 Ω nominal.
Distortion	Less than 0·15%.
RF OUTPUT	
Level	0·2 μV to 200 mV e.m.f.
Controls	*Coarse:* 11 steps of 10 dB. *Fine:* 0 to 10 dB continuously variable. Directly calibrated in voltage and decibels relative to 1 μV.
Total level accuracy (above 2 μV) (at 23°C)	±1 dB ±0·2 μV 100 kHz to 100 MHz. ±2 dB ±0·2 μV 10 kHz to 510 MHz. An additional error of ±1 dB may occur at +10°C and +35°C.
Source impedance	50 Ω. *VSWR:* Better than 1·2:1 with 10 dB or more on COARSE control. 1·5:1 at maximum output.
Counter output	100 mV or greater into 50 Ω (with RF Output loaded with 50 Ω) depending on the setting of the fine RF OUTPUT LEVEL control.
SPURIOUS SIGNALS	
AM on CW	Better than −60 dB relative to 100% modulation over 15 kHz bandwidth.
FM noise	With telephone psophometric weighting, equivalent deviation is less than 10 Hz for carrier frequencies below 360 MHz, and less than 20 Hz for carrier frequencies up to 510 MHz.
AM on FM	At full deviation, typically less than 1% a.m. and not greater than 1·5% a.m. over internal modulation frequency range.
FM on AM	Less than 120 Hz deviation at carrier frequencies up to 100 MHz; less than 600 Hz deviation at carrier frequencies up to 360 MHz; less than 1·2 kHz at carrier frequencies up to 510 MHz, with 30% a.m. at 1 kHz.
Carrier harmonics	Less than 5% total harmonic distortion.
Non-harmonic components	Less than 1% up to 180 MHz and less than 3% up to 510 MHz.
Leakage radiation	Up to 510 MHz with a receiver sensitivity set at 1·0 μV, a 25mm (1 inch) 2 turn loop feeding the receiver cannot detect a signal of this level at a distance greater than 25mm from the generator.
POWER REQUIREMENTS	
AC mains	95 to 130 V or 190 to 264 V 45 to 500 Hz, 22 VA.
External d.c	21 to 32 V – positive-earth 500 mA approximately.
SAFETY REGULATIONS	Complies with IEC 348 and BS 4743 safety requirements.
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 25 kN/m² differential, i.e. 3·7 lbf/in²).

DIMENSIONS AND WEIGHT	Height	Width	Depth	Weight
	285 mm	475 mm	315 mm	21 Kg
	11·25 in	18·5 in	12·5 in	46 lb

The specification for the TF 2008/1 is the same as for the TF 2008 with the following additions

DIGITAL READOUT	Six-digit in-line.
Crystal accuracy	±1 p.p.m.
Ageing accuracy	±1 p.p.m. per year.
Readout accuracy	Crystal accuracy ±1 count.
Least significant figure	10 Hz from 0·01 to 4·5 MHz. 100 Hz from 4·5 to 90 MHz 1 kHz from 90 to 510 MHz.
COUNTER OUTPUT	Not provided.

DIMENSIONS AND WEIGHT	Height	Width	Depth	Weight
	330 mm	475 mm	315 mm	25 Kg
	13 in	18·5 in	12·5 in	56 lb

VERSIONS AND ACCESSORIES

When ordering please quote eight-digit code numbers

Ordering numbers	
	Versions
52008–015T	TF 2008. Basic instrument in a case for bench use. (NATO Cat. No. 6625-99-117-5353. CT 561/3.)
52008–025K	TF 2008/1. Digital Readout Version.
	Supplied Accessories
	Protective Front Panel Cover 41684-003J marked with operating summary (for TF 2008).
	Protective Front Panel Cover 41684-004F marked with operating summary (for TF 2008/1).
	Accessory Kit 46883-134K comprising RF Connecting Cable TM 4969/3 (43126-012S) 50 Ω, 1524 mm (5ft) BNC. Phone Jack Plug 23421-612R. Adaptor Phone Socket to BNC 43168-016X.
	Optional Accessories
44416–077J	Detector Probe TM 9650.
44425–501E	20 dB Pad TM 5573, BNC to BNC.
44425–002D	6 dB Pad TM 5573/1, BNC to BNC.
44411–001M	50 Ω to 75 Ω Adapter TM 5569 BNC to Belling Lee.
43281–007C	RF Fuse Unit with spare fuses TM 9884 type BNC.
54127–021W	Rack Mounting Kit (for TF 2008 only).
54711–021X	Maintenance Kit.
41174–029T	Attenuator Dial calibrated in p.d.
54311–041E	Adapter, BNC Plug to Conhex screw-on plug.
	Associated Equipment
52212–910P	X-Y Display TF 2212A.
52212–911X	X-Y Display TF 2212A/1. Long persistence version
52213–910E	X-Y Display TF 2213A (Dual channel).
52213–911U	X-Y Display TF 2213A/1. Long persistence version.

b

10 to 520 MHz AM/FM Signal Generator and Digital Synchronizer

- ☐ 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
- ☐ Versatile performance gives good value for money
- ☐ Fundamental oscillators for each range — no non-harmonic components
- ☐ Optional synchronizer gives frequency stability of ± 2 in 10^7
- ☐ Optional i.f. probes simplify tuning to receivers

TF 2015/1

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

TF 2015/1 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 2015/2 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 2015 series to form a manually synthesized signal generator with an accuracy and long term frequency stability of 2 parts in 10^7.

TF 2015 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 2015 has an RF OUTPUT scale calibrated in dBm. For TF 2015/1 and TF 2015/2 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 2015 is tuned by applying a d.c. voltage to variable capacitance diodes 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.*

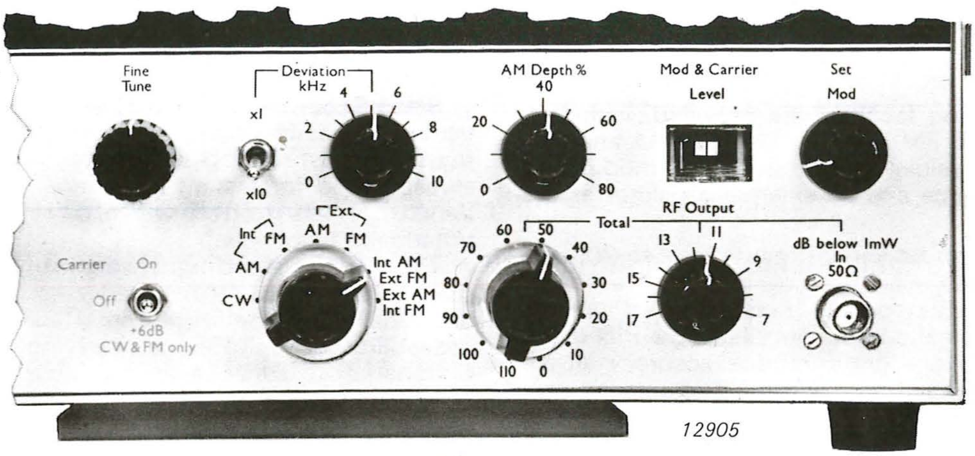
The small size and light weight of the TF 2015 series make them suitable for field servicing, and this is aided by the facility for use on external d.c. supplies and the availability of an optional carrying case. Among the optional accessories available is a range of plug-in, crystal-controlled IF oscillator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

Pulse Modulator TF 2169 is available for use with TF 2015 series enabling high quality pulsed r.f. signals to be generated when pulse waveforms from 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. 20) is available which discusses the use of TF 2015 for swept frequency testing using narrow sweep widths.

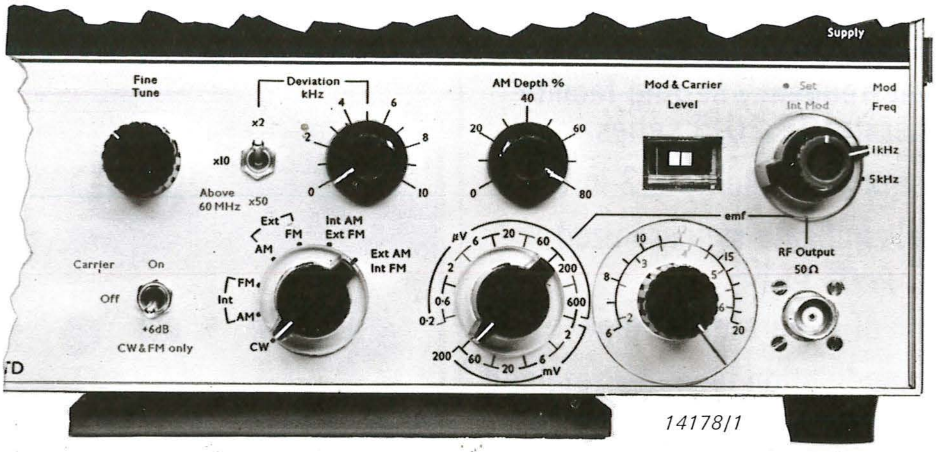
TYPE NUMBER	TF 2015	TF 2015/1	TF 2015/2
FREQUENCY Range	10 MHz to 520 MHz in 11 ranges: 10·0 MHz to 14·3 MHz 14·3 MHz to 20·5 MHz 20·5 MHz to 29·4 MHz 29·4 MHz to 42·0 MHz 42 MHz to 60 MHz 60 MHz to 86 MHz 86 MHz to 124 MHz 124 MHz to 177 MHz 177 MHz to 254 MHz 254 MHz to 363 MHz 363 MHz to 520 MHz		
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 1 µV p.d.)	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	50Ω. VSWR better than 1·3:1 with 10 or more dB inserted in the coarse attenuator.		
Counter output		Greater than 80 mV into 50Ω.	
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.		
AMPLITUDE MODULATION Depth	Performance using internal modulating oscillator at 1 kHz. 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.	
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.		

TF 2015 series



Part of front panel of TF 2015

TYPE NUMBER	TF 2015	TF 2015/1	TF 2015/2
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 (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% (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. When using the Digital Synchronizer TF 2171 typical response will be −2 dB at 100 kHz modulating frequency.
External input requirements	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 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.



Part of front panel of TF 2015/2.

TYPE NUMBER	TF 2015	TF 2015/1	TF 2015/2
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 500 Hz. 10 VA		
External d.c.	24 to 32 V negative earth.		
SAFETY	Designed to meet the requirements of IEC 348.		
LIMIT RANGE OF OPERATION Temperature	0 to 55°C.		
CONDITIONS OF STORAGE AND TRANSPORT Temperature Humidity Altitude	−40°C to +70°C. Up to 90% relative humidity. Up to 2500 m (pressurised freight at 25 kN/m² differential, i.e. 3·7 lbf/in²).		
DIMENSIONS AND WEIGHT	Height 140 mm 5·5 in Width 286 mm 11·25 in Depth 311 mm 12·25 in Weight 5·4 kg 12 lb		
VERSIONS Ordering number and description	52015-015F AM/FM Signal Generator TF 2015.	52015-901E AM/FM Signal Generator TF 2015/1.	52015-902U AM/FM Signal Generator TF 2015/2.
SUPPLIED ACCESSORIES	RF Connecting Cable 43126-012S (TM 4969/3), BNC, 50 Ω 1524 mm (60 in) long. TNC to BNC Adaptor 23443-814X for counter output socket. Protective front panel cover 41690-102S.		
OPTIONAL ACCESSORIES Ordering number and description	41690-044B Carrying Case. 43281-007C RF Fuse Unit TM 9884 for protection of attenuator resistors when connecting to active loads. 44411-001M Matching Unit TM 5569. BNC connectors. Converts source impedance to 75 Ω. 44411-019G Matching Pad TM 5573/3. BNC connectors. Matches 50 Ω generator to 75 Ω load, 6 dB insertion loss. 44425-501E 20 dB Pad TM 5573, BNC to BNC. 54451-061Y IF Probe 470 kHz. 54451-071S IF Probe 10·7 MHz. 54451-121B IF Probe 455 kHz.		
		35901-628E Output Calibration Plate, marked in dBµV e.m.f. on one side and dBµV p.d. on the other side. 35901-701E Output Calibration Plate, marked in dBm on one side and µV and mV p.d. on the other side.	
ASSOCIATED EQUIPMENT Ordering number and description	52171-900B Digital Synchronizer TF 2171. 52169-900J Pulse Modulator TF 2169.		

Digital Synchronizer

- ☐ Provides digital frequency setting facility for Signal Generator TF 2015 series
- ☐ Short term frequency stability ± 2 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 2015

Digital Synchronizer TF 2171 has been designed for use with Signal Generators in the TF 2015 series to give them a digital setting facility and a frequency stability of 2 parts 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 2015, 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.
Selection	Seven decade switches provide 100 Hz increments.
Accuracy	After synchronization, the frequency accuracy and stability is within 2 parts in 10^7, measured in a 10s interval, of the indicated value set on the synchronizer for an ambient temperature range of 0° to 40°C, ten minutes after switching the equipment on (typically five minutes).
Incremental frequency control	After synchronization, the decade controls can be used to digitally increment the generator carrier frequency over a range of typically $\pm 0{\cdot}5\%$ without retuning the generator.
Reference crystal ageing	± 1 part in 10^6 per year.
Leakage	When used with TF 2015 series the r.f. leakage specification of TF 2015 is maintained.

RF INPUT LEVEL	Compatible with the counter output voltage of TF 2015 series.
REFERENCE STANDARD IN/OUT	A rear-panel INT/EXT switch selects operation either from the internal reference standard, which is available as an output at a rear panel BNC socket, or from an external reference signal fed into this socket.
Internal standard	*Frequency:* 5 MHz, divided down to 1 MHz at the output. ***Output Levels:*** TTL level square wave, a.c. coupled.
External standard	*Frequency:* 1 MHz. *Input Level:* TTL level square wave, into nominal 500 Ω.
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	Designed to meet the requirements of IEC 348.
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 25 kN/m² differential, i.e. 3·7 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 Digital Synchronizer TF 2171. Standard version.
	Supplied Accessories RF Lead 43129–063F, 50 Ω BNC to BNC. RF Lead 43129–064G, 50 Ω TNC to BNC. Mounting Kit 46883–214N, for fixing TF 2171 rigidly to TF 2015 series.
41690–044B 43129–103V	Optional Accessories Carrying Case. RF Lead, 50 Ω, TNC to BNC.

IF Probes

54451 series

- ☐ **Crystal-controlled oscillators simplify tuning to receivers**
- ☐ **Range covers commonly-used intermediate frequencies**

These three IF Probes have been designed for use with AM/FM Signal Generator TF 2015 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 2015 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 2015 series.		
POWER REQUIREMENTS DC supply	+19 V to +24 V, 2 mA. Obtained from socket on TF 2015 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

13038

Rear view of TF 2015 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

- ☐ Wide frequency range: 10 kHz to 120 MHz
- ☐ Amplitude modulation up to 100% depth
- ☐ Frequency modulation up to 75 kHz deviation
- ☐ High output level up to 4 V e.m.f.
- ☐ Excellent output level accuracy
- ☐ Fundamental frequency generation — no spurious signals
- ☐ Compact and portable — 24 V battery supply can be used
- ☐ Optional digital synchronizer gives frequency stability of $\pm$ 1 in 10^6

14326/6

TF 2016 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 2016 to form a manually synthesized signal generator with an accuracy and long term stability of $\pm$1 part in 10^6.

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. Good f.m. on a.m. and a.m. on f.m. performance is also obtained. 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 frequency sweep facility is included, by which a voltage swing of 0 to 19 volts applied to the SYNC/SWEEP IN connector varies the carrier frequency over the total cover of any one range.

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 2 μV to 2 V e.m.f. 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. and dBm, or in dB μV e.m.f. and dB μV p.d. Levels below 2 μV are obtained using the supplied 20 dB attenuator which is intended to be mounted at the remote end of the r.f. connecting lead to preserve the best accuracy at a receiver input terminal. When the attenuator pad is not in use it can be stored on the rear panel using the retaining clip fitted for that purpose. Automatic level control ensures ±1 dB output level accuracy across the full range of frequency and output level setting. The low leakage of the generator enables accurate measurements to be made on receivers with sensitivities down to 0·1 μV.

The small size and light weight of TF 2016 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, an RF fuse unit and a 20W, 20 dB attenuator.

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

MODEL 52016-900S

FREQUENCY

Range	10 kHz to 120 MHz in 12 ranges 10 to 22 kHz · 1·1 to 2·4 MHz 22 to 48 kHz · 2·4 to 5·2 MHz 48 to 105 kHz · 5·2 to 11·4 MHz 105 to 230 kHz · 10 to 23 MHz 230 to 500 kHz · 23 to 53 MHz 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 10^5).
Calibration 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 2 parts in 10^5 +100 Hz in 5 mins.
Frequency sweep input	Voltage swing from 0 to +19 V applied to the SYNC/SWEEP IN connector varies the carrier frequency over the frequency cover of any one range.

RF OUTPUT

Level	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. Signal levels below 2 μV are obtained using an external 20 dB attenuator pad supplied with the instrument.
Attenuators	*Coarse:* 11 steps of 10 dB *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: ±1 dB including the a.l.c. loop response.

Source impedance — 50Ω; 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.

Leakage radiation — Up to 120 MHz with a receiver sensitivity set at 0·5 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.

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 (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% Accuracy within*	AM Depth 30% Distortion less than	AM Depth 80% Accuracy within*	AM Depth 80% Distortion less than
0·1–30	±5%	1·5%	±5%	3%
30–90	±5%	3%	+5% −10%	6%
90–120	+0% −7·5%	4%	+0% −15%	8%

* 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) — For a total harmonic distortion not exceeding 2% the maximum deviation obtainable is 5 kHz for carrier levels between 2·4 and 5·2 MHz; 25 kHz between 5·2 and 11·4 MHz and 75 kHz between 10 and 120 MHz. For a total harmonic distortion not exceeding 4% the maximum deviation obtainable is 5 kHz for carrier levels between 1·1 and 2·4 MHz; 25 kHz between 2·4 and 5·2 MHz and 75 kHz between 5·2 and 11·4 MHz.

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 — 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 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 1 V p.d.

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 20 Hz up to 53 MHz and less than 40 Hz up to 120 MHz.

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

SAFETY

Designed to meet the requirements of IEC 348.

POWER REQUIREMENTS

AC supply — Any voltage within the extreme limits 190 to 264 V or 95 to 132 V, at any frequency between 50 Hz and 60 Hz, usable to 500 Hz. 24 VA maximum (50 Hz).

External d.c. — 23 to 32 V negative earth, 0·55 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	7 kg
5·5 in	11·25 in	12·25 in	15·4 lb.

MODEL 52016-301H

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	149 ±2 Hz (Adjustable by internal preset control).
AF output	When the preset modulation facility is in use an 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
52016–900S	AM/FM Signal Generator TF 2016. (Nato Cat. No. 6625–99–645–9230)
52016–301H	AM/FM Signal Generator TF 2016 with preset pilot tone f.m.
	Supplied Accessories
	Protective Front Panel Cover 41690–102S
	20 dB Coaxial Attenuator Pad 44429–018B, 50 Ω, BNC.

	Optional Accessories
35901–869Y	Conversion plate for output attenuator. Reversible plate calibrated in μV p.d. and dBm.
35901–870E	Conversion plate for output attenuator. Reversible plate calibrated in dBμV e.m.f. and dBμV p.d.
	TF 2016 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.).
43281–007C	RF Fuse Unit TM 9884, BNC, for protection of attenuator resistors when connecting to active loads.
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 2016 or TF 2173 alone).
54127–241A	Rack Mounting Kit (for rack mounting TF 2016 and TF 2173 together).
54311–071Z	Adapter TNC to BNC for counter output socket.
54431–021B	20 W, 20 dB Attenuator Pad for use at remote end of connecting cable to provide attenuation and reverse power protection.
54451–061Y	IF Probe 470 kHz.
54451–071S	IF Probe 10·7 MHz.
54451–121B	IF Probe 455 kHz.
	The IF Probes provide crystal controlled signals at standard IF frequencies for use in receiver alignment. For details see page 25

Digital Synchronizer

- Provides digital frequency setting facility for Signal Generator TF 2016
- Frequency stability $\pm$ 1 in 10^6
- 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 2016 to give a digital setting facility and a frequency stability of better than 1 part in 10^6.

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 2016. 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 approximate 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 digitally increment 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 2016, and is supplied with the necessary interconnecting leads and a set of clips to enable the two instruments to be securely fixed together if required.

TF 2173 clipped to TF 2016 *14326/4*

CARRIER FREQUENCY

Range	10 kHz to 119·99999 MHz.
Selection	Seven decade switches provide increments down to 10 Hz.
Accuracy	After synchronization the frequency accuracy and stability, when measured over a period of 10 seconds or greater, is within 1 part in 10^6 of the value indicated by the decade controls. This accuracy and stability is achieved after 10 minutes warm-up at a constant ambient temperature in the range 10° to 35°C.
Incremental frequency control	After synchronization, the decade controls can be used to digitally increment the generator carrier frequency over a range of typically 2% without retuning the generator.
Reference crystal ageing	±1 part in 10^6 per year.
RF leakage	When used with TF 2016 the r.f. leakage specification of the Signal Generator is maintained.

RF INPUT

Level	Compatible with the TF 2016 Counter Output signal level.

REFERENCE STANDARD

Selection	A rear panel INT/EXT switch selects operation either from the internal reference standard or from an external reference signal.
Internal standard output	*Frequency:* 5 MHz, divided down to 1 MHz. *Output level:* TTL level square wave a.c. coupled.
External standard input	*Frequency:* 1 MHz. *Input level:* TTL level square wave into 500 Ω nominal impedance.

SAFETY

Designed to meet the requirements of IEC 348.

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.

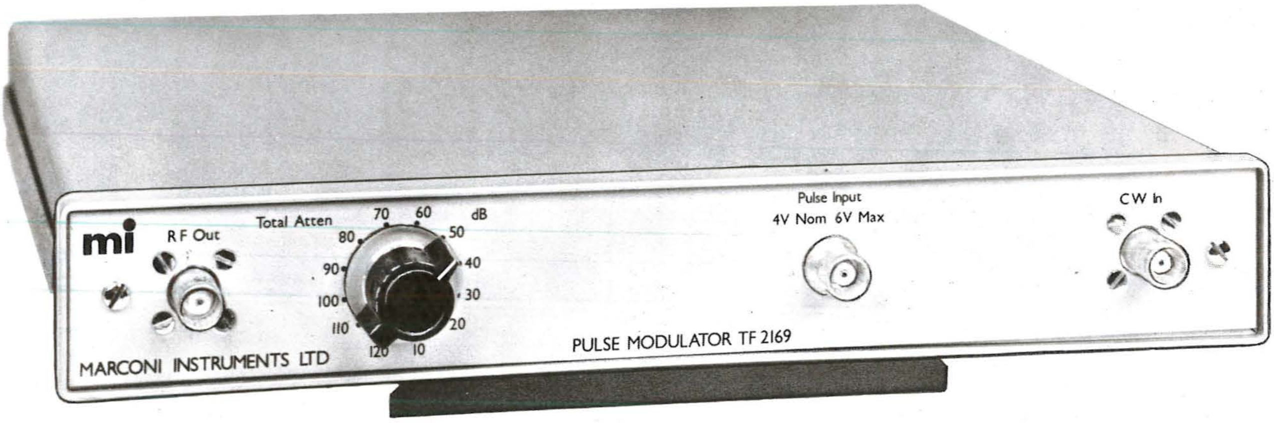
VERSIONS AND ACCESSORIES

When ordering please quote eight digit code numbers

Ordering numbers	
52173–900M	Versions Digital Synchronizer TF 2173. (Nato Cat. No. 6625–99–645–9552).
	Supplied Accessories Protective Front Panel Cover 41690–102S. RF Lead 43129–063F, 50 Ω, BNC to BNC. RF Lead 43129–190H, 50 Ω, TNC to TNC.
41690–044B 54127–231P	Optional Accessories Carrying Case. Rack Mounting Kit (for TF 2016 or TF 2173).

Pulse Modulator

- For use with AM/FM Signal Generators TF 2015 and TF 2016 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 has been designed for use with 10 to 520 MHz AM/FM Signal Generator TF 2015 to enable high quality pulsed r.f. signals to be generated. It may also be used with many other signal generators including TF 2016.

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 2015, 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 2016 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, or with RF Amplifier TF 2175 which has a bandwidth of 2 MHz to 500 MHz and a gain of 27 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	3·5V.
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.

SAFETY	Designed to meet the requirements of IEC 348.
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

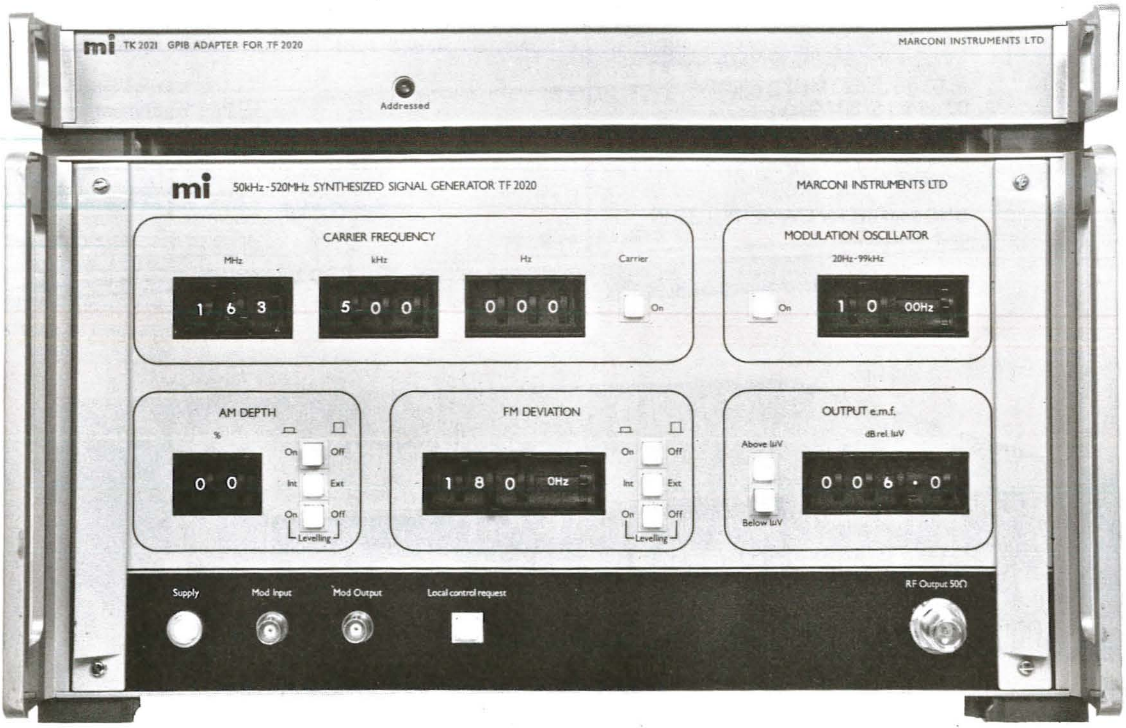
When ordering please quote eight digit code numbers

Ordering numbers	
52169–900J	**Versions** Pulse Modulator TF 2169. (NATO Cat. No. 6625–99–645–9235)
43129–106D 46883–214N 46883–220F	**Optional Accessories** Lead Assembly. To connect TF 2169 to TF 2015. Mounting Kit. To fit to TF 2015 for connection to TF 2169. Mounting Kit. To fit to TF 2169 for connection to TF 2015.
	Associated Equipment 10 to 520 MHz AM/FM Signal Generator TF 2015. RF Amplifier TF 2167. 50 kHz to 80 MHz bandwidth. RF Amplifier TF 2175. 2 MHz to 500 MHz bandwidth.

50 kHz to 520 MHz Synthesized Signal Generator

and GPIB Adapter TK 2021

- ☐ Wide carrier frequency range: 50 kHz to 520 MHz
- ☐ Low sideband phase noise
- ☐ Accurate output level: ± 1 dB overall
- ☐ AM depth: 0 to 99% in 1% steps
- ☐ FM deviation: 0 to 299 kHz in three ranges
- ☐ High r.f. output: 4 V e.m.f. for c.w. and f.m.
- ☐ Wide range modulation oscillator: 20 Hz to 99 kHz
- ☐ Fully programmable by parallel b.c.d. code commands
- ☐ GPIB* Interface



TF 2020 with the optional GPIB Adapter TK 2021

TF 2020 is a new synthesized signal generator providing comprehensive c.w., a.m. and f.m. outputs over the wide frequency range of 50 kHz to 520 MHz. All the operating functions, including carrier frequency, output level and modulation, can be controlled either manually at the front panel or remotely by application of programmable parallel b.c.d. commands. Alternatively with the addition of the GPIB Adapter, TK 2021, the synthesized signal generator may be controlled over the General Purpose Instrument Bus. The generator is thus equally suitable for manually operated bench use or for inclusion in a fully automated test system.

Outstanding features of the generator are its high r.f. output level (4 volts e.m.f. from 50 Ω for c.w. and f.m. signals), accurate output level setting switchable in 0·1 dB steps, and excellent noise performance.

TF 2020 has many applications in receiver production, ranging from LF and MF types right through to VHF and UHF mobiles. As a high quality signal source it will be invaluable in development laboratories, and its programmability makes it a flexible production tool, either as part of a full ATE system or with simpler programming to set up a number of regularly-used frequencies, modulation settings and output levels.

** GPIB – Marconi Instruments General Purpose Instrument Bus is in accordance with IEEE Standard 488-1975 and IEC document 66 (Central Office) 22*

b

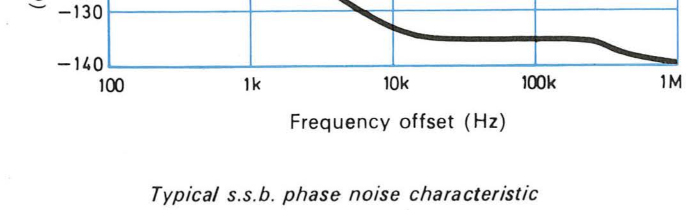
Carrier frequency

The carrier frequency can be set in 1 Hz increments over the range 50 kHz to 520 MHz, either by means of lever decade switches or remotely in the programmable mode. A valuable feature in this mode is the rapid settling time after switching frequency – less than 10 ms to settle to within 500 Hz of the final frequency (50 ms to settle to within 1 Hz). If a frequency is selected above the operating range of the instrument the carrier output is automatically inhibited and the illumination of the carrier on/off switch is extinguished.

Carrier signals are derived by synthesis from an internal 10 MHz voltage controlled oscillator which is phase locked to a 1 MHz signal obtained from a 5 MHz reference standard. This gives the instrument a frequency stability, after 24 hours operation, of better than ± 1 in 10^8 per day. The 10MHz oscillator can, alternatively, be locked to an external standard frequency applied to the instrument via a rear panel connector. This standard frequency may be any sub-multiple of 10 MHz down to 1 MHz, at a minimum level of 100 mV.

The internal 10 MHz standard can be adjusted against an external primary standard by means of a rear-panel ten-turn control with logging scale.

A feature of the instrument is its excellent sideband noise making it very suitable for use as the off-channel signal generator in two-generator selectivity measurements. At 20 kHz offset frequency the sideband noise is at least 130 dB/Hz below the carrier level.



Typical s.s.b. phase noise characteristic

RF output

The output level is selected by an attenuator settable in 0·1 dB steps. For a.m. signals the output level range is from 0·2 µV to 2 volt e.m.f. from 50 Ω (−13·9 to +126·0 dBµV) and for f.m. and c.w. signals the upper limit is extended to 4 volts e.m.f. (+132·0 dBµV). Readout of level is directly in dB relative to 1 µV e.m.f. Automatic level control is incorporated and the total level accuracy is ±1dB for outputs above 2 µV e.m.f.

Despite the high output level of the instrument, leakage has been kept to a minimum, allowing the generator to be used at the minimum output of 0·2 µV e.m.f (−13·9 dBµV) without ambiguity. Non-harmonically related signals are very low, at least 90 dB below the carrier level for frequencies above 120 MHz.

Modulation

TF 2020 provides high quality frequency modulation and amplitude modulation either from an internal oscillator or from an external modulating signal applied via the front panel MOD INPUT socket. Frequency and amplitude modulation functions are completely independent allowing simultaneous f.m. and a.m.

The internal modulation oscillator operates from 20 Hz to 99 kHz in four ranges, and its output is available at a front panel socket, providing a low-distortion signal for audio frequency tests (better than 0·1% distortion from 100 Hz to 99 kHz).

Frequency modulation is available over the modulating frequency range of 50 Hz to 99 kHz. Peak deviation can be set digitally in three ranges of 0 to 2.99 kHz, 0 to 29·9 kHz and 0 to 299 kHz. In-band noise is very low permitting low modulation settings to be used without ambiguity.

Amplitude modulation is available over the modulating frequency range of 20 Hz to 20 kHz. Modulation depth can be set digitally in 1% steps from 0 to 99%.

Controls

All operating functions of the generator are controlled internally by MOS logic designed to be driven by open-collector logic or contact closures. The required connections can be made either manually by front-panel switches or remotely from a control unit or computer.

On manual control, selected by the LOCAL CONTROL DEMAND push-button, selection of all functions is by push-buttons which are illuminated in the 'on' condition. Carrier frequency, modulation frequency, f.m. deviation, a.m. depth and r.f. output levels are all set by means of front-panel lever switches with digital readout on the switches. If the operator attempts to use the instrument above its maximum frequency range or outside its specified r.f. output level range, the output is automatically inhibited and the appropriate function push-button lamp is extinguished to warn the operator.

On remote control all functions and settings are selected by rear panel application of parallel b.c.d. commands by open collector t.t.l. logic or by switch closures. A manual lock-out line is included so that with the lock-out connection made all control is via the remote input, overriding the setting of the LOCAL CONTROL DEMAND button. When the instrument is operating under remote control all the panel push-buttons are unlit.

TK 2021 is connected to the TF 2020 using a multi-way cable. The power requirements are fed from the TF 2020 over this link thus avoiding the need for any further leads. Programming has been made very simple using single alphabetical characters for the appropriate commands. Here is an example of a typical set of instructions.

Set carrier frequency to 10.7 MHz

Modulation code; in this case FM internal no AM

Modulation oscillator frequency 1.3 kHz

```
F107ØØØØØ,L1234,M4,D3ØØØ,A13ØØ(CR-LF)
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Output level of 123.4 dB µVemf

FM deviation 3.Q kHz

Carriage return and line feed

These instructions should be quickly learnt by the operator. The TF 2020 with the TK 2021 may be incorporated easily into larger and more complex fully automated test systems, using GPIB compatible equipment.

Construction

Careful attention has been paid to the mechanical design of this generator. The high output level has necessitated the inclusion of a high degree of screening, which has been achieved without loss of access for servicing. For easy maintenance the r.f. units can be folded out.

Very efficient cooling is provided, with cold air being drawn in from the front panel, routed through the r.f. modules and expelled through the rear. This ensures adequate cooling even if the instrument is rack mounted, and also enables the filters to be readily changed from the front panel. A thermal cut-out is provided so that if the temperature rises above a safe level the power supply unit will be closed down.

TF 2020 has been designed to conform to IEC 348 safety regulations.

FREQUENCY	
Range	50 kHz to 519·999 999 MHz in 1 Hz increments. Manual selection of frequency by means of 9 lever switch decade controls.
Stability (Internal standard)	$\pm$1 in 10^7 per month ageing rate. $\pm$1 in 10^8 per day short term stability after 24 hours operation.
Stability (External standard)	The system may be locked to any submultiple of 10 MHz down to 1 MHz
Accuracy (Internal standard)	Adjustable by 10 turn control with logging scale on rear panel.
Switching time	After 10 ms the frequency is within 500 Hz of the final frequency, after 20 ms it is within 30 Hz and after 50 ms it is within 1 Hz.
Microphony	Less than 20 Hz peak deviation is caused by 0·5g acceleration in the range of 10 Hz to 100 Hz.
RF OUTPUT	
Level	Variable from 0·2 µV e.m.f. to 4 V e.m.f. (−13·9 to + 132·0 dBµV) in CW and FM modes. For AM the maximum output level is 2 V e.m.f. (+ 126·0 dBµV).
Attenuator	145·9 dB in 0·1 dB steps. Attenuation set by lever switch controls which indicate the r.f. output directly in dB relative to 1 µV e.m.f.
Total level accuracy (including ALC loop and attenuator)	$\pm$1 dB for levels above 2 µV e.m.f.
Impedance	50 Ω. VSWR better than 1·2 :1 for output levels below 116 dBµV.
Spurious r.f. radiation	With a receiver set to 0·5µV p.d. sensitivity and a 25 mm 2 turn loop feeding it, no signal can be detected at a distance greater than 25 mm from the generator. Allows the 0·2 uV minimum output level to be used without ambiguity.
FREQUENCY MODULATION	
Peak deviation	Up to 299 kHz deviation may be set digitally with a 3 digit lever switch and thumb wheel range switch.
Deviation ranges	0 to 2·99 kHz in 10 Hz steps. 0 to 29·9 kHz in 100 Hz steps. 0 to 299 kHz in 1 kHz steps. Maximum available deviation rises linearly from 50 kHz at a modulation rate of 50 Hz, to 299 kHz at 300 Hz, and falls linearly from 299 kHz at 33 kHz modulation rate to 100 kHz at 100 kHz modulation rate.
Deviation accuracy	$\pm$5% of setting at 1 kHz modulation frequency.

Demodulated distortion	Less than 2% total harmonic distortion at maximum deviation and less than 1% total harmonic distortion at 25 kHz deviation with 1 kHz modulation frequency (internal).
Response	Relative to the deviation at a 1 kHz modulation rate the variation over the modulation frequency range 50 Hz to 100 kHz is within ±10%.
External input	Levelling on: datum level automatically set with a modulation input signal between 0·8 V and 1·2 V. Levelling off: calibrated with 1·00 V p.d. r.m.s. sinewave input. *Input impedance:* 600 Ω.
AMPLITUDE MODULATION	
Modulation depth	0 to 99% in 1% steps set digitally with a two digit lever switch.
Accuracy	±5% modulation depth at 1 kHz up to 80% indicated modulation depth.
Envelope distortion (using the internal modulation oscillator)	With 30% depth and 1 kHz modulation frequency: less than 2% t.h.d. With 80% depth and 1 kHz modulation frequency: less than 2% t.h.d. at carrier frequencies below 200 MHz and less than 5% t.h.d. at 520 MHz.
Response	Relative to the modulation depth at 1 kHz the variation over the modulation frequency range 20 Hz to 20 kHz is within ±10%.
External input	Levelling on: datum level automatically set with a modulation input signal between 0·8 V and 1·2 V. Levelling off: calibrated with 1·00 V p.d. r.m.s. sinewave input at 1 kHz. *Input impedance:* 600 Ω.
INTERNAL MODULATION OSCILLATOR	
Frequency range	20 Hz to 99 kHz. Adjustable by 2 digital lever switches and thumb wheel range switch. Four ranges: 20 Hz to 99 Hz in 1 Hz steps. 20 Hz to 990 Hz in 10 Hz steps. 100 Hz to 9900 Hz in 100 Hz steps. 1 kHz to 99 kHz in 1 kHz steps.
Frequency accuracy	±5% of setting
Distortion	Less than 0·1% t.h.d. from 100 Hz to 99 kHz. Less than 0·3% t.h.d. from 20 Hz to 100 Hz.
SPURIOUS SIGNALS	
Carrier harmonics	At least 30 dB below fundamental up to output level of +126 dB μV e.m.f. and 27 dB up to +132 dB μV e.m.f.
Non-harmonically related coherent components	All signals at least 90 dB below carrier level for carrier frequencies above 120 MHz; at least 80 dB below carrier level for carrier frequencies below 120 MHz.
Single sideband phase noise	At least 130 dB/Hz below carrier level at 20 kHz offset.
FM on CW	With a post detection 3 dB bandwidth of 30 Hz to 15 kHz the equivalent deviation is less than 2 Hz.
AM on CW	At least 75 dB below carrier level when measured in a 30 Hz to 15 kHz (−3 dB) post detection bandwidth (equivalent to less than 0·04% AM).
AM on FM	Less than 2% modulation depth at maximum deviation. Less than 1% modulation depth at 25 kHz deviation.
PhM on AM	Less than 50 Hz equivalent deviation at 30% modulation depth at 1 kHz modulation frequency (equivalent to less than 0·05 radians).
AUXILIARY FACILITIES	
Remote operation	Carrier frequency RF output level Carrier ON/OFF FM deviation FM ON/OFF Amplitude modulation depth AM ON/OFF Modulation oscillator frequency Modulation oscillator ON/OFF Internal/External modulation AM ALC ON/OFF FM ALC ON/OFF LLO (local lock out) The remote facilities can be programmed using open collector logic or switch closures. The frequency, output level, f.m. deviation, a.m. depth and modulation oscillator frequency are programmed by universal b.c.d. logic. A logic '0' state is established by connecting a line to ground via 400 Ω at 2·4 mA except for the LLO line which is set to logic '0' by connecting 200 Ω to ground at 2·4 mA.
Outputs	1 MHz internal standard signal available on rear panel at a level of 1·5 V p-p e.m.f. *Source impedance:* 250 Ω. Internal modulation oscillator signal available on front panel at a level of 1 V e.m.f. ± 20% from 600 Ω source.
Inputs	An external standard signal may be fed into the generator at any submultiple of 10 MHz down to a minimum frequency of 1 MHz at a level of 100 mV r.m.s. into 50 Ω. Maximum input signal 1·5 V r.m.s.

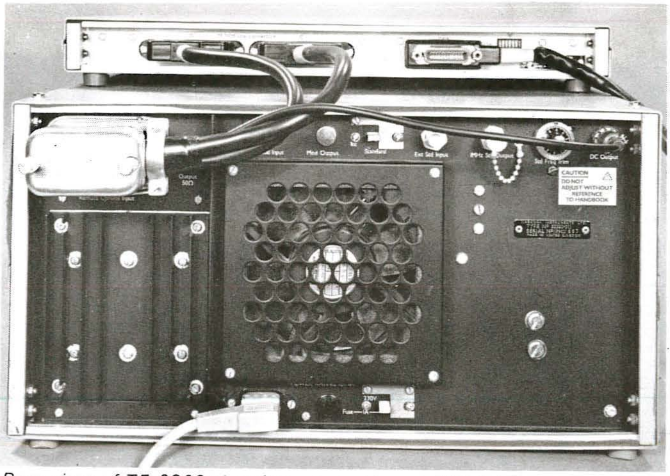
	External modulation signal between 0·8 V and 1·2 V across 600 Ω will automatically be set to the required datum level. 1·00 V r.m.s. sinewave input is required to achieve calibrated modulation with the levelling switched off.
SAFETY	Designed to meet the requirements of IEC 348.
LIMIT RANGE OF OPERATION	
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 25 kN/m² differential, i.e. 3.7 lbf/in²).
POWER REQUIREMENTS	
AC supply	95 V to 130 V or 190 V to 264 V, 45 to 65 Hz. 180 VA approx.

DIMENSIONS AND WEIGHT	Height	Width	Depth	Weight
	234 mm	450 mm	610 mm	36 kg
	9·2 in	17·7 in	24 in	80 lb

VERSIONS AND ACCESSORIES

When ordering please quote eight-digit code numbers.

Ordering numbers	
52020–301S	**Versions** 50 kHz to 520 MHz Synthesized Signal Generator TF 2020.
	Supplied Accessories RF Connecting Cable 43125-019F (TM 4824/1), 50 Ω, 1370 mm (54 in.) Type N.
54712–031V	**Optional Accessories** Socket and Pin Kit (104-way Free Socket and set of pins) To mate with REMOTE CONTROL INPUT Plug.
23443–804G	Adapter, Type N Male to BNC Female.
43126–012S	RF Connecting Cable TM 4969/3, 50 Ω, 1524 mm (5ft) BNC.
44411–019G	Matching Pad TM 5573/3, 50 to 75Ω BNC.
43281–001W	RF Fuse Unit TM 5753, 0·4 W, Type N. Complete with 10 spare fuses.
44425–501E	20 dB Pad TM 5573. BNC
54431–021B	20 dB, 20 W Attenuator, 50 Ω.
46883–315Y	Rack Mounting Kit.
54711–031Z	Maintenance Kit, containing trimming tools, extender boards, extender leads and mechanical supports.
23435–007H	7-pin Free Plug. To mate with DC output socket.
H 52020–301S	Service Manual Vol. 2.



Rear view of TF 2020 showing connection of GP1B Adapter

GPIB ADAPTER (TK 2021)

	GPIB to b.c.d. adapter in accordance with IEEE standard 488-1975 and IEC document 66 (Central Office) 22.
SAFETY	Designed to meet the requirements of IEC 348.
POWER REQUIREMENTS	+7.5 V, 250 mA available from rear-panel socket on TF 2020. Connection lead supplied.
LISTEN ONLY	For ease of control in simple jigs, a listen only toggle is supplied on the rear panel.

DIMENSIONS AND WEIGHT	Height	Width	Depth	Weight
	65 mm	428 mm	450 mm	4.5 kg
	2.6 in	16.9 in	17.7 in	9.9 lb

VERSIONS AND ACCESSORIES

When ordering please quote eight-digit code numbers.

Ordering Numbers	
52021–900F	**Versions** GPIB Adapter, TK 2021
	Supplied Accessories Cable Connector TF 2020 to TK 2021 (43129-285B)
43129–189U	**Optional Accessories** GPIB lead for external connections
54127–261D	Rack Mounting Kit

Mobile Radio Test Set TF 2950 series

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

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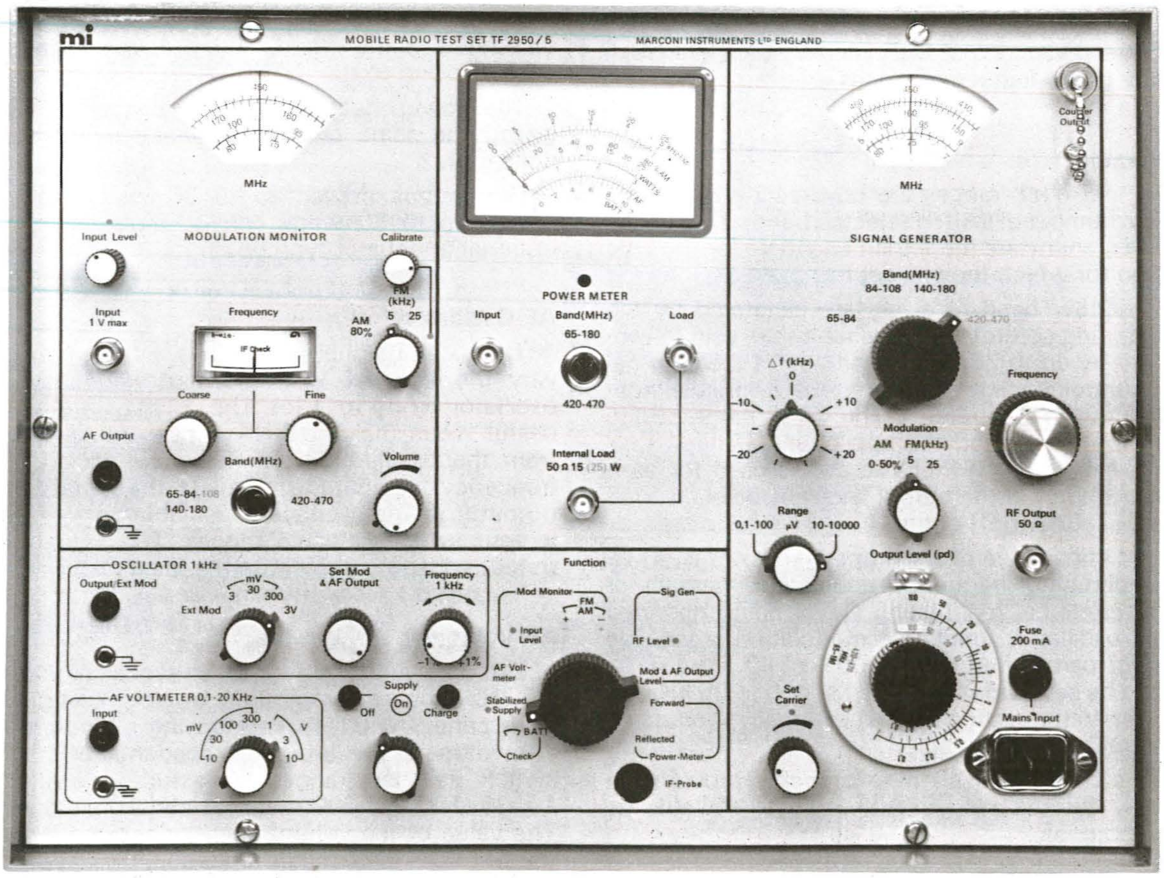

14061/2 TF 2950/5

The TF 2950 is almost certainly the most useful and versatile mobile radio test set that has so far appeared. One of the most important features is that it combines in one unit, many instruments needed to service the type of equipment used in this field. Another advantage is its portability. It is 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 sockets 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 output impedance of the signal generator is 50 Ω. It 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. F M 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%. F M 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 F M + to F M −.

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 to 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 – ON, OFF 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.

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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 ±30%, ±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, 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 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. *Accuracy:* ±5% f.s. for sinusoidal signals. *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. *Sensitivity:* 50 mV (maximum input voltage 1 V). *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	0 to 25 W through line using internal RF 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.

SAFETY

This instrument complies with the requirements of IEC 348.

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

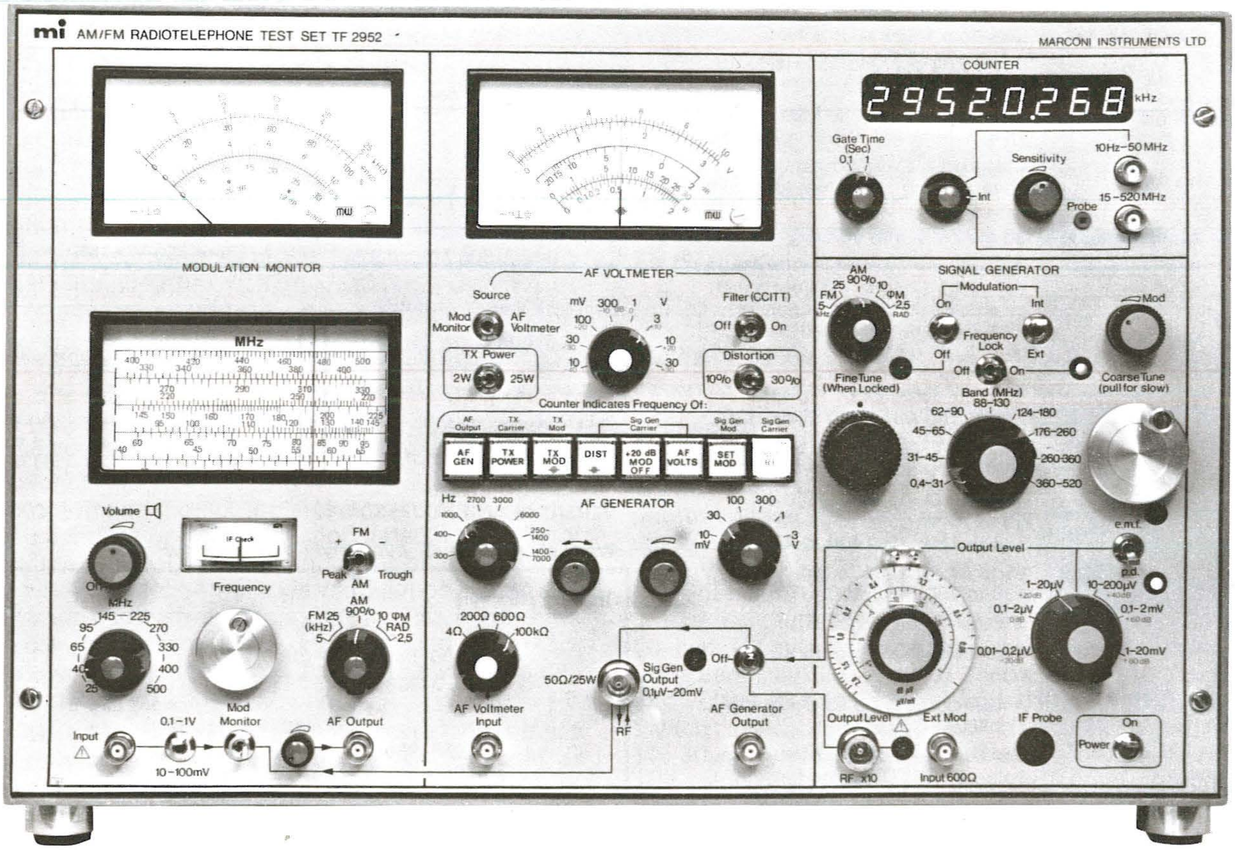
When ordering, please quote eight-digit code numbers.

Ordering Numbers	
	Versions
52950–905Z	TF 2950/5
52950–908U	TF 2950/8 The following versions may be available to special order.
52950–906H	TF 2950/6
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.
	Optional Accessories
6536/1	Coaxial Attenuator. Increases power measurement capability to 30 W continuous, 50 W short-term. Obtainable from Marconi Instruments, Sanders Division.
54451–061Y	IF Probe, 470 kHz.
54451–071S	IF Probe, 10·7 MHz.
54451–121B	IF Probe, 455 kHz. For details see page 46

Made in West Germany

AM/FM Radiotelephone Test Set

- ☐ Test set for transceivers in v.h.f. and u.h.f. bands
- ☐ AM/FM Signal Generator: 400 kHz to 520 MHz
- ☐ Built-in synchronizer for high stability
- ☐ Frequency Counter: 10 Hz to 520 MHz
- ☐ AM/FM Modulation Monitor
- ☐ AF Generator: 250 Hz to 7 kHz
- ☐ AF Voltmeter: 0 to 30 V
- ☐ Distortion Factor Meter: 10% and 30%
- ☐ RF Power Meter: 2 W and 25 W



14443/2

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.

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.

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: $\pm5\times10^{-7}$ per 30 min above 31 MHz. $\pm5\times10^{-6}$ ±500 Hz per 30 min below 31MHz. After 2 hours operation at constant ambient temperature with the synchronizer switched off: $\pm5\times10^{-5}$ per 5 min above 31 MHz. $\pm5\times10^{-5}$ ±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	µV and mV e.m.f. or p.d., switch selected.
Accuracy (above 1 µV p.d.)	±2·5 dB total level accuracy at normal output socket.
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	Using internal routeing the counter will function correctly for input powers to the central socket between 0·2 and 25 W. Using the 10 Hz to 50 MHz input the sensitivity can be varied from 20 mV to 25 V with a front panel control. Using the 15 to 520 MHz input the counter will give correct readings for signal levels in the range 20 mV to 2 V.
Impedance	10 Hz to 520 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 segments 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 50 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.

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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 ±15% around 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 1·4 kHz and 1·4 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%.
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 200 Ω impedance: 10 V 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	1000 Hz.
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	±3% of f.s.d.
Signal-to-noise ratio	Measured using a CCITT telephone noise weighting network relative to 3 kHz deviation: Better than 50 dB for carrier frequencies up to 190 MHz and better than 45 dB for carrier frequencies up to 500 MHz. Measured in a flat bandwidth of 250 to 7000 Hz and relative to 3 kHz deviation the ratio is: 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	±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 to 7000 Hz 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.
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. 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	0 to 2 V nominal 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. VSWR less than 1·15:1.
Maximum input	25 W continuous rating.

GENERAL

SAFETY	Complies with the requirements of IEC 348.

POWER REQUIREMENTS				
AC supply	220 V and 110 V nominal; 45 to 60 Hz, 65 W.			
DIMENSIONS AND WEIGHT	Height	Width	Depth	Weight
	315 mm	490 mm	280 mm	25 kg
	12·4 in	19·3 in	11 in	55 lb

VERSIONS AND ACCESSORIES

When ordering please quote eight-digit code numbers

Ordering numbers	
52952–900P	Versions AM/FM Radiotelephone Test Set TF 2952.
54451–061Y 54451–071S 54451–121B	Optional Accessories IF Probe, 470 kHz. IF Probe, 10·7 MHz. IF Probe, 455 kHz.

Made in West Germany

IF Probes 54451 series

- ☐ Crystal-controlled oscillators simplify tuning to receivers
- ☐ Range covers commonly-used intermediate frequencies

These three IF Probes consist of crystal-controlled oscillators available at the most commonly used intermediate frequencies and they are powered from a 20·7 V supply outlet on the front panel of TF 2952 via a lead attached to the probe.

The probes make it easy to tune 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 2952.		
POWER REQUIREMENTS			
DC supply	+19 V to +24 V, 2 mA. Obtained from socket on TF 2952 via cable attached to probe.		
DIMENSIONS	Length	Diameter	Lead Length
	45 mm	27 mm	1067 mm
	1·75 in	1·06 in	42 in

OSCILLATORS

AF Signal Source (20 Hz to 20 kHz)	TF 2000	48
Two-Tone Signal Source (20 Hz to 20 kHz)	TF 2005R	49
AF Oscillator (3 Hz to 30 kHz)	TF 2102M	51
Wide Range Oscillator (10 Hz to 1 MHz)	TF 2103	52
Mains Power Unit (for use with TF 2103)	TM 9808	53
Waveform Generator	TF 2120	54

For further Oscillators see the Microwave Products Section:

Gunn Diode Oscillator type 6061A	270
YIG-tuned Gunn Oscillator type 6100 series	271

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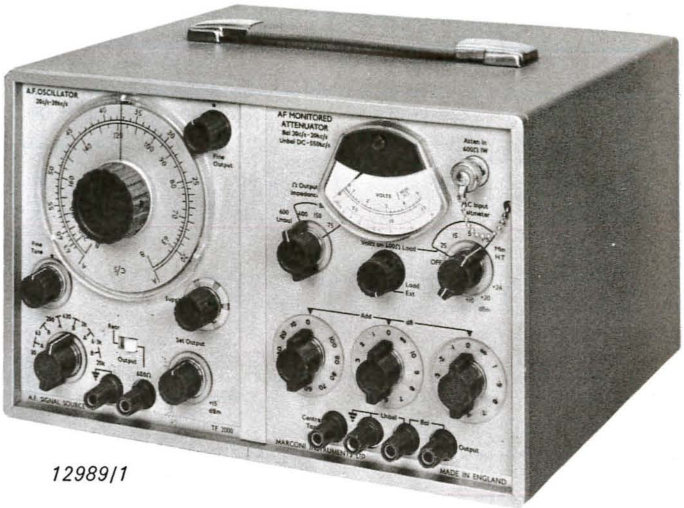
TF 2000 AF Signal Source

- 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.



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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.
SAFETY		Designed to meet the requirements of IEC 348.
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

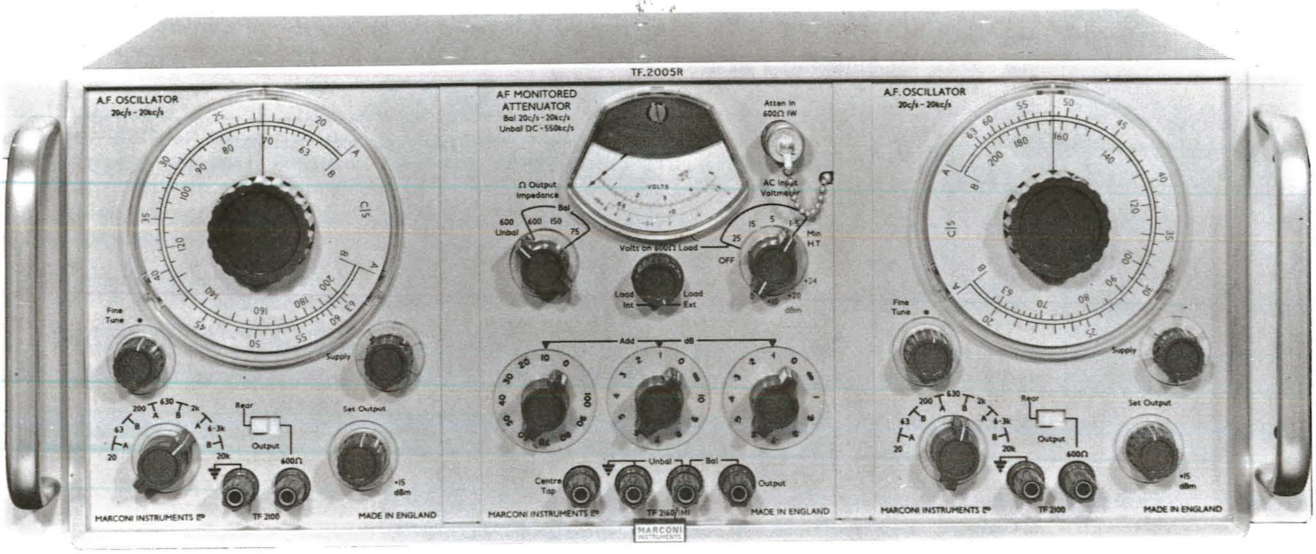
VERSIONS AND ACCESSORIES

When ordering please quote eight digit code numbers

Ordering numbers	
52000–900R	**Versions** AF Signal Source TF 2000.
	Supplied Accessories Shielded Adaptor TB 39868 (43168–008S). Coaxial Free Plug, type BNC.
41635–041P	**Optional Accessories** Rack Mounting Case TM 7010.

Two-Tone Signal Source TF 2005R

- ☐ 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. *Accuracy:* ±1% ±0·2 Hz, including warm-up.
OUTPUT	*Into 600 Ω*: +15 dBm or 31·6 mW or 4·46 volts. *Open circuit:* at least 8·5 volts. *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. 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. ±2% of dB setting, ±0·2 dB at 550 kHz. *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 TF 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. *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. 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.
SAFETY	Designed to meet the requirements of IEC 348.
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 V to 260 V, 500 Hz to 1000 Hz. 14 VA.
DC supply	65 V to 90 V; load 60 mA.
DIMENSIONS AND WEIGHT	Height 200 mm $7\frac{3}{4}$ in; Width 475 mm $18\frac{3}{4}$ in; Depth 270 mm $10\frac{1}{2}$ in; Weight 16·5 kg 36·3 lb

VERSIONS AND ACCESSORIES

When ordering please quote eight-digit code numbers.

Ordering Numbers	
52005–301D	Versions TF 2005R. The basic instrument in rack mounting form.
	Supplied Accessories Signal Lead, TM 6958 (43125–028T) for coupling the Oscillators to the Attenuator. (Two supplied). HT Lead, TM 7053 (43125–029P).

AF Oscillator TF 2102M

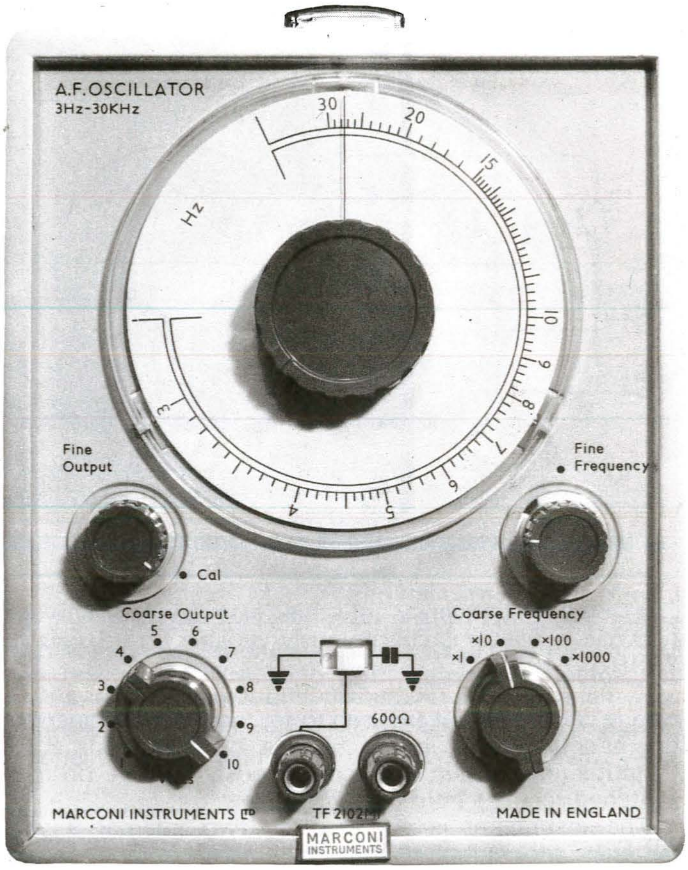
- ☐ 3 Hz to 30 kHz
- ☐ Complete freedom from amplitude bounce
- ☐ 10 V across 600 Ω

This all-solid-state oscillator, intended as a general purpose a.f. source, provides a moderately high output level over a range of frequencies extending well below the normal audio range. In addition to the usual applications as an a.f. test oscillator, therefore, the TF 2102M is suitable for use as a primary source in vibration equipment, and even for tests on servo systems.

An important feature of the instrument is its complete freedom from "amplitude bounce" when rapid frequency changes are made, or with frequency range switching. It is also particularly free from potentiometer noise effects as frequency is varied; and its low impedance circuitry gives a generally low figure for hum and noise.

It comprises an oscillator driving an output amplifier of the complementary symmetric class B type. This amplifier operates at fixed gain, heavily stabilised by negative feed-back, output level control being effected by means of a potential divider system between the oscillator and amplifier. The total output level variation of 0 to 10 volts across 600 Ω is achieved by a switched COARSE control, having ten 1 volt steps, and a continuously variable FINE control covering 1 volt.

The output amplifier has a constant, very low, source impedance, the instrument's 600 Ω output resistance being obtained by internal connection of a fixed series resistor. The general performance and distortion are, therefore, unaffected by the impedance of the external load; and the instrument can be used as a current source, operating directly into a short circuit if desired. By operation of a panel switch, the output circuit can be connected to or isolated from chassis.



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FREQUENCY	
Range	3 Hz to 30 kHz in four decade bands.
Calibration accuracy	2%.
Stability	Drift less than 0·05% (typically less than 0·02%) per 15 minutes after 15 minutes warm-up (assuming fairly constant ambient temperature).
OUTPUT	
Impedance	600 Ω ±5%, floating or unbalanced.
Level	0 to 10 V across 600 Ω (20 V e.m.f.) in approximately 1 V steps, with fine control giving continuous cover between steps with at least 5% overlap.
Stability	Level remains constant within ±1 dB over the full frequency range.
DISTORTION	
Harmonic content	Less than 1%.
Hum and noise	Less than −80 dB relative to full output.

POWER REQUIREMENTS AC supply	105 to 130 V or 210 to 260 V, 45 to 500 Hz, 5 VA.			
DIMENSIONS	Height	Width	Depth	Weight
	200 mm	150 mm	270 mm	3·8 kg
	$7\frac{3}{4}$ in	$5\frac{3}{4}$ in	$10\frac{1}{2}$ in	$8\frac{1}{2}$ lb

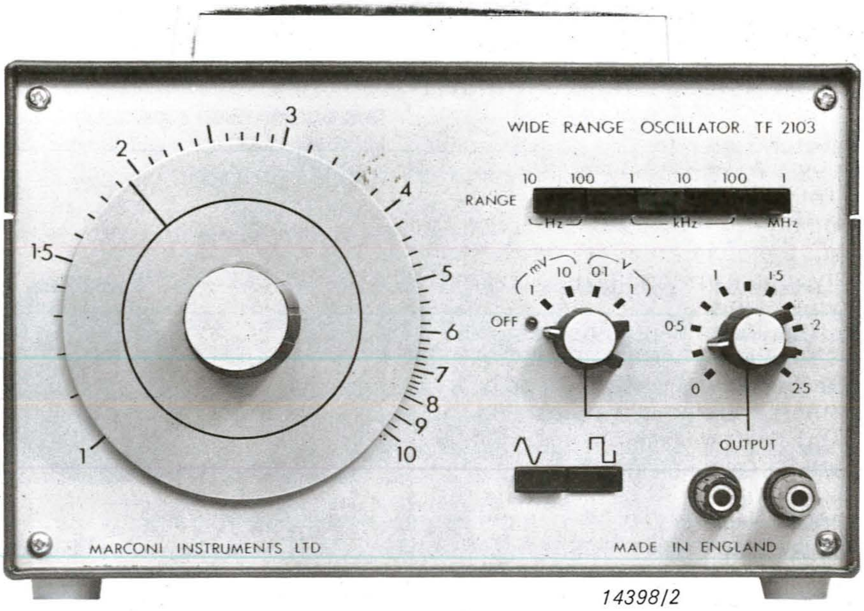
VERSIONS AND ACCESSORIES

When ordering please quote eight-digit code numbers

Ordering numbers	
	Versions
52102–025T	AF Oscillator TF 2102M.
	Optional Accessories
43168–008S	Shielded Adaptor TB 39868. Provides BNC socket output.
43125–069B	Coaxial Output Cable TM 4726/136. 75 Ω, BNC, 915 mm (36 in).

TF 2103 Wide Range Oscillator

- 10 Hz to 1 MHz
- Sinewave and squarewave
- Mains or battery operation



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The output frequency of this sinewave/squarewave portable oscillator is continuously variable from 10 Hz to 1 MHz.

A bank of five range-selecting push-buttons and a clearly calibrated dial are used to set the output frequency; the effective scale length for the band exceeds 3 ft. Output signal amplitude is continuously variable (in four switched ranges) from 0 to 2·5 volts.

The instrument is powered by two internal 9 volt batteries (not supplied with the instrument). If mains operation is preferred, the batteries may be replaced by a Mains Power Unit TM 9808 which is available as an optional extra.

The TF 2103 employs a transistor Wien-bridge variable frequency oscillator as signal source; this is followed by an inverter/amplifier when sinewave output is selected, but by a Schmitt trigger circuit when squarewave output is selected. The signals of selected waveform and frequency are applied to a complementary emitter follower output stage and thence pass via an attenuator to the output terminals. Amplitude stabilisation is provided by thermistor-controlled negative feedback.

FREQUENCY	
Range	10 Hz to 1 MHz. Continuously variable in 5 ranges: 10 Hz to 100 Hz; 100 Hz to 1 kHz; 1 kHz to 10 kHz; 10 kHz to 100 kHz; 100 kHz to 1 MHz. ***Calibration accuracy:*** ±3% of range full scale.
OUTPUT	
Waveform	Sinewave or squarewave. ***Squarewave rise-time:*** Less than 100 ns (typically 50 ns) between 10% and 90% amplitude points.
Sinewave distortion	Less than 2% for frequencies to 100 kHz. Typically 0·5% for frequencies 50 Hz to 10 kHz.
Output amplitude	0 to 2·5 V r.m.s. ±10% of full scale of each range. Continuously variable in 4 ranges: 0 to 2·5 mV; 0 to 25 mV; 0 to 0·25 V; 0 to 2·5 V.
Output impedance	600 Ω on 2·5 mV, 25 mV and 0·25 V ranges. Not greater than 600 Ω on 2·5 V range: typically 100 Ω at maximum output.
	Note: The attenuator is frequency compensated to feed a high impedance load. If excessive capacitance is connected across the output a fall off in high frequency response will result.
SAFETY	Designed to meet the requirements of IEC 348.
POWER REQUIREMENTS	Two series-connected 9 V batteries (not supplied with instrument): Vidor type VT9 or Ever Ready type PP9 or equivalent (Mains Power Unit TM 9808 optional extra). Minimum supply voltage: 12 V d.c. ***Consumption:*** 0·4 W (25 mA: 16V).
Temperature range	0° to +45° C.
DIMENSIONS AND WEIGHT	Height 120 mm, $4\frac{3}{4}$ in; Width 210 mm, $8\frac{1}{2}$ in; Depth 127 mm, 5 in; Weight 1·9 kg, 4·6 lb. Weight without batteries 1·1 kg (2·7 lb).
ORDERING NUMBER 52103–900V	Wide Range Oscillator TF 2103.

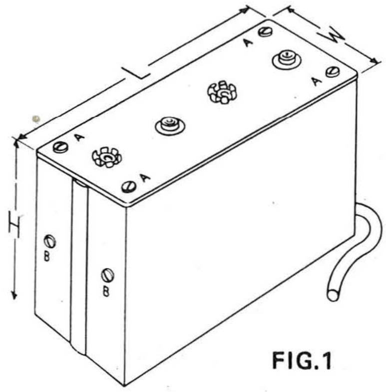
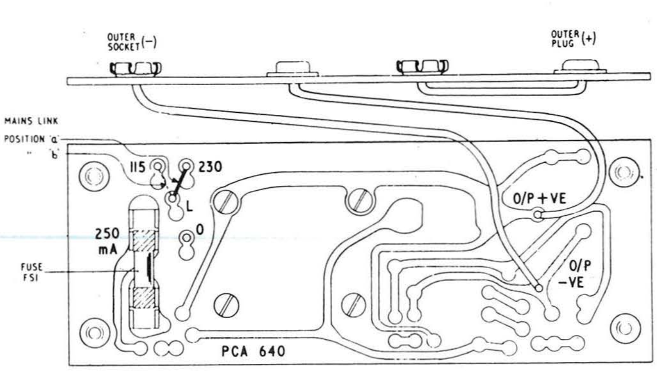
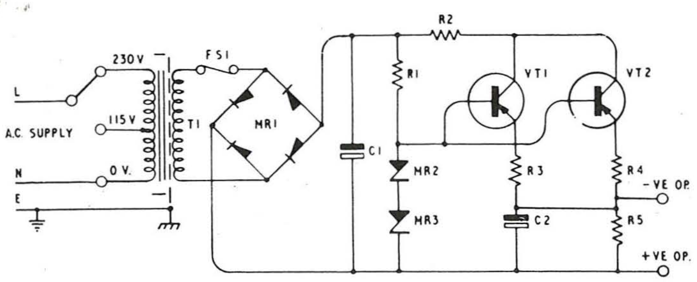


FIG.1



(TOP PLATE REMOVED)

FIG.2



TM9808 CIRCUIT DIAGRAM

FIG.3

This compact mains operated power unit is specially designed for use within Wide Range Oscillator type TF 2103. The need for two series-connected 9 volt batteries (type VT9 or equivalent) is eliminated when the TM 9808 is incorporated.

The circuit employs semi-conductor devices in a stabilizing configuration for which the reverse-breakdown voltages of two Zener diodes combine to serve as reference potential.

Voltage Setting Instructions

Unit type TM 9808 is normally supplied set for 200/250 volts mains operation. To change voltage setting for 100/125 volts operation proceed as below.

(i) Before connecting supply, remove the four screws referenced 'A' in Fig. 1 and raise top plate which is joined by two wires to the internal circuit.

(ii) The 'mains link' (Refer. Fig. 2) should be soldered in position 'b' for 100/125 volts operation (position 'a' for 200/250 volts operation).

(iii) When 'mains link' is appropriately positioned replace and secure top plate.

To install, fit the TM 9808 into the battery compartment of the oscillator and clip the battery connectors to the appropriate mating plugs and sockets on the top plate of the mains unit. Providing both battery connectors are clipped to the mains unit their positions are interchangeable; i.e. it makes no difference which battery connector mates with either plug-and-socket pair.

Maintenance

Note: Disconnect mains supply before removing top plate or wrap.

Fuse: A 250 mA fuse (FS1 in Fig. 3) is provided below the top plate (Refer. Fig. 2).

Removal of Wrap: Should it be necessary to gain access to the interior of the unit, withdraw the six screws referenced A and B in Fig. 1, raise and tilt top plate and lift off wrap via top of unit.

Do not remove screws from the base.

SPECIFICATION

Input	100/125 V or 200/250 V at 40/60 Hz.
Consumption	Approx. 5 W.
Output	15-17 V d.c. Max. current 50 mA.
Output impedance	Typically 10 Ω.

DIMENSIONS AND WEIGHT

Height	Width	Depth	Weight
76 mm	50 mm	128 mm	0·68 kg
3 in	2 in	$5\frac{1}{32}$ in	$1\frac{1}{2}$ lb

CONNECTIONS

(i) Input (mains cable):

Brown core:	mains live
Blue core:	mains neutral
Green and Yellow core:	earth

(ii) Output:

Inner plug:	Positive
Outer socket:	Negative
Outer plug: / Inner socket:	Connected together

Refer to Fig. 2.

CONNECTORS

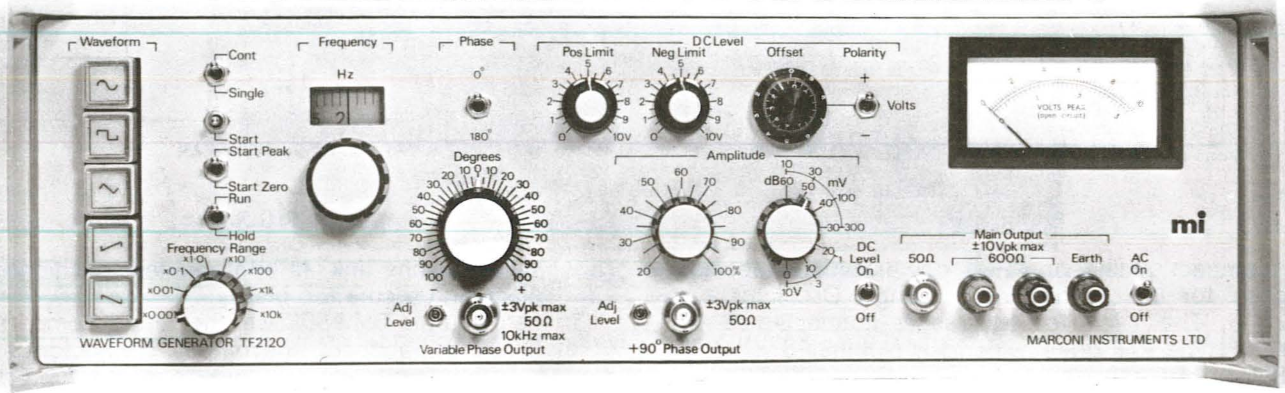
The TM 9808 is designed to unite with two connector strips as used for Vidor batteries type VT9 (or equivalent).

ORDERING NUMBER

44990-118X Mains Power Unit TM 9808

Waveform Generator

- Sine, square, triangular, and ramp output waveforms
- Frequency range: 0·0008 Hz to 100 kHz
- Variable phase and quadrature subsidiary outputs



12330/1

Waveform Generator TF 2120 delivers at its main output terminal any one of five voltage waveforms – sine, square, triangular, positive-going ramp, or negative-going ramp – selection being made by simply depressing the appropriate graphically-labelled push button. Frequency is continuously variable from less than 1 mHz to 100 kHz, and the main output amplitude can be set to any peak-to-peak voltage between 4 mV and 20 volts.

Two subsidiary outputs are also available in the form of phase shifted facsimiles of the main output waveform. One of these is fixed in leading quadrature with the main output, and the other is continuously variable in phase from −100° to +100° with respect to the main output waveform. By operation of a toggle switch the phase of this variable-phase output can be shifted by 180°, giving complete cover over the full 360°. The amplitude of each of these subsidiary outputs is normally preset to 6 volts p-p, the associated control being accessible through the front panel.

A further nine sockets at the rear of the instrument provide continuous output of the sine, square and triangular waveforms in all three phase conditions, irrespective of the waveform selected by the push-button switch. The amplitude of the outputs from these sockets is fixed at 6 volts p-p.

Generating System

The sine, square and ramp waveforms are synthesized from a basic triangular waveform drawn from an integrating-type master generator. This generator also feeds two slave generators, one producing an identical triangular waveform but with exactly 90° phase lead, and the other also delivering an identical waveform but with variable phase.

The output from each of the three generators is passed through a set of shaping circuits to produce the sine, square and ramp waveforms.

Frequency Control

The instrument is continuously tunable over its range in 8 switch-selected tuning bands, the action of the band change switch being that of connecting the appropriate value integrating capacitor. Tuning within the band is effected by variation of the d.c. voltage applied to the integrating circuit; and, for normal manual tuning, this voltage is derived from a precision potentiometer driven via a reduction gear from the main FREQUENCY control. The tuning frequency is indicated on a directly calibrated drum-type dial.

Provision is also made for injection of a d.c. frequency-control voltage derived from an external source. This feature is useful where remote analogue programming is required, but its more important application is that of frequency sweep.

Manual tuning remains operative when an external frequency-control voltage is used, the dial indication corresponding to the frequency for zero input voltage. Either of two linear voltage-tuning laws can be selected by operation of a toggle switch. With the switch set to LAW A the frequency varies by a fixed increment for every volt applied, with a nominal sensitivity of 1 Hz/volt × the range multiplier indicated, regardless of the setting of the manual control. With the switch set to LAW B the frequency varies by 10% of the tuning dial reading for every volt applied. For either law the frequency/input-voltage slope is positive; i.e., the frequency increases for a positive-going change in voltage and decreases for a negative-going change.

The instrument also delivers from a separate socket a d.c. output voltage which is proportional to frequency at 0·2 volts/Hz ÷ the range multiplier. This proportion remains valid for manual or remote tuning, so that the voltage can be utilised in X-Y displays where the X axis represents frequency in absolute terms.

Gated Operation

The TF 2120 can be switched to deliver single cycles of any selected waveform, each cycle being initiated either by operation of a spring biased START switch or by feeding an external trigger pulse to a rear panel socket.

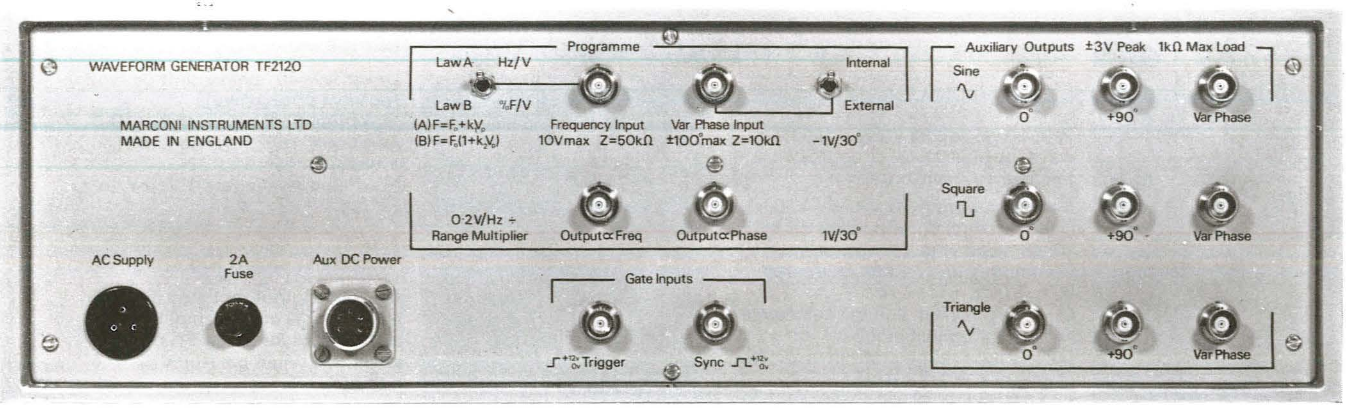
Variable Phase Control

Phase control of the variable phase output is effected manually by means of a directly calibrated control, giving continuous adjustment from 100° lag to 100° lead with respect to the main output. A toggle switch, which inverts the driving triangular wave, gives a further 180° phase shift.

Continuously variable phase shift can also be effected by injection of an analogue programming voltage to a socket at the rear of the instrument. This external facility covers the same range as the internal manual control, the law being linear at 30° per volt. The instrument also delivers a d.c. voltage output which is linearly proportional to phase shift at 1 volt per 30° in both the manual and the external control mode.

Main Output Voltage Control

The main output waveform is fed to the panel outlets via a switched attenuator covering 60 dB in 10 dB steps. Two outlets are provided, giving respectively source impedances of 50 Ω (via a BNC socket) and 600 Ω (via a pair of terminals). The input voltage to the attenuator is variable and monitored by a meter calibrated in peak voltage.



Rear view of TF 2120 showing auxiliary output sockets, etc. *12330/2*

Alternatively, with the instrument switched to its single cycle mode, the waveform can also be gated "on" for any given duration – ranging from a fraction of a cycle to a period of continuous running – by application of a rectangular gating pulse to the appropriate socket on the rear panel. The output waveform is started by the positive-going edge of the pulse and stopped by the negative-going edge.

With both of these gating methods the waveform can be started either at its positive peak or at the zero crossing of the cycle, selection being made by operation of the START PEAK/START ZERO toggle switch.

The instrument also provides a manually operated facility for stopping the waveform at any point on the cycle. This is effected by means of the RUN/HOLD switch. When the switch is set to HOLD the output voltage is immediately arrested and the instrument delivers a d.c. output at the voltage reached. When the switch is reset to RUN the waveform continues from the point at which it was stopped. This facility can be used in the single-cycle mode and in the normal continuous-waveform mode.

The output waveforms are normally symmetrical about zero voltage. Provision is made, however, for superimposing on the main output waveform a positive or negative d.c. offset, which is accurately adjustable from 0 to 10 volts by means of a directly calibrated 10-turn control. An associated on/off switch permits introduction or removal of the offset without disturbing the setting of the variable control.

Provision is also made for limiting (clipping) the positive and negative excursions of waveform at any voltage from 0 to 10 volts relative to zero.

Both the offset and the limiting are applied prior to the final attenuator, so that their voltages are reduced proportionately when attenuation is introduced.

Power Supply

The Waveform Generator is suitable for operation from standard mains supplies in the 115 volt range and the 230 volt range. In addition to providing the operating power for the internal circuits, the instrument's power unit delivers stabilised d.c. outputs at ±18 volts and ±12 volts at an auxiliary power output socket at the rear of the instrument.

FREQUENCY

Range	0·0008 Hz to 100 kHz in 8 switched decade ranges.
Accuracy	±1 division on 254 mm (10 in) scale length between 0·0008 Hz and 10 kHz. ±2 divisions from 10 kHz to 100 kHz.
Stability	±0·01% per degree Centigrade. ±0·1% in eight hours.
Remote frequency sweep	Two linear laws are available for remote control or frequency sweep. Law A: $f = f_0 + k_1$ Vp. Law B: $f = f_0 + k_2$ Vp. Where f_0 is the frequency with no programming input. Vp is the programming voltage in volts. $k_1 = 1$ Hz/volt. $k_2 = 0{\cdot}1$ f_0/volt. Maximum sweep rate 100 mV/μs.
DC output and frequency	0·2 volt/Hz ×range multiplier. (Full scale on frequency dial corresponds to 2 V output).
Sweep range	More than 2 decades (100 to 1). Maximum frequency 100 kHz (10 kHz on VARIABLE PHASE OUTPUT).

MAIN OUTPUT

Function	Sine wave, square wave, triangle wave, positive ramp or negative ramp selected by push-button.
Amplitude	Maximum output 20 V p-p (±10 V). Fixed attenuation of 0 to 60 dB in 10 dB steps with 2% accuracy. Continuous fine control calibrated 20 to 100% ±5% f.s.d. Open circuit peak voltage is indicated on the front panel meter. Total output range more than 70 dB (4 mV p-p to 20 V p-p).
Impedance	50 Ω or 600 Ω.
Protection	Short circuit proof.
Stability	±0·025% per °C. ±0·10% per kHz (triangle only).
Distortion and linearity	*Sine wave:* Departure from true waveform less than 1% at any point. Less than 2% harmonic distortion (typically 0·50%, 0·001 Hz to 1 kHz). *Square wave:* Symmetry ±1%. Overshoot 5% of p-p amplitude. Rise time typically 150 ns, maximum 250 ns. Fall time typically 150 ns, maximum 250 ns. *Triangle:* Linearity ±0·5%. Perturbations not greater than 5% of peak amplitude within 200 ns of crests. *Ramps:* Linearity and perturbations as for triangle. Fly back time typically 150 ns, maximum 250 ns.
DC output	Positive or negative 10 V maximum. Offset may be switched in and set by a 10 turn potentiometer. Maximum excursion of output (signal+offset) ±10 V. Accuracy of setting ±1% of setting ±30 mV.

Limiting	All functions may be clipped at any positive and negative voltage from 0 to 10 V, by adjustment of independent calibrated controls. The main attenuator follows the limiting and offset circuits, so that their voltages are attenuated in the same ratio as the signal.

VARIABLE PHASE OUTPUT (10kHz max)

	Continuously adjustable from −100° to +100° with linear scale. Switched 180° gives 380° total control.
Function	Sine wave, square wave, triangle wave, positive ramp or negative ramp as selected by push-button.
Dial accuracy	±1°.
Amplitude	Maximum output 6 V p-p (±3 V). Preset amplitude adjustment on front panel.
Impedance	50 Ω.
Protection	Short circuit proof.
Stability	±0·1% per °C. ±0·1% per kHz (triangle only).
Remote phase sweep	Linear law 30° phase shift per volt. (positive or negative). Maximum total phase shift ±100°. Additional 180° inversion also available. Maximum sweep rate 100 mV/μs (3°/μs).
DC output phase	1 V/30°. Total phase shift ±100°.
Distortion	As Main Output, but step deviation less than 1% of p-p-amplitude and perturbation less than 5% of p-p amplitude when measured at ±45 degrees.

+90° PHASE OUTPUT

Function	Sine wave, square wave, triangle wave, positive ramp or negative ramp as selected by push-button.
Amplitude	Maximum output 6 V p-p (±3 V). Preset amplitude adjustment on front panel.
Impedance	50 Ω.
Protection	Short circuit proof.
Stability	±0·1% per °C. ±0·1% per kHz (triangle only).
Distortion	As main output but step deviations less than 1%.

AUXILIARY OUTPUT (Rear panel)

Function	Sine wave, square wave and triangle wave in phase with main output, at +90° phase and variable phase. (Nine simultaneous outputs.)
Amplitude	Fixed 6 V p-p (about main zero) to within ±1%.
Impedance	330 Ω, short circuit protected.
Maximum load	1 kΩ.

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OTHER FACILITIES

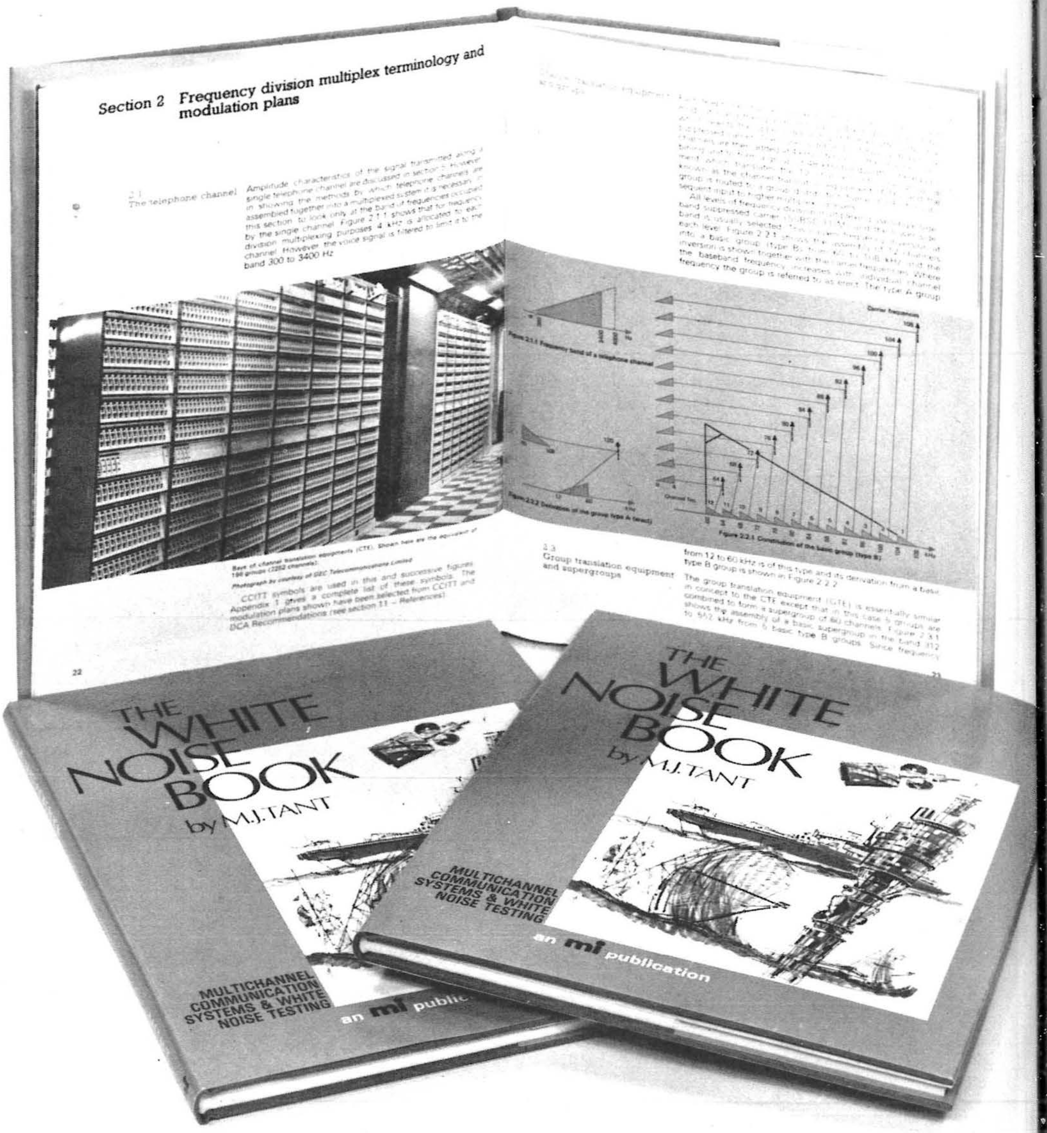
Single cycle	Manually by biased switch or electrically by +12 V pulse applied to external trigger input at rear. (Width 10 μs minimum, rise time 1 μs maximum). Start point at zero or positive peak selected by a switch.
Hold	All waveforms can be stopped at any point on a cycle. On releasing HOLD switch the cycle is resumed. Drift rate better than 10 mV/s × range setting.
Synchronous gate	Start (at zero or peak) +12 V. Stop (at zero or peak) 0 V. Waveform stops at the end of the cycle (zero or peak as set) after the +12 V gate signal is removed.
Earth isolation	The signal low terminal can float with respect to the case (mains earth) up to ±350 V.
Auxiliary power output	5 pin socket giving stabilised supplies of ±18 V and ±12 V. Maximum current 250 mA on each line.

OPERATING TEMPERATURE RANGE	0 to 40°C.
SAFETY	Designed to meet the requirements of IEC 348.
POWER REQUIREMENTS	115 V or 200 to 240 V ±10% 50 to 60 Hz, 40 VA.
DIMENSIONS AND WEIGHT	Height 130 mm 5 in; Width 440 mm 17¼ in; Depth 445 mm 17½ in; Weight 10 kg 22 lb

VERSIONS AND ACCESSORIES

When ordering please quote eight digit code numbers

Ordering numbers	
52120–900N	Versions Waveform Generator TF 2120.
	Supplied Accessories Earthing Link 34461–503Y.
54127–081F	Optional Accessories Rack Mounting Kit. Extension Board, 11 way. Extension Board, 25 way.



'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.

MULTI-CHANNEL TESTING

White Noise Test Set	OA 2090B	60
Noise Filter Extension Unit (for use with OA 2090 series)	TK 2099AB	64
Automatic White Noise Test Set	OA 2090C	65
Filters for White Noise Test Sets		72
Twelve Channel Noise Generator	TM 7816A	75
Selective Level Measuring Set	TF 2356, TF 2357	76

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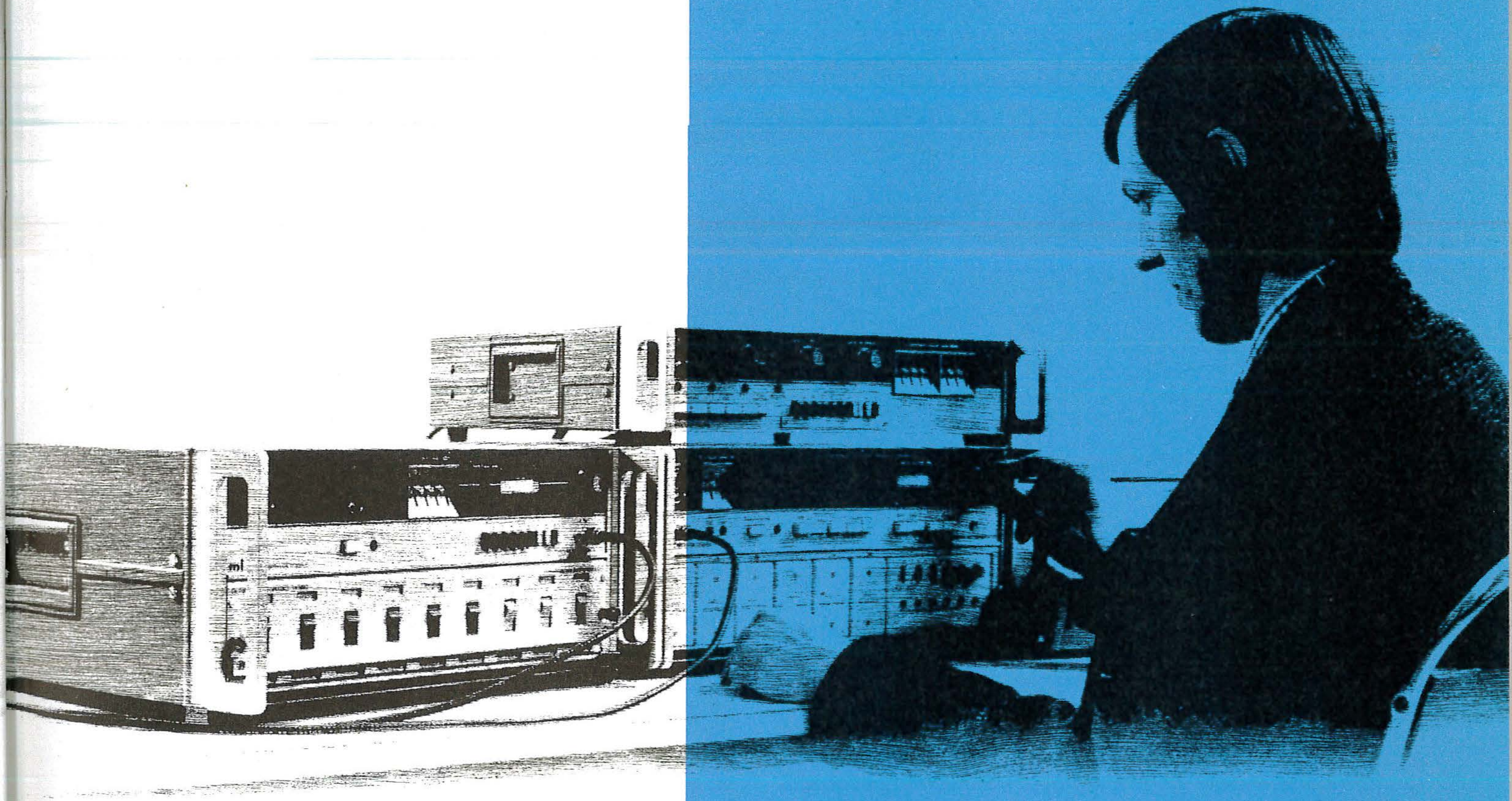
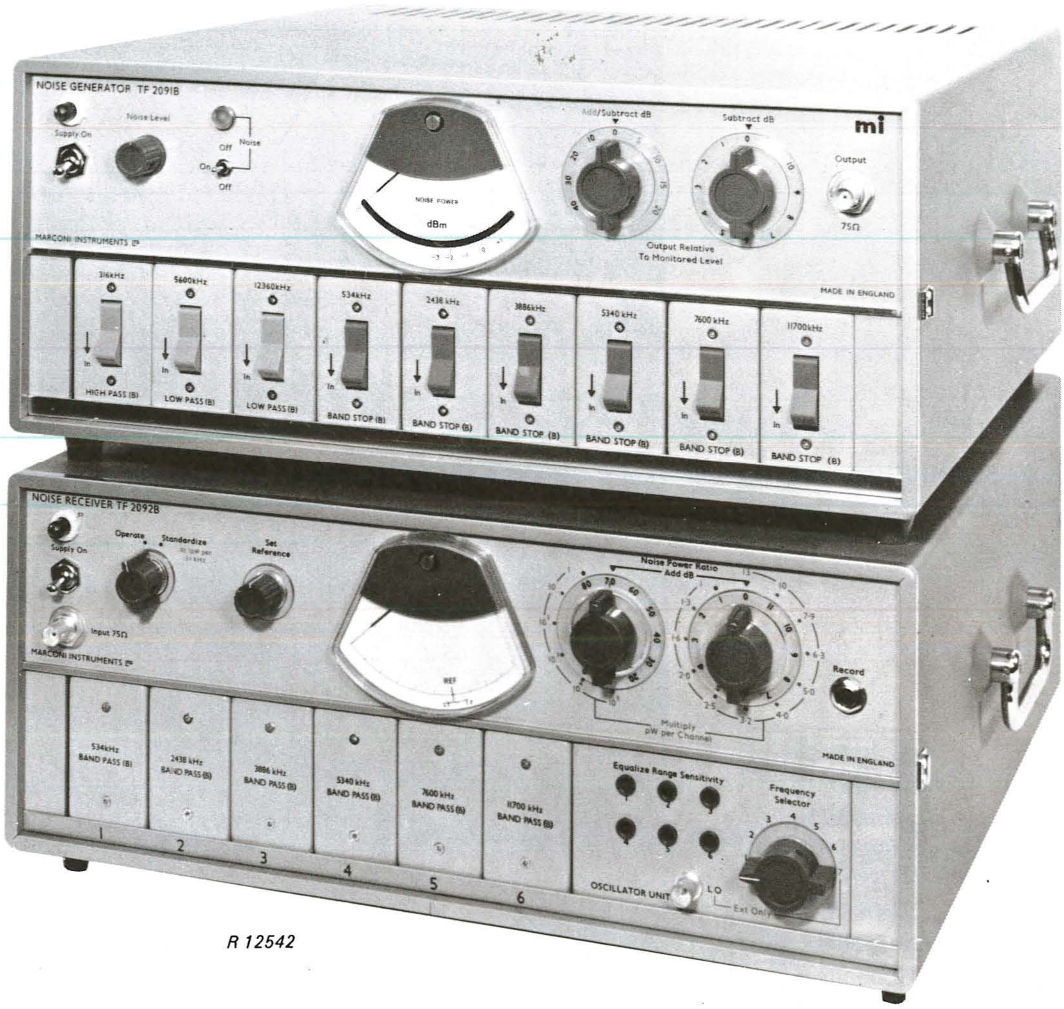


White Noise Test Set

- 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 (Recommendations 399-2, Geneva 1974: 399, Geneva 1963: 398-3, Geneva 1974: 482, Geneva 1974)



R 12542

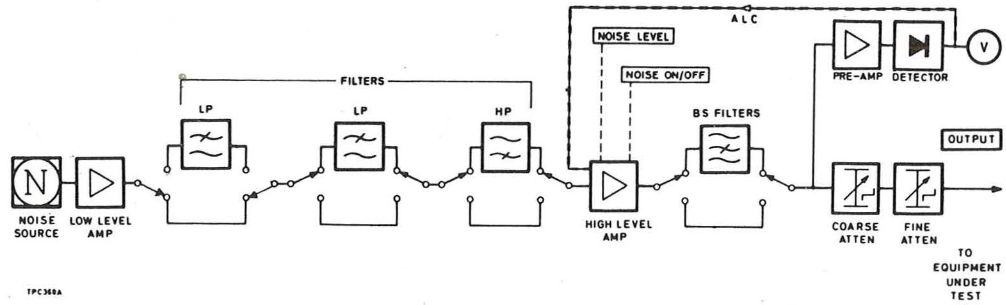
Two compact units form a complete equipment for measurement of noise interference in wideband telecommunication systems by methods based on recommendations of the CCIR (Radio Relay), CCITT (Cable) and INTELSAT. These methods are based on the fact that random noise evenly distributed over the system baseband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

OA 2090B has been specially developed to meet the latest CCIR recommendations 399-2 and 482 (Geneva 1974) when it is used with "B" filters. When fitted with "A" filters OA 2090B conforms to the older CCIR recommendation 399 (Geneva 1963).

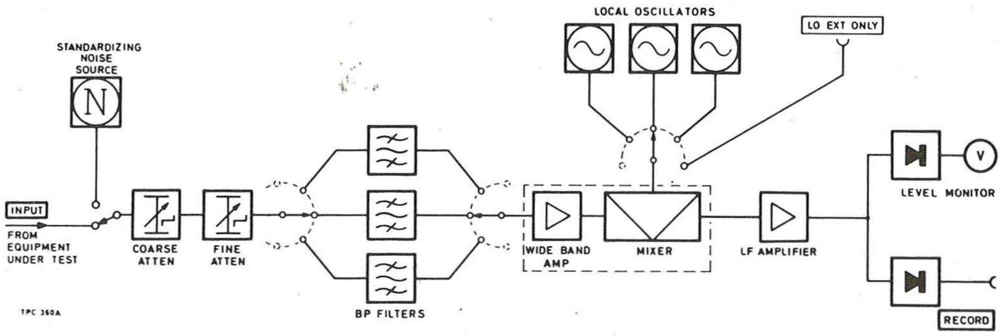
A noise signal which simulates traffic at a specified level of loading, is applied to the communication system from Noise Generator TF 2091B. A quiet test channel is produced by the introduction of a band-stop filter in the generator circuit; and the noise level in this test channel at the output of 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 N.P.R. 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 13×10^5 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 I.f. noise signal, and the smoothed d.c. output is proportional to the mean noise level.

RELIABILITY

Both units of the White Noise Test Set are fully transistorised, with the usual advantages of good reliability, virtually zero warm-up time, and low temperature operation.

Furthermore, in common with other instruments in the M.I. range, the OA 2090B has been subjected to thorough environmental testing.

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.

INCREASED FILTER CAPACITY

Where the filter requirement exceeds the capacity of OA 2090B, the generator and receiver may be modified for use with Filter Extension Unit TK 2099AB. This unit allows filter capacity to be doubled to a maximum of twelve test channels with a corresponding increase in band limiting filter capacity.

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" 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.
A.L.C.	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 A.C. mains	95 to 130 V or 190 to 260 V; 45 to 500 Hz. 50 VA.
DIMENSIONS	Height 195 mm, $7\frac{3}{4}$ in; Width 475 mm, $18\frac{3}{4}$ in; Depth 432 mm, 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).

OA 2090B

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' 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 13×10^6 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.
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. 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 A.C. mains	95 to 130 V or 190 to 260 V; 45 to 500 Hz. 15 VA.
DIMENSIONS	Height 195 mm 7$\frac{3}{4}$ in; Width 475 mm 18$\frac{3}{4}$ in; Depth 432 mm 17 in
WEIGHT	Instrument without filters or local oscillators, 12·3 kg (27 lb.) Weight of typical filter, 0·6 kg (1$\frac{1}{4}$ 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). *With 'B' version filters:* better than 67 dB. *With 'A' version filters:* better than 75 dB above 50 kHz and better than 70 dB at 50 kHz and below.
SAFETY	Designed to meet the requirements of 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 25 kN/m² differential, i.e. 3·7 lbf/in²)

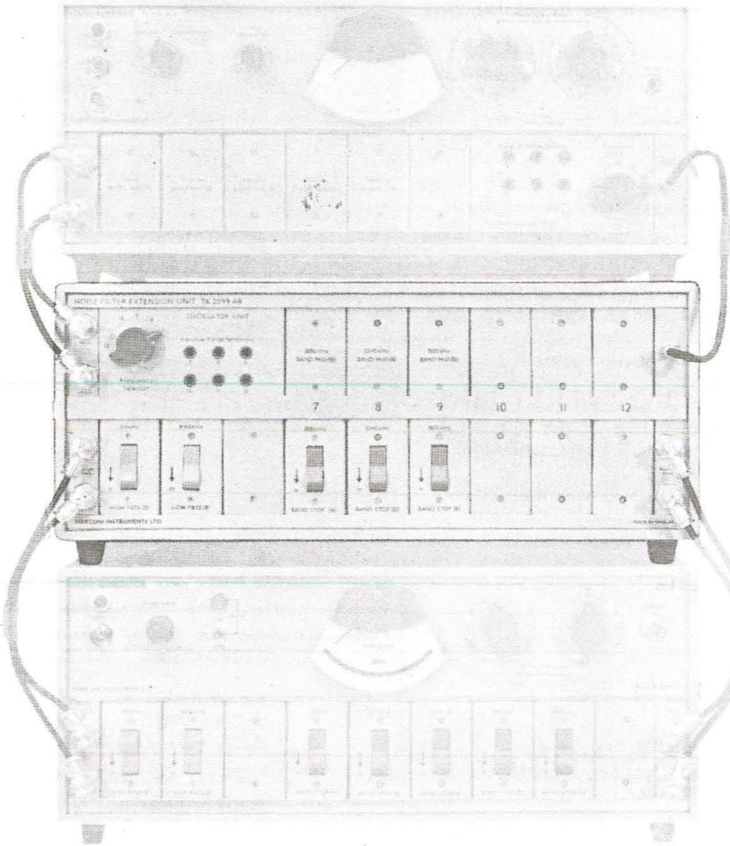
VERSIONS AND ACCESSORIES

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.
52090–924Z	White Noise Test Set OA 2090B/4, for use with TK 2099AB. Consisting of:
52091–924V	Noise Generator TF 2091B/4
52092–924B	Noise Receiver TF 2092B/4.
	Supplied Accessories
	Two BNC Plugs, Greenpar type GE 37570C 30.
	Telephone Plug, Bulgin type P38.
	Two Power Leads TM 7052 (43123–076) for bench mounting OA 2090B.
	OR
	Two Free Sockets, Bulgin type P430/5E for rack mounting OA 2090B.
	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, 75 Ω unbalanced to 150 Ω balanced.
54351–011F	Connecting Lead, BNC, 1830 mm (6 ft).
54124–021N	Front-panel cover (protective) for generator or receiver.
54134–011A	Dummy Front Plate, 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.
	For details of filters and noise measuring sets see page 72

TK 2099AB Noise Filter Extension Unit

- ☐ **Doubles the filter capacity of OA 2090A and OA 2090B**
- ☐ **Accommodates up to six filters for the Noise Receiver and nine filters for the Noise Generator**



The TK 2099AB Noise Filter Extension Unit has been designed to effectively double the filter capacity of Marconi Instruments OA 2090 series of White Noise Test Sets, and is suitable for use with both OA 2090A and OA 2090B.

Existing generators and receivers require some modification in order to make use of this instrument, and modification kits are available for this purpose. As different modification kits are required for OA 2090A and OA 2090B, it is necessary to specify the model concerned at the time of ordering. Alternatively, a modified version of the White Noise Test Set, OA 2090B/4, can be supplied. This comprises Noise Generator TF 2091B/4 and Noise Receiver TF 2092B/4.

Existing filters, as listed in the OA 2090B data sheet, can be fitted into the Extension Unit, which can accommodate up to six Band-pass filters with Oscillator Units for the Noise Receiver, and up to nine selected from Low-pass, High-pass and Band-stop filters for the Noise Generator.

The TK 2099AB is supplied with leads enabling it to be connected to the modified White Noise Generator and Receiver.

SAFETY	Designed to meet the requirements of IEC 348.
POWER REQUIREMENTS	25 V d.c. from the Noise Receiver.
DIMENSIONS	Height 195 mm $7\frac{3}{4}$ in; Width 475 mm $18\frac{3}{4}$ in; Depth 432 mm 17 in
WEIGHT	Instrument without filters 7·25 kg, (16 lb) approx.

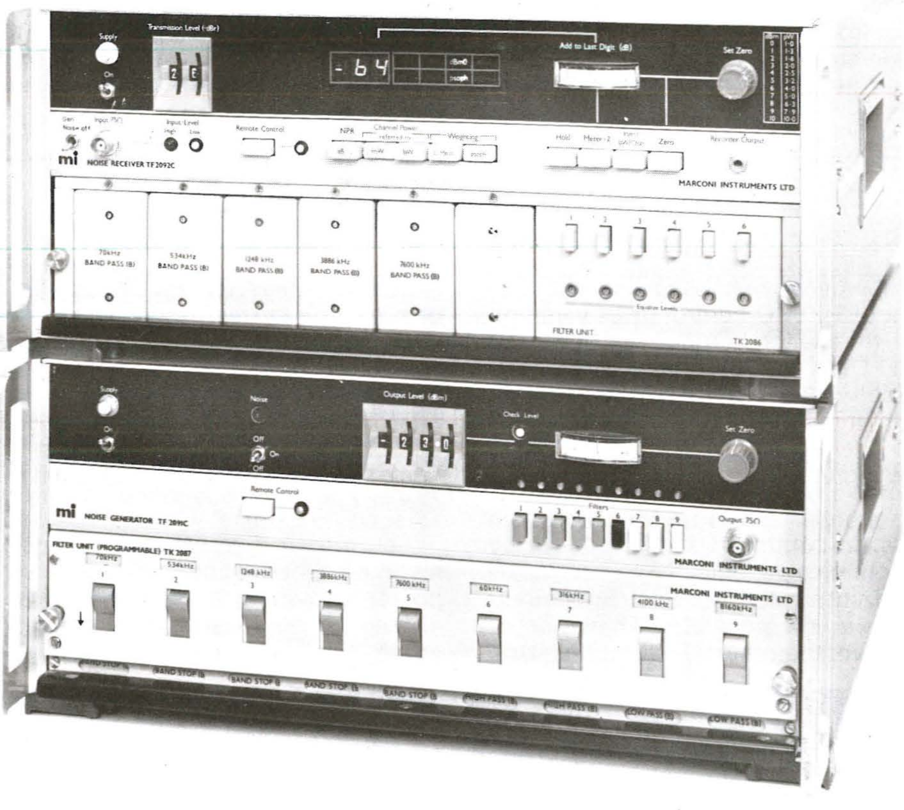
VERSIONS AND ACCESSORIES

When ordering please quote eight-digit code numbers

Ordering numbers	
	Versions
52099–300P	Noise Filter Extension Unit TK 2099AB.
	Modification Kits
	For use with OA 2090A:
54713–101B	Converts TF 2091 into TF 2091/4.
54713–111Y	Converts TF 2092A into TF 2092A/4.
	For use with OA 2090B:
54713–101B	Converts TF 2091B into TF 2091B/4.
54713–121S	Converts TF 2092B into TF 2092B/4.

Automatic White Noise Test Set

- Automatic measurements for all noise loading tests
- Measures n.p.r., dBm0p, dBrnC0 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
- Optional Control Unit for automated measurement sequences
- Remotely programmable
- 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. 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.

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

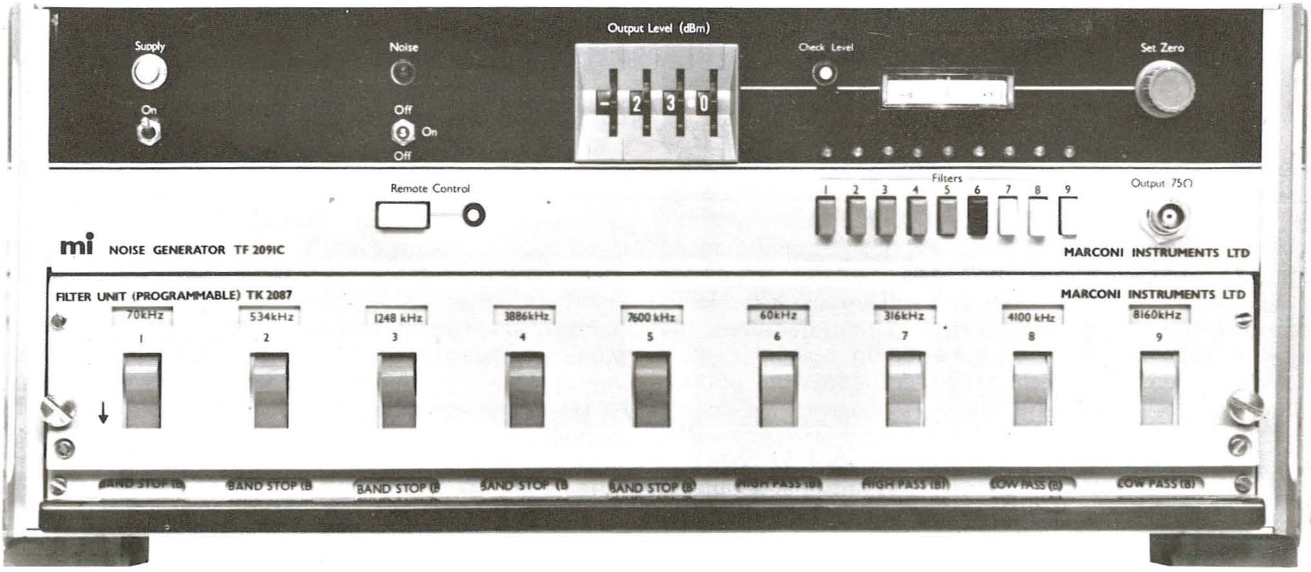
To achieve the desired high accuracy and long-term stability, the noise receiver uses a slide-back measurement technique. The self-balancing attenuator simplifies measurements and removes the need for manual operation of controls.

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.

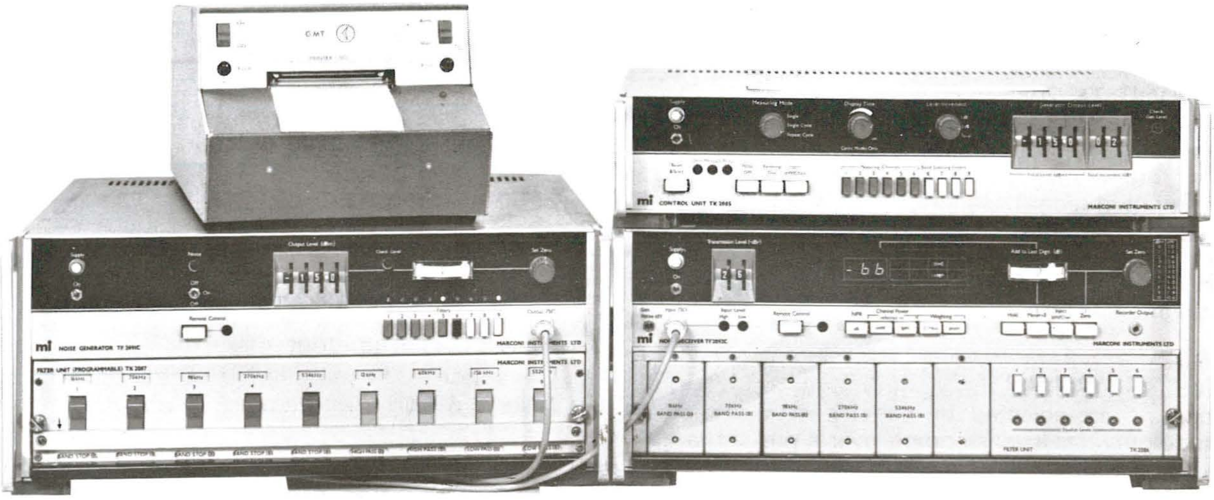
The band-pass filters and local oscillators are mounted in a plug-in Filter Unit TK 2086, which has provision for up to six channels and which permits rapid adaptation to different channel capacities.

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



Noise Generator TF 2091C



OA 2090C with TK 2085 and Digital Printer GMT 301

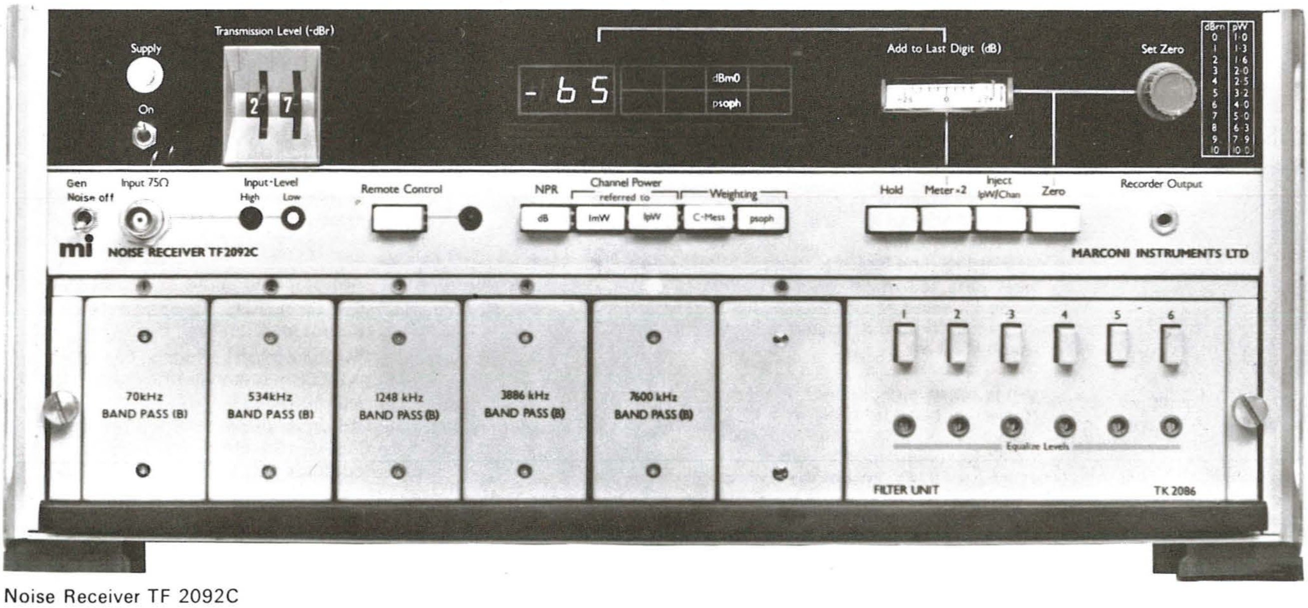
Automatic measurement of channel power For channel power measurements the incoming noise is automatically compared with an internal standard of 1 pW/channel and computed in terms of noise per channel. Measurements can be made unweighted or weighted to CCITT psophometric or C-message standards to give 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 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.



Noise Receiver TF 2092C

CONTROL UNIT TK 2085

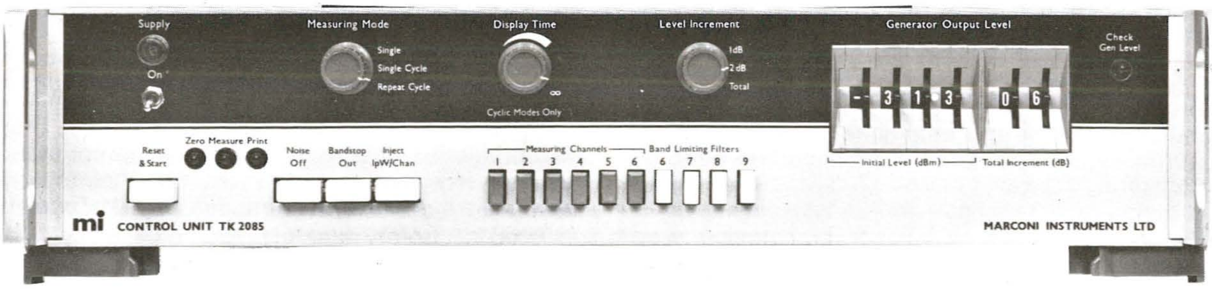
This optional unit controls all programmable functions of the white noise generator and receiver, with capability for carrying out automatically a full sequence of tests and providing a printed record. Generator functions controlled are band-stop and band-limiting filter selection, output level and noise 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



Control Unit TK 2085

14170/4

NOISE GENERATOR TF 2091C

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.

NOISE BAND

White noise is generated over the frequency band from below 6 kHz to above 12360 kHz, complying with CCIR Recommendation 399-2 (Geneva 1974). 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. 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.
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.

±sign	1 wire ('0' = −, '1' = +)
10 dB steps	3 wires
1 dB steps	4 wires
0·1 dB steps	4 wires

Filter selection — 5 or 6 band-stop filters − 3 wires b.c.d.
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.
Logic levels: '0' = 0 to 0·4 V.
'1' = 4·75 to 5·25 V.

POWER REQUIREMENTS

AC supply — 95 to 130 V and 190 to 260 V. 45 to 65 Hz. 45 VA.

SAFETY REGULATIONS — Complies with IEC 348 and BS 4743 safety requirements.

DIMENSIONS AND WEIGHT

Height	Width	Depth	Weight*
188 mm	426 mm	482 mm	14 kg
$7\frac{3}{8}$ in	$16\frac{3}{4}$ 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. Position 6 for either a band-stop or a band-limiting filter.
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.

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 is 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.
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:

1) NPR in dB
2) Channel power relative to:
   a) 1 mW unweighted in dBm or dBm0.
   b) 1 mW psophometrically weighted in dBmp or dBm0p.
   c) 1 pW unweighted in dBrn or dBrn0.
   d) 1 pW psophometrically weighted in dBrnp or dBrn0p.
   e) 1 pW C-message weighted in dBrnC or dBrnC0.

Note: dBm0 and dBm0p are numerically equal to signal-to-noise ratio unweighted and weighted, with sign reversed.
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. 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. 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. 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 mains	95 to 130 V or 190 to 260 V. 45 to 65 Hz, 45 VA.
SAFETY REGULATIONS	Complies with IEC 348 and BS 4743 safety requirements.
DIMENSIONS AND WEIGHT	Height 188 mm (7⅜ in); Width 426 mm (16¾ in); Depth 482 mm (19 in); Weight* 14 kg (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 pre-set 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: Channel Selection (also selects the corresponding generator channel). Set zero. Inject 1 pW per channel. Print trigger.
Control of Noise Generator TF 2091C	The Control Unit outputs control the following generator functions: Band-stop filter selection. Band-limiting filter selection. Output level from +19·9 dBm to −59·9 dBm in 0·1 dB steps. (Warning lamp lights when level is abnormal). Noise on/off (Warning lamp lights when noise is off). Band-stop filters in/out.
Signal levels	All signals are t.t.l. compatible. Logic levels: '0' = 0 to 0·4 V. '1' = 2·4 to 5·0 V. 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 0s, 10s and ∞ which interrupts the cycle on completion of the measurement in progress.
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 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. *Note:* 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.
SAFETY REGULATIONS	Complies with IEC 348 and BS 4743 safety requirements.

DIMENSIONS AND WEIGHT

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

VERSIONS AND ACCESSORIES

When ordering please quote eight digit code numbers

Ordering numbers	Versions
	Automatic White Noise Test Set OA 2090C consisting of:
52091–930D	Noise Generator TF 2091C with either
52092–930Z	Noise Receiver TF 2092C or
52092–301P	Noise Receiver TF 2092C with Programming Board fitted.
	Supplied Accessories
	Telephone Plug 23421–610M for recorder output on TF 2092C.
	Optional Accessories
	Band-stop, Band-pass, Band-limiting Filters and Local Oscillator Boards as listed on page 72.
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).
54490–032H	Programming Board, complete with multiway lead and rear-panel mounting socket and 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.
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.
54112–141R	Carrying Case for TK 2085.
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).
41690–148A	Front Panel Cover (for TK 2085).
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).
	Complementary Equipment
52090–035U	White Noise Test Set OA 2090B.
44990–120P	Twelve channel Noise Generator TM 7816A.

"B" FILTER CHARACTERISTICS

Band-limiting and band-stop filters of the TK 2094, TK 2095 and TK 2096 series meet CCIR Recommendation 399-2 Geneva 1974 or 482 Geneva 1974 at the frequencies specified in the above documents. At other frequencies the characteristics are derived by interpolation from CCIR recommendations.

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
7600	±1·5	±2·4	±4·6	±16	±200
11700	±1·5	±3·0	±7·0	±20	±300

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

Cut-off frequency*

	Nom. freq. kHz	Tolerance kHz	Nom. freq. kHz	Tolerance kHz
High-pass (f1)	12	±0·5		
	60	±1		
	316	±5		
Low-pass (f2)	60	±0·5	1296	±8
	108	±1	1796	±12
	156	±1	2600	±20
	204	±1·5	3284	±25
	252	±2	4100	±30
	300	±2	4892	±40
	408	±3	5600	±50
	552	±4	5884	±50
	804	±6	8160	±75
	1052	±8	12360	±100

Insertion loss

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

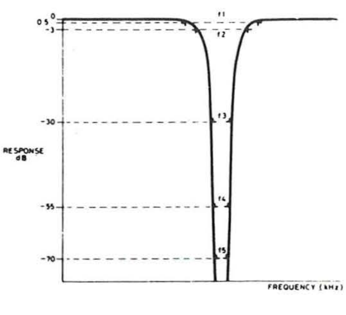
Outside pass-band:

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-STOP FILTERS (Part of TK 2094 series)

Characteristic



BAND-PASS FILTERS AND LOCAL OSCILLATORS (Part of TK 2094 series)

Characteristic Designed to suit the corresponding band-stop filter.

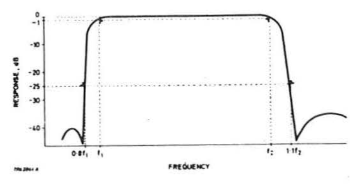
"A" FILTER CHARACTERISTICS

Band-limiting and Band-stop filters of the TM 7720, TM 7728 and TM 7729 series meet CCIR Recommendation 399, Geneva 1963.

BAND-LIMITING FILTERS

(TM 7720 and TM 7728 series)

Characteristic



Insertion loss

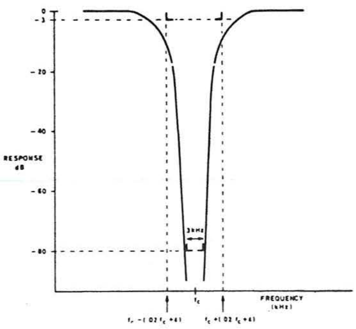
Within pass-band: Variation less than 1 dB.

Outside pass-band:

Frequency	Loss greater than
0·8f1	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 398-2, New Delhi 1970, 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 399-2 and CCIR 482 GENEVA 1974)

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
8160 * †	TK 2095/6	52095–074S
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

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
7600 * †	TK 2094/7	52094–084F
11700 †	TK 2094/8	52094–094P

The specification of the above filters are to the following recommendations:
† *CCIR 399-2 GENEVA 1974*
* *CCIR 482 GENEVA 1974*

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	TM 7728	46855–006K
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	52092–414V
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*

OUT-OF-BAND FILTERS (CCIR 398-3 GENEVA 1974)

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 399-2 (GENEVA 1974)

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 64-1296	60±1	1296±8	70 270 534 1248
600	60-2540 64-2660	60±1	2600±20	70 270 534 1248 2438
900	316-4188	316±5	4100±30	534 1248 2438 3886
960	60-4028 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 60-5564	60±1	5600±50	70 270 534 1248 2438 3886 5340
1800	312-8120 312-8204 316-8204	316±5	8160±75	534 1248 2438 3886 5340 7600
2700	312-12336 316-12388 312-12388	316±5	12360±100	534 1248 2438 3886 5340 7600 11700

CCIR 482 (GENEVA 1974)

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

We are prepared to accept orders for band-limiting filters or noise measuring sets at frequencies other than those in the above tables. The unit cost will necessarily reflect the design time involved and it is essential to specify the Recommendation to which the filter characteristics should conform when making the enquiry.

Twelve Channel Noise Generator TM 7816A

- ☐ Simulates up to twelve voice or data channels
- ☐ Measures complete system line-in to line-out
- ☐ Tests multiplex intermodulation and cross-talk

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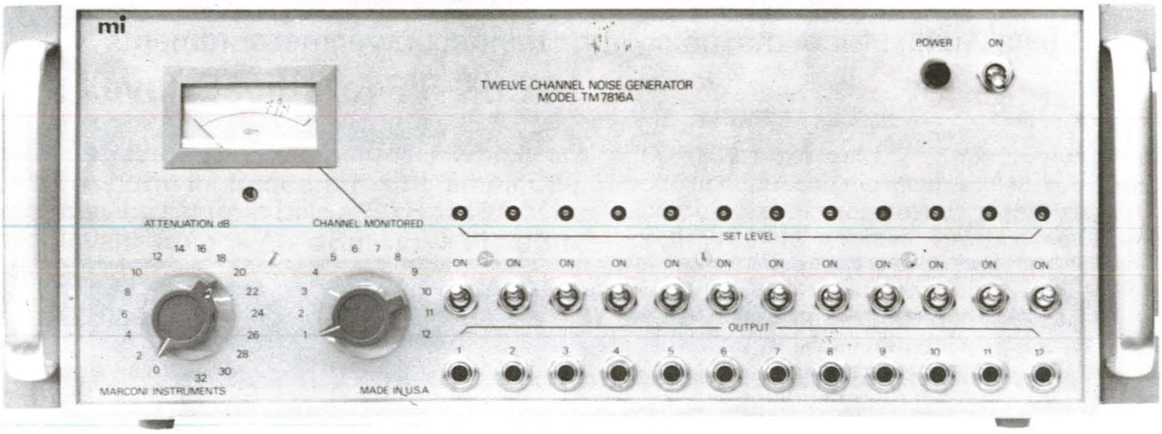


Model TM 7816A extends the usefulness of noise loading techniques to systems having 24 channels or less (or equivalent bandwidths). The twelve voice-frequency-range noise signals produced can be used to simulate traffic input to Troposcatter, SSB, FM or other multi-channel systems. Cross-talk and intermodulation distortion in multiplex equipment can be measured by connecting the multiplex back-to-back.

The instrument has been designed to generate twelve independent voice - frequency - range (300–3400 Hz), gaussian distribution, noise signals.

Semiconductor noise sources are used and the circuitry is completely transistorised. The twelve bank, 32 dB range attenuator is slave driven from the front panel control using a rotary solenoid selector switch.

To test a complete system the noise generator outputs are connected to the telephone or data line inputs of the multiplex equipment at the transmitter. The noise level is adjusted to load the system under test to the desired amount and the resulting noise output (P1) from a given test channel at the remote receiver, measured. Then the noise loading is removed from the test channel and the remaining spurious noise (P2) measured. If P1 is plotted against P2 an overall performance curve of the system will be obtained over its full dynamic range. Also using these results, the NPR, signal-to-noise ratio, weighted spurious noise and error rate to the test channel can be deduced. Tests can be made on several channels to measure the NPR distribution over the baseband.

The distortion and noise measured include components from the complete communication system, from the telephone line input of the sender, to the line output of the remote receiver. Separation of cross-talk and inter-modulation can be achieved by connecting the multiplex back-to-back.

EACH NOISE GENERATOR CHANNEL	
Noise bandwidth	±0·2 dB over the range 300 to 3400 Hz.
Noise power output	0 dBm maximum (1 mW in 600 Ω).
Attenuator	0 to −32 dBm (each channel) in 2 dB steps.
Attenuator accuracy	±0·25 dB incremental, ±1 dB overall.
Noise output meter accuracy	±0·5 dB.
Statistical peak to rms ratio of noise signal	8 dB for 1% of time.
Output impedance	600 Ω balanced.

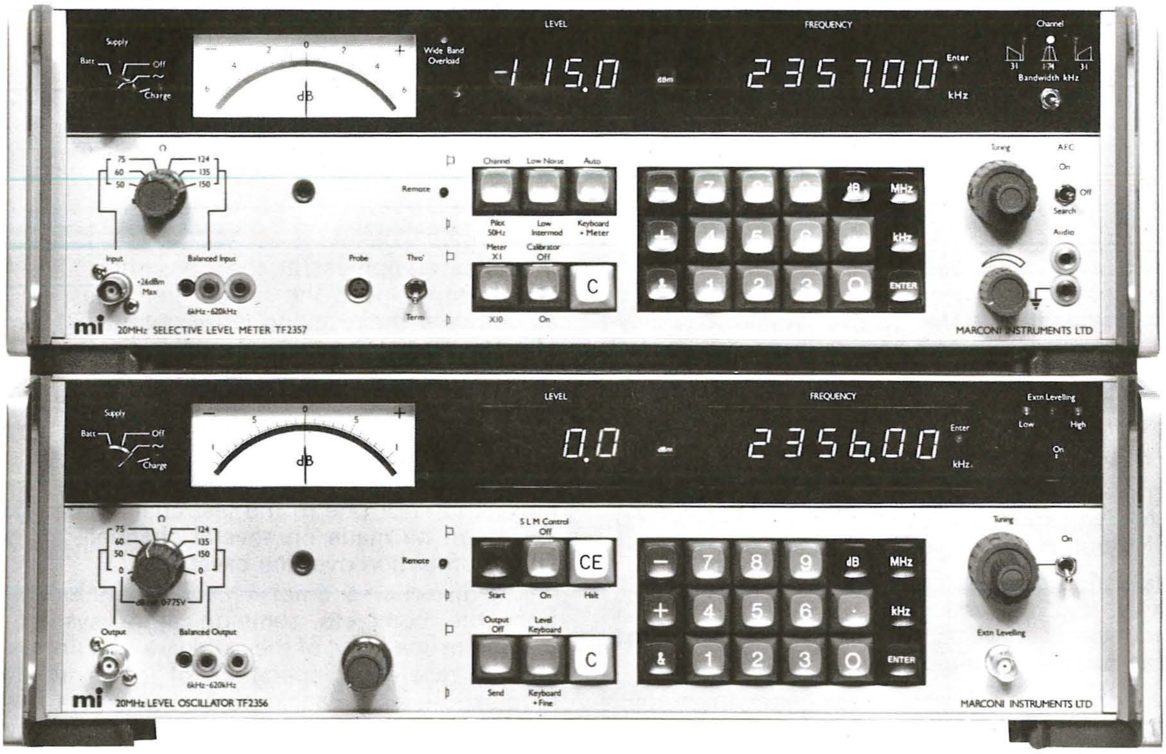
Spurious noise in a nominally "OFF" channel, with all other channels "ON"	Less than 16 dBrnC.
SAFETY	Designed to meet the requirements of IEC 348.
POWER REQUIREMENTS A.C. mains	100 to 125 V or 210 to 250 V. 40 to 100 Hz. 20 W.
DIMENSIONS AND WEIGHT	Height Width Depth Weight 178 mm 432 mm 318 mm 11·4 kg 7 in 17 in 12½ in 25 lb

ORDERING NUMBER 44990–120P	Twelve Channel Noise Generator TM 7816A.

Made in U.S.A.

Selective Level Measuring Set

- ☐ **Microprocessor control** of both sender and receiver for simplicity of operation
- ☐ **Synthesizer tuning** of both sender and receiver. 10 Hz resolution, 6 kHz to 20 MHz
- ☐ **Switched impedances** of 50, 60 and 75 Ω unbalanced; 124, 135 and 150 Ω balanced
- ☐ **Level ranges:** sender from −70 dBm to +10 dBm; receiver from −121 dBm to + 26 dBm
- ☐ **Tracking generator** for network characterization using receiver only
- ☐ **Three receiver bandwidths:** for pilots, noise and channel power measurements



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Level Oscillator TF 2356 (the sender) and Selective Level Meter TF2357 (the receiver) combine to form an entirely new concept in selective level measuring sets. Both sender and receiver incorporate high stability 5 Hz resolution frequency synthesizers and each is microprocessor controlled. The application of these techniques has enabled the instruments to provide a previously unattainable level of versatility coupled with extreme simplicity of operation. At the same time the performance equals (and in some areas exceeds) the measurement precision of earlier generation equipments.

Both sender and receiver are available in manual form or, when fitted with the optional GPIB* interface, they are both fully programmable via the instrument bus. Addition of the GPIB interface (which may be added retrospectively) also allows the sender to control the receiver and a printer. This pre-programmed bus control capability gives the Selective Level Measuring Set several powerful and currently unique modes of operation.

**GPIB - Marconi Instruments' General Purpose Instrument Bus is in accordance with IEEE Standard 488 - 1975 and IEC document 66 (Central Office) 22.*

20 MHz Level Oscillator TF 2356

The Level Oscillator generates signals which are highly stable both in frequency and amplitude. Frequency may be set from below 6 kHz to 20 MHz at power levels from –71 dBm to +11 dBm. Balanced and unbalanced outputs may be selected over a wide range of impedances.

Frequency and level are read from digital displays which flash when an out-of-range condition is selected in error. Pre-programmed bus control and general programmable operation are described later.

Tuning

The tuning synthesizer may be controlled either by the keyboard or by a conventional tuning knob: in both cases the frequency is displayed on a 7 digit display to 10 Hz resolution. Accuracy using the internal standard is 1 in 10^6, or an external 10 MHz standard may be used. The keyboard and MANUAL TUNING control can both be used in two ways. Or the Level Oscillator may be synchronously tuned from the receiver.

Keyboard tuning

Direct Entry. The frequency required is entered on the keyboard.

Incremental. This mode is used to increase or decrease the tuned frequency by a set amount. For example to increase the frequency by 4 kHz enter +4 kHz on the keyboard, then press ENTER key: frequency is incremented by a further 4 kHz each time the ENTER key is pressed.

Manual tuning

Normal Mode. Turning the control increments the synthesizer in 5 Hz steps, thus providing continuous tuning with no range switching.

Spinning Wheel. Spinning the control causes a motor drive to come into operation: this gives the effect of a mechanical flywheel. Having spun the control it will normally continue to rotate until either limit of the frequency range is reached, but it may be stopped at any time either manually or by pressing any key on the keyboard.

Synchronous tuning

The tuning of the Level Oscillator may be controlled from the receiver (TF 2357). This is accomplished by connecting two coaxial cables between the instruments.

Level setting

Output level is entered in dB via the keyboard and displayed with 1 dB resolution on a 3 digit display. Fractions of dB are set with a continuously variable control in conjunction with the meter scaled ±1·1 dB. Alternatively, output level may be entered digitally to 0·1 dB resolution with the meter disabled. Level increments may be entered via the keyboard allowing the output level to be changed a preset number of dB each time the ENTER key is pressed. Though level and attenuator accuracy are high, send level uncertainty may be further reduced by applying an external levelling signal from a monitor such as a standard mW test-set equipped with d.c. error output. Level calibration is switchable to dBm or dB relative to 0·775 V (1 mW into 600Ω) and the output is automatically disabled during changes to frequency or level. Manual output disable is also provided.

20 MHz Selective Level Meter TF 2357

The Selective Level Meter is a high stability receiver, tunable from below 6 kHz to 20 MHz, which measures true r.m.s. levels accurately from –121 dBm to +26 dBm. Three measuring filter bandwidths are provided: a 50 Hz pilot filter and 1·74 kHz and 3·1 kHz channel filters. A wide range of 'thro' or terminated, balanced or unbalanced impedances may be switch–selected and a high impedance zero-loss probe is available.

As in the sender the frequency and level are read from digital displays which flash to indicate that an out-of-range condition has been incorrectly selected.

Tuning

The tuning arrangement is the same as for the sender with frequency displayed on a 7 digit display to 10 Hz resolution. Accuracy is 1 in 10^6 from the internal standard or an external 10 MHz standard may be used. The four modes of tuning considerably simplify measurements of f.d.m. systems.

Keyboard tuning

Direct Entry. To measure the level of a known frequency such as a pilot, the frequency is entered directly.

Incremental. This mode may be used when measuring a series of equally spaced signals such as adjacent channels in a group.

Manual tuning

Normal Mode. Manual tuning using the rotary control is

invaluable when searching for spurious tones or when plotting filter responses.

Spinning Wheel. Spin tuning greatly facilitates searching for high level tones, since the instrument can be set to scan automatically an entire baseband, locking automatically to any signal which exceeds a preset threshold. (See "Search above threshold").

Synchronous tuning

Outputs of the internal 10 MHz standard and variable local oscillator are available at rear sockets for connection to the sender by coaxial cables in the conventional way. The tuning of the sender may thus be entirely controlled from the receiver.

Automatic frequency control (AFC)

Switch selection of automatic frequency control locks the receiver to an incoming signal. The capture range is a function of the filter bandwidth selected, but the hold range extends over the full frequency range of 6 kHz to 20 MHz since the a.f.c. operates by digitally retuning the synthesizer. In this mode signals are held within 5 Hz of the centre frequency of the measuring filter.

Level measurement

The versatility of the receiver is enhanced by the ability to measure level in two ways: either automatically with a digital display, or manually with a meter display. Level indication is switch-selected in dBm or dB relative to 0·775 volts and a warning lamp lights if the total broadband input power exceeds a level which might cause errors due to internal intermodulation products. LOW NOISE or LOW INTERMODULATION measurement is available.

AUTO. The receiver attenuators automatically balance to the tuned signal and the level is presented on a 4 digit display with 0·1 dB resolution (the meter is inoperative). This mode is ideal for fast precision measurements. Low noise or low intermodulation operation is selected automatically.

MANUAL. The meter is used to display the level difference between the incoming signal and a reference level entered on the keyboard and displayed on the digital readout. This is especially useful when setting a signal to a desired level since an analogue movement is easier to follow than changing digits on a digital display. The reference level may be incremented in a similar way to level incrementing on the sender. LOW NOISE or LOW INTERMODULATION may be selected manually.

The meter, which is centre-zero with two switched scales of ±6 dB or ± 0·6 dB, giving a resolution of 0·01dB, may also be externally monitored via the RECORDER output.

Automatic calibration

Errors due to *both* frequency response and attenuation are compensated by an automatic calibrator which injects into the measuring circuits a standard level at the tuned frequency. The process is initiated when the instrument is first switched on and subsequently whenever the bandwidth, frequency or level of the measured signal changes. In steady state conditions the receiver automatically calibrates at approximately five minute intervals.

Search above threshold

In the manual mode the spinning wheel may be used to search for signals above a pre-set level. With AFC selected the threshold level is entered on the keyboard and the spinning wheel is set to search over the frequency band of interest. When a signal is detected above the threshold level the spinning stops and the receiver displays frequency and level. The search may be continued by spinning the tuning control again. The search rate is automatically optimised for the bandwidth selected.

Filter bandwidths

Three switch-selected filters are provided as standard equipment.

50 Hz Pilot Filter. This high selectivity filter with a 60 dB/3 dB shape factor below 4:1, is suitable for measuring pilot tones in traffic, particularly when they are adjacent to signalling tones or suppressed carriers.

1·74 kHz Channel Filter. The filter is suitable for psophometrically weighted noise measurements on individual channels or inter-supergroup slots.

3·1 kHz Channel Filter. Entering the frequency of the suppressed carrier and selecting upper or lower sideband applies automatic carrier shift to give a correctly demodulated output. A built-in loudspeaker with volume control is also provided.

Tracking Generator

A 0 dBm output signal at the tuned frequency is provided to allow characterisation of circuits without the need for the companion sender. It permits a dynamic range in excess of 140 dB.

Battery Operation

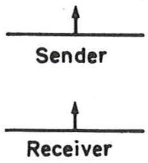
Both sender and receiver can be supplied with rechargeable battery packs to provide approximately 5 hours operation. Recharging time is about 14 hours and the instruments trickle charge during normal operation.

Pre-programmed bus control

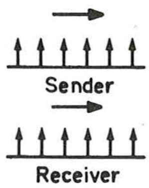
When fitted with GPIB interfaces the sender and receiver may be connected to a printer via the bus. Simple data entry on the sender keyboard provides a number of powerful, and currently unique, automatic measurement sequences.

Frequency Selection

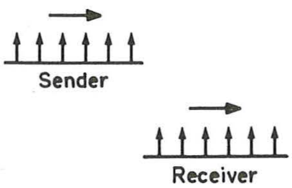
Synchronous (single frequency). Keyboard entry of frequency at the sender sets both sender and receiver to the same frequency.



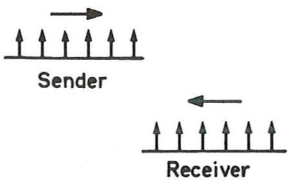
Synchronous incrementing. The sender keyboard is used to enter a start frequency, frequency increment and stop frequency. The instruments will then automatically increment in synchronism.



Incrementing with offset. The sender and receiver increment with a fixed frequency offset. Sender start frequency, increment and stop frequency followed by the receiver start frequency are entered on the sender keyboard.



Inverted increment with offset. This is similar to 'incrementing with offset' except that as the sender frequency steps upwards, the receiver frequency steps downwards. A typical use is for the step-by-step measurement of the frequency response of a group translation equipment.



Level selection

Single level. All measurements are made at the same sender level.
Level incrementing. By entering a start level, level increment and a stop level measurements are made over a range of sender levels.
Output disable. Permits the selected frequency sequence to be executed with sender output off. This may also precede *'Single level'* or *'Level incrementing'*.

Mode selection

Manual. Each measurement is initiated by a manual command. This is especially useful when a digital printer is not used.
Single cycle. One complete automatic sequence (cycle) of measurements is made, a further cycle can be started manually.
Repeat cycle. Further cycles are initiated automatically.
Delay. Can be used in any of the abovc three modes to delay a measurement following any change of level or frequency (delay over the range from 1 second to 1 hour can be entered on the sender keyboard).

Sequence Selection

When both level and frequency increments have been entered, the sender keyboard can be used to select measurements at one level through all frequencies before proceeding to the next level: or vice versa.

Printout

When a printer is connected all initial data values (frequencies, levels, mode and delay) are recorded at the beginning of the first cycle. During a measurement sequence, receive frequency and level data are produced and, under certain conditions, sender frequency and level are printed.
Where a printer is not connected the manual or delay modes may be selected to allow time for the sender and receiver displays to be noted.
The sender will also automatically increment in frequency and level when operated by itself. A GPIB interface is not required in this configuration.

Example printout using pre-programmed capability
The printout shows extracts from a series of measurements of the performance of a master-group translation equipment. The Level Oscillator is acting as the bus controller with inverted increment with offset for frequency; level incrementing with initial output disable; single cycle mode with 5 seconds delay; and frequency within level sequence. Frequency and level ranges apply in this example to a mastergroup translation equipment with input and output transmission levels of –36 dBr and –33 dBr. The first six measurements are of output noise across the top mastergroup and the subsequent groups show frequency response for input levels of –20 dBm0 and –10 dBm0 respectively.

KHZ			
808.00		FS1	Sender start frequency
248.00	+	INC	Sender frequency increment (positive)
2048.00		FS2	Sender stop frequency
12392.00	-	FR1	Receiver start frequency
		DBM	Sign indicates receiver will increment downwards
DISABLE		....	Sender output is first disabled
LS1	-	56.0	Sender output then set to initial level
INC	+	10	Sender level increment (positive)
LS2	-	46.0	Sender final level
5.		DELAY	System waits 5 seconds before printing
			Single automatic measurement cycle
KHZ		DBM	
808.00		....	First sender frequency with output disabled
12392.00		-109.30	First receiver measurement
1056.00		....	Measurement at second frequency, output disabled
12144.00		-109.80	
2048.00		....	Measurement at sixth (and final) frequency, output disabled.
11152.00		-108.40	
808.00	-	56.0	First of six measurements with –56 dBm send level.
12392.00	-	53.42	
2048.00	-	46.0	Last of six measurements with –46 dBm send level.
11152.00	-	43.28	

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General bus control and associated equipment

Both the sender and receiver may form part of a more complex test configuration in which case the sender will act as a listener: its own controller capability being overriden. Such configurations may include, for example, a programmable calculator with a plotter or video display unit for network characterisation, and other bus controlled equipments to test additional parameters.
As part of an automatic test system, the capabilities of the receiver can be considerably extended by the addition of other **mi** bus controllable units.

Coaxial Switch Unit

TF 2365 Coaxial Switch Unit may be used to scan any number of 75 Ω sources for input to the Selective Level Meter. The unit comprises a series of four-way switch modules which are assembled to provide between 4 and 56 inputs per unit. The Coaxial Switch Unit is stackable for requirements in excess of 56 and may be controlled manually, via the instrument bus, or remotely using b.c.d./t.t.l. logic.

Baseband Filter Unit

The bandwidth capabilities of the Selective Level Meter (50 Hz, 1·74 kHz and 3·1 kHz) may be extended to include 48 kHz (group), 240 kHz (supergroup) and 1200 kHz (mastergroup), all tunable over the full 20 MHz range, using TK 2366 Baseband Filter Unit.
Additionally for power measurement in hypergroups (super mastergroups) and complete f.d.m. basebands, high and low pass filters may be selected. For measurement of noise in narrow slots between active blocks of traffic, pre-filtering of the receiver input may be selected to provide the equivalent of 80 dB n.p.r. performance. TK 2366 is addressed via the receiver.

Automatic Baseband Monitor

A particular application of the SLMS and its associated equipment is automatic baseband monitoring. OA 2358 Automatic Baseband Monitor scans up to 56 or more f.d.m. basebands sequentially under the control of OA 1800 General Controller. The operator holds a conversational dialogue via a video display unit for initialising the system, selecting test sequences, choosing methods of fault reporting, and other routines. Measurements may be selected from the following with a further choice of different modes during pre-assigned "routine" and "peak" traffic times:

All pilot levels	Mastergroup power
Selected pilot levels	Supergroup power
Inter-supergroup slot noise	Group power
Baseband power	Channel power
Hypergroup power	Carrier leak

All measurements are compared with limits which are set by the operator. Faults may be reported immediately or retained for summary reporting at set times.

Diagnostic sub-routines can be incorporated in order to determine the cause of faults. If, for example, a supergroup power is found to be high, each group can then be individually measured. Every high level group is then examined further so that high level channels or excessive carrier leaks within the group may be identified. This technique offers considerable time saving compared with the separate measurement of all individual channels or carriers.

Since the monitor contains a non-volatile memory and is self-starting after supply interruption, it is particularly suitable for remote locations from where it can be interrogated and/or controlled from a central computer.

Detailed literature on the Automatic Baseband Monitor is available on application as is information relating to other, less sophisticated, intermediate levels of system configuration.

Systems testing of 12 MHz coaxial cable terminals. *By courtesy of the British Post Office.*

20 MHz Level Oscillator TF 2356

FREQUENCY	
Range	6 kHz to 20 MHz (unbalanced). 6 kHz to 620 kHz (balanced). Usable down to 100 Hz.
Resolution	5 Hz, display resolution 10 Hz.
Accuracy	±1 in 10^6 (internal standard).
Control	Keyboard entry and MANUAL TUNING control.
Display	7 digits with decimal point and units (e.g. 12345·67 kHz).
LEVEL	Switchable to dBm or dB relative to 0·775 V.
Range (see note 1)	—70 dBm to + 10 dBm (—80 dB to 0 dB). 1 dB steps via keyboard plus $\pm$1·1 dB continuously variable or 0·1 dB steps via keyboard. (Remote control —70 dBm to +11 dBm in 0·1 dB steps.).
	Note 1. Maximum output via keyboard of +3 dBm on 50 Ω and 60 Ω unbalanced output impedances.
Display	3 digits with decimal point and meter scaled $\pm$1·1 dB in 0·1 dB divisions. Meter inoperative when level is entered on keyboard to 0·1 dB resolution.
Output disable	The output may be suppressed by at least 60 dB. This is automatic during frequency or level change, or manually controlled.
Level accuracy	$\pm$0·1 dB at 0 dBm 100 kHz, 75 Ω with nominal mains voltage.
Frequency response	$\pm$0·15 dB, 6 kHz to 20 MHz, referred to 100 kHz at 0 dBm, 75 Ω, unbalanced. $\pm$0·15 dB, 6 kHz to 620 kHz, referred to 100 kHz at 0 dBm, balanced.
Attenuator accuracy	$\pm$0·1 dB.
OUTPUT IMPEDANCE	
Unbalanced	0 Ω, 50 Ω, 60 Ω, 75 Ω.
	Return loss: > 34 dB at 75 Ω.
Balanced	0 Ω, 124 Ω, 135 Ω, 150 Ω.
	Return loss: > 30 dB.
	Balance ratio: > 40 dB.
SPURIOUS SIGNALS	
Harmonically related	Better than —50 dB at 1 MHz and 0 dBm.
Non harmonically related	Better than —60 dB.
INPUTS	
External 10 MHz standard	50 Ω input impedance *Level:* —10 to 0 dBm. (d.c. path of less than 10 kΩ must be present to disable internal standard).
30-50 MHz	50 Ω input from receiver for synchronized operation. *Level:* —10 dBm.
External levelling	Approx. 33 mV/dB over range $\pm$1 dB. (equivalent to 2 mV rms per 1% a.m.).
	Bandwidth: d.c. to 100 kHz.
	Impedance: 10 kΩ.
	Application: to enable sender levelling over the range 6 kHz to 20 MHz within typically $\pm$0·02 dB of the response of a standard mW test set with d.c. error output of 30 mV/0·01 dB sensitivity.
Remote command	Remote initiation of pre-programmed sequences is controlled by contact closure at a rear panel socket.

REMOTE CONTROL	All functions are remotely programmable via the IEEE/IEC bus when sender is fitted with GPIB Kit (see optional accessories).
PRE-PROGRAMMED BUS CONTROL CAPABILITY	When connected to the receiver and a printer, the sender acts as bus controller. Modes of operation are described in the text.
SAFETY REGULATIONS	Complies with IEC 348 and BS 4743 safety requirements.
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 25 kN/m² differential, i.e. 3·7 lbf/in²).
POWER REQUIREMENTS	
AC supply	95 to 130 V or 190 to 260 V. 45 to 500 Hz, 40 VA (including GPIB option).
Battery option	See optional accessories.
Operation time	Approx. 5 hours.
Charging time	Approx. 14 hours (trickle charges when mains operated).
DIMENSIONS AND WEIGHT	Height 135 mm 5·25 in; Width 430 mm 17 in; Depth 570 mm 22·5 in; Weight 16 kg 35 lbs

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VERSIONS AND ACCESSORIES

When ordering please quote eight-digit code numbers

Ordering numbers	Versions
52356-900S	Level Oscillator TF 2356
52356-301H	Level Oscillator TF 2356 factory fitted with GPIB interface option.
	Supplied Accessories
	Supply Lead (Side Entry) 43129-003W
	Front Panel Cover (with stowage for leads) 41690–179K.
	Cover Internal Lid (includes operating summary).
	Optional Accessories
41148-605K	Board Extractor.
44827-868H	Extender Board (Wide).
44827-869E	Extender Board (Narrow).
43126-012S	Lead (BNC-BNC) 50 Ω, 1·5 m.
46883-319F	GPIB Interface Kit.
43129-189U	GPIB Lead, 1 m, (Amphenol 57, 24 way connectors).
43113-004K	Battery Unit (including battery pack of 24× 1·2V NiCd D type cells).
54351-011F	Lead (BNC-BNC), 75 Ω, 1·8 m.
54127-071H	Rack Mounting Kit.

20 MHz Selective Level Meter TF 2357

FREQUENCY

Range	6 kHz to 20 MHz (unbalanced). 6 kHz to 620 kHz (balanced). Usable down to 100 Hz.
Resolution	5 Hz. Display resolution 10 Hz.
Accuracy	±1 in 10^6 (internal standard).
Control	Keyboard entry and MANUAL TUNING Control.
Display	7 digits with decimal point and units (e.g. 12345·67 kHz).

LEVEL MEASUREMENT

Switchable to dBm or dB relative to 0·775V.

Automatic mode	*Range:* −115 dBm to +20 dBm (−125 dB to +10 dB). *Resolution:* 0·1 dB. *Display:* 4 digits with decimal point (e.g. −102·6 dBm).
Remote control mode (with GPIB interface only).	*Range:* −120 dBm to +20 dBm (−130 dB to +10 dB). *Resolution:* 0·01 dB.
Manual mode	*Range:* —121 dBm to +26 dBm (—131 dB to +16 dB). *Display (digital):* 3 digit keyboard entered reference level (1 dB resolution). *Display (analogue):* Meter scaled to ±0·6 dB, 0·02 dB divisions and +6 dB, 0·2 dB divisions, switch selected.
Measurement accuracy	±0·1 dB at 0 dBm, 100 kHz, 20° C with nominal mains voltage, after self-calibration. Note : for optimum accuracy AFC should be switched ON ensuring that input and calibrate signals are coincident in frequency.
Frequency response (at 0 dBm relative to 100kHz)	±0.1 dB 20 kHz to 16 MHz ±0·15 dB 6 kHz to 20 MHz } unbal. ±0·15 dB 6 kHz to 620 kHz balanced.
Attenuator accuracy	±0·1 dB.
Calibrate	Calibrates at tuned frequency to compensate for frequency response and r.f. attenuation error. AUTOMATIC, SINGLE SHOT or OFF switch selected. In automatic mode operates whenever frequency or level is changed or every minute and at switch on.

INPUT IMPEDANCE

Unbalanced	50 Ω, 60 Ω, 75 Ω terminated and approximately 10 kΩ 'thro'. *Return loss:* > 34 dB. *Frequency range:* 6 kHz to 20 MHz.
Balanced	124 Ω, 135 Ω, 150 Ω terminated and approximately 20 kΩ 'thro'. *Return loss:* > 30 dB. *Balance ratio:* > 40 dB. *Frequency range:* 6 kHz to 620 kHz.

BANDWIDTH

Pilot	± 0·1 dB, 40 Hz. − 3 dB > 50 Hz. −60 dB, 190 Hz nominal.
Noise	−0·5 dB, 1 kHz. − 3 dB, 1·74 kHz nominal. −60 dB, 5 kHz nominal. ***Effective noise band-width:*** 1·74 kHz.
Channel	−0·5 dB, 2 kHz. −3 dB, 3·1 kHz nominal. −60 dB, 6 kHz nominal.

AUTOMATIC FREQUENCY CONTROL

Function	Phase detector enables receiver to lock input signal to centre of pass band with AFC ON.
Frequency indication	When locked, display frequency is that of input signal ± 5 Hz.
Search above threshold	In manual mode with automatic frequency incrementing initiated by spinning manual tuning control, a.f.c. locks onto any signal exceeding the digitally entered threshold level.

INTERNAL DISTORTION

Harmonic	2nd and 3rd harmonics better than −70 dB.

OUTPUTS

Audio	Output impedance 600 Ω, level approximately 0 dBm when meter reads 0 dB. Upper or lower sideband demodulation by switch selection on 3·1 kHz bandwidth.
Loudspeaker	Permits audible monitoring of demodulated output. A volume control is provided.
Recorder	±0·6 V corresponding to full scale points of centre-zero meter across a 1 kΩ load.
Tracking generator	Provides output signal at tuning frequency. *Impedance:* 75 Ω. *Level:* 0 dBm. *Frequency response:* ±0·2 dB, 6 kHz to 20 MHz.
Synchronising for Level Oscillator TF 2356	Internal 10 MHz standard, 50 Ω output impedance, −10 dBm. 30 to 50 MHz output, 50 Ω output impedance, −10 dBm.
Probe supply	Supply available at front panel socket to power Zero Loss Probe TK 2374 series.

INPUT

External 10 MHz standard	50 Ω input impedance, level in range 0 dBm to − 10 dBm (d.c. path of less than 10 kΩ must be present to disable internal standard).

FILTER UNIT CONNECTIONS

Filter Unit TK 2366 may be connected via the following inputs and outputs.

Wideband output	6 kHz to 20 MHz, 75 Ω output impedance.
2·1 MHz (wide) output	2·1 MHz, 1·2 MHz bandwidth, 75 Ω output impedance.
2·1 MHz (narrow) output	2·1 MHz, 48 kHz bandwidth, 75 Ω output impedance.

Detected input and control lines	Filter Unit detector input to receiver and control lines to control Filter Unit from GPIB via receiver.
REMOTE CONTROL	All functions are remotely programmable via the IEEE/IEC bus when receiver is fitted with GPIB kit (see optional accessories).
BUS CONTROL BY LEVEL OSCILLATOR	When connected to the sender and a printer, the receiver is controlled by the sender. Modes of operation are described in the text.
SAFETY REGULATIONS	Complies with IEC 348 and BS 4743 safety requirements.
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 25 kN/m² differential, i.e. 3·7 lbf/in²).
POWER REQUIREMENTS	
AC supply	95 to 130 V or 190 to 260 V. 45 to 500 Hz, 40 VA (including GPIB option).
Battery operation	See optional accessories.
Operation time	Approx. 5 hours.
Charging time	Approx. 14 hours (trickle charges when mains operated).
DIMENSIONS AND WEIGHT	Height 135 mm 5·25 in; Width 430 mm 17 in; Depth 570 mm 22·5 in; Weight 16 kg 35 lbs

VERSIONS AND ACCESSORIES

When ordering please quote eight-digit code numbers

Ordering Numbers	
	Versions
52357-900Z	Selective Level Meter TF 2357.
52357-301S	Selective Level Meter TF 2357 factory fitted with GPIB interface option.
	Supplied Accessories
	Supply Lead (Side Entry) 43129-003W. Front Panel Cover (with stowage for leads) 41690-179K. Cover Internal Lid (includes operating summary). 10 MHz Standard Output 50 Ω load. 30-50 MHz Output 50 Ω load.
	Optional Accessories
41148-605K	Board Extractor.
44827-868H	Extender Board (Wide).
44827-869E	Extender Board (Narrow).
43126-012S	Lead (BNC-BNC), 50 Ω, 1·5 m.
46883-319F	GPIB Interface Kit.
43129-189U	GPIB Lead, 1 m, (Amphenol 57, 24 way connectors).
43113-004K	Battery Unit (including battery pack of 24× 1·2 V NiCd type cells).
54351-011F	Lead (BNC-BNC), 75 Ω, 1.8 m.
54127-071H	Rack Mounting Kit.
52374-901R	Zero Loss Probe, 75 Ω version, TK 2374/1.
52374-900C	Zero Loss Probe, 50 Ω version, TK 2374.
	Associated Equipment
52365-900Y	75 Ω Coaxial Switch Unit TF 2365.
52366-900T	Baseband Filter Unit TK 2366.

The accuracy of any measuring instrument is dependent on the accuracy of the standards against which it is calibrated, so that the operation of an efficient standards laboratory is a vital element. Our laboratories are fully environmentally controlled and operate under clean air conditions.

GENERAL MEASURING EQUIPMENT

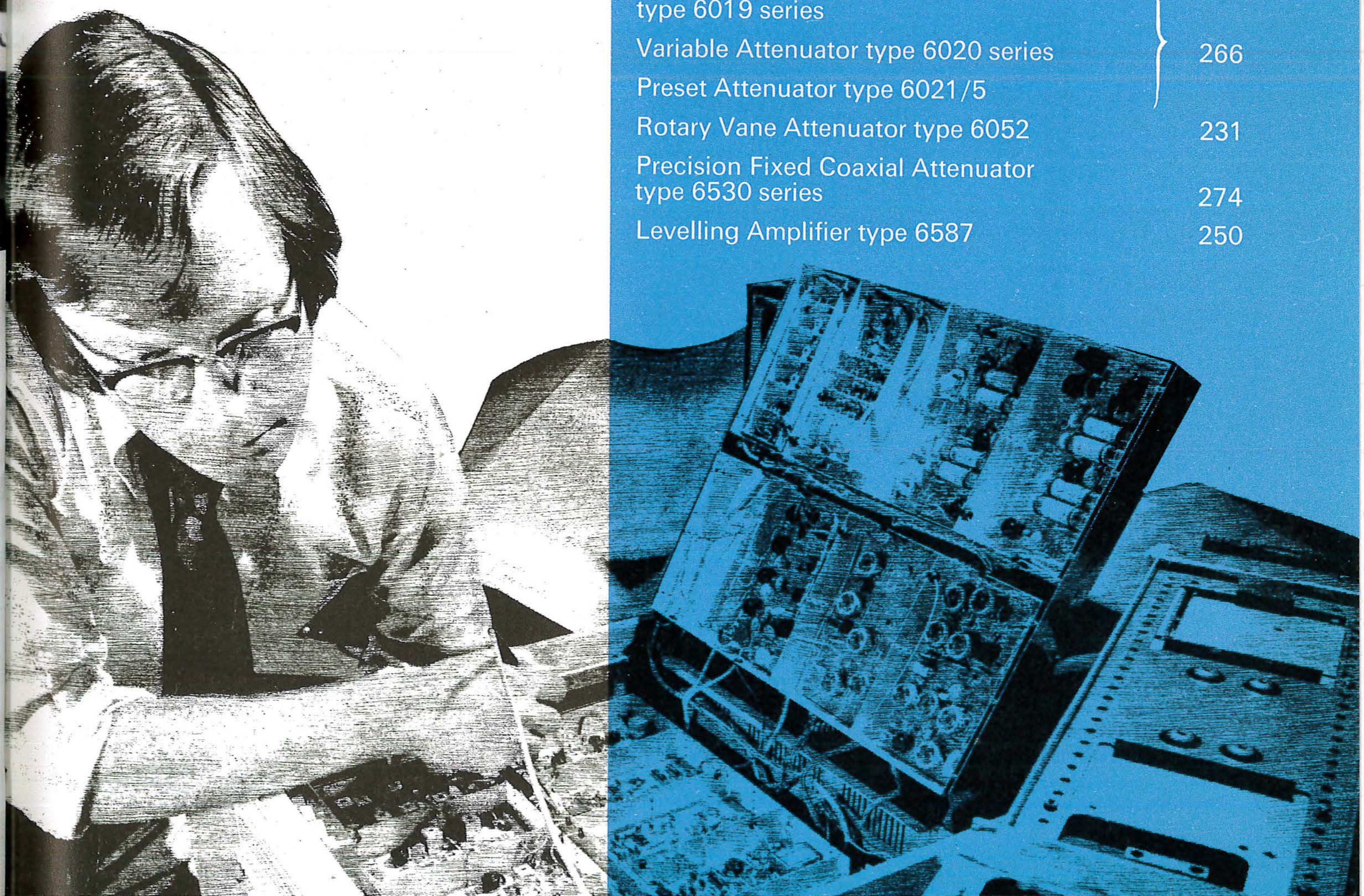
Power Supplies	TF 2154-5	86
Attenuator (D C to 1 MHz)	TF 2162	88
UHF Attenuator (D C to 1 GHz)	TF 2163S	89
RF Amplifier (50 kHz to 80 MHz)	TF 2167	90
RF Amplifier (2 to 500 MHz)	TF 2175	91
X-Y Display (Single channel)	TF 2212A series	92
X-Y Display (Dual channel)	TF 2213A series	94

For further Power Supplies see the Microwave Products Section:

Power Supply type 6590	251

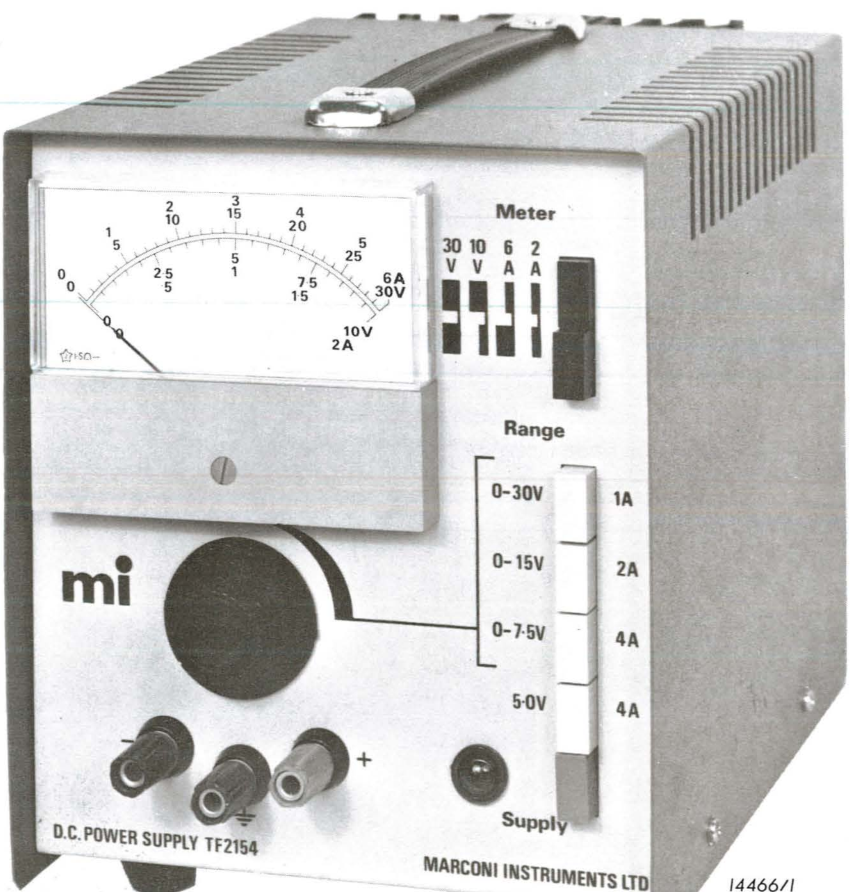
For further Attenuators and Amplifiers see the Microwave Products Section:

Calibrated Variable Attenuator Grade 2 type 6019 series Variable Attenuator type 6020 series Preset Attenuator type 6021/5	266
Rotary Vane Attenuator type 6052	231
Precision Fixed Coaxial Attenuator type 6530 series	274
Levelling Amplifier type 6587	250



DC Power Supply

- Output voltages up to 60 V
- Output currents up to 4A
- 15 or 30W maximum
- Fixed 5 V output for standard logic circuits
- Current limiting for load protection
- Two-terminal and centre-tapped versions



This series of general purposes power supplies provides an output capability of up to 60 volts, depending on model, continuously variable by means of an uncalibrated front panel control. Load current limits of up to 4 amps can be selected.

Carefully arranged push-button controls make the power supplies very simple to operate. Two push-buttons alongside the panel meter select monitoring of output voltage or current, with two sensitivities for each mode. Operation of these buttons has no effect on the output of the unit.

A bank of four push-buttons permits the selection of any of nine combinations of voltage range and current limit. When any one button is pressed the voltage range and current limit associated with it are obtained. If more than one button is operated the output is that corresponding to the lowest levels selected. Thus any current limit can be selected up to the maximum output obtainable on any voltage range.

Protection of the load circuit is given by the current-limiting facility. If the load resistance is such that the current limit would be exceeded at the power supplies voltage setting the circuit automatically converts to a constant current source and the output voltage is reduced to a level such that the current limit is not exceeded. Built-in protection circuits also prevent internal damage in the event of a short circuit across the output terminals.

A useful feature of all these supplies is the provision of an output voltage stabilized at a fixed value of five volts, for use with standard logic circuits.

The standard version of each power supply provides a two-terminal, fully-floating source completely isolated from the case. An alternative version of each unit is available with an accurately regulated centre-tap. The current limit operates if the current in either half of the supply exceeds the specified value, and both halves of the supply voltage are reduced together.

If higher power or voltage outputs are required two or more power supplies may be connected in series.

OUTPUTS	Push-button selected.
TF 2154	0 to 30 V at 1 A. 0 to 15 V at 1 A or 2 A. 0 to 7·5 V at 1 A, 2 A or 4 A. 5 V ±1% at 1 A, 2 A or 4 A.
TF 2155	0 to 60 V at 0·5 A. 0 to 30 V at 0·5 A or 1 A. 0 to 15 V at 0·5 A, 1 A or 2 A. 5 V ±1% at 0·5 A, 1 A or 2 A.
TF 2154/1 TF 2155/1	As above plus centre-tap facility.
OUTPUT IMPEDANCE	Typically 15 mΩ at 1 kHz.
CURRENT LIMIT	Nominally 110% of selected full load current.
REGULATION	
Supply Line	Less than 0·02% of maximum output for a 10% a c. supply line change.
Load	Less than 2 mV +0·05% of maximum output on the range selected for a 100% load change.
RIPPLE AND NOISE	Less than 1 mV p-p.
TEMPERATURE COEFFICIENT	Typically less than 0·02% per °C at 25°C.
METER RANGE	Push-button selected.
TF 2154	0 to 10 V and 0 to 30 V; 0 to 2 A and 0 to 6 A.
TF 2155	0 to 20 V and 0 to 60 V; 0 to 1 A and 0 to 3 A.
TRANSIENT RESPONSE	Recovers to 50 mV within 20 μs for full load step change.
CENTRE TAP TRANSIENT RESPONSE	Recovers to 50 mV within 30 μs for full load step change.
CENTRE TAP TRACKING (TF 2154/1, TF 2155/1)	49 to 51% of total output ±100 mV (down to 4 V total output).
OPERATING TEMPERATURE RANGE	0 to 45°C.
SAFETY	Designed to meet the requirements of IEC 348.
POWER REQUIREMENTS	
AC supply	110, 120, 220, 240 V ±10%. 50 to 60 Hz.

DIMENSIONS AND WEIGHT

Height	Width	Depth	Weight
180 mm	153 mm	255 mm	4·5 kg
7 in	6 in	10 in	9·9 lb

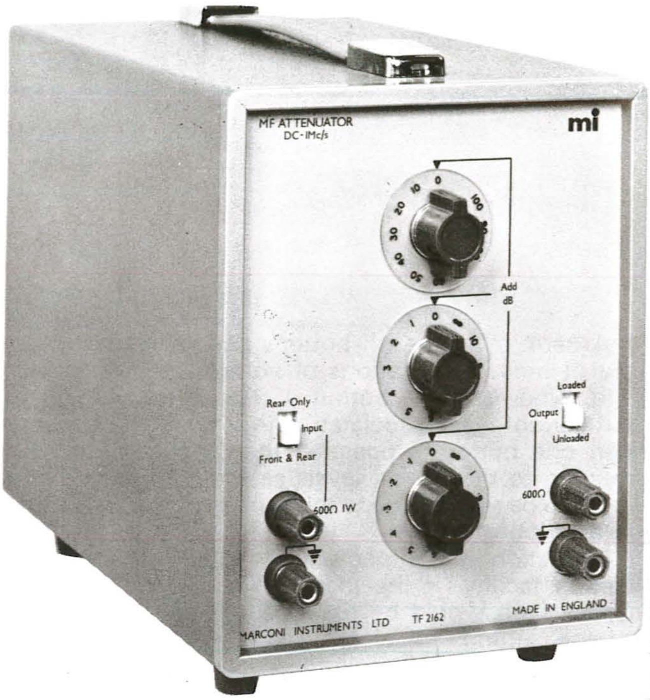
VERSIONS

When ordering please quote eight-digit code numbers

Ordering numbers	Versions
52154–900E	TF 2154.
52154–901V	TF 2154/1, Centre-tapped version.
52155–900W	TF 2155.
52155–901D	TF 2155/1, Centre-tapped version.

MF Attenuator

- ☐ 0 to 111 dB
- ☐ Steps of 0·1 dB



14094/1

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.

The instrument conforms to the M.I. modular dimensional standard; and, in its bench mounting form, is housed in a one-third module casing. It can, of course, occupy any position in a full-module rack-mounting case, and is provided with an auxiliary rear input socket for convenience when used in this way.

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. ±2% of dB setting ±0·2 dB, at 1 MHz.
SAFETY	Designed to meet the requirements of IEC 348.

DIMENSIONS AND WEIGHT	Height	Width	Depth	Weight
	195 mm	145 mm	270 mm	2·5 kg
	$7\frac{3}{4}$ in	$5\frac{3}{4}$ in	$10\frac{1}{2}$ in	$5\frac{1}{2}$ lb

VERSIONS AND ACCESSORIES

When ordering please quote eight-digit code numbers.

Ordering numbers	
	Versions
52162–900L	TF 2162. Instrument in case for bench use.
	Supplied Accessories
	Accessory Kit 46883–095D comprising: Shielded Adapter TB 39868 (43168-008S) Coaxial Free Plug 23441–014W.
	Optional Accessories
41635–041P	Rack-mounting Case TM 7010.
41674–015P	Blank Panel Unit ($\frac{1}{3}$ module) TM 6844.
43125–028T	Signal Lead TM 6958.

UHF Attenuator TF 2163S

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

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.

Controls

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.

Connections

Type N inlet and outlet sockets are provided.

Housing

The instrument conforms to the Marconi modular dimensional standard; and in its bench mounting form is housed in a one-third module casing. It can, of course occupy any position in a full-module rack mounting case. It is supplied with a front panel lid equipped to stow a coaxial fuse unit, spare fuses, and two type N to BNC adapters.

11002/2

FREQUENCY RANGE	DC to 1 GHz.
ATTENUATION	
Range	DC to 1 GHz. 0 to 142 dB in 1 dB steps.
Accuracy	Up to 130 dB at 1 kHz ±0·5% ±0·1 dB. Up to 100 dB at 1 GHz ±1% ±0·2 dB. Up to 130 dB at 1 GHz ±1·5% ±0·2 dB.
IMPEDANCE	50 Ω input and output.
VSWR	Not exceeding: 1·1 below 200 MHz. 1·25 below 500 MHz. 1·5 below 1 GHz.
MAXIMUM POWER INPUT	0·5 W.
INSERTION LOSS	Approx. 0·3 dB per 100 MHz.
SAFETY	Designed to meet the requirements of IEC 348.

DIMENSIONS AND WEIGHT	Height	Width	Depth	Weight
	195 mm	145 mm	270 mm	3·63 kg
	7¾ in	5¾ in	10½ in	8 lb

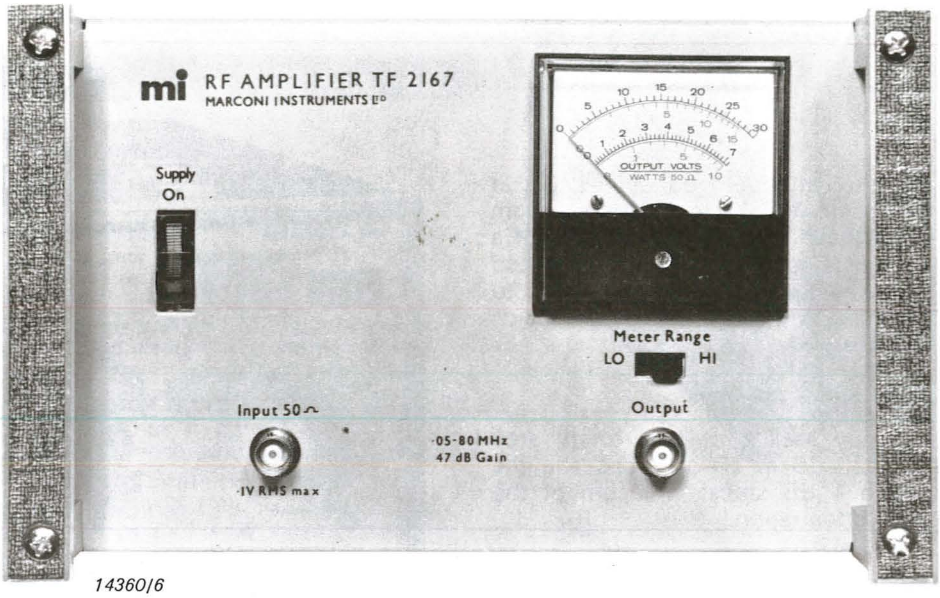
VERSIONS AND ACCESSORIES

When ordering please quote eight-digit code numbers

Ordering numbers	
	Versions
52163–025J	UHF Attenuator TF 2163S. (NATO Cat. No. 6625–99–519–9976. CT 553).
	Optional Accessories
43126–026A	Connecting Lead TM 4726/286, 50 Ω, Type N, 457 mm (18 in).
43281–001W	RF Fuse TM 5753.
23411–503T	Box of five concentric fuses.
41635–041P	Rack Mounting Case TM 7010.
23443–804G	Adapter Type N (male) to BNC (female), 50 Ω.
41674–015P	Blank Panel Unit (1/3 module) TM 6844 (2 required).

TF 2167 RF Amplifier

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



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The TF 2167 is a broad-band, solid-state power amplifier for use over the frequency range 50 kHz to 80 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.

Freedom from the need for tuning or band-switching enables the amplifier to be used with maximum convenience in conjunction with a low-power, variable frequency, signal source – such as a signal generator or sweep generator – for a number of applications. These include calibration and test of r.f. voltmeters and power meters, measurement of feeder loss or v.s.w.r. by monitoring the forward and return power, and plotting the radiation patterns of aerials. The high level r.f. output available is also useful in the calibration of attenuators, in tests on filters, and for testing such components as r.f. transformers, capacitors, and dummy loads. The TF 2167 may also be used as a driver amplifier for checking the output stage of an h.f. transmitter, with a signal generator or sweeper as the primary source. Most modulated signals can be amplified to high power levels without significant distortion.

The instrument is compact and portable, the need for very large dissipative components being obviated by the use of forced air cooling. It is normally housed in a well ventilated cabinet suitable for bench use, but is also available in standard 19-inch rack mounting form.

FREQUENCY	
Bandwidth	50 kHz to 80 MHz.
Response characteristic	Flat ± 1 dB over above bandwith 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	± 3% f.s.
Power ranges	0 to 1 W, 0 to 15 W, switch selected.
Power accuracy	±6% f.s.
SIGNAL PURITY	
Harmonic distortion	Total harmonic content is less than −30 dB relative to fundamental.
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.			
SAFETY	Complies with the requirements of IEC 348.			
POWER REQUIREMENTS				
AC supply	105 to 125 V and 210 to 250 V. 50 to 60 Hz.			
DIMENSIONS AND WEIGHT	Height	Width	Depth	Weight
	130 mm	220 mm	370 mm	9 kg
	5¼ in	8½ in	14¼ in	20 lb

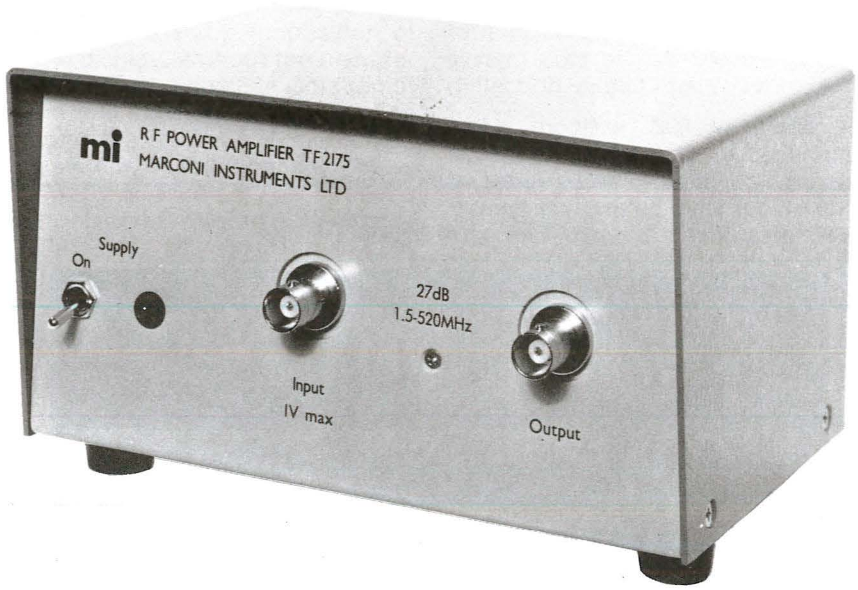
VERSIONS AND ACCESSORIES
When ordering please quote eight-digit code numbers

Ordering numbers	
52167-301Z	**Versions** RF Amplifier TF 2167.
54127-011N	**Optional Accessory** Standard 19 inch Rack Mounting Kit.

Made in U.S.A.

RF Amplifier TF 2175

- Bandwidth: 1·5 MHz to 520 MHz
- 300 mW linear output
- 27 dB gain
- All solid state
- Light and compact



RF Amplifier TF 2175 is a compact, general purpose amplifier capable of providing moderate power outputs over a wide frequency range. It can be used to extend the power output capability of signal generators, sweep generators and other signal sources.

With this amplifier the output of any signal source can be increased by 27 dB, giving a linear output power of more than 300 mW over the frequency range of 1·5 to 520 MHz. The output will be a faithful reproduction of the input for most forms of modulation including AM, FM, SSB, CATV and pulse modulation.

TF 2175 is unconditionally stable and will operate into any load without failure or oscillation. It features a low-noise, linear Class A amplifier and has very low harmonic and intermodulation distortion. When used as a video amplifier it will faithfully reproduce pulse waveforms with rise times as short as 1 ns.

Other likely applications include use as a drive source for antennas and lasers, ultrasonic applications and RFI testing. The high output and low noise figure make it suitable for the amplification and distribution of television and other signals over long cables.

The instrument is all solid-state, using hybrid integrated circuits mounted on a microstrip module, and is light, compact and rugged.

FREQUENCY	
Bandwidth	1·5 MHz to 520 MHz.
Response characteristic	Flat to ±1 dB over the above bandwidth when feeding a 50 Ω load.
OUTPUT LEVEL	
Maximum linear power output	Greater than 300 mW (+24·8 dDm, 3·9V) into a 50 Ω load.
Input for 300 mW output	0·6 mW (−2·2 dBm, 170 mV into 50 Ω).
GAIN	27 dB ±1 dB.
OUTPUT IMPEDANCE	50 Ω.
SIGNAL PURITY	
Harmonic distortion	Total harmonic content is less than −30 dB relative to the fundamental at 200 mW output.
Typical 3rd order intermodulation intercept point	+35 dBm.
Noise figure	Less than 9·5 dB (typically 8 dB).
DYNAMIC RANGE	Greater than 80 dB.
STABILITY	Unconditionally stable.
INPUT CONDITIONS	
Input impedance	50 Ω.
VSWR	Less than 2:1.
Maximum input level	Instrument will withstand an input up to 1 V r.m.s. (+14 dB overdrive) for all output load conditions.
CONNECTORS	BNC.
SAFETY	Designed to meet the requirements of IEC 348
POWER REQUIREMENTS	
AC mains	115 V or 230 V, ±12%. 50 to 400 Hz; 20 W.

DIMENSIONS AND WEIGHT	Height	Width	Depth	Weight
	98 mm	165 mm	112 mm	1·1 kg
	3½ in	6½ in	4½ in	2½ lb

VERSIONS AND ACCESSORIES

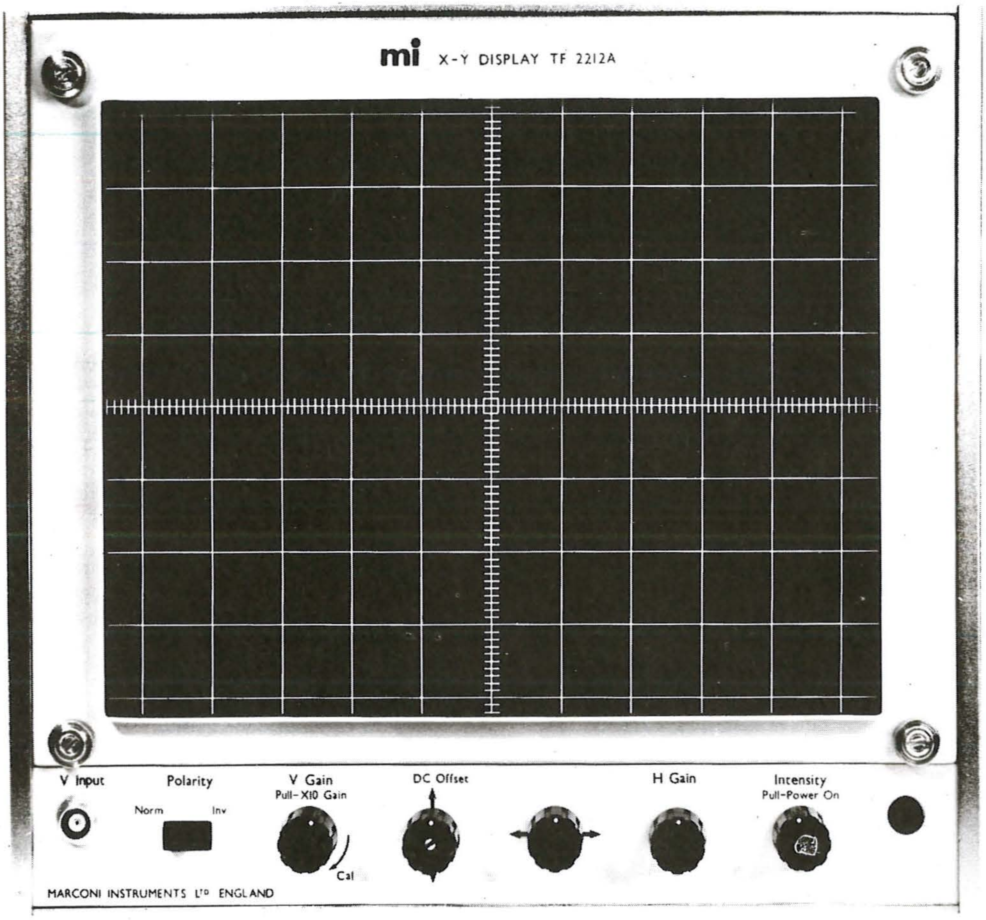
When ordering please quote eight digit code numbers.

Ordering numbers	
52175–301Y	**Versions** RF Amplifier TF 2175.
52167–900V	**Complementary equipment** RF Amplifier TF 2167. Broad band power amplifier for frequency range 50 kHz to 80 MHz.

Made in U.S.A.

X-Y Display

- Large screen display
- Built-in marker adder
- Sensitivity: 5 mV/cm
- Automatic spot blanking



X-Y Display TF 2212A is primarily intended for use with a sweep generator or spectrum analyser, or for similar applications. It is ideally suitable for use with Marconi Instruments Sweep Generator TF 2361, and MI-Sanders Microwave Sweep Oscillator type 6600A. It employs an 11 inch cathode-ray tube with electromagnetic deflection, giving a usable viewing area of 220×170 mm ($8\frac{1}{2} \times 6\frac{1}{2}$ inches). A graticule marked on a removable perspex screen forms a grid of 2 cm squares, with horizontal and vertical centre lines marked in 2 mm divisions.

The vertical deflection system is d.c. coupled, with a 3 dB bandwidth of 10 kHz. The gain of the vertical amplifier is continuously variable from zero to a calibrated sensitivity of 5 mV/cm. By pulling out the rotary gain control knob, a 10:1 attenuator may be switched into circuit, giving a calibrated sensitivity of 50 mV/cm at the maximum gain setting. A front-panel POLARITY switch is provided for inverting the trace.

A marker-adder circuit also forms part of the vertical deflection system. This facilitates the superimposition of vertical marker pulses on the display, without the need for an external mixing network and with complete isolation of the marker generator from the device under test. The associated input socket is at the rear of the instrument together with an inverting switch, enabling marker pulses in the upward and downward direction to be obtained from input pulses of either polarity. Provision is also made for producing brightness markers (Z modulation) from positive or negative going input pulses.

The gain of the horizontal deflection system is also continuously variable down to zero, the deflection sensitivity at maximum gain being normally 100 mV/cm.

In order to prevent accidental burning of the cathode-ray tube screen by a stationary spot, an automatic blanking system cuts off the electron beam when the horizontal deflection velocity falls to zero.

An important feature of the instrument is the ready accessibility of its internal circuit units for ease of servicing. Utilising all-solid-state active elements, the circuits are formed on printed boards, which are easily replaceable. The instrument is constructed on the principle of a basic open framework carrying the circuit units, with detachable panels to form the outer casing.

TF 2212A/1 is a long persistence tube version of the standard TF 2212A.

VERTICAL AXIS	
Sensitivity	Calibrated 5 mV/cm and 50 mV/cm positions with continuously variable control.
Maximum input	250 V.
3 dB bandwidth	DC to 10 kHz.
Input impedance	Approximately 500 kΩ.
Input connector	Front panel BNC.
HORIZONTAL AXIS	
Sensitivity	Approximately 100 mV/cm with continuously variable control.
Maximum input	350 V.
3 dB bandwidth	DC to 1 kHz.
Input impedance	Approximately 500 kΩ.
Blanking	Automatic spot blanking is provided for a no signal input condition.
Input connector	Rear panel terminals.
PULSE MARKER	
Pulse polarity	Switch selected positive or negative.
Repetition rate	Maximum pulse repetition rate 100 kHz.
Input	50 V maximum with independent amplitude control.
Sensitivity	Better than 2 V/cm.
Input impedance	Approximately 50 kΩ.
Input connector	Rear panel terminals.

INTENSITY MODULATION MARKER (Z AXIS)	
Input pulse amplitude	+2/−2 V for intensity modulation.
Maximum input	50 V.
Input connector	Rear panel BNC socket.
VOLTAGE OUTPUT	Rear panel terminal provides sample output from vertical amplifier.
SAFETY	Complies with the requirements of IEC 348.
POWER REQUIREMENTS	100, 110, 120, 200, 220 or 240 V a.c. ±10%. 50 to 60 Hz approximately 40 VA.
DIMENSIONS AND WEIGHT	Height 268 mm $10\frac{1}{2}$ in; Width 280 mm 11 in; Depth 292 mm $11\frac{1}{2}$ in; Weight 6·5 kg 14·3 lb

VERSIONS AND ACCESSORIES

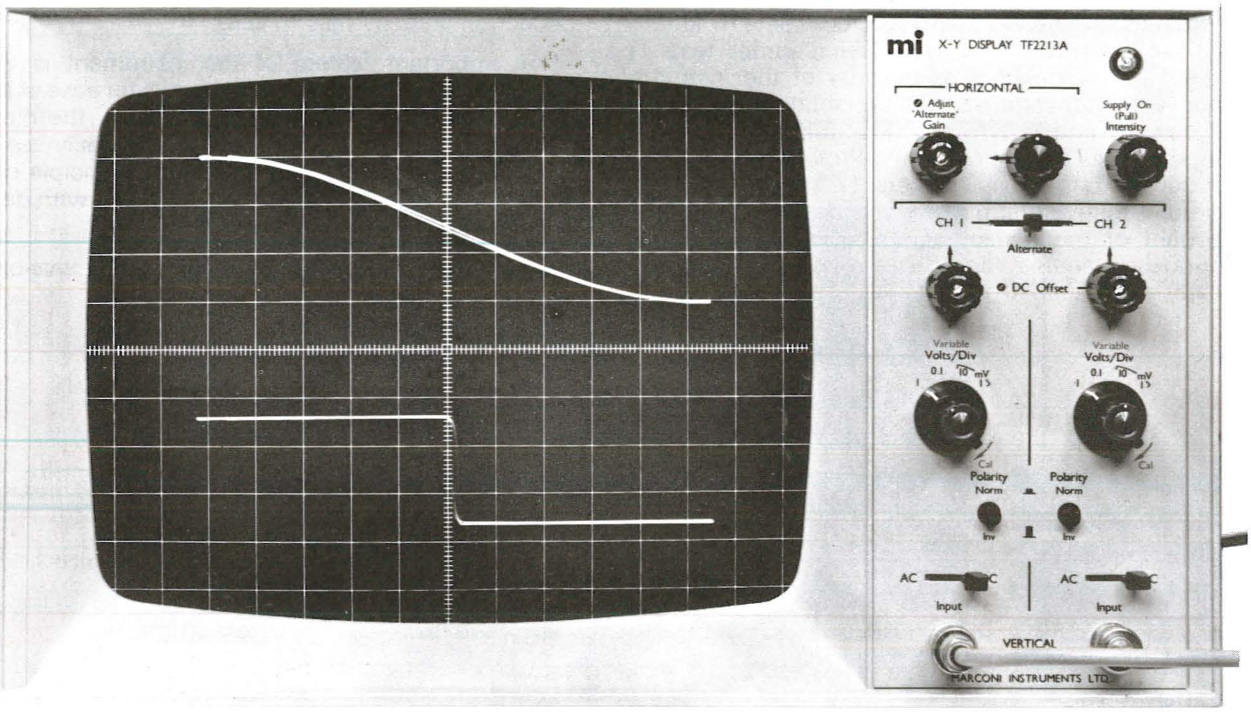
When ordering please quote eight-digit code numbers.

Ordering numbers	
	Versions
52212–910P	X-Y Display TF 2212A. Standard version.
52212–911X	X-Y Display TF 2212A/1. Version with long-persistence P7 tube.
	Optional Accessories
54127–031R	Rack Mounting Kit.

Made in Japan

X-Y DISPLAY

- Dual channel display
- 28 cm screen size
- Sensitivity : 1 mV/div
- Automatic spot blanking



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The X-Y Display TF 2213A is a large screen dual channel unit incorporating trace invert facilities. Although it is primarily intended for use with sweep generators, it has general applications for instructional purposes and wherever a large screen display is required. It is particularly suitable for use with Marconi Instruments Sweep Generator TF 2361 and Television Sweep Analyser OA 2900.

Both vertical channels have switched input attenuators giving calibrated sensitivity of 1 mV/div to 1 V/div in four 20 dB steps, with a fine variable control allowing interpolation between the four switched positions. The frequency bandwidth of each channel is d.c. to 10 kHz ±3 dB, and the maximum input is 250 V p-p.

The vertical display modes are: CHANNEL 1 only, CHANNEL 2 only, or ALTERNATE for horizontal deflection signals in the range 0 to 100 Hz. Both amplifiers have front-panel selection of either a.c. or d.c. coupling and normal or inverted inputs.

Two reference markers may be applied to the vertical amplifiers simultaneously. These are the intensity modulation (Z-axis) markers and the pulse added marker, with associated input sockets at the rear of the instrument. The pulse markers can be switched to positive or negative and their amplitudes attenuated as required.

The horizontal axis amplifier has a 1 kHz bandwidth and a sensitivity of 100 mV/div, with a continuously variable control and a maximum input of 250 V. If no horizontal input is applied the trace is automatically blanked to prevent burning of the screen phosphor.

Screen size is 28 cm (11 inches) with a calibrated graticule of 10 divisions by 14 divisions. Two versions of the instrument are available; TF 2213A with a standard P4 phosphor, and TF 2213A/1 with a long-persistence P7 phosphor.

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VERTICAL AXIS

Sensitivity	1 mV/div to 1 V/div in four calibrated steps.
Accuracy	Within ±5% of indicated deflection with VARIABLE set at maximum clockwise (CAL) position.
Variable attenuator	Reduces the sensitivity by up to ten times the indicated deflection factor.
Frequency bandwidth	Within ±3 dB (referred to 1 kHz). DC to 10 kHz.
Input impedance	500 kΩ ± 30%.
Maximum input voltage	250 V p-p (d.c. + a.c. p-p).
Input coupling	AC or d.c. coupled. Selected by front-panel AC-DC switch.
Vertical display modes	CH 1: Channel 1 only. CH 2: Channel 2 only. ALTERNATE: Dual trace, alternate between channels. For horizontal deflection signals in the range 0 to 100 Hz.
Polarity inversion	Both CH 1 and CH 2 can be inverted.
Vertical linearity	Within 10%.
Vertical sample output	Approx. 0·5 V p-p for 5 division display.
Input connector	BNC connector (both channels).

HORIZONTAL AXIS

Sensitivity	100 mV/div (uncalibrated).
Gain	Continuously variable down to zero.
Frequency bandwidth	Within ±3 dB (referred to 100 Hz). DC to 1 kHz.
Input impedance	500 kΩ ± 30%.
Maximum input voltage	250 V p-p (d.c. + a.c. p-p).
Input coupling	AC or d.c. coupled. Selected by rear-panel switch.
Horizontal linearity	Within 10%.
Horizontal input modes	LINE: Line voltage stepped down. EXT: Sweep signal.
Input connector	BNC type coaxial connector.

Z AXIS

Sensitivity	2 V p-p signal produces noticeable modulation at normal intensity.
Polarity	Positive.
Input connector	BNC type coaxial connector.

PULSE MARKER ADDER

Sensitivity	2 V/div.
Amplitude	Continuously variable down to zero.
Frequency bandwidth	Within ±3 dB (referred to 10 kHz), 20 Hz to 30 kHz.
Input impedance	50 kΩ ± 30%.
Maximum input voltage	50 V p-p (d.c. + a.c. p-p).
Pulse polarity	Positive or negative, switched.
Input connector	12 mm terminal.

SAFETY

Designed to meet the requirements of IEC 348.

POWER REQUIREMENTS

AC mains	90 to 132 V or 180 to 264 V 50 to 60 Hz, 60 VA approximately.

CATHODE RAY TUBE

Tube type	280 VB4 11-inch 90-degree deflection.
Phosphor	**TF 2213A:** P4 (standard). **TF 2213A/1:** P7 (long-persistence).
Accelerating potential	Approximately 6 kV.
Graticule area	10 div (vertical) × 14 div (horizontal).

DIMENSIONS AND WEIGHT

Height	Width	Depth	Weight
220 mm	380 mm	300 mm	8·5 kg
$8\frac{3}{4}$ in	15 in	$11\frac{3}{4}$ in	19 lb

VERSIONS AND ACCESSORIES

When ordering please quote eight-digit code numbers

Ordering numbers	
	Versions
52213–910E	X-Y Display TF 2213A Standard version.
52213–911U	X-Y Display TF 2213A/1. Long persistence tube version.
	Supplied Accessories Hood.

Made in Japan

Marconi Instrumentation

Written by engineers for engineers this journal, issued three times a year, is an authoritative publication recognised throughout the industry for many years as a leading technical publication for users of electronic measuring instrumentation. It gives details of new instrument designs and the associated measuring techniques and measurement problems.

MI Contact

This news bulletin summarises the current activities of Marconi Instruments with features of technical interest, details of new products and brief reviews of useful applications and servicing notes.

Please advise your nearest local sales office if you wish to receive issues of the above two items regularly.

Measuretest

A series of notes describing in detail new and unusual applications for MI measuring instrumentation. Each note deals with one principal new application or measurement technique.

Details of the availability of Measuretest and other informative literature are given in MI Contact.

MODULATION AND DEVIATION METERS

FM/AM Modulation Meter (4 to 1200 MHz)	TF 2300B	98
Programmable FM/AM Modulation Meter	TF 2301A	102
FM/AM Modulation Meter (25 to 520 MHz)	TF 2303	104
FM/AM Modulation Meter (with auto-tuning)	TF 2304	106

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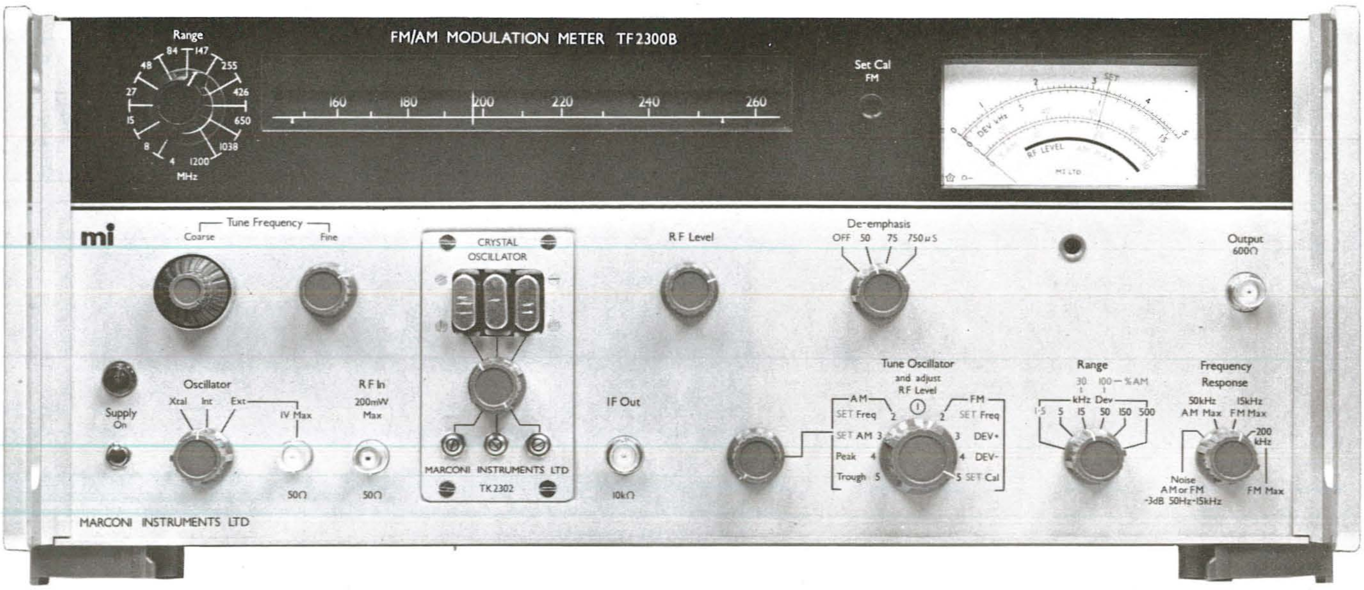
FM/AM Modulation Meter

- Measures f.m. deviation up to 500 kHz at carrier frequencies up to 1200 MHz
- Measures a.m. depth up to 95% at carrier frequencies up to 400 MHz
- Very low inherent noise facilitates narrow-deviation measurement
- Optional crystal oscillator for setting of regularly-used test frequencies



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TF 2300B with optional Crystal Oscillator TK 2302

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

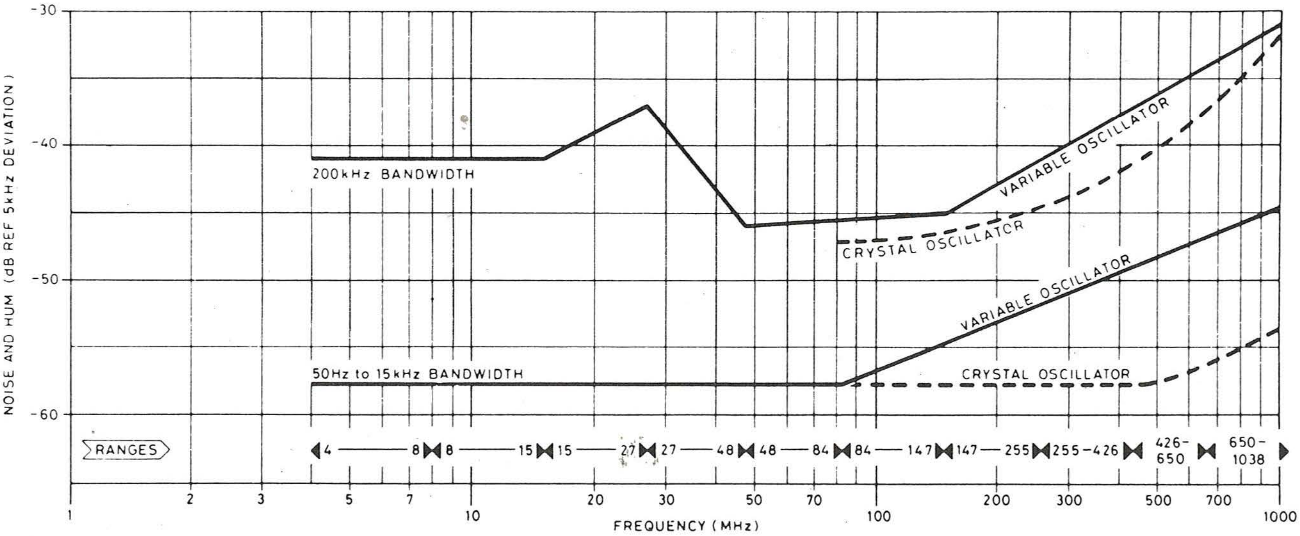
For measurement of very low values of deviation there is provision for connecting a sensitive external indicator, via a coaxial socket to the output of the l.f. amplifier. This outlet is also useful for applying the demodulated signal to secondary test equipment – e.g., an oscilloscope, psophometer or 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.



Typical modulation meter noise levels

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.

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.

I F 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.

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. ±5% of f.s.d. on the 1·5 kHz deviation range. ±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: −50 dB from 4 to 200 MHz (typically −56 dB) −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%. ±5% of f.s.d. for modulating frequencies between 30 Hz and 50 kHz, and modulation depths up to 95%.
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). Better than 35 mV between 426 and 1038 MHz (typically 15 mV). Better than 100 mV 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. 30 Hz to 3·4 kHz on the 1·5 kHz deviation range. 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%). Less than 0·3% for f.m. deviations up to ±300 kHz and modulating frequencies up to 25 kHz (typically less than 0·2%). 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). Less than 2% for a.m. depths between 80% and 90% (typically less than 1·0% between 60% and 90% depth).
SAFETY	Designed to meet the requirements of 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 25 kN/m² differential, i.e. 3·7 lbf/in²).
POWER REQUIREMENTS	
AC mains	95 to 130 V or 190 to 260 V. 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

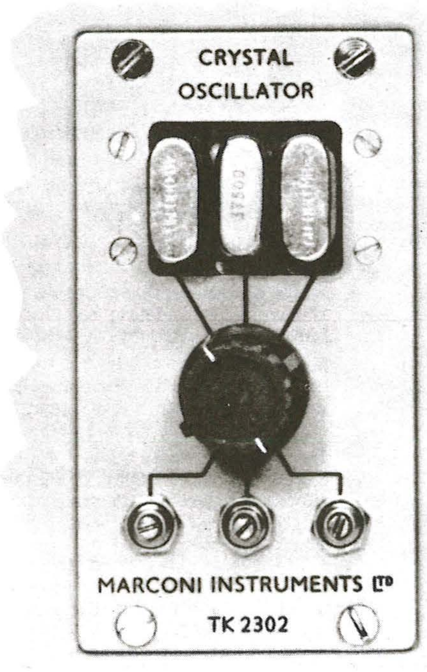
When ordering please quote eight-digit code numbers

Ordering numbers	
	Versions
52300–920F	TF 2300B standard version.
	The following versions may be available to special order.
52300–301J	TF 2300BM With parallel l.f. output socket on the rear panel.
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.
	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).

Optional Accessory

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. 80 to 400 MHz for a.m.
SENSITIVITY	Better than 12 mV between 80 and 500 MHz (typically 5 mV). Better than 100 mV 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: −52 dB up to 800 MHz (typically −56 dB). −50 dB from 800 to 1000 MHz (typically −55 dB).
CRYSTALS	Up to three switch selected crystals may be used. Marconi type QO 1670 Series, in fundamental frequency range 40 to 60 MHz. Equivalent series resistance 35 Ω ± 5 Ω. When ordering crystals please specify the r.f. operating frequency and we will advise the correct crystal frequency.

TF 2300BM

- ☐ Version with low-distortion auxiliary a.m. detector
- ☐ Measurement of a.m on f.m.
- ☐ AM measurements from 1·5 to 1000 MHz
- ☐ Accurate measurement of low modulation depths
- ☐ Distortion measurements on a.m. waveforms

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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 2331 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.

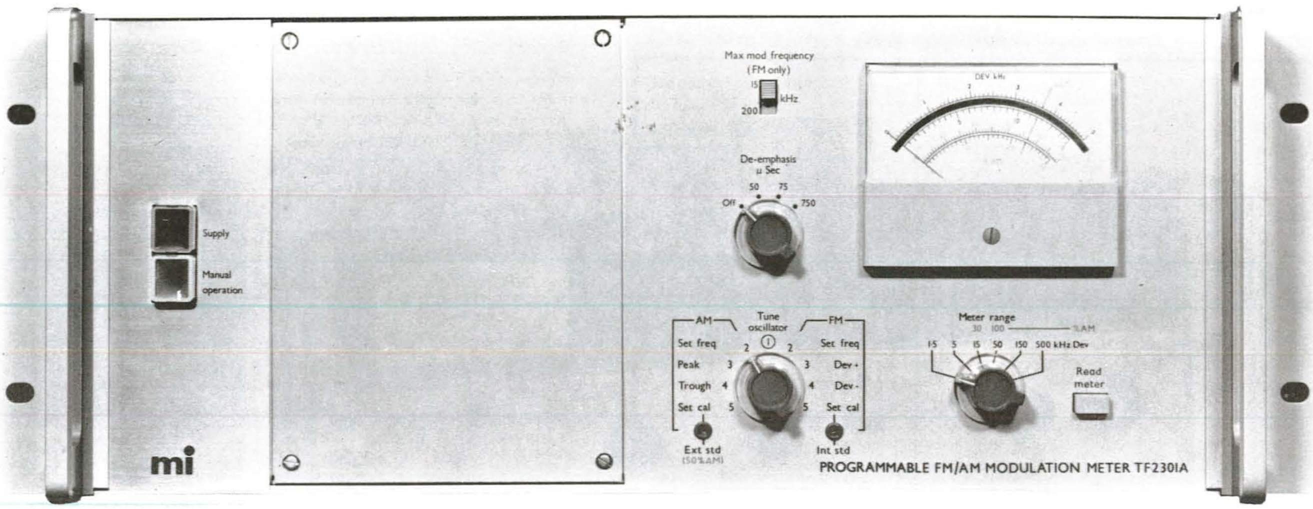
The detector operates over a frequency range of 1·5 to 1000 MHz, with inputs between 1·5 and 3·5 V for 100% a.m. or 1·5 and 5·0 V for 40% a.m. The model retains all functions of the standard model when the auxiliary detector is not in use.

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. 3·5 V r.m.s. at 100% a.m.
Input impedance	Nominally 50 Ω.
Demodulation distortion	Less than 1% at 95% modulation depth with an input of at least 2 V.
LF output level	10 mV per 1% modulation depth ±10%. 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.

Programmable FM/AM Modulation Meter

- ☐ **Suitable for automatic or manual operation**
- ☐ **Measures f.m. deviation up to 500 kHz at carrier frequencies up to 1000 MHz**
- ☐ **Measures a.m. depth up to 95% at carrier frequencies up to 500 MHz**
- ☐ **Modular construction using all-solid-state active elements for maximum reliability**



TF 2301A is an FM/AM Modulation Meter suitable for incorporation into programmed automatic test systems or for use in a manual mode. The switching from one mode of operation to the other is by push-button on the front panel.

Basically the instrument is a low-sensitivity superheterodyne receiver having very linear f.m. and a.m. demodulators. After demodulation the l.f. signal is amplified, then rectified using a peak detector, and the resulting d.c. signal is made available through a socket mounted on the rear panel. In the manual mode the detected signal is also used to drive a panel meter calibrated in peak deviation and percentage modulation depth. A particular feature of TF 2301A is the design of the peak detector in that it can follow rapidly increasing or decreasing modulation depths.

When used in an automatic system executive control of the f.m./a.m. function, modulation range, maximum modulation frequency, and de-emphasis is by b.c.d. signals applied via a multi-pin plug on the rear of the unit. Signal level controls are unnecessary since TF 2301A has an automatic signal levelling circuit (a.l.c.) which maintains the r.f. input level to within the range 500 mV to 5 volts for f.m. or 25 mV to 5 volts for a.m. without further adjustment.

In either mode an external oscillator tuned to 1·5 MHz above the signal frequency is required; in automatic systems this would normally be a programmable synthesiser.

RF INPUT	
Frequency range	4 to 1000 MHz on f.m. Usable to higher frequencies at a reduced r.f. input sensitivity. 4 to 500 MHz on a.m.
RF input level	The instrument has an a.l.c. system which allows the input to be within the range determined at the lower end by the sensitivity and at the higher end by the maximum safe input, without further adjustment. The levelling system comprises a linear control loop acting on the i.f. amplifier, and up/down counter setting the r.f. input attenuator.
Sensitivity	Better than 500 mV on fm.* (typically better than 250 mV). Better than 25 mV on a.m. (typically better than 12 mV). These levels apply for a constant local oscillator level of 800 mV e.m.f. from a 50 Ω generator.
Maximum safe input	0·5 W (5 V r.m.s. for c.w. signal).
Input impedance	Nominally 50 Ω
LOCAL OSCILLATOR	The instrument requires an external generator for use as the local oscillator.
Level	800 mV ±2 dB e.m.f. from a 50 Ω source.
Frequency range	5·5 MHz to 1001·5 MHz. The local oscillator should be tuned to 1·5 MHz above the r.f. input frequency.

IF OUTPUT

Centre frequency 1·5 MHz.

Level Approximately 500 mV.

Output impedance Nominally 10 kΩ

FM MEASUREMENT

Deviation range 6 ranges with full scale indications of 1·5 kHz*, 5 kHz, 15 kHz, 50 kHz, 150 kHz and 500 kHz.

Selection of positive or negative deviation measurements.

Modulation frequency 30 Hz to 200 kHz on deviation ranges 5 to 500 kHz.

30 Hz to 3·4 kHz on 1·5 kHz deviation range.

Measurement accuracy ±3% full scale (±4% using meter readout) on deviation ranges 5 to 500 kHz and at modulation frequencies from 30 Hz to 150 kHz.

±10% of full scale for deviations up to 500 kHz for modulation frequencies from 150 kHz to 200 kHz.

±5% of full scale on 1·5 kHz deviation range.

AM rejection The additional deviation error, when a.m. depth is 80% and the modulating frequency is 1 kHz, is typically less than 300 Hz in a 15 kHz bandwidth.

Inherent noise Using a low noise local oscillator, the residual deviation is less than 25 Hz for a bandwidth of 30 Hz to 15 kHz, measured at the LF output using an r.m.s. voltmeter.

Calibration A front panel preset control is provided for f.m. calibration of the instrument against the internal standard.

AM MEASUREMENT

Modulation depth range 2 ranges with full scale indications of 30% and 100% (maximum usable measurement 95%).

Modulation frequency 30 Hz to 50 kHz.

Measurement accuracy ±3% of full scale (±4% using meter readout) for modulating frequencies from 30 Hz to 15 kHz, and modulation depths up to 80%.

+5% of full scale for modulating frequencies from 30 Hz to 50 kHz, and depths up to 95%.

Calibration A front panel preset control is provided for a.m. calibration against a suitable external 50% a.m. standard.

LF OUTPUT

Bandwidth on f.m. 30 Hz to 200 kHz on deviation ranges 5 to 500 kHz.

30 Hz to 3·4 kHz on 1·5 kHz deviation range.

The bandwidth can be restricted to 15 kHz with a switchable low pass filter. This filter also restricts the deviation measurement bandwidth.

Bandwidth on a.m. 30 Hz to 50 kHz.

De-emphasis Selection of 0, 50, 75 and 750 μs.

Level Nominally 0 dBm (775 mV) into 600 Ω load for full scale on both a.m. ranges, and all f.m. deviation ranges, except the 1·5 kHz deviation range. Normally −10 dBm (245 mV) into 600 Ω load on the 1·5 kHz deviation range.

Output impedance Nominally 600 Ω.

DC OUTPUT The d.c. output is proportional to modulation.

On a.m. 0·1 V for f.s.d. on 100% full scale range.
0·3 V for f.s.d. on 30% full scale range.

On f.m. 0·5 V for f.s.d. on 5, 50 and 500 kHz full scale ranges.
1·5 V for f.s.d. on 1·5, 15 and 150 kHz full scale ranges.

Output impedance Less than 1 kΩ The output is intended for use with a high impedance voltmeter.

CONTROL

Programmable mode Mode selected by panel switch. Programmable operation is not affected by manual control settings, except by the ***set calibration*** controls.

Control is by b.c.d. (1-2-4-8 weighting) data applied to connector on the rear panel.

Control function	No of lines
FM/AM	1
±DEVIATION or PEAK/TROUGH	1
MODULATION RANGE	3
DE-EMPHASIS	2
MAX. MOD. FREQ.	1
HOLD ATTENTION	1

Input levels (see also Optional accessories):

'0' state is 0 to +5 V or short circuit to common, sinking 9 mA maximum.

'1' state is +9 to +25 V or open circuit.

Setting time: 5 s maximum from when the r.f. and local oscillator signals are applied.

Manual mode Mode selected by panel switch. Incoming b.c.d. information is ineffective on Manual operation. Manual working is by front panel controls.

CONNECTIONS All connections to the instrument are to the rear panel.

POWER REQUIREMENTS

AC supply 95 to 130 and 190 to 264 V at 45 to 65 Hz, 60 VA.

DIMENSIONS AND WEIGHT Standard 19 in. rack mounting.

Height	Width	Depth	Weight
180 mm	420 mm	405 mm	16 kg
7 in	16¾ in	16 in	36 lb

ACCESSORIES

Supplied

Mains Lead 43122-017

Shorting link 34461-305

14-way free socket, Ether Ltd., Type No. MRAC 14S-JTC2-1A00-HD with pins.

12-way P.C.B. Extender Card 44815-115

24-way P.C.B. Extender Card 44815-116

Optional

43281-007C RF Fuse Unit TM 9884

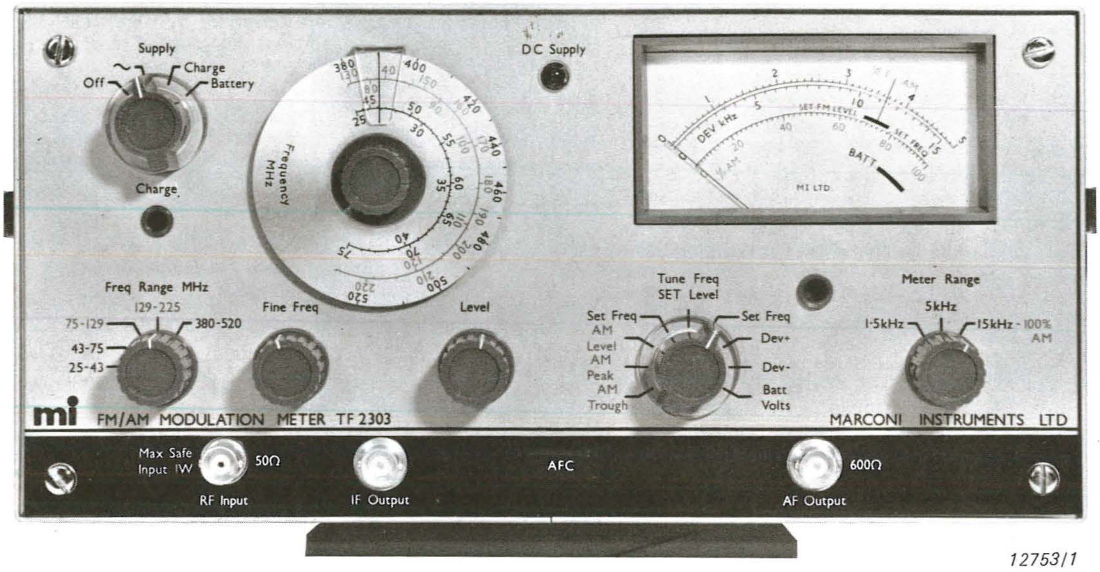
43168-008S Shielded Adapter (GE 51002).

TK 7084/3 Logic Level Converter Module. (This module makes the modulation meter suitable for control by DTL and TTL positive true logic.)

f

FM/AM Modulation Meter

- Specifically designed for tests on mobile radio transmitters
- Measures f.m. deviation in three ranges from 1·5 kHz to 15 kHz at carrier frequencies up to 520 MHz
- Measures a.m. depth up to 95% at carrier frequencies up to 225 MHz
- Operates from a.c. mains or internal rechargeable battery
- Range of accessories facilitates connection to transmitters



12753/1

The TF 2303 FM/AM Modulation Meter, which covers all the frequency bands commonly used for mobile radios, both f.m. and a.m., has been specifically designed for production testing and servicing of narrow band radio transmitters used in fixed and mobile point-to-point communications systems. The sensitivity of the instrument also enables it to be used to check the outputs of signal generators used for receiver measurements.

It is basically a low-sensitivity superheterodyne receiver in which the i.f. output is demodulated, amplified, rectified and applied to a front-panel meter calibrated directly in kHz peak deviation and percent modulation depth as appropriate.

The instrument's small size and light weight, together with its optional internal rechargeable battery, make it very suitable for field use. This is further aided by the optional carrying case which permits operation of the instrument in the case while slung over the shoulder. A wide range of accessories enables measurements to be made on any transmitter with output power from 100 mW to 30 watts. These accessories ensure good interfacing between the transmitter and the modulation meter, and enable measurements to be made at the full transmitter output power.

The instrument can be operated on a.c. mains or from an internal rechargeable nickel cadmium battery pack, which is available as an optional accessory. The battery will give a full 8 hours continuous operation and it can be fully recharged overnight from the a.c. mains supply, using the built-in charger. When the instrument is operated on a.c. mains the battery receives a continuous trickle charge.

FM Measurement

Measurements can be made on f.m. transmitters with carrier frequencies in the range 25 to 225 MHz and 380 to 520 MHz. The frequency range from 225 to 380 MHz is not calibrated, but is available if required. Three narrow-deviation ranges are provided of 1·5 kHz, 5 kHz, and 15 kHz full scale. The modulation frequency range of 50 Hz to 9 kHz caters for low frequency calling tones and for two channel systems in addition to the voice frequency band. The meter can 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 the audio frequency demodulated output is available at a front panel socket for connection to an external sensitive meter. This output can also be used for use with an oscilloscope, wave-analyser or distortion factor meter for checks on waveform, modulation frequency etc. A 750 μs de-emphasis unit is available as an optional accessory for connection to the a.f. output socket to restore a modulation signal that has had pre-emphasis applied.

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 2303 this is ensured by the use of a high stability varactor-diode tuned oscillator employing a low noise FET. By this means low microphony and good spectral purity are obtained. Even at the highest carrier frequencies the deviation due to noise is less than 50 Hz in a nominal 3 dB bandwidth of 10 Hz to 14 kHz. To aid long-term monitoring, or for use with an unstable signal source, an a.f.c. facility is provided for locking the local oscillator to the incoming signal. This can be switched into operation by means of a front-panel push-button after the instrument has been manually tuned.

AM Measurement

Measurements can be made on a.m. transmitters in the carrier frequency range 25 to 225 MHz. Modulation depths up to 95% can be measured at modulation frequencies from 50 Hz to 4 kHz. In order to give an indication of the symmetry of the modulation envelope the meter may be switched to indicate either peak or trough amplitude relative to the mean carrier level. An i.f. output is available at a front panel socket and can be used to examine the symmetry of modulation directly on a low frequency oscilloscope.

RF INPUT	
Carrier frequency range	Five bands: 25 to 43 MHz, 43 to 75 MHz, 75 to 129 MHz, 129 to 225 MHz: a.m. and f.m.; 380 to 520 MHz f.m. only.
Scale accuracy	±5%.
Sensitivity	Better than 50 mV r.m.s. from 25 to 225 MHz; 100 mV r.m.s. from 380 to 520 MHz.
Maximum safe input	1 W (7 V r.m.s. approx.).
Maximum working input	Approximately 150 mV on the bottom range and 700 mV on the top range.
RF level control range	At least 20 dB at 520 MHz.
Input impedance	Nominally 50 Ω.
FM MEASUREMENT	
Deviation ranges	Three ranges with full-scale indications of 1·5 kHz, 5 kHz and 15 kHz. Positive or negative indication is selected by a switch.
Scale accuracy	±3% of f.s.d. at 1 kHz modulation frequency. ±5% at extremes of operating temperature.
Modulation frequency range	Over the range 50 Hz to 9 kHz, deviation measurement are within 0·5 dB with respect to 1 kHz.
Inherent noise	Deviation due to noise is less than 50 Hz at the highest carrier frequency and in a nominal 3 dB bandwidth of 10 Hz to 14 kHz.
AM rejection	Additional deviation error is at least 26 dB below the reading for 5 kHz deviation when a.m. depth is 30% at 1 kHz modulation frequency.
AM MEASUREMENT	
Modulation depth range	Full-scale indication 100%. Usable up to 95%. Peak or trough indication is selected by a switch.
Accuracy	±3% modulation depth for depths up to 80% and modulation frequency of 1 kHz. ±5% at extremes of operating temperature.
Modulation frequency range	Over the range 50 Hz to 4 kHz, modulation depth measurements are within 0·5 dB with respect to 1 kHz.
Noise	Better than −50 dB with respect to 100% modulation in a nominal 3 dB bandwidth of 10 Hz to 24 kHz.

IF OUTPUT	
Frequency	500 kHz.
Level	100 mV e.m.f. nominal.
Output impedance	Nominally 1 kΩ.
AF OUTPUT	
Output level	1 mW nominal into 600 Ω with meter at f.s.d.
Distortion	Less than 1% for f.m. deviations up to 15 kHz. Less than 3% for a.m. depths up to 80%.
SAFETY	Designed to meet the requirements of IEC 348.
POWER REQUIREMENTS	
AC mains	95 to 130 V or 190 to 264 V; 45 to 500 Hz. 5 VA approx.
Internal battery	21 V rechargeable Nickel Cadmium battery can be fitted.
DIMENSIONS AND WEIGHT	Height 140 mm, $5\frac{1}{2}$ in; Width 280 mm, 11 in; Depth 305 mm, 12 in; Weight 5·7 kg, 13 lb (With lid and battery)
CONNECTORS	BNC sockets for r.f. input, i.f. output and a.f. output.

VERSIONS AND ACCESSORIES

When ordering please quote eight-digit code numbers

Ordering numbers	Versions
52303–015F	TF 2303. Standard version.
	Supplied Accessories
	Lid. 41634–065Z
	Optional Accessories
54112–031T	Carrying Case.
54412–011K	750 μs De-emphasis Unit.
54422–011A	12 W, 50 Ω Termination.
54431–011D	20 dB, 1 W Attenuator.
54431–021B	20 dB, 20 W Attenuator.
54452–011E	Signal Sniffer.
54463–011D	Rechargeable Battery.
43126–012S	Coaxial Lead TM 4969/3. 50 Ω.
43281–007C	R.F. Fuse Unit TM 9884.

OPTIONAL ACCESSORIES

CARRYING CASE, 54112–031T

Case with shoulder strap for carrying the TF 2303 and accessories. The instrument is secured by a retaining screw and can be operated in the case.

DIMENSIONS	340 mm × 300 mm × 160 mm ($13\frac{3}{8}$ in × $11\frac{7}{8}$ in × $6\frac{3}{8}$ in).
WEIGHT	Case alone: 1·8 kg (4 lb).

750 μs DE-EMPHASIS UNIT, 54412–011K

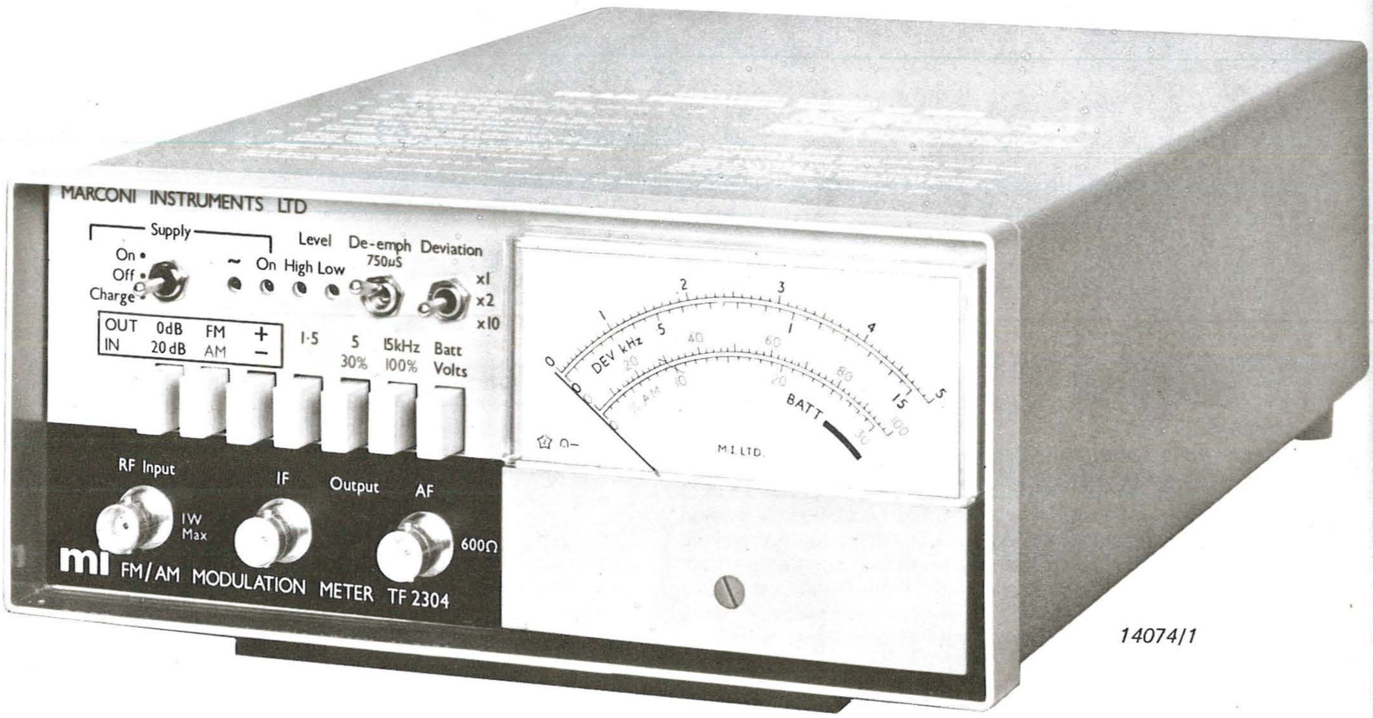
Low-pass R-C filter with a time constant of 750 μs for de-emphasis purposes. It can be connected to the a.f. output socket of the TF 2303. The unit should be terminated in 600 Ω and an internal 600 Ω load can be switched in when working into a high impedance.

CONNECTORS	BNC plug to BNC socket (may be connected either way round).
DIMENSIONS	94 mm × 25 mm × 25 mm ($3\frac{3}{4}$ in × 1 in × 1 in).

For details of other optional accessories refer to pages 110 and 111

FM/AM Modulation Meter

- ☐ Automatic operation – no tuning or signal levelling required
- ☐ 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%
- ☐ Two sensitivity versions available
- ☐ High and low level indication
- ☐ Light and compact; a.c. supply or rechargeable battery operation
- ☐ High accuracy, low price
- ☐ Optional accessories for mobile radio testing



14074/1

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.

Design features

TF 2304 is basically a superheterodyne receiver consisting of a tuneable local oscillator, 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.

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 measurement 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.

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.

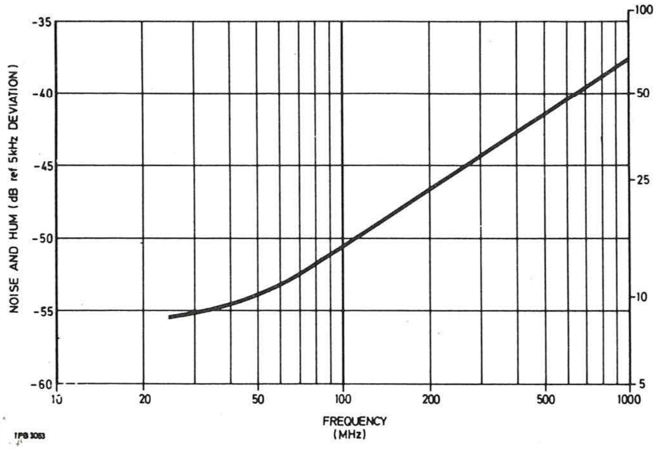


Fig. 1 Typical modulation meter noise levels

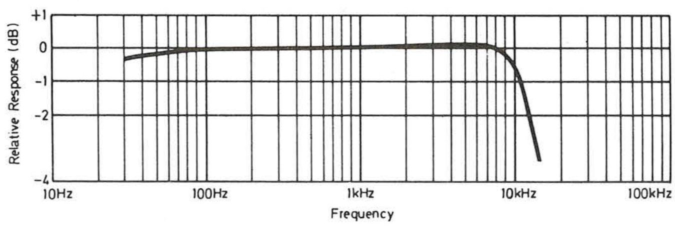


Fig. 2 Sample audio frequency response to f.m signal on 5 kHz range

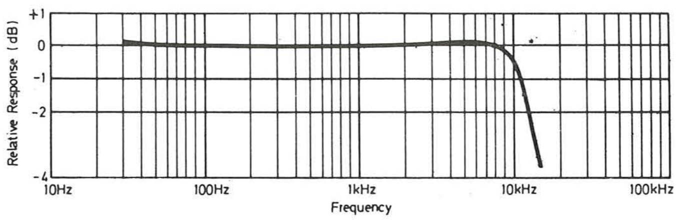


Fig. 3 Sample audio frequency response to a.m signal on 100% range

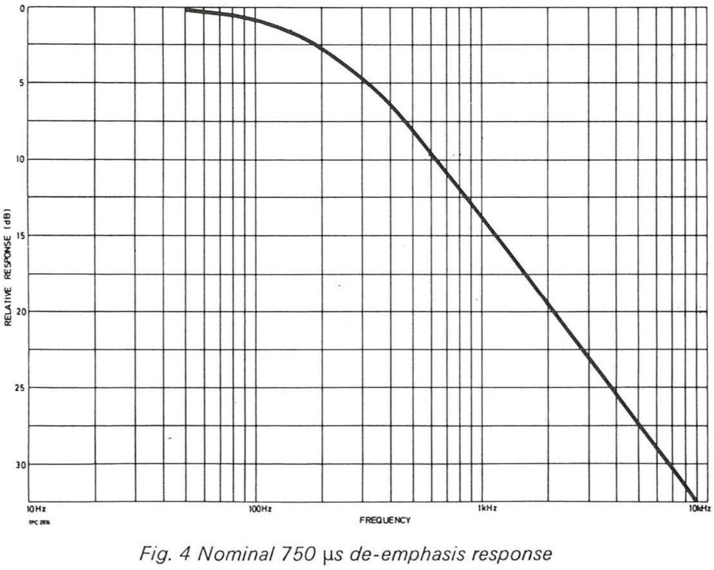


Fig. 4 Nominal 750 μs de-emphasis response

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.

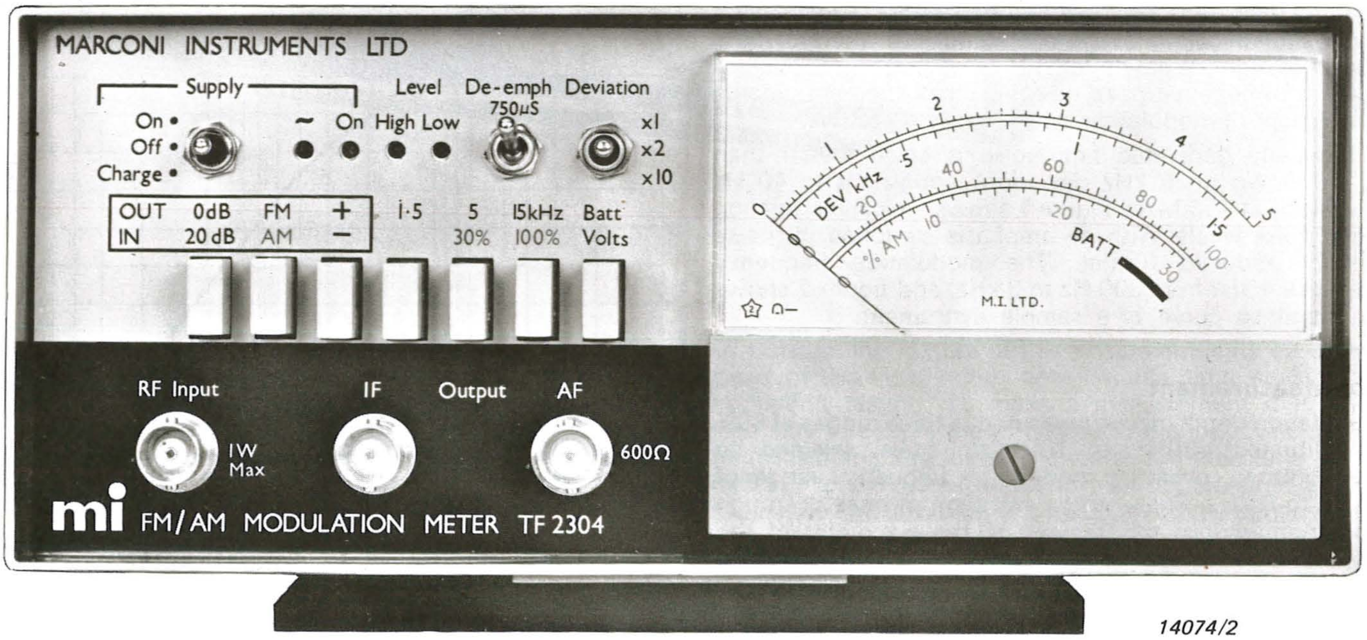
Construction

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. The modulation meter is available in a rack mounting version if required.

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.

A carrying case with a shoulder strap and with provision for carrying accessories is a useful optional accessory for on-site servicing.



14074/2

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 with 20 dB attenuator.
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	This instrument complies with IEC 348 and BS4743 safety requirements.
DIMENSIONS AND WEIGHT	see below

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.)

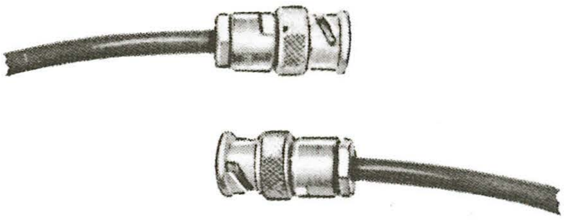
VERSIONS AND ACCESSORIES

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.
	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.
46883–283J	Rack Mounting Kit

OPTIONAL ACCESSORIES

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



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

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

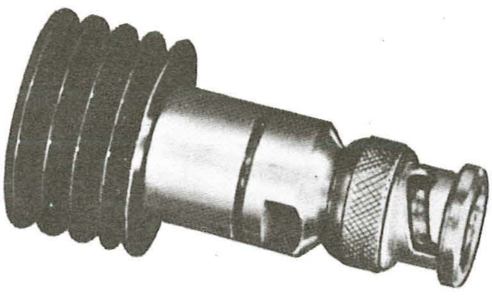
Fuse for protection against accidental overload.

VSWR	Not greater than 1·5 at 470 MHz.
INSERTION LOSS	Not greater than 0·6 dB at 400 MHz. 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).

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).



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

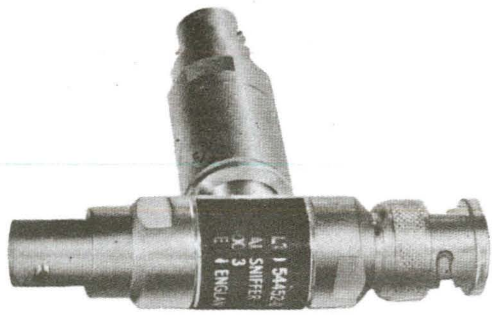
Attenuator or termination for transmitters up to 1 W.

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, 54431–021 B

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.

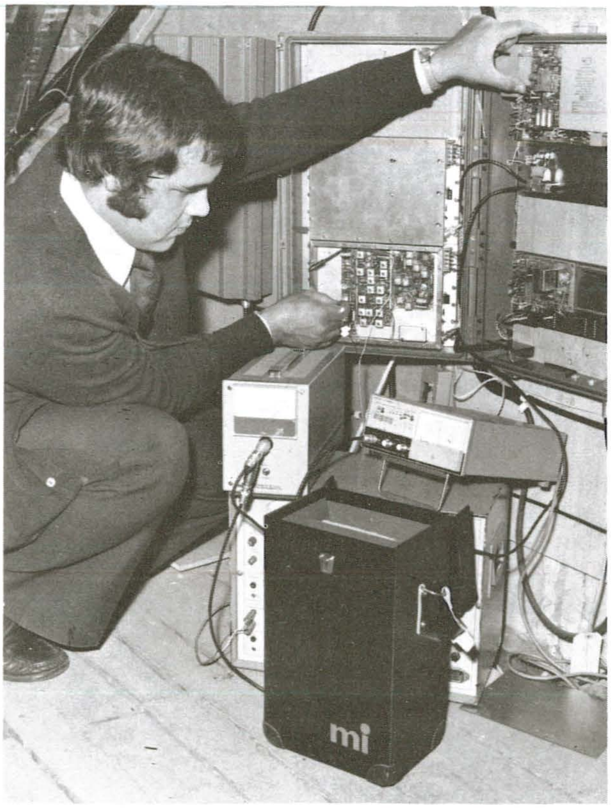
ATTENUATION	20 dB nominal.
FREQUENCY RANGE	DC to 1 GHz.
IMPEDANCE	50 Ω nominal.
RATING	20 W continuous. 30 W for up to 5 minutes with off periods of at least 5 minutes.
CONNECTORS	50 Ω, BNC plug to BNC socket.



SIGNAL SNIFFER, 54452–011 E

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).



TF 2304 being used for on-site testing, showing carrying case in foreground.

CARRYING CASE, 54112–121 N

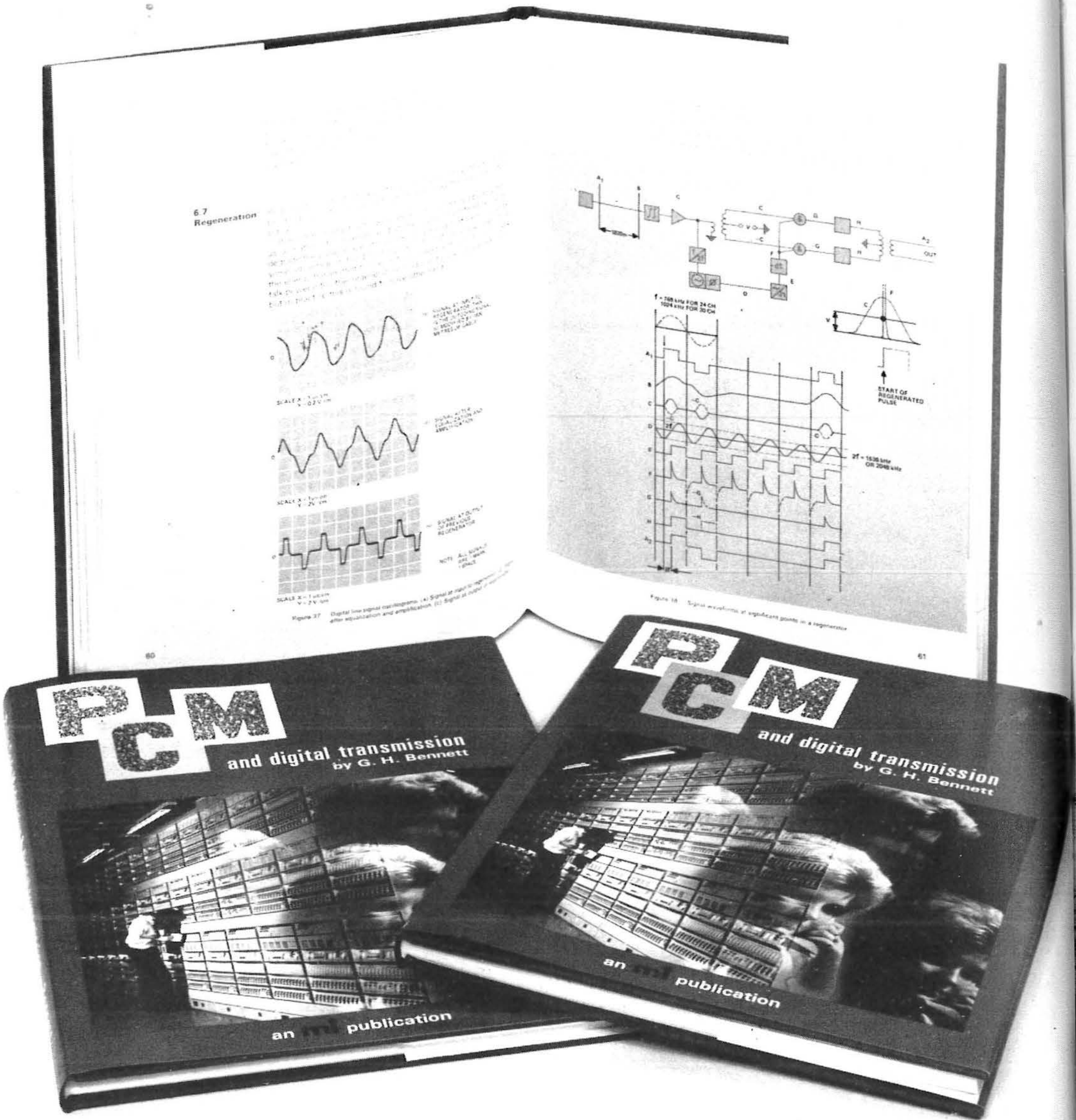
Case with shoulder strap for carrying the TF 2304 and accessories. The instrument is secured by a retaining screw and can be operated in the case.

DIMENSIONS	360 mm × 230 mm × 170 mm (14·2 in × 9·1 in × 6·7 in).
WEIGHT	Case alone: 1·5 kg (3·3 lb).

RECHARGEABLE BATTERY, 54463–011 D

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).



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).

ANALYSERS

Wave Analyser (20 Hz to 76 kHz)	TF 2330A	114
Distortion Factor Meter	TF 2331A	116
MF Transmission Measuring Set (30 Hz to 550 kHz)	TF 2333	118
Automatic Distortion Meter	TF 2337A	120
110 MHz Spectrum Analyser	TF 2370	122
Zero Loss Probe (for use with TF 2370)	TK 2374 series	127

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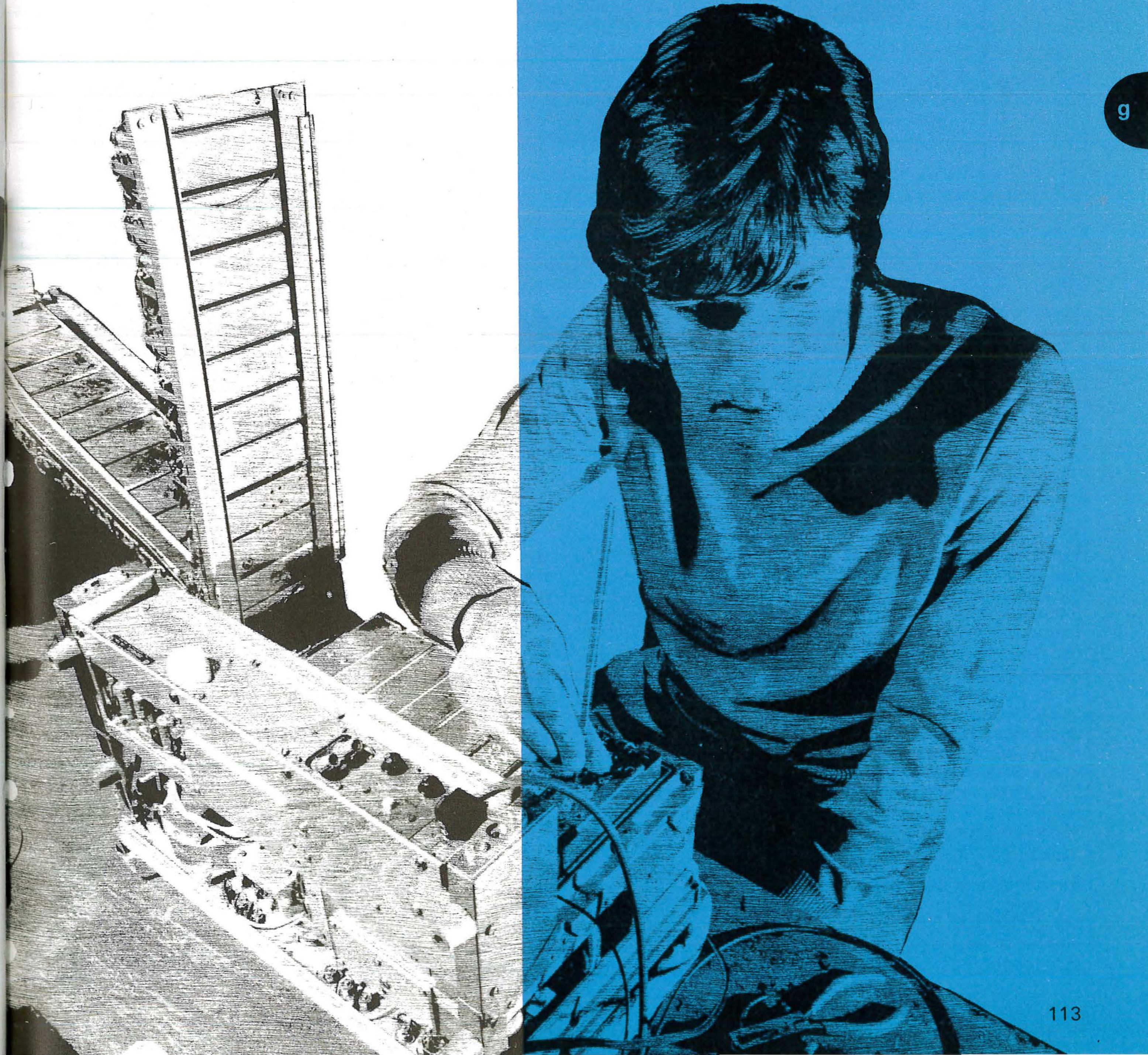
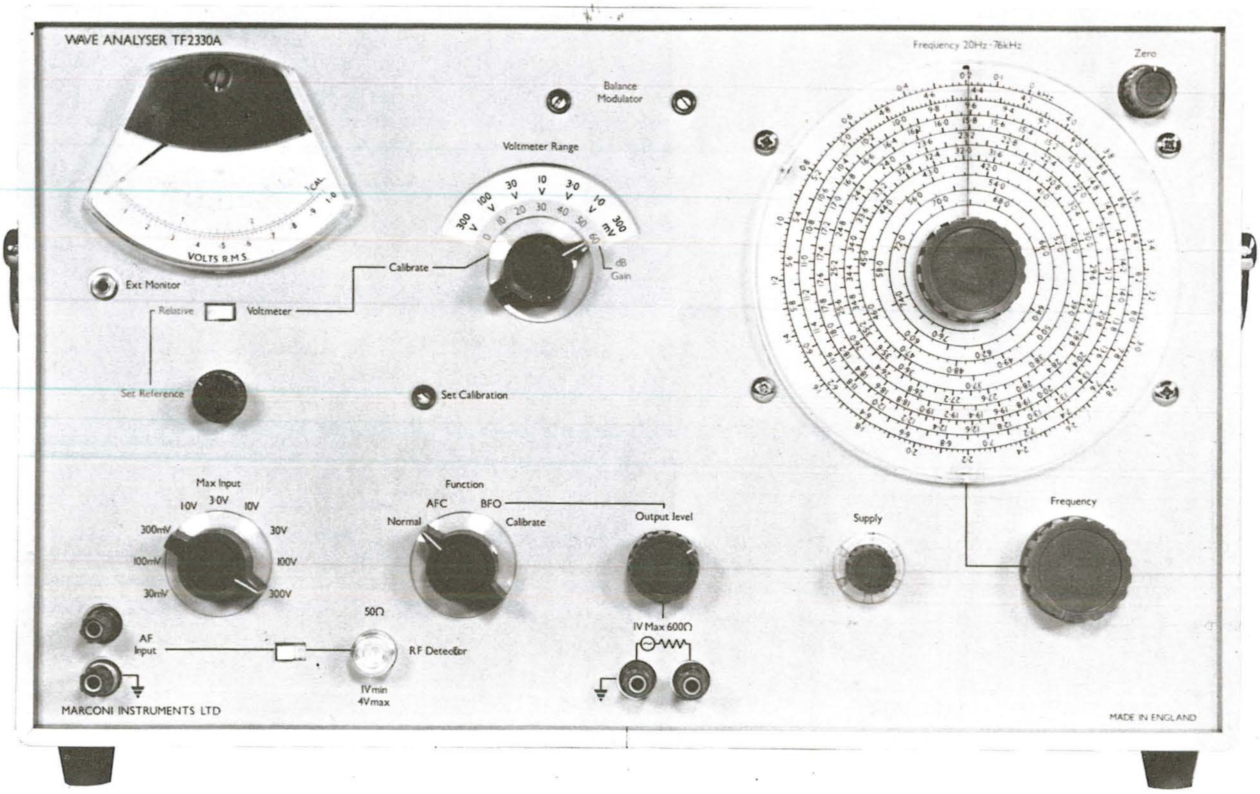


Wave Analyser

- Frequency range: 20 Hz to 76 kHz
- Measures amplitude of individual frequency components
- Suitable for f.m. - stereo encoded signals
- Restored-frequency and BFO outputs
- Built-in r.f. demodulator



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Wave Analyser TF 2330A is a narrow-band selective voltmeter tunable over the frequency range 20 Hz to 76 kHz in one continuous tuning range. It is primarily intended for amplitude measurement of individual frequency components of complex waveforms; and it can be set to indicate directly in voltage or in terms relative to a fundamental datum level — either in decibels or in percentage. In addition to its normal harmonic-analysis applications the instrument may be used for direct measurement of network response over its frequency range, without the need for a separate signal source —see BFO OUTPUT overleaf. The frequency range of the TF 2330A is such that the instrument is suitable for response or amplitude measurements at all f.m.-stereo encoded signal frequencies, including the additional background music channel.

Sensitivity and Selectivity

Discrimination between closely spaced frequency components is facilitated by the 7 Hz bandwidth. This implies a necessity for accurate tuning; but, once the component has been selected, internal automatic frequency control can be switched into operation, locking the Wave Analyser to the signal component and, incidentally, obviating continual retuning to correct for any small amount of frequency drift.

There are 15 ranges of voltage sensitivity from 30 µV full scale to 300 volts full scale, the lowest usable meter reading being at 3 µV. The minimum measurable level of a distortion component, however, depends upon the rejection ratio of the band pass filters within the instrument and, for signal levels between 30 mV and 300 volts fed directly to the Wave Analyser, frequency components down to −75 dB relative to the fundamental can be measured.

Restored Frequency Output

When the Wave Analyser is tuned to any frequency component of a waveform it delivers, at the panel terminals, a "restored-frequency" output; i.e., a voltage at the component's frequency. The output level is variable by means of a manual control; but, for any control setting, the output voltage is a direct function of the amplitude of the frequency component. This feature is useful for the application of particular frequency components to external measuring equipment; e.g., the isolation of the fundamental from very heavy noise. It also facilitates the use of an electronic counter for digital monitoring of any frequency component selected, an application which may be useful in identifying a particular frequency component which is not harmonically related to the others.

BFO Output

The TF 2330A can also be switched to function as a b.f.o., delivering a continuous output at the tuning frequency of the selective voltmeter regardless of the input signal—as distinct from the restored-frequency output of normal operation. This feature provides a very convenient means of measuring the frequency response of active and passive networks. By applying the signal to the input of the network and monitoring the voltage at its output with the tuned voltmeter section the response of the network can easily be measured.

RF Demodulator

For convenience when checking distortion of modulation envelopes the TF 2330A is fitted with a linear r.f. detector, which may be switched into circuit in cascade with the normal a.f. input of the instrument.

Construction Features

The TF 2330A Wave Analyser conforms to the modular standard; and is available in bench or rack-mounting form. All active circuit elements are solid state, with the advantages of portability, reliability, and low power consumption. Although the instrument is normally intended for mains operation, it can be driven from external batteries having voltages between 18 and 30 volts. This is a particularly useful attribute in the case of a wave analyser because, apart from the portability aspect, it may be desirable to use the instrument at frequencies close to the supply frequency or its low-order harmonics, where even the very small hum level resulting from mains operation may be troublesome.

INPUT FREQUENCY	
Working range	20 Hz to 76 kHz.
Accuracy	±1%, ±5 Hz.
AFC	Tuning remains locked to input frequency over ±100 Hz drift.
AMPLITUDE RANGES	
Waveform analysis	*Range:* Measurements down to −75 dB with respect to any fundamental level between 30 mV and 300 V. For fundamental levels below 30 mV the measurement range is progressively reduced.
SELECTIVE VOLTAGE MEASUREMENT	
Range	3 μV to 300 V in 15 ranges of 30 μV to 300 V f.s.d. in 1-3-10 sequence.
Accuracy	±5% of full scale.
Selectivity	±3·5 Hz bandwidth, at least 3 dB down. ±20 Hz bandwidth, at least 45 dB down. ±40 Hz bandwidth, at least 63 dB down. ±80 Hz and above, at least 80 dB down.
Internal noise and distortion	Residual hum and noise, and distortion to measured signal at least 80 dB down.
Input resistance	100 kΩ on maximum attenuator settings between 30 mV and 1V: 1 MΩ on settings between 3 and 300 V.
RF INPUT	
Frequency range	100 kHz to 500 MHz.
Input impedance	50 Ω (type N connector).
Amplitude range	1 to 4 V r.m.s. at maximum modulation depth.
Restored frequency output	*Range:* 20 Hz to 76 kHz. *Output:* Variable up to 2·8 V p-p out of 600 Ω source, when meter reads f.s.d.
BFO output	*Range:* 20 Hz to 76 kHz. *Output:* Variable up to 2·8 V p-p out of 600 Ω source.
Recorder output	*Response:* Flat to within ±0·1 dB over frequency range, terminated or unterminated. 100 μA ±2% into 2·5 kΩ. Recorder input to be isolated from ground.
SAFETY	Designed to meet the requirements of 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 25 kN/m² differential, i.e. 3·7 lbf/in²).
POWER REQUIREMENTS	
AC supply	95 to 130 V and 190 to 260 V, 45 to 1000 Hz, 4 VA.
External DC	18 to 30 V, 110 mA V maximum; positive earth.
DIMENSIONS AND WEIGHT	

Height	Width	Depth	Weight
280 mm	470 mm	280 mm	13·1 kg
11 in	18·5 in	11 in	29 lb

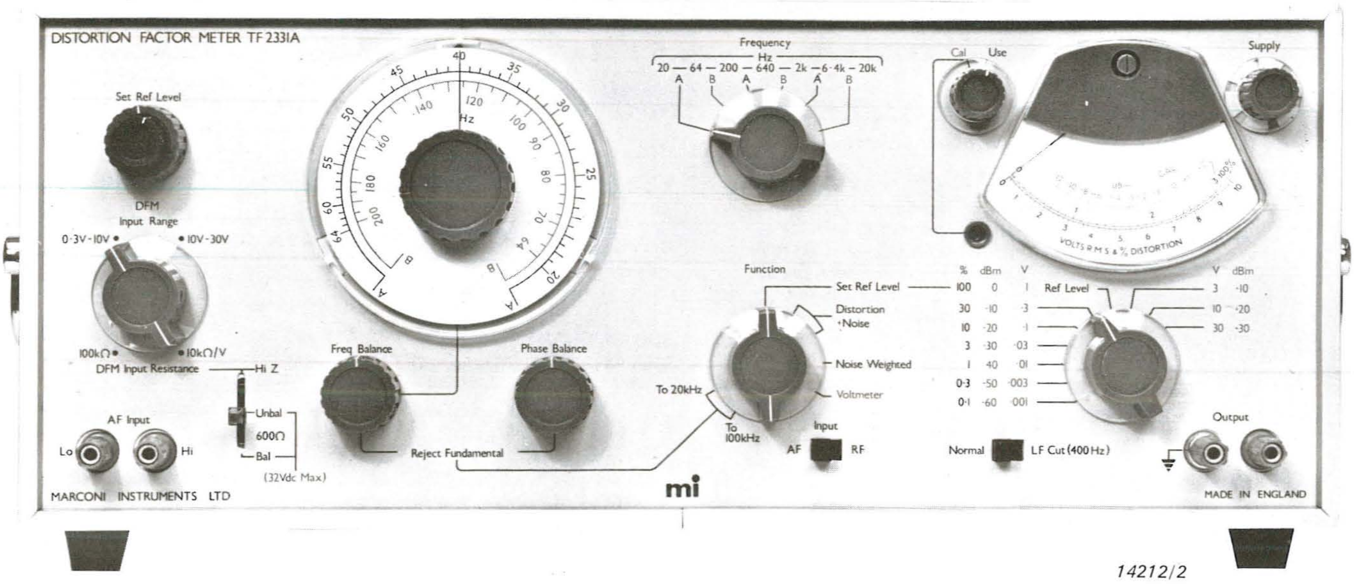
VERSIONS AND ACCESSORIES

When ordering please quote eight-digit code numbers

Ordering numbers	
52330–035C	**Versions** Wave Analyser TF 2330A. Standard version.
	Supplied Accessories Accessory Kit 46883–118S comprising: Shielded Adaptor TB 39868 (43168-008S) (Greenpar type GE 51002) for converting input or output terminals to a BNC coaxial socket. Miniature Jack Plug 23421-610M, for use in Ext. Monitor socket. (Rendar type MJP/600.)

Distortion Factor Meter

- 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



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TF 2331A is an improved version of the Marconi Instruments Distortion Factor Meter TF 2331, retaining all of the previous model's features and offering in addition a fully floating 600 Ω balanced input which is particularly useful for broadcast and line communications work. The noise weighting filter included has also been changed to conform to the current CCIR Recommendation 468. The instrument compensates automatically for the loss introduced when this filter is switched in.

This Distortion Factor Meter 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 recommended by CCIR for broadcast use.

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 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:* Less than 0·025% from 200 Hz to 6 kHz. Less than 0·04% from 20 Hz to 200 Hz and from 6 kHz to 20 kHz. *Balanced:* Less than 0·025% from 200 Hz to 6 kHz. Less than 0·04% from 100 Hz to 200 Hz and from 6 kHz to 20 kHz. Less than 0·1% from 50 Hz to 100 Hz for inputs up to 10 V. 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: 0·5 dB for fundamentals up to 1 kHz. 1 dB for fundamentals up to 6 kHz. 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. ±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. ***Return loss:*** better than 25 dB at 1 kHz. ***Balance:*** better than 50 dB rejection at 1 kHz. HiZ: Nominally 10 kΩ/V up to 10 V input. 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%. 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 (New Delhi 1970).
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. 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 ±2% of full scale ±2% of reading from 20 Hz to 100 kHz. *Balanced:* ±2% of full scale ±1% of reading from 50 Hz to 55 kHz ±8% of full scale ±2% of reading from 20 Hz to 100 kHz.
Input resistance	*Unbalanced:* 1 MΩ or 600 Ω. *Balanced:* 600 Ω. ***Return loss:*** better than 30 dB at 1 kHz. ***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.
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.
SAFETY	Complies with IEC 348 and BS 4743 safety requirements.
DIMENSIONS AND WEIGHT	Height 200 mm 8in; Width 440 mm 17¼ in; Depth 280 mm 11 in; Weight 9·7 kg 22 lb

VERSIONS AND ACCESSORIES

When ordering please quote eight digit code numbers.

Ordering numbers	
	Versions
52331–910T	TF 2331A. Standard version. The following version may be available to special order.
52331–309N	TF 2331AM. HF Screened version.
	Optional Accessories
41635–041P	Rack Mounting Kit TM 7010.
44827–522R	Telephone Weighting Network. To CCITT Recommendations P53 section A (Geneva 1972).
43168–008S	Shrouded Adapter TB 39868 to adapt terminals to BNC connection.

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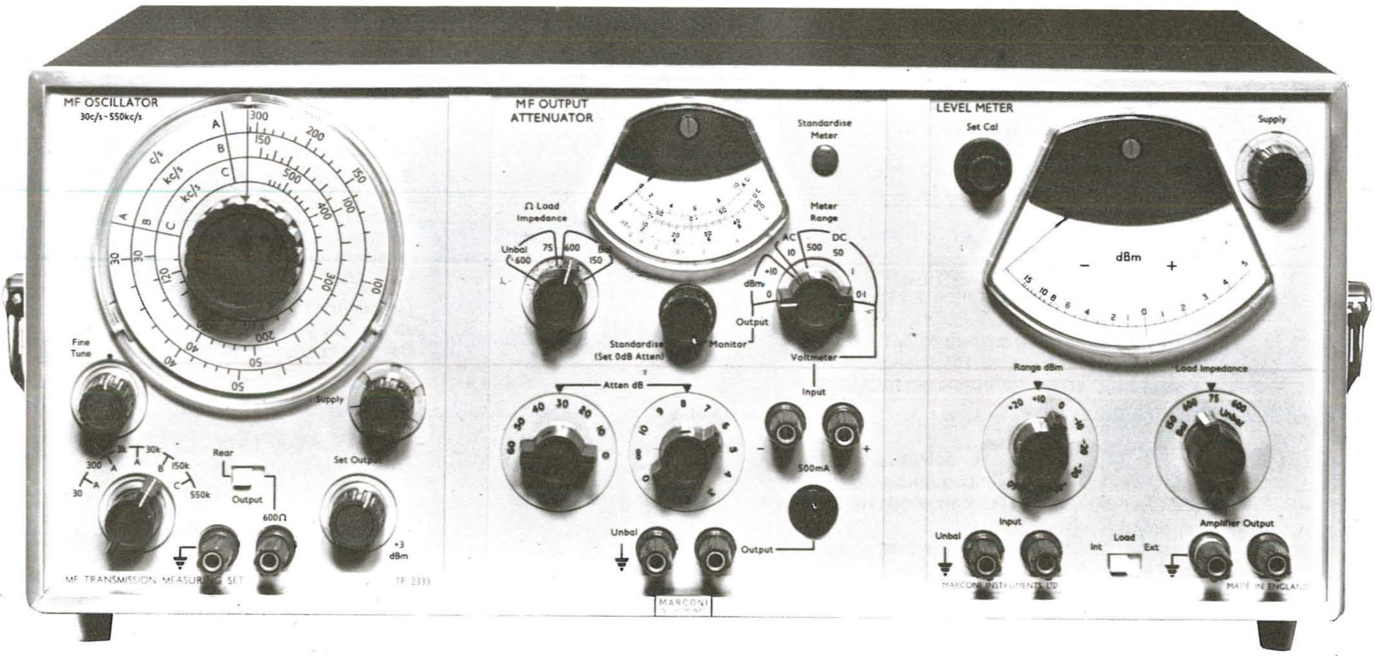
MF Transmission Measuring Set

- Frequency range: 30 Hz to 550 kHz
- Measures response of active and passive transmission networks
- Suitable for multichannel applications up to basic supergroup bandwidth



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The TF 2333 is a transmission measuring set of the conventional type that normally forms part of the essential test gear for audio and baseband equipment of multichannel telecommunications systems.

It comprises a Signal Source, for energising the network under test, and a Level Meter for measuring the resulting output power from the network. It can be used for measurement of gain or attenuation and, therefore, frequency characteristic. The Level Meter can be applied to a.f. and m.f. power measurement. And a multi-range voltmeter facility provided in the instrument can also be used for fault finding.

The Signal Source consists of a variable frequency RC oscillator, covering the range 30 Hz to 560 kHz, followed by a monitored attenuator. The output level, indicated directly in dBm, is variable over the range −70 to +3 dBm. Source impedance is switch selected to suit the equipment under test, the choice being 600 Ω balanced or unbalanced, 150 Ω balanced, or 75 Ω unbalanced.

For normal t.m.s. operation, the oscillator is connected to the attenuator via a coaxial jumper at the rear. Its output can, however, be brought to the front panel terminals by the operation of a switch. In this condition it can be operated separately from the other sections of the instrument for general test purposes.

The input level applied to the attenuator is monitored by its panel meter. The equipment is normally used with the oscillator output set to give a constant deflection (usually 0 dBm)—variation of the test signal level being made by means of the attenuator controls. The sensitivity of the monitor is standardised at 1 kHz at the factory; but provision is made for re-standardisation at other frequencies against an external meter if desired.

The panel meter can also be switched to function as the indicator of a multi-range voltmeter. Four d.c. ranges, with full scale deflections from 0·1 to 500 volts, cover the requirements for checking supply voltages to most valve or transistor circuits; and a single a.c. range with 10 volts f.s.d. facilitates the checking of valve heater supplies.

The Level Meter is a wide-band amplifier/voltmeter designed for use over the frequency band 30 Hz to 560 kHz. It is calibrated directly in dBm and covers the range −70 to +25 dBm. A load impedance switch automatically adjusts the sensitivity of the voltmeter so that the power indication remains direct for each standard impedance used, and the need for calculation is obviated. The Level Meter can be switched to act as the terminating load of a network under test or to high impedance for monitoring the power in an external termination.

The amplified signal is also brought out to a pair of terminals on the front panel of the unit. This enables the amplified test signal to be applied to an oscilloscope or other external measuring equipment.

The instrument conforms to the Marconi modular standard, and comprises three one-third sub-modules. It is available for bench or rack mounting. The bench type can be fitted with a protective front cover which also houses leads and accessories.

Being fully transistorised, the TF 2333 is easily portable and well adapted for field use. Although it is normally intended for a.c. mains operation, it can be operated from external batteries if desired.

SIGNAL SOURCE

OSCILLATOR	
Frequency range	30 Hz to 550 kHz in five ranges: A : 30 to 300 Hz. A×10 : 300 to 3000 Hz. A×100 : 3 to 30 kHz. B : 30 to 150 kHz. C : 115 to 550 kHz. The dial is calibrated and performance maintained up to 560 kHz.
Frequency accuracy	±3%.
Maximum output	At least +3 dBm.
ATTENUATOR	
Range	70 dB in 10 dB and 1 dB steps.
Accuracy	50 Hz to 20 kHz: ±1% of dB setting ±0·2 dB. 20 kHz to 560 kHz: ±2% of dB setting ±0·2 dB.
Output impedance	*Unbalanced:* 600 Ω and 75 Ω. *Balanced:* 600 Ω and 150 Ω.
DISTORTION	Less than 1% at 0 dBm.
HUM	Less than −70 dBm.
MONITOR	
Ranges	0 dBm and +10 dBm centre-scale, meter graduated −6 dBm to +6 dBm.
Accuracy	±0·25 dB under the conditions at which standardisation was carried out. The normal conditions are 600 Ω unbalanced, 1 kHz, 0 dBm meter reading and zero attenuation. A panel preset control allows restandardisation at other impedances.
Frequency response (relative to 1 kHz)	±0·1 dB from 300 Hz to 50 kHz; ±0·5 dB from 100 Hz to 200 kHz; ±1·2 dB from 50 Hz to 560 kHz, not applicable to 600 Ω balanced above 200 kHz.
VOLTMETER	
Ranges	DC: 0·1–1–50 and 500 V full-scale. AC (power line frequencies): 10 V full-scale. Also percentage scale calibrated ±50% relative to 0·5 V d.c.
Accuracy	±5% of full-scale.

LEVEL METER

FREQUENCY RANGE	50 Hz to 560 kHz.
LEVEL MEASUREMENT RANGE	+25 to −70 dBm.
MEASUREMENT ACCURACY	Can be standardised against signal source at 0 dBm, 1 kHz.
FREQUENCY RESPONSE (relative to 1 kHz at 0 dBm)	200 Hz to 20 kHz; ±0·1 dB at all impedances; 50 Hz to 100 kHz; ±0·25 dB at all impedances; 100 kHz to 300 kHz; ±0·25 dB at 150 and 75 Ω; 300 kHz to 560 kHz; ±0·5 dB at 150 and 75 Ω.
RANGE SWITCHING ACCURACY	
Up to 100 kHz	±0·3 dB from +20 to −50 dBm ranges at all impedances. ±0·5 dB on −60 dBm range at all impedances.
Up to 560 kHz	±0·5 dB from +20 to −50 dBm ranges at 150 and 75 Ω. ±1 dB on −60 dBm ranges at 150 and 75 Ω.
METER SCALE ACCURACY	±0·1 dB per 1 dB increment relative to 0 dB between +5 and −5 dB.
INPUT RESISTANCE	
Terminated	*Balanced:* 600 Ω and 150 Ω. *Unbalanced:* 600 Ω and 75 Ω.
Unterminated	At least 15 kΩ on −10 to −60 dBm ranges: 100 kΩ (unbalanced) on 0 to +20 dBm ranges: 200 kΩ (balanced) on 0 to +20 dBm ranges.
REJECTION OF COMMON MODE SIGNALS ON BALANCED LINES	At least 40 dB at 1 kHz; at least 34 dB at 560 kHz (subject to maximum r.m.s. voltage limitations of 0·5 V on −10 dBm ranges and below, 70 V on 0 dBm to +20 dBm ranges at 50 Hz and 14 V at 560 kHz).
MAXIMUM INPUT	AC or d.c. voltage between terminals or from terminals to chassis must not exceed 100 V peak or 0·5 W, whichever is more significant.
AMPLIFIER OUTPUT	Available at two front-panel terminals. Output approximately 85 mV r.m.s. when meter reads 0 dBm. Output impedance nominally 1 kΩ.

GENERAL

POWER REQUIREMENTS				
AC supply	190 to 260 and 95 to 130 V, 45 to 500 Hz; 5 W.			
External d.c.	21·5 to 30 V 50 mA.			
SAFETY	Complies with IEC 348 and BS 4743 safety requirements.			
DIMENSIONS AND WEIGHT (with front cover attached)	Height 190 mm $7\frac{1}{2}$ in	Width 470 mm $18\frac{1}{2}$ in	Depth 320 mm $12\frac{5}{8}$ in	Weight 12·7 kg 28 lb

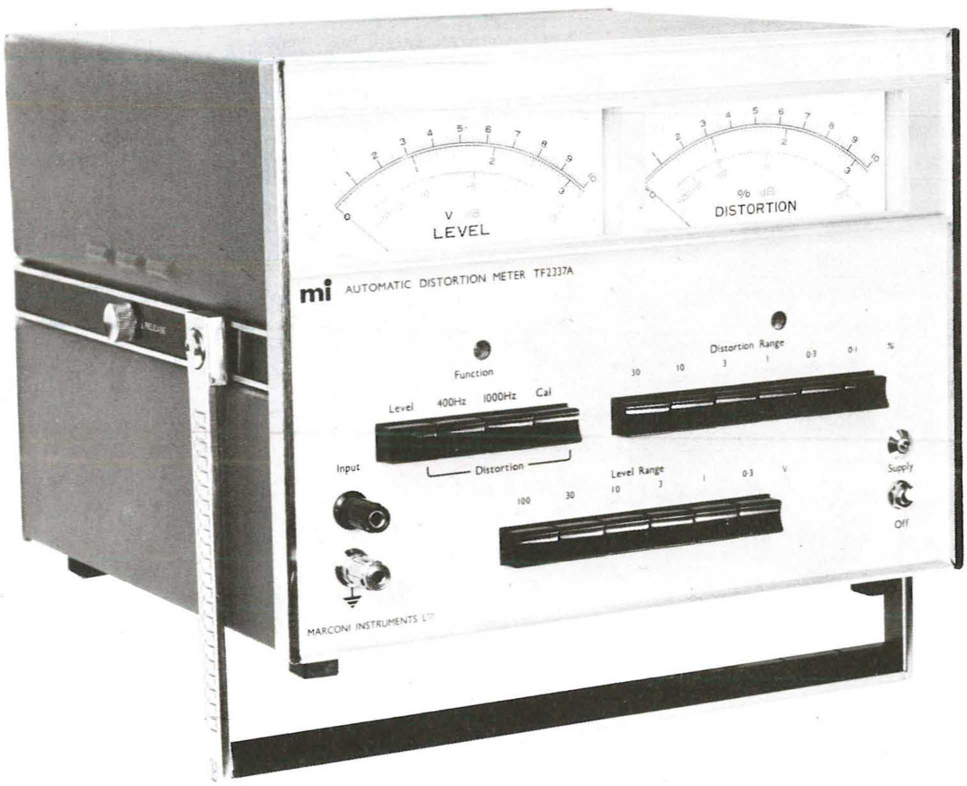
VERSIONS AND ACCESSORIES

When ordering please quote eight-digit code numbers.

Ordering numbers	
52333–900Y	Versions MF Transmission Measuring Set TF 2333. Standard version.
	Supplied Accessories Unbalanced Output Lead TC 40069 (43128–011J). Two supplied. Balanced Output Lead TM 4726/208 (43125–037B). Two supplied. Protective Cover (Lid Assembly) TM 7510 (54124–011K).
41635–041P	Optional Accessories Rack Mounting Case TM 7010.

Automatic Distortion Meter

- ☐ 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.

A novel ratio circuit is used for making the measurement. The input signal, after impedance conversion and amplification, is split into two parallel paths. One path includes a fundamental rejection filter consisting of an active twin-T four stage element. After rejection of the fundamental, the harmonic and noise content are amplified and fed to an a.c. to d.c. converter. In the parallel path the complete signal, fundamental plus harmonic, is passed through an a.c. to d.c. converter and is then recombined with the filtered signal in a ratio circuit. The output of this circuit is related to the value of the harmonic content of the total signal and is displayed on the front-panel DISTORTION meter.

Fundamental Frequency Rejection

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.

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%. 1 kHz ±5%. (Optional frequencies available on application).
BANDWIDTH (Upper −3dB point)	
Level measurement	Nominally 20 kHz.
Distortion measurement	Nominally 10 kHz.
INPUT IMPEDANCE	100 k Ω ±10% unbalanced in parallel with less than 50 pF.
DISTORTION MEASUREMENT	
Range	0·01 to 30·0% in six ranges: 0·01 to 0·1% 0·03 to 0·3% 0·1 to 1·0% 0·3 to 3·0% 1 to 10% 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. At least 66 dB, within ±5% of centre frequency.
Harmonic frequency response	400 Hz filter: 760 Hz to 10 kHz within 0·6 dB. 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: 0·03 to 0·3 V r.m.s. 0·1 to 1·0 V r.m.s. 0·3 to 3·0 V r.m.s. 1·0 to 10·0 V r.m.s. 3 to 30 V r.m.s. 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
POWER REQUIREMENTS	
AC supply	95 to 125 V and 190 to 250 V, 50 to 60 Hz, 6 VA.
SAFETY	Complies with the requirements of IEC 348.
DIMENSIONS AND WEIGHT	Height 210 mm 8·2 in. Width 285 mm 11·2 in. Depth 270 mm 10·6 in. Weight 6kg 12 lb.

VERSIONS AND ACCESSORIES

When ordering please quote eight digit code numbers

Ordering Numbers	
	Versions
52337–910N	Automatic Distortion Meter TF 2337A.
	Optional Accessories
54497–151D	50 Hz Band Stop Filter.
54497–161B	60 Hz Band Stop Filter.
54497–171Y	69 Hz Band Stop Filter.
54497–141L	150 Hz Band Stop Filter.
54497–131A	1600 Hz Band Stop Filter.
	Filters at other frequencies in the range 20 Hz to 2 kHz may be available.
	Complementary Equipment
52331–910T	Distortion Factor Meter TF 2331A. This is a manually-operated distortion meter suitable for development and type-approval testing. For full details see separate data sheet.

Made in Japan

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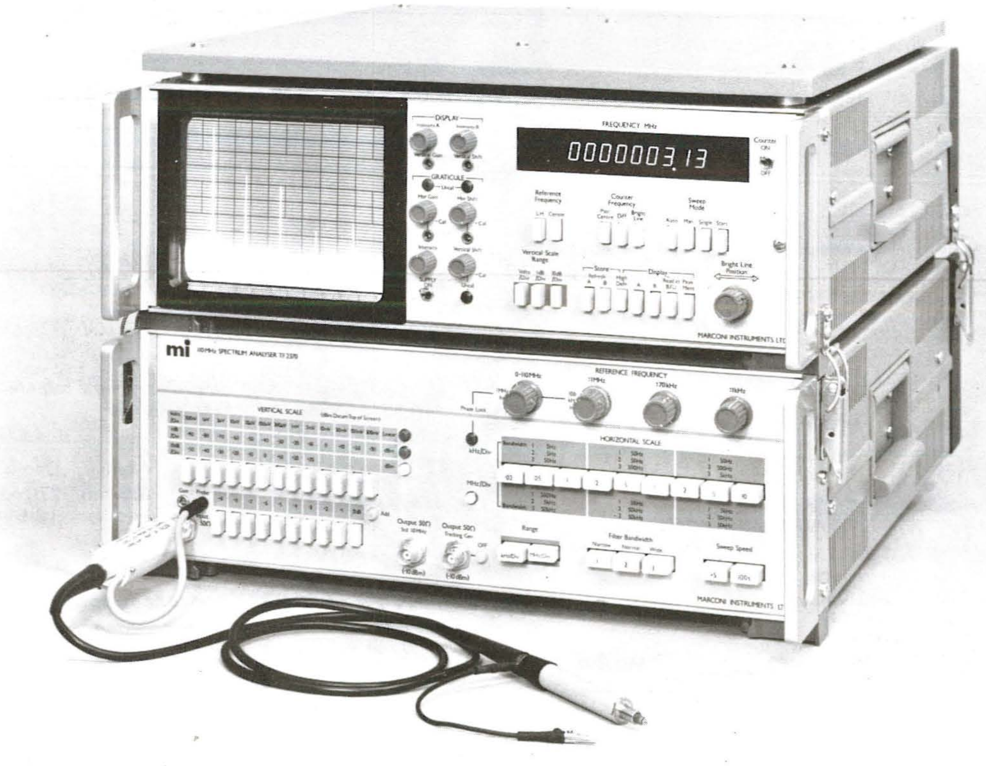
110 MHz Spectrum Analyser

- 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



TF 2370 with Zero Loss Probe TK 2374 14252/1

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.

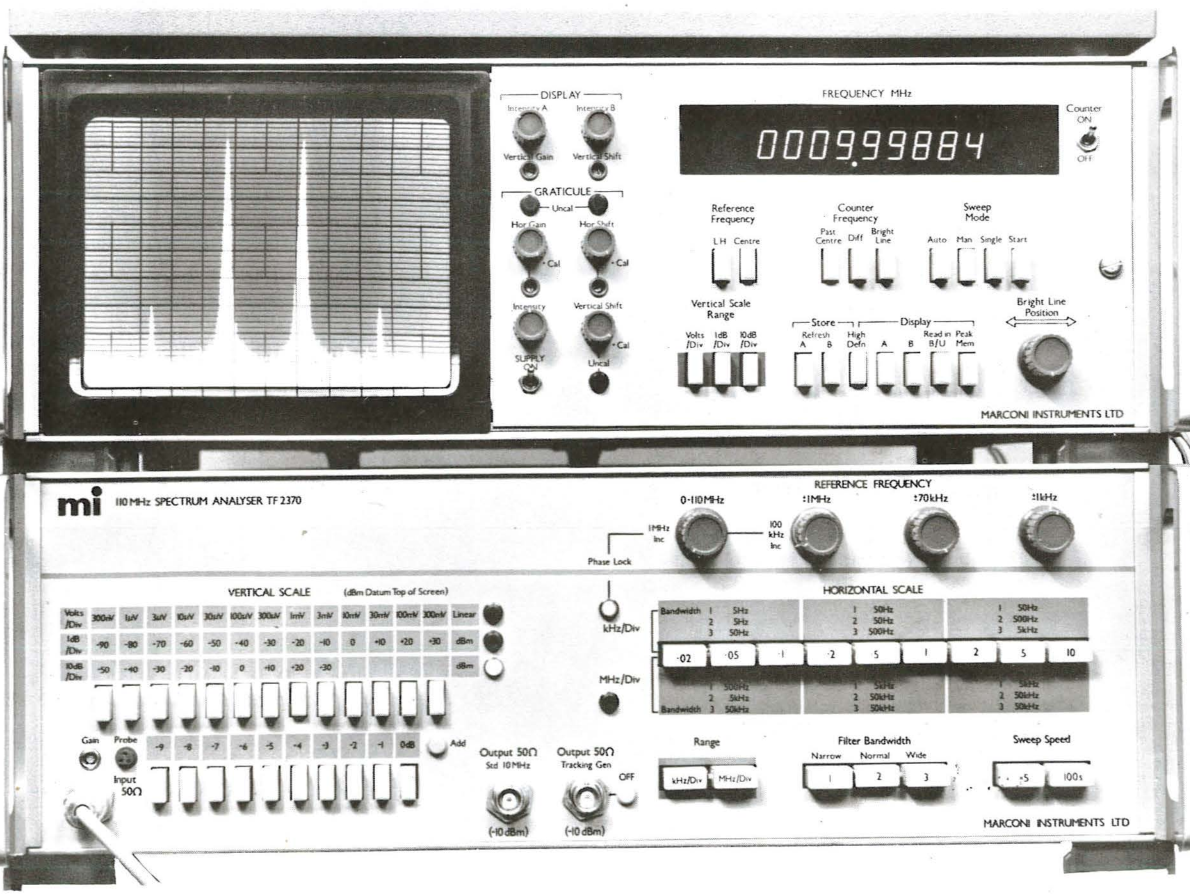
A split-store mode permits the store to be used in two halves, each of 256 ordinates, to superimpose two recorded displays with the facility for updating one store while retaining the other for comparison purposes. One image can be dimmed relative to the other for easy identification.

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.



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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 pushbutton 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.

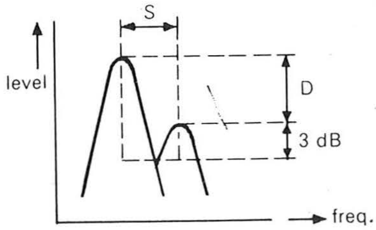
AMPLITUDE MEASUREMENT

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. ***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:* ±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 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, 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 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 1 hour 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)
$\pm 2 \times 10^{-6}$ (temperature coefficient).

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: 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): 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.

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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).
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. Contact switch rating: 10 W Maximum current : 0·25 A Maximum voltage : 100 V Resistance : 0·15 Ω.
PROBE SUPPLY	Supply available at front panel socket to power Zero Loss Probe TK 2374.
POWER REQUIREMENTS AC supply	200 to 250 V or 100 to 130 V at any frequency between 45 and 500 Hz. *Regulation:* ±10% on the nominal supply voltage. Approximately 150 W (190 VA).

SAFETY REGULATIONS	This instrument complies with IEC 348 and BS 4743 safety requirements.
DIMENSIONS AND WEIGHT	

	Height	Width	Depth	Weight
Display unit	172 mm	440 mm	516 mm	20 kg
	$6\frac{3}{4}$ in	$17\frac{5}{16}$ in	$20\frac{5}{16}$ in	44 lb
RF unit	156 mm	453 mm	516 mm	19·5 kg
	$6\frac{1}{8}$ in	$17\frac{13}{16}$ in	$20\frac{5}{16}$ in	43 lb

VERSIONS AND ACCESSORIES

When ordering please quote eight-digit code numbers

Ordering numbers	
	Versions
52370–015F	TF 2370 Standard version. (NATO Cat. No. 6625-99-529-1124).
52370–901E	TF 2370/1. Version with 75 Ω input, Tracking Generator output and Calibrator Output. Specification is otherwise as for TF 2370.
	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.
	Optional Accessories
52374–900C	Zero Loss Probe TK 2374.
52374–901R	Zero Loss Probe TK 2374/1
43168–016X	Adapter (BNC to phone jack).
43281–007C	RF Fuse Unit TM 9884.
54127–211H	Rack Mounting Kit.
46883–267B	Camera Hood. For use with Polaroid Model 77 camera 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.
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.)

- ☐ Active probe for use with Spectrum Analyser TF 2370 series
- ☐ High input impedance
- ☐ Intermodulation performance of TF 2370 maintained
- ☐ Wide range of supplied accessories

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TK 2374 is an active, zero loss probe designed for use with 110 MHz Spectrum Analyser TF 2370 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 Analyser TF 2370, and TK 2374/1 for use with the 75 Ω model TF 2370/1.

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.

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 −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. TK 2374/1: suitable for operation at 75 Ω.
INTERMODULATION CAPABILITY	Does not degrade the specified performance of Spectrum Analyser TF 2370 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. 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 TF 2370: less than −105 dBm with 5 kHz filter, manual sweep and counter off.
PROBE SUPPLY	Available at TF 2370 front panel, or −7·5 V regulated at 60 mA d.c.
TERMINATIONS	Signal lead: BNC Supply lead: Subminiature 3 pin.
DIMENSIONS AND WEIGHT (Accessory case with probe and all accessories)	Height 56 mm 2·2 in; Width 233 mm 9·2 in; Depth 142 mm 5·6 in; Weight 480 gm 1·1 lb

VERSIONS AND ACCESSORIES

When ordering please quote eight-digit code numbers

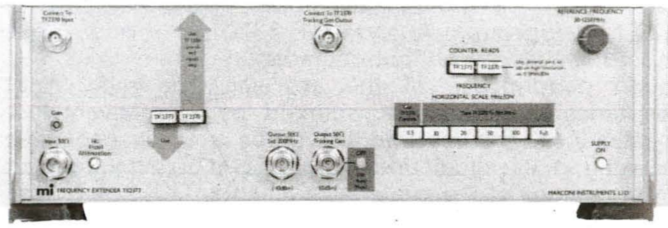
Ordering numbers	
	Versions
52374–900C	Zero Loss Probe TK 2374, for 50 Ω use.
52374–901R	Zero Loss Probe TK 2374/1, for 75 Ω use.
	Supplied Accessories Accessory Case. Voltage Divider 10:1. Voltage Divider 100:1 BNC probe input adapter. Probe hook tip. Earth lead (2 off). Sprung earth bayonet. 50 Ω or 75 Ω Through termination. Spare probe tips (3 off).

COMING SOON

Provisional information is given below of new products which will shortly be introduced into the Marconi Instruments range.

Frequency Extender TK 2373

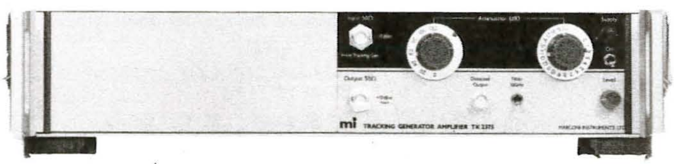
TK 2373 is an extender unit which can be used to increase the frequency range of 110 MHz Spectrum Analyser TF 2370 to 1·25 GHz. The extender provides a range of sweep widths up to the full 50 MHz to 1250 MHz frequency range, with a resolution defined by TF 2370. All basic features of TF 2370 are retained. TK 2373 is mounted beneath TF 2370, and r.f. connections are made via the front panels. The r.f. input and tracking generator output are on the front panel of TK 2373.



FREQUENCY MEASUREMENT	
Frequency range	50 MHz to 1·25 GHz.
Sweep widths	50 MHz to 1250 MHz (full sweep) and 100 MHz/div to 10 MHz/div in a 1, 2, 5 sequence.
TRACKING GENERATOR OUTPUT	
Frequency	50 MHz to 1·25 GHz within 2 Hz of tuned frequency.
Amplitude	0 dBm.

Tracking Generator Amplifier TK 2375

TK 2375 is an amplifier which can be mounted beneath 110 MHz Spectrum Analyser TF 2370 and can be used to amplify its tracking generator output to +10 dBm, with an improved flatness of ±0·5 dB. Its main application will be for frequency response measurements on networks such as filters, amplifiers and i.f. strips, enabling them to be analysed at various levels to test their dynamic ranges.



OUTPUT	
Amplitude	+10 dBm ±0·5 dB at 10 MHz.
Frequency response	±0·5 dB from 100 kHz to 110 MHz, relative to the level at 10 MHz.
Impedance	50 Ω.
VSWR	Better than 1·2:1.
ATTENUATORS	
Range	140 dB in six steps of 20 dB and twenty steps of 1 dB.
Accuracy	At 100 MHz: ±0·5% of setting ±0·2 dB, 0 to 100 dB.
Impedance	50 Ω.
VSWR	Better than 1·1:1.

FREQUENCY METERS

Digital Frequency Meters TF 2340 series 130

For further Frequency Meters see the Microwave Products Section:

Wavemeter Grade 2 type 6017/2 265

Frequency Meter type 6049/1 (2·6 to 8·2 GHz) 230

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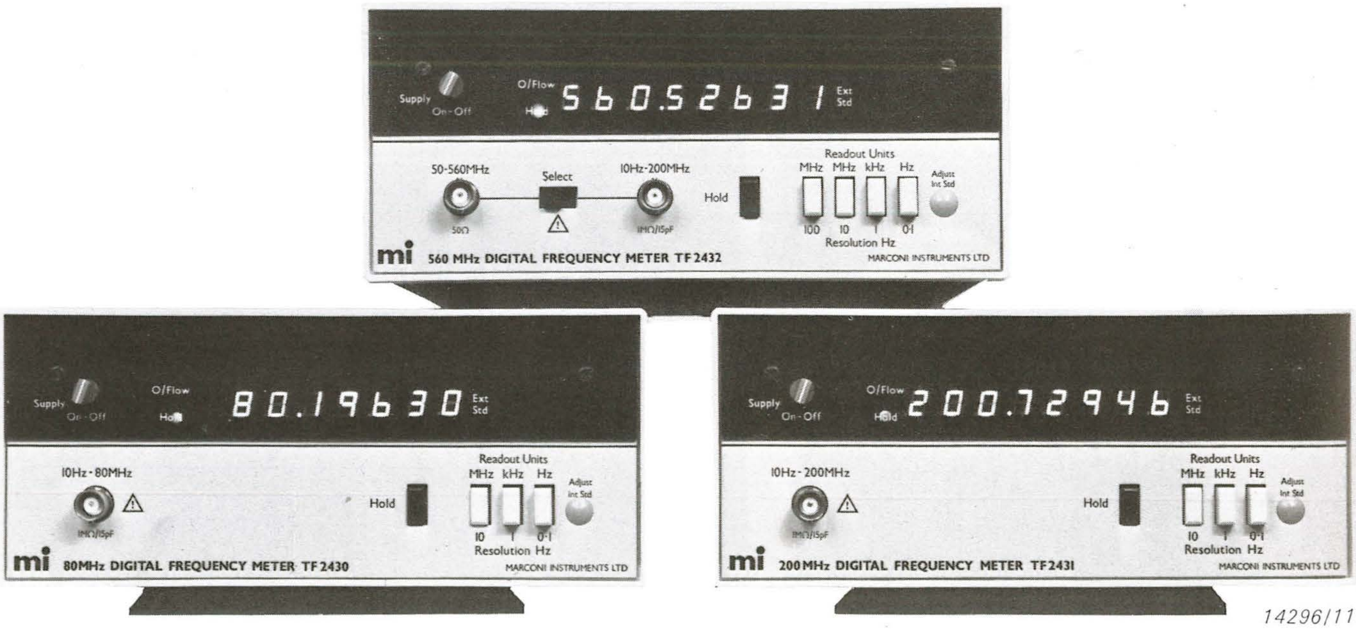
Digital Frequency Meters

- TF 2430: 10 Hz to 80 MHz
  TF 2431: 10 Hz to 200 MHz
  TF 2432: 10 Hz to 560 MHz
- Direct frequency measurement – resolution to 0·1 Hz
- Automatic gain control – wide dynamic range
- Bright LED display
- Simple operation
- Operation on internal or external frequency standard
- Excellent reliability and servicing accessibility, two-year guarantee
- Low cost, small size, light weight



14296/11

This new range of Digital Frequency Meters provides general purpose frequency measurement up to 560 MHz. Direct frequency measurement, without pre-scaling, gives resolution to 0·1 Hz.

Much of the circuitry is contained in an MOS-LSI chip, custom-designed by GEC Semiconductors Ltd. Among the benefits produced are operating simplicity, reliability, small-size and light weight. Other features common to the range are a bright LED display with memory, automatic positioning of decimal point, overflow indication and leading zero suppression. The instruments all have provision for operating with internal or external frequency standard. They differ principally in the frequency ranges covered.

Input channels

TF 2430 and TF 2431 both have single, high impedance inputs, with frequency cover from 10 Hz to 80 MHz and 10 Hz to 200 MHz respectively. TF 2432 has 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 TF 2430 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 the lower frequency range of each model, reducing to 5 V r.m.s. at the highest frequencies. The 50 Ω high frequency input channel of TF 2432 is protected by a built-in r.f. fuse. Application of overload voltages up to 50 volts to this channel will only result in a blown fuse.

Display

Frequency readout is provided by bright LED displays with memory – a seven digit display in TF 2430 and an eight-digit display in the two higher-frequency models. Characters are seven-segment and have a minimum height of 7 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. Readout is retained during the gating period or held indefinitely by means of the front panel HOLD button.

Decimal point positioning, overflow indication and leading zero suppression are all automatic. TF 2432 also includes a digit check facility whereby all the LED segments (i.e. a series of '8's) and all decimal points are displayed when all the gate time buttons are simultaneously released.

Frequency standard

Gate times are derived from a built-in crystal oscillator operating at 10 MHz and offering a stability better than ± 5 in 10^6 over the operating temperature range. To compensate for crystal ageing the frequency of this oscillator can readily be adjusted by means of a pre-set screwdriver control on the front panel.

For measurements which require a greater frequency accuracy there is provision on all models for operation with an external standard frequency applied via a back-panel socket. On TF 2430 and TF 2431 a rear-panel switch is used to select internal or external standard operation, and a front panel display is automatically illuminated to show when the external standard is in use. On TF 2432 the selection of internal or external standard is automatic. When an external standard is connected this overrides the internal oscillator and is again indicated by the front-panel display. If the external standard fails or is removed, the instrument automatically switches over to operation from the internal oscillator. This feature is valuable in automatic or remote set-ups or where there is no access to the rear panel.

TF 2430 and TF 2431 require an external standard operating at 10 MHz. TF 2432 will accept either a 100 kHz or 1 MHz external standard, as selected by a rear-panel switch. The sensitivity and bandwidth versatility of the external input on TF 2432 offer the possibility of ratio measurements.

High stability internal oscillator

Models TF 2431 and TF 2432 are available as versions with a built-in high stability frequency standard replacing the normal oscillator. This high-stability standard consists of an oven-controlled 10 MHz oscillator with a temperature stability of better than ± 1 in 10^7 over the operating temperature range.

Construction

Particular attention has been paid in the design of these frequency meters to good electrical and mechanical construction in order to achieve excellent reliability together with ease of access for servicing. This has resulted in a very open layout despite the small size of the instruments. The toroidal mains transformer is mounted on a small sub-chassis which can be pivoted up to give access to all components of the power supply.

On TF 2432 an additional printed circuit board is included, to which the display unit is connected, but special provision has been made to enable this board to be unplugged from its usual position and plugged in at right angles to give complete servicing accessibility while the instrument is still fully operational.

These frequency meters have been designed to conform to IEC 348 and BS 4743 safety regulations. No mains voltages appear on the printed circuit boards, and all mains voltage points are fully protected when the instrument covers are removed.

Accessories

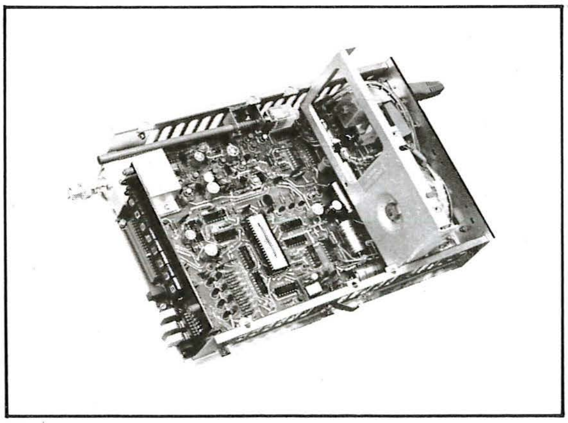
An accessory kit is available which provides a rear stand to enable the instrument to be operated in a vertical position. The kit also includes the necessary right angle mains lead, a protective lid for the front panel and two sets of carrying straps, for hand and shoulder.

A kit is also available for mounting the frequency meters in a standard nineteen inch rack.

TF 2430 series

TYPE NUMBER	TF 2430	TF 2431	TF 2432
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. *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 25 mV r.m.s. (sinewave) from 70 MHz to 200 MHz. *HF INPUT:* 10 mV r.m.s. (sinewave).
	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. *HF INPUT:* 54 dB.
Maximum sinewave input	260 V r.m.s. at 50 Hz 5 V r.m.s. at 80 MHz Degradation from 50 Hz to 80 MHz is approximately 3×10^{-6} V/Hz.	260 V r.m.s. at 50 Hz 5 V r.m.s. at 200 MHz Degradation from 50 Hz to 200 MHz is approximately $1{\cdot}3\times10^{-6}$ V/Hz.	*LF INPUT:* 260 V r.m.s. at 50 Hz 5 V r.m.s. at 200 MHz. Degradation from 50 Hz to 200 MHz is approximately $1{\cdot}3\times10^{-6}$ V/Hz. *HF INPUT:* 5 V r.m.s. from 50 MHz to 560 MHz.
Maximum d.c.	250 V.		*LF INPUT:* 250 V. *HF INPUT:* 5 V.
Maximum pk a.c. +d.c.	250 V at nominal 50 Hz.		*LF INPUT:* 250 V. *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. *HF INPUT:* 50 Ω nominal.
DISPLAY	Seven digit, with memory.	Eight digit, with memory.	
	Seven-segment LEDs of 7 mm minimum height.		
Units and resolution	Three push-buttons select gate times providing resolutions of 10, 1 or 0·1 Hz, and also indicate readout units.		Four push-buttons select gate times providing resolutions of 100, 10, 1 or 0·1 Hz, and also indicate readout units.
	Decimal point automatically selected. Overflow indication. Leading zeros suppressed.		
			Digit check facility to display all LED segments and decimal points.
Display times	Readout retained during gating period or held indefinitely by means of the HOLD button.		
Accuracy	±1 count ± stability of frequency standard.		
FREQUENCY STANDARD	Internal crystal oscillator or external input selected by rear panel switch.		Internal crystal oscillator or external input automatically selected. Application of external signal overrides internal oscillator.
	Front panel indication when external standard is in operation.		
INTERNAL CRYSTAL OSCILLATOR Frequency	10 MHz. Provision for adjusting oscillator frequency via front panel to compensate for ageing.		
Temperature stability	Better than ±5 in 10^6 over the operating temperature range.		
Ageing rate	Approximately 4 in 10^9 per day at constant temperature.		
OPTIONAL HIGH STABILITY FREQUENCY STANDARD Frequency		10 MHz. The crystal frequency may be adjusted via the front panel to compensate for ageing.	
Temperature stability		Better than ±2·5 in 10^9 per °C average.	
Ageing rate		Nominally 1 in 10^7 per week after 1 month of continual use.	
Warm-up time		Stabilises to within 1 in 10^6 of the final value in 5 minutes from switch-on at ambient temperature above 20°C.	
AUXILIARY OUTPUT	Internal standard available at rear panel.		
Frequency	10 MHz		1 MHz
Output level	Greater than 100 mV p-p into 50 Ω (approximately 4·0 V p-p e.m.f.).		
Output impedance	Approximately 2 kΩ.		

TYPE NUMBER	TF 2430	TF 2431	TF 2432
EXTERNAL FREQUENCY STANDARD Frequency	10 MHz sinewave or squarewave.		100 kHz or 1 MHz selected by rear panel switch. Usable from 10 kHz to 10 MHz for ratio measurements.
Input level	2·5 V to 5·5 V p-p.		50 mV r.m.s. to 5 V r.m.s.
Input impedance	Approximately 300 Ω, a.c. coupled.		Approximately 1 MΩ in parallel with less than 25 pF.
SAFETY	Designed to meet the requirements of IEC 348.		
POWER REQUIREMENTS AC supply	95 to 130 V or 190 to 264 V: 45 to 500 Hz.		
	10 VA approximately.		15 VA approximately.
DIMENSIONS AND WEIGHT	Height 100 mm 4 in	Width 220 mm 8¾ in	Depth 310 mm 12 in Weight 2·2 kg 4¾ lb.
OPERATING TEMPERATURE RANGE	0°C to +40°C.		
VERSIONS Ordering number and description	**52430–900Y** 80 MHz Digital Frequency Meter TF 2430	**52431–301Y** 200 MHz Digital Frequency Meter TF 2431. With standard 10 MHz Crystal Oscillator. **52431–302N** 200 MHz Digital Frequency Meter TF 2431. With high stability 10 MHz Crystal Oscillator.	**52432–301T** 560 MHz Digital Frequency Meter TF 2432. With standard 10 MHz Crystal Oscillator. **52432–302P** 560 MHz Digital Frequency Meter TF 2432. With high stability 10 MHz Crystal Oscillator.
OPTIONAL ACCESSORIES Ordering number and description	**46883–281N** Accessory Kit comprising: Storage lid for front panel. Rear stand. Alternative right angle mains lead. 2 sets of carrying straps – hand and shoulder. **46883–282L** Rack Mounting Tray Kit.		



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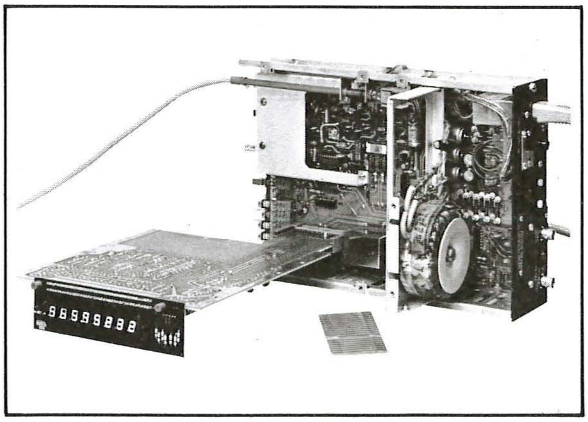
Interior view of TF 2431 showing the transformer sub-chassis pivoted up for access



14175/7

Interior view of TF 2432 showing control p.c.b. mounted in servicing position.

COMING SOON

Provisional information is given below of new products which will shortly be introduced into the Marconi Instruments range.

2 GHz Digital Frequency Meter TF 2435

TF 2435 provides frequency measurement from 10 Hz to 2 GHz with an eight-digit l.e.d. display and resolution to 0·1 Hz. The display incorporates memory, automatic positioning of the decimal point, overflow indication and leading zero suppression.

Two inputs are provided, channels A and B, with automatic gain control on both channels giving a wide dynamic range and high tolerance to signal distortion and noise. Channel B is a high impedance input covering the frequency range 10 Hz to 200 MHz. Channel A is a 50 Ω input covering the range 200 MHz to 2 GHz.

The reference frequency can be derived from either an internal 10 MHz crystal oscillator or an external standard.

FREQUENCY RANGE		
	Channel B	10 Hz to 200 MHz.
	Channel A	200 MHz to 2 GHz.
SENSITIVITY		
	Channel B	10 mV r.m.s. (sinewave) up to 70 MHz. 25 mV r.m.s. (sinewave) up to 200 MHz.
	Channel A	−13 dBm (50 mV r.m.s. p.d. into 50 Ω).
INPUT IMPEDANCE		
	Channel B	1 MΩ in parallel with 25 pF.
	Channel A	50 Ω.
TEMPERATURE STABILITY		±5 in 10^6 over the temperature range 0 to 40°C, with internal frequency standard.

100 MHz Universal Counter Timer TF 2437

TF 2437 is a universal counter timer covering the frequency range 0 to 100 MHz. Measurement functions provided are frequency, single period, period average, time interval, time interval average, count and ratio.

An eight-digit l.e.d. display has automatic positioning of decimal point, overflow indication and leading zero suppression. TF 2437 can be operated either with an internal or external frequency standard.

FREQUENCY		0 to 100 MHz, direct count.
	Resolution	1 kHz to 0·1 Hz.
PERIOD		100 ns to 1000 s, single and average mode.
	Resolution	10 μs to 100 ps.
TIME INTERVAL		100 ns to 1000 s, single and average mode.
	Resolution	10 μs to 100 ps.
COUNT		Up to 10^7 events per second.
RATIO		Frequency range 1 kHz to 10 MHz.
TEMPERATURE STABILITY		±5 to 10^6 over operating temperature range 0 to 40°C, using internal oscillator.

520 MHz Universal Counter Timer TF 2438

TF 2438 is a universal counter timer covering the frequency range 0 to 520 MHz. Measurement functions provided are frequency, single period, period average, time interval, time interval average, count and ratio.

An eight-digit l.e.d. display has automatic positioning of decimal point, overflow indication and leading zero suppression. TF 2438 can be operated either with an internal or external frequency standard.

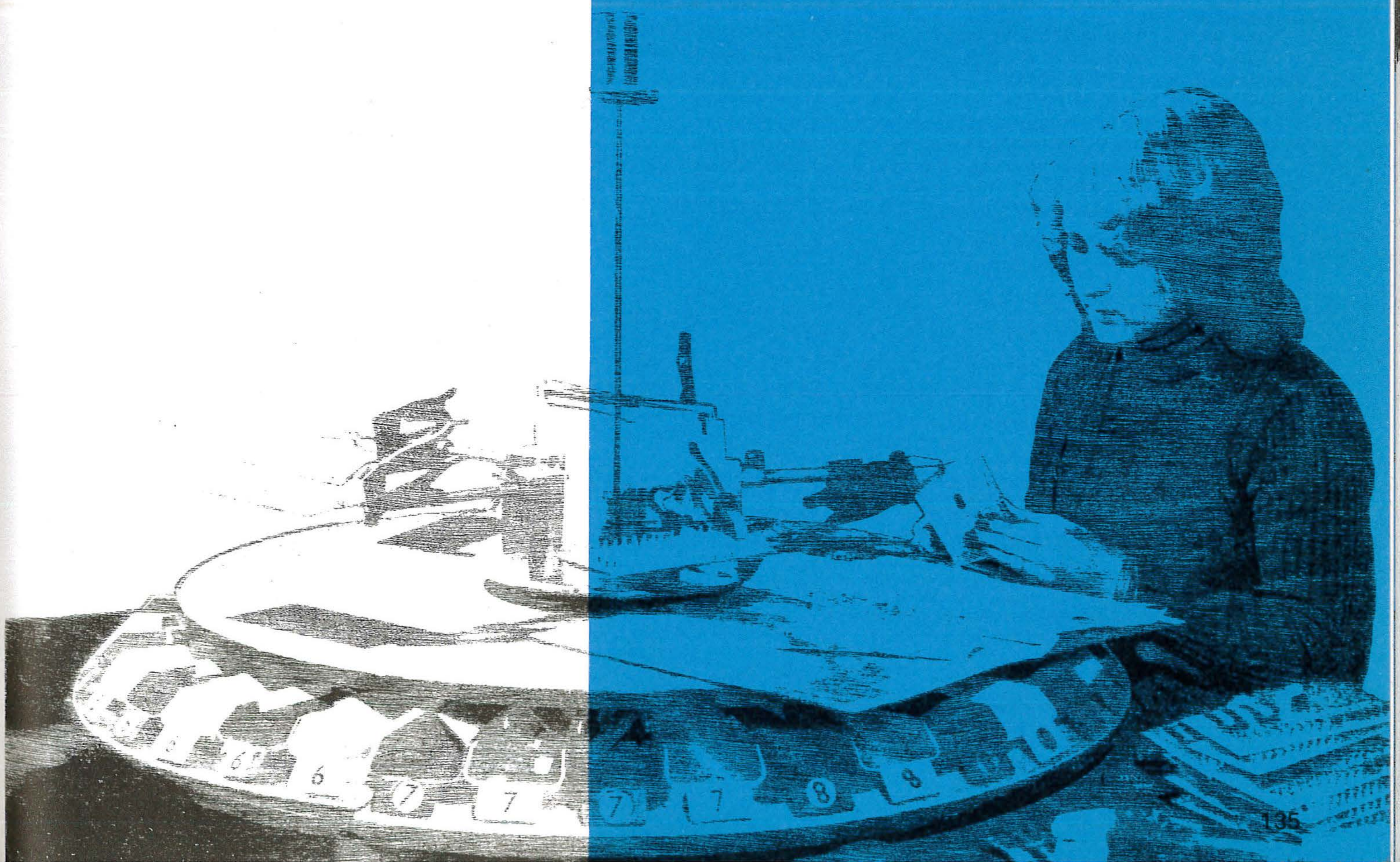
FREQUENCY		0 to 520 MHz.
	Resolution	1 kHz to 0·1 Hz.
PERIOD		100 ns to 1000 s, single and average mode.
	Resolution	10 μs to 100 ps.
TIME INTERVAL		100 ns to 1000 s, single and average mode.
	Resolution	10 μs to 100 ps.
COUNT		Up to 10^8 events per second.
RATIO		Frequency range 1 kHz to 10 MHz.
TEMPERATURE STABILITY		±5 in 10^6 over the operating temperature range 0 to 40°C, using internal oscillator.

POWER METERS

AF Power Meter (10 watts)	TF 893A	136
RF Power Meter (3 watts)	TF 2501	137
RF Power Meter (10 watts)	TF 2502	138
RF Power Meter (100 watts)	TF 2503	139
75/50 Ω RF Transformer	TK 2509	140
RF Power Meter (30 watts)	TF 2512	141

For further Power Meters see the Microwave Products Section:

tft Power Heads type 6440/6420 series (10 MHz to 40 GHz)	240
Thermoelectric Power Meter type 6460 (0·03 μW to 3 W)	245
Programmable tft Power Meter type 6550B (1 μW to 3 W)	248
tft Power Meter type 6555 (3 μW to 3 W)	249



TF 893A 10 Watt AF Power Meter

- ☐ Frequency range: 20 Hz to 20 kHz
- ☐ Five power ranges: 1 mW to 10 W full scale
- ☐ Impedance: 2·5 Ω to 20 kΩ in 48 steps
- ☐ Balanced or unbalanced inputs
- ☐ Direct calibration in watts and dBm

This Audio Power Meter covers an exceptionally wide range of power and maintains its accuracy at both very high and very low frequencies.

Power is measured by a temperature-compensated constant-resistance multi-range rectifier voltmeter, the required input impedance being obtained by the use of a tapped transformer and by a switched resistance-changing pad. Provision is made for measuring either balanced or unbalanced inputs.

The instrument is contained in a compact portable case, with the input terminals fitted in a recess in the case top; this protects the terminals from accidental mechanical damage. The lid of the recess may be swung back to support the instrument at a convenient viewing angle, while the sloping front panel hinges upward for ease of servicing.

Impedance selection

The Meter measures the power delivered by an audio frequency source into a load provided by the instrument itself, and its excellence of performance over so wide a range of power, impedance and frequency is due primarily to two important points of design. Firstly, the patented feature – the use of a resistance network, forming an impedance-changing pad, to select the significant figures of the value of the input impedance; secondly, the use, for the decade multiplication of impedance, of a transformer using a wound-strip core of an isotropic magnetic alloy.

Centre-tapped input

There are five power measurement ranges, with calibration directly in watts or milli-watts and in decibels relative to 1 mW. The overall impedance range of 2·5 to 20 000 Ω is in forty-eight steps arranged in two groups identified by the use of engraving in contrasting colours. The primary of the input (impedance-matching) transformer of low d.c. resistance, is isolated from the case and is provided with a centre tap for push-pull working; the centre tap also allows impedances down to 0·625 Ω to be correctly terminated, but with some falling off in measurement accuracy.

10069

RANGE		
	Power	0 to 10 W in five ranges. Full-scale deflections are: 1-10 and 100 mW, 1 and 10 W.
	Impedance	2·5 Ω to 20 kΩ thus: 2·5–3–4–5–6–8–6·25–7·5–10–12·5–15–20 with multipliers ×1, ×10, ×100, ×1000. Impedances of one-quarter the above – extending the range down to 0·625 Ω – can be obtained by using the input centre tap, but with 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 at the 100 Ω setting or 4 mA at 20 kΩ setting.
ACCURACY (at 1 kHz and 20°C)		
	Power	$2\frac{1}{2}$% of full scale up to half-scale deflection. 5% of the reading from half-scale to full scale deflection.
	Impedance	5%.
FREQUENCY CHARACTERISTIC		With all controls at approximately mid-setting the response of a typical Power Meter is, relative to indication at 1 kHz flat to within –0·5 dB from 50 Hz to 10 kHz; at 20 kHz the response is approx. 1 dB down. At other control settings, the maximum variation from the above is ±1 dB at 50 Hz and ±1·5 dB at 20 kHz. The instrument can be used over the extended frequency range, 20 Hz to 35 kHz, with reduced accuracy.
SAFETY		Designed to meet the requirements of IEC 348.
DIMENSIONS AND WEIGHT		Height 280 mm 11 in; Width 190 mm $7\frac{1}{2}$ in; Depth 170 mm $6\frac{3}{4}$ in; Weight 4·1 kg 9 lb
ORDERING NUMBER	50893–910V	10 Watt AF Power Meter TF 893A.

- 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.

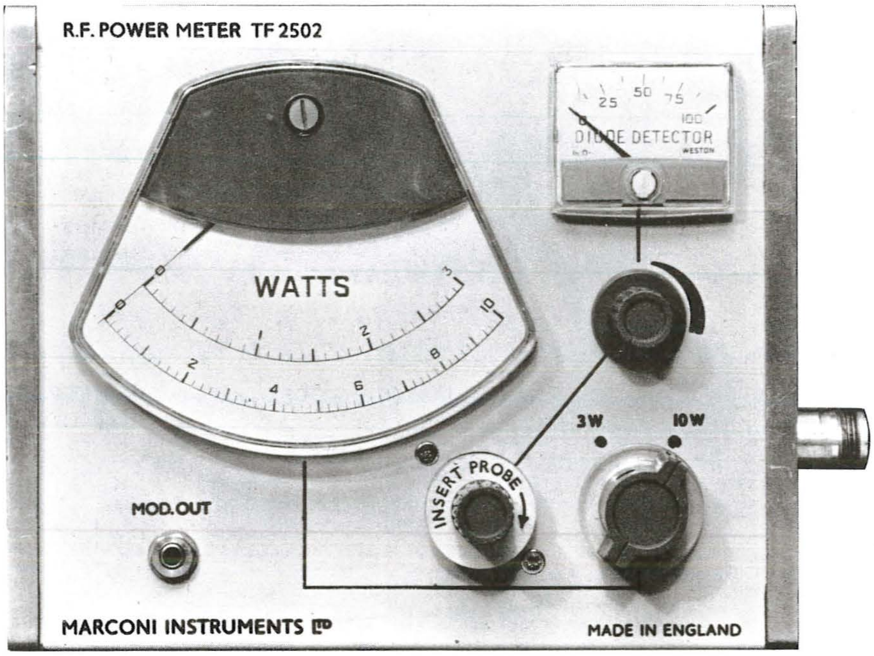
True mean power is indicated by means of a thermocouple meter, with switch-selected sensitivity of 1 watt or 3 watts f.s.d. As range selection is effected by changing the sensitivity of the d.c. side of the measuring circuit, it is impossible to damage the thermocouple by inadvertently switching to the 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).
Ranges	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.
DIODE DETECTOR	(Uncalibrated).
Frequency range	From below 5 MHz to at least 1 GHz.
DIMENSIONS AND WEIGHT	Height 130 mm $5\frac{1}{8}$ in; Width 220 mm $8\frac{5}{8}$ in; Depth 120 mm $4\frac{3}{4}$ in; Weight 1·4 kg 3 lb
SAFETY	Designed to meet the requirements of IEC 348.
ORDERING NUMBER	
52501–015E	RF Power Meter TF 2501.

TF 2502 RF Power Meter

- DC to 1 GHz
- 10 W f.s.d.
- VSWR 1·1 : 1
- Thermocouple 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.

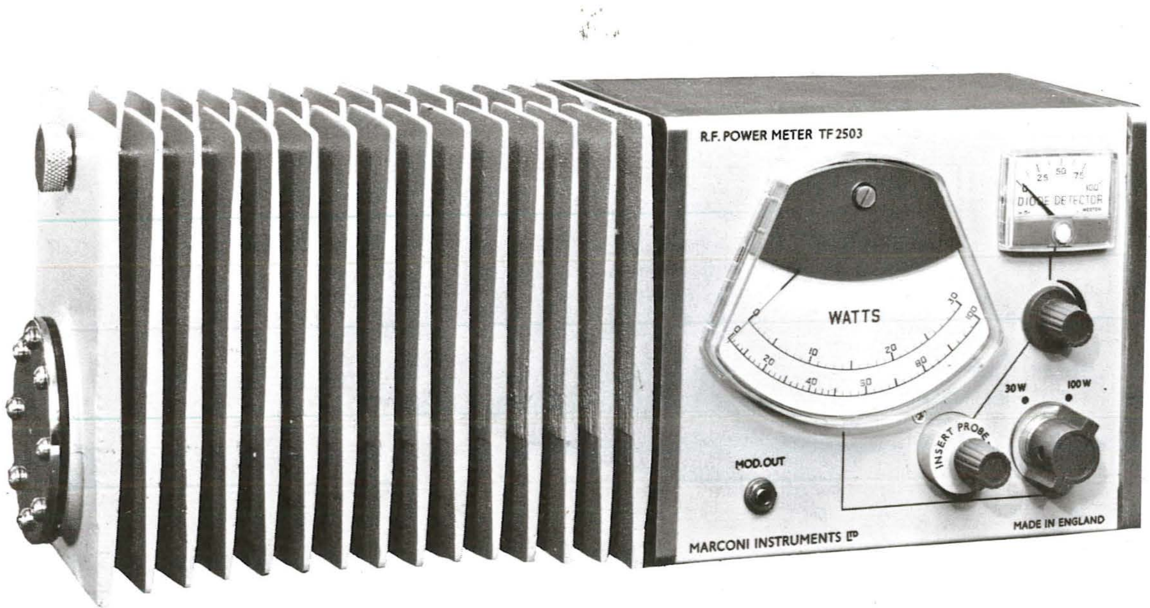
True mean power is indicated by means of a thermocouple meter, with switch-selected sensitivity of 3 watts or 10 watts f.s.d. As range selection is effected by changing the sensitivity of the d.c. side of the measuring circuit, it is impossible to damage the thermocouple by inadvertently switching to 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 130 mm $5\frac{1}{8}$ in; Width 220 mm $8\frac{5}{8}$ in; Depth 120 mm $4\frac{3}{4}$ in; Weight 1·4 kg 3 lb
SAFETY	Designed to meet the requirements of IEC 348.
ORDERING NUMBER	
52502–015W	RF Power Meter TF 2502.

RF Power Meter TF 2503

- DC to 1 GHz
- 100 W f.s.d.
- VSWR 1·1 : 1
- Thermocouple meter 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 new range of power meters, in which the small size and unusually low v.s.w.r. have been achieved by the use of new materials and the application of 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.

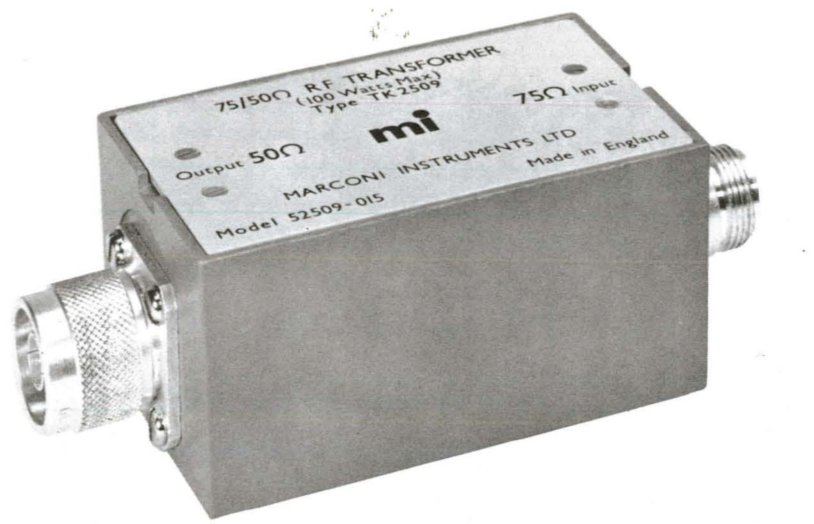
POWER MEASUREMENT	(calibrated thermocouple meter)
Ranges	0 to 30 W and 0 to 100 W.
Accuracy	± 5% of f.s.d. (true mean power).
Frequency range	DC to 1 GHz for stated accuracy.
Input impedance	50 Ω.
VSWR	Not greater than 1·1:1
Overload Capacity	20% continuously 50% for periods of up to 30s.
DIODE DETECTOR	(uncalibrated)
Frequency range	From below 5 MHz to at least 1 GHz.
SAFETY	Designed to meet the requirements of IEC 348.
ORDERING NUMBER 52503–015A	RF Power Meter TF2503.

DIMENSIONS AND WEIGHT

Height	Width	Depth	Weigh
160 mm	280 mm	110 mm	4 kg
6¼ in	11 in	4½ in	10 lb

TK 2509 75/50 Ω RF Transformer

- ☐ 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.

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: Better than 1·1:1 from 1·4 MHz to 100 MHz. Better than 1·2:1 from 100 MHz to 200 MHz.
DISSIPATION LOSS	When terminated in a 50 Ω load: Not greater than 0·25 dB at 200 MHz 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	Designed to meet the requirements of 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).
ORDERING NUMBER 52509–015D	75/50 Ω RF Transformer TK 2509.

RF POWER METER TF 2512

- DC to 500 MHz
- 10 W and 30 W f.s.d.
- VSWR 1·2 : 1
- Measures true mean power

12991/1

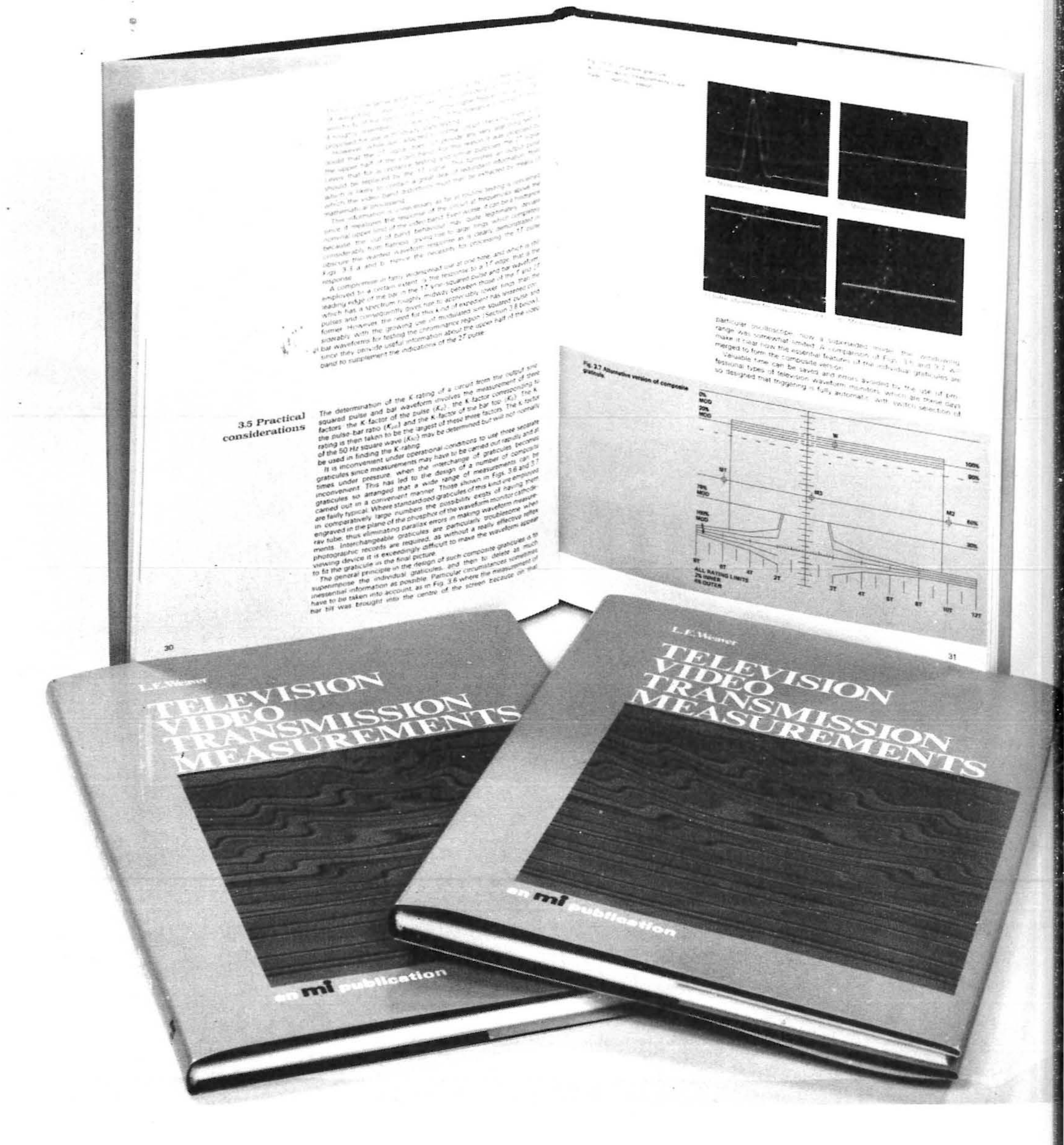
TF 2512 is a low-cost, direct-reading r.f. absorption power meter, specifically designed for use by manufacturers and users of mobile radio communications equipment. It has two measuring ranges of 0·5 to 10 W and 5 to 30 W, and a frequency range from d.c. to 500 MHz. Measurement accuracy is ±5% up to 250 MHz and ±7% up to 500 MHz.

By virtue of its two power ranges, TF 2512 is ideal for measurements on 8 W mobile radio transceivers and 25 W base station transmitters. It measures true mean power, irrespective of the applied wave shape, and so can be used for modulated signals; a.m., f.m. and pulsed. Calibration of the power meter is simple and can be performed at d.c. or 50 Hz using a dynamometer.

The dissipative element consists of a heavy-duty, high-stability resistor mounted so that it forms the central conductor of a slab or parallel-plate line. Connection of the power source is made to a type N coaxial socket, the input being fed to the live end of the resistor by an outward-tapering section which preserves a constant impedance between the connector and the relatively large-diameter resistor. From live to earthy end of the resistor the broad metal plates which form the outer conductor have an inward taper so that continuous matching is maintained along the whole length of the resistor.

Indication is by means of a moving-coil meter and robust vacuum thermocouple fed from a tap on the load resistor. Changing the power range is done by altering the meter sensitivity rather than by altering the proportion of input power applied to the thermocouple heater; it is thus impossible to damage the thermocouple by inadvertently switching to the wrong power range.

POWER MEASUREMENT	
Ranges	0·5 to 10 W and 5 to 30 W.
Accuracy	±5% of f.s.d. of true mean power from d.c. to 250 MHz. ±7% of f.s.d. of true mean power from 250 MHz to 500 MHz.
Frequency range	DC to 500 MHz.
Input impedance	50 Ω nominal, type N connector.
VSWR	Better than 1·2:1.
SAFETY	Designed to meet the requirements of IEC 348.
DIMENSIONS AND WEIGHT	Height 190 mm 7½ in; Width 137 mm 5½ in; Depth 345 mm 13½ in; Weight 3 kg 6½ lb
ORDERING NUMBER	
52512–900L	RF Power Meter TF 2512.



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.

VOLTMETERS

Video Voltmeter	TF 2600B	144
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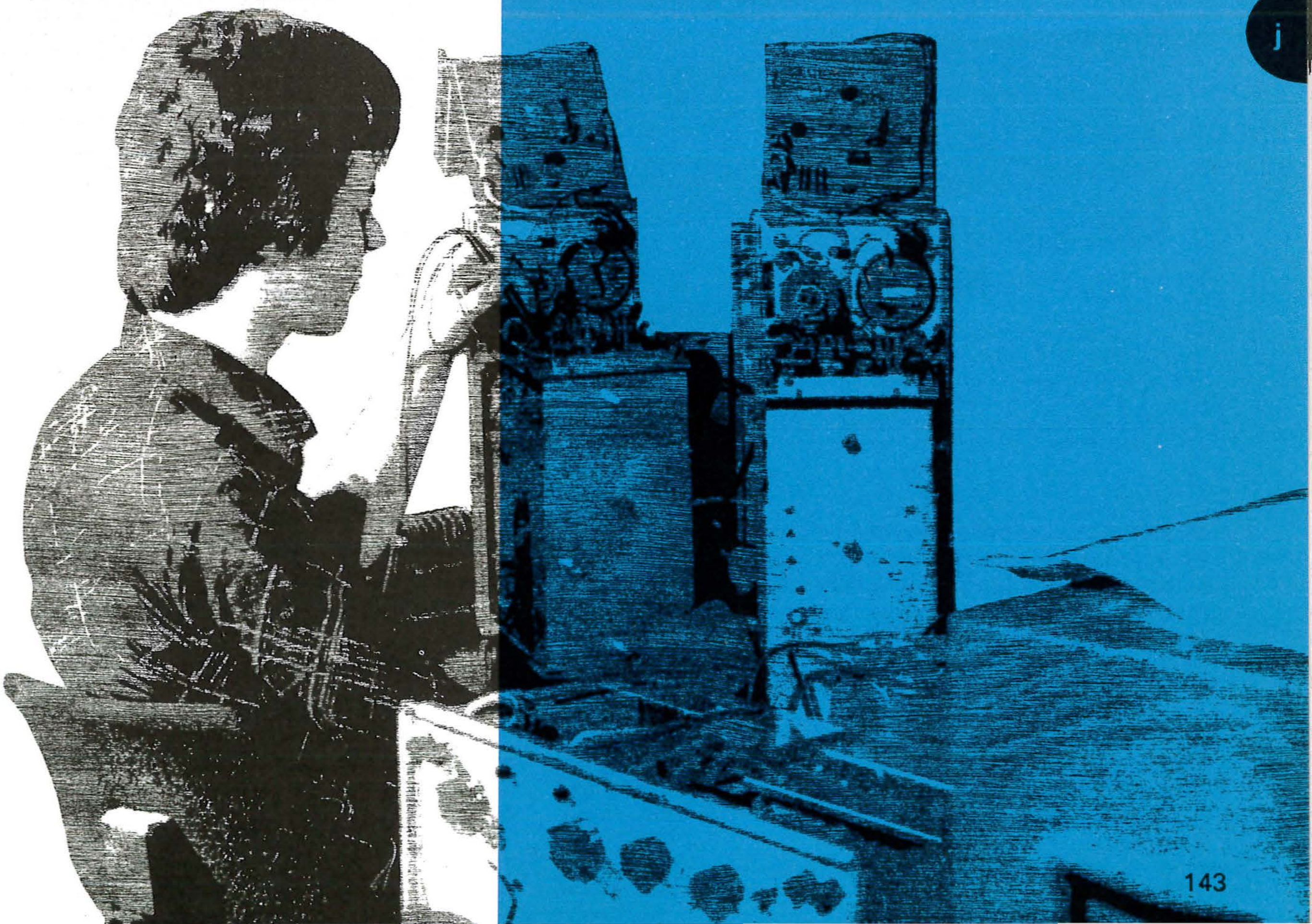
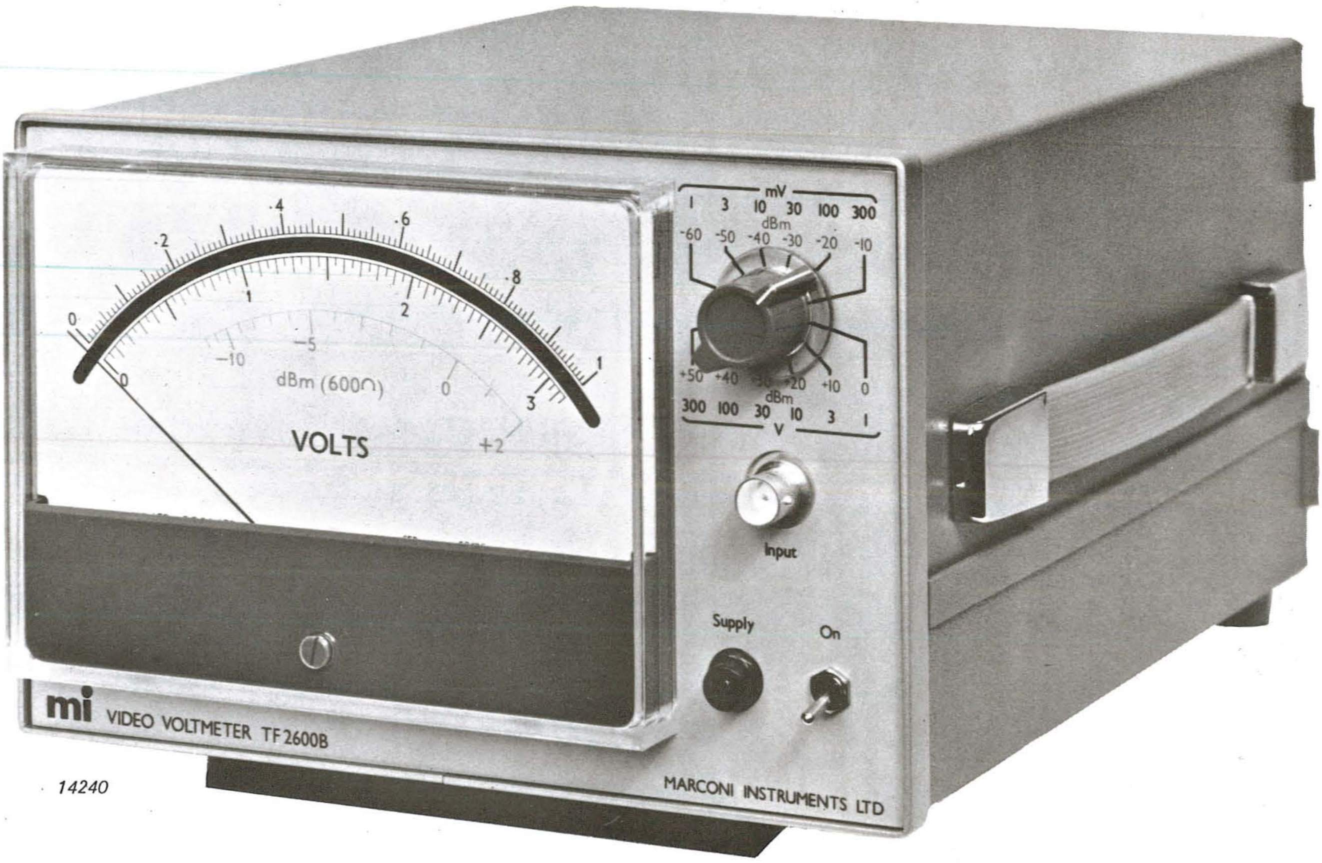


Video Voltmeter

- ☐ Twelve voltage ranges: 1 mV to 300 V f.s.d.
- ☐ Frequency range: 10 Hz to 10 MHz
- ☐ Large, clear linear voltage scales
- ☐ Basic accuracy: 1% over wide range
- ☐ High input impedance
- ☐ DC and AC outputs available



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TF 2600B is a sensitive wide band a.c. voltmeter consisting of a linear video amplifier with a full-wave average-responding detector in the negative feedback loop and a meter calibrated in r.m.s. value of a sinewave. A measurement accuracy of 1% can be obtained over a large part of the frequency and voltage range.

A large panel meter incorporates an anti-parallax mirror for reading accuracy. The 10 dB step attenuator gives twelve voltage ranges in a 1-3-10 sequence from 1 mV to 300 V f.s.d. with two linear voltage scales calibrated down to 10 μV on the most sensitive range. A dB scale gives readings from +2 to −12 dBm. Input impedance is 10 MΩ in parallel with a capacitance of 15 to 25 pF depending on range.

A d.c. output proportional to the a.c. input is available at rear panel terminals, and can be used to provide a very accurate drive to a digital voltmeter. An a.c. output proportional to the a.c. input is available at a rear panel BNC socket, permitting monitoring of the input frequency.

The stability of the instrument is such that the specified accuracy and frequency response applies over the normal working temperature range and no appreciable variation occurs as a result of variations in the mains voltage.

AC VOLTAGE RANGES
1 mV to 300 V f.s.d. in 12 ranges with 1-3-10 sequence.

ACCURACY AND FREQUENCY RESPONSE (at 23°C ± 5°C)

Accuracy on the main voltage ranges is as follows:
% of reading + % of f.s.d.

	10 Hz – 30 Hz	30 Hz – 2·5 MHz	2·5 MHz – 4 MHz	4 MHz – 10 MHz
10 mV to 100 V f.s.d.	±2 ±1	±0·5 ±0·5	±1 ±1	±2 ±1

Accuracy at extremes of the voltage range is modified as follows:

	10 Hz – 30 Hz	30 Hz – 500 KHz	500 KHz – 2·5 MHz	2·5 MHz – 4 MHz	4 MHz – 10 MHz
1 mV f.s.d.	±2 ±1	±1 ±1	±2 ±1		
3 mV f.s.d.	±2 ±1	±1 ±1		±2 ±1	
300 V f.s.d.	±2 ±1	±1 ±1		±2 ±1	±3 ±1

METER

Calibration — Calibrated in r.m.s. value of a sine wave but responding to average value.

Voltage scales — Two linear voltage scales 137 mm (5·4 in) long, calibrated from 0 to 1·0 with 100 minor divisions and 0 to 3·0 with 60 minor divisions.

dB scale — Calibrated from +2 to −12 dB. 0 dB corresponds to 0·775 V.

INPUT

Input impedance — *1 mV to 1 V ranges:* 10 MΩ in parallel with 25 pF ±10%.
3 V to 300 V ranges: 10 MΩ in parallel with 15 pF ±10%.

Connector — 50 Ω BNC socket on front panel.

Maximum safe input — *1 mV to 1 V ranges:*
300 V r.m.s. from 10 Hz to 1 kHz
150 V r.m.s. from 1 to 10 kHz
30 V r.m.s. from 10 kHz to 10 MHz.
3 V to 300 V ranges:
300 V r.m.s. from 10 Hz to 3 MHz
100 V r.m.s. from 3 MHz to 10 MHz.

DC OUTPUT — Available at rear panel terminals.

Level — Not less than 1 V e.m.f. at f.s.d. Output linearly proportional to the a.c. input.

Source impedance — 10 kΩ approximately.

AC OUTPUT — Output proportional to a.c. input available at rear panel BNC socket.

Level — Not less than 50 mV into 50 Ω at f.s.d. on all ranges from 10 mV to 300 V. Not less than 5 mV into 50 Ω at f.s.d. on 1 mV and 3 mV ranges.

Source impedance — 50 Ω nominal.

Frequency range — 10 Hz to 10 MHz.

POWER REQUIREMENTS

AC supply — 95 to 130 V and 190 to 264 V
45 to 500 Hz 7 VA.

SAFETY REGULATIONS — Complies with IEC 348 and BS 4743 safety requirements.

DIMENSIONS AND WEIGHT

Height	Width	Depth	Weight
132 mm	204 mm	255 mm	3·0 kg
5¼ in	8 in	10 in	6¾ lb

ORDERING NUMBER
52600–920L — Video Voltmeter TF 2600B.

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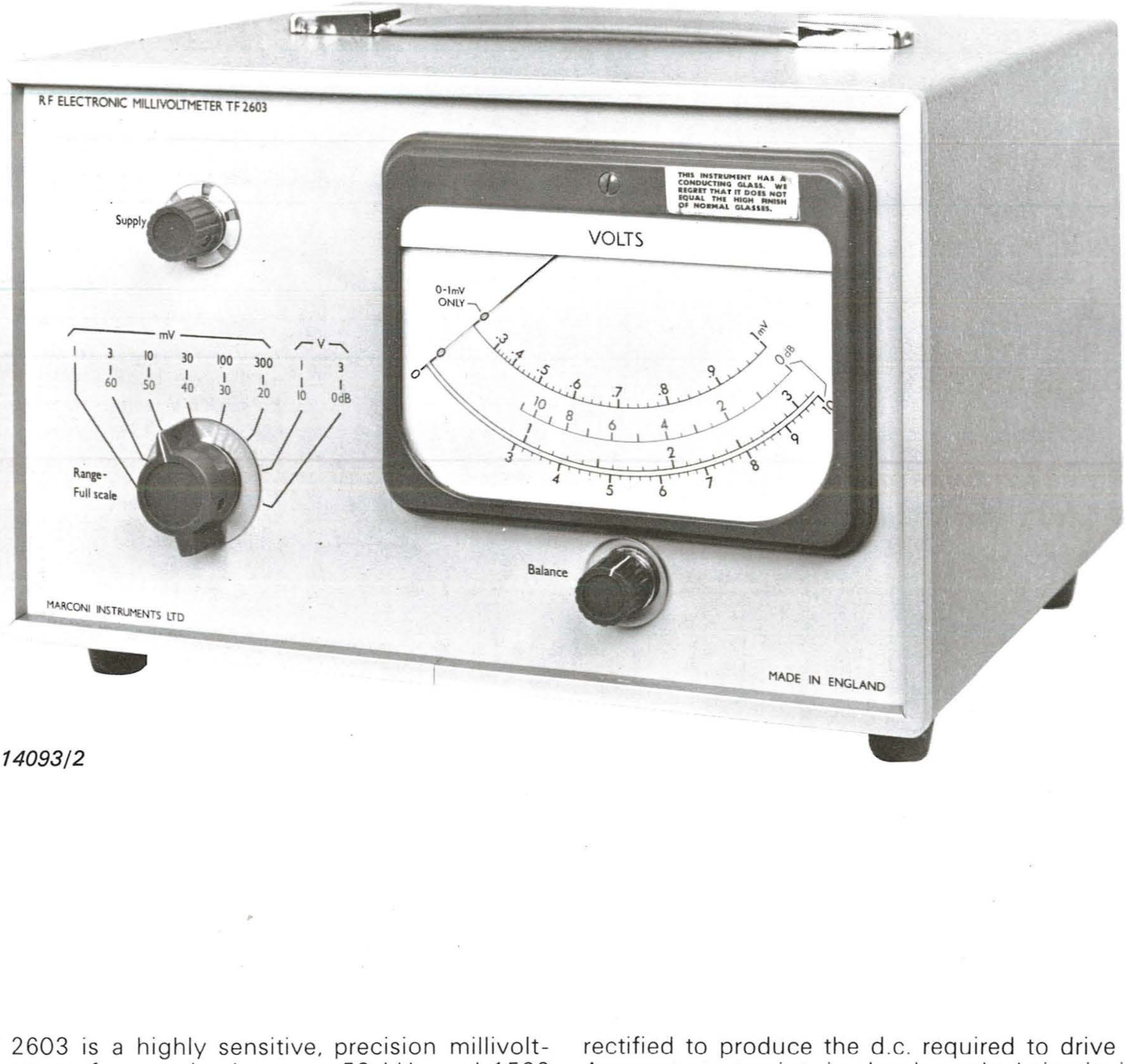
RF Electronic Millivoltmeter

- Wide frequency range 50 kHz to 1500 MHz
- High sensitivity: from 300 μV



14093/2

The TF 2603 is a highly sensitive, precision millivoltmeter for use at frequencies between 50 kHz and 1500 MHz. Reliability and freedom from microphony are assured by the use of semi-conductors throughout. Inherent noise within the instrument is low, enabling voltage measurements down to 300 μV r.m.s. to be made.

The basic configuration consists of a detector, located in a probe head, from which the d.c. output is passed via a balanced attenuator to an electro-mechanical chopper. The resultant 100 Hz square wave is then amplified and rectified to produce the d.c. required to drive the meter. Access to test points in closely packed circuits is eased by the small diameter of the detector probe—only ½ inch. Full-wave detection, using a pair of gold bonded diodes, gives minimum errors when dealing with signals containing asymmetric waveforms or noise. A spring-loaded earthing spike facilitates low-inductance connection for measurements at high frequencies.

To achieve the low inherent noise level peculiar to the instrument a number of precautions have been taken.

These include the use of a balanced output from the detector circuit, a 100 Hz chopper of the electro-mechanical variety, and low noise transistors in the narrow band a.c. amplifier. The choice of a synchronous detector not only discriminates against noise but retains polarity sense. This means that on the most sensitive ranges, any inherent noise will only show as a small dither about the mechanical zero mark.

Front panel controls have been reduced to two: a range switch and balance control. The latter is used only to balance out residual microvolts of d.c. developed in the instrument, and will have maximum effect on the 1 mV range, with no significant effect on the 30 mV range and above. A meter voltage scale, 127 mm (five inches) long, gives good resolution and is virtually linear. Adjacent to the voltage scale there is a dB scale, the 0 dB coinciding with full scale deflection. The 1 mV range is an exception, being 95 mm (3¾ in.) long and square law; and the dB scale does not apply.

Only one supply rail is used, stabilised by means of a well-tried conventional series regulator circuit. Provision for external battery operation is included for portability, and conditions where accurate voltage measurement is difficult due to earth loops. Any battery supplying a voltage of 20 to 32 volts may be used; e.g. five PP8 batteries giving 120 hours at 4 hours per day rate.

Among the many tasks that this instrument can perform are:

(*a*) The search for spurious oscillations at frequencies between 1 and 1500 MHz in wide band video multi-stage amplifiers—carried out using a loop connected to the probe and holding it near to each part of the circuit in turn.

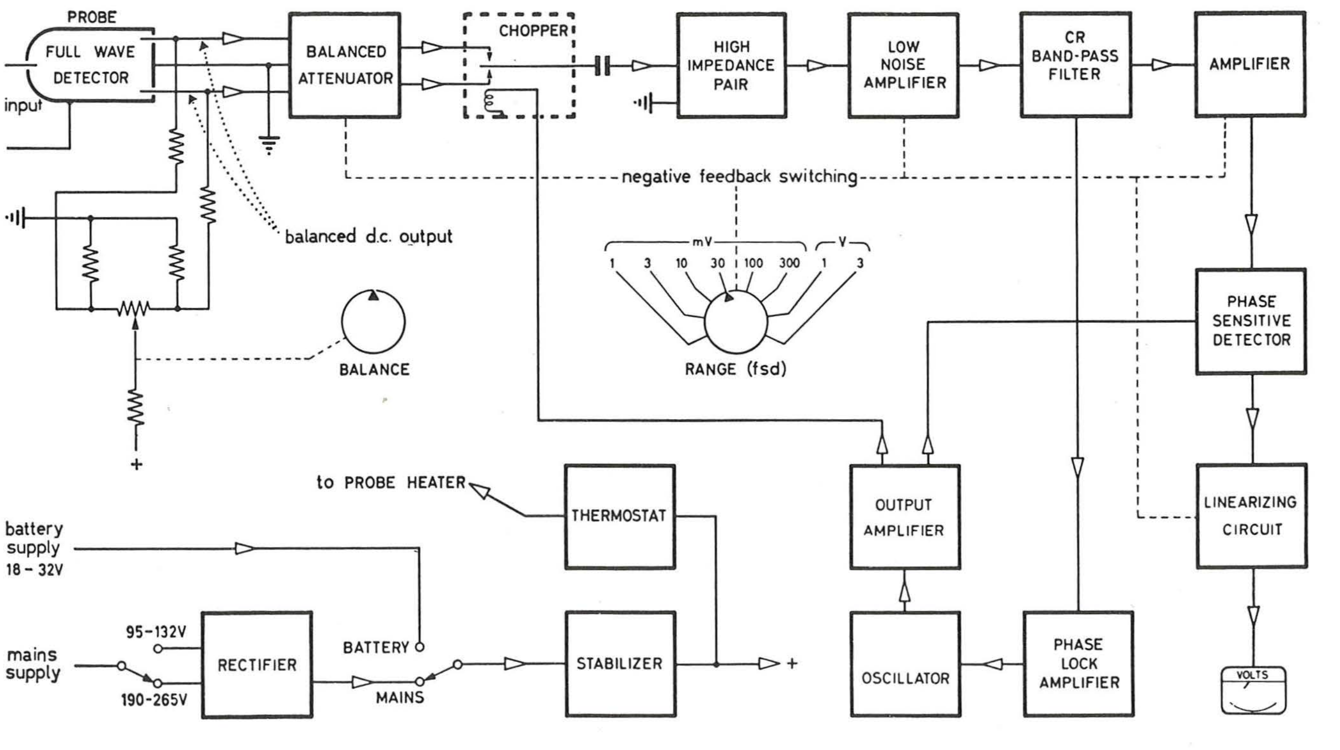
(*b*) Accurate measurement of noise, made possible by the response of the probe being almost true r.m.s. for inputs less than 30 mV—extending to 3 volts by the addition of the 100:1 multiplier TM 7947.

(*c*) Testing of filter frequency responses, particularly in the stop band—achieved without excessive voltage requirements from the signal generator.

(*d*) Measurements of transistor parameters—for instance f_T in the 500 to 1500 MHz range.

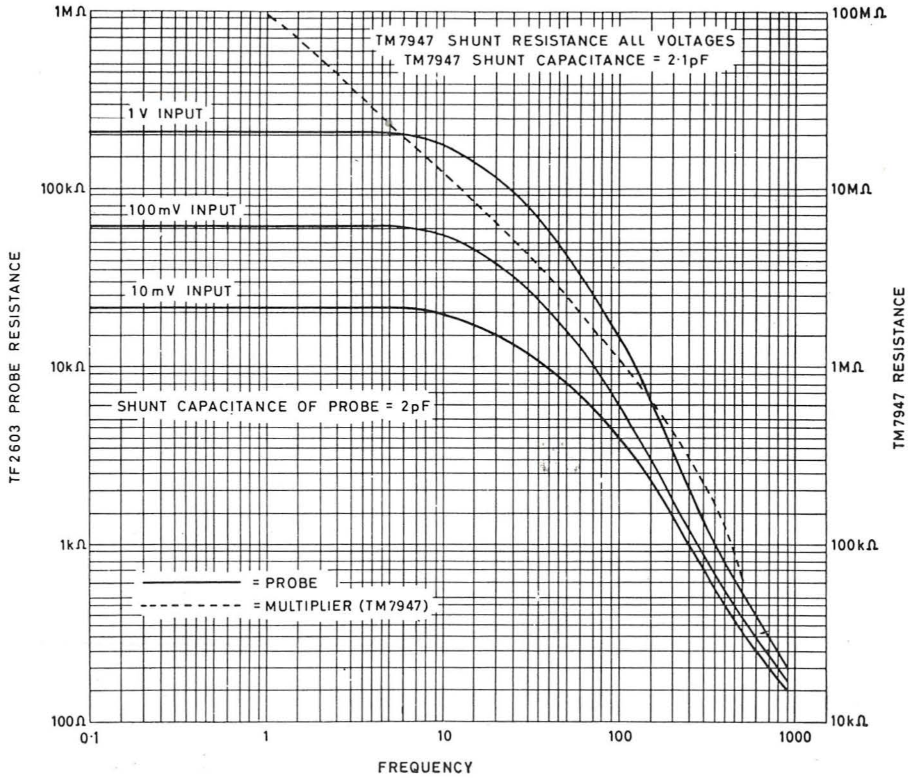
(*e*) Measurement of distortion over a wide frequency range.

(*f*) Measurement on battery-operated equipment at locations remote from mains supply.



Block diagram of RF Electronic Millivoltmeter type TF 2603

TF 2603



Typical input resistance of probe and multiplier

VOLTAGE RANGE	1 mV r.m.s. to 3 V r.m.s. in 8 ranges. ***Maximum input:*** 8 V r.m.s. Probe will withstand up to 300 V d.c.
FREQUENCY RANGE	50 kHz to 1500 MHz.
ACCURACY	10 mV and higher ranges: ± 3% of f.s.d. 3 mV range: ± 5% of f.s.d. 1 mV range: ± 5% of f.s.d. 200 kHz to 50 MHz. (From 18°C to 28°C.)
FREQUENCY RESPONSE CHARACTERISTIC	Using Coaxial 'T' Connector TM 7948 with respect to 200 kHz; 50 kHz to 200 kHz: + 0, − 0·4 dB, 50 MHz to 200 MHz: ± 0·4 dB, 200 MHz to 500 MHz: ± 1·0 dB, 500 MHz to 900 MHz: ± 2·0 dB, 900 MHz to 1500 MHz: ± 3·0 dB.
METER SCALES	0 to 3·162 and 0 to 10 virtually linear, 127 mm (5 inches) long. Calibrated in the r.m.s. value of a sinewave. Special scale for 1 mV range. Decibel scale 0 to −11 dB, 0 dB at full scale. Range switch in 10 dB steps dB scale not applicable to 1 mV range.
INPUT IMPEDANCE	*Input resistance:* > 150 kΩ at 1 MHz and 1 V r.m.s. *Input capacitance:* < 2·5 pf at 1 MHz and 1 V r.m.s.
SAFETY	Designed to meet the requirements of IEC 348.
POWER REQUIREMENTS	
AC Mains	190 to 265 V or 95 to 132 V, 45 to 500 Hz (also 500 to 1000 Hz at ± 10% on 230 V). Power 5·4 W.
External DC	20 V minimum, 32 V maximum. *Current:* 142 mA (heater on), 67 mA (heater off). Supply to be floating; i.e., neither side earthed.

DIMENSIONS AND WEIGHT

Height	Width	Depth	Weight
200 mm	290 mm	280mm	8·75 kg
8 in	11½ in	11 in	19½ lb

VERSIONS AND ACCESSORIES

When ordering please quote eight-digit code numbers.

Ordering numbers	
52603–304P	**Versions** RF Electronic Millivoltmeter TF 2603.
	Supplied Accessories Earthing Clip TM 7936 (44314–602L). Earthing Sleeve TB 46843 (33631–901J). 100:1 Multiplier TM 7947 (44416–050G). Accessory Case TM 7960 (41673–015N).
43167–007Z 43168–011S 43168–010V 44411–015N	**Optional Accessories** Coaxial 'T' Connector TM 7948. Adapter type N, terminated TM 7949. Adapter type N, unterminated TM 7950. 50 Ω Load, ¼ W, TM 7967.

Accessories

SUPPLIED

TM 7936 — **Earthing Clip** (44314–602L)

TB 46843 — **Earthing Sleeve** (33631–901J)

TM 7947 — **100:1 Multiplier** (44416–050G)

100:1 capacitive divider giving 100 mV f.s.d. to 300 V f.s.d., in 8 ranges over frequency range 500 kHz to 500 MHz.

Accuracy (with respect to exact 100:1 ratio):
0·5–20 MHz: ± 0·1 dB.
20–100 MHz: ± 0·3 dB.
100–300 MHz: ± 0·7dB.
300–500 MHz: ± 1·5 dB.

Input impedance:
Resistance: > 20 MΩ at 1 MHz, > 1 MΩ at 50 MHz, > 150 kΩ at 300 MHz.
Capacitance: <2·5 pf.

Maximum input:
300 V r.m.s. up to 100 MHz. Above 100 MHz, max. r.m.s. voltage is:

$$\text{voltage} = \frac{3 \times 10^6}{f^2}$$

where f is in MHz.
Peak a.c. plus d.c. shall not exceed 1000 V.

TM 7960 — **Accessory Case** (41673–015N)

OPTIONAL

TM 7948 — **Coaxial "T" Connector** (43167–007Z)

VSWR not greater than 1·2:1 at 1500 MHz when terminated in 50 Ω and TF 2603 probe plugged in side entry. When using this connector, the accuracy and frequency response figures given earlier apply to voltage across a 50 Ω load.

TM 7949 — **Adapter type "N", terminated** (43168–011S)

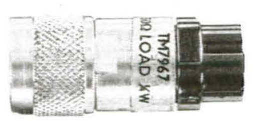
Allows voltage measurement across load mounted in 50 Ω type "N" plug. Maximum power input, ¼ W. VSWR when mounted on TF 2603 probe: maximum of 1·1:1, 50 kHz–500 MHz; maximum of 1·2:1, 500 MHz –900 MHz.

TM 7950 — **Adapter, type "N", unterminated** (43168–010V)

50 Ω type "N" adapter, as above but without 50 Ω load.

TM 7967 — **50 Ω load, ¼ W.** (44411–015N)

Load mounted in type "N" plug. VSWR not greater than 1·05:1, d.c.—1500 MHz.



Electronic Voltmeter

- Excellent zero stability
- Seven a.c. ranges: 300 mV to 300 V full scale, 20 Hz to 1500 MHz
- Input capacitance: 1·5 pF
- Eight d.c. ranges: 300 mV to 1 kV full scale
- Multipliers for up to 2 kV a.c. and 30 kV d.c.

The TF 2604 is an electronic voltmeter combining versatility with high accuracy and extremely good stability. It allows for precision measurements to be made within the range of 20 Hz to 1500 MHz with further facilities included for measuring a wide range of d.c. voltages and resistance.

The major variant affecting the reading stability of a valve voltmeter is its power supply. So it is not surprising that the greatest emphasis was placed on this aspect throughout the design stages of the TF 2604. Thus the good reading stability inherent in this instrument is realised by the full stabilisation of valve heaters and the h.t. line; using a series valve circuit for the h.t.; and a transistor circuit controlled by a zener diode for the l.t. supply. This means that changes in the mains supply voltage by as much as 10% will cause a deflection change of less than 4 mV at full scale on all ranges.

Voltmeter Circuit

A well proven push-pull circuit is used to drive the meter, each half of the push-pull circuit consisting of a valve amplifier and cathode-follower. To ensure that the accuracy is relatively independent of valve selection, the amplifier has a high loop gain with a large amount of negative feedback. The meter is protected from gross overload on the most sensitive ranges, and the effects of meter temperature coefficient are offset by a series thermistor. Both a.c. and d.c. inputs are isolated from the voltmeter chassis by 50 MΩ.

AC Measurements

The probe used for a.c. measurements houses a disk-seal diode rectifier of an advanced type. A low capacitance of only 1·5 pF, short transit time, and a 3000 MHz resonance frequency, together with a unique probe head design, make possible the frequency response of up to 1500 MHz. Small and cylindrical, this lightweight probe has been designed for easy handling.

A special plug-on ground connector is also supplied to facilitate the making of the ultra-short connection necessary at the higher frequencies. The high stability circuits combined with the special diode enable a wide range of voltages to be measured; down to 25 mV on the most sensitive range, and up to 300 volts on the highest range. An a.c. multiplier probe TM 5032 is available as an optional extra to extend the range to 2 kV r.m.s. at frequencies from 10 kHz to 10 MHz.

DC Measurements

Volts and ohms measurements are simplified by the special dual purpose d.c. probe with its finger-tip V/Ω selector; set to V, an isolating resistor is introduced to shield the circuit under test from the effects of probe lead capacitance. For d.c. measurements the meter can be switched to give forward deflection with positive or negative voltages; for centre zero measurements, such as the precise determination of the null point in bridges or discriminators, a standing d.c. current is applied to bias the meter to mid-scale.

DC measurements as low as 10 mV and as high as 1000 volts can be made, the input resistance being 100 MΩ. By using the optional d.c. multiplier type TM 5033A the higher limit can be extended to 30 kV, with an input resistance of 3000 MΩ.

Resistance Measurements

The d.c. supply for resistance measurement is derived from a stabilised l.t. supply, obviating the need for batteries. A common zero control is included to standardise at infinity ohms before connecting the unknown resistor.

Four optional accessories still further increase the usefulness of the TF 2604. High voltages up to 30 kV d.c. and 2 kV a.c. can be measured with plug-on d.c. and a.c. multipliers. For measuring voltages on a coaxial line, there is a plug-on T-connector for the a.c. probe.

AC MEASUREMENTS	
Ranges	25 mV to 300 V in seven ranges. Full scale deflections: 300 mV, 1-3-10 30-100 and 300 V.
Accuracy	1-3-10-30-100 and 300 V ranges: ±2% of full scale ±10 mV. 300 mV range: ±3% of full scale ±10 mV. (At 1 kHz and between 18° and 28°C.)
Frequency response	Typical characteristic (measured using 'T' Connector TM 5031B) relative to response at 1 kHz: 20 Hz −0·25 dB ±0·25 dB 40 MHz −0·1 dB ±0·3 dB 100 MHz −0·5 dB ±0·5 dB 400 MHz −1·0 dB ±1·0 dB 900 MHz +0·5 dB ±1·5 dB 1500 MHz +4·5 dB ±2·5 dB
Input conditions	*Shunt capacitance:* approx. 1·5 pF. *Resistance:* approx. 5 MΩ at 1 kHz. approx. 500 kΩ at 10 MHz, and approx. 150 kΩ at 100 MHz.
DC MEASUREMENTS	
Ranges	10 mV to 1000 V in eight ranges. Full scale deflections: 300 mV, 1-3-10 30-100-300 and 1000 V, positive or negative. Centre zero facility on all ranges.
Accuracy	±2% of full scale ±10 mV on all ranges (except for centre zero) between 18° and 28°C.
Input conditions	*Resistance:* 103·5 MΩ ±5%. *Capacitance to ground:* approx. 2 pF.
STABILITY	A mains supply variation of 10% will cause a deflection change at full scale of less than 4 mV at full scale on all ranges.

RESISTANCE MEASUREMENTS	
Ranges	0·2 Ω to 500 MΩ in seven ranges. Full scale deflections: 500 Ω, 5 kΩ, 50 kΩ, 500 kΩ, 5 MΩ, 50 MΩ and 500 MΩ.
SAFETY	Designed to meet the requirements of IEC 348.
POWER REQUIREMENTS	100 to 130 V and 200 to 250 V, 45 to 500 Hz; 36 W.
DIMENSIONS AND WEIGHT	Height 203 mm 8 in; Width 292 mm $11\frac{1}{2}$ in; Depth 251 mm $10\frac{1}{4}$ in; Weight 5·8 kg 12·75 lb

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VERSIONS AND ACCESSORIES

When ordering please quote eight-digit code numbers

Ordering numbers	
52604–902S	**Versions** TF 2604, The basic instrument in a case for bench use.
	Supplied Accessories Grounding Clip, TC 23535/3C, to fit a.c. probe. RF Grounding Sleeve, TC 23533/3, to fit a.c. probe.
 43167–008H 44416–003Z 44416–037E 41675–003X	**Optional Accessories** Coaxial 'T' Connector, TM 5031B. AC Multiplier, TM 5032. DC Multiplier, TM 5033A. Carrying Case for accessories TM 4935. *Details of accessories are described below.*

Optional Accessories

Two multipliers and a coaxial 'T' junction are available for use with the Voltmeter. For stowing the multipliers and 'T' junction, a polished carrying case, Type TM 4935, can also be supplied.

AC Multiplier, TM 5032

Transmitter voltages up to 2 kV r.m.s. at frequencies of 10 kHz to 10 MHz can be measured with this auxiliary probe cap which fits readily over the normal a.c. probe head. It comprises a capacitive divider with a nominal ratio of 100:1, and places a capacitance of about 2 pF across the circuit under test. The calibration of the multiplier is accurate to +4 −0% at 10 kHz changing to ±2% at 10 MHz, i.e. it is accurate to within ±2% of a standard curve.

Coaxial 'T' Connector, TM 5031B

This device can be fitted to the a.c. probe head to facilitate voltage measurements on 50 Ω coaxial cables. For this purpose one of the two series arms of the 'T' is terminated in a type N plug and the other in a type N socket. The v.s.w.r. of the connector is of the order of 1·2 at 800 MHz.

DC Multiplier, TM 5033A (with connector TM 5749)

This enables high voltages, such as in television receivers, to be measured with safety. When connected to the Voltmeter, it gives a voltage reduction ratio of 30:1, and is usable up to 30 kV. When using the multiplier, measurement accuracies of approximately $4\frac{1}{4}$% can be obtained, and it has an input impedance of 3000 MΩ.

FET Multimeter

- 1·5 mV to 1500 V full scale, a.c. and d.c.
- 0·15 µA to 1·5 A full scale, a.c. and d.c.
- 50 kV and 150 A with optional probes
- Accuracy: ± 1·5% over wide range
- Resistance and decibel measurement
- Temperature measurement with optional probe
- Battery or a.c. supply operation

14397/2

TF 2650 is a comprehensive, general purpose, all-solid-state multimeter, employing a FET front end which gives high input resistance and overload protection. The instrument also features excellent linearity, high sensitivity and outstanding long-term stability. A wide range of measurement functions is offered, including a.c. and d.c. voltage and current, resistance and decibels. These features combine to form a very versatile meter which is equally suitable for laboratory, education and service applications.

Thirteen voltage and eight current ranges are provided giving full scale readings of 1·5 mV to 1500 V and 0·15 µA to 1·5 A, both a.c. and d.c. The frequency limits for a.c. measurements are 10 Hz to 20 kHz. On most ranges accuracy is ±1·5% and input resistance for voltage measurement is 100 MΩ.

Resistance can be measured in four ranges from 10 kΩ to 10000 MΩ full scale, with mid scale readings of 100 Ω to 100 MΩ. A low-level test voltage is available, to allow measurements to be made on solid-state circuits without turning-on the device. Decibel measurements can be made from −80 to +66 dB with the meter scaled with reference to 1 mW into 600 Ω.

The 150 mm (6 in) mirror-backed scale gives excellent reading discrimination and resolution, with coloured scales used to avoid confusion. A centre-zero facility permits use of the multimeter as a sensitive null detector for use with bridges or for f.m. discriminator alignment. The floating input circuit ensures safety in operation and adds to the measurement versatility, giving a high common-mode rejection factor of 90 dB. Good overload protection is incorporated for voltage, current and resistance measurements.

A wide range of optional accessories is available, including probes to extend voltage measurements up to 50 kV and current measurements up to 150 A. An RF Detector Probe extends the frequency limit of both voltage and current measurements to 1 GHz, and a temperature probe is also available which gives the capability of measuring temperatures from −150°C to +500°C.

The instrument is operated from internal batteries, with an optional Mains Power Supply Unit available. TF 2650 is supplied in a heavy duty leather carrying case with shoulder and neck straps. These facilities make the multimeter suitable for use in the laboratory and workshop and also for field use. This latter use is enhanced by the very rugged meter movement incorporated.

14397/4

TF 2650 in its supplied carrying case

MEASUREMENT RANGES	DC and AC voltage. DC and AC current. Resistance. dBm with reference to 600 Ω. Optional temperature range.
Mode and range selection	Six push-button switches plus 25-position rotary switch.
DISPLAY	150 mm (6 inch) mirror backed scale.
Voltage, current and temperature scales	Two black linear scales calibrated 0 to 5 and 0 to 15.
Resistance scale	Green, calibrated 0 to 1000.
dBM scale	Red, calibrated −20 to +6.
Additional scales	Centre zero scale and battery supply voltage level indicator.
DC VOLTAGE	
Ranges	1·5, 5, 15, 50, 150, 500 mV. 1·5, 5, 15, 50, 150, 500, 1500 V full scale. (The optional High Voltage Probe 54451−081C extends the range to 50 kV).
Accuracy	±1·5% of f.s.d.
Input impedance	100 MΩ.
AC VOLTAGE	
Ranges	1·5, 5, 15, 50, 150, 500 mV, 1·5, 5, 15, 50, 150, 500, 1500 V full scale. (The optional High Voltage Probe 54451−081C extends the range to 30 kV r.m.s.)
Frequency range	10 Hz to 20 kHz. (The optional RF Detector Probe 54451−091E extends the frequency range to 1 GHz.)
Accuracy	±1·5% of f.s.d. except on 1·5 mV range, where the accuracy is additionally: ±1·5% of reading from 30 Hz to 10 kHz. ±3% of reading from 10 Hz to 30 Hz and from 10 kHz to 20 kHz.
Input impedance	10 MΩ in parallel with approx. 60 pF on 1·5 to 150 mV ranges. 100 MΩ in parallel with approx. 20 pF on 500 mV to 1500 V ranges.

TF 2650

DC CURRENT

Ranges	0·15, 1·5, 15 μA, 0·15, 1·5, 15 mA, 0·15, 1·5 A full scale. (The optional Current Shunt 54461–021Z extends the range to 150 A.)
Accuracy	±1·5% of f.s.d.
Input voltage drop	5 or 50 mV nominal depending on range selected and on input current level.

AC CURRENT

Ranges	0·15, 1·5, 15 μA, 0·15, 1·5, 15 mA, 0·15, 1·5 A full scale. (The optional Current Shunt 54461–021Z extends the range to 150 A.)
Frequency range	10 Hz to 20 kHz on 15 μA range and above. 10 Hz to 1 kHz on 0·15 μA and 1·5 μA ranges.
Accuracy	±1·5% f.s.d. and additionally: ±3% of reading from 10 Hz to 30 Hz, ±1·5% of reading from 30 Hz to 20 kHz.
Input voltage drop	5 or 50 mV nominal depending on range selected and on input current level.

RESISTANCE

Ranges	*X10:* 100 Ω mid scale, 10 kΩ full scale. *X1 k:* 10 kΩ mid scale, 1 MΩ full scale. *X100 k:* 1 MΩ mid scale, 100 MΩ full scale. *X10 M:* 100 MΩ mid scale, 10,000 MΩ full scale.
Accuracy	±5% at mid scale.
Test voltage on input terminals	24 mV on × 10 range, 1·2 V on other ranges.

DECIBELS

Range	−80 dB to +66 dB in 13 steps.
Meter scale	−20 to +6 dB (0 dB= 1 mW or 0·775 V into 600 Ω).
Accuracy	±1·5% of f.s.d. except on −60 dB range where the accuracy is additionally: ±1·5% of reading from 30 Hz to 10 kHz, ±3% of reading from 10 Hz to 30 Hz and from 10 kHz to 20 kHz.

CENTRE ZERO SENSITIVITY

Up to 50 μV or 5 nA per division nominal.

COMMON MODE REJECTION FACTOR

90 dB nominal.

TEMPERATURE

Using the optional Temperature Probe 54451–131Y, temperatures in the range 0° to +500°C can be measured to an accuracy of ±1·5% f.s.d. ±2°C. Temperatures in the range 0°C to −150°C can be measured at reduced accuracy by reference to charts in the instruction manual.

STABILITY

Zero stability (at constant temperature)	Zero drift less than 40 μV in eight hours.
Temperature coefficient	Less than 15 μV per °C from 0° to +50°C (specification accuracy maintained from +5°C to +40°C).
Internal noise	Less than 30 μV with 100 kΩ series resistor.

OVERLOAD PROTECTION

Short term overload (less than 1 second)	1700 V on all DC and AC ranges.
Continuous overload	170 V on 1·5 mV to 150 mV ranges 1700 V on remaining ranges.
Maximum voltage between common line and earth	1000 V.

SAFETY

Designed to meet the requirements of IEC 348.

POWER REQUIREMENTS

Internal d.c.	12 to 18 V, 4 mA approx. Provided by 12 batteries of 1·5 V (IEC size R6), housed in battery cassette supplied.
AC supply	115 V or 230 V ±15%, 40 to 60 Hz or 400 Hz, 5 VA. Using optional Mains Power Supply Unit 54441–011T.

DIMENSIONS AND WEIGHT

Height	Width	Depth	Weight
200 mm	192 mm	105 mm	2·5 kg
$7\frac{1}{4}$ in	$6\frac{1}{2}$ in	$3\frac{1}{2}$ in	5·5 lb

(Includes leather carrying case.)

VERSIONS AND ACCESSORIES

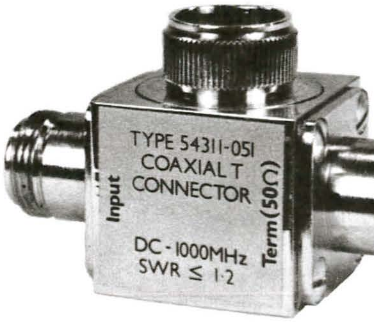
When ordering please quote eight-digit code numbers

Ordering numbers	
	Versions
52650–900B	FET Multimeter TF 2650.
	Supplied Accessories
	Coaxial Cable, 1·5 m (59 in), BNC to two banana plugs.
	Crocodile Clips (2 supplied). For fitting into banana plugs.
	Test Probes 105 mm (4·1 in) long, (2 supplied). For fitting into banana plugs.
	Leather Carrying Case.
	Optional Accessories
54311–051G	Coaxial T Connector.
54441–011T	Mains Power Supply Unit.
54451–081C	High Voltage Probe.
54451–091E	RF Detector Probe.
54451–101L	Peak-to-Peak Probe.
54451–111D	RF Voltage Divider.
54451–131Y	Temperature Probe.
54451–141S	Clip-on Flexible Test Probe, 150 mm, Red.
54451–151C	Clip-on Flexible Test Probe, 150 mm, Black.
54461–021Z	Current Shunt.

OPTIONAL ACCESSORIES

The accuracy specifications quoted below for the optional accessories are the total accuracy of the combination of TF 2650 and the accessory.

COAXIAL T CONNECTOR 54311–051G
For use with 50 Ω coaxial systems



Frequency range	1 kHz to 1000 MHz.
VSWR (when fitted with RF Probe)	Typically 1·2:1 at 1000 MHz.
Connector	Type N sockets, 50 Ω.

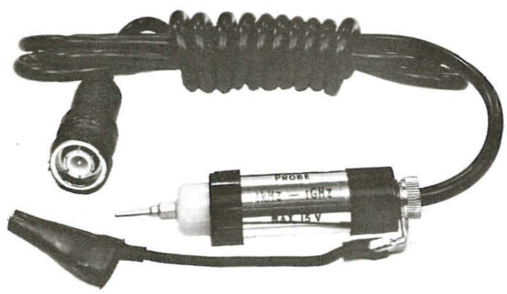
MAINS POWER SUPPLY UNIT 54441–011T
Replaces battery cassette

Power requirements	115 V or 230 V ±15% (selected by slide switch). 40 to 60 Hz or 400 Hz ±10%. 5 VA.

HIGH VOLTAGE PROBE 54451–081C

Voltage ratio	Nominally 1000:1
Additional measurement ranges	1·5, 5, 15, 50 kV f.s.d. DC or AC. (Max peak voltage at probe input 50 kV).
Accuracy	±5% of reading ±1·5% of f.s.d.
Frequency range	DC and 40 to 60 Hz.

RF DETECTOR PROBE 54451–091E
Compatible with Coaxial T Connector



Additional measurement capability	Frequency range extended to 1 GHz.
Measurement ranges	1·5, 5, 15 V f.s.d.
Accuracy (at 10 kHz)	±5% of f.s.d. on 5V and 15V ranges ±7·5% of f.s.d. on 1·5 V range.
Frequency response (when used with Coaxial T Connector into 50 Ω load)	Relative to response at 10 kHz: ±1 dB from 1 kHz to 100 MHz ±2 dB from 100 MHz to 700 MHz ±3 dB from 700 MHz to 1000 MHz.
Input impedance	Approximately 300 kΩ in parallel with 2·5 pF at a frequency of 1 kHz.

TF 2650

PEAK-TO-PEAK PROBE 54451–101L

Additional measurement ranges	5, 15, 50, 150, 500, 1500 V p-p
Maximum input voltage	1500 V p-p.
Accuracy (at 1 kHz)	±5% of f.s.d. on 50 V to 1500 V ranges ±10% of f.s.d. on 15 V range ±20% of f.s.d. on 5 V range.
Frequency response (relative to 1 kHz)	±0·5 dB from 30 Hz to 1 MHz ±3 dB from 10 Hz to 10 MHz.

RF VOLTAGE DIVIDER 54451–111D
For use with RF Detector Probe

Additional measurement ranges	150 and 500 V f.s.d.
Division ratio (when used with RF Detector Probe)	Nominally 100:1.
Frequency range	10 kHz to 10 MHz.
Maximum input voltage	500 V pk.

TEMPERATURE PROBE 54451–131Y

Additional measurement capability	−150° to + 500°C in 5 ranges. 0 to −150°C 0 to −50°C 0 to +50°C 0 to +150°C 0 to +500°C
Accuracy	±2°C ± 1·5% of f.s.d. from 0° to +500°C. Below 0°C ranges 0 to −50°C and 0 to −150°C may be used with reduced accuracy by reference to charts in the instruction manual.

CLIP-ON FLEXIBLE TEST PROBES 54451-141S Red 54451-151C Black
Test Probes with flexible shank and gripping claws which open when plunger is depressed.

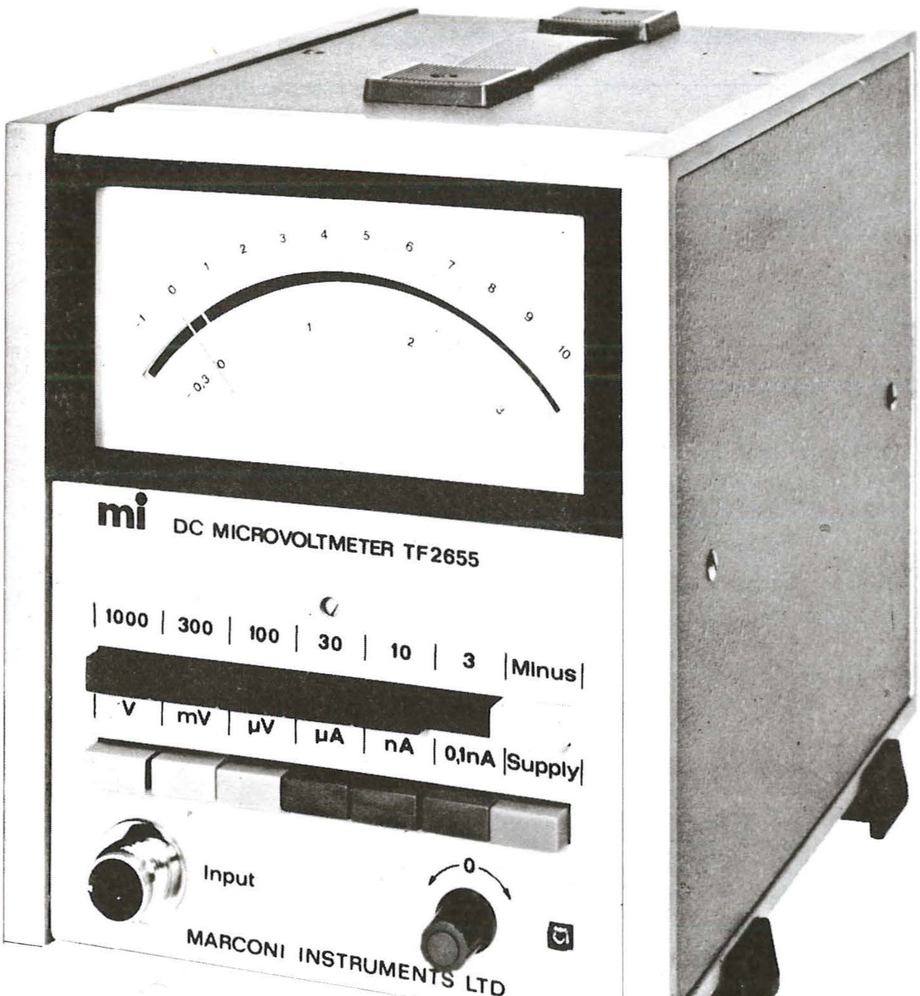
Length	150 mm
Shank breakdown voltage	3·2 kV
Current rating	0·5 A
Insulation resistance	Greater than 75 MΩ.
Maximum working temperature	60°C.

CURRENT SHUNT 54461–021Z

Additional measurement ranges	5, 15, 50, 150 A f.s.d. AC and DC.
Accuracy	±3% of f.s.d. at DC and between 30 Hz and 500 Hz. ±5% of f.s.d. 500 Hz to 1 kHz.
Shunt resistance	Nominally 1 mΩ.
Maximum measurement duration	30s on 50 A and 150 A ranges.

DC Microvoltmeter TF 2655

- □ Measures direct voltage from 0·3 μV to 1000 V
- □ Measures direct current from 30 pA to 1 mA
- □ Stable and linear amplifier
- □ Null detector facility
- □ Push-button selection of function and range
- □ All solid-state



DC Microvoltmeter TF 2655 is a versatile, general purpose meter for the measurement of direct voltage from 0·3 μV to 1000 V, and direct current from 30 pA to 1 mA. For voltage measurement the instrument has a high input resistance varying from 5 MΩ to 100 GΩ depending on range; for current measurements it has a low and constant voltage drop at the fully-floating input terminals.

TF 2655

The capability of measuring very low levels of current and voltage makes this voltmeter particularly suitable for use with thermal and optical devices and with a wide range of transducers for the measurement of physical quantities such as temperature, pressure and force. Thus it will find wide application in universities, research establishments and medical and biological laboratories.

The inclusion of a meter with a 10% offset zero allows the TF 2655 to be used as a null detector for d.c. bridges, and it may also be used as a very stable and linear amplifier with a regulated voltage gain, the output being available at the rear panel.

Front-panel push buttons provide rapid selection of function, range and input polarity, whilst the two clear 95 mm meter scales permit easy and reliable reading. Adequate overload protection is included and the zero stability is very good.

The instrument is all solid-state, robust and shock proof, and will withstand a wide range of operating temperatures.

MEASUREMENT RANGES	
DC voltmeter	3 μV to 1000 V f.s.d. in 18 ranges.
DC ammeter	0·3 nA to 1 mA f.s.d. in 14 ranges.
Accuracy	±2% f.s.d.
Polarity	Selected by front-panel push button.
Zero drift	Less than 1 μV in 24 hours.
READOUT	
Meter	Two scales calibrated 3 and 10 f.s.d. *Scale length:* 95 mm. 10% offset zero position.
Response time (from 10% to 90% f.s.d.)	Less than 5 s on 3 μV range. Less than 3 s on 10 μV range. Less than 2 s on 30 μV range. Less than 1 s on remaining ranges.
INPUT	
Voltmeter mode	*Resistance:* 5 MΩ to 100 GΩ depending on range selected. *Maximum current:* 10 pA. *Overload protection:* ±100 V on 3 μV to 1 V ranges. ±1200 V on remaining ranges.
Ammeter mode	*Voltage drop across terminals:* 10 mV f.s.d. *Maximum current overload:* 150 mA on μA range. 5 mA on nA range. 1·5 mA on 0·1 nA range.
Amplifier a.c. noise	Less than 0·05 μV (with input short circuited).
Isolation between negative terminal and case	500 MΩ (maximum voltage ±500 V).
OUTPUT	
Maximum voltage	1 V ±10%.
Maximum current (without degrading accuracy)	1 mA.
Recorder gain (output/input)	−60 dB to 110 dB depending on range selected.
Amplifier gain	0 dB to 110 dB in 10 dB steps.
POWER REQUIREMENTS	
AC mains	110 or 220 V, −15% +10%. 45 to 65 Hz, 10 VA.

DIMENSIONS AND WEIGHT

Height	Width	Depth	Weight
184 mm	145 mm	230 mm	4 kg
7·2 in	5·8 in	9·3 in	8·8 lb

VERSIONS AND ACCESSORIES

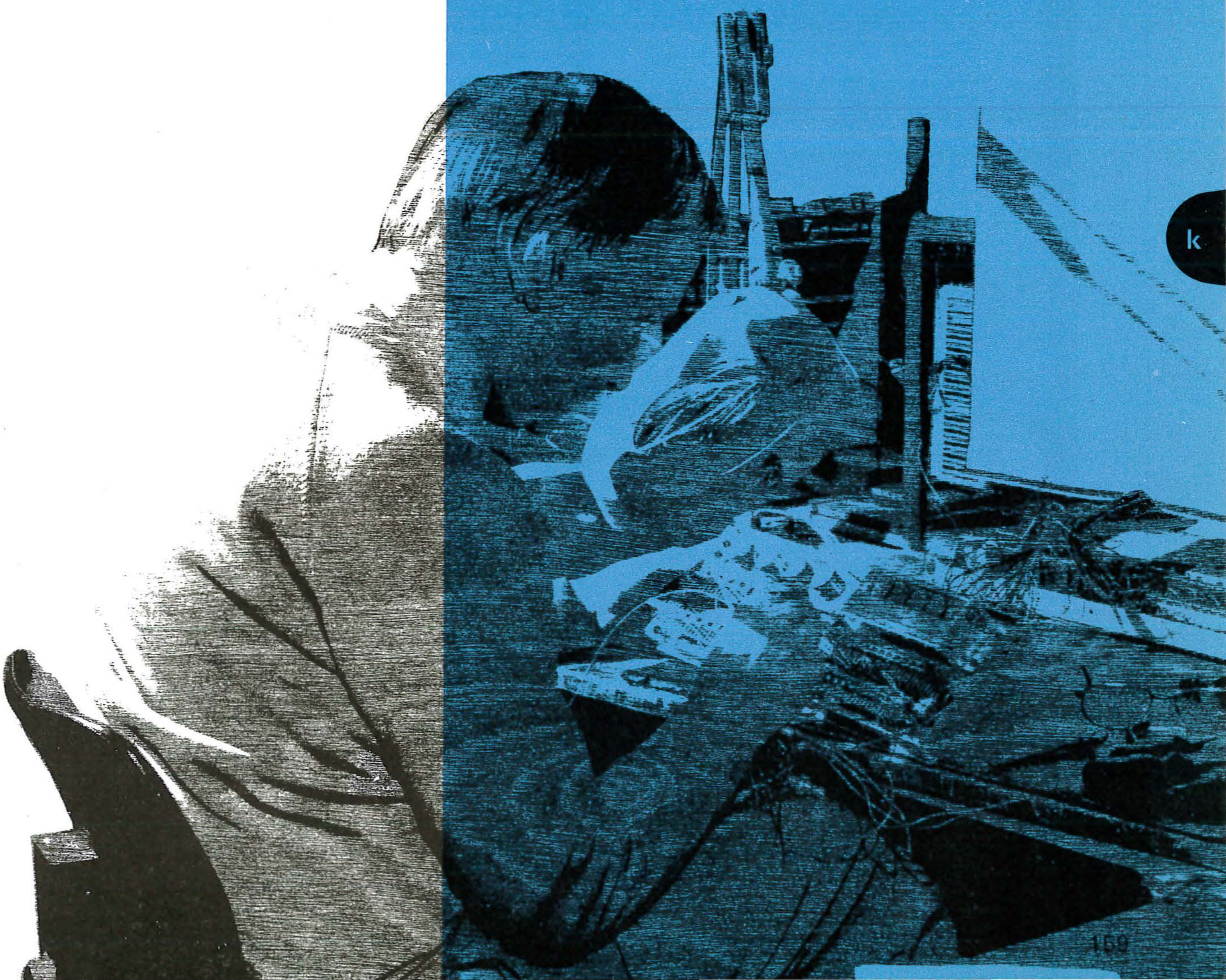
When ordering please quote eight-digit code numbers

Ordering numbers	
52655–900H	Versions DC Microvoltmeter TF 2655.
	Supplied Accessories Input Cable.

Made in Poland

BRIDGES AND Q METERS

Circuit Magnification Meter (Including Oscillators, TF 1246 and TF 1247)	TF 1245A	160
0·1% Universal Bridge	TF 1313A	163
Universal Bridge	TF 2700	165



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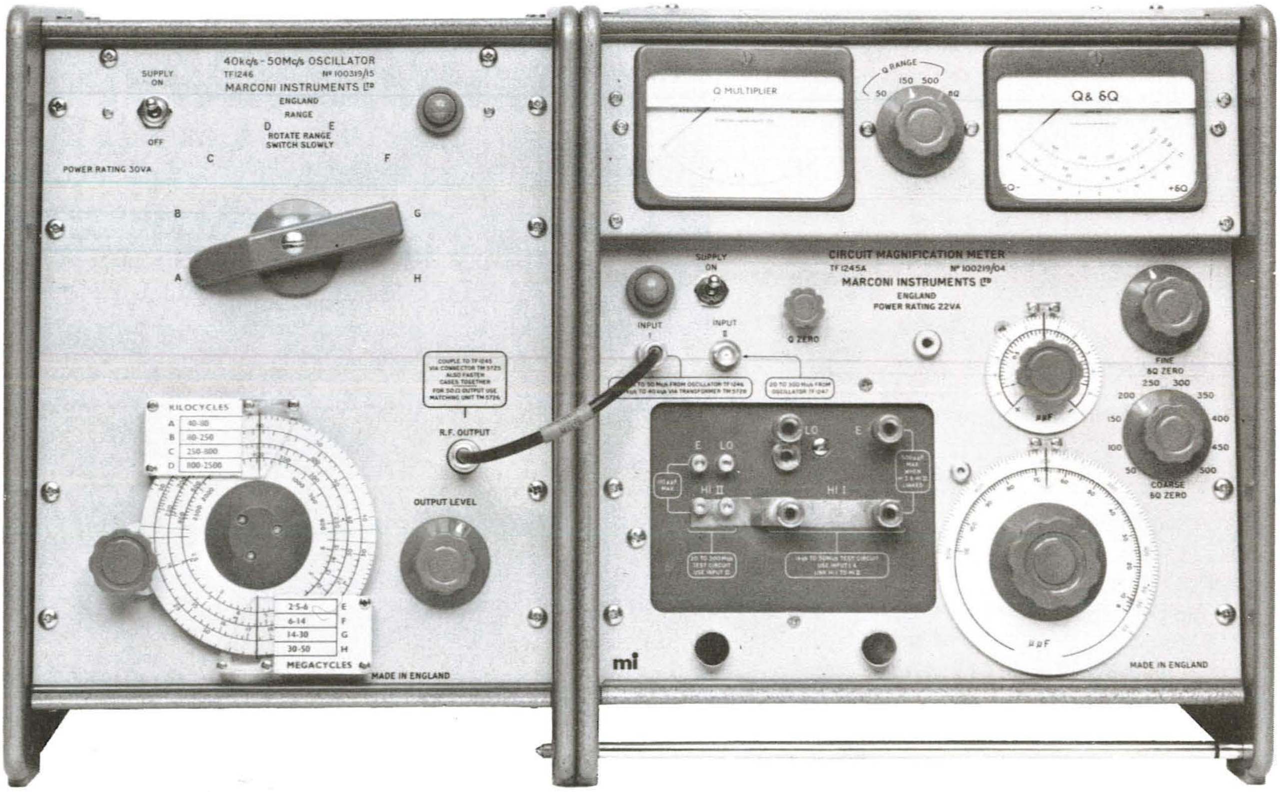
Circuit Magnification Meter (with Oscillators, types TF 1246 and TF 1247)

- ☐ Frequency range: 1 kHz to 300 MHz
- ☐ Very low residual loss
- ☐ Capacitance range: 7·5 to 500 pF
- ☐ Measures Q from 5 to 1000
- ☐ Delta-Q and Q multiplier facilities
- ☐ External oscillators, customer selected



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Q Meter and TF 1246 Oscillator

TF 1245A is a wide range Circuit Magnification Meter suitable for direct measurement of Q values from 5 to 1000 at any frequency between 1 kHz and 300 MHz. It utilises the well known series-resonance method of measurement; and the constant very low loss of its test circuit is an important feature, particularly at high frequencies, where difficulty is experienced with some Q meters due to variations in a significant residual shunt loss.

The TF 1245A gives accurate and repeatable indication of Q up to 1000 at all frequencies within its range regardless of the dynamic impedance of its resonant circuit.

The Q-indicator and test-circuit section is a separate unit energised by one of two specially designed external oscillator units TF 1246 and TF 1247: these have ranges of 40 kHz to 50 MHz and 20 to 300 MHz respectively, and one or both can be supplied as required. Below 40 kHz a conventional l.f. oscillator may be used. A transformer is available for coupling such an oscillator to TF 1245A over the frequency range 1 to 40 kHz.

This flexible arrangement means economy for the customer, whether the initial requirement is for wide-band or restricted coverage; it also allows for the addition of extra units at a later date.

Matching units are available to allow the oscillators to be used as general-purpose signal sources.

Test circuits

TF 1245A incorporates two separate low-loss test circuits to ensure optimum operating conditions over the complete 1 kHz to 300 MHz range. Both are of the conventional series-resonant type, in which Q is measured in terms of the voltage developed across the tuned-circuit capacitance. The l.f. test circuit uses 0·02 Ω resistive injection and operates in the range 1 kHz to 50 MHz; whereas the h.f. test circuit, range 20 to 300 MHz employs 0·1 nH inductive injection.

All surfaces of r.f. conductors in the test circuits are gold plated to avoid the formation of resistive oxides, which would otherwise cause deterioration of the very low residual loss.

The test circuits are coupled to separate panel inlets to which the appropriate oscillator unit is connected by means of a special lead provided. Q is read directly on a 3-scale panel meter common to both test circuits and operated by a transductor-stabilised valve voltmeter. A second meter monitors the input level to the test circuits and is calibrated in terms of Q-reading multiplication factor.

For certain measurements it is desirable to read small changes in Q very precisely. The TF 1245A therefore has provision for backing off the meter reading in steps of 50 Q, so that any portion of the Q range above 50 can be expanded. This expanded – or δQ-scale is directly calibrated to ±25 Q from a centre zero which corresponds to the setting of the switched backing-off control.

FREQUENCY RANGE	1 kHz to 300 MHz using external oscillators.
MAGNIFICATION FACTOR (Q)	
Ranges	5 to 50, 10 to 150, and 60 to 500, with Q multiplier at × 1.
Q Multiplier range	× 0·9 to × 2.
Accuracy of Q reading	With the Q multiplier at × 1 and a Q reading of 50: ±5% up to 100 MHz, ±12% at 200 MHz, ±20% at 300 MHz. At Q readings of 150 and 500 measurement accuracy falls by about ±1% from figures quoted above.
Delta-Q range	20–0–25.
NOMINAL TEST CIRCUIT PARAMETERS	
1 kHz to 50 MHz test circuit	*Injection impedance:* resistive, 0·02 Ω. *Shunt loss:* 12 MΩ at 1 MHz.
20 to 300 MHz test circuit	*Injection impedance:* inductive, 0·1 nH. *Shunt loss:* 0·3 MΩ at 100 MHz.
TUNING CAPACITOR (1 kHz to 50 MHz test circuit)	
Main capacitor	20 to 500 pF; accuracy, ±1 pF ±1%
Incremental	5–0–5 pF with 0·2 pF increments; accuracy, ±0·2 pF above 50 pF.
TUNING CAPACITOR (20 to 300 MHz test circuit)	
Main capacitor	7·5 to 110 pF; accuracy, ±0·5 pF ±1%.
Incremental	1–0–1 pF with 0·05 pF increments; accuracy, ±0·1 pF above 16 pF. The h.f. test circuit capacitor can be used in the l.f. circuit by external cross connection.
POWER REQUIREMENTS	
AC supply	95 to 130 V and 190 to 260 V. 40 to 100 Hz. 22 W.
DIMENSIONS AND WEIGHT	Height 360 mm 14 in; Width 430 mm 17¼ in; Depth 240 mm 9½ in; Weight 10·5 kg 23 lb

Oscillators TF 1246 and TF 1247

RANGE	
TF 1246	40 kHz to 50 MHz in 8 bands.
TF 1247	20 to 300 MHz in 6 bands.
Frequency accuracy	±1% when used with TF 1245A. Additional errors of up to ±1% may be encountered when used with TM 5726 or TM 5727 and matched load.
Output	Suitable for use with TF 1245A, or with optional Matching Unit added, approx. 3 V across 50 Ω load.
POWER REQUIREMENTS	
AC supply	100 to 150 V and 200 to 250 V. 40 to 100 Hz.
DIMENSIONS AND WEIGHT	Height 360 mm 14 in; Width 260 mm 10¼ in; Depth 240 mm 9½ in; Weight 12 kg 27 lb

VERSIONS AND ACCESSORIES

When ordering please quote eight-digit code numbers

Ordering numbers	
	Versions
51245-910Y	TF 1245A. The basic instrument for bench use.
	Oscillators
51246–900J	TF 1246. 40 kHz to 50 MHz.
51247–900M	TF 1247. 20 to 300 MHz.
	Supplied Accessories
	Inductor Support Platform TC 28850 (37563–103V). Supports small test components.
	Coaxial Lead TM 5725 (43125-010A). Couples the TF 1245A to either the TF 1246 or TF 1247 Oscillator.
	Two Tie Bars TB 28691 (33563-401V). Bond the TF 1245A to either the TF 1246 or TF 1247 Oscillator.
	Optional Accessories
44811–702G	Series Loss Test Jig TJ 230. (For details see next page).
44411–009E	50 Ω Matching Unit TM 5726. Enables TF 1246 Oscillator to be used as a 50 Ω general-purpose test source.
44411–008H	50 Ω Matching Unit TM 5727 Enables TF 1247 Oscillator to be used as a 50 Ω general-purpose test source.
43527–001C	1 to 40 kHz Transformer TM 5728A. 600 to 0·5 Ω. For coupling TF 1245A to a conventional l.f. oscillator.
46884–013C	Set of 18 Inductors in case. TM 4520. Details of these inductors, which can be supplied separately, are to be found in the table on the next page under the type number TM 1438 series. Ordering numbers for individual inductors are featured alongside each type number.
44133–003B	Inductor TM 4947/1 } Details of these are to be found in the table on the next page.
44123–202T	Inductor TM 4947/2
44114–001U	Inductor TM 4947/3

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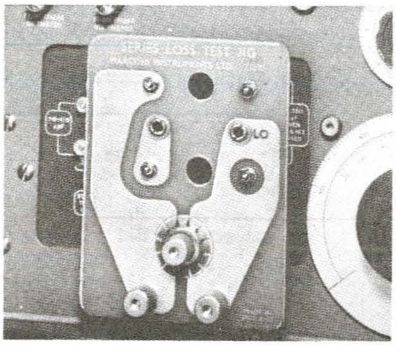
OPTIONAL ACCESSORIES



Series Loss Test Jig TJ 230

TJ 230 enables the measurement of small values of R and L and large values of C to be made by connecting them in series with the test circuit of the Q Meter.

The unit consists of a printed-circuit base on which are mounted sockets to accept the TM 1438 series of inductors; and a pair of low inductance series-connection terminals across which the unknown is connected. The Jig is arranged for connection to the l.f. test circuit terminals of the Q Meter.

MEASUREMENT RANGE		
	C	480 pF to 0·25 µF.
	L	0·005 µH at 50 MHz to 25 mH at 40 kHz.
	R	0·003 Ω at 50 MHz to 1·5 kΩ at 40 kHz
ACCURACY		
	C and L	Maximum accuracy of about 4% when C reading changes by 2:1.
	R	Maximum accuracy of about 10% when Q of circuit is halved.
DIMENSIONS		Height 127 mm 5 in; Width 95 mm $3\frac{3}{4}$ in; Depth 35 mm $1\frac{3}{8}$ in

Inductors TM 1438 series   TM 4947 series

A range of twenty-one inductors, any of which can be supplied separately, is available for use with the Q Meter. Two basic series are available:

TM 1438 series: for l.f. test circuit; eighteen fully screened inductors on ceramic formers, fitted with "banana" plug connectors. Values range from 0·2 µH to 25 mH; each adjusted to within ±3% ±0·05 µH of its nominal value. Can be supplied as a complete set, type TM 4520, in a polished hard-wood case.

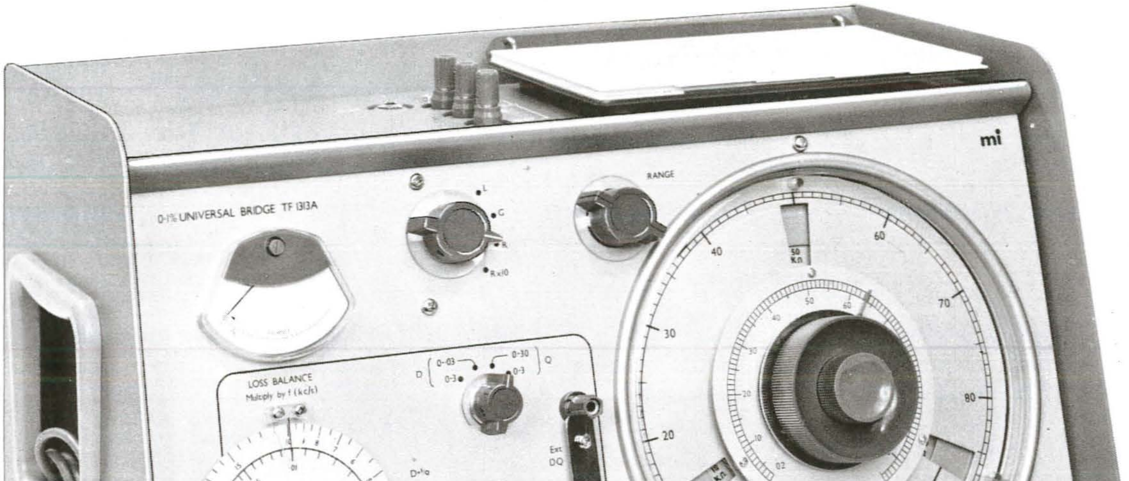
TM 4947 series: for h.f. test circuit; three fully screened inductors fitted with spade-lug connectors.

The inductors available and details of their frequency coverage are given in the table opposite.

Type		Nominal Inductance	Approx. Magnification	Approx. Self-Capacity pF	Approx. Frequency Range
TM 1438A	(44118–902U)	0·2 µH	200	8	40–15 MHz
TM 1438B	(44127–901X)	1·0 µH	200	8	22–8·5 MHz
TM 1438P	(44123–002C)	1·5 µH	200	8	18–6·5 MHz
TM 1438C	(44125–201V)	2·5 µH	200	8	14–5·2 MHz
TM 1438D	(44133–004K)	5·0 µH	200	8	9–3·5 MHz
TM 1438E	(44135–003M)	10 µH	200	8	6·5–2·5 MHz
TM 1438F	(44143–801U)	25 µH	200	8	4·3–1·6 MHz
TM 1438G	(44153–802N)	50 µH	200	8	2·9–1·1 MHz
TM 1438R	(44153–804J)	75 µH	200	8	2·4–0·9 MHz
TM 1438H	(44153–803L)	100 µH	200	8	2·0–0·8 MHz
TM 1438Q	(44157–804H)	200 µH	200	8	1·5–0·6 MHz
TM 1438I	(44157–803Z)	250 µH	200	8	1·3–0·5 MHz
TM 1438J	(44163–801N)	500 µH	160	9	970–370 kHz
TM 1438K	(44167–801A)	1·0 mH	160	9	680–270 kHz
TM 1438L	(44173–601V)	2·5 mH	150	10	410–150 kHz
TM 1438M	(44177–802H)	5·0 mH	130	10	280–110 kHz
TM 1438N	(44177–803E)	10 mH	80	11	220–80 kHz
TM 1438O	(44182–601H)	25 mH	80	11	140–50 kHz
TM 4947/1	(44133–003B)	2·5 µH	350	4·0	20–30 MHz
TM 4947/2	(44123–202T)	0·5 µH	350	1·5	25–70 MHz
TM 4947/3	(44114–001U)	0·05 µH	300	1·2	70–230 MHz

0·1% Universal Bridge TF 1313A

- ☐ Measures L: 0·1 μH to 110 H at 1 and 10 kHz
- ☐ Measures C: 0·1 pF to 110 μF at 1 and 10 kHz
- ☐ Measures R: 0·003 Ω to 110 MΩ at d.c.
- ☐ 0·1% accuracy
- ☐ Discrimination: 0·01% of full-scale



The TF 1313A is a wide-range general-purpose impedance bridge with a measurement accuracy of 0·1%.

At balance, the Inductance, Capacitance or Resistance value is read from the concentric dials of the coarse and fine main balance controls. The coarse control is, in fact, a 110-position switch; and its associated dial is directly calibrated, with the units and numerical markings appearing in shuttered windows coupled to the function and range selector switches to avoid any possibility of confusion. The continuously variable fine control also has a directly calibrated dial – the reading being added to that of the coarse control – and it permits accurate interpolation between the switched steps to an ultimate reading discrimination of 0·01% of full-scale.

Comprehensive phase balance arrangements permit measurement of all a.c. impedances within the range of the instrument in either the series loss or parallel loss configuration at 1 kHz or above. Most of the cases met in practice can be measured in the appropriate configuration at lower frequencies; but, in order to permit measurement in those comparatively rare instances where the loss factor of the impedance is outside the range of the balance controls, the facility is provided for connecting an external variable resistor to panel terminals.

Provision is also made for the injection of a d.c. polarising voltage for use when testing electrolytic capacitors. Incremental inductance measurement can be made by the use of the DC Choke Adaptor TM 6113 connected externally.

The out-of-balance voltage is indicated by an a.c. amplifier detector, which has adequate sensitivity over the whole of the measurement range. When the bridge is d.c. energised for resistance measurement, the amplifier is preceded by a photo-electric chopper to convert the d.c. out-of-balance voltage to an a.c. signal. The internal a.c. excitation source can be switched to operate at either 1 kHz or 10 kHz, the amplifier detector being switch tuned to the appropriate frequency in order to avoid errors due to distortion or to non-linearity in the impedance under test.

For measurement at frequencies other than 1 or 10 kHz, an external source may be connected via a telephone jack on the front panel; inserting the plug into this jack automatically stops the internal oscillator.

The output from the detector amplifier is available at a second jack socket on the front panel. This is useful when it is desirable to connect the bridge to a special form of balance indicator such as an oscilloscope or selective voltmeter for use at frequencies other than 1 or 10 kHz. Insertion of the plug into the jack disconnects the filters from the amplifier but leaves the meter in circuit, permitting the use of the internal detector, in an untuned condition, when an external oscillator is used.

RESISTANCE MEASUREMENT	
Range	0·003 Ω to 110 MΩ in eight ranges with maxima of 11 Ω to 110 MΩ in decade steps.
Accuracy	*Basic measurement error:* ±0·1% of reading, or ±0·015% of range maximum whichever is greater. *Range errors:* 110 Ω to 1·1 MΩ ranges, inclusive – basic errors only. 11 Ω and 11 MΩ ranges – basic errors, and additional ±0·1% of reading. 11 MΩ×10 range – basic errors, and additional, ±0·15% of reading.
Residual resistance	Less than 0·003 Ω.
INDUCTANCE MEASUREMENT	
Range	0·1 μH to 110 H in seven ranges with maxima of 110 μH to 110 H in decade steps.
Accuracy	*Basic measurement error at 1 kHz:* ±0·1% of reading, or ±0·015% of range maximum, whichever is greater. *Basic measurement error at 10 kHz:* ±0·2% of reading, or ±0·025% of range maximum, whichever is greater. *Range errors:* 1·1 mH to 11 H ranges inclusive – basic errors only. 110 μH and 110 H ranges – basic errors and additional ±0·1% of reading. *Additional errors at low Q:* $\pm(0{\cdot}1 \times \frac{f}{Q})$%, where f is in kHz.
Residual resistance	Typically 0·05 μH.
CAPACITANCE MEASUREMENT	
Range	0·1 pF to 110 μF in seven ranges with maxima of 110 pF to 110μF in decade steps.
Accuracy (when D is not greater than 0·031)	*Basic measurement error at 1 kHz:* ±0·1% of reading, or ±0·015% of range maximum, whichever is greater. (When D is greater than 0·031 additional error is typically ±0·3D²%). *Basic measurement error at 10 kHz:* ±0·2% of reading or 0·025% of range maximum whichever is greater. (When D is greater than 0·031 and less than 0·31 additional error is typically ±6D²%). *Range errors:* 0·0011 to 11 μF ranges inclusive – basic errors only. 110 pF and 110 μF ranges – basic errors, and additional ±0·1% of reading
Residual capacitance	Less than 0·05 pF.
TEMPERATURE RANGE	18°C to 28°C for the stated accuracies.
Temperature coefficient	Additional error of ±0·01% per degree C, for temperatures between 10°C and 18°C, 28°C and 35°C.

Q AND D MEASUREMENT			
Range		1 kHz	10 kHz
	Low Q:	0 to 3	0 to 30
	Normal Q:	0·5 to 31	5 to 310
	Normal D:	0·0005 to 0·031	0·005 to 0·031 (limited)
	High D:	0·005 to 3	Not required
Accuracy	Normal Q: ±5% of reading, ±0·5% of full-scale. Normal D: ±5% of reading. Low Q and High D: ±10% of reading, ±3% of full-scale. Additional D or $\frac{1}{Q}$ error below 1 kHz, less than ±0·0005 with correction supplied or less than ±0·0015 without correction. (Above 1 kHz multiply by f kHz.)		
BRIDGE SOURCES AND DETECTOR			
Internal sources	1 kHz and 10 kHz oscillators for L and C measurement, accuracy ±2·5%; output level, depending on loading, up to 750 mV. DC supply for R measurement, less than 100 mW component loading.		
External oscillators	*Frequency range:* 20 Hz to 30 kHz. *Input level required:* 3 to 20 V depending on frequency. (An external tuned detector is also necessary to achieve the quoted measurement accuracies.)		
Additional L & C errors	Typically:	Frequency	% error
		20 Hz	±0·05
		100 Hz	±0·03
		20 kHz	±0·2
		30 kHz	±0·35
CAPACITOR BIAS	Up to 350 V d.c. may be applied for polarising electrolytic capacitors.		
POWER SUPPLY			
AC mains	100 to 130 V and 200 to 250 V 45 to 180, 275 to 300, 366 to 400 Hz, 25 VA.		

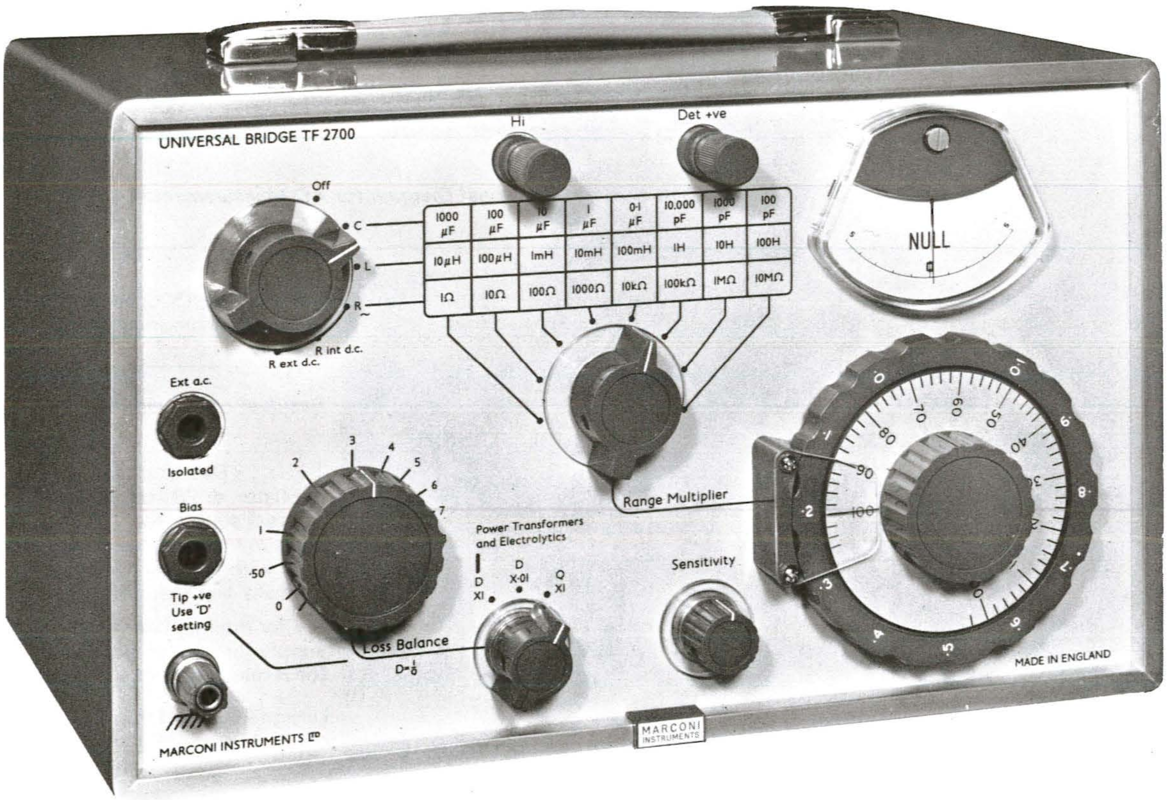
DIMENSIONS AND WEIGHT	Height	Width	Depth	Weight
	300 mm	500 mm	260 mm	13·2 kg
	11½ in	19½ in	10 in	29 lb

VERSIONS AND ACCESSORIES

When ordering please quote eight digit code numbers.

Ordering Numbers	
51313–025C	Versions 0·1% Universal Bridge TF 1313A
	Supplied Accessories Three telephone plugs, type P40, for external oscillator and detector and bias jacks.
44412–702T	Optional Accessories DC Choke Adapter TM 6113 Enables direct current up to 200 mA from an external supply to be passed through inductors under test at 1 kHz in the range 100 mH to 100 H. Errors introduced by the adapter do not generally exceed 3% and may be eliminated by simple substitution methods.

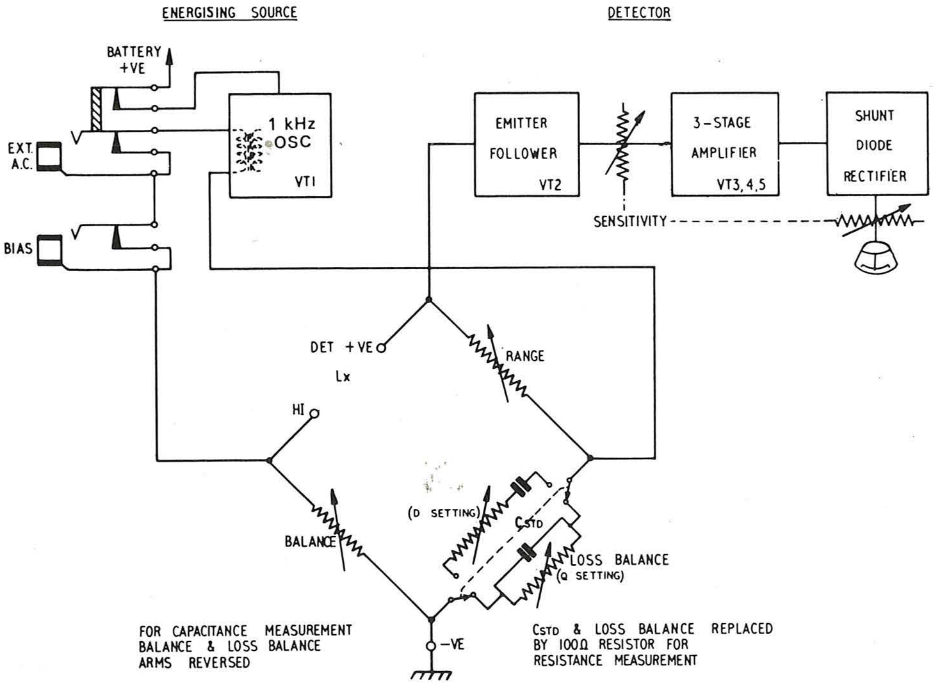
- ☐ Transistorised oscillator/detector
- ☐ Battery operation
- ☐ Remarkable versatility



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

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 11μH. +2%–10% of reading, +0 –0·3 μH dependent upon Q below 11μH.

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 –110Ω, 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 1·1Ω.

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.

SAFETY

Designed to meet the requirements of 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.

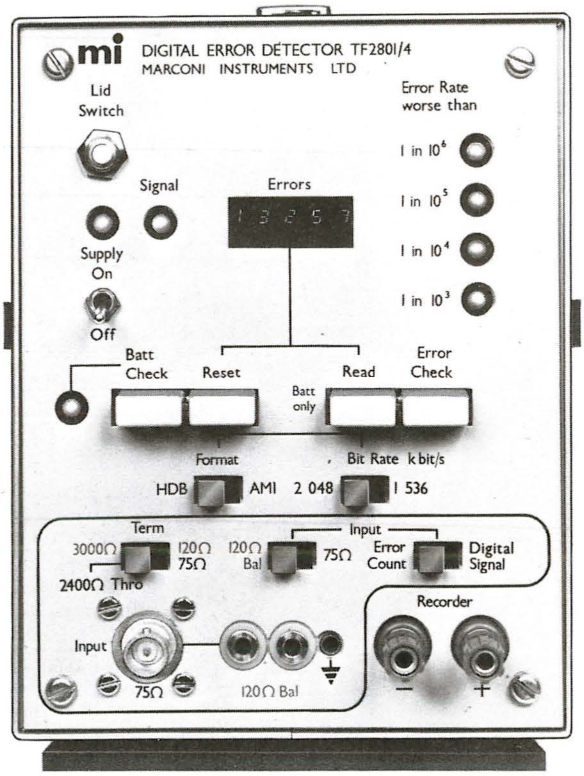
Ordering numbers	
52700-015L	**Versions** TF 2700 standard version.
	Supplied Accessories Jack Plug, type P40. (Two supplied).
43535-009J 44412-702T	**Optional Accessories** Isolating Transformer TM 7120. DC Choke Adapter TM 6113.

PCM TEST EQUIPMENT

Digital Error Detector	TF 2801/4	168
Pattern Generator and SLMS	TF 2802/2	170
PCM Regenerator Test Set	OA 2805A	172
PCM Multiplex Tester	TF 2807A	174
Data Line Analyser	TF 2809	178
PCM Regenerator Tester	TF 2823	180
Cable Simulator	TF 2825	183
PCM Digital Simulator	TF 2828	186
PCM Digital Analyser	TF 2829	190

Digital Error Detector

- 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 batteries. 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.
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).
b) 2400 Ω THRO: 37 mV to 100 mV (72 mV nominal).
c) 120 Ω BAL: 1·7 V to 3·8 V (3·0 V nominal).
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.
75 Ω TERM: for use when the instrument is used to terminate a 75 Ω source.
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.
120 Ω: for use when the instrument is used to terminate a 120 Ω source
3000 Ω: for use when the 120 Ω source is terminated other than by the instrument.

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 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
Designed to meet the requirements of IEC 348.

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 mains
95 V to 130 V and 190 V to 264 V.
45 to 500 Hz.
2 VA maximum.

DIMENSIONS AND WEIGHT

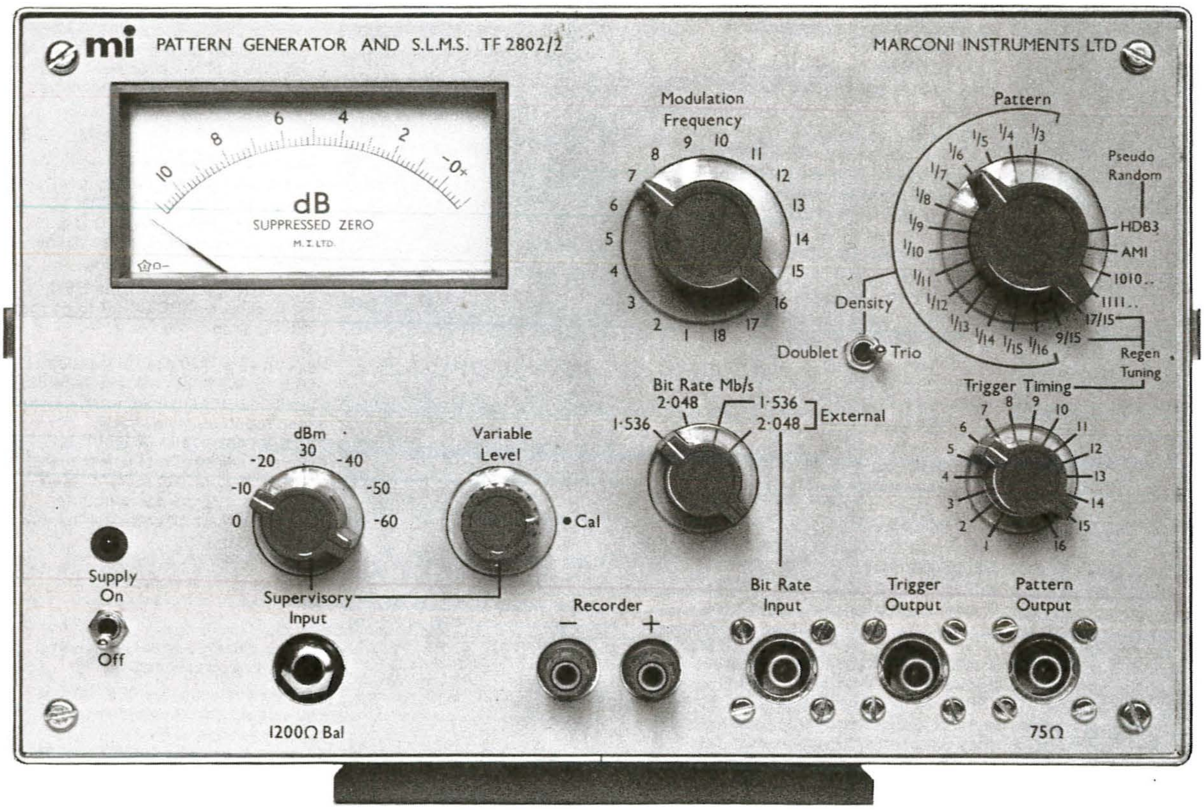
Height	Width	Depth	Weight
190 mm	146 mm	375 mm	4·1 kg
7½ in	5¾ in	14¾ in	9 lb

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.
	The following versions may be available to special order.
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.

- 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

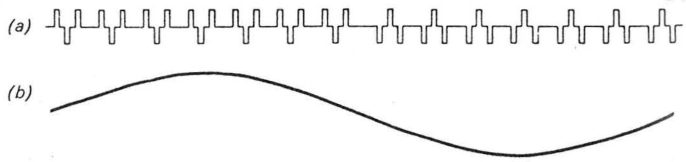


The Pattern Generator and Selective Level Measuring Set TF 2802/2 is a combined pulse pattern generator and selective level measuring set used for testing and fault finding on p.c.m. links consisting of up to 18 regenerators. When used with, or as part of, a regenerator test set the clock tuning patterns 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.



(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.

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.

PATTERN GENERATOR

PATTERN OUTPUT

Bit rate
Internal clock or external input, switch selected.
Internal clock:
a) 1·536 Mbit/s ± 60 bit/s.
b) 2·048 Mbit/s ± 80 bit/s.
External input:
a) Pattern output driven from external clock, digital drive (2nd regenerator) from an internal 1·536 Mbit/s clock.
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.
Pulse amplitude: 2·37 V ± 0·24 V across 75 Ω.
Difference between positive and negative pulse amplitude not greater than 5%.
Overshoot: Not greater than 5%.
Mean pulse level: Nominally 0 V.

Output impedance
75Ω 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) Pseudo-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.
Switch selects digital drive phase locked to digital output or not locked.
1·536 Mbit/s ± 60 bits/s.
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).
Balance: Better than 50 dB at 1·5 kHz.

Power feed
To energise the filter amplifier whilst simultaneously measuring the audio frequency.
20 V ± 0·5 V.
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.
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

Designed to meet the requirements of IEC 348.

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

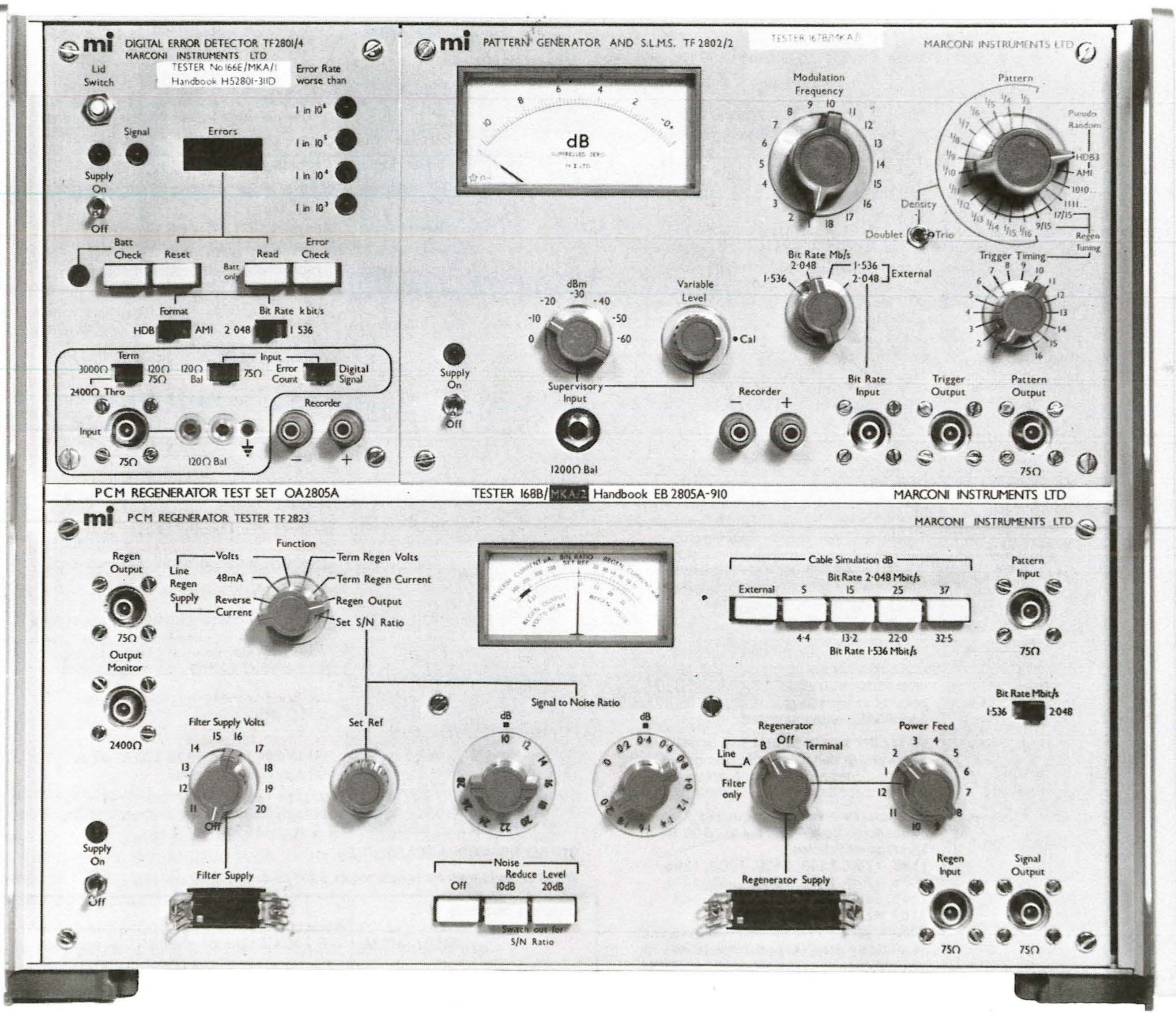
When ordering please quote eight digit code numbers

Ordering numbers	
	Versions
52802–302M	TF 2802/2 Version with BNC connectors.
	The following versions may be available to special order.
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.
	Signal Input Lead 1·8 m long.
	PO Plug (No. 316) 43125–070C
	Board Extractor 41148–605K (TM 8089).
	Optional Accessories
44836–104L	Extender Board.
54411–011S	Matching Unit, 75 Ω unbalanced to 120 Ω balanced.

PCM Regenerator Test Set

- ☐ 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 HDB 3 formats

IMPROVED



Model 52805-315S with P.O. connectors 14598/2

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.

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 the improvements referred to in the TF 2823 pages of this catalogue.

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.

SAFETY	Designed to meet the requirements of IEC 348.			
POWER REQUIREMENTS AC supply	95 to 130 V or 190 to 264 V. 45 to 500 Hz.			
DIMENSIONS AND WEIGHT	Height	Width	Depth	Weight
	370 mm	430 mm	380 mm	25 kg
	$14\frac{1}{2}$ 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.

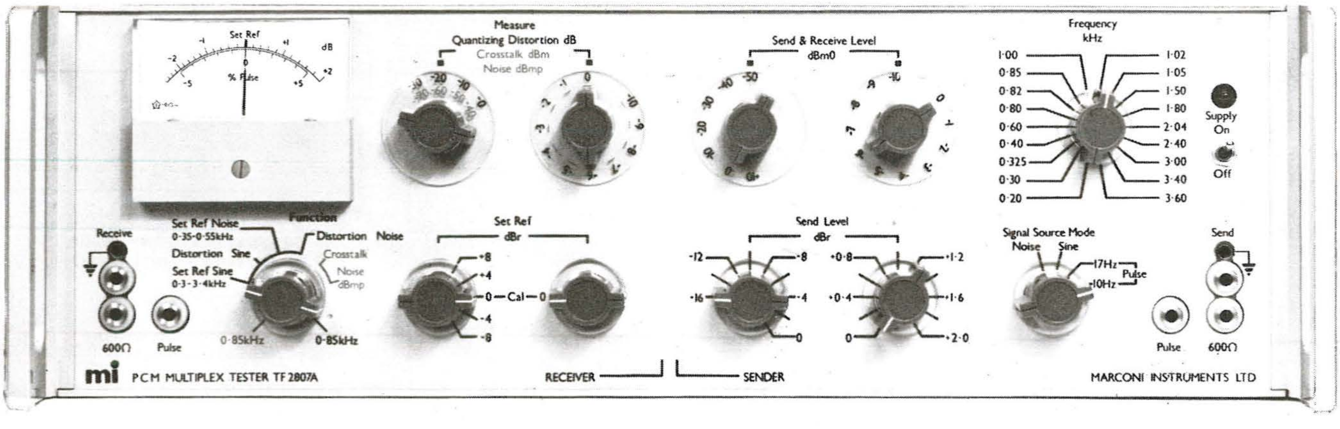
VERSIONS AND ACCESSORIES

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; BNC connectors. Comprises: TF 2801/4 (52801–904B) TF 2802/2 (52802–302M) TF 2823 (52823–312D) The following versions may be available to special order.
52805–309F	OA 2805A. Version with bit rates 1·544 and 2·048 Mbit/s; BNC connectors. Comprises: TF 2801/4 TF 2802/2 TF 2823
52805–315S	OA 2805A. Version with bit rates 1·546 and 2·048 Mbit/s; P O. connectors. Comprises: TF 2801/4 (52801–311D) TF 2802/2 (52802–301X) TF 2823 (52823–311W)
	Supplied Accessories (For 52805–314V version) Supply Lead 23423–159P. Terminal Regenerator Supply Lead 43129–050K. Filter Supply Lead 43129–051A. Line Regenerator Supply Lead 43129–052Z. Interface Lead 43129–056Y (TF 2802/2 to TF 2823 rear panels). Flexible 'U' Link 43125–050Y (BNC to BNC plugs: 3 supplied) Supply Distribution Unit 44990–094H. Board Extractor 41148–605K.

PCM Multiplex Tester

- ☐ 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



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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 sine wave 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 sine wave 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 530 Hz. Greater than 55 dB down at 250 Hz and below. Greater than 20 dB down at 300 Hz. Greater than 6 dB down at 580 Hz. Greater than 20 dB down at 650 Hz. Greater than 40 dB down at 700 Hz. Greater than 50 dB down at 750 Hz. Greater than 60 dB down at 800 Hz and above.
Peak : r.m.s. ratio	10·5 dB.
Amplitude accuracy	*Overall accuracy:* ±0·35 dB for total range of levels. ± 0·15 dB at 0 dBm0, 0 dBr. ± 0·1 dB at 0 dBm0, 0 dBr at + 20°C ± 5°C.

SINE WAVE OUTPUT	
Frequency range	200 Hz to 3600 Hz. 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. Less than 0·2% at 200 Hz.
Amplitude accuracy	*Overall accuracy:* ±0·35 dB for total range of levels. ±0·1 dB at 0 dBm0, 0 dBr and 1kHz at +20°C ±5°C. ±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

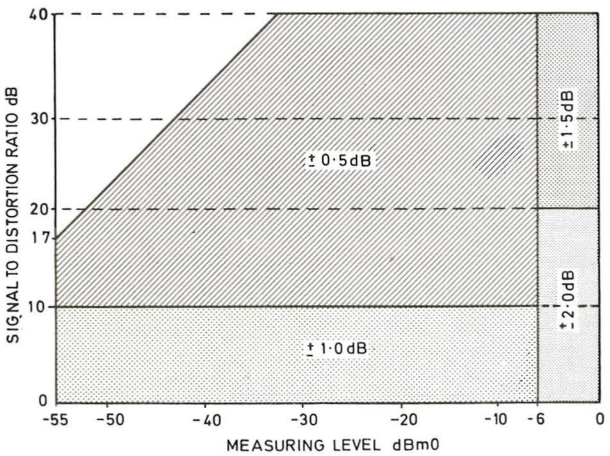
Accuracies include meter, level, attenuators and frequency response errors as applicable.

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 350 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.
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.

SAFETY	Designed to meet the requirements of 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 25 kN/m² differential, i.e. 3·7 lbf/in²).

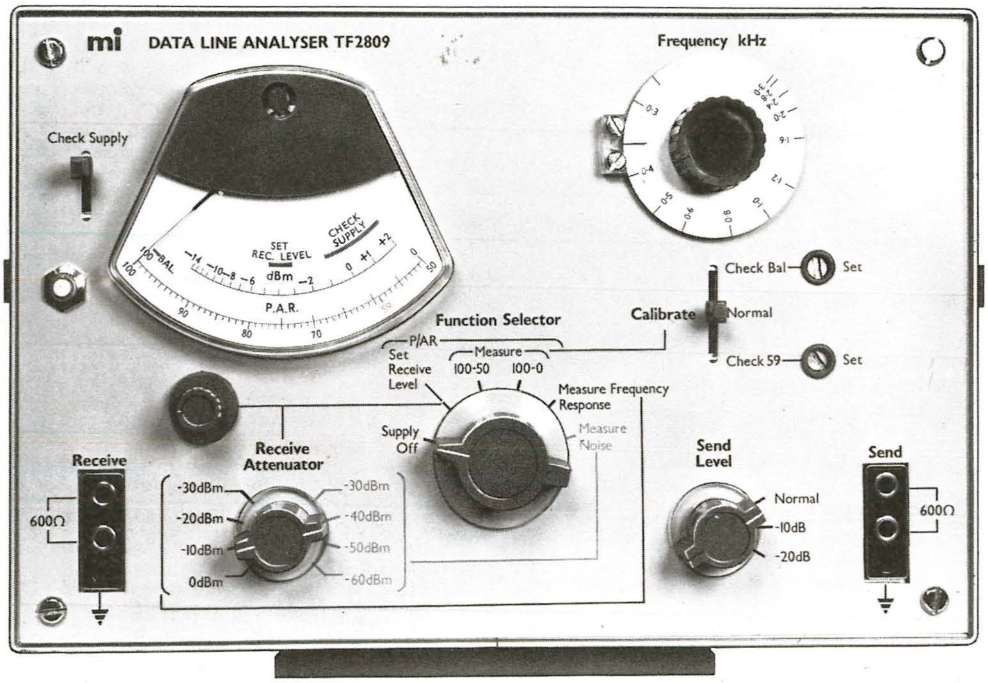
VERSIONS AND ACCESSORIES

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.

Data Line Analyser

- ☐ For testing data transmission links
- ☐ Measures peak-to-average rating, frequency response, and noise
- ☐ Self-contained and portable; battery operated



Data Line Analyser TF 2809 is a self-contained test set for assessment of overall distortion produced by communication links when used for data transmission. It is useful for testing the suitability of voice-band transmission systems – including telephone lines, coaxial cable systems, and microwave links – for data transmission; and it can also be used as the monitoring unit for adjustment of delay equalisers and in the manufacture of modems.

Three types of measurement can be made with the instrument; viz., peak-to-average rating (usually known as P/AR), frequency response characteristic, and the noise level introduced by the system.

The peak-to-average rating, or P/AR, is a single number rating of the fidelity of a channel used for the transmission of data. This rating is a weighted measure of the total gain and phase distortion in the channel, and is derived by comparing the peak-to-average ratio of an ideal signal with the peak-to-average ratio of the output signal of the system under test.

$$\text{P/AR} = \left\{ 2 \cdot \frac{\text{Peak-to-average ratio of the distorted signal}}{\text{Peak-to-average ratio of an ideal signal}} - 1 \right\} \times 100$$

The peak-to-average ratio of the waveform is the ratio of its peak amplitude to its full-wave rectified average value. The scale of P/AR measurement is such that a perfect transmission system would have a P/AR of 100, and a very poor system (which halved the peak-to-average ratio of the signal) would have a P/AR of zero.

Distortion in a data link usually lengthens the data pulses, so that each begins to interfere with the next pulse in the train. Gain and delay distortion in the system cause most of this "smearing", which reduces the peak-to-average ratio of the received signal. Non-linear distortion and noise also cause the peak-to-average ratio of the received signal to fall. Thus P/AR is affected by gain distortion, delay distortion, non-linear distortion, and noise. The P/AR of a data link can also be correlated with the likelihood of transmission error.

The Measurement System

The TF 2809 consists of a test-signal source – the *send* section – and a measuring circuit – the *receive* section – both of which are automatically arranged for the desired measurement function by the action of a single selector switch on the front panel.

For P/AR measurement the *send* section generates a test signal having a fixed duty cycle, and the *receive* circuit is so arranged that the meter indicates the P/AR of the system under test directly. The spectrum of the P/AR test signal includes odd harmonics from 126·5 Hz to 3415·5 Hz. This signal is fed to the system under test at a level determined by the setting of the Send Attenuator, and the output signal from the system is monitored by the *receive* section of the analyser.

In the *receive* section the signal is filtered so that its spectrum approximates to that of a 2·4 kbit data signal, and it is then detected by a peak-to-average ratio circuit. Since the test signal has a known fixed peak-to-average ratio and the received signal is measured by a true ratio circuit the meter reads P/AR directly, and accurate setting of the received-signal average level is unnecessary.

An important feature of the *receive* section is the inclusion of a special circuit for correction of phase-intercept distortion. This phenomenon occurs in single sideband telephone systems, and is caused by reinsertion of the carrier with incorrect phase. The effect of this distortion on data transmitted is marginal because of the action of the modem. But the reciver P/AR waveform can be affected quite severely when measured at voice band. P/AR readings with instruments having no correction for phase-intercept distortion may vary as much as 8 units as the phase of the reinserted carrier drifts in and out of synchronism.

The correction circuit of the TF 2809 completely overcomes this difficulty so that this type of distortion produces negligible error in the P/AR reading.

Careful attention has also been given to the accuracy of the characteristics of the P/AR *send* signal. In the TF 2809 the signal is derived from a crystal oscillator and has an accurately controlled frequency/phase characteristic. An internal standard network with a P/AR of 59 is included in the instrument for calibration of the *receive* section. For end-to-end testing of a data link, therefore, the *send* section of one Analyser can be used in conjunction with the *receive* section of another without loss of accuracy.

For frequency response measurements, the *send* section has a built-in audio frequency oscillator, which is continuously tunable from 300 Hz to 3·1 kHz, and the *receive* section becomes a simple level meter calibrated in dBm.

For noise measurement, only the *receive* section of the Analyser is used, and the average noise level in the system under test is indicated in dBm.

P/AR Measurement

SEND SECTION (P/AR test signal produced)	Bipolar pulse shaped by linear band pass filter.
Signal spectrum	Odd harmonics from 126·5 Hz to 3415·5 Hz.

Freq Hz	Level dB
126·5	−20·5
379·5	− 2·3
632·5	− 1·5
885·5	− 0·8
1138·5	− 0·2
1391·5	0
1644·5	− 0·4
1897·5	− 2·2
2150·5	− 5·2
2403·5	− 8·7
2656·5	−12·4
2909·5	−16·0
3162·5	−19·5
3415·5	−23·1

	Even harmonics −50 dB on 1391·5 Hz.
Signal amplitude (Switch in *Normal* position)	0·69 V p-p ±5%. Equivalent in peak amplitude to a −10 dBm sine wave signal (−17·5 dBm power level).
Output impedance	600 Ω balanced.
Balance rejection	Better than 50 dB.
Return loss	Not less than 25 dB at 1 kHz.
Send attenuator	−10 dB (±0·2 dB) −20 dB (±0·2 dB)
RECEIVE SECTION	
Input impedance	600 Ω balanced.
Input levels	+15 dB to −25 dB relative to the normal send level.
P/AR range	Peak/Average Rating measured on calibrated range 100–50. Uncalibrated range 100–0.

Frequency/Response Measurement

SEND SECTION (Sinewave test signal produced)	
Frequency range	300 Hz to 3·1 kHz continuously variable.
Typical accuracy	±1%.
Amplitude	0 dBm (±0·3 dB.).
Send level	0 dBm, −10 dBm or −20 dBm.
RECEIVE SECTION	
Input level range	+2 dBm to less than −44 dBm using lower attenuator and meter scale.
Level accuracy	±0·3 dB at 0 dBm meter reading.
Input impedance	600 Ω balanced.
Balance rejection	Better than 50 dBm.
Return loss	Not less than 25 dB at 1 kHz.

Noise Measurement

RECEIVE SECTION	
Frequency response	Approximately psophometric.
Input level range	−28 dBm to −74 dBm using lower attenuator and meter scale.
Accuracy	Average noise level measured within ±0·3 dB at 800 Hz reference frequency.
Input impedance	600 Ω balanced.
SAFETY	Complies with the requirements of IEC 348.
POWER REQUIREMENTS	
Internal batteries	Two PP9 or equivalent (13 to 18 V d.c. at 50 mA).
DIMENSIONS AND WEIGHT	Height 205 mm 8 in; Width 280 mm 11 in; Depth 305 mm 12 in; Weight 6·75 kg 15 lb

VERSIONS AND ACCESSORIES

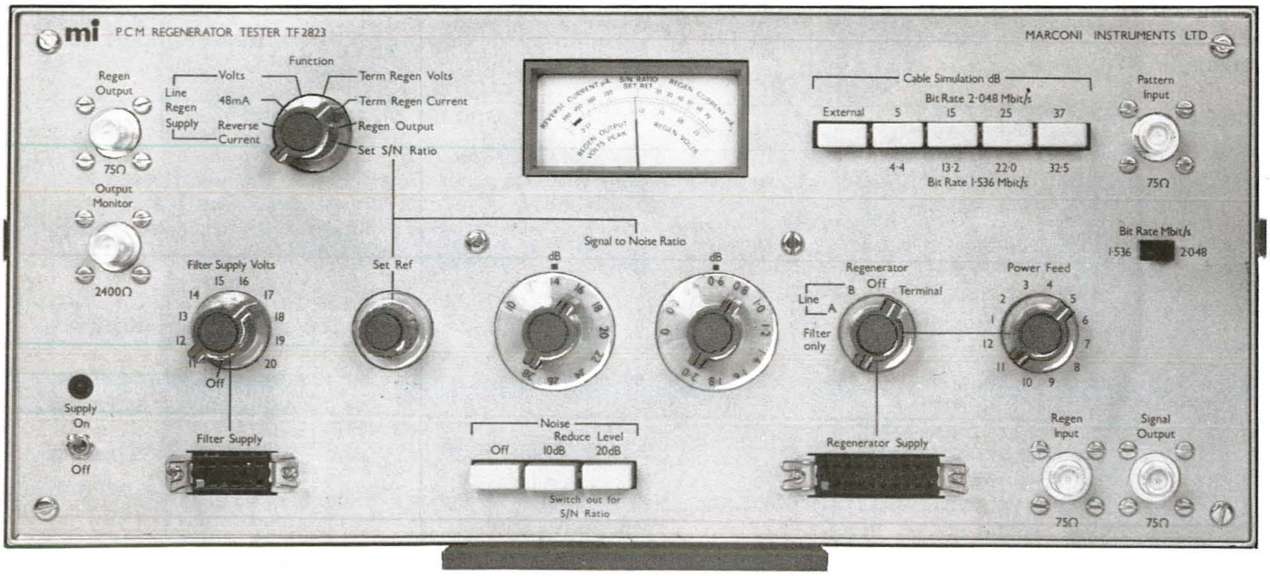
When ordering please quote eight digit code numbers.

Ordering numbers	
52809–015S	Versions TF 2809. European version.
	Supplied Accessories Clip-on front cover. 9 volt Battery, two supplied.
44836–104L	Optional Accessories Extender Board.

PCM Regenerator Tester

- ☐ 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
- ☐ Improved signal-to-noise measurement accuracy
- ☐ New long-life switch contacts

IMPROVED



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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.

The latest version of TF 2823 features $\pm\frac{1}{2}$ dB signal-to-noise measurement accuracy, and it also has switches with improved contact materials which ensure that TF 2823 can cope easily with the continual switching which may be required in production testing.

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.

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 dB; 13·2 dB; 22 dB and 32·5 dB nominal.
WHITE NOISE GENERATOR	A white noise signal 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). 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).
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	$\pm\frac{1}{2}$ dB.

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 and linked to CABLE SIMULATION, selecting insertion loss over the range 0 dB to 36 dB. *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. Intermediate regenerator – input feed. 8. Intermediate regenerator – input feed (reversed). 9. Intermediate regenerator – output feed. 10. Intermediate regenerator – output feed (reversed). 11. Power turn-round regenerator – input feed. 12. Power turn-round regenerator – output feed.

TF 2823

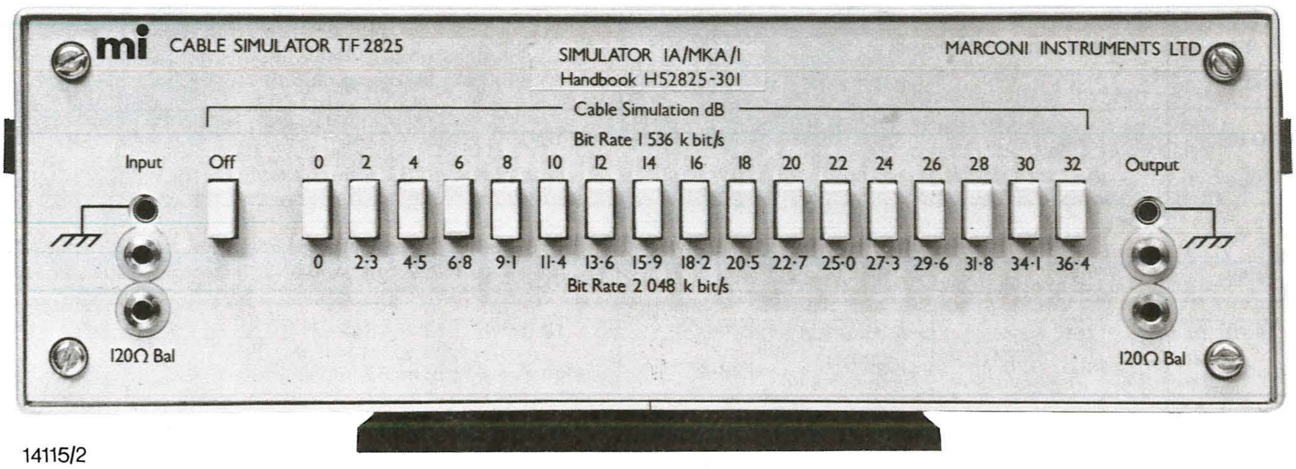
Terminal regenerator voltage	24 V d.c. nominal, isolated from earth.
FILTER SUPPLY	Interface for supervisory filter, comprising test signal, return signal for measurement and power supplies. (Front panel socket 11-way Plessey (Painton) 159 series socket, type No. 74/10/1156/10).
Signal output	The TRIO 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.).
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 reverse current	Indicates supply current to regenerator on reverse current check. Calibrated 200 μA to 500 μA.
2) Line regenerator 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%.
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.)
SAFETY	Designed to meet the requirements of IEC 348.
POWER REQUIREMENTS	
AC supply	190 to 264 V and 95 to 130 V. 45 to 500 Hz.
DIMENSIONS AND WEIGHT	Height 186 mm 7·3 in; Width 420 mm 16·5 in; Depth 410 mm 16·2 in; Weight 10·9 kg 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.
	The following versions may be available to special order.
52823–304F	TF 2823 Version in single bench case with BNC connectors.
52823–305G	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 (suppled with version 52823–305G). Comprising Filter Supply Lead 43129–110T and Line Regenerator Supply Lead 43129–111P.
	Lead 43125–050Y (TM 4726/164) BNC (three supplied with versions 52823–312D, 52823–304F and 52823–305G). 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.
	Optional Accessories
44836–104L	Extender Board; for use when servicing printed boards.

- ☐ Simulates loss and phase of cable in p.c.m. links
- ☐ Sixteen switchable simulators
- ☐ Can be used to extend cable simulation of PCM Regenerator Test Set OA 2805A
- ☐ Maintains regenerator power feeding continuity



14115/2

TF 2825 simulates both the loss and phase characteristics of 120 Ω balanced cable pairs used to connect between regenerators in a primary order p.c.m. system. The unit consists of sixteen passive networks individually selected by front panel switches, and introduced between the 120 Ω balanced input and output sockets. Provision is made within the simulator for maintaining regenerator power feeding continuity.

The Cable Simulator may be connected between installed regenerators, for example for loop-back purposes when checking a link, and may also be connected toPCM Regenerator Test Set OA 2805A to increase the number of cable lengths which can be simulated internally.

Design of the cable simulators is based upon the loss and phase response of 0·63 mm PCQT cable of 1 km length, giving an equivalent loss of 17·4 dB at 1000 kHz and 15·3 dB at 800 kHz. Table 1 shows the relationship between loss, cable length and conductor diameter for the simulators included in TF 2825.

The simulators are housed in a portable case complete with protective lid providing storage for the interconnecting leads.

Loss at 800 kHz (dB)	Loss at 1000 kHz (dB)	Equivalent cable length (0·63mm)	Nominal Cable Length		
			0·63mm	0·9mm	1·27mm
2	2·3	131	130	180	245
4	4·5	261	260	360	490
6	6·8	392	390	535	735
8	9·1	523	520	710	980
10	11·4	654	650	890	1225
12	13·6	784	780	1070	1470
14	15·9	915	910	1250	1715
16	18·2	1046	1050	1430	1960
18	20·5	1176	1180	1600	2230
20	22·7	1307	1310	1780	2450
22	25·0	1438	1440	1960	2700
24	27·3	1564	1570	2140	2940
26	29·6	1699	1700	2320	3190
28	31·8	1830	1830	2500	2430
30	34·1	1961	1961	2670	3680
32	36·4	2091	2090	2850	3920

Table 1. Relationship between loss, cable length and conductor diameter.

Characteristics of Cable Simulators

Each cable simulator is identified by its insertion loss at 800 kHz (approximately half bit rate of a 1536 kbit/s system). Referring to British Post Office 28 pair 0·63 mm (10 lb) PCQT (Paper Covered Quad Trunk) cable, a 1 km length of a typical cable pair has an insertion loss of 15·3 dB at 800 kHz.

In the table, Loss = insertion loss in dB and Phs = phase distortion in degrees (i.e. deviation from linear phase/frequency characteristic of 1700°/MHz for 1 km).

Frequency (MHz)		0·1	0·5	0·8	1·0	1·5	2·0
2 dB cable	Loss	0·9	1·4	2·0	2·3	3·0	3·5
	Phs	−2·1	−5·5	−5·1	−4·4	−2·1	+1·0
4 dB cable	Loss	1·8	2·8	4·0	4·5	6·0	7·0
	Phs	−4·2	−11·0	−10·2	−8·9	−4·2	+2·0
6 dB cable	Loss	2·3	4·2	6·0	6·8	8·8	10·6
	Phs	−6·3	−16·5	−15·3	−13·3	−6·3	+2·9
8 dB cable	Loss	3·1	5·8	8·0	9·1	11·8	13·6
	Phs	−8·4	−22·0	−20·4	−17·8	−8·4	+3·9
10 dB cable	Loss	3·5	7·1	10·0	11·4	14·3	16·7
	Phs	−10·5	−27·5	−25·5	−22·2	−10·5	+4·9
12 dB cable	Loss	4·1	8·9	12·0	13·6	17·5	20·7
	Phs	−12·5	−32·9	−30·6	−26·7	−12·5	+5·9
14 dB cable	Loss	4·9	10·3	14·0	15·9	21·0	25·0
	Phs	−14·6	−38·4	−35·7	−31·1	−14·6	+6·9
16 dB cable	Loss	5·7	12·3	16·0	18·2	23·6	27·5
	Phs	−16·7	−43·9	−40·8	−35·6	−16·7	+7·8
18 dB cable	Loss	6·0	13·7	18·0	20·5	26·3	30·8
	Phs	−18·8	−49·4	−45·9	−40·0	−18·8	+8·8
20 dB cable	Loss	6·6	15·2	20·0	22·7	29·5	34·6
	Phs	−20·9	−54·9	−51·0	−44·4	−20·9	+9·8
22 dB cable	Loss	7·3	16·9	22·0	25·0	32·3	38·1
	Phs	−23·0	−60·4	−56·1	−48·9	−23·0	+10·8
24 dB cable	Loss	8·0	18·5	24·0	27·3	35·1	40·9
	Phs	−25·1	−65·9	−61·2	−53·3	−25·1	+11·8
26 dB cable	Loss	8·8	19·9	26·0	29·6	37·8	44·0
	Phs	−27·2	−71·4	−66·3	−57·8	−27·2	+12·7
28 dB cable	Loss	8·8	21·8	28·0	31·8	41·0	48·5
	Phs	−29·3	−76·9	−71·4	−62·2	−29·3	+13·7
30 dB cable	Loss	9·7	23·1	30·0	34·1	43·6	50·6
	Phs	−31·4	−82·4	−76·5	−66·7	−31·4	+14·7
32 dB cable	Loss	9·7	24·1	32·0	36·4	46·9	54·4
	Phs	−33·5	−87·8	−81·6	−71·1	−33·5	+15·7

SIGNAL INPUT

Pattern Bi-polar p.c.m. signal.

Bit rates 1536 kbit/s or 2048 kbit/s nominal.

Amplitude 6 V p-p nominal.

Input impedance 120 Ω balanced.

Return loss Better than 20 dB from 100 kHz to 2·5 MHz.

Input transformer balance Balance about centre tap is greater than 40 dB from 100 kHz to 2·5 MHz.

Connector Three 4 mm sockets on front panel to fit Siemens 3-pin plug.

SIGNAL OUTPUT

Output Input signal modified by cable simulator selected.

Output impedance 120 Ω balanced.

Return loss Better than 20 dB from 100 kHz to 2·1 MHz.
Better than 18 dB from 2·1 MHz to 2·5 MHz.

Output transformer balance Balance about centre tap is greater than 40 dB from 100 kHz to 2·5 MHz.

Connector Three 4 mm sockets on front panel to fit Siemens 3-pin plug.

CABLE SIMULATORS

Selection By 18 push-button switches providing an OFF (open circuit) position, a 0 dB (through) position and 16 simulator positions marked with insertion loss at 800 kHz for 1536 kbit/s and at 1 MHz for 2048 kbit/s.

Insertion loss In dB at approximately half the bit-rate frequency with switch buttons numbered from left to right.

Switch position	Insertion Loss (dB) 1536 kbit/s (800 kHz)	Insertion Loss (dB) 2048 kbit/s (1 MHz)
1	—	—
2	0	0
3	2	2·3
4	4	4·5
5	6	6·8
6	8	9·1
7	10	11·4
8	12	13·6
9	14	15·9
10	16	18·2
11	18	20·5
12	20	22·7
13	22	25·0
14	24	27·3
15	26	29·6
16	28	31·8
17	30	34·1
18	32	36·4

Phase distortion Phase response designed to simulate phase distortion encountered in PCQT cables from 100 kHz to 2 MHz.

Insertion loss accuracy ±0·5 dB at 800 kHz.
±1·0 dB at 1 MHz.
Over the frequency range 100 kHz to 2 MHz:
±1·0 dB for losses between 0 and 40 dB.
±1·5 dB for losses between 40 and 50 dB.
±2·0 dB for losses greater than 50 dB. Less than 1 dB loss in 0 dB (through) position.
In OFF switch position:
Greater than 70 dB from 100 kHz to 1 MHz.
Greater than 55 dB from 1 MHz to 2·5 MHz.

POWER FEEDING

Continuity of phantom pair power feed arrangements is maintained between input and output. Maximum current 100 mA (50 mA per leg) at a voltage not exceeding 150 V d.c. relative to earth.

INTERFACE

Compatibility Compatible with PCM Regenerator Test Set OA 2805A.

Interconnection Via 19-way socket on rear panel. Provides input and output connections in parallel with front panel sockets. When used with OA 2805A it also provides connections to three attenuator networks and a diode network built into TF 2825. When used as a cable simulator only, these circuits have no effect on the operation and specification of the instrument.

Attenuators Three networks with attenuation selected by the cable simulator switch buttons.
Attenuation accuracy: ±0·5 dB.
Impedance: 75 Ω nominal.

Switch position	Attenuation in dB: Network 1 (Signal measurement)	Network 2 (Noise measurement)	Network 3 (Noise Attenuator)
1 & 2	Open circuit	Open circuit	Open circuit
3 & 4	21·4	21·9	0·1
5 & 6	18·3	18·8	2·0
7 & 8	15·1	15·6	4·3
9 & 10	11·1	11·6	6·9
11 & 12	8·4	8·9	10·6
13 & 14	5·2	5·6	13·0
15 & 16	2·5	3·0	15·0
17 & 18	0·1	0·6	18·9

SAFETY

Designed to meet the requirements of IEC 348.

DIMENSIONS AND WEIGHT

Height	Width	Depth	Weight
95 mm	290 mm	330 mm	3·2 kg
3·7 in	11·4 in	13·1 in	7 lb

VERSIONS AND ACCESSORIES

When ordering please quote eight digit code numbers

Ordering numbers	Versions
52825–301E	Cable Simulator TF 2825
	Supplied Accessories Interface Lead Assembly 43129–139T (For connection to OA 2805A) Interface Lead Assembly 43129–140W (For connection to PCM Regenerator Tester TF 2342) Front Cover Assembly

PCM Digital Simulator

- ☐ 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 2828 generates a 2048 kbit/s frame structure to CCITT Recommendation G732. Provision is made, through front panel controls, for the simulation of a range of frequencies from 200 Hz to 3600 Hz at a level of 0 dBmO. It is also possible to simulate a range of levels at 850 Hz from +3 dBmO to −60 dBmO. These digital sequences may be inserted in any one or all 30 channel time slots. In the case of the former, remaining channel time slots may be loaded with zero code, or a pseudo random code, representative of traffic.

Any of the 128 coding levels may be represented by manual selection, and if required an automatic sweep of levels from 0 to 128 may be made in both positive and negative directions. It is also possible to generate increments of frequency 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 commercially available 'x-y' plotters which may be used to plot individual channel frequency response.

Alarms may be simulated in time slots 0 and 16 following the protocol recommended in CCITT G732. Selection of the required alarm condition is made through a front panel control, and this actuation, in conjunction with the multiplex alarm logic, can be used to check the multiplex loss and regain of the alarm conditions. The result is indicated by 'pass' and 'fail' lamps which are an integral part of TF 2828.

Display lamps and switches provide for the control of all bits contained within TS0 and TS16 including 'not' words in frame 0 and signalling word in TS16.

The equipment may be remotely controlled through a TTL interface. An option for GPIB* interface bus will also be available.

**GPIB – Marconi Instruments' General Purpose Instrument Bus is in accordance with IEEE Standard 488-1975 and IEC document 66 (Central Office) 22.*

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 subharmonic frequency components of the fundamental in the frequency range 300 Hz to 3·4 kHz.

CONTROL MODE 2 (850 Hz sine wave)

Generates digital sequences representing a sine wave of nominally 850 Hz (859 Hz) at the nine levels listed in the table below. Theoretical level error of fundamental is introduced by quantizing.

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

CONTROL MODE 3

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 left hand switch gives the most significant bit and the 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' = −106 then 'Word +1' = −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 words +1.

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.

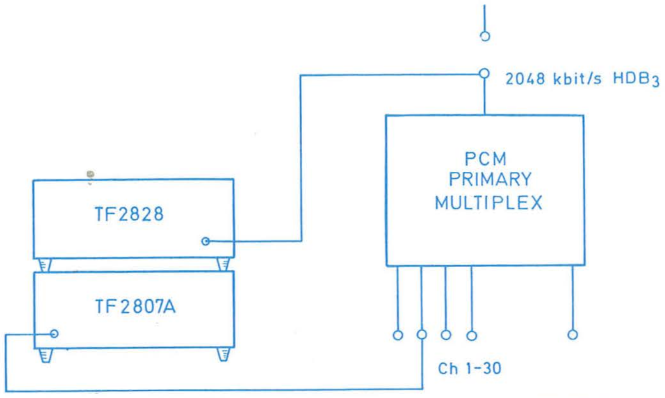
Sweep step + Step test is automatically sequenced starting at +0 through to +126.

Sweep step − Step test is automatically sequenced starting at −0 through to −126.
For the preceding four tests the word changes after approximately two seconds (1024 multiframes).

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.

TF 2828



TF 2828 used with TF 2807A for testing a PCM Primary Multiplex

Sweep frequency (0 to 4 kHz)
0 dBm0 sine wave is automatically sequenced in approximately 30 Hz steps between 15 Hz and 4 kHz giving 128 frequencies. The frequency changes approximately every 0·25s (128 multiframes).
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 or 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: greater than 10 kΩ.
The above levels are CMOS compatible.

ALIGNMENT TESTS

CONTROL MODE 4
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.
Error conditions are activated by depressing the control function 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, 50 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.
MULTIPLEX ALARM AND SIGNALLING HIGHWAY MONITOR	The conditions monitored are SBRC, SRH and SF which are alarm conditions monitored by the BPO. However, access to a single alarm condition on the multiplex and applied to SBRC and SRH inputs will enable alarm functioning to be assessed while sequence testing in Control Mode 4.
	Alarm lamps ON condition.
SBRC (System busy receive common)	Logic 1 (normally logic 0). TTL logic.
SRH (Secondary receive highway)	Continuously high (normally varying data).
SF (System fail)	Line connected to earth (normally open circuit).
REMOTE	All essential functions can be remotely controlled via a socket on the rear panel (50 way Amp connector). A lamp indicates REMOTE operation. The following table indicates the functions controlled (TTL negative logic).
Control lines and functions	Remote enable Data valid (held high while changing control functions). 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 mode 1 and 2. Nine levels (at a frequency set by Test word/frequency lines) and CCITT 0 dBm0 at 1 kHz. Control mode 3. Channel word, level tests 1 and 2, step test. (Channel word set by Test word/frequency lines). Control mode 4. Alarm tests (except LINE). Control mode 5. Set frame or not frame or multiframe or signalling words. (Word set by Test word/frequency lines). Test word/frequency select (8 lines): Sets frequency in control mode 1 and 2. Sets channel word in control mode 3. Sets word in control mode 5. Line Off. Sine or Pseudo random on level tests. SBRC (output). SRH (output). SF (output). Alarm sequence test pass/fail (output). Alarm sequence test pass/inhibit (output). Ground.
SAFETY	Designed to meet the requirements of IEC 348.
POWER REQUIREMENTS	
AC supply	95 to 130 V and 190 to 264 V. 45 to 65 Hz. 15VA 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
52828–900R	PCM Digital Simulator TF 2828.
	Supplied Accessories
	Accessory Pack 46883-366M, including Board Extractor, Lamp Extractor, Push button lamps and Fuse Links.
	Optional Accessories
54127–071H	Rack Mounting Kit.
54347–012A	Interconnecting Lead. For connection of a.c. supply between TF 2828 and TF 2829.
54347–013Z	Lead Assembly (Multiplex). Lead to connect TF 2828 to a Multiplex
54511–012R	Extender Board.
54712–041M	Multiway Plug (7 way). Painton.
54712–051H	Multiway Plug (15 way). Painton.
46883–368R	50 way Plug Kit. Amp.
	Associated Equipment
	PCM Digital Analyser TF 2829.
	PCM Multiplex Tester TF 2807A.

PCM Digital Analyser

- 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 channels
- Optional GPIB* interface

PCM Digital Analyser TF 2829 provides for the 'in-service' or 'out-of-service' monitoring of 2048 kbit/s HDB3 encoded digital line signals conforming to CCITT Recommendation G732. The choice of both input impedance and sensitivity allows the user to operate TF 2829 in either a 'through' or 'terminated' mode. This obviates the need to remove the system from traffic before determining the state of alarms or to gain access to individual channel time slots.

Through a combination of front panel controls and displays, all alarm functions associated with time slots 0 and 16 in the frame structure can be continuously monitored and displayed. The presentation of alarms is given in a logical priority including a range of error conditions associated with TSO. Arrangements are made for channel time slot selection 1 to 30 inclusive. In this mode a decimal display indicates the peak code present in the channel, and the operator can select the display to indicate the maximum positive, maximum negative, or whichever is greater (modulus) within the sampling period.

An analogue output is also provided which represents the digital signal contained within the selected channel. The distortion introduced by the digital to analogue converter is small compared with the minimum quantizing distortion associated with commercially available multiplexes. The alarm and signalling monitor functions combined with the precision digital to analogue converter allow for rapid and accurate determination of the primary p.c.m. multiplex performance. The diagram indicates how these functions can be determined in combination with Marconi Instruments PCM Multiplex Test Set TF 2807A.

The equipment may be remotely controlled through a TTL interface. An option for GPIB* interface bus will also be available.

**GPIB – Marconi Instruments' General Purpose Instrument Bus is in accordance with IEEE Standard 488-1975 and IEC document 66 (Central Office) 22.*

INPUT	PCM frame structure to CCITT Recommendation G732.
Format	HDB 3 code.
Bit rate	2048 kbit/s ±200 bit/s. Synchronization will be maintained with up to 1·5 bits p-p jitter in the range 5 Hz to 3·9 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 26 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.

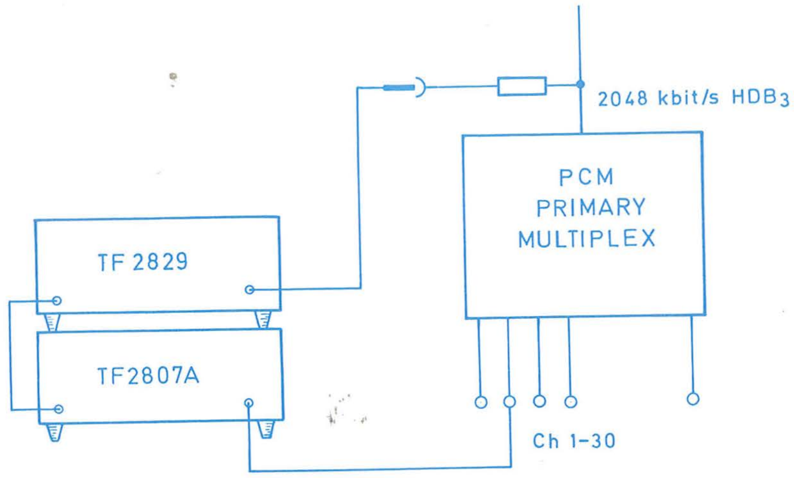
FRAME STRUCTURE MONITORING

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 facility 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 2828	Rear panel terminal provides for connection to PCM Digital Simulator TF 2828 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 3·6 kHz ±0·2 dB w.r.t. 850 Hz.
Linearity	±0·2 dB from +3 dBm0 to −60 dBm0 w.r.t. level at −10 dBm0, measured selectively at 850 Hz.
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). 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. Balance greater than 60 dB from 200 Hz to 3·6 kHz.
Noise test (30 dB gain)	For low level output signal not exceeding code levels ±32 (idle channel noise, cross-talk etc.) a digital gain may be switch selected. This effectively increases the gain by 30 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. Output of alarm states and peak code detector are available. The following table indicates the functions controlled. (TTL negative logic unless stated otherwise).
Control lines and functions	Remote enable Control lines (8 lines) select Peak code (2 lines) +ve, −ve, modulus. Reset peak code. Noise test (+30 dB gain). Reset alarms. Frame structure monitor (3 lines). Multiframe word bits 5 to 8, not-frame word bits 5 to 8, not-frame word bits 1 to 4, signalling word in selected channel. Channel select (5 lines). Peak code outputs (8 lines) +ve logic. TS(n) selected channel timing signal. Alarm lamp outputs (10 lines) +ve logic: Alarm present Line AIS Frame Error rate 1 in 10^3, 1 in 10^4, 1 in 10^5. Multiframe Distant Distant Multiframe Frame structure monitor lamp (4 lines) +ve logic Ground.
AUXILIARY OUTPUTS	Auxiliary outputs (t.t.l.) on 7-way Painton socket: Data NRZ. Clock. TS(n) selected channel timing signal. Frame errors.
SAFETY	Designed to meet the requirements of IEC 348.
POWER REQUIREMENTS AC supply	95 to 130 V and 190 to 264 V. 45 to 65 Hz. 18 VA nominal.
DIMENSIONS AND WEIGHT	see below

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	
52829–900L	**Versions** PCM Digital Analyser TF 2829
	Supplied Accessories Accessory Pack 46883-367C, including Board Extractor and Fuse Links.
	Optional Accessories
54127–071H	Rack Mounting Kit.
54347–012A	Interconnecting Lead. For connection of a.c. supply between TF 2828 and TF 2829.
54511–012R	Extender Board.
46883–368R	50 way Plug Kit. Amp.
	Associated Equipment PCM Digital Simulator TF 2828 PCM Multiplex Tester TF 2807A

TV MEASURING EQUIPMENT

Colour Gain and Delay Test Set	TF 2904	194
Sine-Squared Pulse and Bar Generator	TF 2905/8	195
Grey Scale Generator	TF 2909	199
Non-Linear Distortion Analyser	TF 2910/4	203
Television Test Line Generator and Inserter	TF 2913	213
Insertion Signal Analyser	TF 2914A	217
Data Monitor	TF 2915	221
Data Selector	TK 2917	225

TF 2904 Colour Gain and Delay Test Set

- ☐ For all colour television systems
- ☐ Measures relative gain and delay between luminance and chrominance channels

13002/2

The Colour Gain and Delay Test Set is used for measurement of inequalities in gain and delay between the chrominance and luminance channels of colour television systems. It is based on an original design by the British Broadcasting Corporation.

The test set is used in conjunction with a sine-squared pulse and bar generator giving combined luminance and chrominance test waveforms, a suitable oscilloscope also being used as the indicator. The measurement is made by introducing a calibrated amount of gain or phase inequality in the opposite sense to that of the system under investigation, the test set being adjusted to produce a fully equalised display on the oscilloscope.

Gain inequality can be measured over the range ±3 dB, and delay inequality over the range 110 ns lag to 110 ns lead by operation of a push-button switch and a fine control. There is also a three position switch which enables the luminance or chrominance components to be displayed separately from the combined waveform.

TELEVISION SYSTEMS	625 line colour, NTSC or PAL with sub-carrier frequency of 4·43 MHz approximately.
GAIN MEASUREMENTS	
Range	−3 dB to + 3 dB continuously variable. Calibrated in 0·5 dB steps.
Accuracy	±0·1 dB w.r.t. centre zero.
DELAY MEASUREMENTS	
Range	110 ns lag to 110 ns lead by coarse and fine controls. *Coarse:* 100 ns lag to 100 ns lead in switched 20 ns steps. *Fine:* 10 ns lag to 10 ns lead continuously variable. Calibrated in 2 ns intervals.
Accuracy	±2 ns up to 10 ns. ±5 ns above 20 ns. Varies linearly from ±2 ns to ±5 ns over the range 10 ns to 20 ns.
COMBINED TEST SIGNAL REQUIREMENTS	
Luminance component	Sine-squared pulse and bar waveform at video frequency.
Chrominance component	Sub-carrier with 100% amplitude modulation by sine-squared pulse and bar waveform.
Amplitude	0·35 V peak-to-peak luminance. 0·7 V peak-to-peak chrominance. 0·7 V peak-to-peak combined luminance and chrominance. 0·3 V peak-to-peak sync (when provided). 1 V peak-to-peak complete waveform.
Sine-squared pulse	4Tc (20T) or 2Tc (10T) with half amplitude durations of 2 µs or 1 µs. When using 10T a small amount of ripple appears at the base of the pulse.
INSERTION LOSS	0 dB.
IMPEDANCE	
Input	75 Ω nominal, return loss better than 30 dB up to 6 MHz.
Output	75 Ω nominal, return loss better than 30 dB up to 6 MHz.
SAFETY	Designed to meet the requirements of IEC 348.
POWER REQUIREMENTS	
AC supply	95 to 130 V and 190 to 264 V. 45 to 65 Hz, 6 VA.

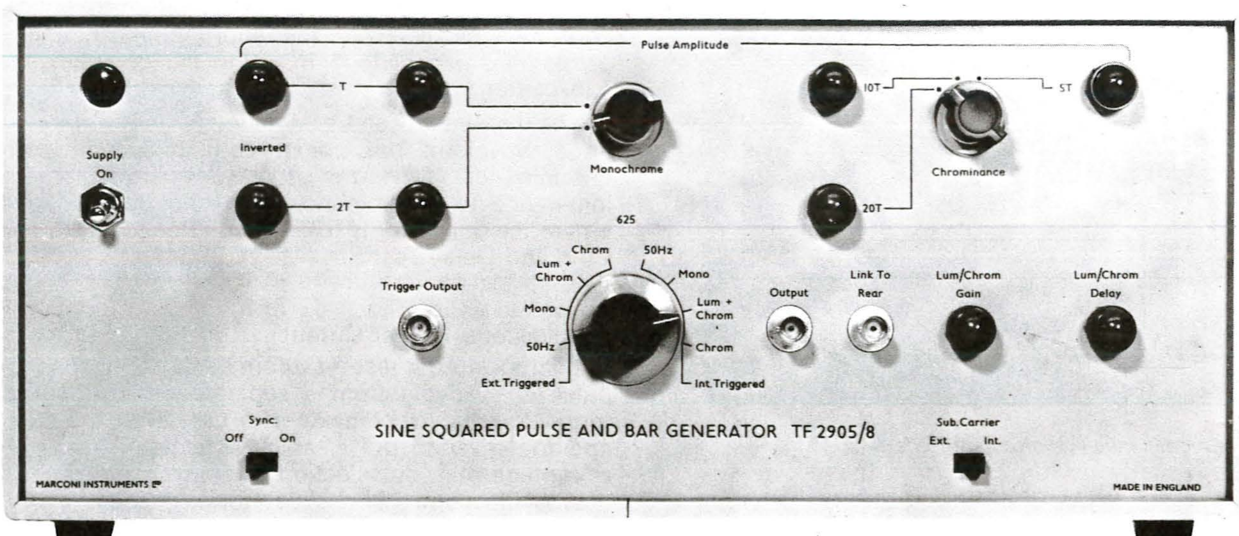
DIMENSIONS AND WEIGHT	Height	Width	Depth	Weight
	153 mm	470 mm	355 mm	6·8 kg
	6 in	18½ in	14 in	15 lb

VERSIONS AND ACCESSORIES
When ordering please quote eight-digit code numbers

Ordering numbers	
52904–900J	Versions Colour Gain and Delay Test Set TF 2904.
46883–031B	Optional Accessories Rack Mounting Kit TM 9743.

Sine-Squared Pulse & Bar Generator TF 2905/8

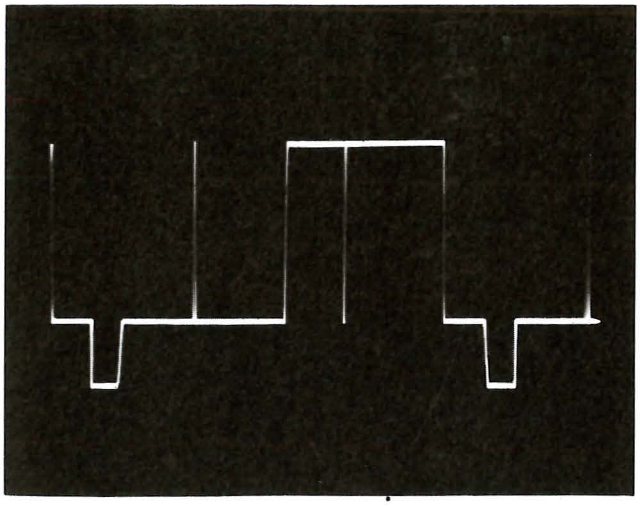
- ☐ Generates sin² pulse and bar waveforms for monochrome and colour
- ☐ Conforms with C.C.I.R. and British Post Office recommendations
- ☐ Triggered internally from crystal oscillator or externally from television studio equipment
- ☐ Suitable for 625 line systems



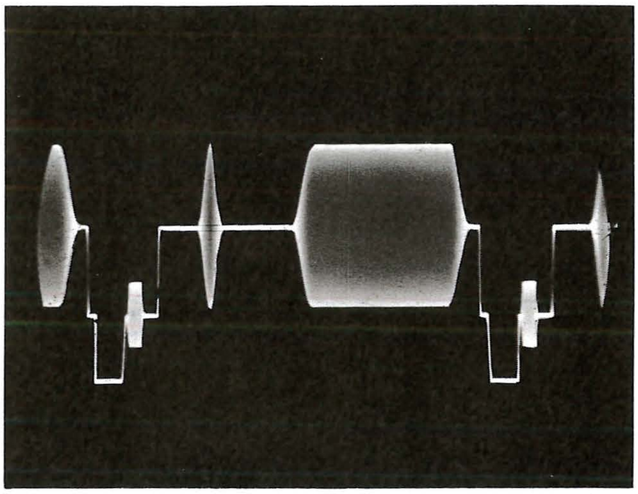
12535/1

This sine-squared pulse and bar generator provides four switch-selected test waveforms, which cover the requirements for accurate K factor measurement as recommended by the British Post Office.

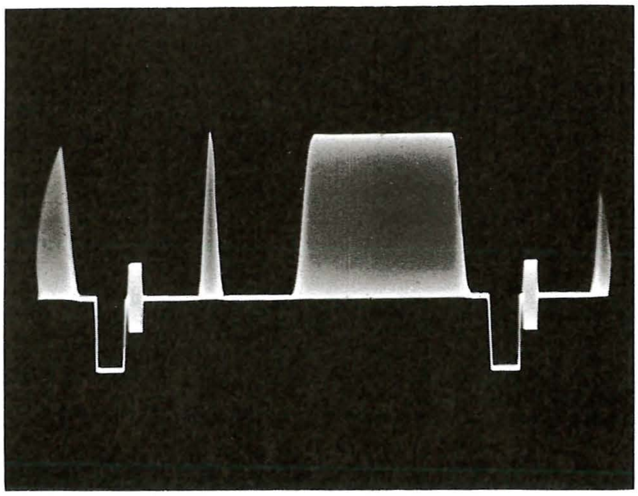
It is suitable for commissioning and maintenance tests on transmission systems in the absence of a picture signal or for generation of an insertion waveform for continuous monitoring.



625 line Monochrome Waveform



Chrominance Waveform on Pedestal, 625 line



Combined Luminance and Chrominance, 625 line

Test Waveforms

For low frequency response analysis the generator produces a square wave at the mains supply frequency. This is superimposed upon, but not synchronised with, a train of internally generated line sync pulses. When the instrument is used with external composite sync (see *Waveform Triggering*) the square wave is synchronised with the incoming sync pulses from the studio system. It can be made asynchronous by connecting an internal link.

For monochrome K factor assessment, a line waveform is available comprising a $\sin^2$ pulse (switchable T or 2T) and bar on sync pulses. This waveform includes a second, inverted, $\sin^2$ pulse during the bar period, used mainly for checking quadrature distortion on suppressed sideband systems. Provision is made for removing this inverted pulse by disconnection of an internal link.

Two test line waveforms are obtainable for measurements on colour transmission systems. Both of these are based on a chrominance $\sin^2$ pulse and bar sequence comprising a 10 cycle sub-carrier burst, with a sub-carrier modulated $\sin^2$ pulse and bar (switchable to 5T, 10T or 20T). The sub-carrier is normally derived from a crystal controlled oscillator at the appropriate frequency, but provision is also made for inserting an externally generated sub-carrier.

The instrument can be switched to deliver the chrominance waveform only or a combined luminance and chrominance waveform for such measurements as luminance to chrominance gain and delay inequalities, where the generator is used in conjunction with a Colour Gain and Delay Test Set (MI TF 2904).

Oscilloscope Trigger Output

In addition to the test waveforms, an oscilloscope trigger pulse is available from a separate outlet. Oscilloscope trigger pulses are coincident in time with the $\sin^2$ pulse and the inverted pulse, an arrangement which has the advantage that, by selection of appropriate sweep times, the oscilloscope can be set to display either a single coherent facsimile of the test waveform or a double overlapping facsimile in which any sag on the bar is easily measurable.

When the squarewave test waveform is used, the squarewave also appears at the trigger outlet.

Waveform Triggering

As an independent source for measurements on transmission links, etc., the generator delivers its line waveform at a stable repetition frequency derived from a crystal oscillator.

Provision is made, however, for external triggering; e.g., from line drive, from a field insertion unit, or from studio generated line pulses. Maximum flexibility is afforded by provision for either utilising the internally generated line sync pulses or injecting blanking and sync pulses from the studio equipment. The instrument contains a built-in mixer circuit for this purpose. Internally or externally generated sync pulses can be removed from the output waveform by operation of a front panel switch.

TELEVISION SYSTEMS	
TF 2905/8	625 line monochrome 625 line colour with sub-carrier frequency 4·43361875 MHz 50 fields/s.
MASTER OSCILLATORS	
Line repetition	15·625 kHz ±0·1% derived, via divider circuit, from 125 kHz crystal oscillator.
Sub-carrier	Crystal controlled at 4·43361875 MHz ±5 Hz at 20°C, ±100 Hz over range 2° to 40°C. Harmonic content less than −46 dB ref. amplitude of fundamental.
SINE-SQUARED PULSE	
T pulse, monochrome	100 ns ±2% h.a.d.
2T pulse, monochrome	200 ns ±2% h.a.d.
5T pulse, colour	500 ns ±2% h.a.d.
10T pulse, colour	1000 ns ±2% h.a.d.
20T pulse, colour	2000 ns ±2% h.a.d.
Amplitude	Adjustable from 0·65 to 0·75 V p-p. Normally set to give pulse/bar ratio of unity.
First overshoot	0·9% ±0·5% of pulse amplitude.
Second overshoot	0·4% ±0·25% of pulse amplitude.
BAR WAVEFORM	
Amplitude	Adjustable from 0·65 to 0·75 V p-p. Normally set to 0·7 V ±2%.
Duration	25 μs ±5% h.a.d.
Tilt	Less than 0·2% relative to amplitude at middle of bar, ignoring first and last 0·625 μs (T and 2T); 1·562 μs (5T); 3·125 μs (10T); 6·25 μs (20T).
Edge shape	Sine-squared (T or 2T monochrome, 5T, 10T or 20T colour) as for corresponding sine squared pulse.
Corners	Free of exponential distortion on all four corners.
Overshoot	Relative to amplitude at middle of bar and depending upon sine squared characteristics, 0·6% ±0·3% (T), not greater than 0·5% (2T, 5T, 10T, 20T). Measuring from half amplitude point of bar edge and depending upon sine squared characteristics, decays to at least 0·2% within 0·625 μs (T and 2T); 1·562 μs (5T); 3·125 μs (10T); 6·25 μs (20T).

LUMINANCE/ CHROMINANCE GAIN (Pulse and bar)	
Inequality	Adjustable from −0·5 dB to +0·5 dB. Normally set to zero.
Stability	Better than ±0·1 dB over range 2° to 40°C.
LUMINANCE/ CHROMINANCE DELAY (Pulse and bar)	
Inequality	Adjustable from −10 to +10 ns. Normally set to zero.
Stability	Better than ±3 ns over range 2° to 40°C.
COLOUR BURST	
Amplitude	Adjustable from 0 to 0·35 V p-p. Normally set to 0·3 V ±2%.
Duration	10 cycles ±1 cycle (2·2 ±0·2 μs).
Phase	Phase angle relative to pulse and bar is zero at all temperatures.
PEDESTAL	
Amplitude	Adjustable from 0·3 to 0·4 V p-p. Normally set to 0·35 V ±2%.
Duration	52 μs ±5%.
Edge shape	T or 2T sine squared shapes.
SET UP	
Amplitude	Adjustable from 0 to 0·1 V p-p. Normally set to 0.
Duration	52 μs ±5%.
Edge shape	T or 2T sine squared shapes.
SQUARE WAVE (asynchronous)	
Frequency	50 Hz.
Amplitude	Adjustable from 0·65 to 0·75 V p-p. Normally set to 0·7 V ±2%.
Duration	For each half cycle, 10 ms ±5% h.a.d.
Tilt	Less than ±0·25% of square wave amplitude (measured from mid points at white and black levels).
Black/white transition	Within duration of one line bar for black to white and vice versa.
Line bar edges	T or 2T sine squared shapes.
Discontinuities	At blanking level, no discontinuities visible with d.c. coupling to oscilloscope.
SYNC PULSE	
Amplitude	Adjustable from 0·25 to 0·35 V p-p. Normally set to 0·3 V p-p ±2%.
Duration	4·7 μs ±0·2 μs.
Edge shape	Approximately sine squared with rise and decay times 0·3 μs ±0·1 μs.

m

OUTPUT	
Amplitude	Complete waveform adjustable from 0·9 to 1·1 V p-p. Normally set to 1 V ±2%.
Impedance	75 Ω. Return loss greater than 30 dB between 50 Hz and 10 MHz.
Jitter	Not greater than 1 ns relative to trailing edge of sync pulse.
Random h.f. noise	Less than −50 dB (ref. 0·7 V) when bandwidth is restricted by low-pass filter (f_c=5·8 MHz).
Hum	Less than −50 dB (ref. 0·7 V).
Sub-carrier leak	Measured at blanking level, less than −46 dB (ref. 0·7 V) at 20°C. Less than −40 dB over range 2° to 40°C.
Residual disturbances	Less than 1% of picture signal amplitude.
TRIGGER OUTPUT	
Sine-squared pulse and bar	5 V p-p.
Squarewave	10 V p-p.
Impedance	3·5 kΩ nominal.
INPUT WAVEFORM REQUIREMENTS	
Burst gate	2 to 6 V p-p.
Sub-carrier	1 V p-p nominal. Frequency 4·43361875 MHz ±100 Hz.
Blanking	2 to 6 V p-p.
Sync pulses	2 to 6 V p-p.
Input impedance (all waveforms)	Internally or externally terminated, 75 Ω. Return loss, greater than 30 dB up to 5 MHz.
POWER REQUIREMENTS	
AC supply	95 to 130 V and 190 to 264 V, 45 to 65 Hz, 23 VA.

DIMENSIONS AND WEIGHT

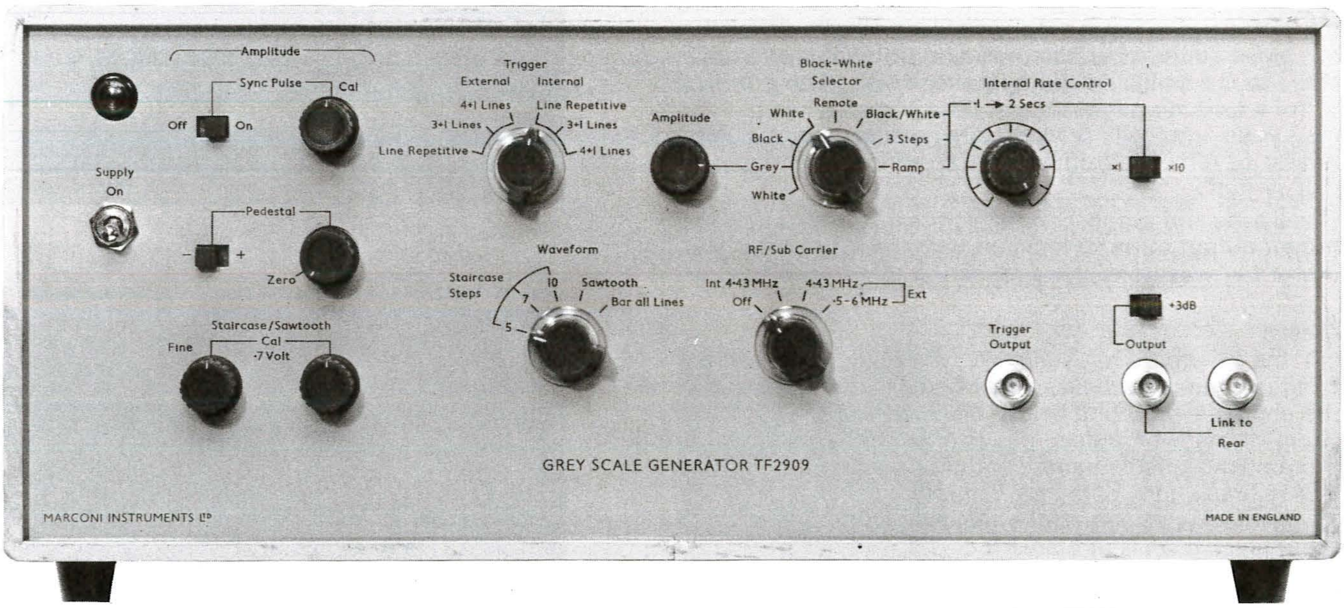
Height	Width	Depth	Weight
194 mm	470 mm	352 mm	10·6 kg
$7\frac{5}{8}$ in	$18\frac{1}{2}$ in	$13\frac{7}{8}$ in	23 lb

VERSIONS AND ACCESSORIES

When ordering please quote eight-digit code numbers

Ordering numbers	
52905-045A	**Versions** TF 2905/8. Standard version.
	Supplied Accessories Extender Board 44688-012H. For use when servicing printed boards. Coaxial Plugs, BNC, 46883-069U. Two supplied.
46883-072U 23443-398M	**Optional Accessories** Rack Mounting Kit TM 9712/3. Coaxial U-link. For transferring output to rear socket.

- ☐ Suitable for monochrome and colour television systems
- ☐ Conforms with C.C.I.R. and British Post Office recommendations
- ☐ Switch-selected grey scale waveforms and test-line sequence
- ☐ Excellent signal-to-noise ratio
- ☐ Highly accurate waveform parameters



12122

The Grey Scale Generator provides the necessary waveforms for linearity measurement on colour and monochrome television transmission systems.

TF 2909 may be regarded as complementary to the Sine-Squared-Pulse and Bar Generator TF 2905/8 (625-line) which produces the waveforms for measurement of frequency/response and frequency/phase characteristics over the video band. Together, the TF 2909 and TF 2905/8 can provide all the necessary waveforms for comprehensive video-to-video testing of any television transmission system.

Test Waveforms and Line Sequence

The generator delivers a series of test line waveforms, with or without sync pulses. Settings of two panel switches determine the type of waveform generated and the line sequence. A grey scale waveform may be selected in the form of a 5, 7 or 10 step staircase or a linear sawtooth conforming to C.C.I.R. recommendations; or, by setting the waveform-selector switch to a fifth position, the grey scale waveform can be removed altogether, a full-line bar then appearing on every line.

By operation of the line-sequence switch the instrument can be set to deliver the grey scale waveform on every line, every fourth line, or every fifth line. In these last two conditions each of the intermediate lines carries a full-line bar.

The amplitude of the grey scale waveform is continuously variable from 0 to 0·7 volts by means of coarse and fine panel control, the fully clockwise position of the coarse control being the calibrated 0·7 volt setting. The fine control gives ±2% variation, and is set to an indexed mid-range position for calibrated output.

Trigger and Sync

As an independent source for measurements on transmission links etc., the generator delivers its line waveforms at a stable repetition frequency, which is controlled by an internal crystal oscillator. When the instrument is operating in this internally triggered mode the timing of the test line waveform is also controlled by the crystal clock.

Provision is made, however, for triggering from externally generated line sync pulses or from the output of a field insertion unit. When the generator is used in this way, blanking and sync pulses are derived from the incoming signal, which also triggers the multivibrator controlling the line-waveform timing. The instrument can also be triggered from a line drive waveform; and, in this mode of operation, blanking and sync pulses are generated internally, timed by the multivibrator.

By operation of a panel control, the amplitude of the sync pulse (internal or external) is continuously variable from 0 to 0·4 volts. At the fully-clockwise setting of the control a switch operates to set the sync-pulse amplitude to 0·3 volts. Internally or externally generated sync pulses can also be removed from the waveform by operation of a slider switch.

In all sync and trigger conditions the instrument delivers a trigger output pulse, coincident with the start of the grey scale or bar waveform, for application to an oscilloscope.

Pedestal

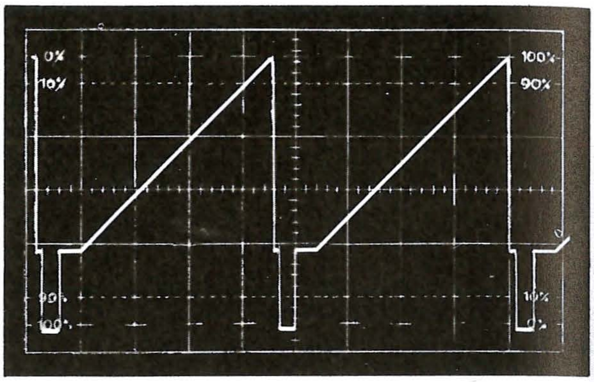
With the sawtooth or staircase, provision is made for inserting a pedestal, the level of which is adjustable to 0·6 volts above or 0·3 volts below blanking level; i.e., to the bottom of the sync pulse. This is effected by means of a continuously variable panel control in conjunction with a POLARITY switch. With the variable control at its fully counter-clockwise setting the pedestal amplitude is zero, so that black level is at blanking level.

The black level of the bar waveform is coincident with the blanking level on TF 2909, but on TF 2909/1 a fixed 50 mV set-up is used.

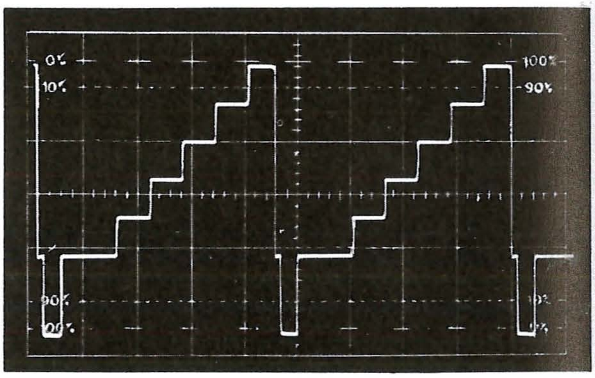
Average Picture Level

The bar amplitude may be set manually, or automatically by the use of internal electronic switching. Provision is also made for switching from white to black level by means of a remote contact closure.

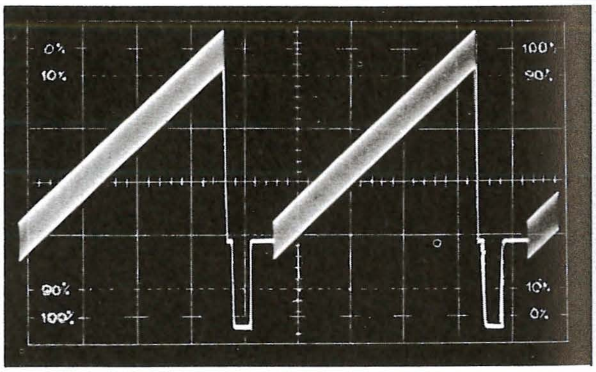
For manual switching a single movement of the BLACK/WHITE SELECTOR can effect the transition between black and white, black and grey, or grey and white, the grey level being continuously variable from black to 95% peak white by means of an AMPLITUDE control. In the automatic switching mode, the instrument can be set to select black level and white level alternately at switching intervals variable from 0·1 to 20 seconds. The bar can also be brought from black to white level and back to black in three equal-amplitude steps at the same switching rate; or it can be made to change progressively between the extremes in the form of positive and negative ramps.



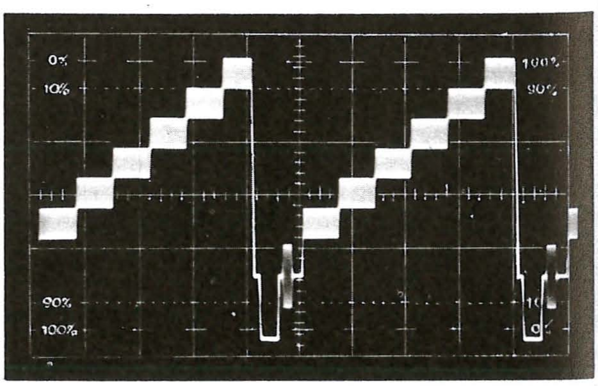
Sawtooth on sync pulses



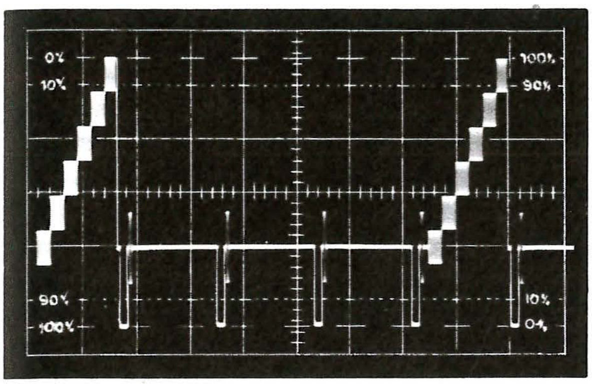
Five-step staircase on sync pulses



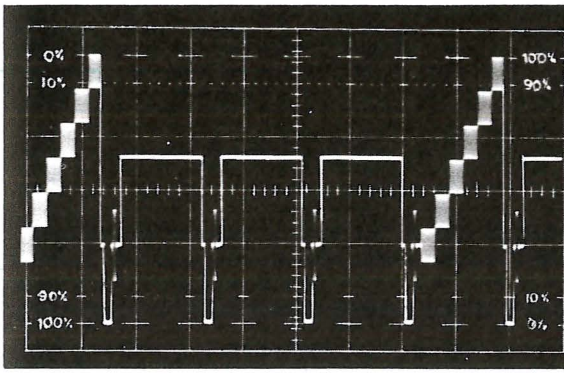
Sawtooth with 1 MHz sinewave for differential gain measurement



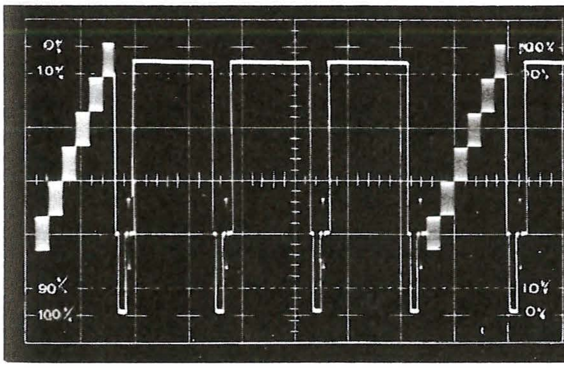
Staircase with colour sub-carrier on positive pedestal



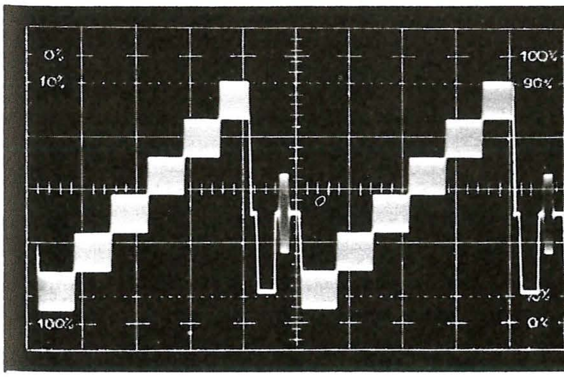
3 + 1 lines
Staircase with black-level bars



3 + 1 lines
Staircase with grey-level bars



3 + 1 lines
Staircase with white-level bars



Staircase with colour sub-carrier on negative pedestal

Sub-Carrier

For differential phase and gain measurements on colour television systems a sub-carrier sinewave can be superimposed on the staircase, sawtooth, or bar, with a 10 cycle sub-carrier reference burst at the start of each line. This sub-carrier may be derived from an internal crystal oscillator (at 4·434 MHz for the TF 2909 or 3·58 MHz for the TF 2909/1) or from an external source. With externally generated sub-carrier the output level remains within the limits shown in the specification over a range of input levels from 0·75 to 2·2 volts p-p.

For differential gain measurements over the video band an externally generated sinewave at any frequency between 0·5 and 6 MHz can be superimposed on the video test waveform only i.e., with no reference burst.

As an optional facility, the timing of the staircase waveform may be modified so that the top step extends beyond the sinewave to give a white-level reference. If this facility is required it must be requested at the time of ordering.

Input and Output Arrangements

The test signal is drawn from a coaxial socket on the front panel, with provision for linking to a socket at the rear when this is more convenient; e.g., in rack-mounted assemblies. The output is normally fed to this socket via a 3 dB attenuator pad, which can be switched out of circuit to give a calibrated 3 dB increase in output level.

The oscilloscope trigger output is also drawn from a front panel socket. All externally generated waveforms are fed into the instrument via BNC sockets at the rear. In every case provision is made for switching an internal 75 Ω termination into circuit or for looping through to external 75 Ω equipment via an adjacent BNC socket.

STAIRCASE	
Number of steps	5, 7, or 10; switch selected.
Duration	TF 2909: 52 μs ±5% TF 2909/1: 52·5 μs ±5%.
Amplitude	Adjustable at front panel, 0 to 0·7 V p-p. When controls are set to CAL mark, staircase amplitude is 0·7 V p-p ±2%.
Line time non-linearity	Not greater than 0·1% with zero pedestal. Not greater than 0·5% with pedestal.
Tilt on steps	Not greater than 2% of amplitude of one step.
SAWTOOTH	
Duration	TF 2909: 52 μs ±5% TF 2909/1: 52·5 μs ±5%.
Amplitude	Adjustable at front panel 0 to 0·7 V p-p. When controls are set to CAL mark sawtooth amplitude is 0·7 V p-p ±2%.
BAR	
Duration	TF 2909: 52 μs ±5% TF 2909/1: 52·5 μs ±5%.
Amplitude	At white level: 0·7 V p-p ±2%.
Tilt	Not greater than 1% of 0·7 V at white level, and not greater than 0·5% of 0·7 V at blanking level, measured from centre of bar, ignoring first and last μs.
Grey control	Bar amplitude manually adjustable between black and at least 95% of white level.

TF 2909 series

AUTOMATIC SWITCHING OF BAR AMPLITUDE	
Switching rate	Adjustable between 0·1 and 20 s.
Black/White	Total change between black and white levels.
3 step function	Amplitude changes between black and white levels in adjustable, predetermined, amounts. Normally set for equidistant amounts.
Ramp	Gradual change between black and white levels at rate depending on switching rate.
Long term step response	When bar is switched between black and white levels: (a) sync pulse amplitude does not vary by more than 1%. (b) signal bounce is negligible, (c) d.c. shift is less than 2% of 1 V, (d) amplitude and tilt of bar remains within specification.
SYNC PULSE	
Repetition frequency	TF 2909: 15·625 kHz TF 2909/1: 15·75 kHz. Derived from crystal oscillator via 8:1 divider circuit: accuracy ±0·1%.
Amplitude	Continuously variable 0 to 0·4 V p-p. When control is set to CAL mark cyns pulse amplitude is:- TF 2909: 0·3 V } ±2% TF 2909/1: 0·25 V } ±2%
Duration	TF 2909: 4·7 µs ±0·2 µs. TF 2909/1: 4·75 µs ±0·2 µs.
Shape of edges	Approximately $\sin^2$ with rise and fall times 0·3 µs ±0·1 µs.
PEDESTAL	
Amplitude (with staircase or sawtooth)	Continuously adjustable 0 to +0·6 V and 0 to −0·3 V p-p relative to blanking level.
Amplitude (with bar waveform)	Adjustable between 0 and 0·1 V w.r.t. blanking level. TF 2909: Normally set to 0. TF 2909/1: Normally set to 50 mV ±5%.
SUB-CARRIER	
Frequency	TF 2909: 4·433620 MHz TF 2909/1: 3·579545 MHz. *Accuracy* ±100 Hz.
Harmonic content	Less than −40 dB with respect to 0·7 V p-p.
Amplitude on staircase sawtooth and bar	Adjustable between 0·08 and 0·3 V p-p. Set to 0·14 V p-p ±14 mV.
Colour burst amplitude	Set to 0·3 V p-p ±14 mV.
Colour burst duration	TF 2909: 10 cycles } ±1 cycle of sub-carrier. TF 2909/1: 9 cycles } ±1 cycle of sub-carrier.
Phase	The phase angle of the colour burst relative to the subcarrier at blanking level is nominally zero.
MAIN OUTPUT CIRCUIT	
Impedance	75 Ω.
Return loss	Greater than 30 dB when measured using the following signals: (a) 625/525 line mono T pulse and bar waveform. (b) 625/525 line composite luminance + chrominance 10T pulse and bar waveform.
3 dB attenuator	*Level Change:* 3 dB ±0·1 dB.
Differential gain	Not greater than 0·1%.
Differential phase	Not greater than 0·1°.
SIGNAL PURITY	
Hum	Not greater than −50 dB with respect to 0·7 V.
Residual sub-carrier	Less than −46 dB with respect to 0·7 V p-p picture signal.
Random h.f. noise	Peak to peak noise voltage not greater than −50 dB with respect to 0·7 V on any of the output waveforms when bandwidth is restricted by a low-pass filter having cut-off frequency of 5·8 MHz.
Residual disturbance	Not greater than 1% white level.
TRIGGER OUTPUT	
Amplitude	5 V p-p into high impedance.
Source impedence	1 kΩ nominal.
SUB-CARRIER OUTPUT	
Amplitude	1 V p-p nominal.
Source impedence	75 Ω nominal
REMOTE CONTROL SOCKET	Short circuit switches bar from white to black level.
BURST GATE INPUT	
Input requirement	2 to 6 V p-p. nominal.
Input impedance	*Terminated:* 75 Ω. *Unterminated:* greater than 35 kΩ.
Return loss	Greater than 30 dB up to 5 MHz with internal termination or looped through into 75 Ω ±1% load.
SYNC PULSE INPUT	
Input requirement	2 to 6 V p-p. nominal.
Input impedance	*Terminated:* 75 Ω. *Unterminated:* greater than 35 kΩ.
Return loss	Greater than 30 dB up to 5 MHz with internal termination or looped through into 75 Ω ±1% load.
BLANKING PULSE INPUT	
Input requirement	2 to 4 V p-p. nominal.
Input impedance	*Terminated:* 75 Ω. *Unterminated:* graeter than 35 kΩ.
Return loss	Greater than 30 dB up to 5 MHz with internal termination or looped through into 75 Ω ±1% load.
RF/SUB-CARRIER INPUT	
Input requirement	*Sub-carrier:* 0·75 to 2 V p-p nominal at appropriate frequency. RF: 1 V p-p nominal for 140 mV superimposed upon output.
Input frequency	0·5 to 6·0 MHz.
Input impedance	*Terminated:* 75 Ω. *Unterminated:* Greater than 35 kΩ.
Return loss	Greater than 30 dB up to 6 MHz with internal termination or looped through into 75 Ω ±1% load.
SAFETY	Designed to meet the requirements of IEC 348.
POWER REQUIREMENTS	
AC supply	95 to 130 V or 190 to 264 V. 45 to 65 Hz.

DIMENSIONS AND WEIGHT

Height	Width	Depth	Weight
178 mm	430 mm	310 mm	8·0 kg
7 in	17in	12¼ in	1lb 7½

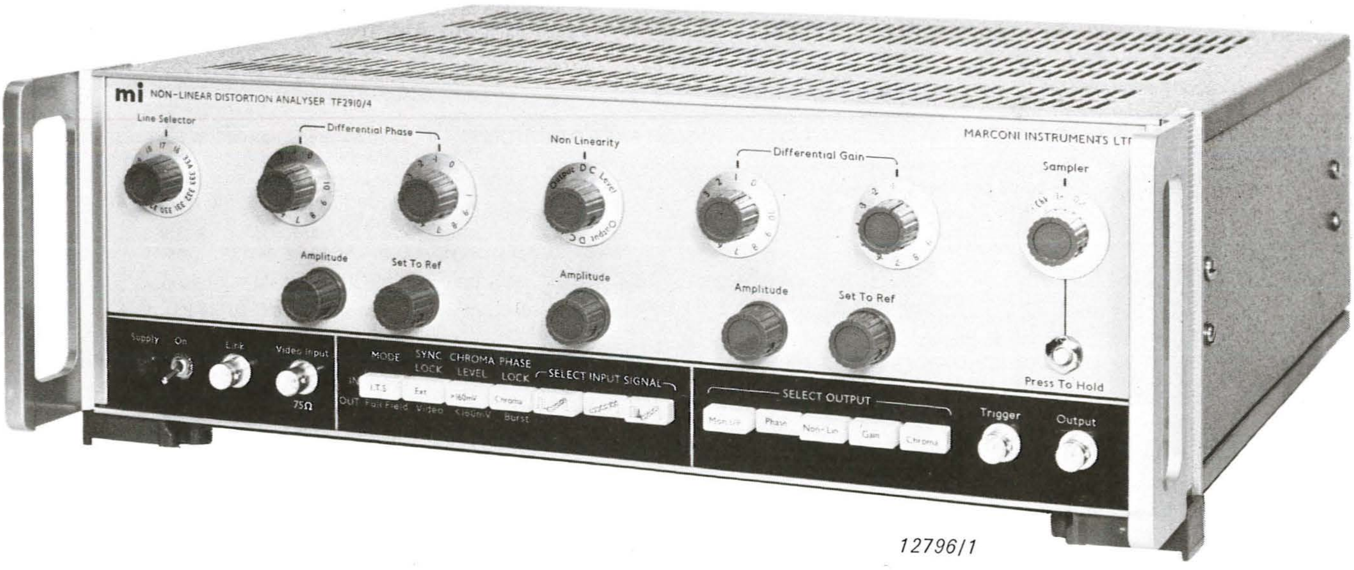
VERSIONS AND ACCESSORIES

When ordering please quote eight-digit code numbers

Ordering numbers	
	Versions
52909–015C	Grey Scale Generator TF 2909, 625 line version. The following versions may be available to special order.
52909–901W	Grey Scale Generator TF 2909/1, 525 line version.
52909–302E	Grey Scale Generator TF 2909 with SECAM frequency crystal.
	Supplied Accessories Mains Lead TM 7052. Extender Board TM 8658 (44688–012H).
	Optional Accessories
46883–072U	Rack Mounting Kit TM 9712/3.
23443–398M	Coaxial U Link, for rack mounted version only.

Non-Linear Distortion Analyser TF 2910/4

- Differential Gain
- Differential Phase
- Luminance non-linearity
- Built-in sampler with line repetitive read out
- Line selection for ITS measurements
- Simultaneous analysis of all three parameters
- Operates in the presence of sound in sync



TF 2910/4 is a test set designed for the measurement of non-linear distortion using a test signal consisting of a video line waveform 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 detector. This detector is also fed from a local oscillator locked to either the reference colour burst or to the initial chrominance on the waveform. The output of the phase detector 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 reference control enables any part of the measurement waveform to be set against the calibration pulse base line when viewed on an oscilloscope. Measurements of differential phase can be made up to 11° in 0·1° steps using the calibrated pulse.

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 reference 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 extrapolation of the calibration pulse, measurements can be taken up to 15% differential gain and 35° differential phase.

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.

Outputs

All of the measurement waveforms or the test signal, as selected by push button switches, are fed to the front panel output socket. In addition the measurement waveforms are fed independently to sockets on the rear panel to allow simultaneous monitoring of all three parameters.

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	E.B.U. test line signal C, British National test line signal A 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 75Ω.
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 differential gain 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.
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	Positive 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 REGULATIONS	Complies with IEC 348 and BS 4743 safety requirements.
DIMENSIONS AND WEIGHT	Height 133 mm $5\frac{1}{4}$ in; Width 425 mm $16\frac{3}{4}$ in; Depth 380 mm 15 in; Weight 9·8 kg $21\frac{1}{2}$ lb

VERSIONS AND ACCESSORIES

When ordering please quote eight-digit code numbers

Ordering numbers	
52910–904C	Versions TF 2910/4.
	Supplied Accessories Extender Board 44836–106F. Board Extractor 41700–048A. Rack Mounting Kit 46883–175Y.
23443–398M 54127–191D	Optional Accessories "U" Link 75 Ω. Rack Slide Kit.

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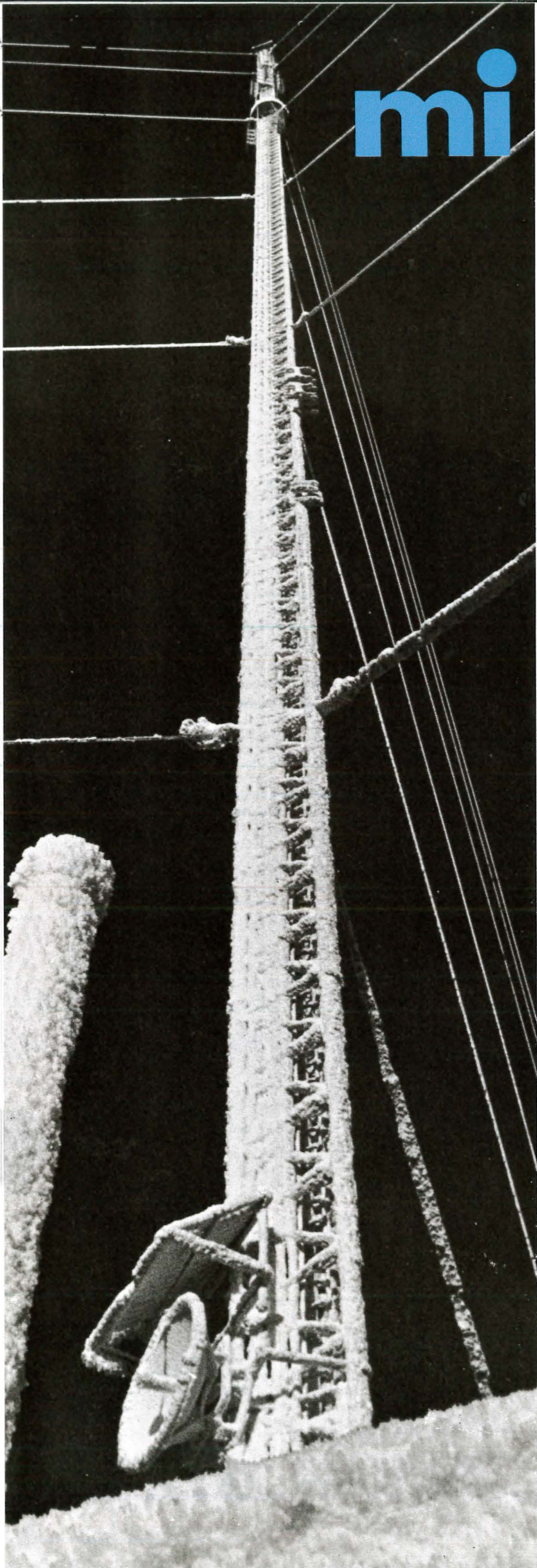
mi brings objectivity



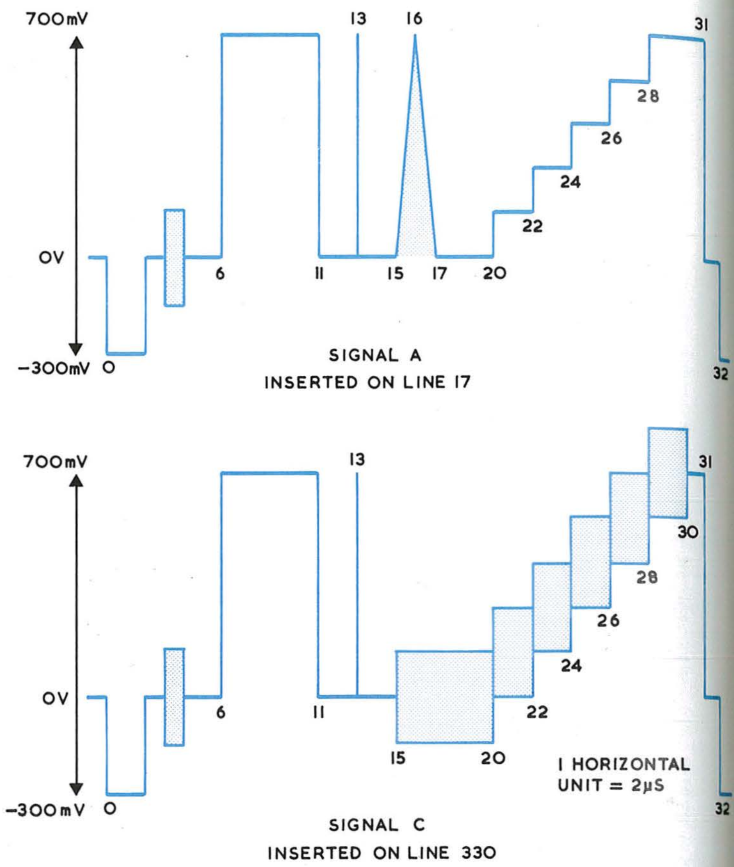


Figure 1. International Insertion Test Signals

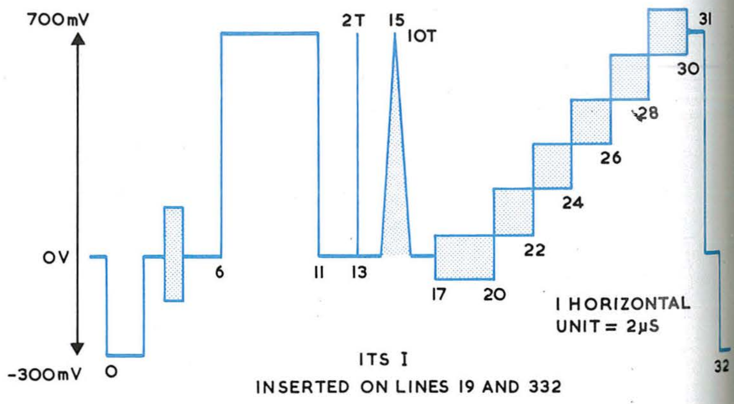


Figure 2. British National Insertion Test Signals

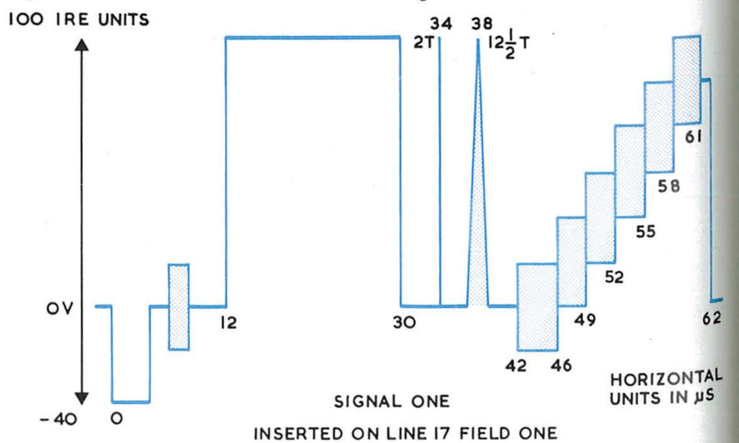
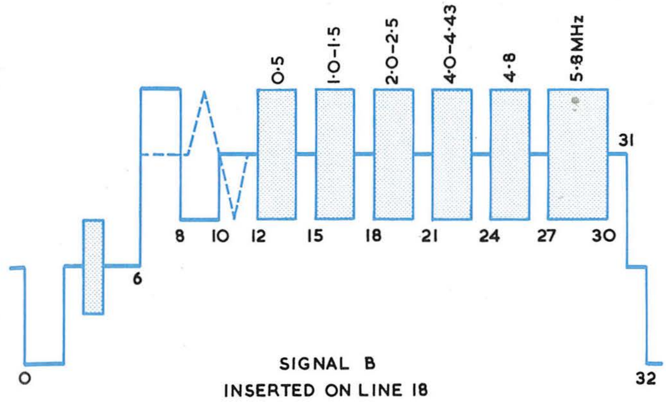
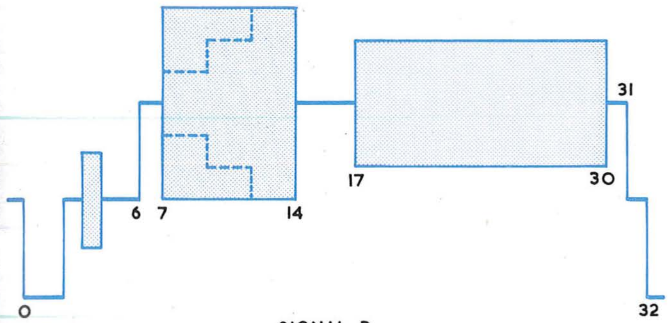


Figure 3. NTC Insertion Test Signals

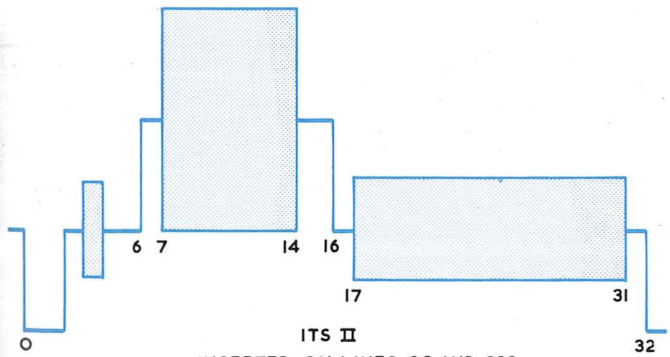
to TV measurements



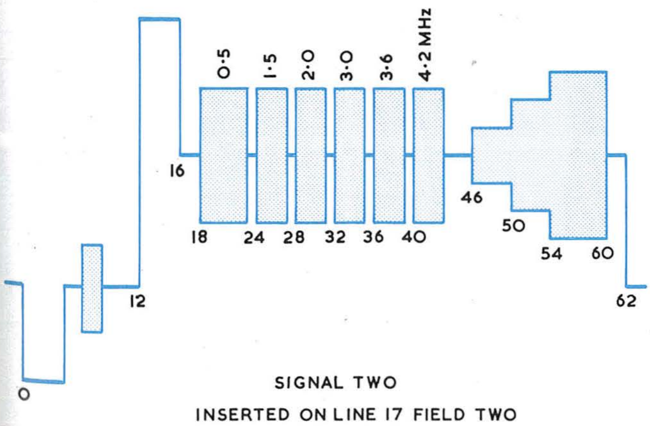
SIGNAL B
INSERTED ON LINE 18



SIGNAL D
INSERTED ON LINE 331



ITS II
INSERTED ON LINES 20 AND 333



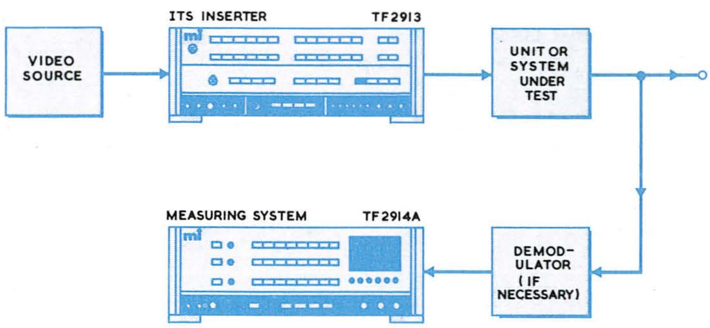
SIGNAL TWO
INSERTED ON LINE 17 FIELD TWO

The traditional method of testing a video unit or system has been to apply a line repetitive signal and to analyse the system output on an oscilloscope. Fair accuracy can be achieved using modern measurement oscilloscopes but the results are nonetheless subjective, being dependent upon the interpretation of the test engineer. Such methods are time consuming and can only be carried out when the system is not in use. With transmission time getting longer, the time available for maintenance testing is becoming more and more restricted: often to the 'unsociable' hours during the night.

The problem of testing during programme time is being overcome by the international use of ITS — Insertion Test Signals — inserted in the field blanking interval. But what of the other problem — that of traditional analysis techniques relying upon the skill of test engineers, which takes up so much precious time?

Marconi Instruments has provided the answer with Insertion Signal Analyser TF 2914A. This one instrument will select the appropriate line, make any one of 20 or more measurements and display the answer on its digital readout. The measurement to be made is selected by a push button to give fast, accurate and unambiguous results without wasting the engineers valuable time.

Figure 4. Video transmission system with the Marconi Instruments measuring system



Insertion test signals

Marconi Instruments Test Line Generator and Inserter TF 2913 and Insertion Signal Analyser TF 2914A are available to meet most national and international standards.

The international ITS (shown in figure 1), which are to CCIR recommendations and inserted on lines 17, 18, 330 and 331, are used when a programme is being transmitted across international boundaries. This helps maintain uniformity of quality from country to country.

Within national boundaries the ITS used are determined by the nation concerned. Two examples, illustrated in Figs. 2 and 3 respectively, are the UK national signals inserted on lines 19, 20, 332 and 333, and NTC signals used in the USA which are inserted on line 17 in field one and line 17 in field two.

Wherever there is a composite video signal the **mi** Test Line Generator and Inserter TF 2913 can be used to provide the ITS, while Insertion Signal Analyser TF 2914A provides the results. Fig. 4 shows where these two instruments fit into a video network for continuous monitoring.

Insertion Signal Analyser TF 2914A introduces a new concept to television testing — objectivity: the instrument provides digitally displayed results from over 20 measurements made on insertion test signals. The Analyser is available in several versions for monitoring different ITS including CCIR, NTC7, CBC and UK National.

The instrument is equipped with five video inputs either terminated in 75 Ω or used in feed-through mode. Selection of the appropriate video input and parameter to be measured is by front panel push buttons giving an instantaneous readout of the result.

High accuracy, simplicity, clarity and repeatability are major features of the Insertion Signal Analyser TF 2914A. Gone are the days when a skilled operator had to spend hours of his valuable time in front of an oscilloscope to obtain accurate results. The same accuracy can be achieved in minutes using the **mi** Insertion Signal Analyser. A unique electronically generated graticule in TF 2914A, allows 2T 'K' factors up to 10% to be measured over the range −8T to +12T.

In addition to the five video inputs, there are three auxilliary inputs which accept d.c. signals, from external devices, and display the results digitally along with the other parameters. The auxilliary inputs can be used to monitor parameters, both related and unrelated to the system under test. Examples include forward and reflected power to an aerial, mast lights, intruder alarms and fire alarms.

The Insertion Signal Analyser can be provided with facilities to allow remote control if it is required and this is described in a later section.

The instrument finds applications wherever there are video signals: studio outputs, control centres, video transmission systems and transmitters; for maintenance, commissioning, design, quality control and continuous monitoring. TF 2914A represents a tremendous time-saver in any of these areas with the added advantage of providing continuous monitoring facilities for use during programme time.

Insertion signal analyser measurements

1. Luminance bar amplitude
The difference in amplitude between the mid point of the luminance bar and 700 mV. The measured difference is displayed as a percentage of 700 mV.

2. Sync amplitude
The difference in amplitude between the peak amplitude of sync and 300 mV. The measured difference is displayed as a percentage of 300 mV. The amplitude is measured 6 μs after the start of the first field sync pulse.

3. 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. The measurement is displayed as a percentage of the luminance bar amplitude.

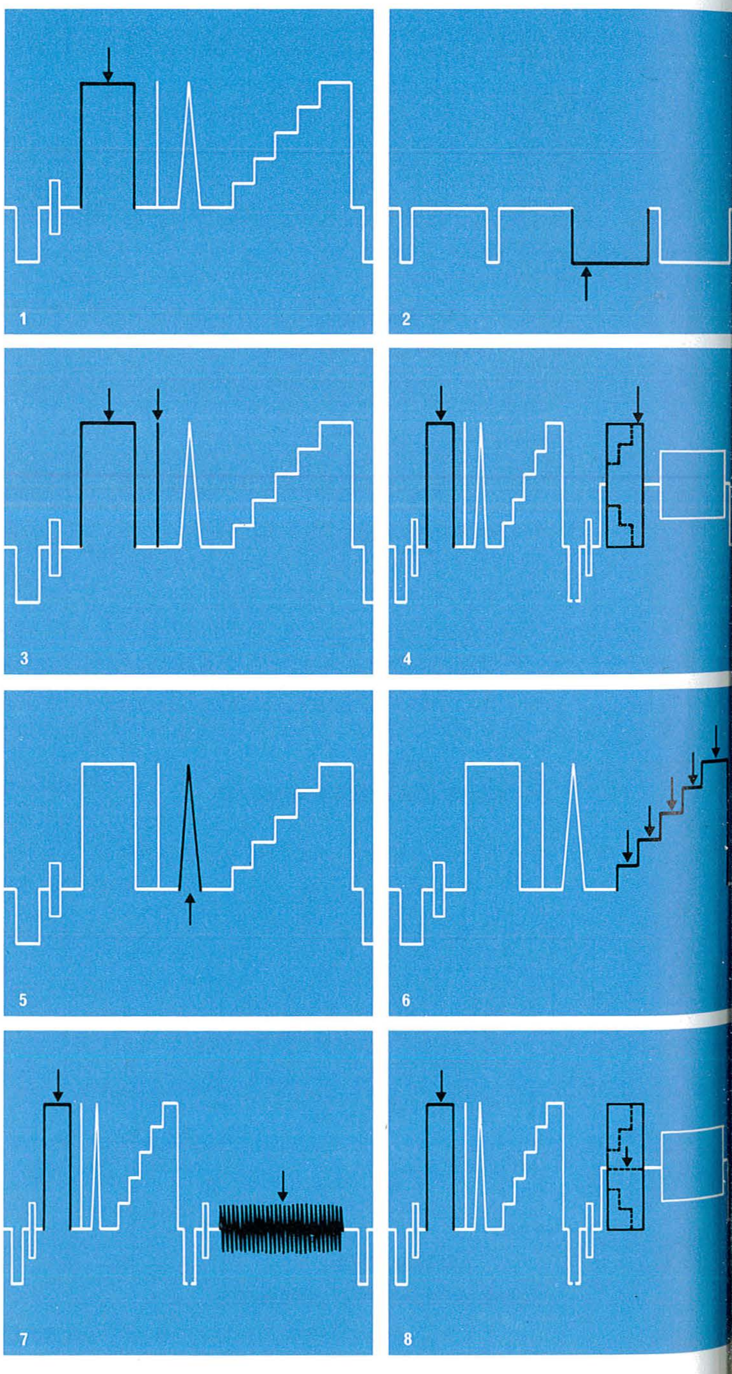
4. Chrominance to luminance gain inequality
The difference in amplitude between the peak of the chrominance bar and the mid-point of the luminance bar. The measured difference is displayed as a percentage of the luminance bar amplitude.

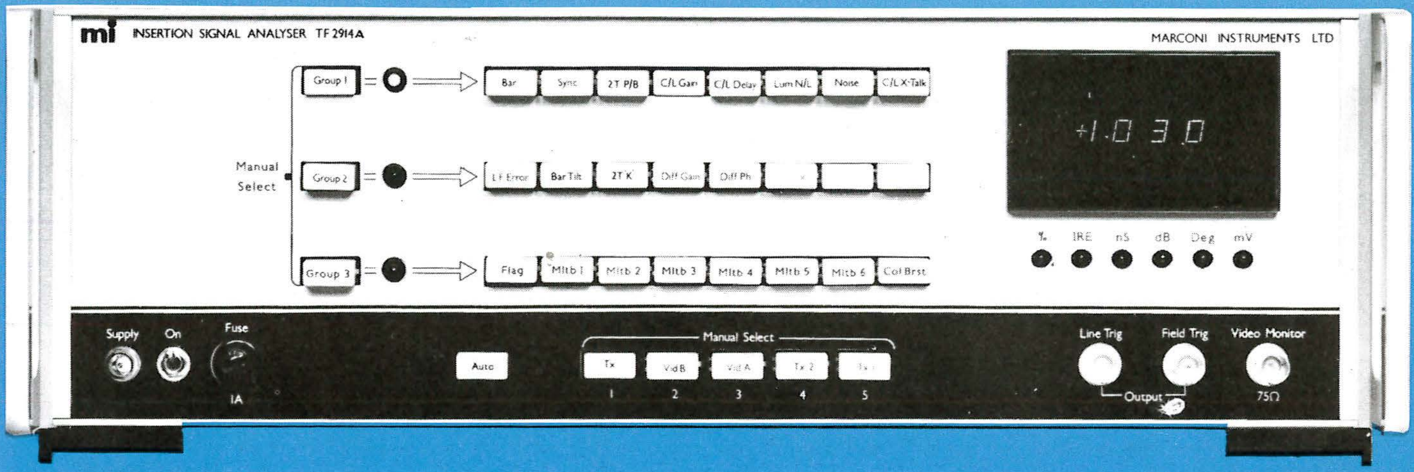
5. Chrominance to luminance delay
The time difference between the chrominance and luminance components of the composite sine squared pulse. A positive reading indicates chrominance components delayed relative to the luminance.

6. Luminance non-linearity
Measured as the difference between the largest and smallest step amplitudes of the luminance staircase. It is displayed as a percentage of the largest step.

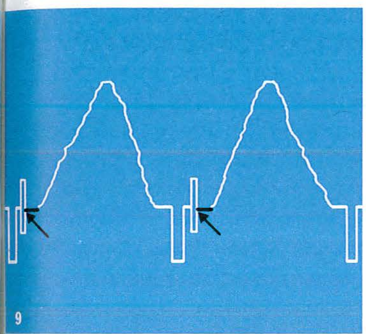
7. Noise
The true r.m.s. noise level is expressed in dB's relative to the amplitude of the mid-point of the luminance bar. The measurement may be weighted or unweighted.

8. Chrominance to luminance crosstalk (intermodulation)
Measured as the change in amplitude of the luminance pedestal during the chrominance bar. The measurement is displayed as a percentage of the mid-point of the luminance bar.





For simplicity, only 625 line measurements (TF 2914A-600 series) are illustrated.
525 line measurements (TF 2914A-500 series) differ in details of timing, frequencies and nomenclature.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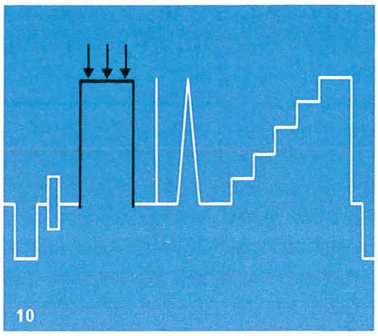
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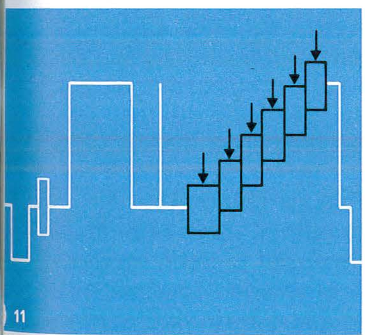
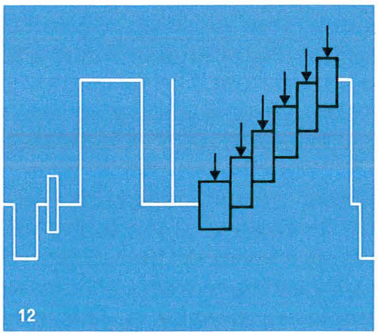
9. Low frequency error
The weighted measurement of the peak to peak amplitude of bar frequency signals superimposed on the full field signal. Weighting network approximately—6 dB at 50 Hz and 550 Hz relative to 300 Hz.

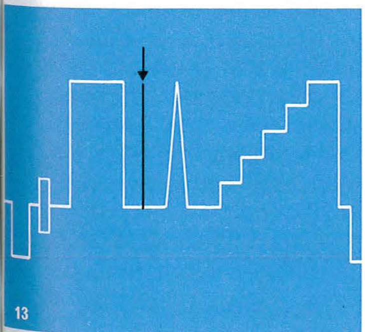
10. Bar tilt
The difference in amplitude of the luminance bar at two points approximately 1·0 microseconds and 9·0 microseconds after the leading edge of the bar. The measurement is displayed as a percentage of the bar amplitude.

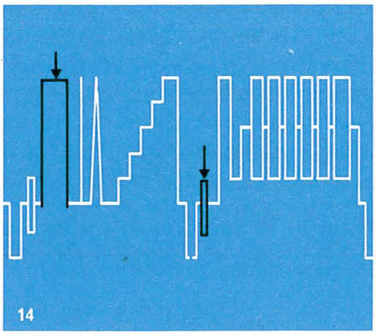

11


12

11. Differential gain
The modulus of maximum amplitude deviation of the sub-carrier superimposed on the luminance staircase. It is expressed as a percentage of the sub-carrier amplitude at black level.

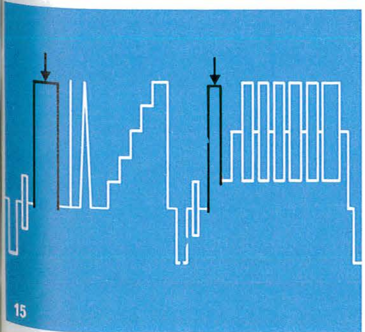
12. Differential phase
The modulus of maximum phase deviation of the sub-carrier superimposed on the luminance staircase. It is expressed relative to the sub-carrier phase at black level.

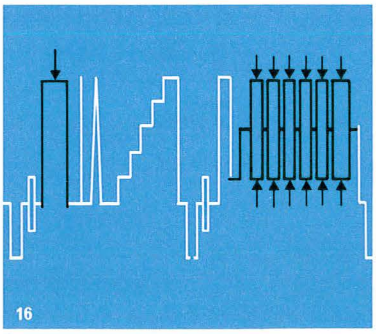

13


14

13. 2T K-factor
A time weighted measurement of pre-pulse and post pulse ringing against an electronically generated graticule. The result is displayed in percentage K.

14. Colour burst amplitude
The amplitude of the colour burst is measured relative to the amplitude of the luminance bar. The result is expressed as a percentage related to the luminance bar.

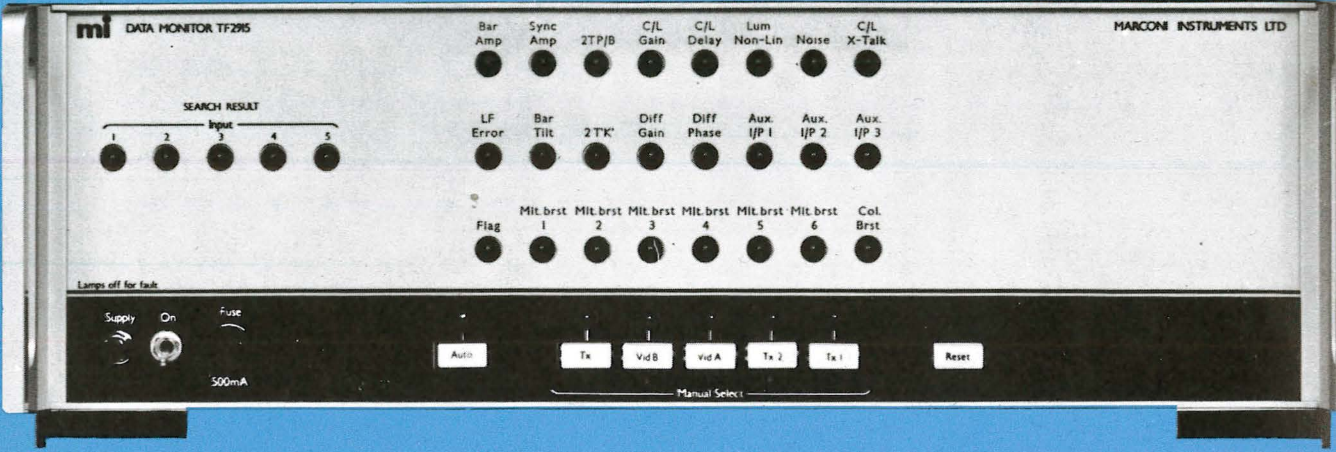

15


16

15. Flag amplitude
Measured as the peak amplitude of the flag. The result is expressed as a percentage related to the bar amplitude.

16. Multiburst
The gain/frequency response is measured by measuring the peak to peak amplitude of the signal bursts relative to the luminance bar. The result is expressed as a percentage related to the luminance bar.

m

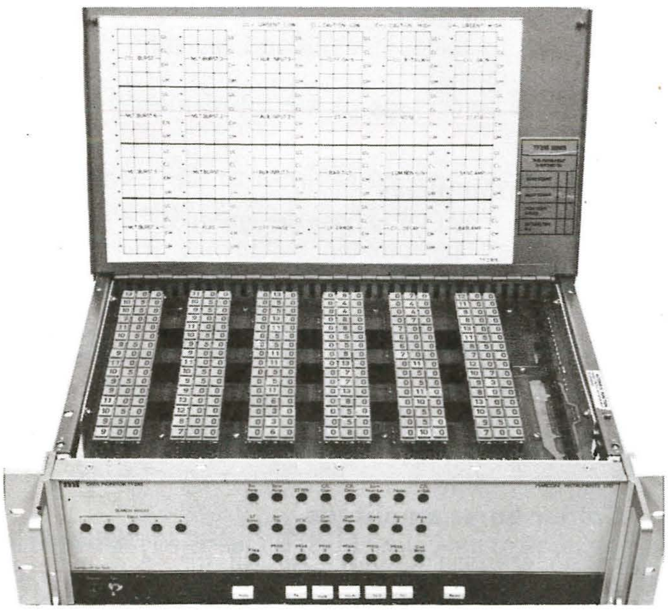


Automating TV measurements

With the addition of the **Data Monitor TF 2915,** the use of the Insertion Signal Analyser TF 2914A can be extended to provide limits comparison, automatic parameter scanning and an executive control capability.

The heart of this instrument is a bank of preset limits (shown in figure 5) against which parameter values, measured by the Insertion Signal Analyser can be compared. There are two sets of upper and lower limits for each parameter — 'caution' and 'urgent' — and these allow the instrument to be employed in a number of different ways.

Figure 5. Preset limits in Data Monitor, TF 2915



The Data Monitor can be switched either to instruct the analyser to monitor oneof the five video inputs continuously until a fault condition occurs, or to cycle around all five inputs sequentially, comparing each with its preset limits.

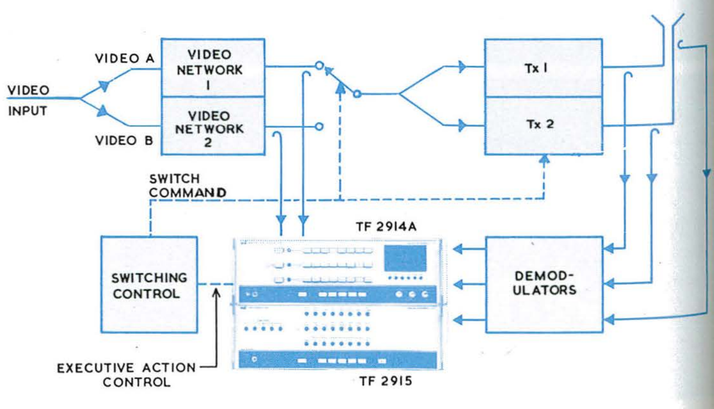
The first mode is mainly for applications at transmitter sites, although its use is by no means limited to this situation. Its operation is illustrated, by way of example, in Figure 6. The five inputs to the Analyser are the main and standby video feeds, the two individual transmitter outputs and the combined output. Data Monitor TF 2915 holds the analyser continuously monitoring the combined output until a parameter exceeds either its 'urgent' or 'caution' limits, the latter being used to sound an audio alarm but not precipitate any further action. When the 'urgent' limits are exceeded, the Data Monitor scans the parameters several more times and decides by counting the number of times a fault is detected, whether the fault is genuine or a transient. If the fault is genuine the Data Monitor enters this information into its store and switches the Analyser to monitor each of the video feeds in turn. In this case it is the more stringent 'caution' limits that are used for comparison. The Data Monitor determines whether or not each video feed is faulty and enters the results into the store.

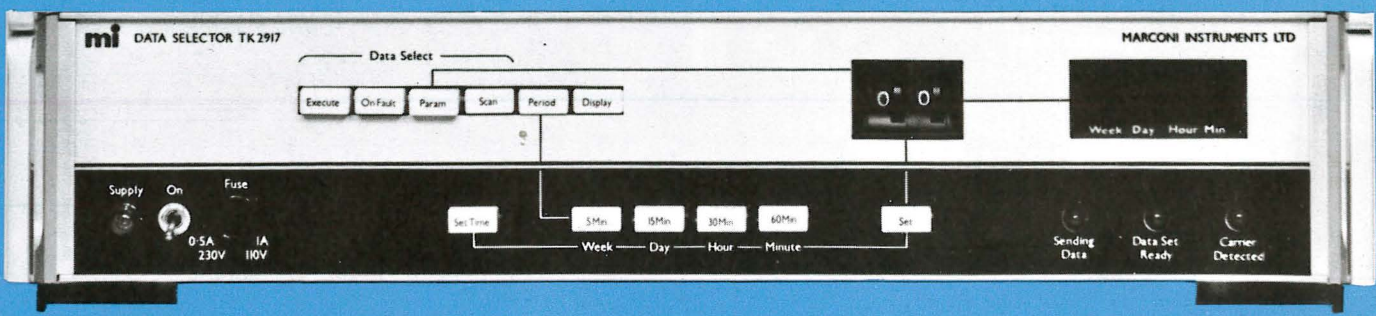
The instrument will then cause the Analyser to monitor each of the individual transmitter outputs in turn, comparing each with the urgent limits and enters the results into the store as before. The contents of the store are used as the basis for initiating executive action.

For example, if the main video feed is faulty, TF 2915 will cause the network to switch to the reserve feed or if one of the transmitters is faulty it will be switched off.

In the second 'continuous scanning' mode, the Data Monitor switches the Analyser from input to input sequentially and the two sets of limits now provide an operator with two levels of warning. This mode is used in studios, control rooms and switching centres where there are several video feeds to be monitored simultaneously. Each parameter of each input is measured up to 30 times and is considered faulty if it exceeds its preset limits a given number of times. This fault/scan ratio is set during manufacture but, together with the selection of those limits which are to be used for initiating executive action, they can be modified as required.

Figure 6. TF 2915 and TF 2914A used to monitor the inputs and outputs of a parallel transmitter network





Data Selector TK 2917 is used with Insertion Signal Analyser TF 2914A alone, or with the Insertion Signal Analyser and Data Monitor TF 2915, to provide a data interface between the measuring instrument and a digital data acquisition terminal which provides remote data logging and system interrogation.

The Data Selector can be supplied with data output in the ASCII serial format or parallel b.c.d. The parallel b.c.d. output version is primarily for use where the recorder need not be remote from the Data Selector so that cost advantages can be gained through the use of an inexpensive, b.c.d printer. Since telemetry systems necessary to carry b.c.d. information over long distances are expensive, remote applications are usually better served using the ASCII code. Use can be made of existing telephone links for data transmission, provided that suitable MODEMS are available.

A further advantage of the use of ASCII is that alpha-numeric printers can be used so that the full details of the measurements made may be recorded, as shown in the comparison in figure 7.

Each Data Selector has its own identity and a built-in digital clock. When information is requested, whether via the front panel or from a remote data terminal, the Data Selector transmits its identity number, the time and the date and then the full details of the information requested. If the receiving terminal is purely numerical the information received will show: the parameter number; the video input number; and each result with an indication as to whether the reading was outside limits or not. In the examples shown in figure 7 parameter 02 is exceeding 'caution' limits and parameter 09 is exceeding 'urgent' limits.

If the receiving terminal is an alpha-numerical type the printout will also give each parameter name and its unit of measurement.

The Data Selector can be made to transmit information in languages other than English and can feed directly into a computer if required.

If the Data Monitor TF 2915 is not being used, the Data Selector TK 2917 provides automatic parameter scanning without limits comparison or executive control facilities.

Figure 7. Typical parallel BCD and ASCII serial printouts

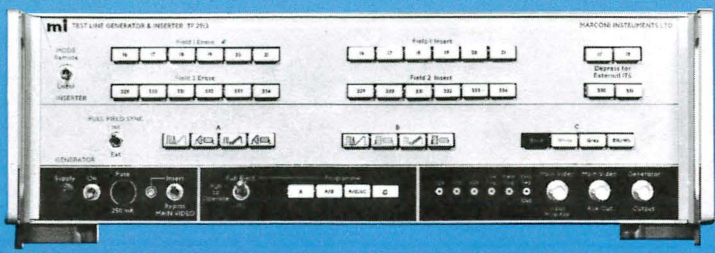
(a) Information format using a parallel b.c.d. printer

IDENTITY NUMBER		01	23	4 12 55	DATE / TIME
		1	00	+107 .4	
		1	01	+100 .2	
CAUTION LIMIT EXCEEDED	:	1	02	+072 .9	
		1	03	+093 .6	
		1	04	+001 .9	
		1	05	+001 .1	
		1	06	+001 .0	
		1	07	+000 .9	
		1	08	+003 .1	
URGENT LIMIT EXCEEDED	•:	1	09	+019 .0	RESULTS
		1	10	+000 .3	
		1	11	+000 .2	
VIDEO INPUT NUMBER		1	12	+000 .3	
			PARAMETER NUMBER		

(b) Information format from an ASC11 serial printer

IDENTITY NUMBER	AME01	Wk23 D4 12:54				DATE / TIME
		1	BAR AMP	+107.2	%	UNITS
		1	SYNC AMP	+100.1	%	
CAUTION LIMIT EXCEEDED	C	1	2T P/B	+073.1	%	
		1	C/L GAIN	+093.7	%	
		1	C/L DELAY	+002.2	NS	
VIDEO INPUT NUMBER		1	LUM N-LIN	+001.1	%	
		1	NOISE	+001.0	mV	
		1	C/L X-TALK	+000.8	%	
		1	LF ERROR	+003.0	mV	
URGENT LIMIT EXCEEDED	UC	1	BAR TILT	+019.1	%	
		1	2T 'K'	+000.3	%	
		1	DIFF GAIN	+000.2	%	
		1	DIFF PHASE	+000.3	DEG	
			PARAMETER NAME	RESULTS		

m



Test Line Generator and Inserter TF 2913 is an extremely versatile test waveform generator. Various models are produced to generate and insert most international or national ITS including CCIR and UK National waveforms on the recommended lines. The composite video signal is actually fed through the Test Line Generator and Inserter which makes use of the various sync pulses contained in the signal to ensure correct timing for the insertion operation. A built-in bypass relay in the inserter ensures that there is no interruption of the transmitted video signal in the event of a mains power supply failure.

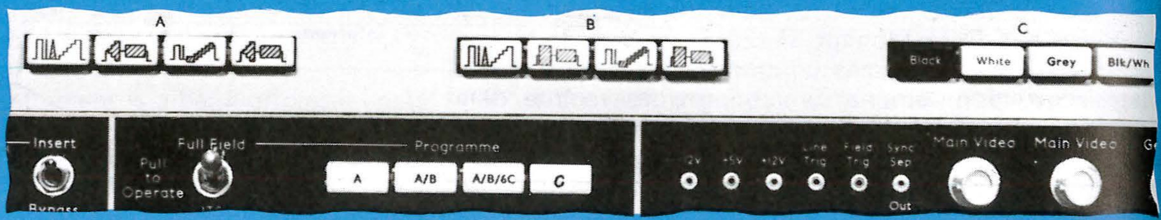
If the ITS waveform required is not one of those generated as standard in the generator, it can be generated externally and inserted via the inserter. Also the instrument can be used to erase unwanted test signals from lines in the field blanking interval.

The lines for erasure and insertion can be remotely selected via a rear panel socket which will accept a hard wired plug to override the front panel controls.

In addition to generating and inserting ITS, the Test Line Generator and Inserter TF 2913 will generate line repetitive waveforms which can be made into composite video signals if a sync pulse generator is available. There is a wide range of formats for the line repetitive waveform including: one of the ITS; two ITS on alternate lines; two ITS followed by a block of black, white or grey (the block of black, white or grey is used to vary the average picture level). Line repetitive, black, white, grey or alternating black and white can also be generated.

When TF 2913 is used as a line repetitive generator it provides waveforms for all linear and non-linear distortion measurements. If there is no 'live' video signal being transmitted, TF 2913 can be used to generate line repetitive signals *and* insert ITS in the field blanking interval of the signal, if a sync pulse generator is available. Figure 8 shows the line repetitive and ITS waveforms available on standard models.

Figure 8.
ITS and line repetitive waveforms available from TF 2913



Summary of facilities available

BASIC EQUIPMENT

(a) **TF 2913 Test Line Generator and Inserter** — Generates and inserts ITS to various national and international standards. Also generates line repetitive waveforms.

(b) **TF 2914A Insertion Signal Analyser** — Measures TV waveform parameters objectively.
Measurements available include:
- Luminance bar amplitude
- Sync pulse amplitude
- 2T pulse amplitude
- Chrominance to luminance gain
- Chrominance to luminance delay
- Luminance non-linearity
- Noise
- Chrominance to luminance crosstalk
- Low frequency error
- Bar Tilt
- 2T 'K' Factor
- Differential Gain
- Differential Phase
- Multiburst measurement
- Flag measurement
- Colour burst measurement
- and three independent auxiliary d.c. inputs.

WITH ASSOCIATED EQUIPMENT

(c) **TF 2915 Data Monitor** — Adds limits comparison, executive action, automatic waveform parameter scanning and video channel cycling.

(d) **TK 2917 Data Selector** used with printer, v.d.u. or data terminal — Adds automatic scanning of waveform parameters. Presents measured results locally or remotely. Printouts can be periodic or on demand from a selected video input.

(e) **TF 2915 Data Monitor** and **TK 2917 Data Selector** used with printer, v.d.u. or data terminal — Gives all additional facilities of (c) and (d) plus real time fault and installation status reporting.

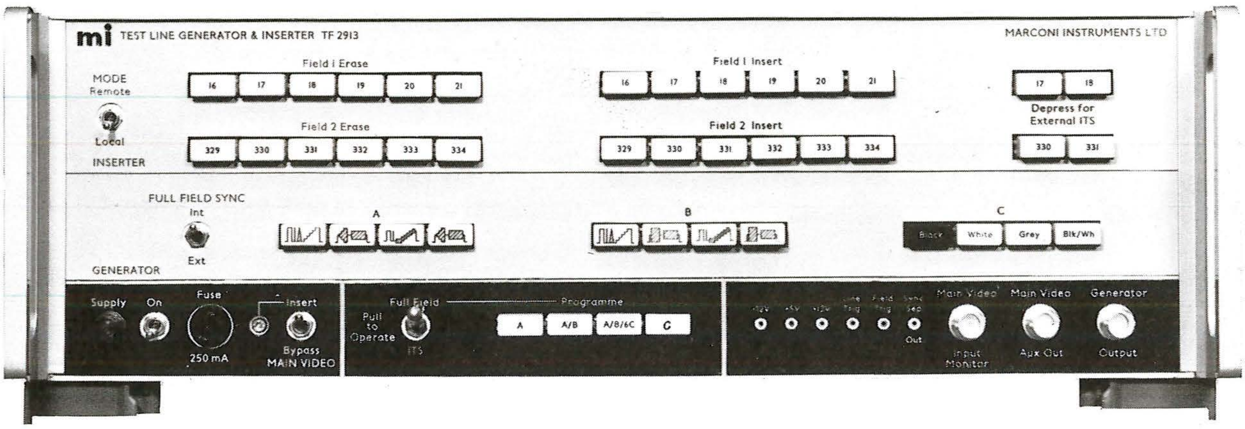
For details of the above equipment see the following pages.

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 and 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.



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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 and output 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 at the rear. 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 adjustable from 1·0 to 10 seconds. (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. Also in this mode two output sockets on the rear panel are driven with pulses nominally of line sync and line blanking duration for triggering external test generators.

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 can also be switched independently into any of the line positions 16, 19, 20, 21 on field 1, and 329, 332, 333 and 334 on field 2, by internal switching.

INSERTER SECTION

GENERAL	
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.
Selection of insertion lines	Selection is made by numbered push-buttons. Erasure of previous information on the selected line is automatic. Signals may be inserted in lines 16 to 21 of one field and 329 to 334 of the other field.
Remote control	Insertion and erasure may be controlled remotely.
BLACK LEVEL STABILITY	The change in black level of an inserted line, relative to the black level of the main signal, does not exceed 5 mV.
MAIN SIGNAL PATH	
Normal input	Standard level 625 line monochrome or colour video signal.
Nominal input level	*Picture:* +0·7 V. *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.
INFLUENCE ON MAIN VIDEO SIGNAL	
Chrominance/luminance inequalities	*Gain:* Less than ±0·05 dB. *Delay:* Less than ±5 nsec.
2T pulse/bar ratio	±0·25% if incoming signal ratio is unity.
2T pulse overshoot	Will 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. Sub-carrier: greater than 65 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. Sub-carrier: less than −60 dB pk-pk.
By-pass relay	System protected against failure by a by-pass relay operating on the main signal path which operates in the following events: a) Failure of mains supply. b) Failure of power supply. c) Removal of any printed circuit board in mains video path. d) Removal of instrument from rack. e) By-pass switch on front panel operated. f) Remote by-pass switch operated. Operation of relay does not cause any significant disturbance to the picture.
Insertion loss	±0·15 dB.
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 the presence of coded pulses which may be superimposed on the sync pulses, (e.g. for transmitting or accompanying sound signal), and the inserter will not affect any such signals.

ISOLATION BETWEEN MAIN & AUXILIARY OUTPUTS	Better than 46 dB up to 1 MHz. Better than 36 dB up to 4·43 MHz.
EXTERNAL TEST LINE INPUT	
Lines	16, 17, 18, 19, 20, 21 and 329, 330, 331, 332, 333, 334.
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	
ITS mode	Generator may be used in ITS mode or full field mode, locked or free running. Generator can be locked to the sync pulses (and colour burst, if present) of the incoming video signal. The lines for insertion of the required signal can then be selected.
Full field mode (locked) with external drives	No incoming video is required in this mode. The generator signal contains: a) Mixed sync pulses. b) A choice of APL during active picture time. c) Sub-carrier burst with phase alternation and Bruch blanking (provided that required external input signals are connected).
Full field mode (free running)	As full field mode, locked, except that the generator is free running at approximately line repetition rate. Generator provides line sync pulses and a single phased colour burst. No field information is provided.
Choice of APL	The choice of APL during active picture time is by front panel push-buttons as follows: a) Black (internally adjustable between 0 and 15% of luminance bar amplitude). b) White (internally adjustable between 85 and 100% of luminance bar amplitude). c) Grey (50% ±2% of luminance bar amplitude). d) Black and white switched alternately to constitute a square wave of unity mark/space ratio and with a period internally adjustable between 1 and 10 seconds.
Selection of programme	By pressing the appropriate push-buttons the following signal combinations are available: a) Any one of the four available signals repeated every line. b) Any two of the four available signals repeated line alternately. c) Any two of the four available signals repeated every eight lines, the intervening 6 lines being at: white, black, grey or black/white, described under choice of APL, as required. d) Black, white or grey or bump test continuously.
LINE SYNC PULSES	
Repetition frequency	Crystal controlled oscillator at 1 MHz divided by 64 to give line repetition frequency of 15·625 kHz ±0·05%.
Amplitude	0·3 V pk-pk ±3%.
Duration (half amplitude)	4·7 ±0·2 µs.
Rise and decay time	300 ±100 ns.
TIMING	Line duration is divided into 32 equal time periods.
Time periods	Time periods within ±20 ns of each other.
Characteristic instants of luminance waveform	Characteristic instants of luminance waveform, w.r.t. sync pulse occurs within ±250 ns of the nominal positions.
Characteristic instants of chrominance waveform	Characteristic instants of chrominance waveform with exception of 20T pulse within ±500 ns of their nominal positions.
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 sync pulse, over a range of ±1·0 µs.
Resetting of timing	It is possible, by internal alteration, to reset the individual timings of any of the luminance or chrominance elements in increments of 2 µs.

INSERTION TEST SIGNAL ELEMENTS

LUMINANCE BAR	
Position of transitions	6H/32, 11H/32.
Amplitude	0·7 V pk-pk ±1%.
Shape	Determined by a Thomson filter with a transfer-function modulus having its first zero at 4·43 MHz.
Rise and decay time	300 ±100 ns.
Duration	10 µs.
Tilt (10 µs period)	Less than 0·5%.
STAIRCASE	Level of the uppermost tread of staircase within ±0·25% of luminance-bar amplitude.
Position of transitions	20H/32, 22H/32, 24H/32, 26H/32, 28H/32, 31H/32.
Numbers of risers	Five.
Shape of risers	Shape determined by a Thomson filter with a transfer-function modulus having its first zero at 4·43 MHz (300 ±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 the external burst (when 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 ±2% of luminance amplitude.
Start and finish	15H/32, 30H/32.
2T PULSE	
Peak position	13H/32.
Amplitude	±0·5% of luminance bar amplitude.
Half-amplitude duration	200 ±6 ns.
Ripple after pulse	1st overshoot: (0·9 ±0·5)% of pulse amplitude. 2nd overshoot: (0·4 ±0·2)% of pulse amplitude.
20T COMPOSITE PULSE	
Peak position	16H/32.
Amplitude	±1% of luminance bar amplitude.
Half-amplitude duration	2 ±0·06 µs.
Ripple after pulse	1st overshoot: (0·9 ±0·5)% of pulse amplitude. 2nd overshoot: (0·4 ±0·2)% of pulse amplitude.
Inherent chrominance/luminance delay inequality	Not greater than ±5 ns.
Inherent chrominance/luminance gain inequality	Not greater than ±0·5%.
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.
CHROMINANCE BAR (single level)	
Position of transitions	7H/32, 14H/32.
Pk-pk amplitude	Within ±1% of luminance bar amplitude.
Pedestal	+0·35 V ±1%.
Envelope rise time	1 µs approximately.

THREE-LEVEL CHROMINANCE BAR	
Positions 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). *2nd section:* Within ±1% of 3/5 of luminance bar amplitude (nominal value 0·42 V). *3rd section:* Within ±1% of luminance bar amplitude (nominal value 0·7 V).
Pedestal	+0·35 V ±1%. *Position of transitions:* 6H/32, 31H/32.
Envelope rise time	1 μs approximately.
CHROMINANCE REFERENCE	
Positions of transitions	17H/32, 30H/32.
Amplitude	0·42 V pk-pk ±1% of luminance bar amplitude.
Pedestal	+0·35 V ±1%. *Position of transitions:* 6H/32, 31H/32.
Envelope rise time	1 μs approximately.
Inherent luminance/chrominance cross modulation	Not greater than ±0·5% of pedestal amplitude.
PHASE STABILITY	Phase difference of chrominance signal elements in adjacent lines does not exceed 2°.
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 10 MHz.
Sub-carrier leak	Less than 3 mV pk-pk on insertion lines.
Harmonic content of sub-carrier	Less than −40 dB w.r.t. fundamental.
EXTERNAL TRIGGER REQUIREMENTS	Instruments 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	0·2 to 4 V pk-pk nominal, mixed sync signal.
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.
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 nominal.
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.
Impedance	*Return loss ratio:* greater than 31 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 sub-carrier burst gate and PAL squarewave signals are available.
SAFETY	Designed to meet the requirements of IEC 348.
POWER REQUIREMENTS	
AC supply	95 to 132 V or 190 to 264 V: 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	14¾ in	25·1 lb

VERSIONS AND ACCESSORIES

When ordering please quote eight digit code numbers

Ordering numbers	
	Versions
52913–015N	TF 2913. Standard version.
52913–302W	TF 2913. With one additional external line card.
52913–303D	TF 2913 With two additional external line cards
52913–304T	TF 2913. With multiburst.
52913–305P	TF 2913. With multiburst and one additional external line card.
52913–306X	TF 2913. With multiburst and two additional external line cards.
52913–311C	TF 2913. Standard UK National version.
	Supplied Accessories Accessory Kit 46883–245Y, including: Basic Rack Mounting Kit 46883–175Y Board Extractor 41148–605K Extender Board 44836–106F Buttons Plugs.
	Optional Facilities
54127–191D	Rack Slide Kit.
54541–071M	External Line Insertion Card.
54541–051U	Multiburst (Signal B).
	Associated Equipment Insertion Signal Analyser TF 2914A series. Data Monitor TF 2915 series. Data Selector TK 2917 series.

Optional facilities

EXTERNAL LINE INSERTION CARDS 54541–071M

The basic inserter provides for four external inputs, two per field on lines 19, 20 and 332, 333. By re-plugging the external input board into one of the two extra socket positions these four inputs can be shifted to lines 17, 18 and 330, 331 or to 16, 21 and 329, 334 If more than four external inputs or a different line combination is required then additional input boards must be ordered. The purchase of two additional four-input boards will provide the full twelve lines of insertion.

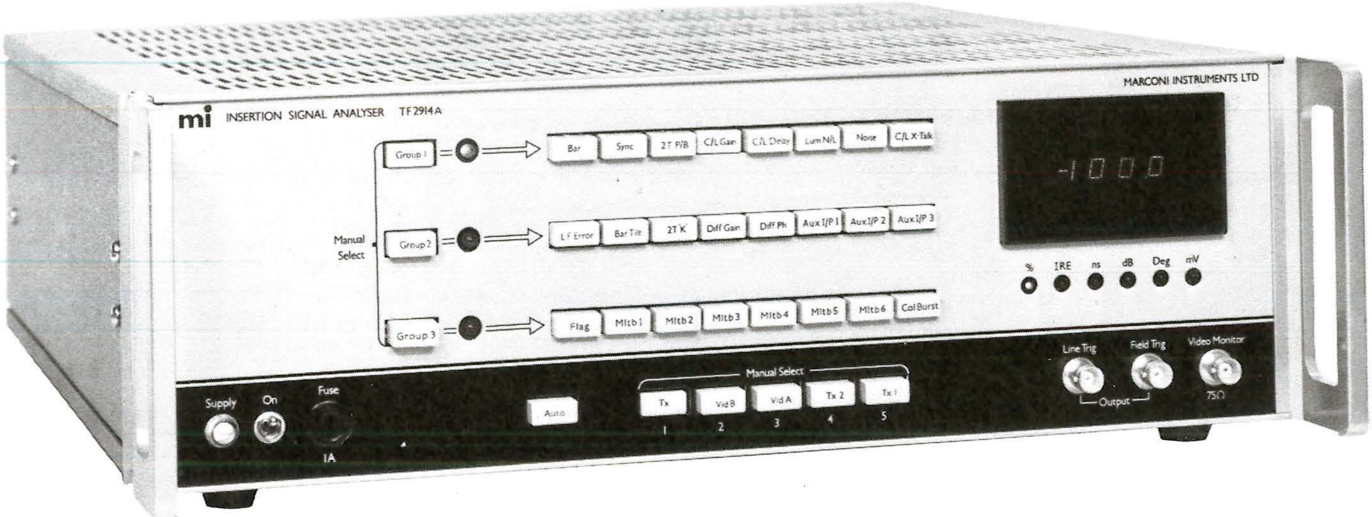
MULTIBURST (Signal B) 54541–051U

The Multiburst signal consists of six frequency bursts preceded by a reference bar. Each burst has a duration of 4 to 5·6μs, and contains a discrete number of complete cycles, starting at zero phase.
N.B.—For customers who have no requirement for the Multiburst waveform, Signal D 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	0·42 V ±1%. *Position of transitions:* 6H/32, 8H/32, 10H/32.
Burst amplitude	0·42 V pk-pk within ±1% of the reference bar amplitude.
Pedestal	0·35 V within ±1% of the reference bar amplitude. *Position of transitions:* 6H/32, 31H/32.

The Multiburst and External Line Insertion Card facilities will be factory-fitted if they are ordered with TF 2913. If they are ordered subsequently the TF 2913 should be returned for factory fitting of these accessories.

- Automatic television waveform measurements
- 625 line operation - PAL or SECAM (525 line – NTSC also available)
- National or CCIR International waveforms
- Objective high-resolution readings from digital panel meter
- Measures up to a total of 24 separate parameters
- Manual and automatic modes of operation



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 (600 series)

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, or test signals defined by national authorities.

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. Details of the 525 line NTSC measurements are given on the data sheet for the TF 2914A (500 series).

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 zero).
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 can be linked to display either the deviations from a normal error free reading, or the absolute value.

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 0 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.
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 peak to peak amplitude of low frequency signals superimposed on the full field signal.

Measurement range	0 to 150 mV.
Reading uncertainty	±3 mV.
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 0 to +20% ±2% from −50 to +50%.
Resolution	±0·1%.
10 2T PULSE 'K' FACTOR	Measurement of the pre-pulse and post-pulse ringing amplitudes by comparison with an electronically generated mask within the measurement time interval. Displayed as percentage K.
Measurement range	0% to 10% K.
Time interval	−8T to −2T and +2T to +12T for 625 line systems, where T is 100 ns.
Reading uncertainty	±1% K.
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	0 to 50%.
Reading uncertainty	±0·5% from 0 to 10% ±2% from 10 to 20% ±3% from 20 to 30% ±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	0 to ±45°.
Reading uncertainty	±1° from 0 to 10° ±2° from 10 to 20° ±3° from 20 to 30° ±5° from 30 to 45°
Resolution	±0·1°.
13-15 AUXILIARY DC INPUTS	These are available as an optional facility.
Measurement range	−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. +1 V = +100·0 d.p.m. reading −1 V = −100·0 d.p.m. reading.
Signal source impedance	1 kΩ.
Resolution	±0·1 V.
16 FLAG	The peak amplitude of the flag as a percentage of 560 mV related to the amplitude of the luminance bar.
Measurement range	50 to 150%.
Reading uncertainty	±1% from 80 to 150% ±2% from 50 to 80%.
Resolution	±0·1%.
17-22 MULTIBURST	
Gain-frequency Response	The peak to peak amplitude of each frequency burst as a percentage of 420 mV related to the amplitude of the luminance bar.
Measurement range	50 to 150%.
Reading uncertainty	±1% from −20 to +20% ±2% from −50 to +50%.
Resolution	±0·1%.
23 COLOUR REFERENCE BURST	The amplitude of the colour reference burst as a percentage of 300 mV related to the amplitude of the luminance bar.
Measurement range	50 to 150%.
Reading uncertainty	±1% from −20 to +20% ±2% from −50 to +50%.
Resolution	±0·1%.
DATA LINE EXTRACTION	This facility is available as an alternative to the auxiliary d.c. input measurement capability. 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. *Five input:* each of the five video inputs may be selected. *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. *Parameter reading:* 14 bits. *Control:* 5 bits. *Video input select:* 3 bits. *Levels:* TTL.
Analogue signal socket	Rear panel mounted. *Video input select:* Analogue voltage output of each parameter measurement.
VIDEO MONITOR OUTPUT	Front panel BNC socket.
Source impedance	75 Ω.
Return loss	Greater than 28 dB up to 7 MHz.
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. 3½ digit l.e.d. display with decimal point and automatic polarity indication.

TF 2914A (600 series)

CONTROLS	
Parameter selection buttons	The parameters to be measured are provided in three separate groups, each having eight parameters. The selected group is indicated by an l.e.d. lamp.
Video input buttons	Five interlocking push-buttons permit manual selection of 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.

POWER REQUIREMENTS	
AC supply	95 to 132 V and 190 to 264 V. 45 to 65 Hz. 100 VA.
SAFETY REGULATIONS	Complies with IEC 348 and BS 4743 safety requirements.

DIMENSIONS AND WEIGHT	Height	Width	Depth	Weight
	133 mm	425 mm	380 mm	11.4 kg
	5¼ in.	16¾ in.	15 in.	25 lb.

ACCESSORIES

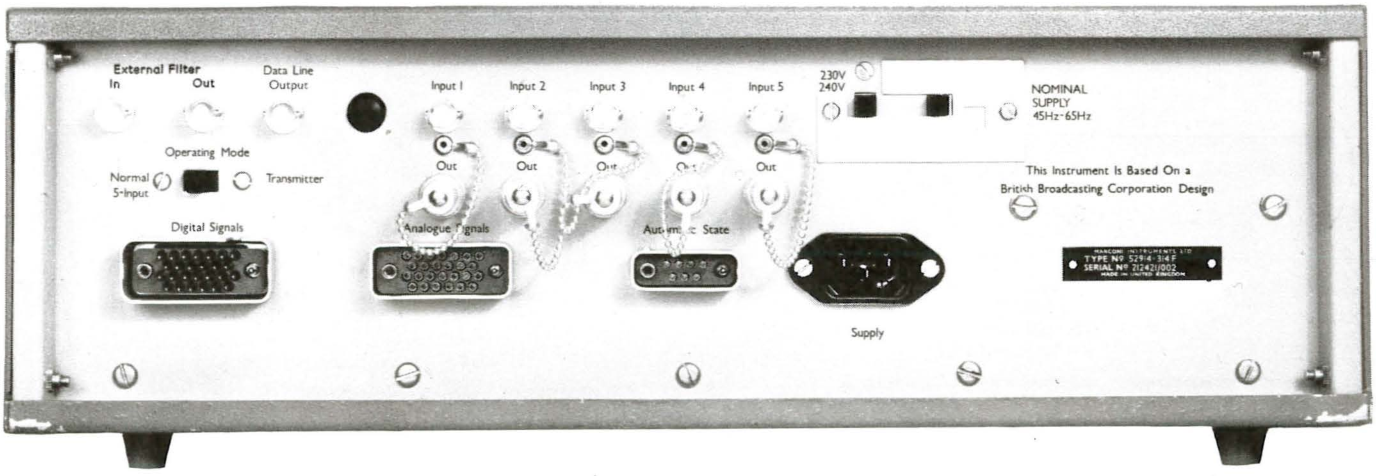
When ordering please quote eight digit code numbers

Ordering Numbers	Supplied Accessories
	Accessory Kit 46883-339A. Comprises: Extender Board 44827-235W. Mains Lead, side-entry 43129-003W Free Plug 23443-328T, 75 Ω, (4 supplied). Seven-way Plug 23435-416A Board Extractor 41700-048A Tx Button 37590-072V Plain Grey Button 23465-599D. Rack Mounting Kit (basic) 46883-175Y. Coaxial Lead Assembly 43129-209T.
	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.
46883–354F	Ventilation Kit.
	Associated Equipment Television Test Line Generator and Inserter TF 2913 series. Data Monitor TF 2915 series. Data Selector TK 2917 series.

VERSIONS

MODEL 52914-	600T	601P	602X	603M	610K	630W	640R
System	PAL	PAL	PAL	PAL	PAL	SECAM	PAL
ITS Waveform	CCIR	CCIR	CCIR	CCIR	CCIR	CCIR	UK
Differential phase and gain (5 level modulation)				*			
Differential phase and gain (6 level modulation)	*	*	*		*	*	*
Multiburst and colour burst					*	*	
Luminance non-Linearity and Chrominance to Luminance gain	*	*	*	*	*	*	*
Bar tilt and Chrominance to luminance crosstalk	*	*	*	*	*	*	*
Chrominance to Luminance delay	*	*	*	*	*	*	*
2T 'K' Factor	*	*	*	*	*	*	*
LF error	*	*	*	*	*	*	*
Noise	*	*	*	*	*	*	*
Auxiliary Inputs		*					
Data Line Extraction			*				

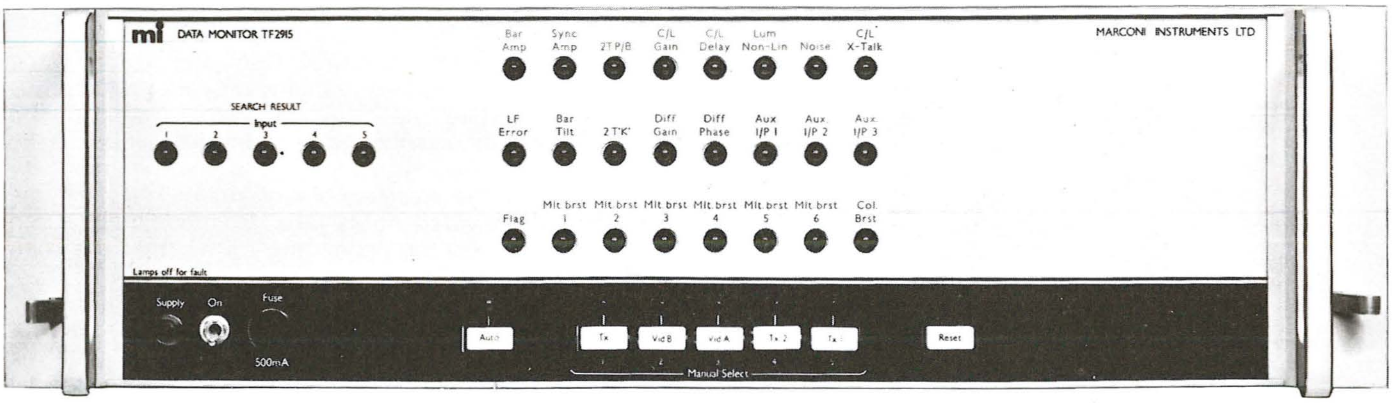
Variants of these models can be supplied on request.
Versions are also available for 525 line operation. For details see data sheet for TF 2914A (500 series).



Rear view of TF 2914A

Data Monitor TF2915

- ☐ 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



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Data Monitor TF 2915 provides the facility for comparison of measured data parameters with pre-determined limits and the taking of automatic executive action as a result of these comparisons.

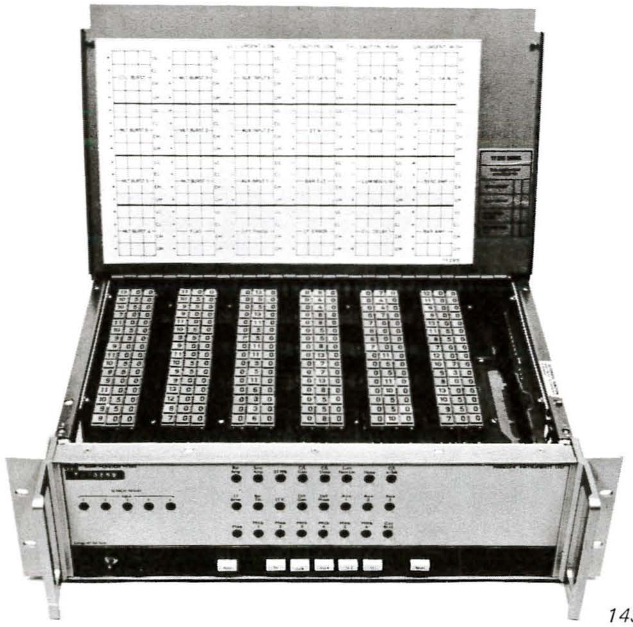
The analogue outputs from the TF 2914A, representing the measured values of the parameters, are taken to a Parameter Switch in the TF 2915. This switch is automatically cycled around the parameters and feeds back the measured value for each in sequence to the TF 2914A where it is converted to b.c.d. form by an analogue to digital converter incorporated in the digital panel meter. This b.c.d. signal is returned to a Limits Comparator in the TF 2915 where it is compared with a pre-set limit set up in a Limits Bank. Four limits can be set up for each parameter, consisting of high and low limits of two grades – 'urgent', on which executive control switching takes place, and 'caution', where an external indication only is given. 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 lamp corresponding to each parameter to be measured and to the search result status for each video input. These lamps are normally illuminated, but are extinguished by an out-of-limits result for the corresponding parameter or video input.

TF 2915

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. When the number of faults occurring in a given number of scans exceeds a 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



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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.

When a fault condition occurs the instrument goes through the complete search process at the various monitoring points then a signal is provided by the executor which can switch transmitters or video inputs as necessary to maintain transmission quality. Data output is also provided to give indication of the condition of the stores and to report transmitter failure or complete station failure as necessary.

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 even in the presence of high noise. 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 the zero 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: (a) One or more video inputs sequentially. (b) Main or cold-standby transmitters. (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.

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. value	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
Model 52915-303F	Parameters 00 to 15
Model 52915-306D	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

CONTROL OUTPUT

Transmitter 1 or 2 selector Two relays	Contact closure for selection. Rating 42 V; 0·25 A; 10 VA.

EXECUTIVE OUTPUT

Video A failed 1 Relay TX 1 failed 1 Relay TX 2 failed 1 Relay	Contact closure for failure Rating 42 V; 1A; 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.

SAFETY

Designed to meet the requirements of IEC 348.

DIMENSIONS AND WEIGHT

Height	Width	Depth	Weight
133 mm	483 mm	457 mm	10·7 kg
5·2 in	19 in	18 in	23·5 lb

m

VERSIONS AND ACCESSORIES

When ordering please quote eight digit code numbers.

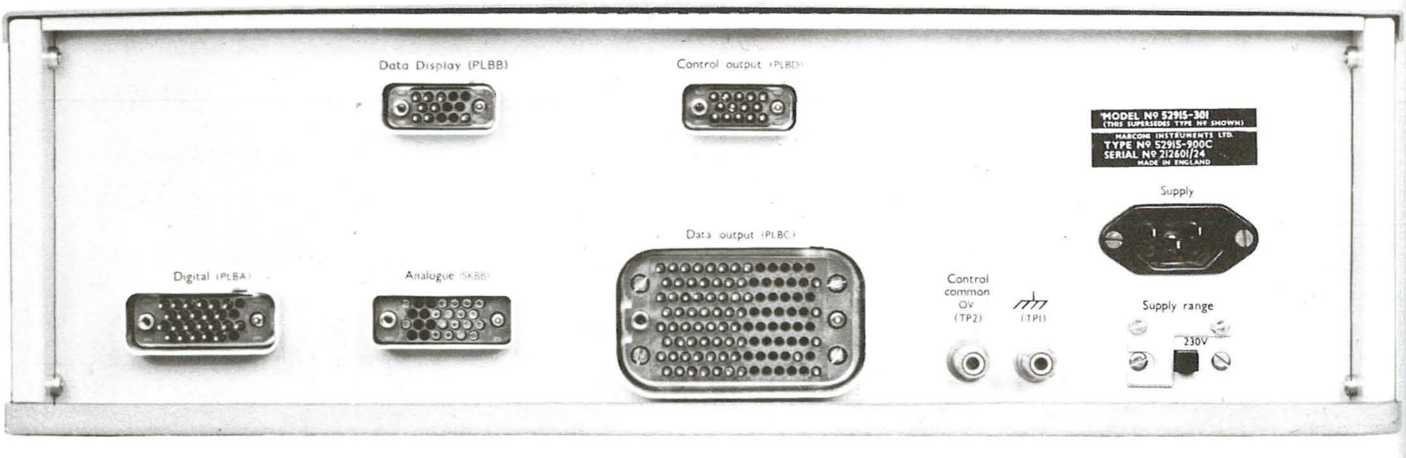
Ordering numbers	
	Versions
52915-301F	TF 2915 with 14 monitored parameters.
52915-302G	TF 2915 with 24 monitored parameters. (For transmitter applications.)
52915-303V	TF 2915 with 16 monitored parameters.
52915-306D	TF 2915 with 24 monitored parameters. (General purpose.)
	Supplied Accessories Accessory Kit 46883-247L. Comprises: 14 way Socker 23435-435W. 104 way Socket 23435-499W. Blank Button 23435-599D (5 supplied). Tx button 37590-072V. Digital Cable 46883-212U. Analogue Cable 46883-213V. Plug Extractor 22951-399D. Plug Tops (586 supplied).
	Associated Equipment Television Test Line Generator and Inserter TF 2913 series. Insertion Signal Analyser TF 2914A series. Data Selector TK 2917 series. *For details see separate data sheets.*

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	Executive 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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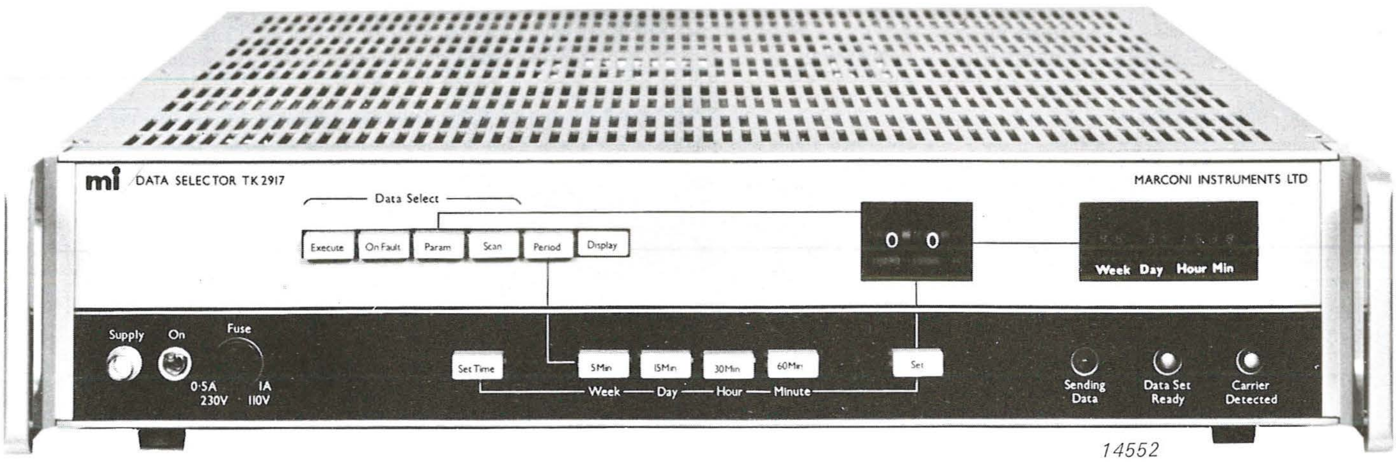
Data Selector TK 2917

- 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



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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 ACSII 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 TAME.

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.

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 +1·5 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	push-button
5, 15, 30, 60 minutes or 3, 6, 12, 24 hours	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.

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.

Control output

Zero reset	1 bit
Inhibit	1 bit
Video input select	8 bits

Levels: Open collector TTL output.
ON state less than 0·4V 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 readings 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.
TAME operating description (delay, inhibit).
Spaces, carriage return, line feeds.

Input/output port
To CCITT V 24 specification.
Input: Serial data
Line signal detected
Calling indicator
Data set ready.
Levels: Logic '1' greater than +3 V
Logic '0' less than −3 V
(Maximum ±25 V).
Output: Serial data
Connect data set to line
Request to send
Signal ground.
Levels: Logic '1' greater than +6 V
Logic '0' less than −6 V
into 3 kΩ, maximum ±12 V
into open circuit.

Baud rate
110, 300, 600, 1200 or 2400 internal switch selected.
Serial input and output with even parity.

Input/output port for local recording
Serial output levels:
Logic '1' +6 V nominal
Logic '0' −6 V nominal
into 3 kΩ maximum ±12 V into open circuit.

Byte serial output
8 bits.

Punch command
1 bit
Levels: open collector output with 1 kΩ pull up resistors (to less than 30 V).
Logic '0' less than 0·7 V at 40 mA.

Punch busy
1 bit
Input levels:
Logic '0' less than 0·8 V
Logic '1' greater than 2·0 V, not greater than 7·0 V.

Pull up power rails
+12 V nominal
+5 V nominal
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.
45 to 65 Hz, 60 VA approx.

SAFETY

Designed to meet the requirements of IEC 348.

DIMENSIONS AND WEIGHT

Height	Width	Depth	Weight
89 mm	483 mm	457 mm	10·4 kg
3½ in	19 in	18 in	23lb

EXAMPLE OF A PRINT OF THE INFORMATION FROM THE TAME

A print of a parameter scan on input 1 at station number 01 at 00·39 hours on day 1 (Monday), week number 01.

Information provided at the bit serial output in ASCII printed on a Transdata Printer type 312

Information demand →

```
AME05S?
AME05 Wk01 D1 00:39
      1 BAR AMP      +101.0  %
      1 SYNC AMP     +105.6  %
      1 2T P/B       +098.6  %
      1 C/L GAIN     +012.0  %
      1 C/L DELAY    +021.0  NS
      1 LUM N-LIN    +004.7  %
      1 SIG./NOISE   +063.5  dB
      1 C/L X-TALK   -000.4  %
      1 LF ERROR     +002.6  mV
      1 BAR TILT     -000.0  %
      1 2T 'K'       +000.5  %
      1 DIFF GAIN    +010.3  %
      1 DIFF PHASE   +000.9DEG
      1 AUX I/P  1   +005.4
      1 AUX I/P  2   +005.4
      1 AUX I/P  3   +052.1
      1 MLT BAR      +062.0  %
      1 MLT BRST 1   +162.7  %
      1 MLT BRST 2   +003.2  %
      1 MLT BRST 3   +103.0  %
      1 MLT BRST 4   +098.3  %
      1 MLT BRST 5   +098.2  %
      1 MLT BRST 6   +100.9  %
      1 COL. BRST    +103.9  %
```

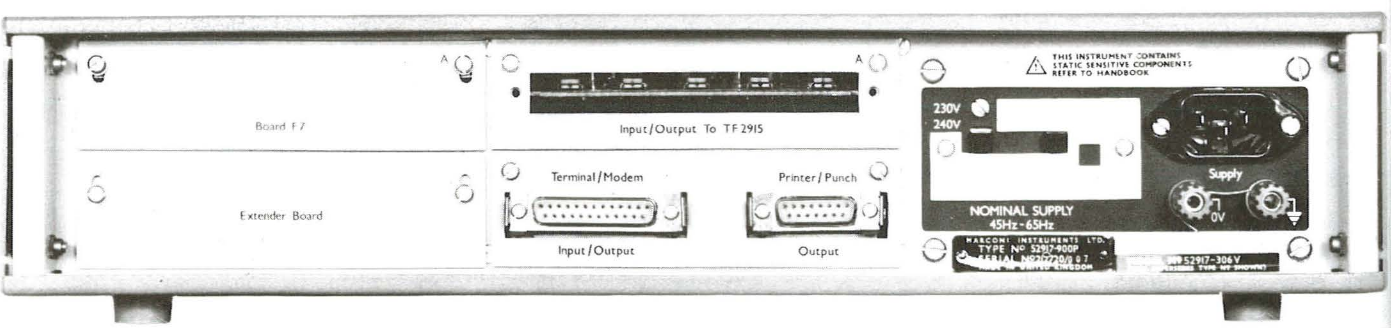
VERSIONS

MODEL 52917–	301N	302L	303J	304F	305G	306V	307S	308W
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 Bir parallel output Numerical print out		*		*				
International units English Language print out	*		*					
International units French language print out							*	*
NTC/CBC Insertion test signals Print out with IRE units					*	*		

ACCESSORIES

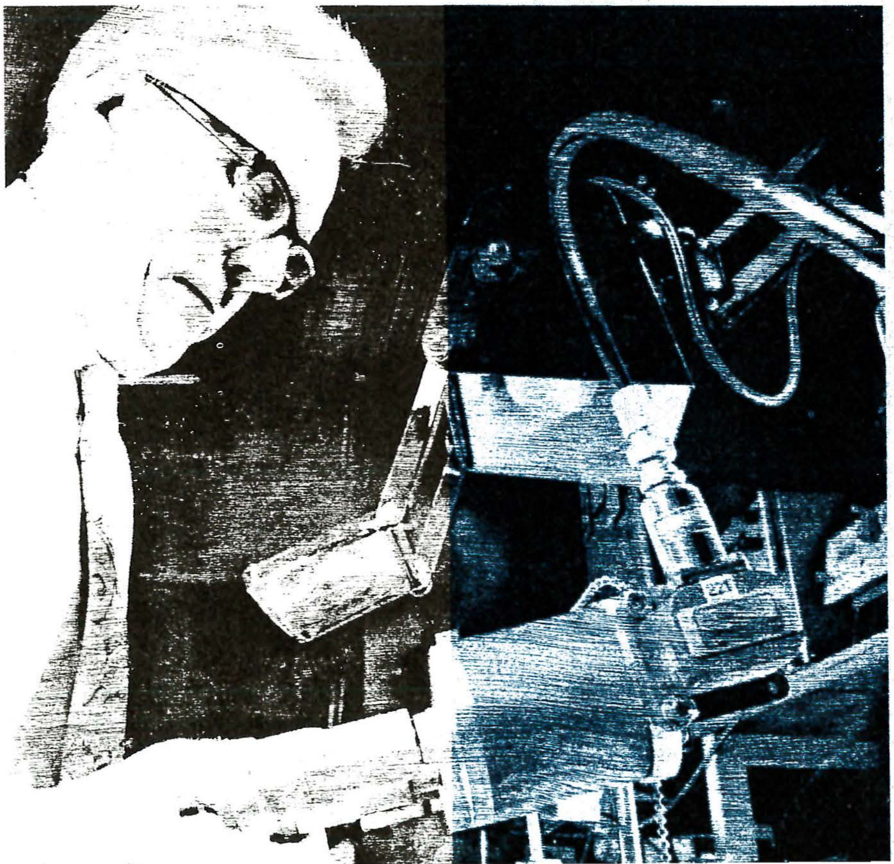
When ordering please quote eight digit code numbers

Ordering numbers			
	Supplied Accessories		*The following accessories are for use with serial input/output options only*
	Accessory Kit 46883–287S comprising Board Extractor, Supply Lead, Rack Mounting Kit and 3, 6, 12, 24 hour buttons.	43129–167V	Terminal Interface Cable (25 way Female).
	TAME Interface Lead. (Either lead 43129–164J for TF 2914A or lead 43129–165F for TF 2915 supplied.)	43129–170V	Terminal Interface Cable (25 way Male).
	Modem Interface Cable 43129–161Y for serial input/output option.	43129–171S	Local Receive Only Terminal Interface Cable (25 way Male).
	38-way socket and shroud 43169–012A for parallel input/output option.	43129–323B	Local Receive Only Terminal Interface Cable (25 way Female).
	(Either of the above two items are supplied, depending on the input/output option.)	46883–320L	Modem Interface Cable (43129-161Y).
			The following accessories are for use with parallel input/output options only.
		43129–162N	Punch Interface Cable (25 way Male).
		43129–166G	GMT Printer Interface Cable.
	Optional Accessories		**Associated Equipment**
44319–004H	Battery Back-up for digital clock.		Television Test Line Generator and Inserter TF 2913 series.
46883–298R	Kit of parts for external 1 Hz digital clock drive.		Insertion Signal Analyser TF 2914A series.
54127–251L	Rack Slider Kit.		Data Monitor TF 2915 series.
			For full details see separate data sheets.



Rear panel view of TK 2917 14552/1

MICROWAVE PRODUCTS



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Type 6049/1 Frequency Meter

☐ Waveguide or coaxial
☐ Absorption or transmission

6049/1 with accessories

Waveguide Attachment R48

Waveguide Attachment R40

Auxiliary Outlet Type N Connector

FREQUENCY METER with Passing Coaxial Attachment and stand

Waveguide Attachment R32

Crystal Detector with BNC Connector

Waveguide Attachment R70

The 6049/1 Precision Frequency Meter has been carefully designed to combine ease of operation with a high standard of measurement accuracy over the frequency range 2·6 to 8·2 GHz. The instrument may be used with its passing coaxial attachment and associated stand as an absorption or transmission wavemeter or may be coupled directly into a waveguide system. Optional waveguide attachments are available which can be fitted in place of the coaxial system so that a high degree of flexibility can be achieved with a complete range of accessories.

In order to achieve wideband performance the cavity is of a hybrid type which will support a mode that is partly coaxial and partly waveguide, tuning is effected by means of an axial plunger and the entire frequency range is covered without any spurious mode interference.

The frequency is indicated by means of a parallax-free dial-reading, spiral dial, with a 85 inch scale which provides a high order of resolution due to the high Q cavity. An output to an external metering system may be taken via the auxiliary type 'N' outlet or via the optional BNC outlet incorporating a diode detector and also permits the cavity to be used as a transmission filter.

The attachments are fitted to the frequency meter by means of four captive screws, but when fitted to the bench stand the spiral scale lies at an angle of 30° from the vertical which facilitates an easy direct readout. An Allen Key housed in the stand is provided for locking and unlocking the captive screws.

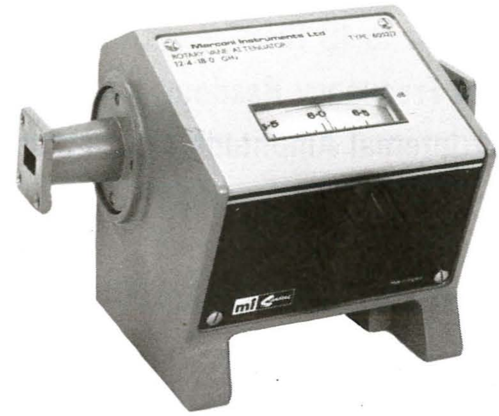
The attachments for waveguide sizes R32, R48 and R70 have special flanges that mate with British and American round flanges and also with international rectangular flanges. The attachment for Waveguide size R40 mates with flange type CPR229.

FREQUENCY	
Range	2·6 to 8·2 GHz.
Overall accuracy	±5 MHz or 0·1% with passing coax. attachment. ±5 MHz or 0·15% with waveguide attachments.
Calibration increments	5 MHz between 2·6 and 5·0 GHz. 10 MHz between 5·0 and 8·2 GHz.
INPUT CONDITIONS	
VSWR	Passing coaxial attachment (Part No. 2523009): Less than 1·5. (relative to 50 Ω). All waveguide attachments less than 1·1.
RESPONSE	
Q-factor	Typically 1000.
Dip at resonance	Greater than 0·5 dB.
Aux. type N outlet	−12 dB typical coupling.
Crystal detector	2 mV/mW of input signal typical.

DIMENSIONS AND WEIGHT		Height 254 mm (10 in). Weight 2·3 kg (5 lb) for frequency meter with coaxial mount.	
ACCESSORIES		Part No.	Description
	Supplied	2523009	Passing coaxial attachment complete with two female Type 'N' connectors.
		2523048	Stand for coaxial attachment.
		2523015	Auxiliary outlet with Type 'N' female connector.
		2523041	Cover plate.
	Optional	2523008	Waveguide attachment R70 (WG 14)
		2523006	Waveguide attachment R48 (WG12)
		2523007	Waveguide attachment R40 (WG11A)
		2523005	Waveguide attachment R32 (WG10)
		2523011	Detector with BNC connector.

Rotary Vane Attenuator Type 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 achieved by 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 of the attenuation reading 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.

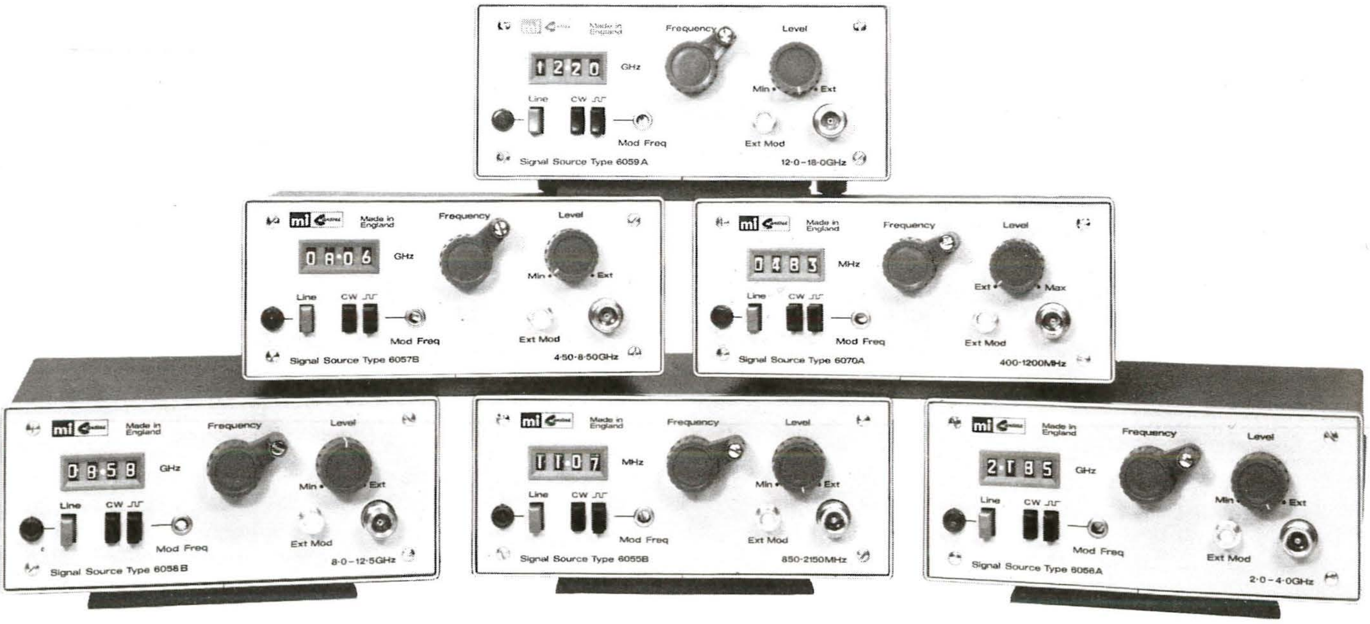
These Rotary Vane Attenuators offer a sensibly flat attenuation response over the whole of each waveguide band for all values of attenuation setting which, coupled with the low phase-shift characteristics, make them ideal for use in swept frequency systems.

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	6052/5
RF PERFORMANCE				
Frequency range	26·5–40 GHz	12·4–18·0 GHz	8·2–12·4 GHz	5·3–8·2 GHz
Waveguide size	R320, WG22	R140, WG18	R100, WG16	R70, WG14
CW Power rating	1 Watt	5 Watts	7 Watts	10 Watts
VSWR	1·15 max	1·15 max	1·15 max	1·15 max
Insertion loss	0·75 dB max	0·75 dB max	0·75 dB max	0·75 dB max
Phase shift	2° max	2° max	2° max	2° max
ATTENUATION CHARACTERISTICS				
Calibration range	0 to 60 dB			
Absolute accuracy	0 to 10 dB: ±0·1 dB 10 to 40 dB: ±1%		40 to 50 dB: ±2% 50 to 60 dB: ±3%	
Scale increments	0 to 0·1 dB: 0·01 dB 0·1 to 2·0 dB: 0·02 dB 2·0 to 10·0 dB: 0·1 dB 10·0 to 30·0 dB: 0·2 dB		30·0 to 40·0 dB: 0·5 dB 40·0 to 50·0 dB: 1·0 dB 50·0 to 60·0 dB: 2·0 dB	
Resettability	0·005dB at 1dB		0·02 dB at 10 dB	
TEMPERATURE RANGE	0 to 50°C			
FLANGE COMPATIBILITY	Square Flange Mates with UG 599/U	Square Flange Mates with UG 419/U	Square Flange Mates with UG 39/U	Multi-drilled Round
MECHANICAL				
Length	190 mm, 7½ in	206 mm, 8½ in	270 mm, 10¾ in	428 mm, 16⅞ in
Weight	2·04 kg, 4 lb 8 oz	2·04 kg, 4 lb 8 oz	2·94 kg, 6 lb 8 oz	6·35 kg, 14 lb

Solid State Signal Sources

- ☐ 400 MHz to 18 GHz
- ☐ Digital Frequency Readout
- ☐ 1 kHz Internal Amplitude Modulation
- ☐ External Levelling Capability
- ☐ Manual Sweep Facility
- ☐ Small Size and Low Weight



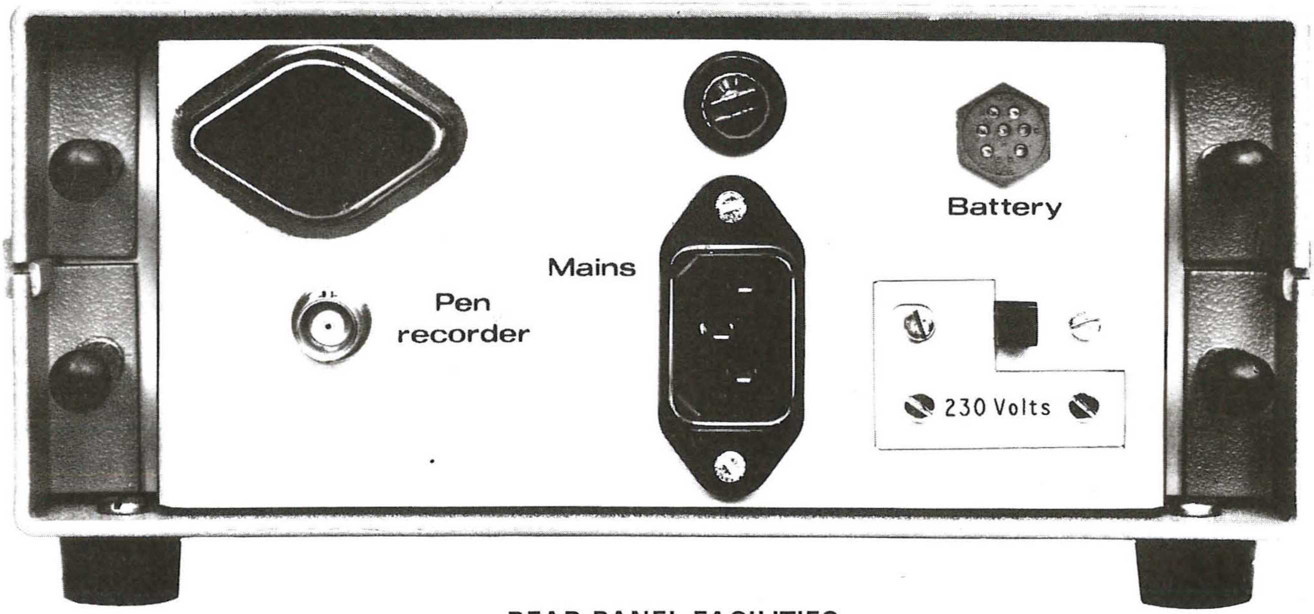
This range of all solid state microwave signal sources operates within the frequency range 400 MHz to 18 GHz. Two types of oscillators are used to achieve the wide frequency coverage. The 6070A, 6055B and 6056B (400 MHz to 4 GHz), use a high frequency transistor oscillator while the 6057B/1, 6058B and the 6059A (4·0–18·0 GHz) use a Gunn diode operating in fundamental mode coaxial cavities.

R.F. 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 sensitivity 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 110 volt supply.



REAR PANEL FACILITIES

BNC CONNECTOR PROVIDING OUTPUT VOLTAGE DIRECTLY PROPORTIONAL TO FREQUENCY.
EUROPEAN TYPE MAINS CONNECTOR.
BATTERY CONNECTIONS. (SEE TABLE BELOW).
MAINS VOLTAGE SELECTOR SWITCH.
FUSE.

BATTERY CONNECTIONS TO SIGNAL SOURCES

SIGNAL SOURCE	BATTERY VOLTAGES	CURRENT RATINGS	SUGGESTED BATTERY CAPACITIES	SOCKET CONNECTIONS TO BATTERY
6070A	36 VOLTS	200 mA	36 VOLTS at 2·5 AH	+VE to E, −VE to D
6055B	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	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

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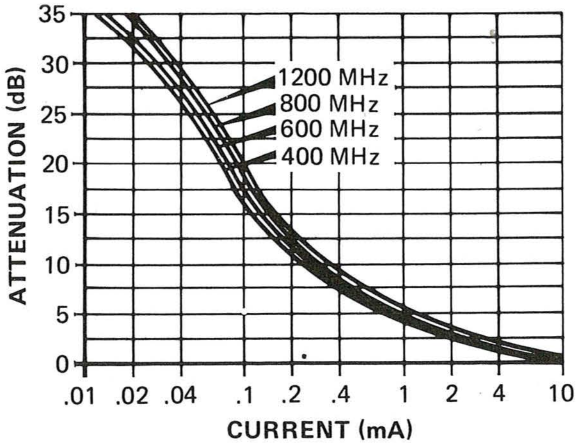
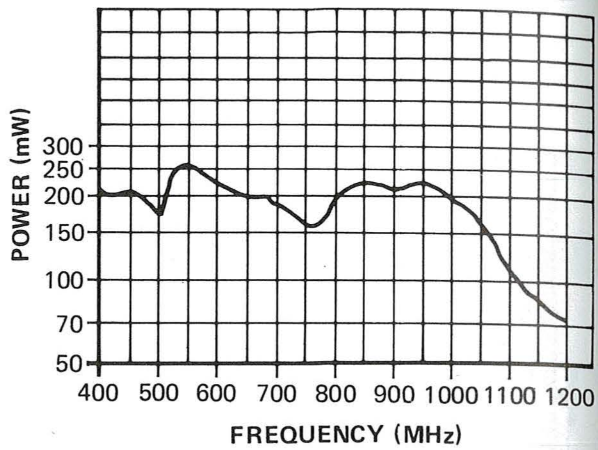
Type 6070A

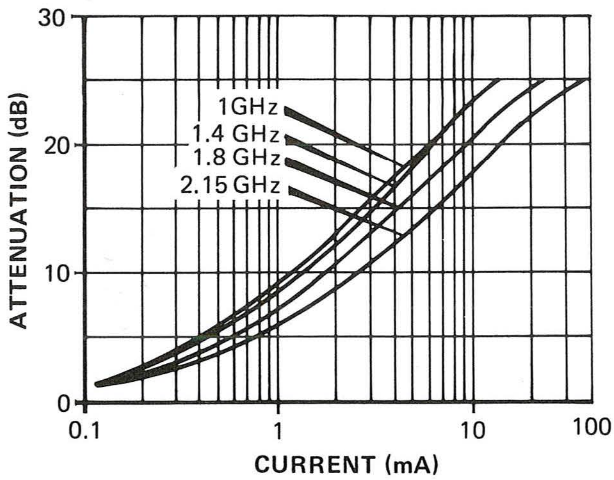


Typical Modulator Performance

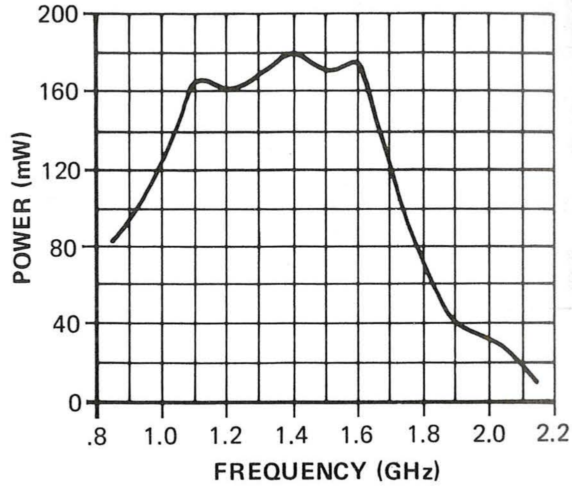


Typical Power Output

Type 6055B

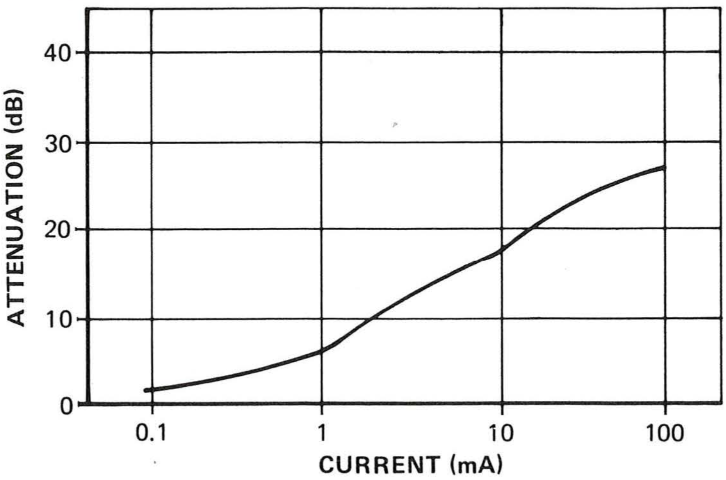


Typical Modulator Performance

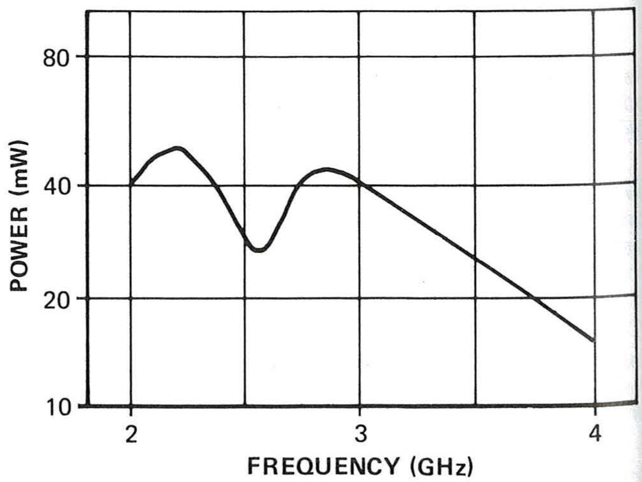


Typical Power Output

Type 6056B

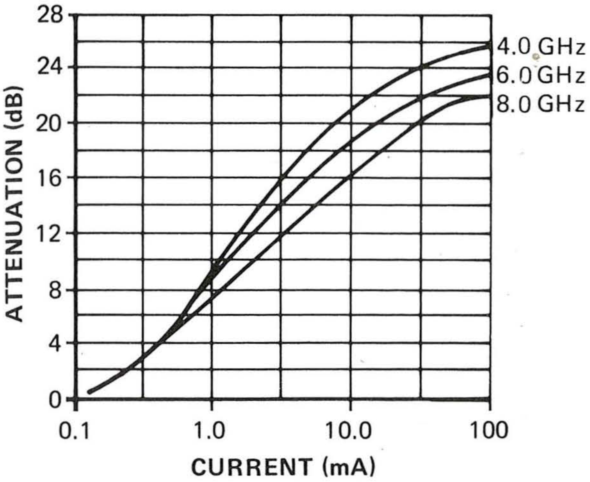


Typical Modulator Performance

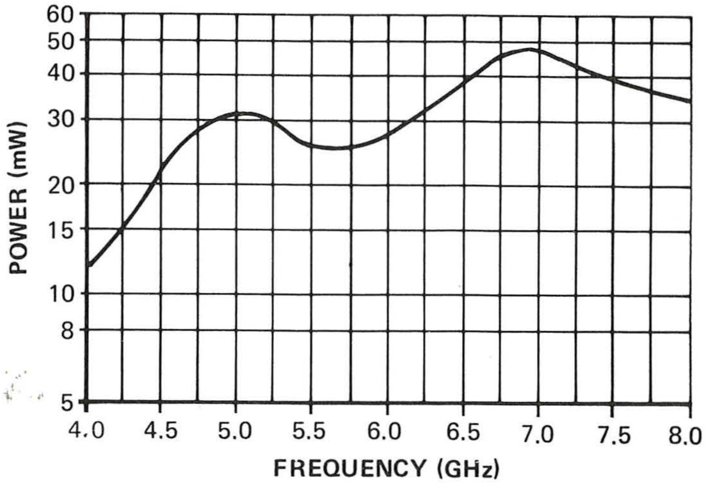


Typical Power Output

Type 6057B/1

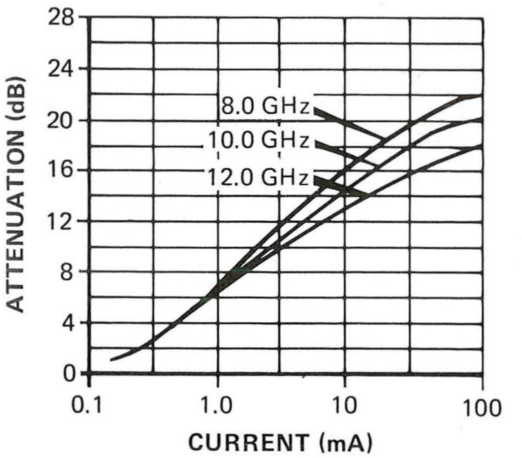


Typical Modulator Performance

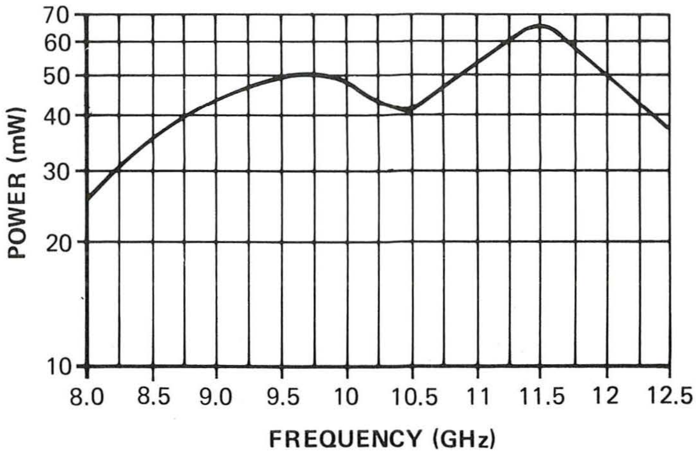


Typical Power Output

Type 6058B

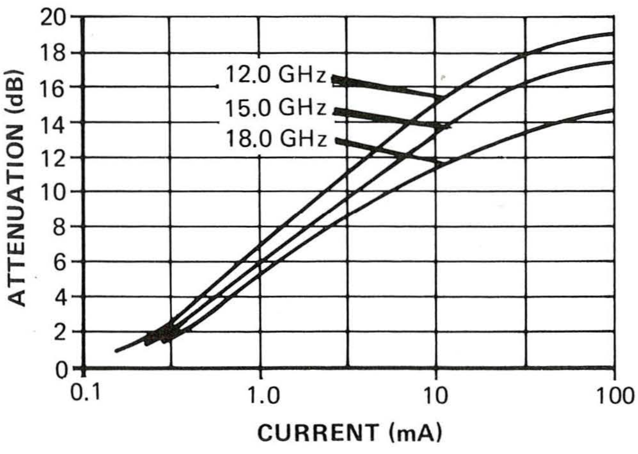


Typical Modulator Performance

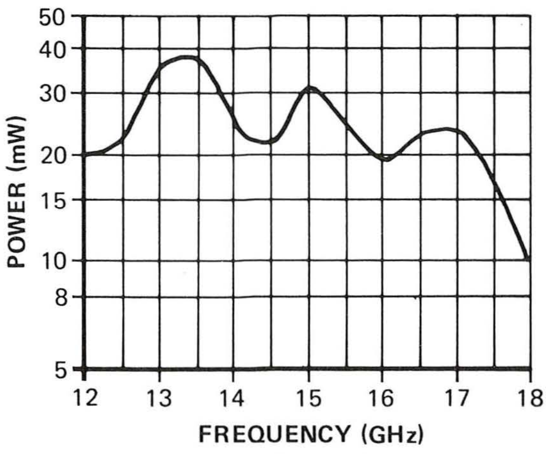


Typical Power Output

Type 6059A



Typical Modulator Performance



Typical Power Output

n

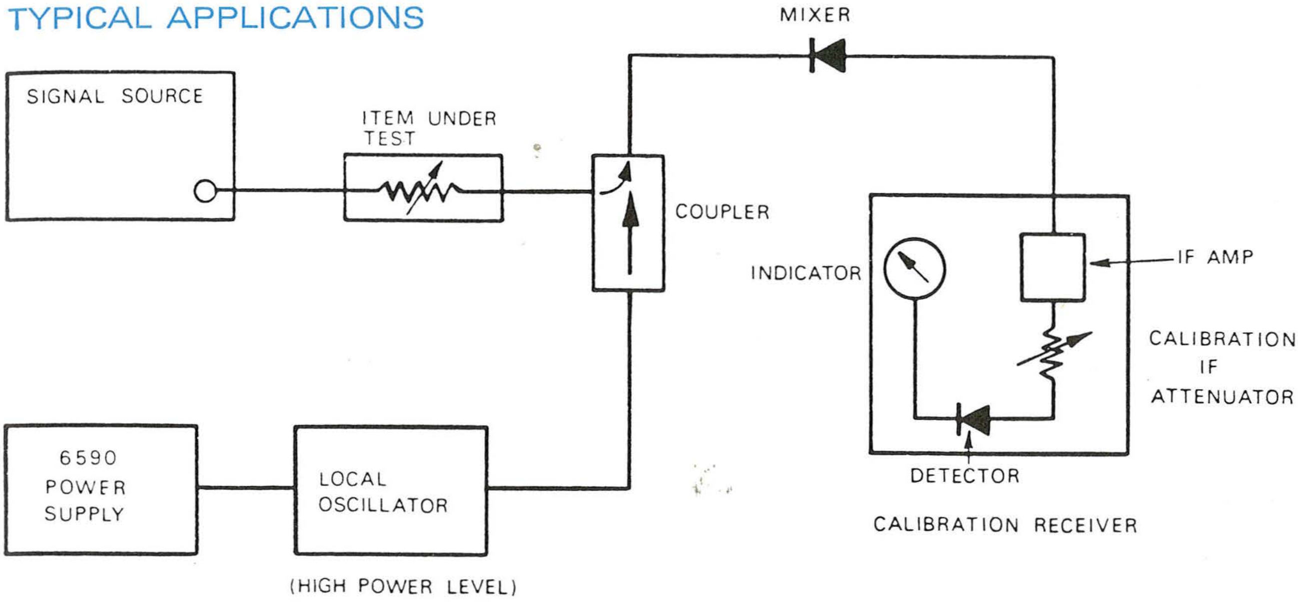
Type 6055B Series

SPECIFICATIONS

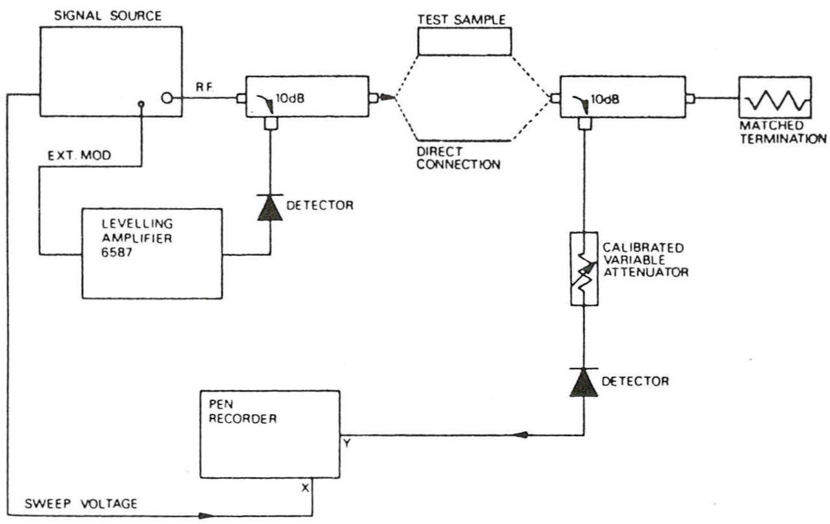
	TRANSISTOR FUNDAMENTAL OSCILLATORS			GUNN FUNDAMENTAL OSCILLATORS		
MODEL	6070A	6055B	6056B	6057B/1	6058B	6059A
FREQUENCY RANGE	400 to 1200 MHz	850 to 2150 MHz	210 to 4·0 GHz	4·0 to 8·0 GHz	8·0 to 12·5 GHz	12·0 to 18·0 GHz
R.F. POWER OUTPUT Minimum / Typical	50 mW 150 mW	10 mW 50 mW	10 mW 30 mW	5 mW 10 mW	20 mW 40 mW	5 mW 20 mW
FREQUENCY ACCURACY AT 22°C AND MAXIMUM R.F. POWER	±1% ①	±1%	±1%	±1%	±1%	±1%
FREQUENCY PULLING (Typical)	Effect of V.S.W.R. of 1·25:1 0·08% at 400 MHz 0·02% at 500 MHz 0·005% at 1000 MHz	Effect of V.S.W.R. of 1·25:1 0·01% at 1000 MHz 0·01% at 1500 MHz 0·01% at 2000 MHz	Effect of V.S.W.R. of 3:1 0·1% at 2 GHz 0·05% at 3 GHz 0·1% at 4 GHz	Effect of 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 V.S.W.R. of 3:1 0·09% at 8·0 GHz 0·06% 10·0 GHz 0·09% at 12·0 GHz	Effect of 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)	25 dB	20 dB	20 dB	20 dB	15 dB	10 dB
HARMONIC LEVEL Minimum / Typical	−20 dB −25 dB	−20 dB ② −30 dB	−20 dB ③ −30 dB	−20 dB −30 dB	−20 dB −30 dB	−20 dB −30 dB
AMPLITUDE MODULATION Internal depth (1 kHz ±100 Hz min)	100%	20 dB	20 dB	20 dB	15 dB	10 dB
External Depth	25 dB For 24 volts Input	20 dB For 20 volts Input	20 dB For 20 volts Input	20 dB For 100 mA Input	17 dB For 100 mA Input	14 dB For 100 mA Input
Rise Time	<1 μsec	<1 μsec	<1 μsec	<5 μsec	<5 μsec	<5 μsec
FREQUENCY STABILITY (Typical) ④ Short Term ⑤	0·001%	0·0015%	0·0015%	0·004%	0·003%	0·002%
Long Term ⑥	0·006%	0·006%	0·005%	0·007%	0·008%	0·009%
With Temperature ⑦	0·006%	0·006%	0·006%	0·007%	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.			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 **or battery operation**			100–120 or 200–250 volts, 50–60 Hz, 20 VA **or battery operation**		
DIMENSIONS AND WEIGHT	Height 98 mm $3\frac{7}{8}$ in; Width 203 mm 8 in; Depth 298·5 mm $11\frac{3}{4}$ in; Weight 3·4 kg 8lb			Height 98 mm $3\frac{7}{8}$ in; Width 203 mm 8 in; Depth 298·5 mm $11\frac{3}{4}$ in; Weight 4·0 kg $8\frac{3}{4}$lb		

① Except in the frequency range 400 to 550 MHz where the frequency accuracy is ±2%.
② −17 dB below 1000 MHz.
③ −15 dB below 2150 MHz.
④ After 1 hour warm-up in a constant environment.
⑤ Over a 5 minute period and with a settling time of 15 minutes, after the frequency change.
⑥ Over a 1 hour period.
⑦ Change per °C in the range +10°C to +50°C.

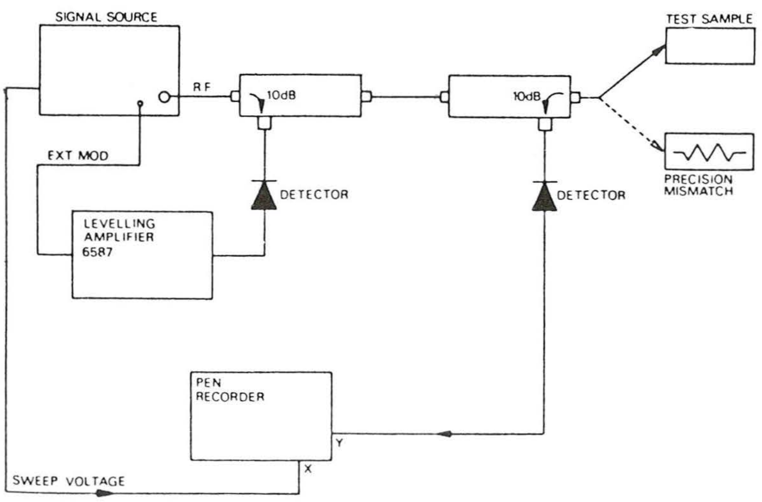
TYPICAL APPLICATIONS



High Attenuation Measurement



Transmission Loss Measurements



V.S.W.R. Measurements

AM-FM Signal Sources

- YIG Linearity
- AM and FM Modulation
- Electronic Sweep Capability
- 0·5% Frequency Accuracy
- L.E.D. Frequency Readout
- Phase-lock Capability

The 6150 series of microwave AM–FM Signal Sources is a range of tunable solid state instruments which use the MI Sander's designed YIG gunn oscillators, Type 6100 series, as active r.f. elements. The frequency ranges of the units are essentially wide band and are detailed on the table overleaf. The output frequency can be varied manually by a front panel potentiometer control or remotely via a rear panel BNC input. In both cases, an LED digital display indicates the frequency to 0·5% accuracy and offers excellent resetability and speed of operation.

The 6150 series offer significant advantages over mechanically tuned instruments and can be used as stable CW signal sources with minimal residual FM.

The YIG gunn oscillator is fitted with an FM coil with a wide input bandwidth and linear deviation capability. The input to this coil is independant of the main tuning coil and can be used for fine frequency control and external phase locking to achieve crystal stability.

The electronically tuned YIG gunn oscillator can be driven from an external control signal so that the inherent tuning capability can be used to remotely preset, step or sweep the microwave frequency. These capabilities make these signal sources ideal for systems applications.

All AM functions are performed by a PIN modulator fitted to the signal sources. This multi-function component can control the r.f. output level over a 20 dB dynamic range and can be used to apply AM from either the internal 1 KHz squarewave modulation circuit or from an external AM pulse input.

The 6587 levelling amplifier is compatible with these instruments and can be connected such that swept frequency signals can be produced with output levelling.

The signal sources produce a dc output voltage proportional to frequency, via a rear panel socket, which can be used to drive external recording devices such as X–Y pen recorders or display oscilloscopes. This facility is available in both the manual or externally controlled mode.

A mains selector switch on the instrument enables the units to be operated from either a 230V or 110V mains supply.

SPECIFICATIONS

MODEL	6158	6150
FREQUENCY RANGE	8·0—12·4 GHz	10·0—15·0 GHz
R.F. POWER OUTPUT Minimum Typical	 10 mW 20 mW	 10 mW 20 mW
FREQUENCY ACCURACY AT 20°C AND MAXIMUM R.F. POWER	0·5%	0·5%
FREQUENCY PULLING External Internal	 0·1% DUE TO 2:1 V.S.W.R. 0·1% DUE TO 10 dB CHANGE IN LEVEL CONTROL	 0·1% DUE TO 2:1 V.S.W.R. 0·1% DUE TO 10 dB CHANGE IN LEVEL CONTROL
FREQUENCY STABILITY (Typical) ① Short Term ② Long Term ③	 0·005% 0·01%	 0·005% 0·01%
SPECTRAL PURITY Residual f.m. Harmonic Content	 10 p.p.m. −25 dBc	 10 p.p.m. −25 dBc
R.F. LEVEL CONTROL (Internal and External) ④	 20 dB	 20 dB
AMPLITUDE MODULATION Internal Depth ④ (1 kHz ±100 Hz min) External Depth ④ Rise Time	 20 dB 20 dB for 20 Volts Input 1 μsec	 20 dB 20 dB for 20 Volts Input 1 μsec
FAST FM INPUT Deviation Maximum Rate	 ±20 MHz for ±10 Volt Input 100 kHz	 ±20 MHz for ±10 Volt Input 100 kHz
SWEEP CAPABILITY Input Maximum Sweeprate Output	 0 to +10 Volts for full sweep. Start frequency determined by frequency control setting. 100 Hz 0 to +10 Volts for full sweep, reduced for narrow band	 0 to +10 Volts for full sweep. Start frequency determined by frequency control setting. 100 Hz 0 to +10 Volts for full sweep, reduced for narrow band
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	Precision Stainless Steel 'N' Type Female 50 Ω	Precision Stainless Steel 'N' Type Female 50 Ω
POWER REQUIREMENTS	100–125 or 200–250 volts, 50–60 Hz, 50 VA	100–125 or 200–250 volts, 50–60 Hz, 50 VA
DIMENSIONS AND WEIGHT	Height 98 mm 3⅞ in; Width 270 mm 10½ in; Depth 254 mm 10 in; Weight 4·5 kg 10 lb	Height 98 mm 3⅞ in; Width 270 mm 10½ in; Depth 254 mm 10 in; Weight 4·5 kg 10 lb

① After 1 hour warm-up in a constant environment.

② Over a 5 minute period and with a settling time of 15 minutes, after the frequency change.

③ Over a 1 hour period.

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 of 20 dB.

tft Power Heads

- ☐ Frequency Range 10 MHz—40 GHz
- ☐ Type N, APC7 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

All the thin film thermoelectric (**tft**) ®* Power Heads can be used with the complete range of MI/Sanders **tft** Powermeters. These include the Type 6460 Powermeter, the Type 6550B Programmable Powermeter and the Type 6555 Powermeter, as well as the various system instruments.

Measurement of power levels as low as 0·03µW (−45dBm) can be made with the Type 6422. Direct reading power measurements as high as 3 watts (+35dBm) 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 10MHz to 18GHz.

A series of waveguide **tft** Power Heads are available from 8·2 to 40GHz with a mean power rating of up to 10mW.

18 GHz Coaxial tft Power Heads

The 6440 series is a new range of coaxial **tft** Power Heads which extends the operating frequency of the **tft** Powermeters to 18GHz. Low VSWR and compensated efficiency combine to provide precision power measurements at levels from 10mW to as low as 0·3µW.

Type N, APC7 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 0·01µW to 1mW and the Type 6423 covers the range 0·1mW to 3 watts, so that only these two coaxial Heads are required to cover the complete 80dB 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 0·1µW to 10mW and Type 6421 covers 1µW to 100mW.

All these coaxial Power Heads are suitable for frequencies ranging from 10MHz to 12·4GHz.

SPINNER 7/16 INPUT Connector for tft Head 6423-5

The 3 watt **tft** Power Head 6423-5 is fitted with the Spinner Type 7/16 input connector, in place of the Type N. It has a frequency range from 0·01 to 2GHz and has been specifically designed for the European Communication Authorities.

Waveguide tft Power Heads

Waveguide **tft** Power Heads covering the power range 0·3μW to 10mW are available in standard waveguide sizes for use over the frequency range 8·2GHz to 40GHz. These heads are fitted with square mating flanges. Details of performance, waveguide size, and frequency range of each of these Power Heads is 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.

With the Junction Box, Model 963R, multipoint power measurements with each of five **tft** Power Heads may be made by a single powermeter.

As the **tft** Power Head does not require any external bias or excitation supplies, its impedance characteristics remains unchanged whether or not it is connected to a powermeter, so that the r.f. loading is unaffected. No warmup or rezeroing is required when switching from one **tft** Power Head to another.

By cascading Junction Boxes larger numbers of **tft** Power Heads can be employed.

Programmable Junction Boxes are available to special order.

Field Replacement

In the event of failure of the **tft** Power Heads the following replacement procedures are available:–

1. Head Exchange Scheme

   Under this scheme a new, fully calibrated replacement **tft** Head will be shipped within 24 hours of the customer contacting the Technical Services Dept. The customer retains this unit and returns the original damaged **tft** Head for repair and is billed for relevant work. This means minimum down-time.

2. tft replacement Power elements

   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 2GHz. 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 dc output voltage.

(ii) CALIBRATION FACTOR is the ratio of audio reference power to RF power incident on the **tft** Head for the same dc output voltage.

tft®* Thin Film Thermoelectric

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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	0·01–18						1·5:1 from 0·01 to 0·015 GHz		SMA-male
6440N	0·01–18	0·3μW –35dBm	10mW +10dBm	1W	5	5	1·35:1 from 0·015 to 10 GHz	TL–4A	Type N male(2)
6440P	0·01–18						1·6:1 from 10 to 18 GHz		APC–7

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)
6440P 3·23"L × 1·28" Dia. (82,0 × 32,5 mm) (3)
Nett Weight: Approx. 3 oz. (35,1 gm)

(1) For MI Sanders Powermeter Type 6555 the lower power limit is increased by 20dB and Type 6550B the lower power limit is increased by 10dB. 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		0·3μW –35dBm	10mW +10dBm	3W	34	11		TL-0A	Precision Type N 50Ω male to MIL-C-39012
6421	0·01–12·4	3μW –25dBm	100mW +20dBm	30W	180	6	100MHz to 1GHz 1·1:1 10MHz to 5GHz 1·25:1 (I)	TL-1A	
6422		0·03μW –45dBm	1mW 0dBm	0·3W	2	7	5GHz to 12·4GHz 1·4:1 (II)	TL-2A	
6423		0·3mW –5dBm	3W +35dBm	60W	500	8		TL-3	
6423/5	0·01-2·0	0·3mW –5dBm	3W +35dBm	60W	500	8	100MHz to 1GHz 1·1:1 10MHz to 2GHz 1·3:1	TL-3	Spinner 7/16, 50Ω
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	0·3μW –35dBm	10mW +10dBm	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 in the range 10MHz to 15MHz where VSWR may rise to 1·75:1

(II) Except 6423 where VSWR from 11 to 12·4 GHz may rise to 1·7:1

Nett Weights: 6420, 6421, 6422: 1lb 2oz 505g
6423 2lb 2oz 975 g
6423/5 2lb 3oz 1kg
6425, 6426, 6427, 6428 1lb 10oz 800g

Educational Antenna Test Bench   Type 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.

The Educational Test Bench 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 with the 6452A/2 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 in the equipment so that each experiment can be constructed with ease.

Antennae 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 receive antenna.

The antennae are designed to operate at a frequency of 9·0GHz with the exception of the linear arrays which operate at 9·375GHz. All components are constructed in WG16 (R100), WR90 and are fitted with the internationally standardized square flanges.

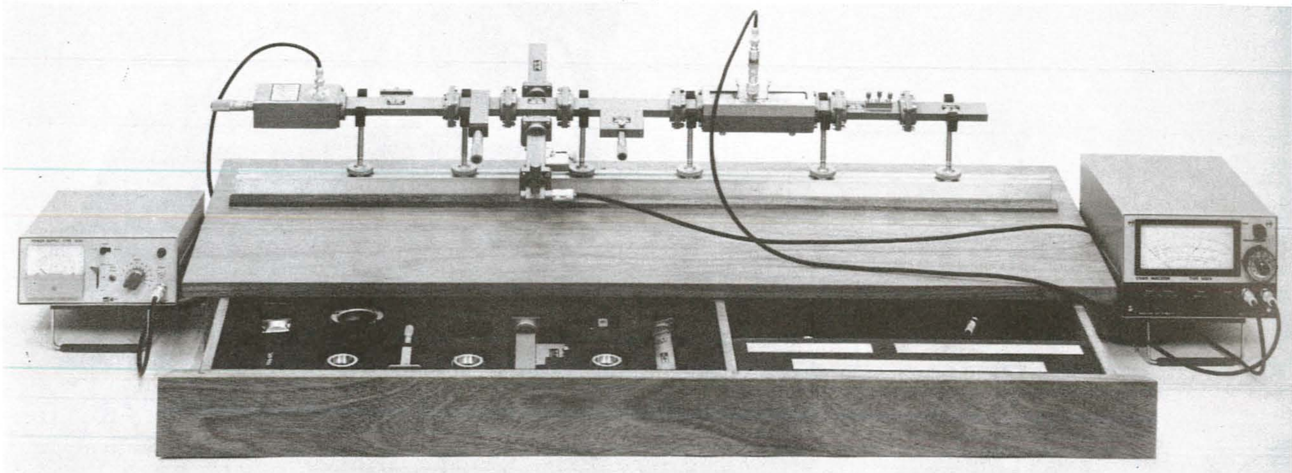
In order to complete the Test Bench a microwave signal source, a power supply and an indicating instrument are required. For most applications the Gunn Diode Oscillator Type 6061A together with its Power Supply Type 6590 and VSWR indicator Type 6593A are recommended.

Further equipment from the wide catalogue range offered by MI-Sanders 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.

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

Type 6599/2 Microwave Educational Test Bench

- ☐ 10 different experiments
- ☐ Rugged design
- ☐ Comprehensive handbook — experimental microwaves



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 to those suggested in the Instruction Manual. The components selected for this equipment are typical of those widely used in development and test departments so that students may get a good idea of the type of equipment being used throughout the microwave industry.

The 6559/2 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 by MI Sanders 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.

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 0-20dB
Type 6019/4	1	Glass Vane Precision Calibrated Attenuator 0-40dB 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 6037/3	1	WG/Coaxial Transformer
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	
Part No. 2139013-9"	1	Sections of straight waveguide
Part No. 2139012-12"	1	
Part No. 2139004		
Part No. 2139005	6	Waveguide Support Assemblies comprised from Part Numbers quoted
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.
Part No. 2139001	1	Polished Wood Storage Base with Soft Plastic Dust Cover

Thermoelectric Power Meter Type 6460

- ☐ Power measurement from 0.03 µW to 3 watts
- ☐ Instrumentation accuracy 1%
- ☐ Negligible noise and drift
- ☐ Temperature stability 0.1% per deg. C
- ☐ Frequency range 10 MHz to 40 GHz
- ☐ Coaxial and waveguide power heads
- ☐ Fast response
- ☐ Field replaceable **tft*** Power Head elements

The MI-Sanders 6460 is a thin-film microwave power meter combining the sensitivity and speed of bolometers with the accuracy and stability of a calorimeter. Among its other outstanding features are its very wide dynamic range, almost complete freedom from errors due to noise and drift, and virtually negligible sensitivity variation with temperature.

Its unrivalled performance has been achieved principally by the use, in the instrument's interchangeable power heads, of **tft*** dissipative elements formed by advanced thin-film techniques. Each element comprises an array of thermoelectric junctions which delivers a d.c. output e.m.f. that is linearly proportional to the r.f. power dissipated.

***tft**® Thin-Film Thermoelectric.

Type 6460

THE tft BREAKTHROUGH

Development of the **tft** (thin-film thermoelectric) power sensors marks a major advance in the technology of microwave power measurement, and has initiated a new generation of power meters having extremely wide dynamic range and excellent zero stability.

Hitherto, the thermistor-bridge system has been regarded as the most satisfactory method of power measurement at microwave frequencies. Although a higher order of accuracy is attainable with elaborate calorimetric instrumentation, the thermistor-bridge power meter offers considerable advantage, in terms of convenience and speed of operation, for measurement of true mean power, without the waveform and phase-angle errors of peak-voltage indicators such as diode detectors.

The **tft** Power Meter 6460, however, is as compact and convenient as the thermistor-bridge instrument, but provides a very much higher standard of measurement accuracy. Its stability is almost two orders better, and its temperature coefficient of only 0·1%°C is three orders better than can be achieved with thermistor power meters.

tft POWER METER

Wide Dynamic Range

The **tft** Power Meter, 6460 with its interchangeable power heads, cover a total dynamic range of 80 dB, with about 0·01 dB measurement discrimination for all but the lowest power levels.

Dissipated power is indicated on a taut-band mirror-scale panel meter, calibrated directly in terms of mean power and in decibels relative to its full-scale reading. Eight push-button selected sub-ranges give 35 dB variation in full-scale sensitivity in 5 dB steps, the absolute-power range being determined by the **tft** PowerHead used. Respective power heads cover each of the following full-scale-sensitivity ranges: 0·3 μW to 1 mW, 3 μW to 10 mW, 30 μW to 100mW, and 3 mW to 3 watts.

The Type 6460 features automatic scale selection, which ensures that only the scale corresponding to the sensitivity of the **tft** power head in use is activated.

Instrumentation Accuracy

The special circuit techniques employed minimise unwanted thermal e.m.f.'s, drift, and hum pick-up, to ensure an instrumentation accuracy of ±1% of full-scale on all measurement ranges.

Low Noise and Drift

Noise and drift are completely negligible on all but the lowest power range settings, where random changes in meter reading are perceptible, but do not normally exceed 1% (peak-to-peak) of full scale, unless the most sensitive power head is used, when peak-to-peak values of noise and drift may reach 2% of full scale.

Fast Response

Whereas calorimetric power meters of comparable accuracy require at least several minutes to yield final power readings, the time constant of the **tft** Power Head is only a few milliseconds. The overall response time of the Power Meter 6460 is normally of the order of 100 ms, so that it can conveniently be used as the indicator for tuning adjustments or similar applications where simple thermocouple type power meters cause difficulty.

For high-accuracy measurements at low power levels, however, a rather slower response has the advantage that it eliminates the effects of low-frequency noise from the power indication. Provision is therefore made for switching into the circuit an integrating network which increases the response time to about 1 second. This is sufficient to prevent errors in mean power reading due to random noise, but the response remains fast enough to follow normal fluctuations in r.f. power.

Simplicity of Use

Unlike instruments based on thermistor-bridge or bolometer-bridge power sensors, the Thermoelectric Power Meter requires no balancing or bias-current adjustments. It is as simple to operate as a conventional electronic voltmeter, the only pre-adjustment being that of normal zero setting. This is done with the instrument switched to maximum sensitivity, and no further zero adjustment is then necessary after any subsequent measurement-range selection. Zero adjustment is unnecessary when the instrument is used at lower sensitivity settings.

Multipoint Measurements

Junction Box, Model 963R – available as an optional accessory – permits rapid switching of a single 6460 Power Meter to each of five **tft** Power Heads.

With the Power Head's complete freedom from external bias or excitation supplies, its impedance characteristics remain unchanged whether or not it is connected to the Power Meter, so that the r.f. loading is unaffected. No warm-up or re-zeroing is required when switching from one Power Head to another, and the automatic range indication facilitates the use of any combination of Power Heads without ambiguity.

By cascading Junction Boxes larger numbers of **tft** Power Heads can be employed.

Remote Measurements

By use of extension cables the Power Meter may be operated at distances up to 120 metres (400 ft) from the **tft** Power Head, a feature which is very usefull when the measuring point is not easily accessible.

Recorder Output

A d.c. output directly proportional to the meter reading is available from a jack connection at the rear of the Power Meter.

This output level is also adjustable to suit the sensitivity of an external digital monitor or pen recorder. (0 to −1 volts full scale).

Battery Operation

The 6460 normally draws its energising power from the a.c. mains supply. Provision is made, however, for fitting a rechargeable battery pack, which is available as an optional accessory, a built-in mains operated battery charger being a standard feature of the instrument.

Ruggedized Case Versions

For field service applications the 6460 Power Meter is available as a 6460R in a double-skin ruggedized case, with front panel protective loops and top carrying handle. The 6460RL is the ruggedized version with a clip-on front panel cover.

tft POWER HEADS

Coaxial Power Heads

Four coaxial power heads of the 6420 series give respective measurement sensitivities corresponding to those given in the four columns of the Power Meter's indicator panel.

Coaxial Power Head type 6422 covers the measurement range 0·03 μW to 1 mW, and type 6423 covers the range 0·3 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 the intermediate sub-ranges; so two further **tft** Power Heads are available: type 6420 covers 0·3 μW to 10 mW, and type 6421 covers 3 μW to 100 mW.

The 6420 Series of coaxial Power Heads are designed for frequencies from 10 MHz – 12·4 GHz. The new 6440 Series of coaxial **tft** Power Heads extend the frequency of operation of the power meter 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, APC7 and SMA connectors are available on the 6440 series Heads.

Waveguide Power Heads

Waveguide **tft** Power Heads covering the power range 0·3 μW to 10 mW are available, in the standard wave-guide sizes, for use over the frequency range 8·2 GHz to 40 GHz. Details of performance, waveguide size, and frequency range of each of these Power Heads is given in the 6420 series table.

Burnout Protection

The **tft** Power Head is, of course, completely immune to burnout due to bias transients, which causes failure in thermistor and bolometer bridge types of sensor. It can also be connected to or disconnected from the 6460 Power Meter in all conditions without causing damage to the element.

Each **tft** Power Head is rated to withstand overloads of up to 300%, all elements being factory tested for a minimum of four hours continuous duty at 300% overload and an additional four hours at rated loading.

Field-Replaceable Power Elements

In the event of failure, **tft** elements may be replaced in the field, the procedure for doing so being described in the operating instructions for the **tft** Power Head.

ACCURACY IN POWER MEASUREMENT

The total uncertainty in measurements with thermo-electric power meters stems from four main sources of potential error, as follows:

(1) *R.F. losses and d.c.-microwave substitution error in the* **tft** *power head.* An *Effective Efficiency* control on the power head is adjusted to a calibrated setting appropriate to the power meter with which it is to be used.

(2) *Mismatch between* **tft** *power head and the micro-wave source.* The power meter is calibrated in terms of available power to a load giving unity v.s.w.r. The limits of uncertainty are determined by the v.s.w.r. of the **tft** head and of the source impedance. If either were equal to unity the mismatch error would be zero. Thus the uncertainty can be reduced considerably by improvement in source v.s.w.r.

(3) *Calibration standards.* The accuracy of any instrument obviously depends on the accuracy of the standards against which it is calibrated. All MI-Sanders standards are traceable to the most accurate available, and the limits of uncertainty for those used for calibration of **tft** power heads are given in the accompanying table.

(4) *Instrumentation error.* The limits of measurement uncertainty with the MI-Sanders 6460 Power Meter are ±1% f.s.d. on all ranges. This can be reduced to 0·5% by accurately monitoring the recorder-output voltage.

Limits of Uncertainty for Power Calibration Standards

Freq. GHz	Total Uncertainty [1]%	Probable Uncertainty [2]%
0·4	3·5	2·1
1	3·5	2·1
2	3·5	2·1
3	3·5	2·1
4	3·5	2·1
6	4·0	2·5
8	3·5	2·1
10	4·4	2·8
12·4	4·3	2·7

British Calibration Service

Each **tft** Head or **tft** Head/Power Meter combination can be calibrated in our Microwave Standards Laboratory which is approved within the British Calibration Service. The accuracy of the resultant calibration depends upon the current B.C.S. approval, which for coaxial measurements can be as good as 2%. The B.C.S. Certificate issued is acceptable to all inspecting authorities within the U.K. and to most overseas. This service is now available at extra cost. Full details will be supplied upon request.

[1] *Including Uncertainty in Absolute Standard plus Transfer Uncertainty.*

[2] *Square root of the sum of the individual uncertainties squared.*

POWER RANGES	Fifteen ranges in four overlapping scales, with f.s.d. of:

μW	dBm	dBm	Watts		dBm
0·3	−35	1	0	1	+30
1	−30	3	+5	3	+35
3	−25	10	+10		
10	−20	30	+15		
30	−15	100	+20		
100	−10	300	+25		
300	−5				

ACCURACY	±1% f.s.d. on all ranges from 0°C to +55°C
NOISE AND DRIFT	Less than 1% f.s.d. on lowest range (except for the highest sensitivity position, where it may rise to 2% peak), at constant ambient temperature, correspondingly less on higher ranges.
TEMPERATURE COEFFICIENT	Less than 0·1% per deg. C, using any **tft** Power Head.
FREQUENCY RANGE	10 MHz to 40 GHz, depending on the **tft** power head in use.
RESPONSE TIME	100 ms approz. or less than 1 second.
RECORDER OUTPUT	Proportional to indicated power (−1 volt corresponding to full scale ±0·5% of f.s.d.) 1000 Ω output impedance, or adjustable d.c. output (0 to −1 volt f.s.d.) for recorder use.

INPUT CONNECTORS	Two provided, one on front panel and one at the rear.
METER	4½" mirror scale, taut-band suspension.
POWER REQUIREMENT	115/240V ±10%. 50-400 Hz, 5 watts. Mains connector to CEE 22 (BS.4491).

DIMENSIONS AND WEIGHT

Height	Width	Depth	Weight
185 mm	200 mm	350 mm	4 kg
7¼ in	8 in	13¾ in	9 lb

ACCESSORIES

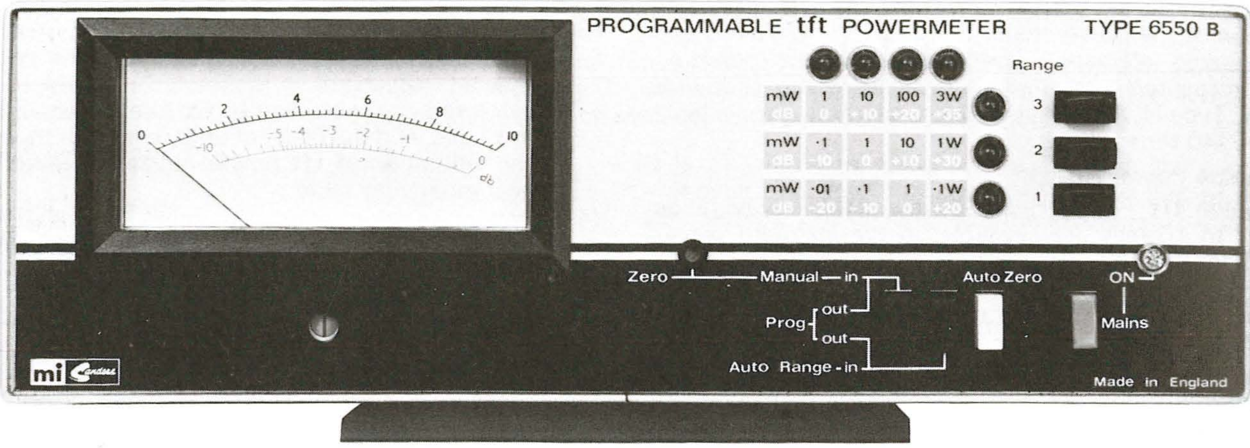
	Model	
Supplied		Power cable 2·50 m (8 ft) long.
Optional	3058	Calibrator – Provides all required calibration voltages for type 6460.
	2200186	Rechargeable Battery Pack – Permits portable or field use of type 6460. Providing up to 16 hours operation.
	963R	Junction Box – Each permits operation of up to five **tft** power heads with one type 6460. They can be cascaded.
	3850001	Rack Adaptor (19"). Permits rack mounting of the type 6460 by itself, or with any other MI unit packaged in the half-rack configuration.

SPECIAL VERSIONS

6460R	Ruggedized case version of 6460 Powermeter with top carrying handle.
6460RL	Powermeter 6460R with clip-on front panel protective cover.

Type 6550B Programmable tft Powermeter

- ☐ BCD Programmable ranging
- ☐ Automatic range and scale selection
- ☐ Auto-zero
- ☐ Power measurement from 1μW to 3 Watts
- ☐ Frequency 10 MHz to 40 GHz
- ☐ Field replaceable **tft** Power Head elements



The 6550B Thermoelectric Power Meter is a highly accurate instrument which will measure radio frequency power over a wide frequency and power range. It is used in conjunction with the 6440/6420 series of **tft** ®* Power Heads covering frequencies between 10MHz and 40GHz and input power ranges from 1μ Watt (−30 dBm) to 3 Watts (+35 dBm).

The instrument measures and indicates the true mean power absorbed by the **tft** heads which can accept amplitude and frequency modulated, pulse and CW signals.

The 6550B features manual, automatic or programmable ranging (by BCD coded signals) as well as an auto-zero facility. A rear panel analogue output is fitted so that an external recorder or digital voltmeter can be operated.

Extension cables for the **tft** Power Heads are offered and can be used at distances up to 120 metres (400 ft) from the 6550B Power Meter. Rack-mounting kits for 19″ cabinets are also available.

POWER RANGES	1mW **tft** heads: 1mW (OdBm) to 1μW (−30dBm). 10mW **tft** heads: 10mW (+10dBm) to 0·01mW (−20dBm). 100mW **tft** heads: 100mW (+20dBm) to 0·1mW (−10dBm). 3W **tft** head: 3W (+35dBm) to 10mW (+10dBm).
FREQUENCY RANGE	10MHz to 40GHz depending on the **tft** Power Head used. See page 240
ACCURACY	±2% fsd on all ranges on meter (+10 to +50°C.). ±1/2% fsd on all ranges at analogue output from +10 to +50°C.
NOISE	Less than ±0·75% peak to peak on lowest range, less on higher ranges.
PROGRAMMABLE RANGING	BCD code (1248) command for operating ranges. TTL compatible.
AUTO-RANGING AND SCALING	Fully automatic ranging and scaling to most significant range.
ZERO SETTING	Manual or automatic zeroing operated by either front panel control or remotely programmable (Range 'O'). Internal relay change-over contacts available (250V, 5A a.c.) for disabling the RF source.
TEMPERATURE COEFFICIENT FOR **tft** HEADS	Less than 0·1% per deg C using all **tft** Power Heads. Up to 300% overload rating for all Heads.
TEMPERATURE COEFFICIENT FOR 6550B	Less than 0·1%/°C on range 3, 0·2%/°C on range 2 and 0·5%/°C on range 1 using any **tft** Power Head.
ANALOGUE OUTPUT	Calibrated analogue output giving −1V d.c. corresponding to fsd. Circuit protected against short circuits.
RESPONSE TIME	Range 3. 70mSec. Range 2. 100mSec. Range 1. 1·5 sec. approx.
INPUT CONNECTOR	One provided on rear panel.
METER RANGES	92mm scale, calibrated with 0 to 10 linear scale and 0 to −10dB scale. Meter protected against overload.
POWER REQUIREMENT	240V ±10%, 45-400Hz. Mains connector to CEE22 (BS4491).
DIMENSIONS AND WEIGHT	Height 98mm 3·86in; Width 269mm 10·6in; Depth 254mm 10 in; Weight 3kg 7 lb.

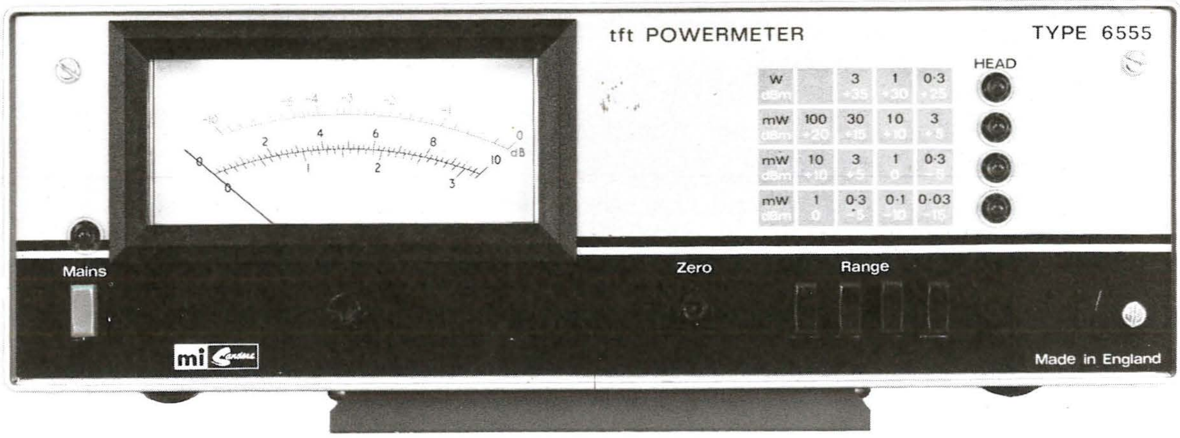
ACCESSORIES

Supplied		Power cable 2·50 m (8 ft) long.
Optional	Model 305B	Calibrator – Provides all required calibration voltages for type 6555.
	963R	Junction Box – Each permits operation of up to five **tft** Power Heads with one type 6555. They can be cascaded.
	3850001	Rack Adaptor (19 in) – Permits rack mounting of the type 6555 by itself, or with any other MI unit packaged in the 2/3 rack configuration of the same height.

tft ®* Thin Film Thermoelectric.

tft Powermeter Type 6555

- ☐ Power measurement from 3μW to 3 Watts
- ☐ Instrumentation accuracy 2%
- ☐ Frequency 10 MHz to 40 GHz
- ☐ Field replaceable **tft** Power Head elements



The 6555 Thermoelectric Power Meter is an accurate yet economically priced instrument which will measure radio frequency power over a wide frequency and power range. It is used in conjunction with the 6440/6420 series of **tft** ®* Power Heads covering frequencies between 10 MHz and 40 GHz and input power ranges from 3μ Watts (−25 dBm) to 3 Watts (+35 dBm).

The instrument measures and indicates the true mean power absorbed by the **tft** heads which can accept amplitude and frequency modulated, pulse and CW signals.

The 6555 has four manually operated power ranges and is fitted with a rear panel analogue output so that an external recorder or digital voltmeter can be operated.

Extension cables for the **tft** Power Heads are offered and can be used at distances up to 120 metres (400 ft) from the 6555 Power Meter. Rack-mounting kits for 19″ cabinets are also available.

POWER RANGES	Range 1: 0·03 mW (−15 dBm) to 1·0 mW (0 dBm). Range 2: 0·3 mW (−5 dBm) to 10 mW (+10 dBm) Range 3: 3·0 mW (+5 dBm) to 100 mW (+20 dBm). Range 4: 300 mW (+25 dBm) to 3 W (+35 dBm).
ACCURACY	±2% fsd on all ranges on meter from 0 to +50°C. ±1% fsd on all ranges on analogue output from 0 to +50°C.
NOISE	Less than 0·5% fsd on most sensitive range, less on higher ranges.
ZERO DRIFT	Less than 0·03% full scale per deg. C on least sensitive range. Proportionally more on lower ranges.
TEMPERATURE COEFFICIENT FOR **tft** HEADS	Less than 0·1% per deg. C using any **tft** Power Head. 300% overload rating for all Heads.
FREQUENCY RANGE	10 MHz to 40 GHz depending on the **tft** Power Head used.
RESPONSE TIME	70 mSec on all ranges.
RECORDER OUTPUT	Proportional to indicated power (−1 volt d.c. corresponding to full scale). 100 Ω output impedance.

INPUT CONNECTOR	One provided on rear panel.			
METER	3·625 in scale, calibrated with 3 & 10 linear scales and dBm scale. Taut band suspension.			
POWER REQUIREMENT	240 V ±10%, 45-400 Hz. Mains connector to CEE22 (BS4491) 115 V by internal link.			
DIMENSIONS AND WEIGHT	Height	Width	Depth	Weight
	98 mm	269 mm	185 mm	2·3 kg
	3·86 in	10·6 in	7·3 in	5·0 lb

ACCESSORIES

Supplied		Power cable 2·50 m (8 ft) long.
Optional	Model 305B	Calibrator – Provides all required calibration voltages for type 6555.
	963R	Junction Box – Each permits operation of up to five **tft** Power Heads with one type 6555. They can be cascaded.
	3850001	Rack Adaptor (19 in) – Permits rack mounting of the type 6555 by itself, or with any other MI unit packaged in the 2/3 rack configuration of the same height.

tft ®* Thin Film Thermoelectric.

Type 6587 Levelling Amplifier

- Reduces signal level variations of 20 dB to ± 0·1 dB
- May be used with any oscillator
- Amplitude modulation facility
- Straightforward operation

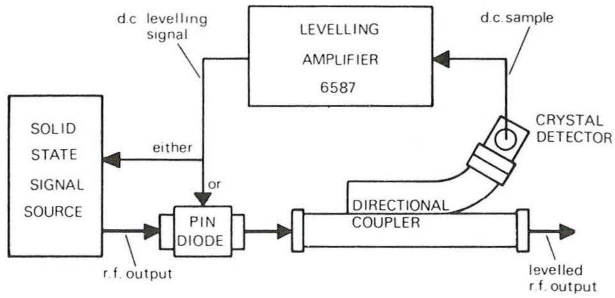
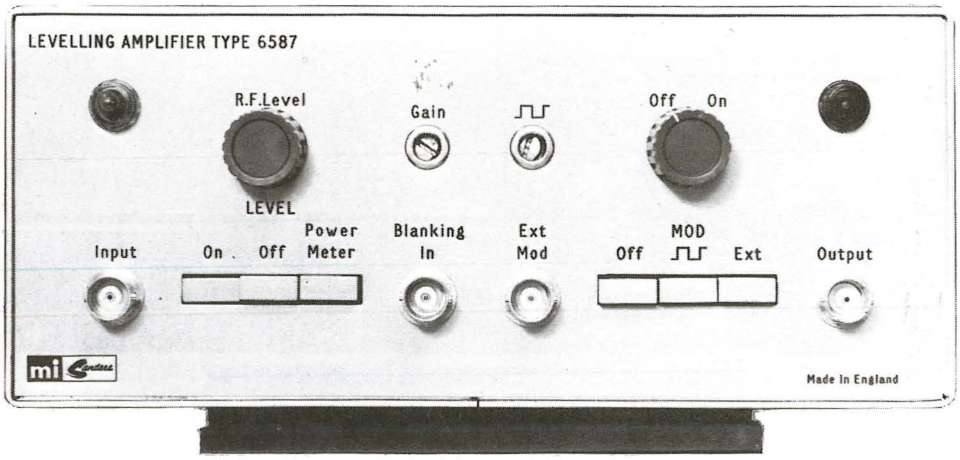


Fig 1 Typical Levelling Loop



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 (fig. 1). 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 B.N.C. 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 supression 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 thermistor-type power meter as the d.c. sample source in place of the crystal detector. The power meter (placed in the same position as the crystal detector shown in fig. 1) 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. A list of suitable PIN diode modulators will be found in the specification table. Coaxial and waveguide directional couplers are also available.

Each of the MI-Sanders Signal Sources, type 6055B series, incorporates an internal PIN diode modulator in its r.f. output circuit 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	Width	Depth	Weight
	85 mm	200 mm	255 mm	1·8 kg
	$3\frac{1}{4}$ in	8 in	10 in	4 lb

RECOMMENDED ANCILLARY EQUIPMENT		
Solid state signal sources	Type 6070A,	400–1200 MHz.
	Type 6055B,	850–2150 MHz.
	Type 6056B,	2·0– 4·0 GHz.
	Type 6057B/1	4·0– 8·0 GHz.
	Type 6058B,	8·0–12·5 GHz.
	Type 6059A,	12·0–18·0 GHz.

Power Supply Type 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 MI-Sanders Gunn Diode Oscillator type 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	50 to 250 mA.
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.

DIMENSIONS AND WEIGHT

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)

Type 6593A V.S.W.R. Indicator

- High sensitivity: 0·5 μV F.S.D.
- Dual channel inputs
- Expanded VSWR scale
- Large meter
- 70 dB attenuator

The voltage Standing Wave Ratio Meter Type 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 R.M.S., F.S.D. A rear-panel bolometer input is also provided which has an input sensitivity of 0·15 μV R.M.S., F.S.D.

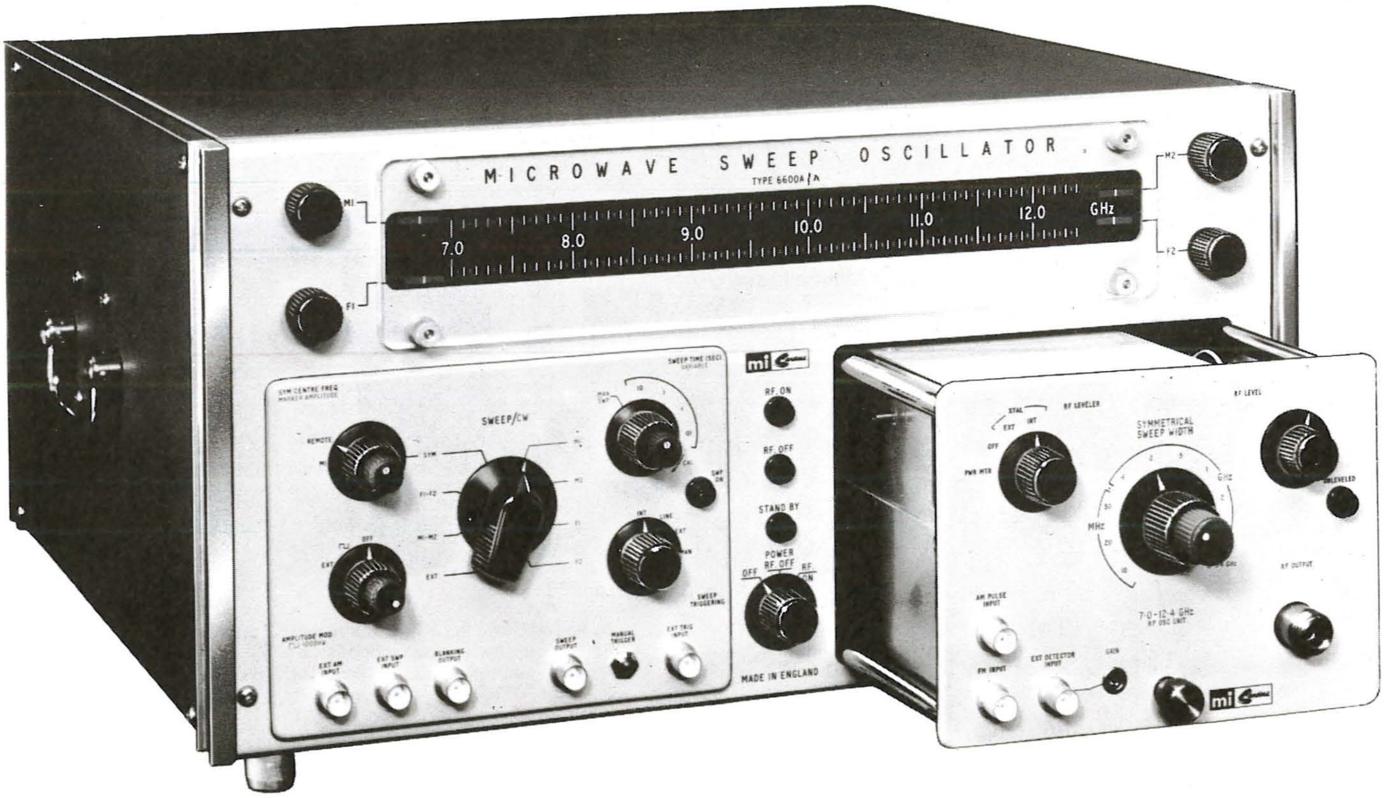
The EXPANDED V.S.W.R. scale is included to enable V.S.W.R.'s between 1·01 and 1·3 to be measured with high resolution and an additional scale is provided to measure V.S.W.R.'s up to 20:1.

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 R.M.S. for F.S.D. on channels A and B. 0·15 μV R.M.S. for F.S.D. 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	
A.C. mains	115 or 230 V a.c. 50 to 60 Hz.
DIMENSIONS AND WEIGHT	Height Width Depth Weight 140·5 mm 202 mm 284 mm 2·64 kg 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.

Microwave Sweep Oscillator Type 6600A/1

- ☐ 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



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.

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Type 6600A/1

All plug-in RF units are fitted with a levelling amplifier which is connected either to the appropriate grid of the BWO tube or to a Pin Diode Modulator, where fitted. This means that external levelling, using a suitable wideband directional coupler and detector, can be obtained for any frequency band in the range.

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 changes in the control signal 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 can be fitted 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 the minimum power output 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 the harmonic component of a crystal oscillator.

This correction signal may be applied to the FM input socket which is DC coupled to the BWO helix. Since the input bandwidth of the external F.M. input is in excess of 5 MHz for BWO units operating between 1 and 40 GHz no problem will be presented in holding the frequency stability of the microwave source to that of the crystal oscillator.

The 6600A/1 sweep oscillator is compatible with commercially available pen recorders, display oscillo-scopes and network analysers. High accuracy measure-ments can therefore be made using the inherent stability and frequency accuracy available.

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 oscil-lators 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. 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	280 mm	340 mm	12 kg
	9 in	11 in	13½ in	26 lb

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 instantaneous frequency; 0 volts at low end and +18 to +42 volts (pre-settable) at high end.
BLANKING OUTPUT	20 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

	Height	Width	Depth	Weight
Basic unit	222 mm	438 mm	534 mm	20·4 kg
	8¾ in	17¼ in	21 in	45 lb
Plug-in oscillators	130 mm	178 mm	457 mm	5·4 to 8·1 kg
	5⅛ in	7 in	18 in	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. 400 Hz operation to special order.
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.
6600/31	Rack Mounting Kit.

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Plug-in Oscillator Units

		GRID LEVELLED				DIODE LEVELLED				
		Internal directional detector				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	±0·5	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	—	6676	—	—	—	—	—	—	BWO	50 Ω Type N Female
7–16	—	6677	—	—	—	—	—	—	BWO	50 Ω Type N Female

OTHER BANDS CAN BE OFFERED AS BWO BECOME AVAILABLE.

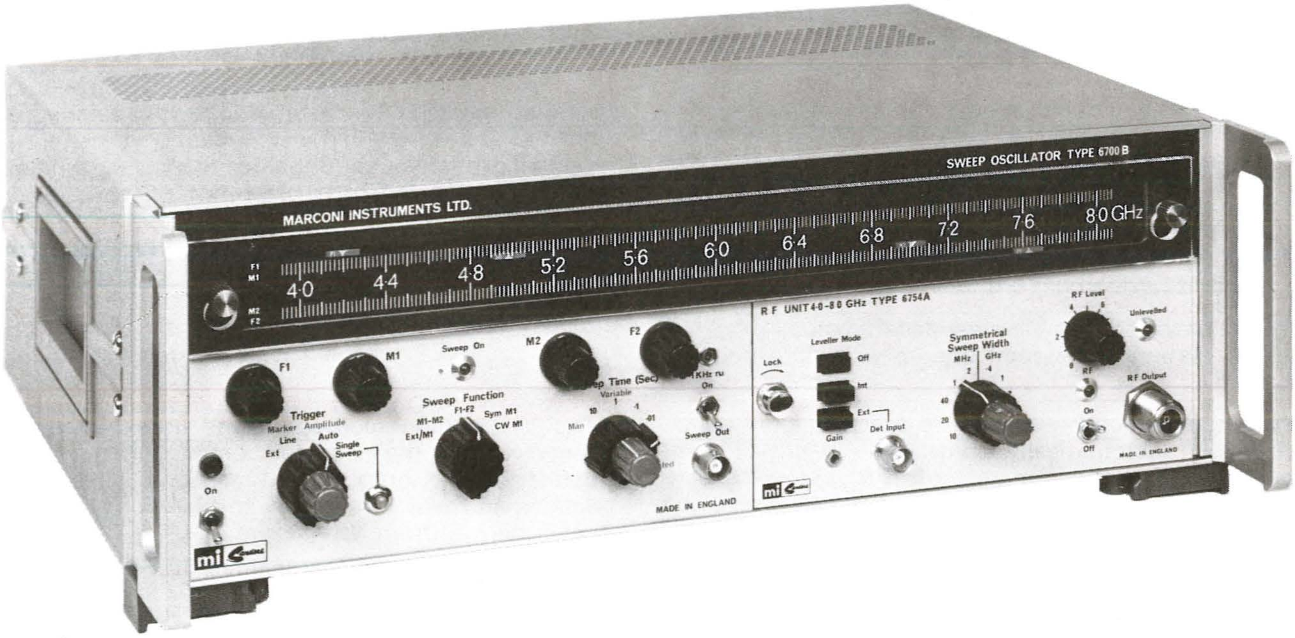
MILLIMETRIC OSCILLATOR UNITS

40–60	3	6654	—	—	—	—	—	—	BWO	Round flange
60–90	3	6655	—	—	—	—	—	—	BWO	Round flange
33–50	10	6659	—	—	—	—	—	—	BWO	Round flange
50–75	4	6671	—	—	—	—	—	—	BWO	Round flange
75–110	3	6672	—	—	—	—	—	—	BWO	Round flange
33–50	4	6675[2]	—	—	—	—	—	—	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 1dB less when an internal directional coupler is fitted.
2. Special model designed for application where low Residual FM is imperative.

Microwave Sweep Oscillator Type 6700B

- ☐ Frequency range 10 MHz to 18 GHz
- ☐ Front entry plug-in oscillator units
- ☐ Low residual f.m. and a.m.
- ☐ Comprehensive modulating and programming facilities
- ☐ Calibrated 100% symmetrical sweep
- ☐ Full Multi Band network analyzer compatibility



The Type 6700B is an all solid-state Microwave Sweep Oscillator featuring plug-in versatility. Type 6700B/1 mainframe is also available but cannot be fitted with the digital remote frequency programming facility (option 01).

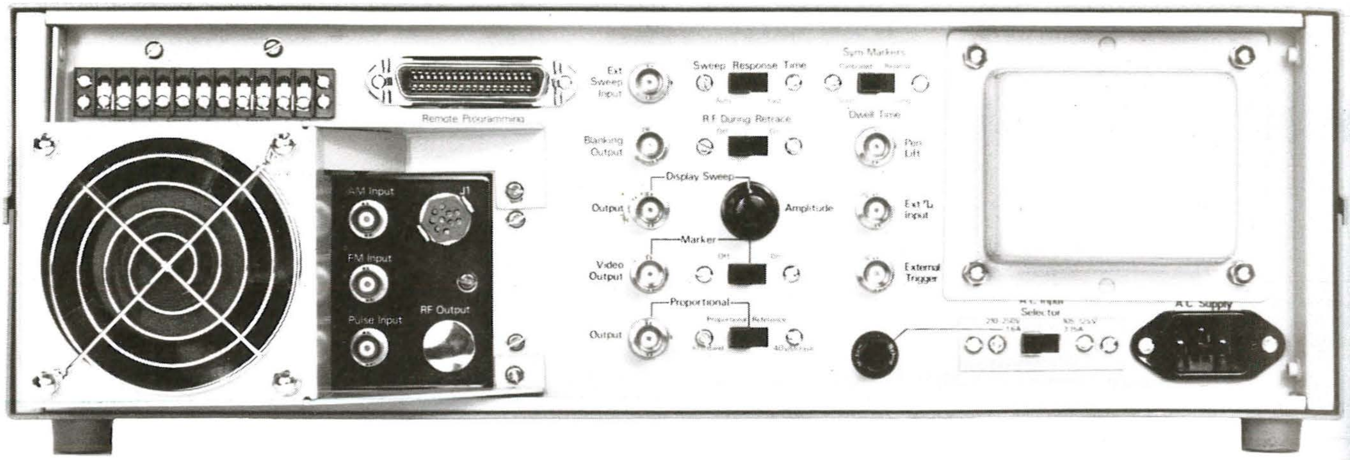
This high performance sweeper, with its r.f. units, provides stable, multi-decade coverage down to 10 MHz with exceptionally low spurious and harmonic content and provides continuous coverage to 18 GHz.

The r.f. units contain all the frequency-related circuitry of the system, such as r.f. oscillators, modulators and directional couplers for internal levelling. Each r.f. 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. The layout of all the controls is designed for functional simplicity and operator convenience. Many facilities which are only occasionally used are to be found on the rear panel, leaving the front as uncomplicated as possible.

Two pairs of controls, adjacent to the frequency scale, set 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 Sweep Function switch. For applications where Symmetrical sweep is preferred, this is continuously adjustable from 0 to 100% of the band or can be set to any of nine discrete calibrated sweep widths from 0·25% to 100% of the available band. Most r.f. units are available with push-button controlled internal levelling. External levelling capability is standard on all r.f. units.

All models have low residual f.m., typically 2 kHz peak for the 2 to 4 GHz range. Residual a.m. is typically 60 dB down for most models.

The Type 6700B has, as standard, three unique circuits that automatically perform functions which are manual



operations on other sweepers. The tuning supply bandwidth circuit automatically adjusts the bandwidth for lowest possible residual f.m. regardless of sweep rate; the external detector input circuit automatically sets the power levelling loop to the proper input polarity for external crystal detectors and power meters, and the power levelling loop gain circuit automatically adjusts the leveller-loop gain for optimum levelling of a given power setting.

The 6700B mainframe has several unique features provided on the rear panel to increase the versatility of the instrument.

Sweep output is provided on the rear as well as the front panel for convenience in rack cabinets. R.F. units protrude through the rear of the mainframe to provide rear-panel access.

In addition to a proportional sweep of 10 volts/band, a reference sweep of 40 volts/octave may be selected, providing a programming signal for phase locking compatability with network analyzers.

Pre-sweep Dwell-time may be switched to LONG (3 mSecs minimum—essential when used with Network Analysers) or to SHORT (to minimise brilliance of pre-sweep spot on oscilloscope display).

R F PLUG-IN UNITS. 10 MHz to 18 GHz.

The design approach to the r.f. units for the Type 6700B employs numerous integrated circuits to achieve excellent performance, long-term reliability and compact size. The oscillators are varactor tuned from 10 MHz up to 2 GHz and YIG-tuned from 2 GHz to 18 GHz.

The YIG tuning method results in excellent tuning linearity without the need for complex shaping circuits. Extremely stable outputs that are unaffected by load variations and which have low spurious content are also benefits derived from YIG tuning.

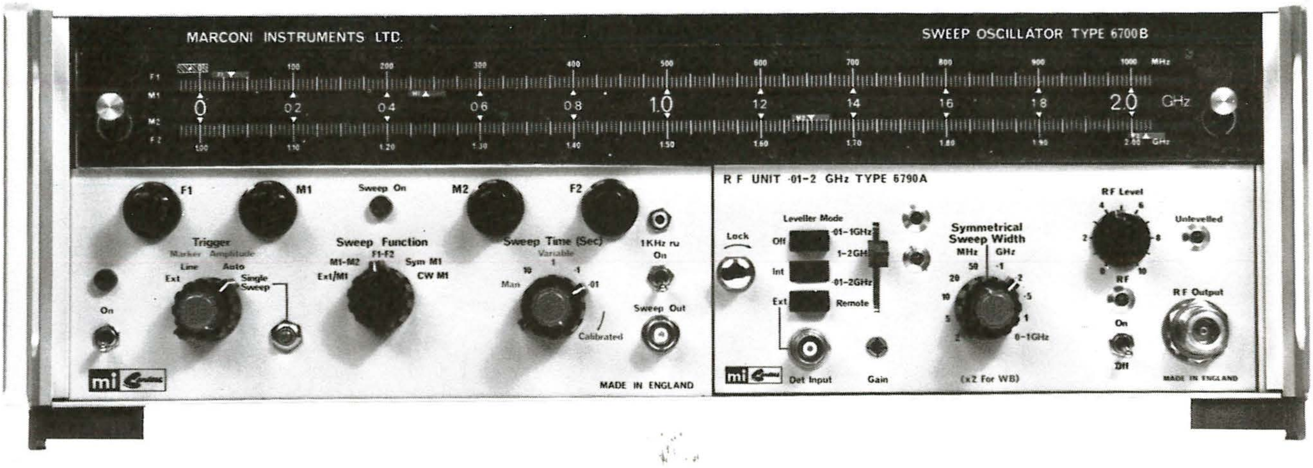
The full range of oscillator units available is given in tabular form with specifications.

A front panel switch on the R F Units permits complete cut off of the r.f. output power. In addition to the front panel switch, an R F ENABLE (On/Off) input is provided on the rear panel for digital remote control.

The frequency can be stabilized by a feedback phase-lock loop provided by a frequency synchronizer or synthesizer, either at a desired frequency or an i.f.-offset frequency. R F units having wideband f.m. input capability (d.c.–1 MHz) have exceptionally good spectral purity when phase locked, in addition to highly stable average frequency.

The frequency markers in the symmetrical sweep mode can be either calibrated or relative to the sweep width. The width of the relative marker is maintained proportional to whatever sweep width is selected. The relative marker is normally selected when sharp, bright markers are desired for very narrow-band sweeping.

Digital remote frequency programming, mainframe option 01 (not available for mainframe type 6700B/1) allows for 1000 point frequency resolutions from a 12 line b.c.d. input. An additional input line permits storing in memory any one digital word (frequency) on the 12 line input. The R F ENABLE input, a standard feature, permits remote on/off control of the r.f. output power.



MULTIBAND PLUG-IN 0·01–2·0GHz.

The 6790A Plug-in r.f. unit, in conjunction with the 6700B Sweep Oscillator mainframe, provides frequency coverage from 10 MHz to 2·0 GHz.

Frequencies between 10 MHz—1 GHz are generated using a heterodyne technique while the 1—2 GHz band is generated by a varactor tuned fundamental oscillator.

Full band sweep from 10 MHz to 2 GHz is achieved by sequentially sweeping the two bands available and automatically multi-plexing the outputs.

Internal levelling over the whole frequency band is fitted as standard and the Plug-in gives a minimum levelled power output of +13 dBm (20 mW). The total frequency excursion can be achieved in 13 msec.

Power variation in the levelled mode is less than ±0·5 dB over the entire frequency range.

The Plug-in unit offers both low peak residual f.m. and residual a.m. The unit can be amplitude and frequency modulated by external signals and with suitable ancillary equipment, can be phase locked.

Excellent narrow band resolution is achieved since three frequency scales are provided covering the hetero-dyne, the fundamental and the multiplexed modes.

High accuracy measurements can be made using the inherent high stability and frequency accuracy available

FREQUENCY CHARACTERISTICS:	
Range: Three switchable bands: (can also be remotely selected)	10MHz to 1GHz (heterodyne mode) 1 to 2GHz (fundamental mode) 10MHz to 2·0GHz (multiplexed mode)
usable:	5MHz to 2·1GHz
Accuracy (25°C) all modes:	±10MHz
Linearity (typical):	±5MHz
STABILITY	
With temperature:	±600kHz/°C
With 10% line voltage change:	±10kHz
With 10dB power level change:	±1MHz
With 3:1 load VSWR (all phases):	±0·1%
Residual f.m. (CW mode):	5kHz peak
With time (after 1 hour warm up):	typically ±50kHz/10 min.
OUTPUT CHARACTERISTICS	
Minimum levelled power (25°C):	±13dBm (20mW)
POWER VARIATION	
Internally levelled:	±0·5dB
Externally levelled:	±0·1dB (excluding coupler and detector variation)

RESIDUAL AM IN 100kHz BANDWIDTH:	50dB below fundamental at maximum power.
SPURIOUS SIGNALS (below fundamental):	
Harmonics:	−20dB at +13dBm[1]
Non-harmonics:	−30dB: 0·01 to 0·85GHz −25dB: 0·85 to 1·0GHz −50dB: 1·0 to 2·0GHz
	1. Between 1·0 and 1·1 GHz this may rise to —17dB.
MODULATION CHARACTERISTICS:	
External AM	
Rise and fall time:	2μsec
Frequency response:	150kHz
RF on/off ratio:	40dB
Modulation sensitivity:	5dB/volt
Internal AM	
1kHz square wave: on/off ratio	40dB
RF blanking during retrace:	40dB
External FM:	
Maximum deviations for Modulation frequencies:	
DC to 100Hz:	full band
100Hz to 1kHz:	±100MHz
1kHz to 5MHz:	±5MHz
Sensitivity (typical):	10MHz/volt

Type 6700B

SINGLE BAND R.F. PLUG-INS

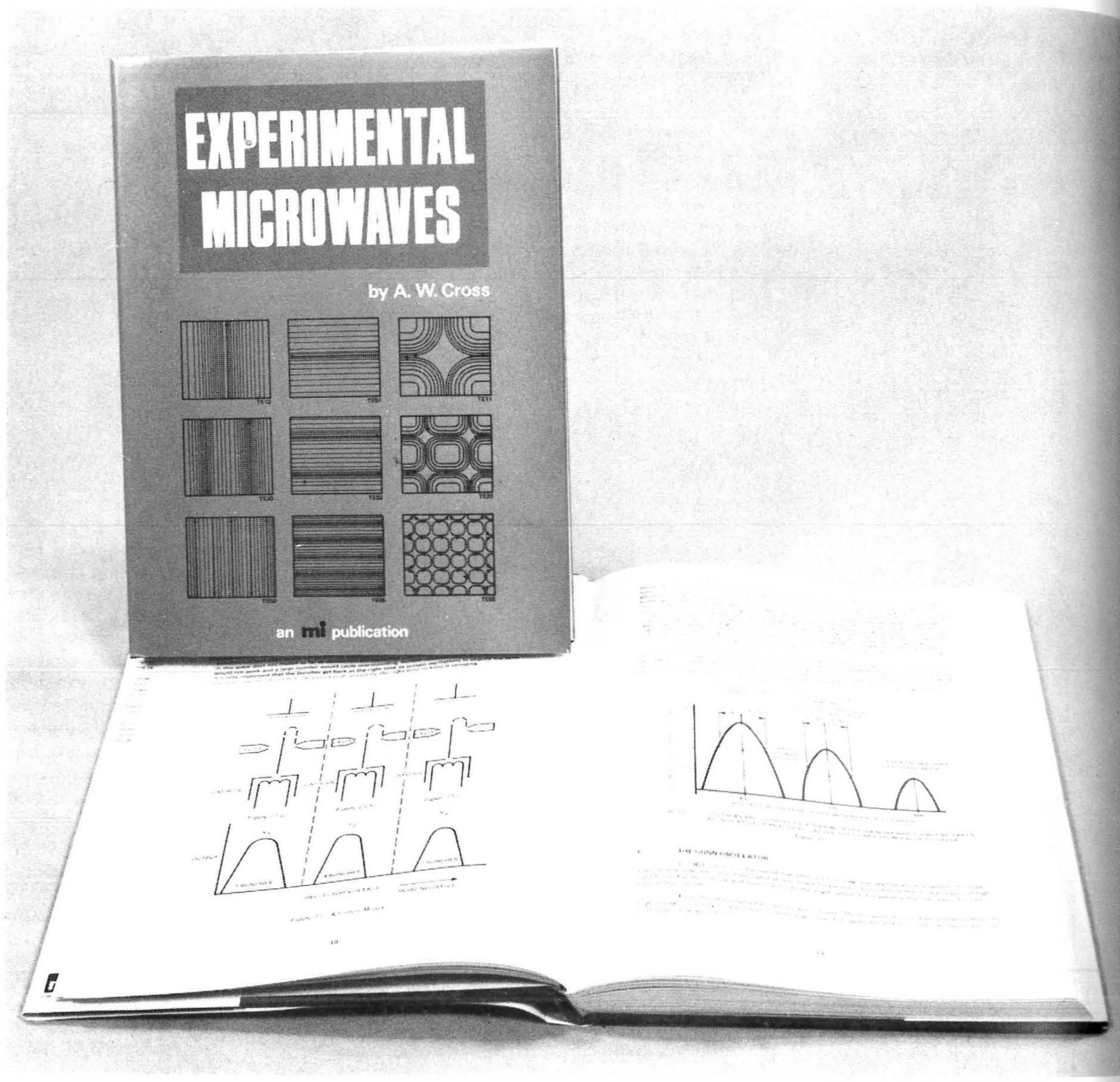
Specification with plug-in installed in 6700B	6730A	6738A	6742A	6754A	6760A	6766A	6770A	6774A
FREQUENCY RANGE (GHz)	1·0—2·0	1·7—4·3	2·0—4·0	4·0—8·0	7·0—11·0	8·0—12·4	10·0—15·0	12·4—18·0
FREQUENCY ACCURACY (at 25°C)	±0·5%	±0·5%	±0·5%	±0·5%	±0·5%	±0·5%	±0·5%	±0·5%
FREQUENCY LINEARITY (% sweep width)		0·25%	0·25%	0·25%	0·25%	0·25%	0·25%	0·25%
FREQUENCY STABILITY								
With temperature (1°C)	1MHz	500kHz	400kHz	750kHz	1·4MHz	1·4MHz	2MHz	3MHz
With 10% change of line voltage	10kHz	20kHz	20kHz	30kHz	40kHz	40kHz	50kHz	60kHz
With 10dB change of output power level	2MHz	1MHz	1MHz	1MHz	1MHz	1MHz	1·5MHz	2MHz
With 3:1 load V.S.W.R. (all phases)	±5MHz	±0·1%	±0·1%	±0·1%	±0·1%	±0·1%	±0·1%	±0·1%
POWER OUTPUT								
Minimum (at 25°C) with internal levelling (Option—1) see Note 1	20mW	10mW	20mW	10mW	10mW	10mW	10mW	6mW
Minimum (at 25°C) without internal levelling	25mW	15mW	25mW	12mW	12mW	12mW	12mW	8mW
POWER VARIATION								
Internally levelled (Option—1) see Note 1	±0·5dB	±0·5dB	±0·5dB	±0·5dB	±0·7dB	±0·7dB	±1·0dB	±1·0dB
Externally levelled (excluding coupler and detector variation)	±0·1dB	±0·1dB	±0·1dB	±0·1dB	±0·1dB	±0·1dB	±0·1dB	±0·1dB
PEAK RESIDUAL F.M.	5kHz	7kHz	7kHz	10kHz	25kHz	25kHz	25kHz	25kHz
PEAK RESIDUAL A.M.	−50dB	−50dB	−50dB	−50dB	−50dB	−50dB	−50dB	−50dB
SPURIOUS SIGNALS (dB below fundamental at specified max power)								
Harmonics	−20dB [4]	−15dB	−20dB	−20dB	−30dB	−30dB	−20dB	−30dB
Non-harmonics	−60dB	−60dB	−60dB	−60dB	−60dB	−60dB	−60dB	−60dB
MODULATION								
External F.M. input bandwidth.	d.c. −1MHz	d.c. −100kHz	d.c. −100kHz	d.c. −100kHz	d.c. −100kHz	d.c. −100kHz	d.c. −100kHz	d.c. −100kHz
Internal A.M. square wave on/off ratio.	40dB	40dB	40dB	40dB	40dB	40dB	40dB	40dB
NETT WEIGHT	2·0kg	2·2kg	2·2kg	2·2kg	2·3kg	2·3kg	2·3kg	2·6kg

NOTES:

1. Plug-ins with internal levelling (Option—1) include built-in directional coupler and detector. Refer to R.F. plug-in specifications.
2. Levelling loop bandwidth is 150kHz for all units
3. All 6700A series RF plug-in units except 6790A are compatible with the MI-Sanders Oscillator mainframe types 6700A, 6700B, 6700A/1 and 6700B/1. 6790A RF plug-in is only compatible with mainframes 6700B and 6700B/1.
4. Specified at +13 dbm. Between 1·0 and 1·1 GHz this may rise to −17 dB.

6700B Specifications

FREQUENCY RANGE	Determined by r.f. unit installed.
SWEEP FUNCTIONS	
Sweep end limits	Any two frequencies in band set by F1 and F2 controls. Sweeps in either direction from F1 to F2.
Marker end limits	Any two frequencies in entire band set by M1 and M2 controls.
Symmetrical sweep	Centre frequency set by either M1 control or an external 10 kΩ potentiometer. Sweep width adjustable from 0 to 100% of entire band with continuous, uncalibrated control, or in nine discrete widths calibrated directly in MHz or GHz, from about 0·25% to 100% of band. Width accuracy is ±3% of sweep width for YIG-tuned units; ±10% for varactor-tuned units.
External	Direct coupled 10 V for full sweep: positive voltage increases output frequency. Response time: down to 1 msec for full sweep. Provision for external resistance programming. Input impedance 5 kΩ.
C.W. operation	Continuously variable single frequency controlled by position of M1 marker. Externally controllable with either 10 kΩ potentiometer or an analogue voltage between 0 and +10V.
MARKERS	Two independent, adjustable calibrated markers displayed either as dips in r.f. output or externally as video markers. Constant proportion width marker selectable for sharp, bright marking in narrow-width symmetrical displays.
Accuracy	Same as r.f. unit frequency accuracy.
Resolution	Better than 0·05% of r.f. unit bandwidth.
Amplitude	Continuously variable.
Output	Auxiliary video marker: amplitude −5 V. Output impedance 5 kΩ.
TRIGGERED SWEEP MODES	
External	−10 V input initiates sweep.
Automatic	Sweeps recurs automatically.
Line	Line frequency triggers sweep.
Single sweep	Front panel momentary switch starts sweep.
SWEEP RATES	
Automatic	Four decade ranges continuously adjustable from 0·01 sec/sweep to 100 sec/sweep. Vernier has 10 to 1 range.
Manual	Three-quarter-turn control for sweep between limits set in either end-limit or symmetrical sweep modes.
Sweep dwell time	Delay at start to allow r.f. power level to stabilize. Also delay at end of sweep. Pre-sweep dwell may be switched to Long (for compatibility with Network Analysers), or Short for other applications.
SWEEP OUTPUT	Direct-coupled, constant amplitude sawtooth adjustable from +2V to +10 V peak, concurrent with swept r.f. output.
PROPORTIONAL OUTPUT	
Switch selectable	a. Direct-coupled voltage proportional to instantaneous frequency. 0 V at low end and 10 V at high end of band. b. Direct-coupled voltage proportional to instantaneous frequency. 0 V at low end and 40 V/octave at high end of band.
BLANKING	
Operation	R.F. automatically attenuated during retrace to provide base line except when disabled with rear panel switch.
Z-Blanking Output (rear panel)	Direct-coupled −5 V pulse: impedance 2·2 kΩ, covering the entire period between end of sweep and commencement of next sweep.
PEN LIFT OUTPUT	Relay contact closure during forward-trace portion of sweep.
R.F. OUTPUT	
Levelling	With internal levelling, power variation is as indicated for r.f. unit. With an external directional coupler and detector, power variation is maintained to within ±0·1 dB, plus coupler and detector variation. Provision for power meter levelling from + or − meter output. Levelling input impedance is 1 kΩ.
Amplitude	R.F. level controlled from front panel or with external 10 kΩ potentiometer or an analogue input voltage at rear panel.
R.F. Level ON/OFF	Front panel switch permits complete r.f. cut off. Rear panel binary input permits remote control.
MODULATION	
Amplitude modulation	*Internal:* Square wave adjustable from 950 to 1050 Hz with rise time of 10 μsec maximum. On/off ratio greater than 40 dB. *External:* +10 V signal increases r.f. output to rated level (with r.f. level control set at minimum). Rise and fall time 1 μsec unlevelled and 2 μsec levelled. Input impedance 10 kΩ.
Frequency modulation	Direct-coupled wide-band f.m. input with maximum deviation rate determined by r.f. unit.
SPURIOUS SIGNALS	60 dB below rated r.f. output, except 2nd harmonic which is 20 dB to 8 GHz and 30 dB from 8 to 18 GHz.
GENERAL	
Dimensions	145 mm high × 426 mm wide × 390 mm deep.
Weight (mainframe only)	10 kg. Nett
Power input	115/230 V ±10%, 48–62 Hz, approximately 100 VA.
OPTION—01 (not for 6700B/1)	Digital remote frequency programming.
Frequency resolution	1000 points (12-line, 3 digit BCD input).
Memory storage	Any one digital word (frequency) on 12-line input.
R.F. enable	1-line binary for on/off control (standard feature).
Logic	+5 V logic remote contact closure.



EXPERIMENTAL MICROWAVES

by A. W. Cross

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.

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Broad Band Detector-type 6000/3

Type No.	Frequency range in GHz	Flange fitted	Diode	Height	Length	Weight	Waveguide size
6000/3	9·2 to 12·4	Square UG39/U	CV2154 CV2155	57·9 mm (2·28 in)	63·5 mm (2·5in)	0·17 kg (6 oz)	R100 (WG16)

NOTE: Detectors 6003/3 and 6002 series are supplied less diodes, but those specified are available at extra cost.

Coaxial Detectors-type 6002 series

Type No.	RF input connector	Frequency range	Internal DC return	Type of diode required	Length	Width	Weight	Nato Stock No.
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)	
6002/3	C Male	200 MHz to 12 GHz	No	CV2154 CS9B CV2155	76·5 mm (3·01 in)	18·5 mm (0·73 in)	0·088 kg (3 oz)	5960–99–972–9266 when fitted with CV2155

Waveguide Detector-type 6003/3

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 type 6003/3 is supplied less diodes, but those specified are available at extra cost.

Short Circuit-type 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	Tuning	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-type 6006/2

The tuner is suitable for general lab. use where matches of up to about 10:1 are required to be reduced to a reasonable value.

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)

Grade 2 Waveguide Standing Wave Detector-type 6009/2

This instrument has been specially designed for use in educational and production establishments.

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)

Universal Slotted Line System-type 6010A & 6011 series

Incorporating Universal Probe Carriage Type 6010A and Slotted Waveguide Sections Type 6011 Series

These instruments collectively represent the most economic method currently available for achieving a universal range of extremely accurate and highly reliable Slotted Line Systems. A single precision probe carriage can be fitted to any one of a series of slotted waveguide sections, thus obviating the cost of duplicating this item. The probe carriage can be transferred from one waveguide section to another in a matter of seconds, so that the versatility is achieved with no significant increase in setting up time. The range of slotted waveguide sections available offers the very wide frequency coverage of 2·6 to 18 GHz, and all systems have been designed to conform to a laboratory standard accuracy.

Type No.	Waveguide Size	Flange Designation	Frequency Coverage GHz	Residual VSWR	Attenuation Slope dB/cm	A mm (inches)	B mm (inches)	C mm (inches)	D mm (inches)	E mm (inches)	F mm (inches)	Weight
6011/8	R32 (WG10), WR284)	Special 14 Hole	2·60–3·95	1·009:1	·001	546·1 (21·5″)	120·7 (4·75″)	139·2 (5·48″)	155·1 (6·11″)	80·5 (3·17″)	149·3 (5·88″)	7·2 kg (15¾ lb)
6011/7	R40 (WG11A, WR229)	To order	3·30–4·90	1·009:1	·0012	489·0 (19·25″)	120·7 (4·75″)	108·7 (4·28″)	87·3 (3·44″)	52·4 (2·06″)	98·4 (3·88″)	6·6 kg (14½ lb)
6011/6	R48 (WG12, WR187)	Round UG149/A	3·95–5·85	1·009:1	·0014	457·2 (18·00″)	120·7 (4·75″)	101·6 (4·00″)	95·3 (3·75″)	49·3 (1·94″)	92·1 (3·63″)	5·65 kg (11¼ lb)
6011/4	R70 (WG14, WR137)	Round UG344/U	5·85–8·20	1·009:1	·002	371·5 (14·63″)	120·7 (4·75″)	95·3 (3·75″)	85·7 (3·38″)	46·1 (1·82″)	79·4 (3·13″)	4·3 kg (9½ lb)
6011/3	R84 (WG15, WR112)	Square UG51/U	7·05–10·00	1·009:1	·002	330·2 (13·00″)	120·7 (4·75″)	92·5 (3·64″)	68·3 (2·69″)	44·5 (1·75″)	47·6 (1·88″)	3·74 kg (8¼ lb)
6011/2	R100 (WG16, WR90)	Square UG39/U	8·2–12·4	1·009:1	·003	330·2 (13·00″)	120·7 (4·75″)	92·5 (3·64″)	66·4 (2·61″)	45·8 (1·80″)	41·3 (1·63″)	3·18 kg (7 lb)
6011/10	R140 (WG18, WR62)	Square	12·40–18·00	1·009:1	·005	293·3 (11·55″)	120·7 (4·75″)	90·4 (3·56″)	61·2 (2·41″)	44·6 (1·76″)	33·3 (1·31″)	2·84 kg (5½ lb)

Grade 2 Wavemeters-type 6017/2

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 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)

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Grade 2 Calibrated Variable Attenuators-type 6019 series

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	12·5, 14·0, 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 UG40A/U	8·5, 9·0, 9·5, 10·0	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-type 6020 series

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 Attenuators-type 6021/5

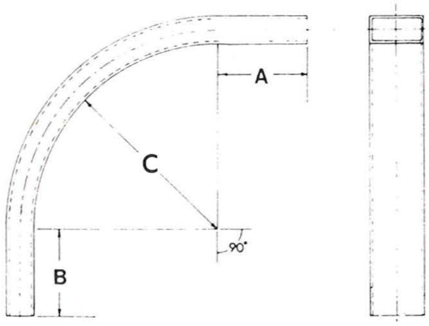
Type No.	Frequency range in GHz	Flange fitted	Input V.S.W.R.	Max. attenuator	Insertion Loss	Length	Width	Height	Weight	Waveguide size
6021/5	8·2 to 10·5	Square UG39/U	1·075:1	40 dB	0·1 dB	152·4 mm (6·00 in)	41·2 mm (1·62 in)	59·4 mm (2·34 in)	311 g (11 oz)	R100 (WG16)

Phase Shifters-type 6022/4

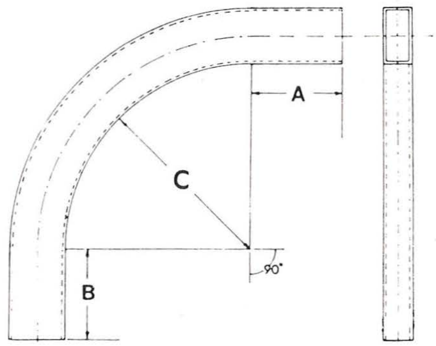
Type No.	Frequency range in GHz	Flange fitted	Minimum total phase Shift	V.S.W.R.	Calibration frequency in GHz	Length	Height	Weight	Waveguide size
6022/4	8·2 to 12·4	Square UG39/U	180°	1·20:1	10·5	152·7 mm (6·00 in)	107·9 mm (4·25 in)	425 g (15 oz)	R100 (WG16)

E Plane Bends-type 6025 series

Type No.	Frequency range in GHz	Flange fitted	Bend	Dimensions A	B	C	Weight	Waveguide size
6025/2	12·4 to 18·0	Square 5985–99–083–0030	E Plane	19·05 mm (0·75 in)	19·05 mm (0·75 in)	29·36 mm (1·156 in)	113·4 g (4 oz)	R140 (WG18)
6025/3	8·2 to 12·4	Square UG39/U	E Plane	33·32 mm (1·31 in)	33·32 mm (1·31 in)	23·65 mm (0·94 in)	212·6 g (7½ oz)	R100 (WG16)
6025/5	7·05 to 10·0	Square 5985–99–083–0034	E Plane	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)



Type 6025 series



Type 6026 series

H Plane Bends-type 6026 series

Type No.	Frequency range in GHz	Flange fitted	Bend	Dimensions A	B	C	Weight	Waveguide size
6026/2	12·4 to 18·0	Square 5985–99–083–0030 or UG419/U	H Plane	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	H Plane	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)

Waveguide Twists-type 6027/3

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 Couplers-type 6029/2

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 on)	76·2 mm (3·00 in)	59·1 mm (2·33 in)	340·2 g (12 oz)	R100 (WG16)

Multi-Hole Directional Couplers-type 6030 series

An extremely important waveguide component is the directional coupler, 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. Its 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.

6030A/10

Type No.	Frequency Range in GHz	COUPLING Nominal	Nominal Coupling Accuracy	Spread	V.S.W.R. Main-line	Side-arm	Flange fitted	Length	Height	Weight	Waveguide size
6030A/5	12·4–18·0	10 dB	±0·4dB	±0·5dB	1·06	1·1	Square 5985–99–083–0030	366·8 mm 14·44 in	79·5 mm 3·13 in	0·3969 kg 14 oz	R140 (WG18)
6030A/7	8·2–12·4	3dB	±0·4dB	±0·5dB	1·1	1·1	Round 5985–99–083–0004	581·0 mm 22·86 in	99·6 mm 3·92 in	0·9922 kg 2lb 0oz	R100 (WG16)
6030A/8	8·2–12·4	3dB	±0·4dB	±0·5dB	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	10dB	±0·4dB	±0·5dB	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)
6030A/12	8·2–12·4	20dB	±0·4dB	±0·5dB	1·04	1·1	Square UG39/U	376·2 mm 14·81 in	99·6 mm 3·92 in	0·638 kg 1lb 10oz	R100 (WG16)

Short Matched Terminations-type 6032 series

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 ($5\frac{1}{4}$ 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 ($8\frac{1}{4}$ 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 $1\frac{3}{4}$ oz)	R70 (WG14)
6032/7	2·6 to 3·95	Round 5985–99–083–0010	1·02:1	10W mean	244·5 mm (9·62 in)	2075 g (4 lb 9 oz)	R32 (WG10)

Broad Band Isolators-type 6033/3

Type No.	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: V.S.W.R. = 1.2 under matched load conditions.
NOTE 3: Flange mates with UG39/U OR 5985– 99-083-0052

Waveguide Horn type 6036/4

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-type 6037 series

Type No.	Frequency range in GHz	Flange fitted	Length	Weight	Waveguide size	Maximum V.S.W.R.
6037/1	12·0 to 18·0	Square 5985–99–083–0030	33·3 mm (1·31 in)	99·219 g (3½ oz)	R140 (WG18)	1·5:1
6037/2	8·5 to 12·0	Round 5985–99–083–0004	34·9 mm (1·37 in)	113·40 g (4 oz)	R100 (WG16)	1·5:1
6037/3	8·5 to 12·0	Square UG39/U	34·9 mm (1·38 in)	113·40 g (4 oz)	R100 (WG16)	1·5:1
6037/4	7·0 to 10·0	Square 5985–99–083–0034	43·3 mm (1·70 in)	170·1 g (6 oz)	R84 (WG15)	1·55·1
6037/5	5·85 to 8·2	Round 5985–99–083–0038	40·1 mm (1·58 in)	340·2 g (12 oz)	R70 (WG14)	2·0:1
6037/6	4·2 to 5·85	Round 5985–99–083–0042	55·2 mm (2·17 in)	0·533 kg (1 lb 3½ oz)	R48 (WG12)	1·5:1
6037/7	2·6 to 3·95	Round 5985–99–083–0010	97·6 mm (3·84 in)	1·304 kg (2 lb 14 oz)	R32 (WG10)	1·5:1

Waveguide Support Bench-type 6039/3 and 6040 series

Type 6039/3 Waveguide Support Bench

Type No.	Length	Features and Composition
6039/3	3ft	The bench consists of: 2 end plates 2 stainless steel rails

Type 6040 Carriage
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 Type 6042 clips or Type 6043 table.

Type 6041 Free Standing Support
A specially designed base casting permits close proximity support. This casting houses the same mechanism as the Type 6040 carriage and can be fitted with Type 6042 series clips or Type 6043 table.

Type 6042 series Support Clips
For use with Type 6040 and Type 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)

Type 6043 Instrument Table
For use with Type 6040 and Type 6041 supports

Suitable for supporting the large microwave instruments.

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Wide Band Detector-type 6060

FREQUENCY	
Range	10 MHz to 12·4 GHz.
Response	Flat within ±0·3 dB per GHz from 10 MHz to 12·4 GHz.
INPUT	
Impedance	50 ohms.
V.S.W.R.	Less than 1·5:1 over the full frequency range.
Maximum power	100 mW.
SENSITIVITY	
Unloaded	150 µV per µW up to 30 mV output.
With load resistor	50 µV per µW up to 100 mV output.
OUTPUT	
Capacitance	10 pF.
Polarity	Negative (Positive polarity to order or by reversing diode element.

CONNECTORS	
Input	Precision Type N male.
Output	Type BNC female.
CONSTRUCTION	
Body and Type N connector	Stainless steel.
BNC connector	Silver plate, rhodium flash.
DIMENSIONS AND WEIGHT	
Detector Type 6060	63 mm (2·5 in) long×18 mm (0·7 in) diameter. 0·065 kg (3 oz).
2200154 resistor	64·3 mm (2·53 in) long×14·25 mm (0·56 in) diameter. 0·065 kg (2 oz).
ACCESSORIES	
Optional 2200154	Load resistor with male and female BNC connectors. Finish: body, stainless steel. Connectors: Silver plate, rhodium flush. Resistance: approx. 5 kΩ.
2561001	Diode Element. Replacement kit.

Gunn Diode Oscillator-Type 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 due to the frequency being determined by the position of a non-contacting RF short circuit.

The oscillator has been designed to be tolerant to different gunn diode characteristics which resulted in a unit which will accept virtually any X band diode, making diode replacement economic, should the need arise.

The unit is particularly suitable for use with the educational test benches types 6599/2 and 6452A/2.

FREQUENCY	
Range	8·5 to 10·5 GHz min. 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.	13V. 200 mA typically detailed calibration data provided with each unit.
NETT WEIGHT	580 g (1 lb 6 oz) Gunn Diode.
RECOMMENDED POWER UNIT	M.I. Sanders Gunn Diode Power Supply, Type 6590.
Optional extra	Spare Gunn Diode P/N 2200169.

Coaxial Low Pass Filters-type 6067 series

IMPEDANCE	50 Ω.
INSERTION LOSS	1 dB maximum (d.c. to cut-off frequency.
REJECTION	Stop-band 50 dB minimum at 1·3 times cut-off frequency.
CONNECTORS	Type 'N' stainless steel, one male, one female.
MAXIMUM POWER INPUT	100 W.

Type No.	Length		Weight		Cut-off Frequency
	mm	inches	grammes	ounces	
6067/1	104	4·1	114	4	4·4 GHz +0·1 GHz −0·2
6067/2	86·4	3·4	100	3·5	6·9 GHz ±0·1 GHz
6067/3	79	3·1	92	3·25	8·3 GHz +0·1 GHz −0·2
6067/4	71	2·8	89	3	12·5 GHz ±0·1 GHz

YIG Tuned Gunn Oscillators Type 6100 series

Type No.	6106	6104A/2	6104A	6107	6105
R F PERFORMANCE					
Frequency range	5·0 to 9·0 GHz	7·0 to 11·0 GHz	8·0 to 12·4 GHz	10 to 15 GHz	12·4 to 18 GHz
Minimum power Output at 25°C	20 mW	20 mW	20 mW	20 mW	10 mW
Power variation	<10 dB	<10 dB	<10 dB	<10 dB	<10 dB
Maximum 'Harmonic' content	20 dBc	20 dBc	20 dBc	20 dBc	20 dBc
Temperature stability	0·02%/°C	0·02%/°C	0·02%/°C	0·02%/°C	0·02%/°C
TUNING CHARACTERISTICS					
Maximum sweep rate	100 Hz	100 Hz	100 Hz	100 Hz	100 Hz
Linearity	±0·25%	±0·25%	±0·25%	±0·25%	±0·25%
Hysteresis	12 MHz	12 MHz	12 MHz	14 MHz	20 MHz
Tuning sensitivity	22 MHz/mA	22 MHz/mA	22 MHz/mA	22 MHz/mA	22 MHz/mA
Tuning coil resistance	15 Ω	14 Ω	14 Ω	13 Ω	12 Ω
Tuning coil inductance	135 mH	135 mH	135 mH	135 mH	135 mH
F M COIL CHARACTERISTICS					
A C sensitivity	200 kHz/mA	200 kHz/mA	200 kHz/mA	180 kHz/mA	150 kHz/mA
Input bandwidth	100 kHz	100 kHz	100 kHz	100 kHz	100 kHz
Maximum continuous current	300 mA	300 mA	300 mA	300 mA	300 mA
Resistance	1 Ω	1 Ω	1 Ω	1 Ω	1 Ω
Inductance	60 μH	60 μH	60 μH	60 μH	60 μH
ELECTRICAL					
Gunn diode voltage (Typical)	18 V	16 V	16 V	14 V	12 V
Gunn diode current (Typical)	400 mA	600 mA	600 mA	600 mA	600 mA
Heater voltage	22-28 V	22-28 V	22-28 V	22-28 V	22-28 V
Maximum oscillator Mount temperature	60°C	60°C	60°C	60°C	60°C
D C connections	Solder Terminals	Solder Terminals	Solder Terminals	Solder Terminals	Solder Terminals
Output connector	SMA Female 50 Ω	SMA Female 50 Ω	SMA Female 50 Ω	SMA Female 50 Ω	SMA Female 50 Ω
Weight	All units 800 g (1·75 lb)				
Dimensions	Height, 68·5 mm. Width, 74 mm. Depth, 52 mm.				

n

SMA Wide Band Detector Type 6160

FREQUENCY	
Range	10 MHz to 18 GHz.
Response	±0·5 dB; 0·01–12·4 GHz. ±1·0 dB; 12·4–18 GHz.
INPUT	
Impedance	50 Ω.
V.S.W.R.	Less than 1·8:1 over the full frequency range.
Maximum power	100 mW.
Sensitivity	0·4 mV/μW.
OUTPUT	
Capacitance	10 pF.
Polarity	Negative (Positive polarity to order).

CONNECTOR	
Input	3 mm SMA male.
Output	Type BNC Female.
CONSTRUCTION	Body and SMA connector, Stainless Steel. BNC connector, Bright Tin Nickel.
DIMENSIONS AND WEIGHT	50 mm long × 11 mm diameter. 20 g.
ACCESSORIES	
Optional	2200206 Diode replacement.
Match pairs tracking	±0·2 dB/octave; 0·01–8 GHz. ±0·3 dB; 8–12·4 GHz. ±0·6 dB; 12·4–18·0 GHz.

Coaxial wideband detector Type 6161

FREQUENCY	
Range	10 MHz to 18 GHz.
Response	±0·5 dB: 0·01–12·4 GHz. ±1·0 dB: 12·4–18 GHz.
Matched pairs tracking	±0·2 dB/octave: 0·01–8 GHz. ±0·3 dB: 8–12·4 GHz. ±0·6 dB: 12·4–18·0 GHz.
INPUT	
Impedance	50 Ω.
V.S.W.R.	Less than 1·8:1 over the full frequency range.
Maximum power	100 mW.
OUTPUT	
Sensitivity	0·4 mV/μW.
Capacitance	10 pF.
Polarity	Negative (Positive polarity to order).

CONNECTOR	
Input	Type N male.
Output	Type BNC female.
CONSTRUCTION	Body and N connector. Stainless Steel. BNC connector. Bright Tin Nickel.
DIMENSIONS	61 mm long × 20 mm diameter.
WEIGHT	60 g.
ACCESSORIES	2200206 Diode replacement.

Subminiature Broadband Directional Couplers Type 6170 series

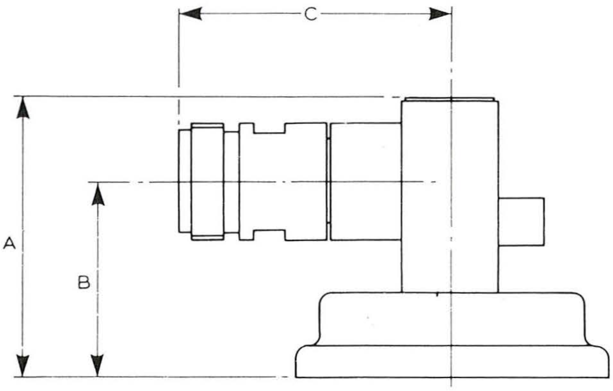
The 6170 series of subminiature directional couplers offer small size, light weight, rugged units which will withstand stringent environmental conditions.

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	6179/10
Coupling +dB	10±1·25	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	12·4–18
Average power W	5	5	5	5	5
Frequency sensitivity dB	±0·5	±0·5	±0·5	±0·5	±0·75
Insertion loss *dB	0·2	0·2	0·2	0·4	0·5
Directivity dB	22	22	18	17	14
VSWR Main Arm	1·15	1·20	1·30	1·35	1·40
VSWR Secondary Arm	1·15	1·20	1·30	1·40	1·50
Length ins/cm	2·75/6·5	1·7/4·3	1·1/3	1·0/2·5	1·0/2·5
Width ins/cm	0·6/1·5	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	0·5/1·25
Weight gms	45	35	28	28	28

Precision Coaxial to Waveguide Transformers Type 6237 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 V.S.W.R. of 1·25:1. The units are ideal for swept frequency applications where low V.S.W.R. is essential and can easily be used in systems applications. Each transformer is fitted with a Stainless Steel 'N' type connector and will handle a maximum mean power of 50 watts.



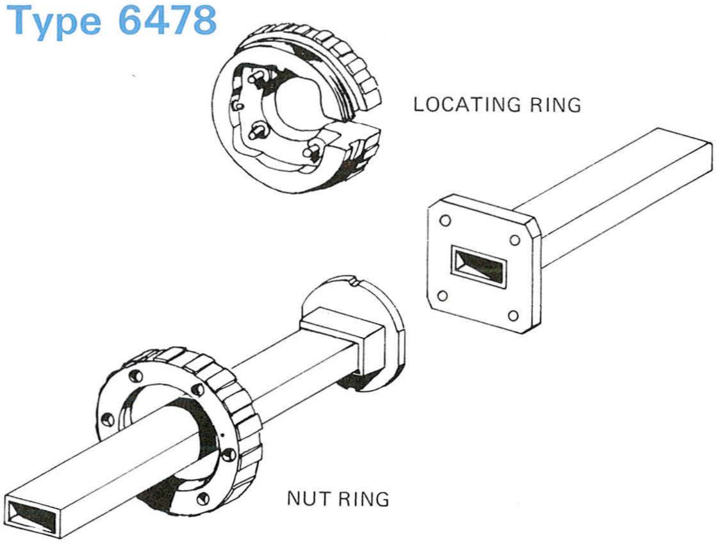
Type No.	Frequency Range (HGz)	Waveguide Size	Maximum V.S.W.R.	Coaxial Connector	Flange Fitted	A inches (mm)	B inches (mm)	C inches (mm)	Weight
6237/1	12·4 to 18·0	R140 (WG18) WR-62	1·25:1	Type 'N' 50 Ω female	Square 5985–99–083–0030	1·36 (34·5)	1·05 (26·55)	1·3 (33·1)	80 g 4 oz
6237/3	8·12 to 4	R100 (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

NATO Stock Numbers
6237/1 5985–99–637–9587
6237/3 5985–99–637–9585

Square to Round Flange Adapter Type 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.

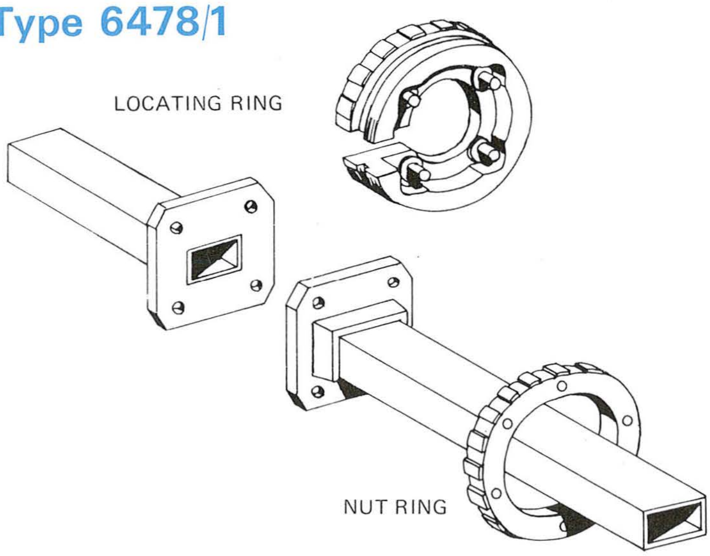
Material: Brass, nickel plated.
Weight: ½ lb (0·23 kg).
Dimensions: Diameter (max): 2·71 in, (68·8 mm)
Width including flanges (max): 0·77 in (19·6 mm).



Square to Square Rapid Coupler Type 6478/1

The square to square rapid coupler – Type 6478/1 is a unique device designed for coupling together X band instruments or components terminated with square flanges containing 0·169 inch 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.

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).



Wideband Coaxial Attenuators and Terminations-type 6530 series

The 6530 series of attenuators offers a selection of high quality 50 Ω 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 V.S.W.R. 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.

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-type 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 6533/2	Type N male Type N female	1 w	1 kW (5 μsec. max. pulse length)	50 Ω ±1 Ω at 25°C.	1·03:1 DC to 1 GHz. 1·05:1 1 to 4 GHz. 1·15:1 4 to 10 GHz.	Typically less than 0·03%/°C.

Wideband Coaxial Attenuators-type 6530 series

Frequency range	Type No.	Attenuation (dB)	Power input Average (W)	Power input Peak (kW)	Maximum deviation of Insertion loss (dB) When properly terminated in 50 Ω			VSWR When properly terminated in 50 Ω	Power sensitivity	Temperature coefficient
					DC–1·0 GHz	1·0–1·5 GHz				
DC–1·5 GHz	6530/1	3	15	10	0·2	0·5		1·15:1 max. DC–1·0 GHz 1·30:1 max. 1·0–1·5 GHz	0·01 dB/dB max. at 10 watts	—
	6530/2	6	10	10	0·2	0·5				
	6530/3	10	10	10	0·2	0·5				
	6530/4	20	10	10	0·5	1·0				
					AT DC	DC–3·0 GHz				
DC–3·0 GHz	6531/1	3	2	2	±0·02	±0·2		1·02:1 at D.C. 1·15:1 max. DC–1·0 GHz 1·20:1 max. 1·0–3·0 GHz	6531/4·1 <·001 dB /dB/w 6531/5-/7 <·002 dB /dB/w	Typically less than 0·0001 dB /dB/°C
	6531/2	6	2	2	±0·02	±0·2				
	6531/3	10	1	2	±0·02	±0·2				
	6531/4	20	1	1	±0·05	±0·2				
	6531/5	30	1	1	±0·05	±0·2				
	6531/6	40	1	1	±0·05	±0·3				
	6531/7	50	1	1	±0·05	±0·3				
					From Nom. at 4·0 GHz	From 4·0 GHz at 1 GHz	From 4·0 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	—	<·0007 dB/dB/°C
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 1·30:1 max. 2·0–10·0 GHz		
2·0–12·4 GHz	6532/4	20	1	1	±0·2	−1·3*	+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				
DC–18·0 GHz	6534/1	3	5	1	±0·3	±0·5		1·20:1 max. DC–4·0 GHz 1·25:1 max. 4·0–8·0 GHz 1·35 max. 8·0–12·4 GHz 1·5:1 max. 12–18·0 GHz	Typically less than 0·002 dB /dB/watt	Typically less than 0·0001 dB /dB/°C
	6534/2	6	5	1	±0·3	±0·5				
	6534/3	10	5	1	±0·5	±0·6				
	6534/4	20	5	1	±0·5	±0·75				
					DC–1·0 GHz	1·0–1·5 GHz				
DC–1·5 GHz	6536/1	3	30	10	0·2	0·5		1·15:1 max. DC–1 GHz 1·30:1 max. 1·0–1·5 GHz	0·01 dB/dB max. at 20 watts	—
	6536/2	6	20	10	0·2	0·5				
	6536/3	10	20	10	0·2	0·5				
	6636/4	20	10	10	0·5	1·0				

*2 GHz minimum frequency

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	½ 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	7·95 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		MCL Factory preform		Max. operating pressure P.S.I.G.	Length† tolerance
		E*	H*	E	H		
W.G.6	6·5×3·25	15·5	31	13·5	26	10	±1/8/Ft
½ ht 6	6·5×1·625	15·5	31	13·5	26	10	±1/8/Ft
W.G.10	2·84×1·34	7	14	4·5	6·4	60	±1/8/Ft
W.G.11A	2·29×1·145	6·5	13	4	6	45	±1/8/Ft
W.G.12	1·872×·872	6·5	13	3·5	5	45	±1/8/Ft
W.G.14	1·372×·622	4	8	2·5	3·5	45	±1/8/Ft
W.G.15	1·122×·497	3	6	1·7	2·5	45	±1/8/Ft
W.G.16	·900×·400	2·5	5	1·4	2·25	60	±1/8/Ft
W.G.18	·622×·311	2	4	1·3	1·75	60	±1/8/Ft

**Multiply These Columns ×4 For Continuous Bending Radii*
‡Minimum Length Tolerance ±1/16

MCL=Mean Centre Line

MECHANICAL DATA (METRIC)

I.E.C. size	Equivalent W.G. dims.	Bending radii static		MCL Factory preform		Max. operating pressure P.S.I.G.	Length‡ tolerance
		E*	H*	E	H		
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	330·20	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

n

FLEXIBLE WAVEGUIDE

'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 Division is registered on the defence contractors registration list, registration number 55 660/2/02 to Defence standard 05-21.

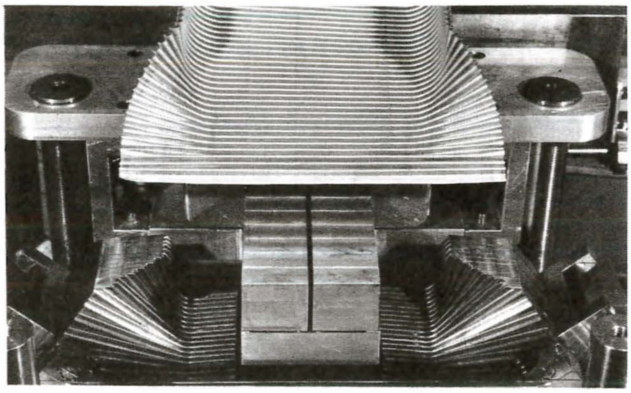
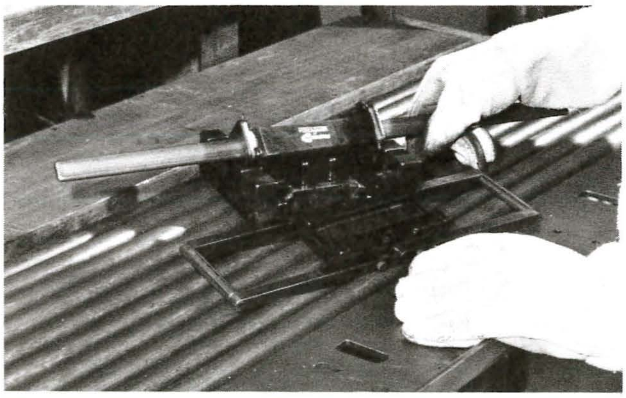
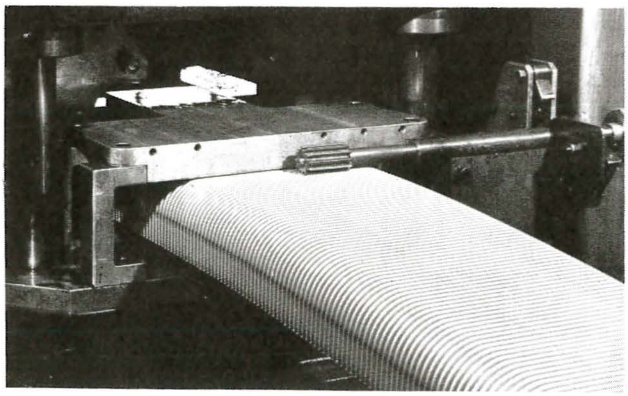


Illustration showing the extremely complicated and accurate tooling used for the forming of Flexaguide sections. (Section shown WG6).



Flexaguide moulding process of protective jacket.



Flexaguide WG6 section being formed.

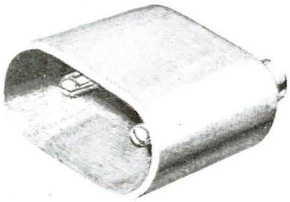
OPTIONAL ACCESSORIES

Adapters Attenuator Pads Coaxial Fuses	278
D.C. Isolating Unit	280
Matching Units	279
Modular Rack	280
RF Connecting Cables	279

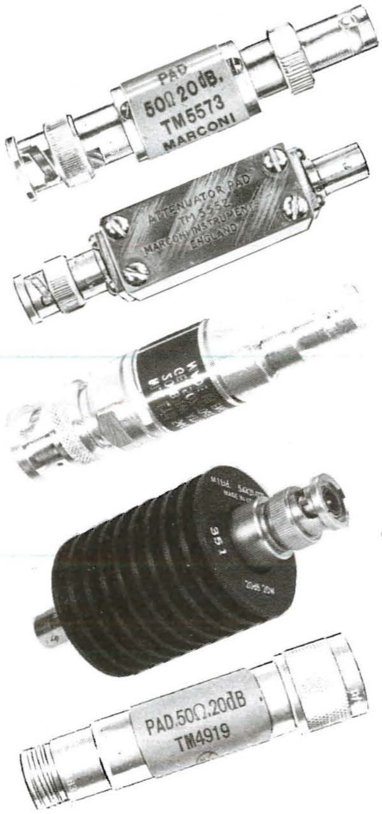
Optional Accessories

A selection of the range of Marconi Instruments accessories.

Adapters



TYPE No.	DESCRIPTION
43168-008S TB 39868	Mates with output terminals of oscillators and signal sources to provide a BNC socket connection.
43168-009W TB 39867	Mates with output terminals of oscillators and signal sources to provide a Type 83 socket connection.



Attenuator Pads

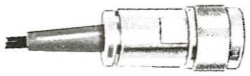
TYPE No.	ATTENUATION	IMPEDANCE	CONNECTORS	REMARKS
44425-501E TM 5573	20 dB	50 Ω	BNC	Frequencies up to 500 MHz
44425-002D TM 5573/1	6 dB	50 Ω	BNC	
44427-001G TM 5552	20 dB	75 Ω	BNC	Frequencies up to 220 MHz
54431-011D 54431-021B	20 dB 20 dB	50 Ω 50 Ω	BNC BNC	1 W (For details see Pages 20 W 110 and 111)
44425-504N TM 4919	20 dB	50 Ω	N	Frequencies up to 500 MHz
44425-503Y TM 4919/1	6 dB	50 Ω	N	
54452-011E		50 Ω	BNC	Signal Sniffer for frequencies up to 1000 MHz. (For details see Page 111)

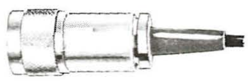
Coaxial Fuses

For use with Signal Generators, Modulation Meters, Counters, etc., to prevent damage to inputs or outputs.

TYPE No.	DESCRIPTION	REMARKS
43281-001W TM 5753	*Rating:* 0·4 watt. *Insertion loss:* Nominally 0·5 dB. *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. *Connectors:* Type N. *Fuse:* 1/16 Amp Littlefuse, Cat. No. 316.062 10 spares are provided.	For use with 50 Ω equipment
43281-007C TM 9884	*Rating:* 0·4 watt. *Insertion loss:* Less than 0·6 dB at 300 MHz. Less than 1·0 dB at 470 MHz. *VSWR:* Not greater than 1·5 at 470 MHz, when terminated with a matched 50 Ω load. *Connectors:* Type BNC. *Fuse:* 1/16 Amp Littlefuse, Cat. No. 316.062 10 spares are provided.	For use with 50 Ω equipment

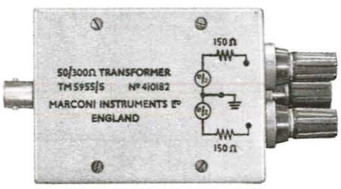
R F Connecting Cables

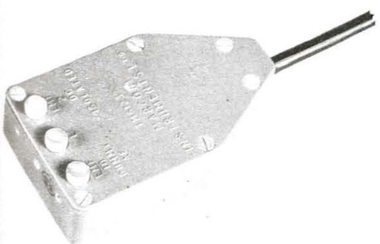


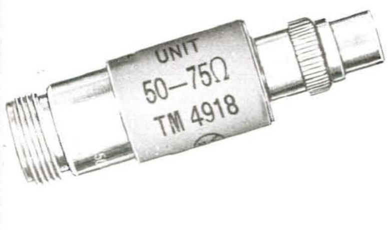


TYPE No.	R₀	LENGTH	CONNECTORS INPUT	OUTPUT	REMARKS
43126-012S TM 4969/3	50 Ω	1524 mm	BNC Plug	BNC Plug	Frequencies up to 500 MHz
43126-026A TM 4726/286	50 Ω	457 mm	N Plug	N Plug	Solid coaxial lead For use up to 1 GHz
43125-019F TM 4824/1	50 Ω	1372 mm	N Plug	N Plug	For use up to 500 MHz
43125-069B TM 4726/136	75 Ω	915 mm	BNC Plug	BNC Plug	Frequencies up to 500 MHz
54351-011F TM 4726/260	75 Ω	1830 mm	BNC Plug	BNC Plug	

Matching Units



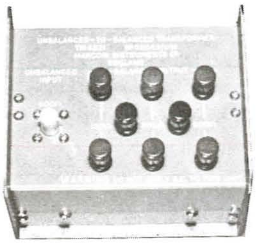




TYPE No.	DESCRIPTION	REMARKS
44411-001M TM 5569	**50 Ω to 75 Ω Matching Pad.** Comprises a single 25 Ω series resistor to convert the 50 Ω source resistance to 75 Ω. *Input connector:* BNC plug. *Output connector:* Belling Lee L734P plug.	For use up to 72 MHz
44411-018F TM 6599	Similar to TM 5569 but with Burndept type PR4E output plug.	For use up to 72 MHz
44412-021C TM 5955/5	**Matching Transformer.** 50 Ω unbalanced to 300 Ω balanced. Comprises toroidal auto-transformer. *Input connector:* BNC plug. *Output connector:* Miniature terminals.	For use up to 100 MHz
54481-011C TM 5955	**Matching Transformer.** 75 Ω to 150 Ω balanced. *Input connector:* BNC. *Output connector:* Miniature terminals.	For use from 12 kHz to 550 kHz
44412-023B 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 50Ω signal generators
44411-004B TM 4918	**50 Ω to 75 Ω Matching Pad.** Comprises a single 25 Ω series resistor. *Input connector:* N socket. *Output connector:* Belling Lee L734P plug.	For use up to 470 MHz
44411-002C TM 5548	**50 Ω to 75 Ω Matching Pad.** Comprises a single 25 Ω series resistor. *Input connector:* N socket. *Output connector:* Burndept PR4D plug.	For use up to 470 MHz.
44411-003R TM 5549	**50 Ω to 75 Ω Matching Pad.** Similar to TM 5548 but with Plessey Major CZ71060 output plug.	For use up to 470 MHz
44411-013U TM 4916	**Matching Unit.** 50 Ω unbalanced to 300 Ω balanced. Uses resistive networks only for measurements on receivers with balanced transformer inputs. *Input connector:* N socket. *Output connector:* Solder spills.	For use up to 470 MHz
44411-019G TM 5573/3	**50 Ω to 75 Ω Matching Pad.** Matches 50 Ω generator to 75 Ω load. 6 dB insertion loss. BNC connectors.	For use up to 500 MHz.

O

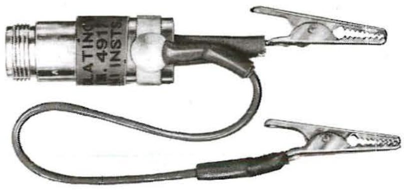
Matching Units (continued)



TYPE No.	DESCRIPTION	REMARKS
54411-021C	**75 Ω to 50 Ω Matching Pad** with BNC connectors	Voltage attenuation 10 dB when fed from a 75 Ω source to a 50 Ω load.
43512-003P TM 6221	**Unbalanced-to-balanced Transformer.** 600 Ω unbalanced input; 600, 200 and 150 Ω balanced output. *Input connector:* BNC plug. *Output connector:* Spring terminals. Distortion factor less than 0·2% over the frequency range 100 Hz to 50 kHz with input levels up to 3 V emf.	For use from 20 Hz to 100 kHz. Response within 1 dB with respect to 1 kHz
43535-009J TM 7120	**Isolating Transformer.** Designed for use with bridges to isolate external sources. *Connectors:* Spring terminals.	For use from 50 Hz to 50 kHz
54413-011F	**Star Network.** Consists of three 16·6 Ω resistors connected to three input/output 50 Ω N sockets.	For combining outputs of two signal generators. Usable from d.c. to 4 GHz.

MISCELLANEOUS

D C Isolating Unit

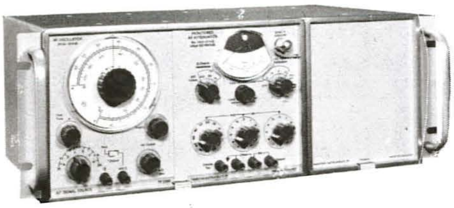


TYPE No.	DESCRIPTION
44413-007B TM 4917	Allows a generator to be used for testing at d.c. potentials up to 300 V. *Connector:* Type N.

12W, 50 Ω Termination

TYPE No.	DESCRIPTION
54422-011A	*Connector:* BNC (For details see Page 110)

Modular Rack Mounting Kit



TYPE No.	DESCRIPTION
41635-041P TM 7010	3/3 Module Rack Mounting Kit.
41674-015P TM 6844	1/3 Module Blank Panel Unit.

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p

For sensitivity measurements on receivers it is essential that the signal generator shall deliver an accurately calibrated r.f. output voltage from a source impedance equal to that of the aerial with which the receiver is to be used. (N.B. This is not normally equal to the true input impedance of the receiver).

As this aspect of signal generator performance is sometimes controversial the following notes may be helpful.

OUTPUT VOLTAGE

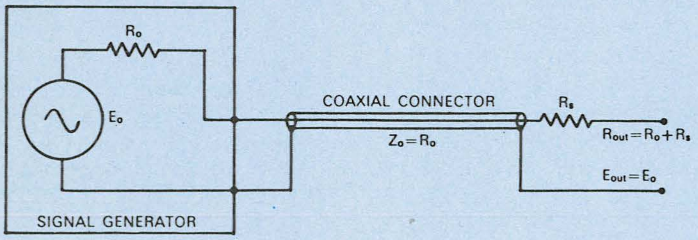
At frequencies up to about 1 GHz radio receivers are generally regarded as voltage sensitive devices, and their sensitivities are specified in appropriate terms. In Great Britain and Europe it is standard practice to state the sensitivity in terms of source e.m.f. available via the specified source impedance, the receiver input impedance, and hence the p.d. across it, usually being unknown. In some engineering circles, especially in the U.S.A., the sensitivity is stated in terms of the p.d. that would appear across a matched load; i.e., half the e.m.f. voltage. Although most authorities recommend the use of e.m.f. – as the more logical way of stating the voltage – it makes little difference which form is used providing the voltage statement is qualified by the appropriate initials; e.g., 100 µV e.m.f. or 50 µV p.d.

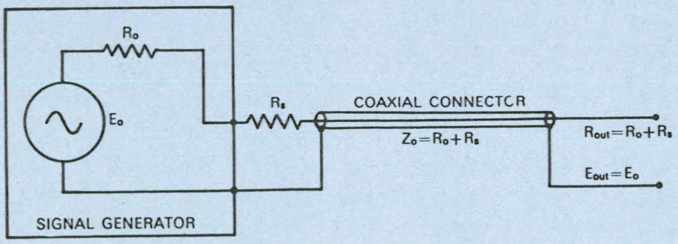
In the U.S.A. the terms "hard microvolts" for e.m.f. and "soft microvolts" for p.d. across a matched load are sometimes used.

Marconi Instruments signal generators are calibrated basically in terms of e.m.f., with provision for reading p.d. across a matched load directly from the attenuator if desired.

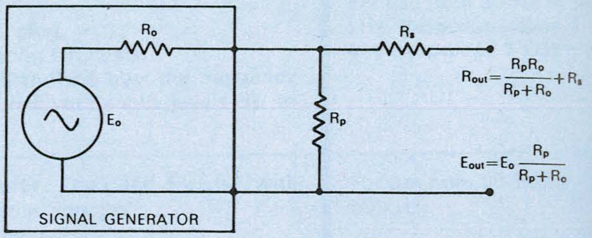
SOURCE IMPEDANCE

Marconi Instruments signal generators, used with standard accessories, offer the choice of 50 Ω or 75 Ω source impedance, with a 300 Ω balanced output accessory available for most signal generators in the range. A standard dummy aerial is also available for use at frequencies below about 1·5 MHz. These source impedances cover most requirements, but other values are sometimes needed for special measurements. At frequencies up to several hundred megahertz, resistive impedance-conversion pads can be constructed using the following arrangements.





Increasing Effective Source Impedance This can be achieved by the addition of a single resistor, R_s, whose value is given by $R_s=R_{out}-R_o$, where R_{out} is the required source impedance and R_o is the source impedance of the signal generator. The additional resistor can be fitted at either end of the connecting cable, but, if it is at the sending end, the characteristic impedance of the cable must be equal to R_{out}.

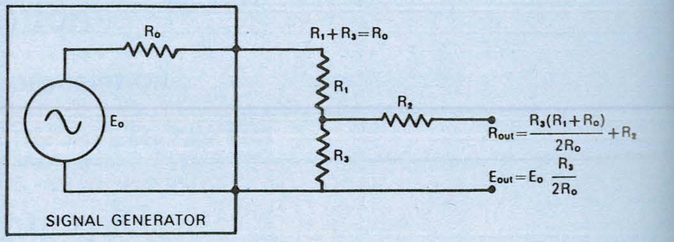


Decreasing Effective Source Impedance The effective source resistance can be reduced by simply connecting a resistor, R_p, in parallel with the load, so that $R_{out}=R_pR_o/(R_p+R_o)$.

Unfortunately the output e.m.f., E_{out}, is then also reduced as $E_{out}=E_oR_p/(R_p+R_o)$. This can produce an inconvenient voltage conversion ratio, and it is usually more satisfactory to make up a two-element pad of the form shown above. Choosing a convenient value, N, for E_o/E_{out}, the resistor values are given by,

$$R_p=\frac{R_o}{N-1} \text{ and } R_s=\frac{R_p\,R_o}{R_p+R_o}$$

A nomograph for calculating these values is given on page 289.



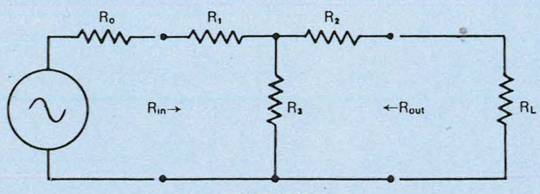
Three-element Reduction Networks The two-element pad has the slight disadvantage that, unless N=2, the receiving end of the cable is mismatched regardless of the ultimate load impedance. Providing the source impedance, R_o, is accurately matched to the cable no voltage error is caused by this mismatch, but there may be other factors demanding correct termination at the receiving end; e.g., susceptibility to the effects of r.f. radiation fields. If the additional attentuation can be tolerated, such requirements can usually be satisfied by the use of the simple two-element network in conjunction with the 20 dB Attenuator Pad available as a standard accessory for the signal generator; but, for other cases, a three-element impedance conversion pad is useful.

For applications where the ultimate load impedance is normally high compared with R_{out} there is some advantage in using a pad which terminates the cable correctly when the pad is unloaded. In this type of pad R_o, R_1, and R_3 form a simple potential divider, so that

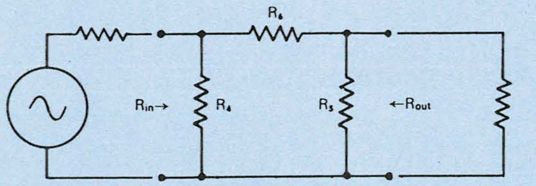
$$R_3=2R_o/N$$
$$R_2=R_o-R_3$$
$$R_2=R_{out}-[R_3(R_1+R_o)/2R_o]$$

These values can also be calculated using the nomograph on page 289.

The more usual requirement, however, is for an impedance-conversion attenuator of the form shown below, where $R_{in}=R_o$ when $R_L=R_{out}$.



T NETWORK



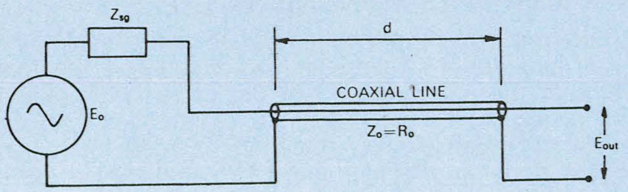
π NETWORK

These are the conventional T and π networks. Standard design formulae are usually given in terms of power ratio, whereas receiver sensitivity (and hence signal generator output) is usually expressed in voltage for frequencies up to about 1 GHz. Data for calculation of the resistor values on both the power-ratio and the voltage-ratio basis are given on page 285.

SOURCE IMPEDANCE ACCURACY

The full significance of the need for accurate matching of the source impedance to the characteristic impedance of the output connecting cable stems from the fact that, when the cable is correctly terminated at the receiving end by R_o, the phase and magnitude of the voltage developed across R_o by the reflected power exactly matches the effect of the related standing wave. The e.m.f. and source impedance at the receiving end of the cable are, therefore, exactly equal to the e.m.f. and source impedance at the sending end regardless of the final terminating impedance. A complete explanation of this effect has been given by Flanagan, *Marconi Instrumentation,* vol. 4, p. 105, March, 1954.

The anology can thus be made to the existence of an "image source" at the receiving end of the cable, which is identical to the real source. If the signal generator source impedance does not match the cable impedance, however, the image source will not be an exact facsimile of the real source, and there will be errors in the e.m.f. and source impedance of magnitude depending on the degree of mismatch and angular length of the cable.



REAL SOURCE + NETWORK

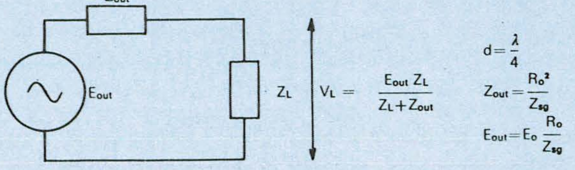


IMAGE SOURCE (LOADED)

Image E.M.F. Error The e.m.f. error reaches a maximum when the cable length is equal to an odd multiple of $\lambda/4$, and is zero for cable lengths equal to even multiples.

The magnitude of the maximum error is given by

$E_{out}=E_o.R_o/Z_{sg}$ .... (1)

where

E_o is the real source e.m.f.

E_{out} is the image source e.m.f.

R_o is the nominal source impedance—equal to the characteristic impedance of the cable.

Z_{sg} is the actual source impedance of the signal generator.

Image Source Impedance Error For cable lengths equal to odd multiples of $\lambda/4$, the image source impedance $Z_{out}=R_o^2/Z_{sg}$. .... (2)

For cable lengths equal to even multiples of $\lambda/4$, $Z_{out}=Z_{sg}$. .... (3)

V.S.W.R. It is now customary to state a signal generator's source impedance accuracy as voltage-standing-wave-ratio. This may be defined as the ratio between the voltages at the nodes and antinodes of the standing wave that would appear on a loss-free line, of characteristic impedance R_o, when terminated by the signal generator (i.e., with the signal generator's source impedance as the load). It is also the ratio of the maximum to minimum level of image e.m.f. that would occur if the cable length were varied over a half wavelength.

The v.s.w.r. figure given bears no relationship to the standing wave pattern on the connecting cable when the signal generator is in use. This is entirely a function of the terminating impedance at the receiver end of the cable.

Interpreting the Accuracy Although nominally resistive, the signal generator's source impedance is inevitably complex, containing series and parallel reactive components of positive and negative sign, so that the actual impedance must vary with frequency. The v.s.w.r. figure given in Marconi Instruments specifications, therefore, represents the worst condition within the stated frequency range.

A simple statement of v.s.w.r. gives no indication of the phase angle of the source impedance, a statement of the angular displacement of the voltage node also being required in order to carry this information. As the phase angle is a function of frequency, however, its omission from the general performance statement is virtually unavoidable.

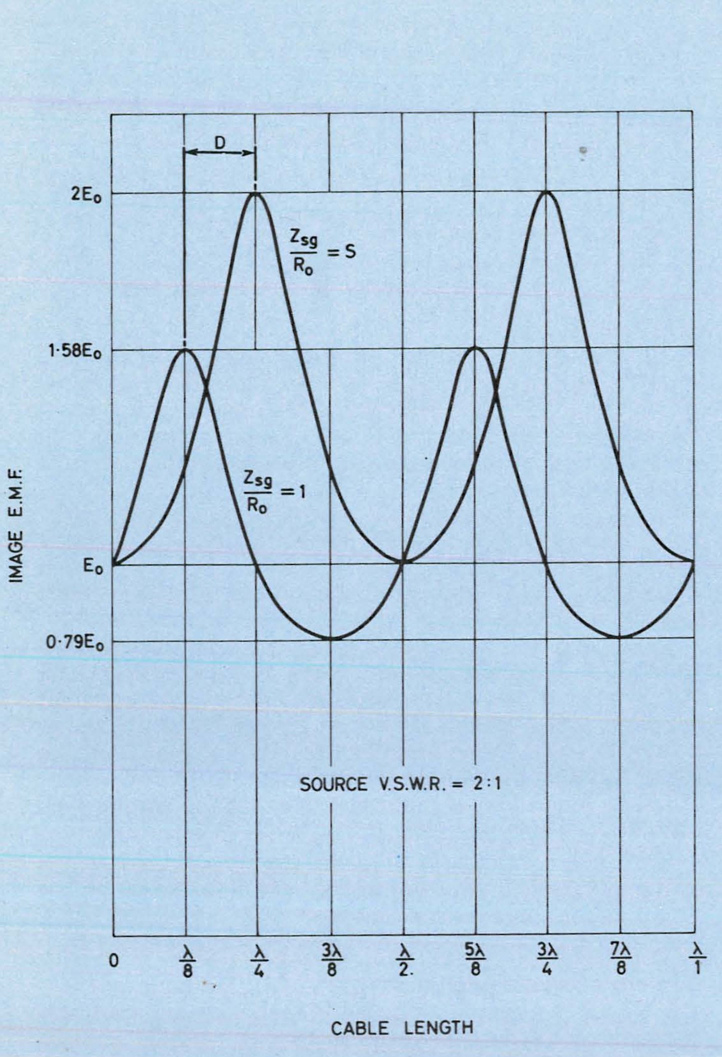
Nevertheless, the phase angle of the real source impedance is a relevant factor in assessing the image e.m.f. and image source impedance. The following diagram (page 284) shows the variation of image e.m.f. with cable length for a v.s.w.r. of 2:1, caused by a resistive error in source impedance and by a phase-angle error.

It is clear from this diagram that, although the variation is equal to the v.s.w.r. in both cases, the greatest departure from the true e.m.f. occurs when the source impedance is resistive.

Taking the worse case – if the connecting cable is equal to an odd number of quarter wavelengths and the signal generator's source impedance is purely resistive, the possible image e.m.f. error is given by

$E_{out}=E_o+E_o(S-1)$ or $E_o-E_o(1-1/S)$,

which, if the v.s.w.r. is close to unity, is very nearly equal to $E_o \pm E_o\ (S-1)$.



This magnitude of error is, however, never actually realised, because the v.s.w.r. figure quoted in the specification is invariably partly due to reactive components in the signal generator's source impedance.

The limits of image source impedance error for both even and odd quarter wavelength cables are given by.

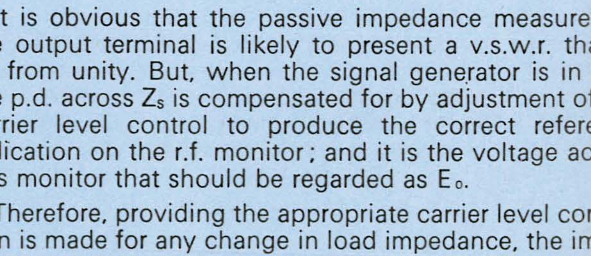
$Z_{out} = R_0 \pm R_0\ (S-1)$.

The error in actual voltage across a practical load is further reduced by the fact that signal generator output level is calibrated with a termination equal to R_0 fitted.

SOURCE IMPEDANCE AT HIGH OUTPUT VOLTAGE LEVELS

Restriction of the v.s.w.r. specification to output levels up to 20 dB below maximum output carries a generally accepted implication that this aspect of the signal generator's performance deteriorates over the highest voltage decade. But this is only true in certain circumstances; for, although the output impedance may appear to be seriously in error when measured by an r.f. bridge or the standing-wave-ratio method, the error in the test voltage is not necessarily significantly greater at maximum output than at the lower levels.

The diagram below shows the effective form of all Marconi Instruments signal generator output circuits, the carrier level from the r.f. source being monitored by means of an r.f. voltmeter before application to a constant impedance variable attenuator. Providing the attenuation exceeds about 20 dB, the r.f. source is effectively isolated from the output socket, and the source impedance of the signal generator is that of its output attenuator. At the small attenuation settings required for high output level, however, this isolation disappears; and the impedance or the r.f. source, Z_s, becomes a significant part of the source impedance of the signal generator.



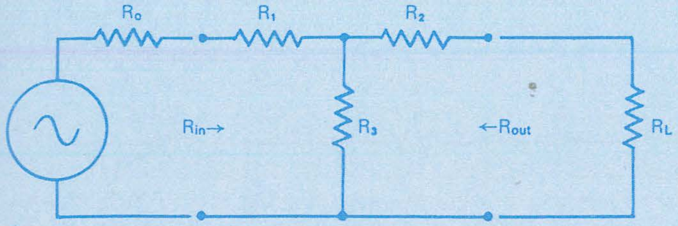
It is obvious that the passive impedance measured at the output terminal is likely to present a v.s.w.r. that is far from unity. But, when the signal generator is in use, the p.d. across Z_s is compensated for by adjustment of the carrier level control to produce the correct reference indication on the r.f. monitor; and it is the voltage across this monitor that should be regarded as E_0.

Therefore, providing the appropriate carrier level correction is made for any change in load impedance, the image source at the receiving end of the cable will retain the form giving $V_L = E_0 Z_L/(R_0 + Z_L)$ for all attenuator settings. Several of the signal generators in the Marconi Instruments range include an effective automatic level control system (a.l.c.), so that the correction is made automatically and the dynamic impedance of the internal r.f. source is very low indeed.

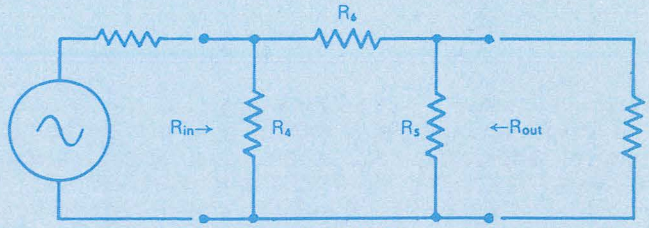
This effective source impedance is not, however, the impedance that the signal generator would present, while in operation, to an external source; e.g., a second signal generator used in two-signal tests on a receiver. It is therefore important, in such applications, to make due allowance for a possible mismatch, which would affect the voltage applied by the second generator – not the one giving near maximum output.

Matching Pads

$R_{in}/R_{out} = F, \quad E_{in}/E_{out} = N, \quad P_{in}/P_{out} = A$



T NETWORK



π NETWORK

T Networks

$$R_3 = \frac{2\sqrt{A\,R_{in}\,R_{out}}}{A-1} = R_{in}.\frac{2N}{N^2-F}$$

$$R_2 = \left[R_{out}.\frac{A+1}{A-1}\right] - R_3 = \left[R_{out}.\frac{N^2+F}{N^2-F}\right] - R_3$$

$$R_1 = \left[R_{in}.\frac{A+1}{A-1}\right] - R_3 = \left[R_{in}.\frac{N^2+F}{N^2-F}\right] - R_3$$

π Networks

$$\frac{1}{R_6} = \frac{2}{A-1}.\sqrt{\frac{A}{R_{in}\,R_{out}}} = \frac{1}{R_{out}}.\frac{2N}{N^2-F}$$

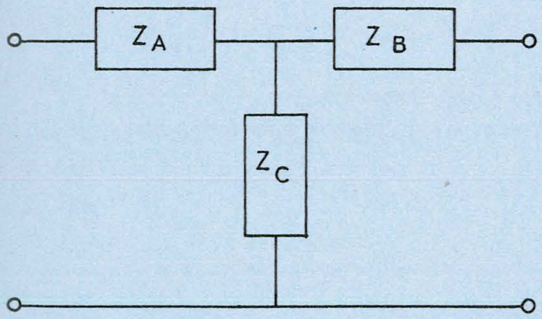
$$\frac{1}{R_5} = \left[\frac{1}{R_{out}}.\frac{A+1}{A-1}\right] - \frac{1}{R_6} = \left[\frac{1}{R_{out}}.\frac{N^2+F}{N^2-F}\right] - \frac{1}{R_6}$$

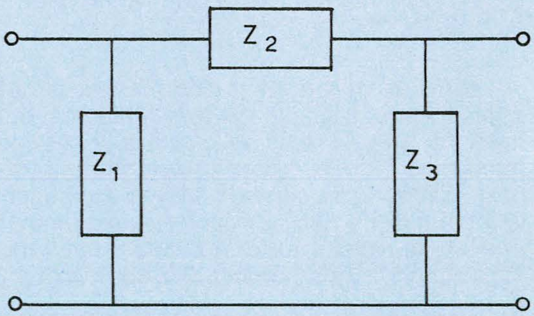
$$\frac{1}{R_4} = \left[\frac{1}{R_{in}}.\frac{A+1}{A-1}\right] - \frac{1}{R_6} = \left[\frac{1}{R_{in}}.\frac{N^2+F}{N^2-F}\right] - \frac{1}{R_6}$$

In practice *T* and π impedance matching pads are usually designed to give some convenient voltage ratio, which may be stated in decibels even though the input and output impedances are different. The table shows resistive values for commonly used impedance and attenuation ratio. The figures in the column *N* (dB) are those equivalent to 20 log $\frac{E_{in}}{E_{out}}$ and should not be regarded as the true $\left(\frac{P_{in}}{P_{out}}\right)$ decibel attenuation.

Attenuation Ratio		Resistance values in ohms							
N (dB)	*N*	R_{in}	R_{out}	R_1	R_2	R_3	R_4	R_5	R_6
10	√10	75	50	45·7	11·8	55·8	317	82·1	67·2
14	5	75	50	52·7	24·5	31·8	153	71·2	118
20	10	75	50	62·1	36·3	15·2	103	60·4	246
6	2	75	60	34·1	5·3	110	843	132	41·1
10	√10	75	60	42·2	22·9	54·2	196	107	83
14	5	75	60	51·4	34·8	31·5	129	87·6	143
20	10	75	60	61·7	46·3	15·2	97·1	72·9	296
6	2	60	50	25·7	7·1	86·1	425	117	34·9
10	√10	60	50	33·2	20·5	43·1	146	91·2	69·6
14	5	60	50	40·9	29·9	25·1	100	73·4	119
20	10	60	50	49·3	39·1	12·1	76·8	60·8	247

Star-Delta Transformations





$$Z_A = \frac{Z_1 Z_2}{Z_1 + Z_2 + Z_3} \qquad Z_1 = \frac{Z_A Z_B + Z_B Z_C + Z_A Z_C}{Z_B}$$

$$Z_B = \frac{Z_2 Z_3}{Z_1 + Z_2 + Z_3} \qquad Z_2 = \frac{Z_A Z_B + Z_B Z_C + Z_A Z_C}{Z_C}$$

$$Z_C = \frac{Z_1 Z_3}{Z_1 + Z_2 + Z_3} \qquad Z_3 = \frac{Z_A Z_B + Z_B Z_C + Z_A Z_C}{Z_A}$$

p

Attenuator Pads

Resistive attenuators usually comprise T or π networks of the forms shown in Fig. 1, either singly or in the multiple form of ladder networks. In the usual case of a single network, where the input and output impedances are equal, only two values of resistance need be calculated, and the design formulae simplify to the following expressions.

T Networks:

$$R_1 = R_o\frac{n-1}{n+1} \qquad R_2 = R_o\frac{2n}{n^2-1}$$

π Networks:

$$R_3 = R_o\frac{n^2-1}{2n} \qquad R_4 = R_o\frac{n+1}{n-1}$$

where $n = E_{in}/E_{out}$ and $R_o = R_{in} = R_{out}$.

For any given value of n, therefore, $R_1/R_o = R_o/R_4$ and $R_2/R_o = R_o/R_3$, so that it is possible to construct two composite nomographs to give all four values. Those in Fig. 2 give values of the resistive elements for values of R_o from 10 to 100 ohms for attenuation ratios from 1 dB to 20 dB, the symbol N being used to signify 20 log n.

Fig. 2 (a) gives the values of R_2 and R_3. To find R_2 (T network) place a straight edge on the nomograph so that it joins the value of R_o on Scale 1A with the attenuation on Scale 3; then read the value of R_2 from Scale 2A. To find R_3 (π network) use Scale 1B and Scale 2B.

Fig. 2 (b) gives the values of R_1 and R_4. To find R_1 (T network) use Scale 4R and Scale 5R, and to find R_4 (π network) use Scale 4B and Scale 5B.

As all four resistance values vary linearly with R_o, the input and output resistance range can be extended indefinitely in either direction by application of decade multiplying factors. For example, to design a T pad with a characteristic impedance R_o=600 ohms, simply find the values of R_1 and R_2 for R_o=60 ohms and multiply them by 10.

Extension of the attenuation range, is not possible by application of a simple multiplying factor; but the requirement for such extension is unusual. Attenuators giving more than 20 dB loss are usually built up of two or more basic networks in cascade. Where permanent connection is intended the two adjacent elements may be combined in a single resistor to form a ladder network as shown in Figs. 3 and 4. Any number of steps may be used in order to build up the required attenuation.

For balanced networks the values of the series elements are half those for the basic T or π pad as shown in Fig. 5.

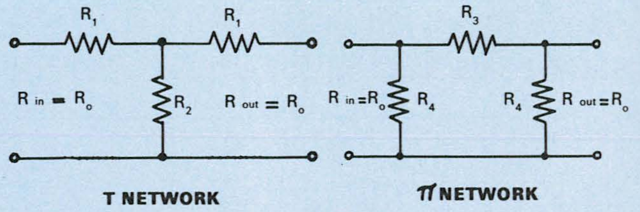


Fig 1

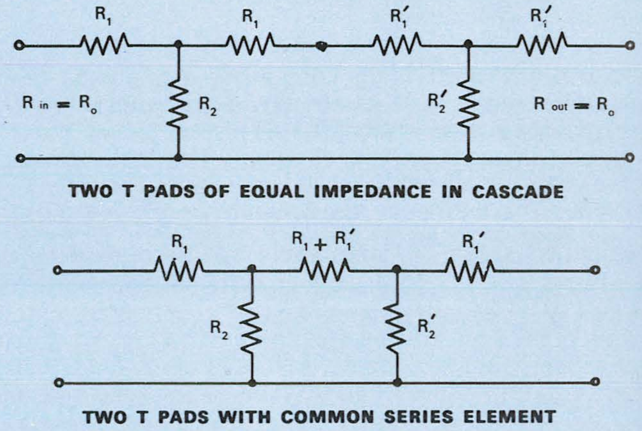


Fig 3

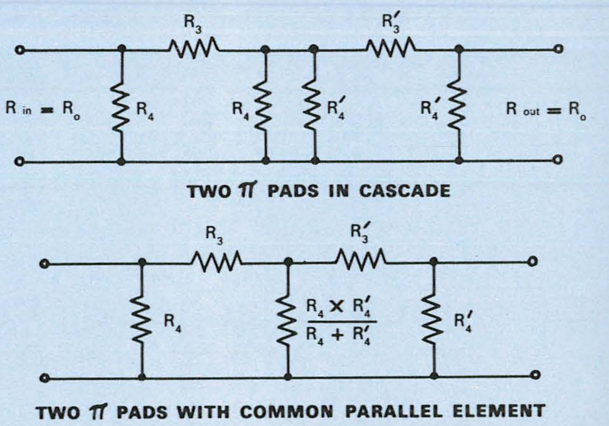


Fig 4

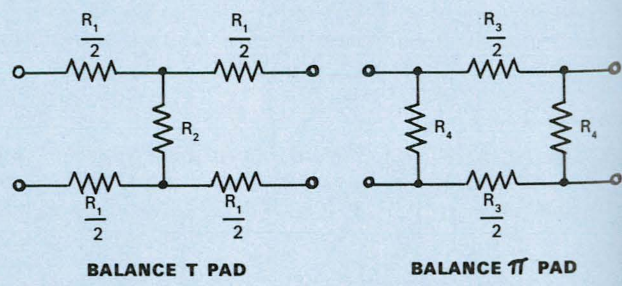


Fig 5

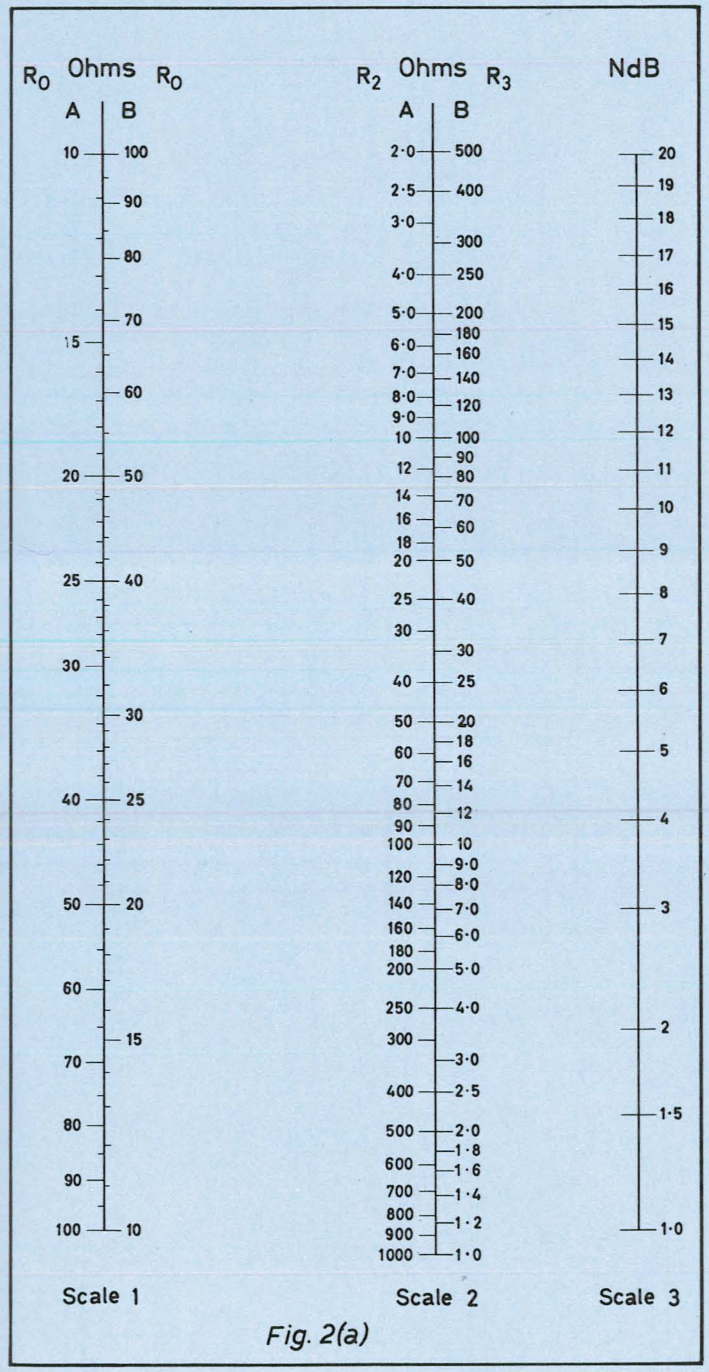

R0 Ohms R0
A B
R2 Ohms R3
A B
NdB
Scale 1
Scale 2
Scale 3

Fig. 2(a)

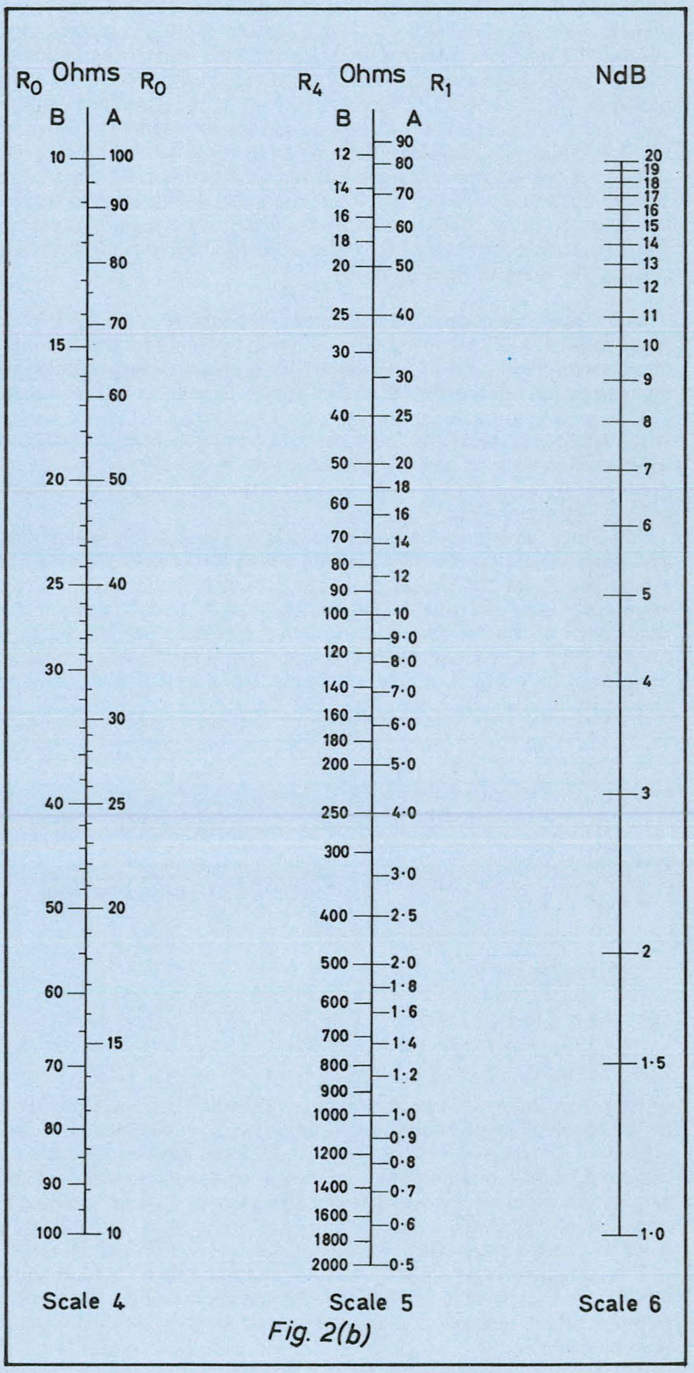

R0 Ohms R0
B A
R4 Ohms R1
B A
NdB
Scale 4
Scale 5
Scale 6

Fig. 2(b)

Potential Dividers—Source Resistance & Ratio

Provided the power loss can be tolerated the potential divider circuit forms the basis of a convenient impedance conversion network for a wide range of applications. The diagram of Fig. 1 shows the simplest arrangement, in which a generator of e.m.f. E and impedance R_O, is converted to an effective source delivering an e.m.f. of E/N via the source impedance R_X.

The nomographs (Fig. 2 opposite) give values of R_X and N for values of R_Z and R_Y from 10 to 1000 Ω. If values outside this range are required, or where greater discrimination is desirable, any convenient multiplication factor may be applied to *all three* resistance values. The value of N remains unchanged by the resistance multiplier.

Obviously, the lowest value of N is obtained when $R_S=0$. R_O then becomes equal to R_Y. But this may result in an inconvenient voltage division; and it is sometimes better to use the arrangement shown in Fig. 3 in which a third resistor determines the final source impedance.

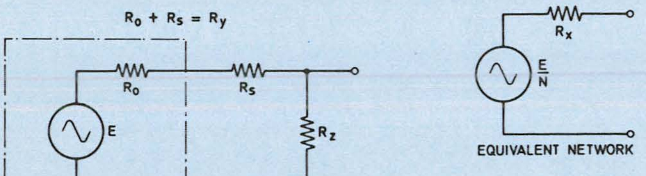
To find the resistance values for this arrangement, first choose a convenient value of N and use the nomograph in Fig. 2 (a) to obtain the value of R_Z, R_Y being equal to R_O. Then use the nomograph in Fig. 2 (b) to find the value of R_X. If the required final output impedance is R_{out}, the value of R_a is given by

$$R_a=R_{out}-R_X$$

Remember, however, that the minimum possible value of N for a given reduction of source impedance is that obtained for the arrangement where $R_a=0$. If too low a value of N is chosen when calculating the resistance values of Fig. 3, R_a will appear to have a negative value.

This simple impedance converting network is particularly useful when a signal generator is to be used for testing a receiver designed for operation with an aerial impedance which is less than the signal generator's source impedance; e.g., for testing a 50 Ω receiver with a 75 Ω signal generator.

The input impedance of a receiver is seldom equal to the specified aerial impedance; so the fact that the arrangement in Fig. 3 may not match the Z_O of the signal generator's output feeder cable is not important. Provided this feeder is terminated in its characteristic impedance at the sending end, no voltage error is introduced by a mismatch at the receiving end. Depending upon the cable available, therefore, the network maybe connected in either of the positions shown in Fig. 4.



$$R_X=\frac{R_Y R_Z}{R_Y+R_Z}$$

$$N=\frac{R_Y+R_Z}{R_Z}$$

Fig. 1

However, there may be other factors demanding correct termination at the receiving end of the feeder cable; e.g., susceptibility to the effects of r.f. radiation fields. If the additional attenuation can be tolerated, such a requirement can usually be satisfied by use of the simple two-element network in conjunction with a 20 dB attenuator pad – usually available as an accessory to the signal generator. But, in other cases a three-element impedance-conversion pad is useful.

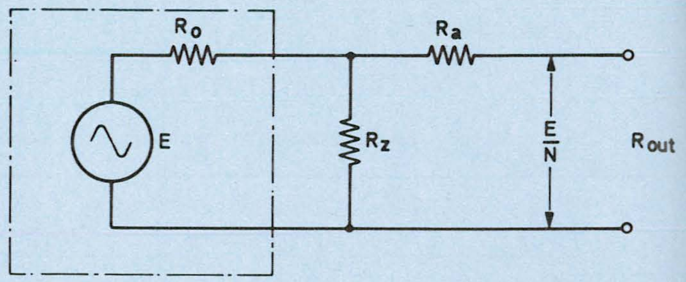
For applications where the ultimate load impedance is high compared with R_{out} there is considerable advantage in using a conversion network which terminates the feeder correctly when the final output is unloaded.

The arrangement is shown in Fig. 5. In order to fulfil the conditions $R_S+R_Z=R_O$ so that

$$R_Z=2R_O/N, \text{ and } R_S=R_O-R_Z$$

There is, thus, no need to use the nomograph of Fig. 2 (a) in calculating these values. Resistance R_Y is, of course, R_S+R_O. To find the value of R_a, use the nomograph of Fig. 2 (b) to obtain the value of R_X; and $R_a=R_{out}-R_X$.

The nomograph of Fig. 2 (b) can, of course, also be used for obtaining the value of any two resistances connected in parallel, R_Y and R_Z being the two individual values and R_X their combined value. Similarly the nomograph of Fig. 2 (a) is useful for finding the p.d. across a load when it is fed via a known source resistance. R_Y is the source resistance, R_Z is the load resistance, and the p.d. is the e.m.f. multiplied by $1/N$.



$$R_{out}=\frac{R_O R_Z}{R_O+R_Z}+R_a=R_X+R_a$$

$$N=\frac{R_O+R_Z}{R_Z}$$

Fig. 3

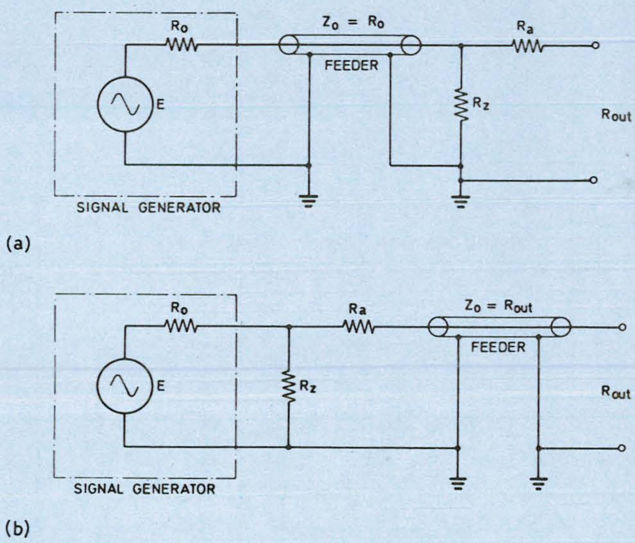
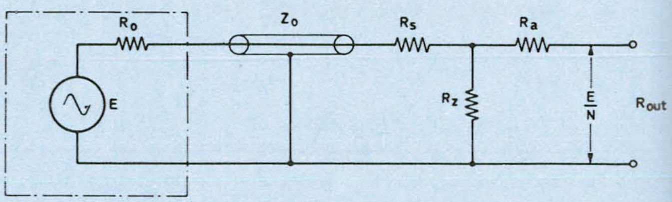


Fig. 4

$$R_O+R_S=R_Y$$

$$Z_O=R_O$$



$$R_S+R_Z=R_O$$

$$R_{out}=\frac{R_Z(R_S+R_O)}{2R_O}+R_a=R_X+R_a$$

$$N=\frac{2R_O}{R_Z} \quad \therefore \quad R_Z=\frac{2R_O}{N}$$

Fig. 5

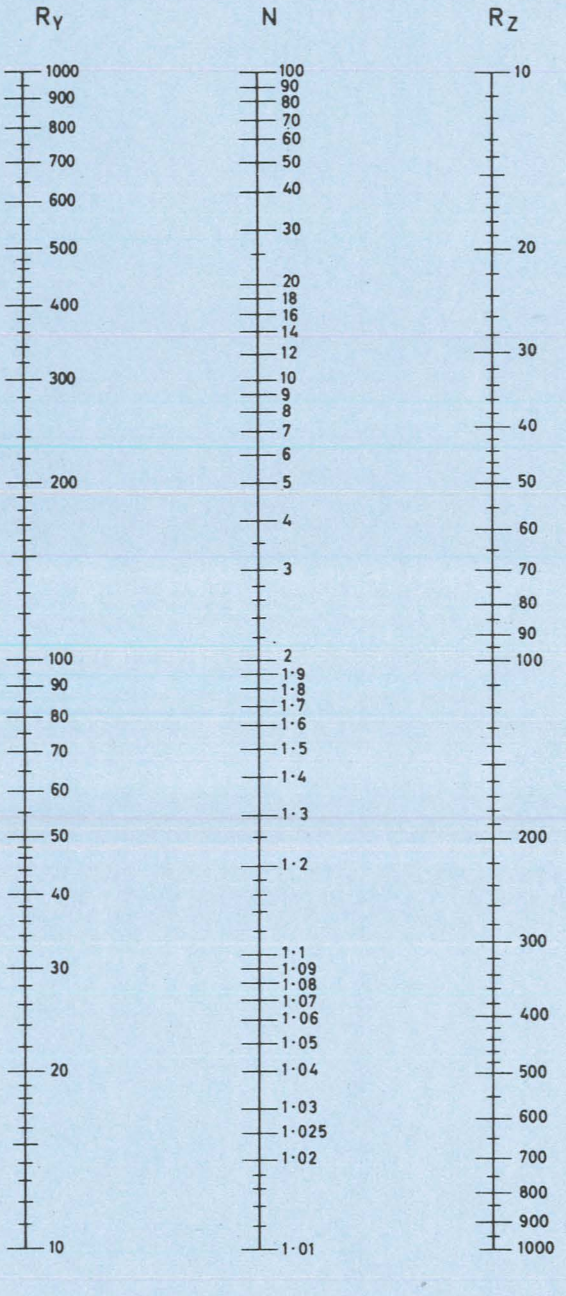


Fig. 2(a)

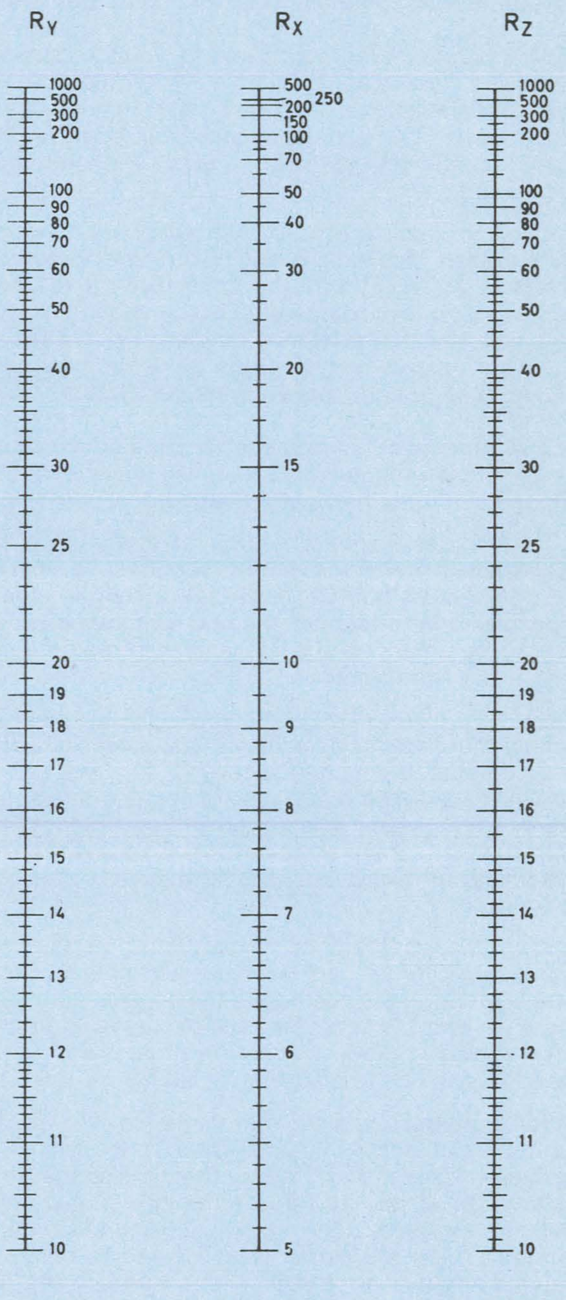


Fig. 2(b)

Voltage to Power Conversion

Depending on the normal application of a signal source, its output level may be calibrated in terms of (i) power in a stated load, (ii) e.m.f. from a stated source impedance, (iii) p.d. across a stated resistance, or (iv) simply terminal voltage.

Interconversion between (ii), (iii), and (iv) is so easy that it warrants little comment; and, for those cases where some calibration is necessary, the previous nomograph on page 289 is helpful. When a power to voltage conversion is necessary, however, a suitable nomograph can obviate tedious calculation. The nomograph accompanying this article covers two voltage decades and gives the power in load impedances commonly used in communications engineering.

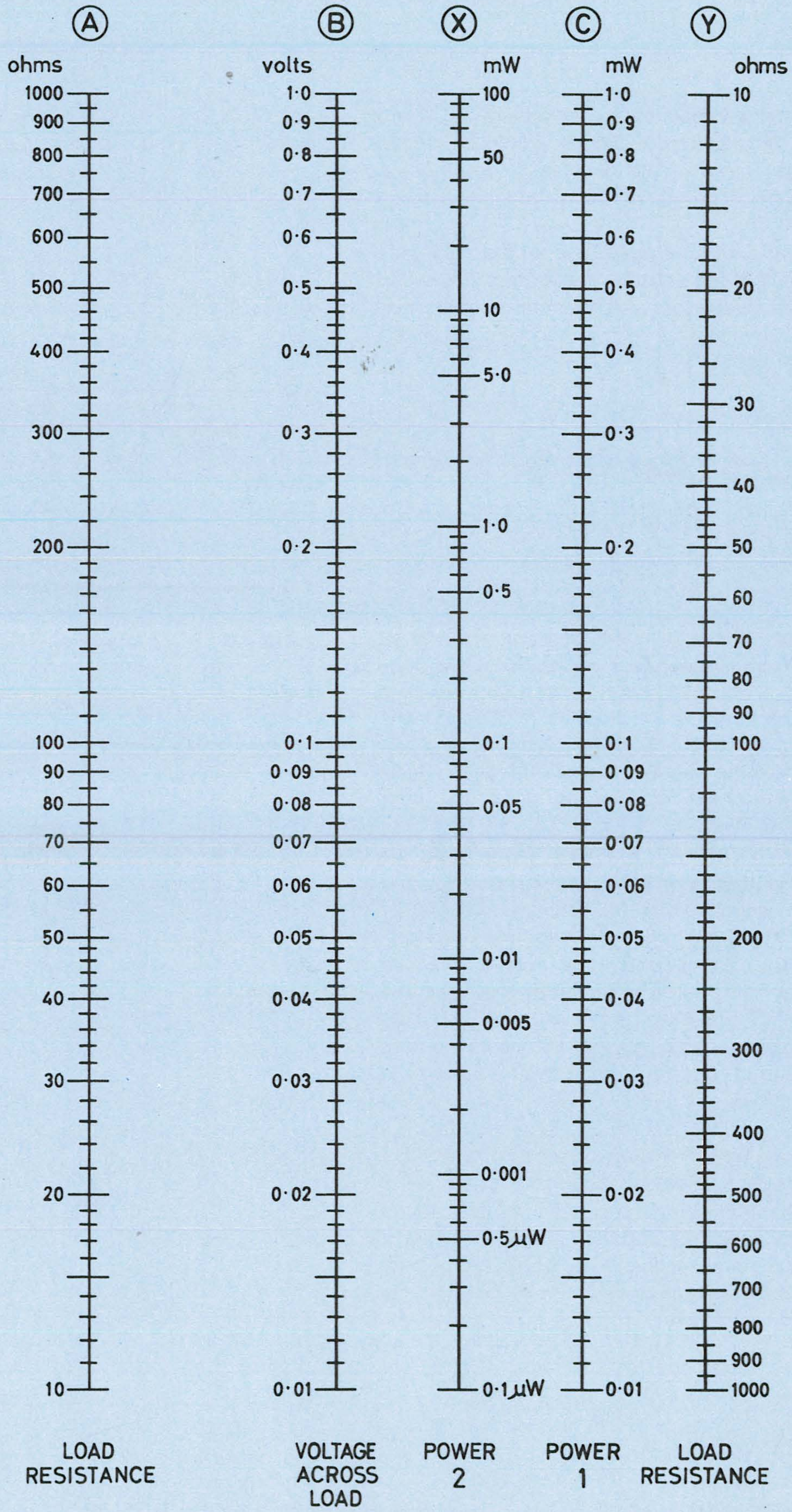
It really consists of two nomographs with a common voltage scale. Scales A, B, and C form one nomograph, and scales B, X, and Y form the other. Both give direct conversion of voltage to power over the voltage range 10 mV to 1 volt and the resistance range 10 to 1,000 Ω. Scales B, X, and Y cover every possible value of power obtainable within voltage and resistance ranges shown; but, as the power scale, X, covers six decades the reading discrimination is somewhat limited. For accurate conversion, therefore, there is some advantage in using scales A, B, and C, which cover only two power decades.

These scales are direct reading for power values between 10μW and 1 mW. For example, suppose we have a p.d. of 0·5 volts across 600 Ω. Simply lay a straight edge in such a position that it touches the 600 Ω mark on scale A and the 0·5 volt mark on scale B, and then read the power as 0·417 mW from scale C.

But, if we have 0·5 volts across 50 Ω, a straight line linking these values on scales B and A respectively would pass beyond the end of scale C. The conversion can, however, be made directly by laying the straight edge in the position where it links the 0·5 volt mark on scale B with the 50 Ω mark on scale Y. The approximate value of the power is then given where the edge crosses scale X – at 5 mW.

With the approximate value found in this way, the significant figures can be obtained more accurately by simply ignoring the position of the decimal point and using the A, B, and C scales; for example, by laying the straight edge against the 500 Ω mark on scale A and the 0·5 volt mark on scale B, to read from scale C.

For voltages outside the range of the nomograph, multiply the actual voltage by 10^n to obtain a value between 10 mV and 1 volt. Then make the voltage to power conversion, and divide the power value read from the nomograph by 10^{2n}. For resistance values outside the range multiply the actual value by 10^n to obtain a value between 10 Ω and 1,000 Ω, and multiply the indicated power value by 10^n. To find the resistance or voltage when the power is known simply reverse these procedures as appropriate.


A
B
X
C
Y
ohms
volts
mW
mW
ohms
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
1·0
0·9
0·8
0·7
0·6
0·5
0·4
0·3
0·2
0·1
0·09
0·08
0·07
0·06
0·05
0·04
0·03
0·02
0·01
100
50
10
5·0
1·0
0·5
0·1
0·05
0·01
0·005
0·001
0·5μW
0·1μW
1·0
0·9
0·8
0·7
0·6
0·5
0·4
0·3
0·2
0·1
0·09
0·08
0·07
0·06
0·05
0·04
0·03
0·02
0·01
10
20
30
40
50
60
70
80
90
100
200
300
400
500
600
700
800
900
1000
LOAD RESISTANCE
VOLTAGE ACROSS LOAD
POWER 2
POWER 1
LOAD RESISTANCE

p

R.C. Coupling: Attenuation and Phase Shift

The simple resistance-capacitance networks of Fig. 1 are used in almost all electronic circuits either as simple coupling networks or as elementary filters, designed to produce desired frequency/response or frequency/phase characteristics.

If N is the ratio of the input and output voltages (V_{in}/V_{out}), and θ is the relative phase angle between these voltages, the phase shift and attenuation of the two arrangements are given by

(*a*) $N^2 = 1 + \left(\frac{1}{\omega T}\right)^2$

$\tan\theta = \left(\frac{1}{\omega T}\right)$ (V_{out} leading)

(*b*) $N^2 = 1 + (\omega T)^2$

$\tan\theta = \omega T$ (V_{out} lagging)

where T seconds = R ohms × C farads.

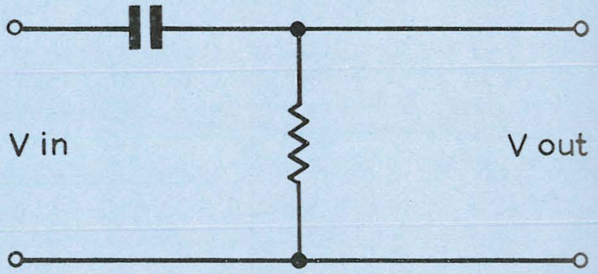


Fig 1 a

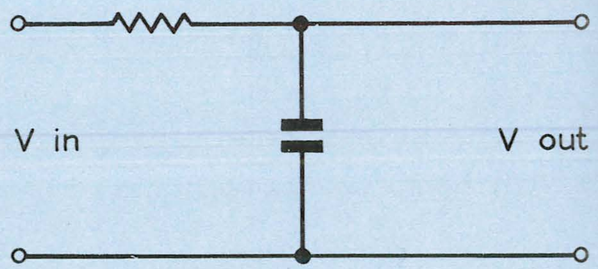


Fig 1 b

The nomograph of Fig. 2 facilitates the evaluation of N and θ for both arrangements. For the high-pass configuration of Fig. 1(a) read the time constant, T, from scale 1(a) and the frequency, f, from scale 3(a). For the low-pass arrangement of Fig. 1 (b) read the time constant from scale 1(b) and the frequency from scale 3(b). Scale 2(a) gives the value of θ in degrees, and scale 2(b) gives the value of N in decibels.

When T is in seconds, f is in Hz; when T is in msec, f is in kHz; when T is in µsec, f is in MHz; and so on.

It is generally accepted that, for values of ωT greater than unity, the slope of the frequency/response characteristic of either network is close to 6 dB per octave. This is an approximation in which the error does not become negligible until $1/\omega T$ (for Fig. 1(a)) or ωT (for Fig. 1 (b)) is of the order of 8. The 3 dB attenuation occurs in either configuration when ωT is unity, and at this frequency the phase shift is 45°.

Where two or more networks are connected in cascade with suitable impedance isolation, both their phase shifts and their attenuations in decibels are, at any given frequency, directly additive – although it must be remembered that, for this purpose, the phase shift of Fig. 1(a) should be regarded as negative and that of Fig. 1(b) as positive.

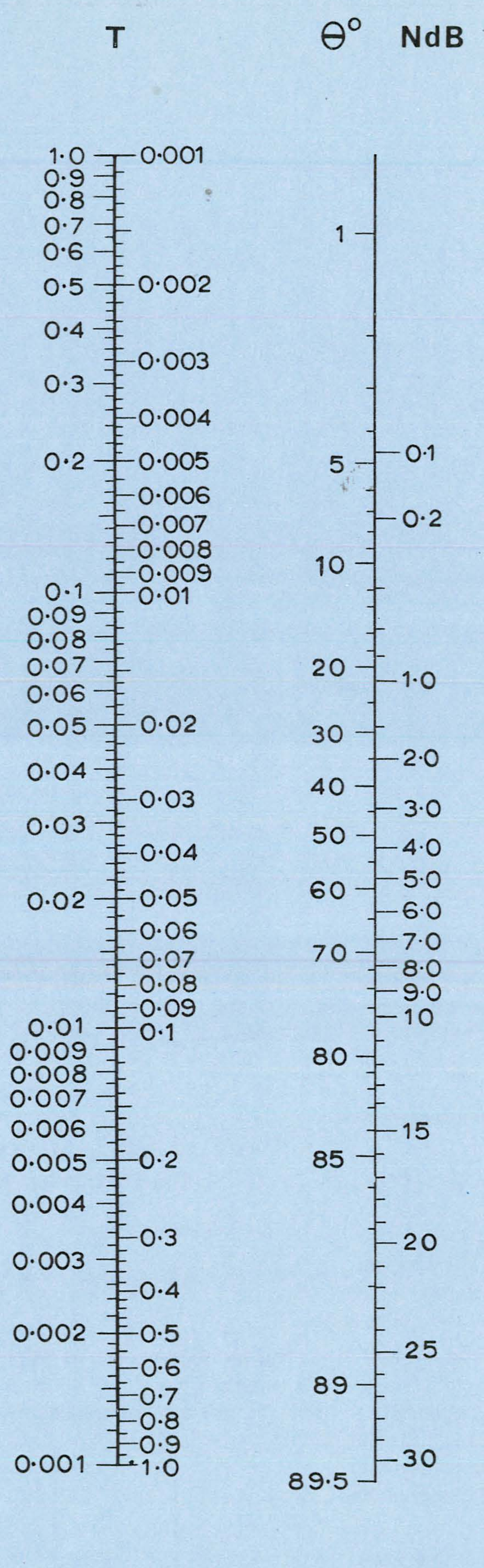


Fig 2

Squarewave Testing of A.C. Coupled Amplifiers

A common test method with audio frequency amplifiers is that of passing through the amplifier a low-frequency squarewave and examining the output waveform on an oscilloscope. This method is particularly useful for assessing the low frequency performance when the cut-off frequency is lower than the minimum frequency of available sinewave test sources.

Although a squarewave contains no frequency components below its fundamental frequency, the shape of the output waveform is largely determined by the relative phase shift at the fundamental and third harmonic frequencies, and this factor is closely related to the shape of the response characteristic at the very low frequency.

The actual relationship depends on the nature, distribution, and time constants of the amplifier's RC coupling circuits. But, with the majority of amplifiers, the low-frequency roll-off is ultimately shaped by a single series capacitance and parallel resistance giving the time constant T. The -3 dB point then occurs at the frequency where $\omega = 1/T$.

When a squarewave is passed through such a network the shape of the output wavetop will be such that:

$$\log_e \frac{Vp}{Vp - V_{sag}} = t/T$$

the terms being as shown in Fig. 1.

The squarewave frequency is, of course equal to $1/2t$, so that the lower 3 dB cut-off frequency is given by the expression.

$$f_c = \frac{1}{2\pi} \log_e \frac{Vp}{Vp - V_{sag}} \times 2fs$$

where f_c is cut-off frequency and
f_s is the squarewave frequency

This can be written as

$$f_c = 0{,}366 \log_{10} \frac{Vp}{Vp - V_{sag}} \times 2fs$$

The nomograph in Fig. 2 gives the cut-off frequency for values of V_{sag}/V_p of 0,05 to 0,5 (i.e., 5% to 50% sag) and squarewave frequencies for 100 to 1000 Hz.

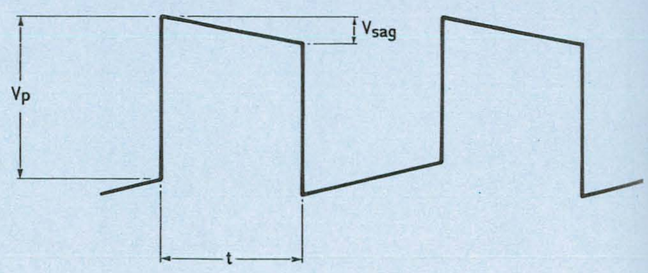
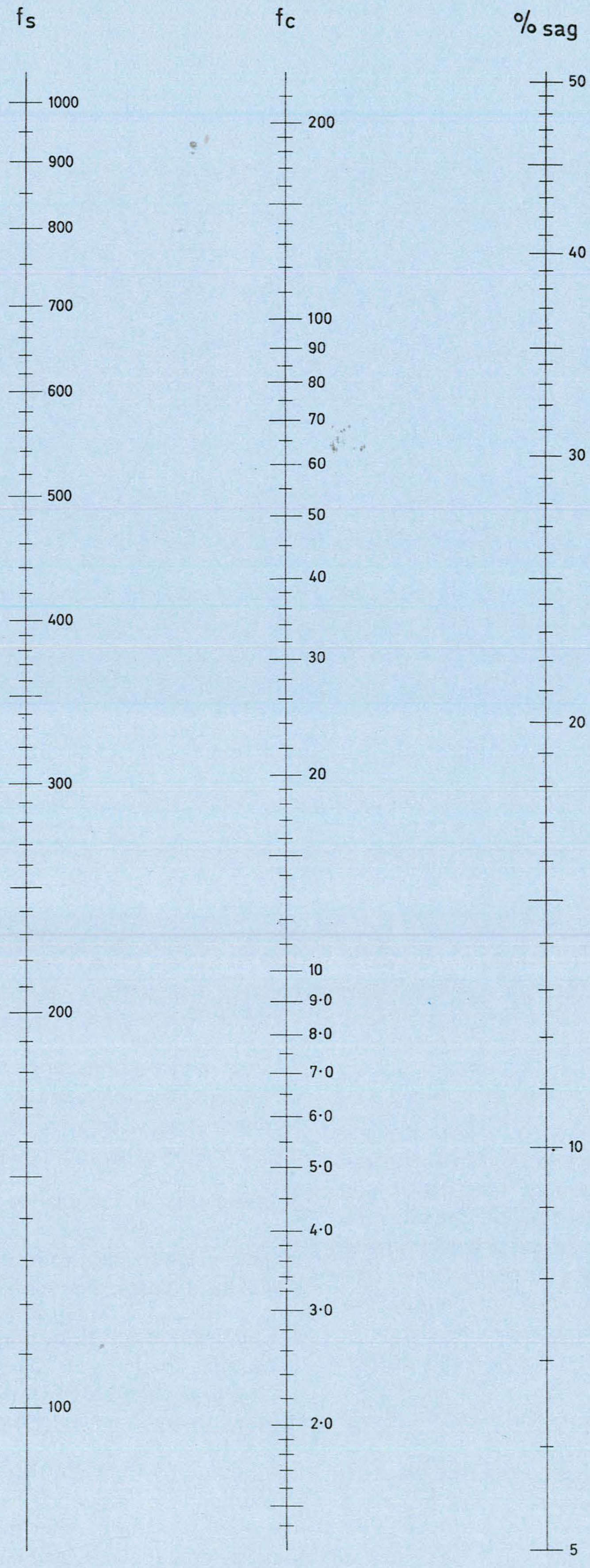


Fig. 1



f_s
f_c
% sag
1000
900
800
700
600
500
400
300
200
100
200
100
90
80
70
60
50
40
30
20
10
9·0
8·0
7·0
6·0
5·0
4·0
3·0
2·0
50
40
30
20
10
5

Fig 2

Reactance of capacitors and inductors

The criticism levelled at many of the graphic aids available for calculating reactance of inductors or capacitors stems either from their complexity or lack of precision. This is usually brought about by an effort to produce a chart covering several decades of frequency and inductance or capacitance.

On the grounds that multiplication or division by any power of ten is undoubtedly the simplest of all arithmetical processes, the nomographs presented here cover one decade only of frequency, capacitance and inductance, to give easily readable scales. The inductance nomograph (Fig. 1) indicates the reactance in ohms when the frequency is in hertz and the inductance is in henries. The capacitance nomograph (Fig. 2) indicates reactance in kilohms when the frequency is in hertz and the capacitance is in microfarads.

Both nomographs also carry a related ω scale giving angular velocity in radians per second.

In order to convert the indicated figures to the practical values multiplication factors are used in the following ways:—

1 Inductance and frequency to reactance

Multiply the practical inductance by 10^a and the frequency by 10^b to give values within the range of the nomograph; then divide the indicated reactance by $10^{(a+b)}$. Where the inductance in henries or frequency in hertz is greater than 10 the indices will, of course, be negative.

2 Frequency and reactance to inductance

Multiply the frequency by 10^b and the reactance by 10^c to give values within the range of the nomograph; then divide the indicated inductance by $10^{(c-b)}$.

3 Inductance and reactance to frequency

Multiply the inductance by 10^a and the reactance by 10^c to give values within the range of the nomograph; then divide the indicated frequency by $10^{(c-a)}$.

4 Capacitance and frequency to reactance

Multiply the capacitance by 10^a and the frequency by 10^b to give values within the range of the nomograph; then multiply the indicated reactance by $10^{(a+b)}$.

5 Frequency and reactance to capacitance

Multiply the frequency by 10^b and the reactance by 10^c to give values within the range of the nomograph; then multiply the indicated capacitance by $10^{(b+c)}$.

6 Capacitance and reactance to frequency

Multiply the capacitance by 10^a and the reactance by 10^c to give values within the range of the nomograph; then multiply the indicated frequency by $10^{(a+c)}$.

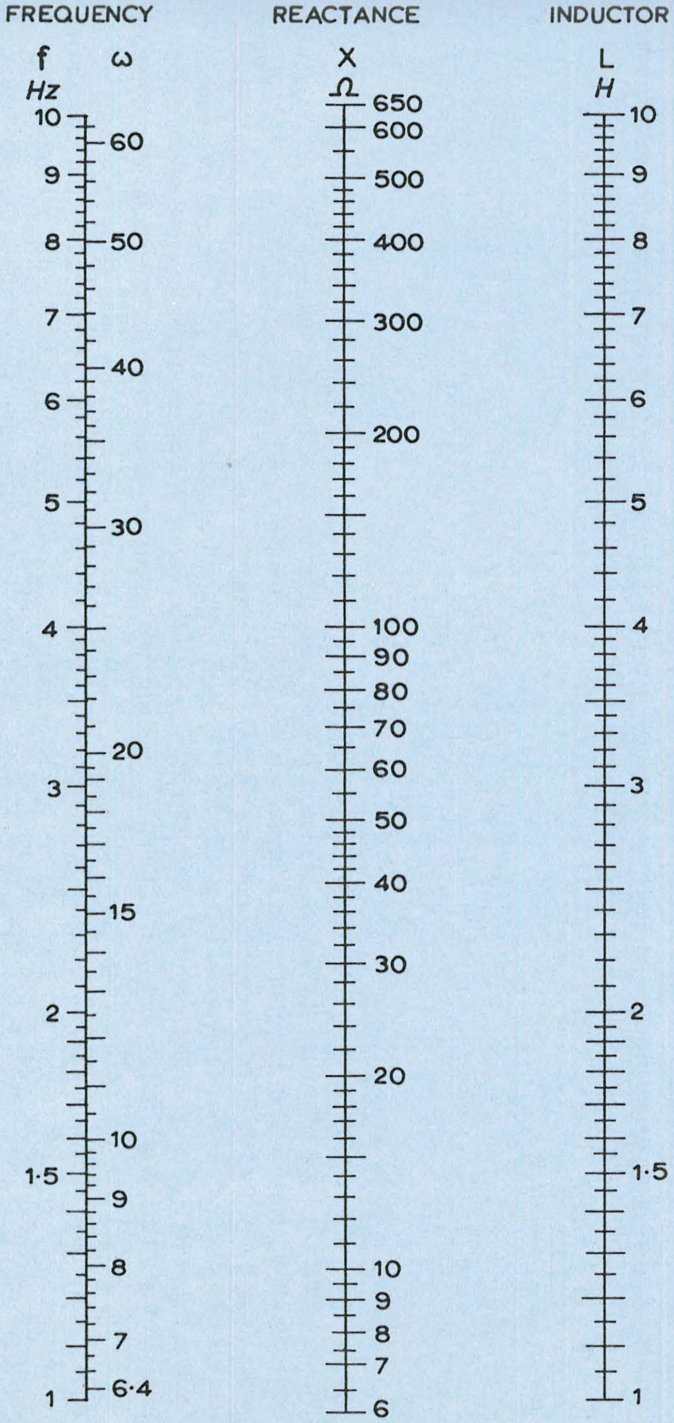

FREQUENCY
REACTANCE
INDUCTOR
f ω
Hz
X
Ω
L
H
10 9 8 7 6 5 4 3 2 1·5 1
60 50 40 30 20 15 10 9 8 7 6·4
650 600 500 400 300 200 100 90 80 70 60 50 40 30 20 10 9 8 7 6
10 9 8 7 6 5 4 3 2 1·5 1

Fig. 1

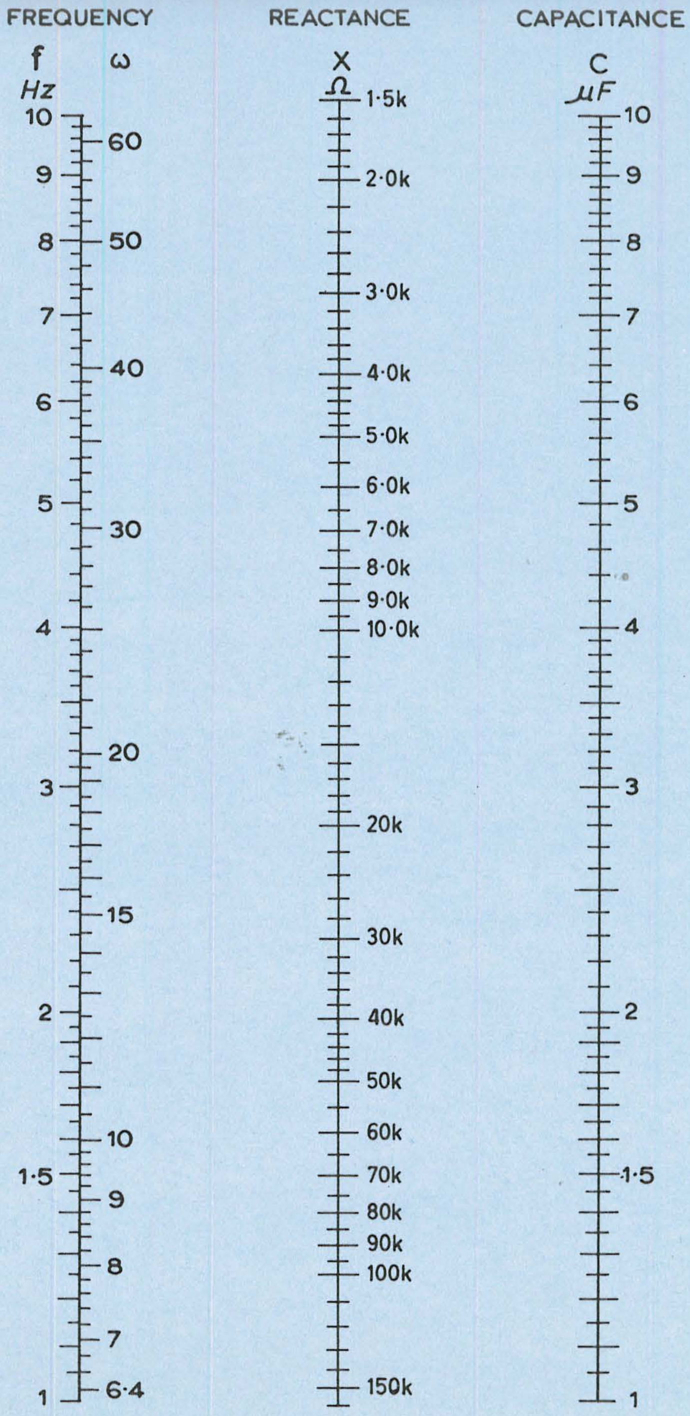

FREQUENCY
REACTANCE
CAPACITANCE
f ω
Hz
X
Ω
C
μF
10 9 8 7 6 5 4 3 2 1·5 1
60 50 40 30 20 15 10 9 8 7 6·4
1·5k 2·0k 3·0k 4·0k 5·0k 6·0k 7·0k 8·0k 9·0k 10·0k 20k 30k 40k 50k 60k 70k 80k 90k 100k 150k
10 9 8 7 6 5 4 3 2 1·5 1

Fig. 2

Reactance, Resistance and Q

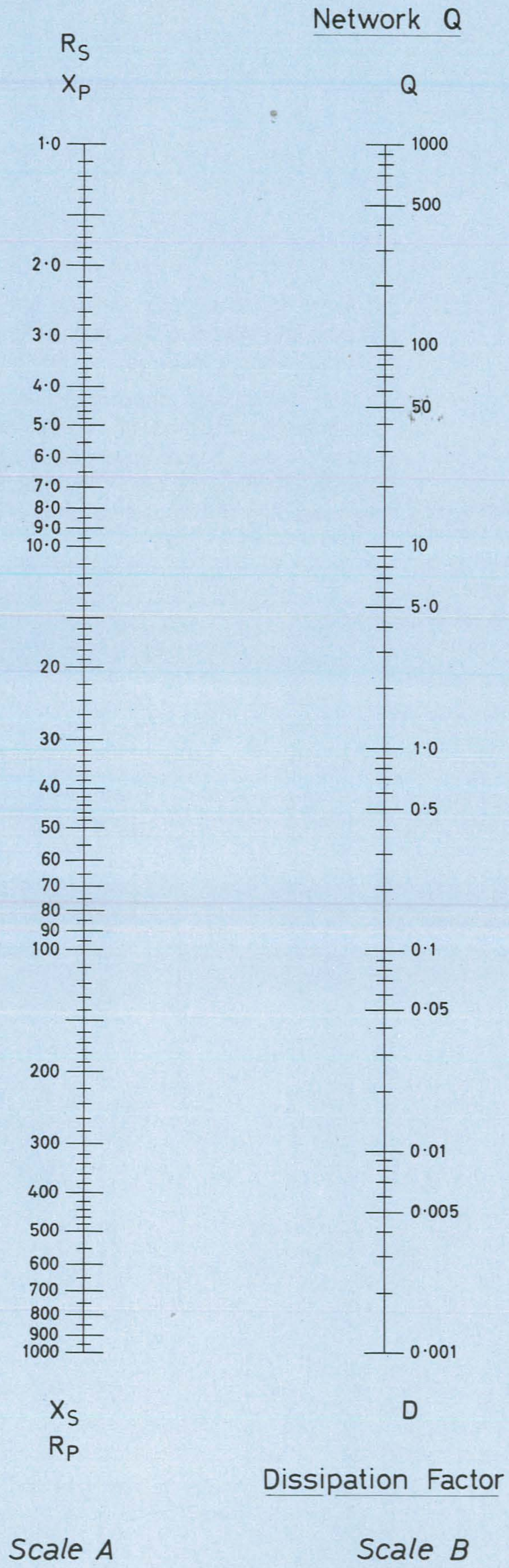
The associated nomograph gives the values of Q and D corresponding to values of reactance and resistance, where Q is defined as X/R for series networks and R/X for parallel networks. The dissipation factor, D, is, of course, equal to 1/Q so that both factors can be found from a single nomograph having only three scales.

The legends at the top of the nomograph show the scales to be used for calculation of Q values. For series networks scale A gives values of resistance, scale C gives values of reactance, and the Q is read from scale B. For parallel networks scales A and C are reversed, so that scale A gives reactance values and scale C gives the resistance, Q again being read from scale B.

The legends at the bottom of the nomograph show the scales to be used for calculation of D. Here scale A gives series reactance or parallel resistance and scale C gives series resistance or parallel reactance.

For convenience the resistance and reactance scales each cover three decades, so that impedances can be reckoned directly in ohms, kilohms, megohms, etc., without the need for conversion factors. It is, of course, essential that R and X are reckoned in the same units.

This automatically gives a centre scale (B) covering values of both Q and D from 0,001 to 1000. Recognising, however, that one is seldom interested in values of Q below unity or values of D above unity, it may be helpful to regard the upper half of scale B as its "Q" section and its lower half as its "D" section, which conforms logically with the placing of the legends.



Network Q
R_S
X_P
Q
X_S
R_P
1·0
2·0
3·0
4·0
5·0
6·0
7·0
8·0
9·0
10·0
20
30
40
50
60
70
80
90
100
200
300
400
500
600
700
800
900
1000
1000
500
100
50
10
5·0
1·0
0·5
0·1
0·05
0·01
0·005
0·001
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10·0
9·0
8·0
7·0
6·0
5·0
4·0
3·0
2·0
1·0
X_S
R_P
D
R_S
X_P
Dissipation Factor
Scale A
Scale B
Scale C

p

Capacitance & Inductance to Resonance Frequency

This nomograph gives the resonance frequencies of LC tuned circuits according to standard formula,

$$f = \frac{1}{2\pi\sqrt{LC}}$$

which ignores the loss factor.

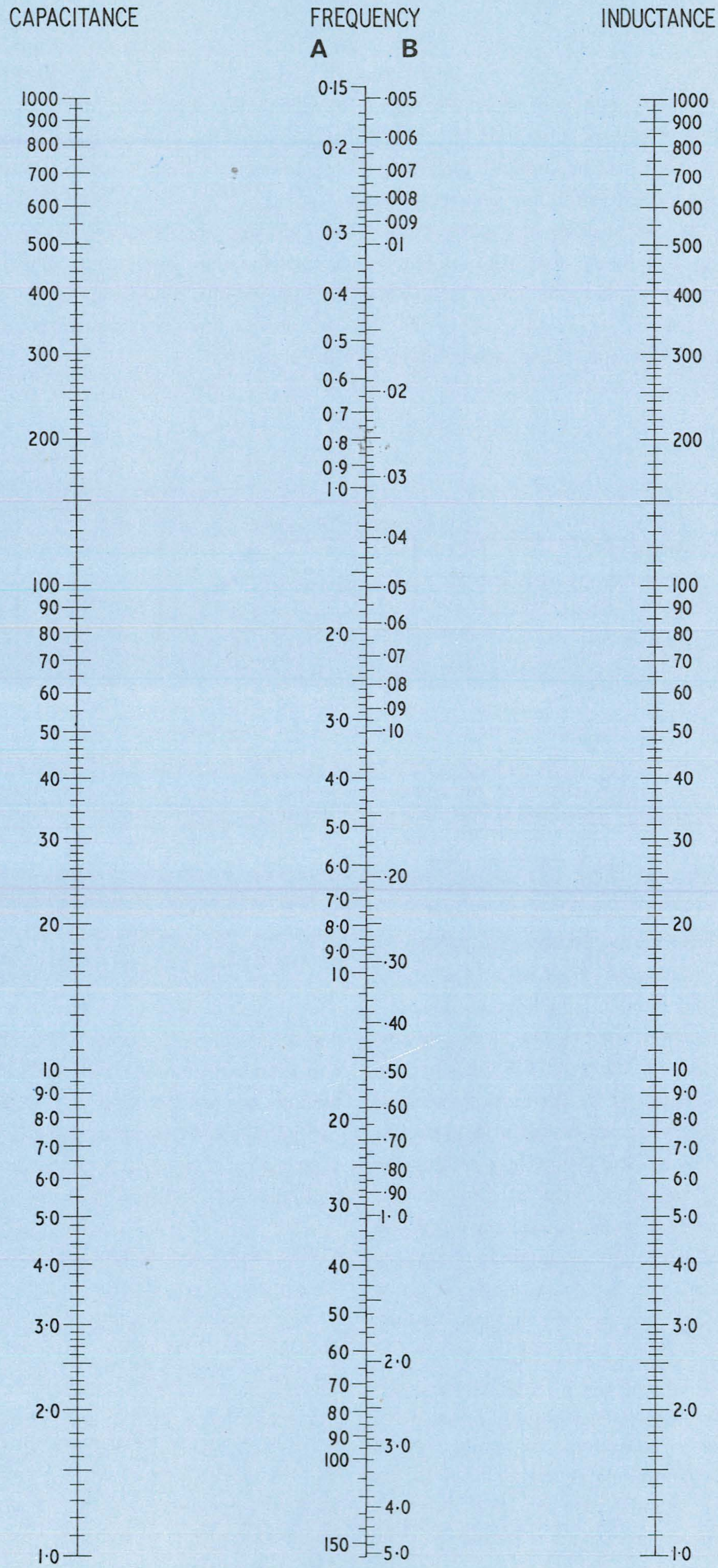
Students are frequently taught that this formula is valid for series tuned circuits, but that the effect of resistive loss must be taken into account in calculating the resonance frequency of parallel tuned circuits. This is only true, however, if it is assumed that the loss resistance is effectively in series with one or both of the reactive elements.

Such an assumption is totally unrealistic because inductors and capacitors have both equivalent series and parallel loss. At any given frequency a nominally reactive component's value may be measured in terms of its equivalent series or parallel inductance or capacitance, and conversion from one to the other is easily made. A nomograph for this conversion is featured on a later page.

If the effective series inductance and capacitance is taken as the basis for calculating the resonance frequency of series tuned circuits and the effective parallel values for parallel tuned circuits, no modification to the standard formula need be made to account for loss resistance.

The nomograph opposite covers three decades of capacitance, inductance and frequency. The two frequency scales A and B are given to avoid the necessity for conversion factors, the nomograph being completely direct reading in the desired units if used in conjunction with the following table.

Capacitance Scale	Inductance Scale	Frequency Scale A.	Frequency Scale B.
pF	μH	MHz	—
nF	μH	—	MHz
μF	μH	kHz	—
pF	mH	—	MHz
nF	mH	kHz	—
μF	mH	—	kHz
pF	H	kHz	—
nF	H	—	kHz
μF	H	Hz	—


CAPACITANCE
FREQUENCY
A
B
INDUCTANCE
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
9·0
8·0
7·0
6·0
5·0
4·0
3·0
2·0
1·0
0·15
0·2
0·3
0·4
0·5
0·6
0·7
0·8
0·9
1·0
2·0
3·0
4·0
5·0
6·0
7·0
8·0
9·0
10
20
30
40
50
60
70
80
90
100
150
·005
·006
·007
·008
·009
·01
·02
·03
·04
·05
·06
·07
·08
·09
·10
·20
·30
·40
·50
·60
·70
·80
·90
1· 0
2·0
3·0
4·0
5·0
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
9·0
8·0
7·0
6·0
5·0
4·0
3·0
2·0
1·0

p

Swept-Frequency Signal Generators

The application of sweep-generator techniques to receiver alignment is now well accepted, but, for general measurements on receivers, it is an advantage if the sweep-generator also has the normal attributes of a standard signal generator; i.e., an output attenuator at the correct impedance, giving an accurately controlled amplitude down to the order of 1 μV, and full modulation facilities—a.m. or f.m.

Apart from television receivers, most receiver bandwidths are within the deviation range of an f.m. signal generator. V.h.f. and u.h.f. signal generators are available which can be frequency modulated to deviations upwards of 100 kHz. For example, a Marconi TF 995B/2 Signal

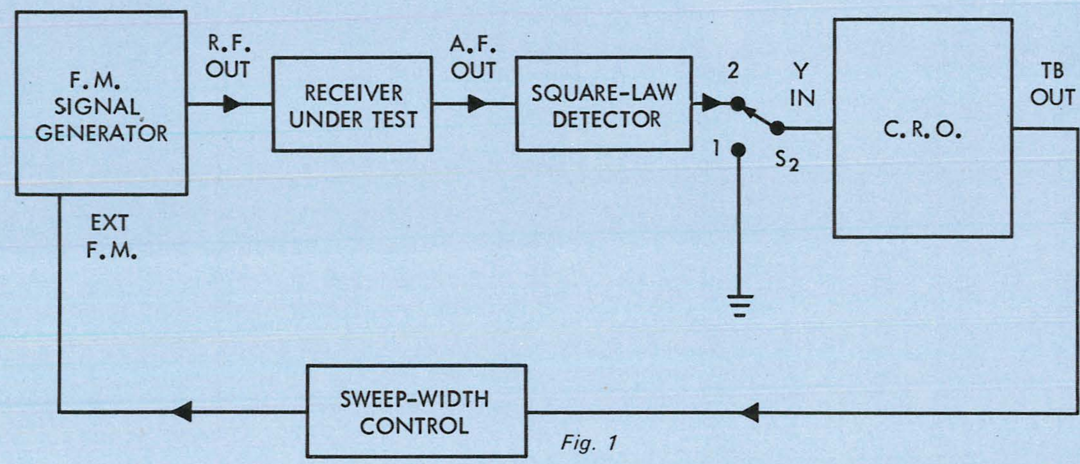


Fig. 1

Figure 1 shows the method of connecting a signal generator and oscilloscope to a receiver in order to display the i.f. or overall frequency/response characteristic. The diagram shows an external detector in use; this is necessary for f.m. receivers and may be convenient for a.m. receivers in which the internal detector is not readily accessible. With many a.m. receivers, however, it is possible to make direct connection to the internal detector so that an external one is unnecessary. But, if this is done, care must be taken to be sure that any time constants in the detector load do not modify the shape of the displayed curve. For example, if the receiver is fitted with a signal strength meter, the Y input to the oscilloscope can be connected in parallel with it. Although this makes connection very easy, such meters are usually by-passed by a fairly large capacitor, which must either be disconnected or allowed for by keeping the sweep speed so slow that the time constant of the capacitive detector-load does not modify the displayed characteristic.

This second course can only be taken if (1) the oscilloscope timebase operates at very low speeds—say 5 Hz; (2) the external modulation circuit of the signal generator will accept such low frequencies, and (3) the Y amplifier is d.c. coupled.

It is not usually possible to display frequency markers when a signal generator is used in this way; but, fortunately, Marconi Instruments f.m. signal generators are equipped with directly calibrated incremental frequency controls so that the width of the displayed characteristic can be measured by varying the tuning to bring relevant points on the curve to a central cursor line on the c.r.t. graticule.

F.M. signal generators do not normally operate at frequencies below about a megahertz; and, until recently, swept-frequency measurement on receivers in the m.f. and h.f. bands has been restricted to orthodox sweep-generators. The Marconi Instruments Signal Generators TF 2002 series, however, have f.m. and frequency sweep facilities at centre frequencies tunable from 100 kHz to 88 MHz. These instruments can be frequency swept from an external source with d.c. coupling to the voltage-controlled reactor, so that very low sweep speeds can be used if necessary.

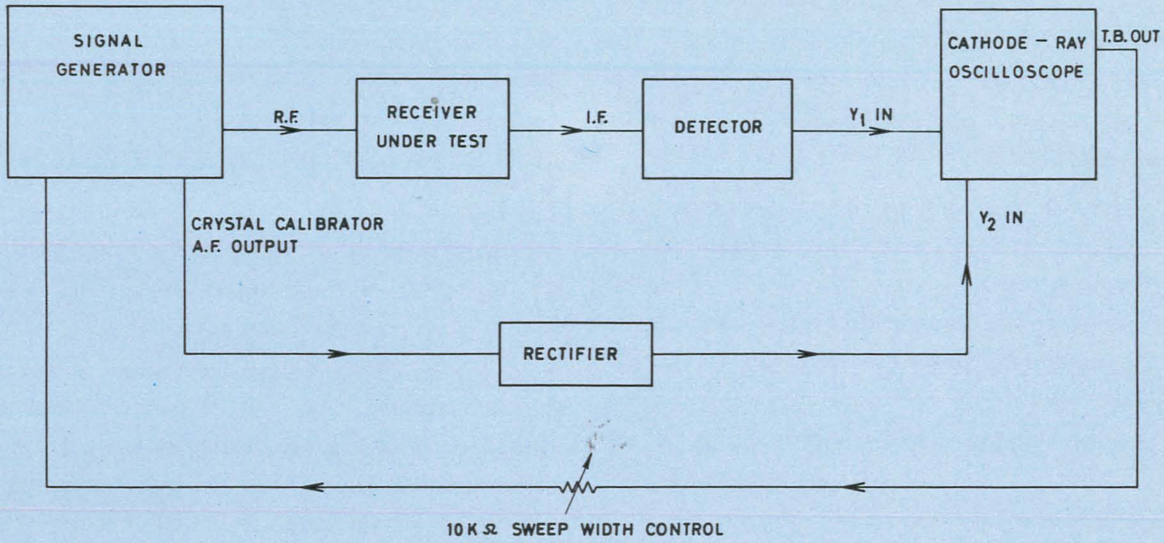


Fig. 2

The built-in crystal calibrator of the TF 2002 series gives calibration beats at 10 kHz intervals. When the signal is being frequency swept, the audio output from the crystal calibrator can be rectified and applied to the Y deflection or Z modulation terminal of the oscilloscope to provide frequency markers. At the comparatively narrow sweep widths used, however, these markers have a very definite double-pulse form with the zero point between the two pulses corresponding to the 10 kHz interval mark. Figure 2 shows the connections.

At these lower frequencies, receivers are used which have very narrow acceptance bands and crystal controlled ocal oscillators; e.g., single-sideband and independent-sideband receivers. When making protracted measurements on such receivers with a signal generator the problem of the generator's frequency stability can be quite serious. With a frequency swept signal generator this problem is greatly eased because, unlike the single-frequency signal which gradually drifts out of tune, the swept signal is continually traversing the acceptance band, and the only effect of a small amount of drift is a movement of the displayed characteristic curve across the oscilloscope trace. Thus the attributes of the frequency swept signal generator can offer advantages for purposes other than actual frequency/response measurement or circuit alignment.

F.M. Demodulator Response

A somewhat specialised case arises in the setting up of f.m. receivers.

Important as the shape of the frequency/response characteristic is in this type of receiver, the main application of the swept frequency measurement is probably for examination of the demodulation characteristic. For this particular application the dynamic display of the characteristic can be made using an oscilloscope and a frequency modulated signal generator of the type that would normally be used for general tests on the receiver. The method of connecting the test set-up is given in Figure 3.

In order to test the demodulation under realistic conditions the test voltage applied to it should be the full limiter voltage and it should also be derived from the correct source impedance. To obtain these conditions, it is convenient to use the i.f. amplifier of the receiver as the connecting network between the signal generator and the demodulator. So the output of the signal generator is fed into the input of the receiver's i.f. amplifier or into the aerial socket.

However, care must be taken that the displayed demodulation characteristic is not modified by frequency/response characteristic of the receiver's tuned amplifiers; and to do so the modulating frequency should be kept

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as low as conveniently possible, 50 Hz being quite satisfactory in normal circumstances. The bandwidth of the receiver must be sufficient to accommodate the multiple f.m. sidebands at much higher modulation frequencies, so all significant sidebands at 50 Hz spacing are easily handled.

It is necessary to modulate the signal generator from an external source; and, in this case, a sinewave source is more convenient than a sawtooth. With sinewave modulation the signal generator's modulation meter indicates the frequency deviation, which is, of course, half the sweep width. The horizontal deflection on the oscilloscope is obtained by also feeding the output of the modulating oscillator to the external time base terminal of the oscilloscope; and the total length of the trace then corresponds to twice the f.m. deviation as indicated on the modulation meter. With the comparatively restricted frequency sweep, errors due to non-linearity of the f.m. modulator are fairly small and the calibrated graticule of the oscilloscope can safely be used as a frequency scale.

The Y input of the oscilloscope is connected directly to the audio output terminal of the receiver's f.m. demodulator. The high input impedance of the oscilloscope is unlikely to affect the operation of the demodulator, so no special precautions are necessary from this point of view.

To adjust the demodulator, the signal generator is set accurately to the i.f. (or r.f.) centre frequency, and sufficient output is applied to operate the limiter of the receiver. The familiar "S" shaped demodulator response will then be displayed on the c.r.t. screen; and the demodulator trimming controls can be adjusted to bring it to the centre of the display. If the receiver contains a ratio detector, the normal precaution of replacing the bias capacitor with a suitable voltage source must be taken in the same way as for static methods of measurement.

The Derivative Curve

Providing the signal generator is suitable, it is possible to produce a very much more useful display by the use of two superimposed modulating frequencies.

For really comprehensive assessment of true linearity of the demodulator over the nominally linear part of its characteristic, the ideal display is that of the derivative of the demodulation curve; or, in other words, a display in which the instantaneous vertical position of the spot is proportional to the instantaneous slope of the demodulation curve. Such a display provides far better discrimination than the direct picture of the "S" shaped curve; for if the demodulator were perfectly linear, the display would take the form of a straight horizontal line, any deviation from this form representing non-linearity.

Figure 4 shows examples of direct and derivative curves for linear and non-linear demodulation. Note that the vertical locus of the derivative curve falls to zero at the turnover points of the direct curve where the slope is zero. The correct theoretical curve beyond these zero points is shown by the dotted lines in the diagram, but, for reasons that will become obvious, the displayed derivative curve takes the shape of the full line in the diagram. As only the part between the zero points is required, however, this does not matter very much.

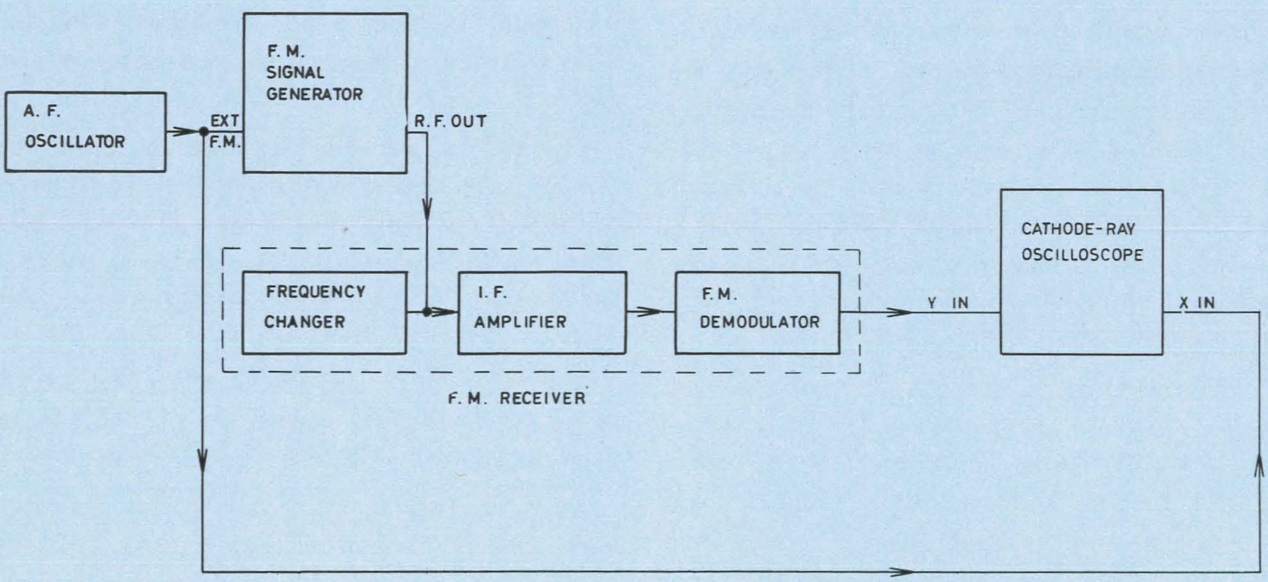


Fig. 3

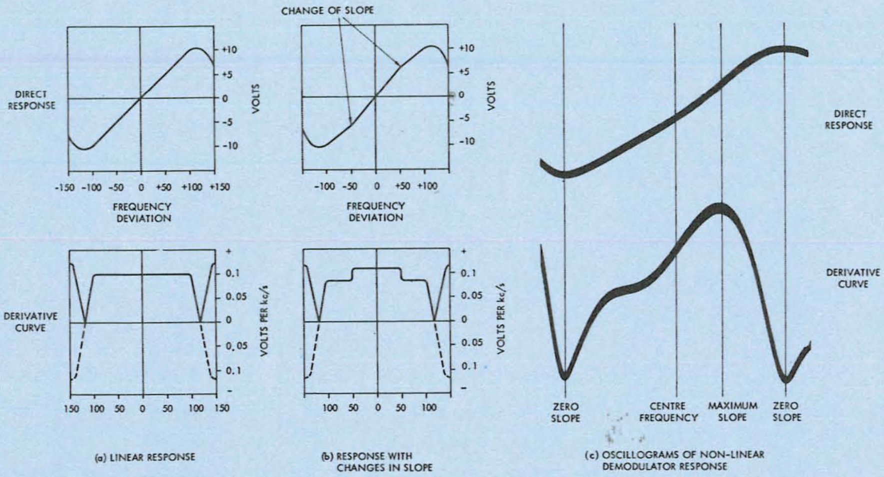


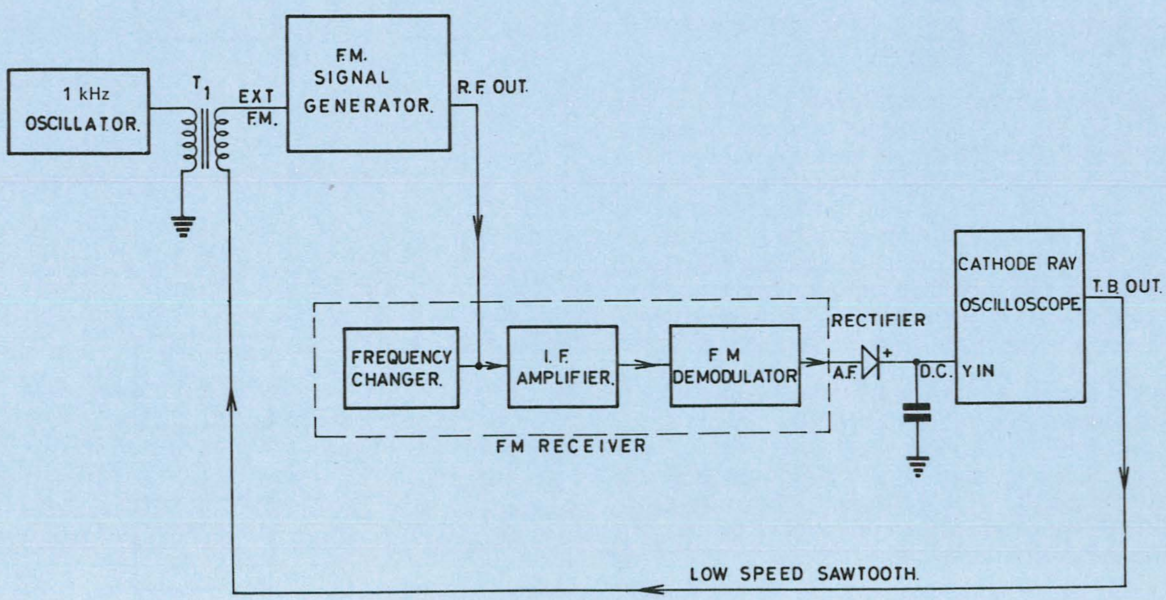
Fig. 4

The connections for obtaining this display are shown in Figure 5. A very slow sawtooth voltage (or very low frequency sinewave) is applied to the external modulation terminals of the signal generator and simultaneously to the X deflection system of the oscilloscope. In the diagram the internal timebase generator is used. This is the actual sweep voltage and its amplitude should be such as to give a frequency sweep which completely accommodates the demodulator characteristic. Its frequency should be below the l.f. response of the receiver's audio amplifier.

Superimposed upon this voltage, by means of transformer T_1, is an audio frequency voltage (say 1 kHz) of sufficient amplitude to give about 1% of maximum rated deviation.

The Y input terminal of the oscilloscope is connected via a rectifier to the a.f. output of the receiver, thus utilising both the gain and the l.f. cut of the audio amplifier. The 1 kHz output from the receiver at any instant is then directly proportional to the slope of the demodulation curve at the instantaneous input frequency, so that the spot traces out the derivative curve. Any non-linearity is easily detected by aligning the curve with one of the graticule lines on the oscilloscope. Furthermore, the relative magnitude of the non-linearity can be measured by comparing the amplitude of the departure from this line with the mean height of the display from the zero points.

Frequency calibration is best done by a slide back method against the signal generator's incremental frequency control.



Multi-Signal Receiver Selectivity Tests

Two-signal tests for assessing the receiver's response to unwanted adjacent-channel signals usually utilise the arrangement shown in the upper diagram. The output from signal generator A represents the wanted signal, and that from signal generator B the unwanted signal. The interfering signal is regarded as part of the noise, and the suppression is evaluated in terms of degradation of the signal-to-noise ratio.

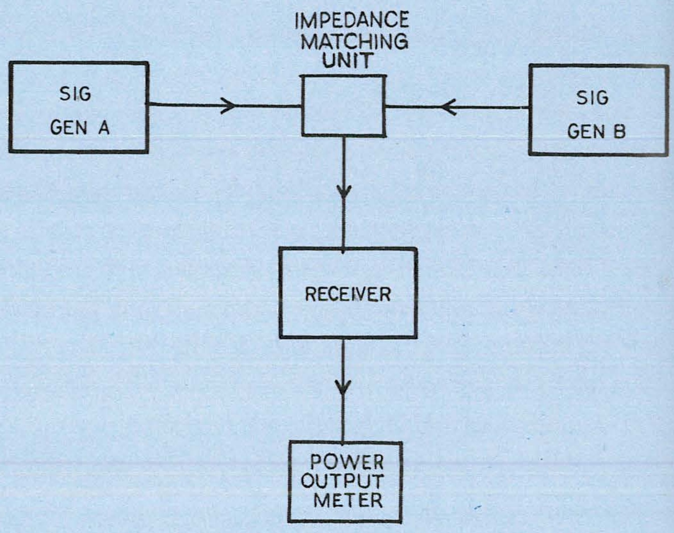
For identification, and to avoid heterodyne beats, it is usual to modulate the two signals at different frequencies. Signal generator A is normally modulated at 1 kHz and signal generator B at 400 Hz, their a.m. depths or f.m. deviations being equal—usually 30% a.m. or 30% of maximum f.m. deviation.

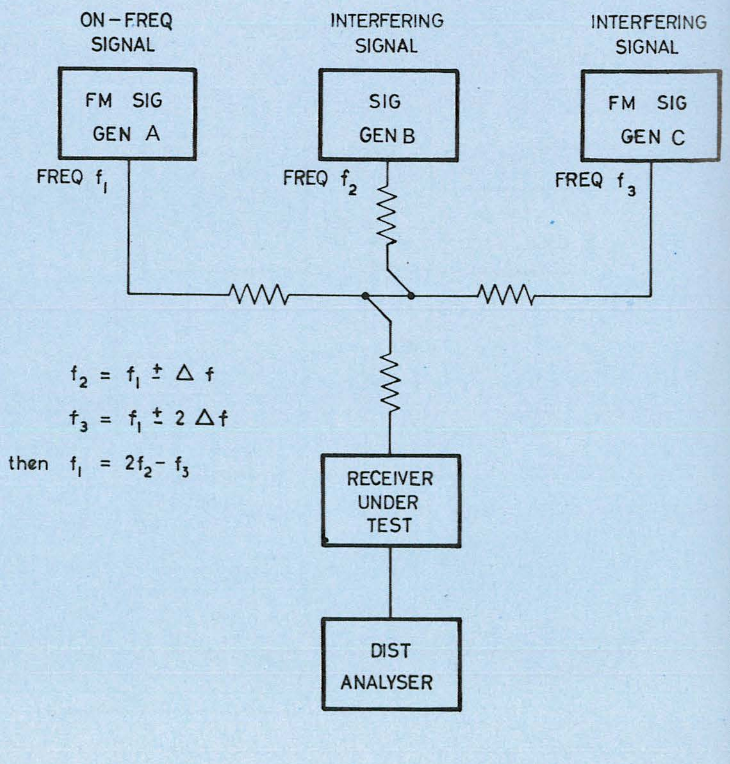
With zero output from signal generator B, generator A is tuned to the receiver's centre frequency, and the r.f. level is adjusted to produce a signal-to-noise ratio of 20 dB (10 dB for mobile radio).

Signal generator B is then tuned to one channel spacing away from the centre frequency and its output is adjusted to produce a signal-to-noise+interference ratio which is 3 dB less than the ratio measured with signal generator A alone. The ratio between the input levels due to each of the signal generators, expressed in decibels, is the adjacent-channel suppression figure for the receiver. The suppression should be at least 70 dB.

The arrangement shown in the lower diagram is that recommended by the U.S. Electronic Industries Association for intermodulation measurement on f.m. communications receivers. With signal generators B and C delivering zero output, signal generator A is tuned to the receiver's centre frequency, and its r.f. output adjusted to produce 12 dB signal-to-noise ratio. Signal generator B is then tuned to one channel spacing above or below the centre frequency, and generator C to two channel spacings from the centre frequency in the same direction as B. The equivalent outputs of generators B and C are maintained equal, and the levels are increased until the signal-to-noise ratio is reduced to 6 dB.

The ratio of the level from B or C to that from generator A, expressed in decibels, is the measure of intermodulation. In the U.S.A. the recommended minimum is 60 dB, but in some European countries the standard is raised to 70 dB.





Power and Voltage Ratios in Decibels

The decibel notation is basically a method of expressing power ratio, the number of decibels (N dB) being given by

$$N \text{ dB} = 10 \log_{10} \frac{P_2}{P_1}$$

where P_1 and P_2 are the two power levels under comparison.

On the assumption of constant impedance the notation is also used for voltage ratio, giving

$$N \text{ dB} = 20 \log_{10} \frac{V_2}{V_1}$$

where V_1 and V_2 are the two voltage levels.

In the above expressions the denominator (P_1 or V_1) is the reference level, so that a power or voltage may be expressed as "N dB with respect to x watts or volts". This is often contracted to dB μV (to mean decibels with respect to 1 μV), dBm (with respect to 1 mW), dB W (with respect to 1 watt), etc.

Table I

Ratio Down			Ratio up	
VOLTAGE	*POWER*	*DECIBELS*	*VOLTAGE*	*POWER*
1·0	1·0	0	1·0	1·0
·9886	·9772	·1	1·012	1·023
·9772	·9550	·2	1·023	1·047
·9661	·9333	·3	1·035	1·072
·9550	·9120	·4	1·047	1·096
·9441	·8913	·5	1·059	1·122
·9333	·8710	·6	1·072	1·148
·9226	·8511	·7	1·084	1·175
·9120	·8318	·8	1·096	1·202
·9016	·8128	·9	1·109	1·230
·8913	·7943	1·0	1·122	1·259
·8710	·7586	1·2	1·148	1·318
·8511	·7244	1·4	1·175	1·380
·8318	·6918	1·6	1·202	1·445
·8128	·6607	1·8	1·230	1·514
·7943	·6310	2·0	1·259	1·585
·7762	·6026	2·2	1·288	1·660
·7586	·5754	2·4	1·318	1·738
·7413	·5495	2·6	1·349	1·820
·7244	·5248	2·8	1·380	1·905
·7079	·5012	3·0	1·413	1·995
·6683	·4467	3·5	1·496	2·239
·6310	·3981	4·0	1·585	2·512
·5957	·3548	4·5	1·679	2·818
·5623	·3162	5·0	1·778	3·162
·5309	·2818	5·5	1·884	3·548
·5012	·2512	6	1·995	3·981
·4467	·1995	7	2·239	5·012
·3981	·1585	8	2·512	6·310
·3548	·1259	9	2·818	7·943
·3162	·1000	10	3·162	10·000
·2818	·07943	11	3·548	12·59
·2512	·06310	12	3·981	15·85
·2239	·05012	13	4·467	19·95
·1995	·03981	14	5·012	25·12
·1778	·03162	15	5·623	31·62
·1585	·02512	16	6·310	39·81
·1413	·01995	17	7·079	50·12
·1259	·01585	18	7·943	63·10
·1122	·01259	19	8·913	79·43
·1000	·01000	20	10·000	100·00

Where the numerator of the ratio is less than the denominator N becomes negative; this may be expressed as "$-N$ dB" or "N dB down", positive values of N being regarded as "N dB up" by analogy.

Tables I and II facilitate rapid conversion between decibels and voltage or power ratios. To convert decibels to voltage or power ratio use Table I; to convert voltage or power ratio to decibels use Table II.

Table I covers dB ratios up to 20 dB only. For values of N greater than 20 proceed as follows.

Let X be the whole number of times that 20 can be divided into N, to leave a remainder that falls within the range of the table. Look up the voltage or power ratio corresponding to this remainder on the appropriate side of the table. For voltage ratio "up" multiply by 10^X, and for voltage ratio "down" divide by 10^X. For power ratio multiply or divide, as appropriate, by 10^{2X}.

Table II covers voltage and power ratios from 1 to 10. For power ratios outside this range move the decimal point to the left or right to bring the figure within the range, then add 10 dB for each position that the point is moved to the left, or subtract 10 dB for each position that it is moved to the right. For voltage ratios use the same procedure, but add or subtract 20 dB instead of 10 dB. Ratios close to 1 and to 10 are given in smaller increment than the rest of the table for convenience of conversion when errors are to be expressed in decibels.

Table II

Voltage *or* Power Ratio	*dB Voltage*	*dB Power*
1·0	0·0	0·0
1·1	0·83	0·41
1·2	1·58	0·79
1·3	2·28	1·14
1·4	2·92	1·46
1·5	3·52	1·76
1·75	4·86	2·43
2·0	6·02	3·01
2·5	7·96	3·98
3·0	9·54	4·77
3·5	10·88	5·44
4·0	12·04	6·02
4·5	13·06	6·53
5·0	13·98	6·94
5·5	14·81	7·40
6·0	15·56	7·78
6·5	16·26	8·13
7·0	16·90	8·45
7·5	17·50	8·75
8·0	18·06	9·03
8·5	18·58	9·29
9·0	19·08	9·54
9·25	19·32	9·16
9·5	19·55	9·27
9·6	19·65	9·32
9·7	19·74	9·87
9·8	19·83	9·91
9·9	19·91	9·95
10·0	20·0	10·0

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Circuit Magnification Meter

The symbol Q and the term Circuit Magnification are generally taken to be synonymous; but technical usage has produced a second—more common—meaning for Q, which is sufficiently different from magnification to cause ambiguity in certain circumstances.

Magnification is a term really applicable only to series tuned circuits at resonance, where Q is equal to the ratio of the voltage developed across either reactance to the applied e.m.f.; i.e., V/E in Fig. 1. The current in the circuit at resonance is equal to E/R_T, where R_T is the *total* effective series resistance in the circuit. At resonance the inductive and capacitive reactances are, of course, equal, and we can write

$$V = X.E/R_T, \text{ so that } V/E = X/R_T = Q.$$

But in this context R_T is the total effective series resistance in the circuit, as distinct from the loss resistance of either of the reactive elements.

Taking the point that in practical tuned circuits most of the loss is in the inductor, it has become customary to specify the loss in inductors in terms of Q, on the assumption that the associated capacitor is virtually loss free; and the philosophy is then extended to regard Q as a general statement of X/R for any reactive component, either capacitive or inductive.

It is, however, often more convenient to use the reciprocal term, D or dissipation factor, which is equal to R/X. For low loss components, this is numerically nearly equal to the power factor or ratio of true power to VA. Power factor may be represented by the cosine of phase angle ϕ between the voltage and current vectors. In other words, $\cos\phi$ is the ratio between resistance and impedance—as distinct from reactance (see Fig. 2). The dissipation factor, D, is equal to the tangent of the complementary angle, δ, and the expression $\tan\delta$ is frequently used as an alternative to the symbol D.

Circuit Q

Expressed as X/R_T, Q is the magnification of a series resonant circuit, but, in practical selective amplifiers, etc., parallel tuned circuits are probably more common. With these, the term magnification has very little meaning, and the significance of the circuit Q is in its relevance to dynamic resistance and bandwidth.

If resonance of a parallel circuit is defined as the frequency at which the circuit becomes purely resistive, the dynamic resistance is equal to the parallel combination of the effective shunt loss resistances of the reactive circuit elements—R_p in Fig. 3. If R_p is then regarded wholly as the shunt loss in either element, $D = \tan\delta = X/R_p$, and hence, $Q = R_p/X$.

The dynamic resistance is thus equal to ωLQ or $Q/\omega C$. For Q values above 10, the dynamic resistance is very nearly equal to L/CR_s, where R_s is the effective series resistance, but it must be remembered that this expression is an approximation, which is not valid for very low Q values.

The $-$ 3dB bandwidth of a series tuned circuit is taken as the interval between the two frequences (f_1 and f_2) either side of resonance where the voltage (V_b) across either reactance is equal to $\frac{1}{\sqrt{2}}$ of the voltage (V_r) at resonance. If $\triangle f = f_1 - f_2$, $Q = f_o/\triangle f$, where f_o is the resonance frequency. The same expression is applicable to a parallel circuit when f_1 and f_2 are defined as the frequencies at which the dynamic impedance of the circuit falls to $\frac{1}{\sqrt{2}}$ times the dynamic resistance at resonance. When a parallel tuned circuit is fed from a constant current source (e.g., a transistor or pentode) the voltage across it is directly proportional to the dynamic impedance, so that the symbols V_r and V_b can be applied to both series and parallel networks.

The general expression for bandwidth at any voltage ratio can then be written as

$$Q = \frac{f_o}{\triangle f}\left(\frac{V_r^2}{V_b^2} - 1\right)^{\frac{1}{2}}$$

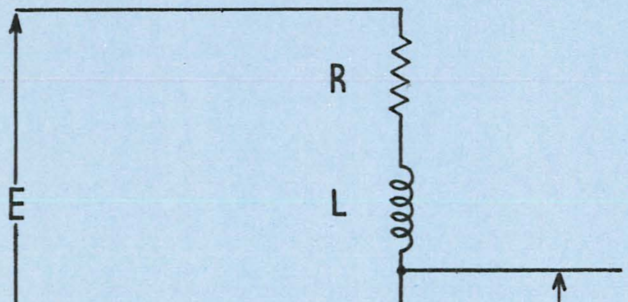


Fig. 1

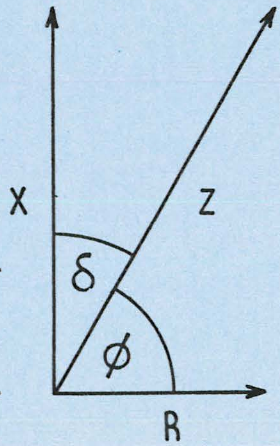


Fig. 2

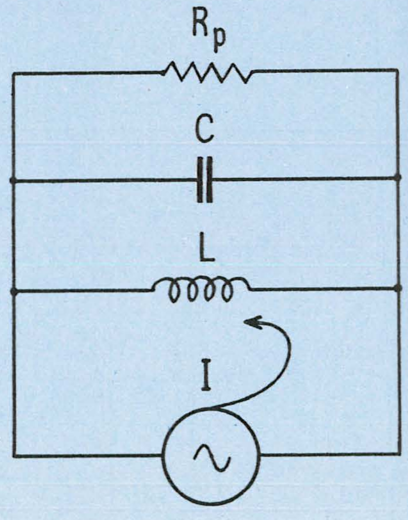


Fig. 3

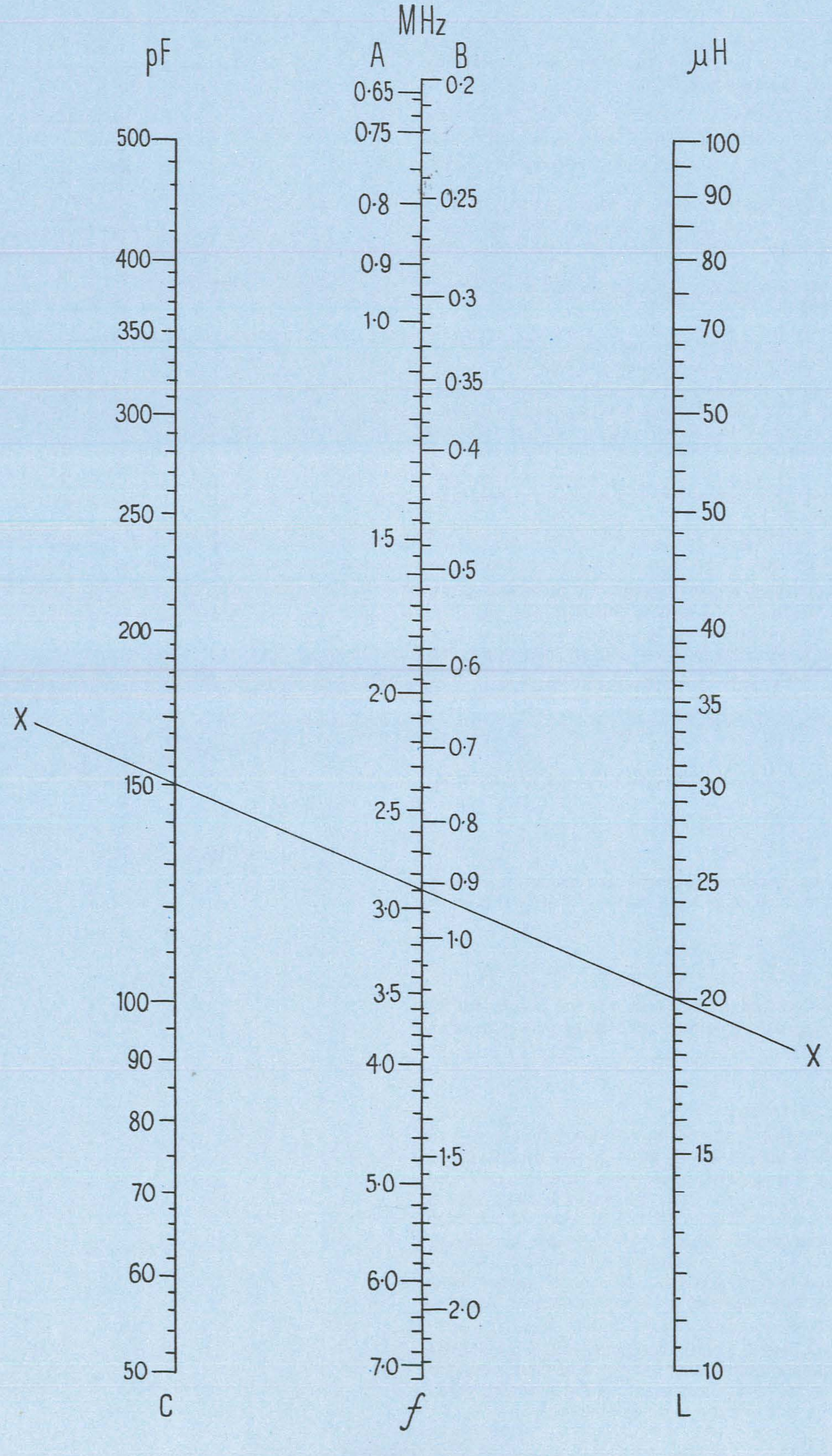
Resonance Frequency Chart

This abac gives the resonance frequencies of series tuned circuits over the capacitance range of the Circuit Magnification Meter TF 1245A, and the inductance range 10 μH to 100 μH. Within this range the frequency is read directly on scale A. The capacitance or inductance range can be extended in decades in either direction by multiplying by the appropriate power of ten; i.e., 10^n. The frequency must then be multiplied by $10^{-n/2}$, and to avoid unnecessary calculation scale B indicates the frequencies of scale A multiplied by $10^{-1/2}$.

If the capacitance is equal to the scale reading multiplied by 10^{n_c} and the inductance is equal to the scale reading multiplied by 10^{n_L}, $n=n_c+n_L$.

Example: C=150 pF, L=20 μH; line X–X gives frequency on scale A as 2·9 MHz.

But if C=150 pF, L=200 μH (20×10), frequency is read from scale B as 0·92 MHz.



The Q-Bandwidth Relationship

The –3dB bandwidth of a single-stage amplifier of the form shown in Fig. 1 is generally taken to be the product of its centre frequency and the reciprocal of its tuned-circuit Q; i.e.

$$B = f_0/Q$$

where B is the bandwidth when the output voltage is 0·707 times the voltage at resonance, and f_0 is the resonance frequency of the tuned circuit.

This relationship is based on the fact that, assuming the loss to be entirely due to parallel resistance, the impedance of a parallel tuned circuit at frequencies close to resonance varies according to the expression

$$Q = \frac{f_0}{2\Delta f}\left(\frac{Z_r^2}{Z^2} - 1\right)^{\frac{1}{2}}$$

where Δf is the frequency change from resonance, Z_r is the impedance at resonance, and Z is the impedance at $f_0 \pm \Delta f$.

Provided that the source impedance of the active element (transistor or valve) is high, the gain of the amplifier stage is a direct function of the impedance of the tuned circuit, so that the ratio Z_r/Z is equal to the response at $F_0 \pm \Delta f$ in terms of the response at resonance.

Similarly, with the series tuned circuit of Fig. 2 the voltage Q-bandwidth relation is given by

$$Q = \frac{f_0}{2\Delta f}\left(\frac{V_r^2}{V^2} - 1\right)^{\frac{1}{2}}$$

where V_r is the voltage across either reactance at resonance and V is the voltage at $f_0 \pm \Delta f$. This is relevant to the design of selective amplifiers because the tuned circuit in the arrangement of Fig. 3 in, in fact, a series circuit, the input e.m.f. being developed across the mutual inductance.

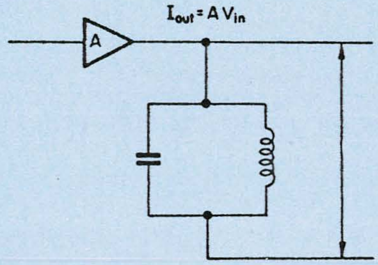


Fig. 1

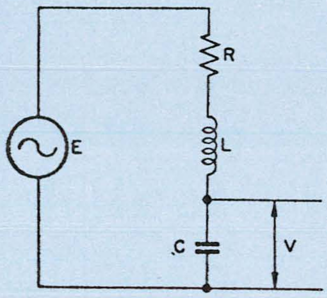


Fig. 2

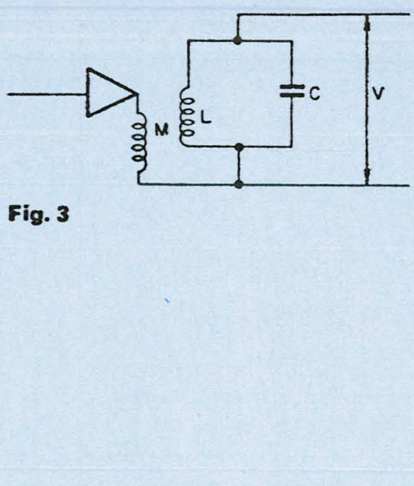


Fig. 3

We can therefore write a general expression for the two arrangements; i.e.

$$Q = \frac{f_0}{2\Delta f}\,(N^2 - 1)^{\frac{1}{2}}$$

where N is the ratio between the response at resonance and the response at $f_0 \pm \Delta f$. For the special case where $N = \sqrt{2}$, $(N^2 - 1)$ is equal to unity, and

$$Q = \frac{f_0}{2\Delta f} = \frac{f_0}{B}$$

If several similar stages are connected in cascade the bandwidth for a given value of Q decreases progressively according to the expression

$$Q = \frac{f_0}{B}\,(N^{2/n} - 1)^{\frac{1}{2}}$$

where n is the number of stages.

The two nomographs given provide the relation between Q and bandwidth for amplifiers having up to three similar tuned stages. The nomograph in Fig. 4 gives the conversion values for Q, N, and B/f_0 in a single stage, N being given as a ratio and in decibels relative to the response at resonance. The scales in Fig. 5 do not comprise the usual type of nomograph, but provide a simple conversion between values of N for a given bandwidth and Q with one, two, or three stages, the scales being marked N_1, N_2, and N_3 respectively. Scale N_1 is repeated at both sides of the chart in order to assist in establishing the horizontal.

To find the required Q to give a particular bandwidth and response with a two or three stage amplifier, first use Fig. 5 to find the value of N_1 corresponding to N_2 or N_3; and then use Fig. 4 to find the Q appropriate to this value of N and the required bandwidth.

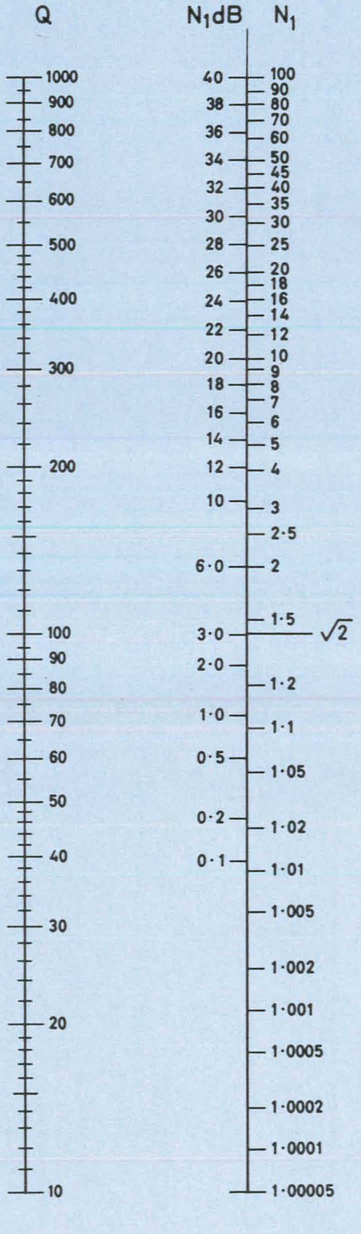


Fig. 4

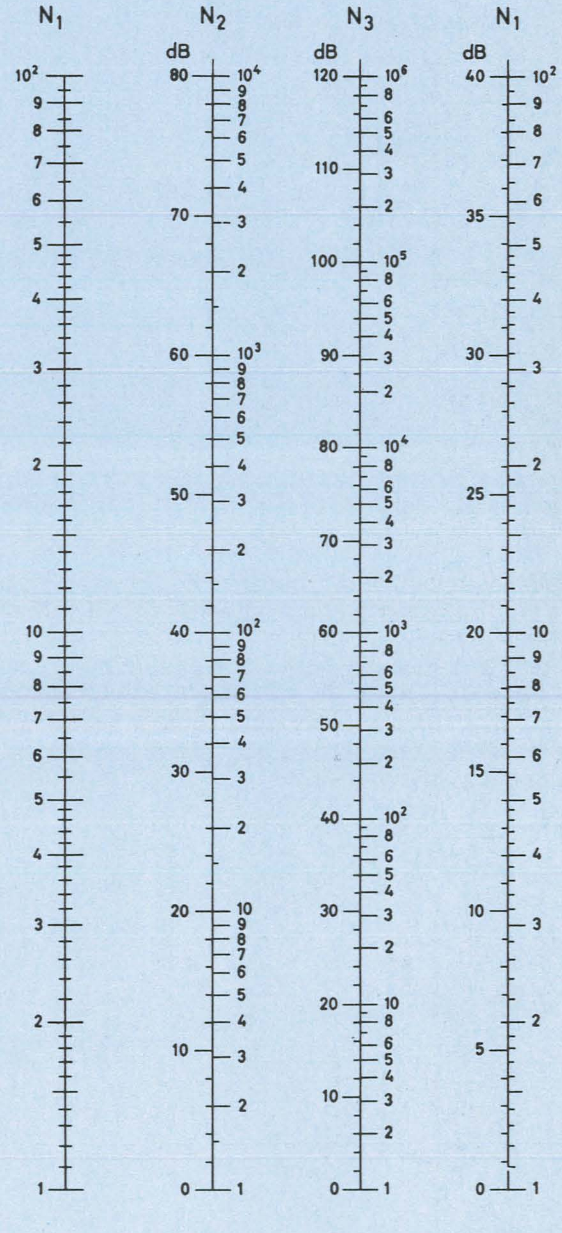


Fig. 5

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Equivalent Series and Parallel Networks

Parallel Circuit

$$\text{Impedance } |Z| = \frac{Rp\,Xp}{\sqrt{Rp^2 + Xp^2}}$$

$$\text{Phase angle } \phi = tan^{-1} \frac{Rp}{Xp}$$

Series Circuit

$$\text{Impedance } |Z| = \sqrt{Rs^2 + Xs^2}$$

$$\text{Phase angle } \phi = tan^{-1} \frac{Xs}{Rs}$$

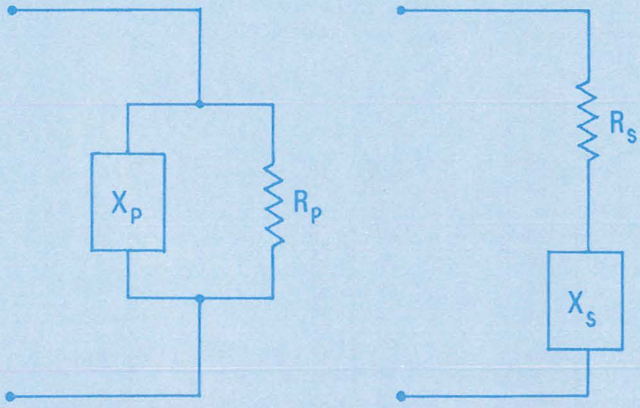
When the two circuits are equivalent

$$Xs = \frac{Xp\,Rp^2}{Rp^2 + Xp^2} = \frac{Z^2}{Xp}$$

$$Rs = \frac{Rp\,Xp^2}{Rp^2 + Xp^2} = \frac{Z^2}{Rp}$$

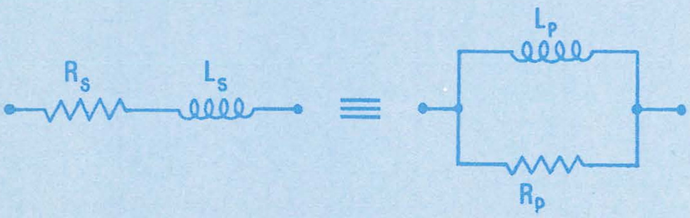
$$Xp = \frac{Rs^2 + Xs^2}{Xs} = \frac{Z^2}{Xs}$$

$$Rp = \frac{Rs^2 + Xs^2}{Rs} = \frac{Z^2}{Rs}$$

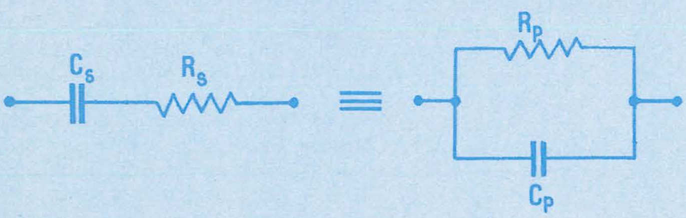


A nominally inductive or capacitive component is usually equivalent to reactance and resistance in a network that is predominantly series or parallel. For realistic measurement it is important that the correct configuration is chosen, especially if the loss in the component is significant.

At any given frequency a series network has an equivalent parallel network giving the same impedance and phase angle as shown below.



$L_p = L_s\,(1 + D^2)$
$R_p = R_s\,(1 + Q^2)$

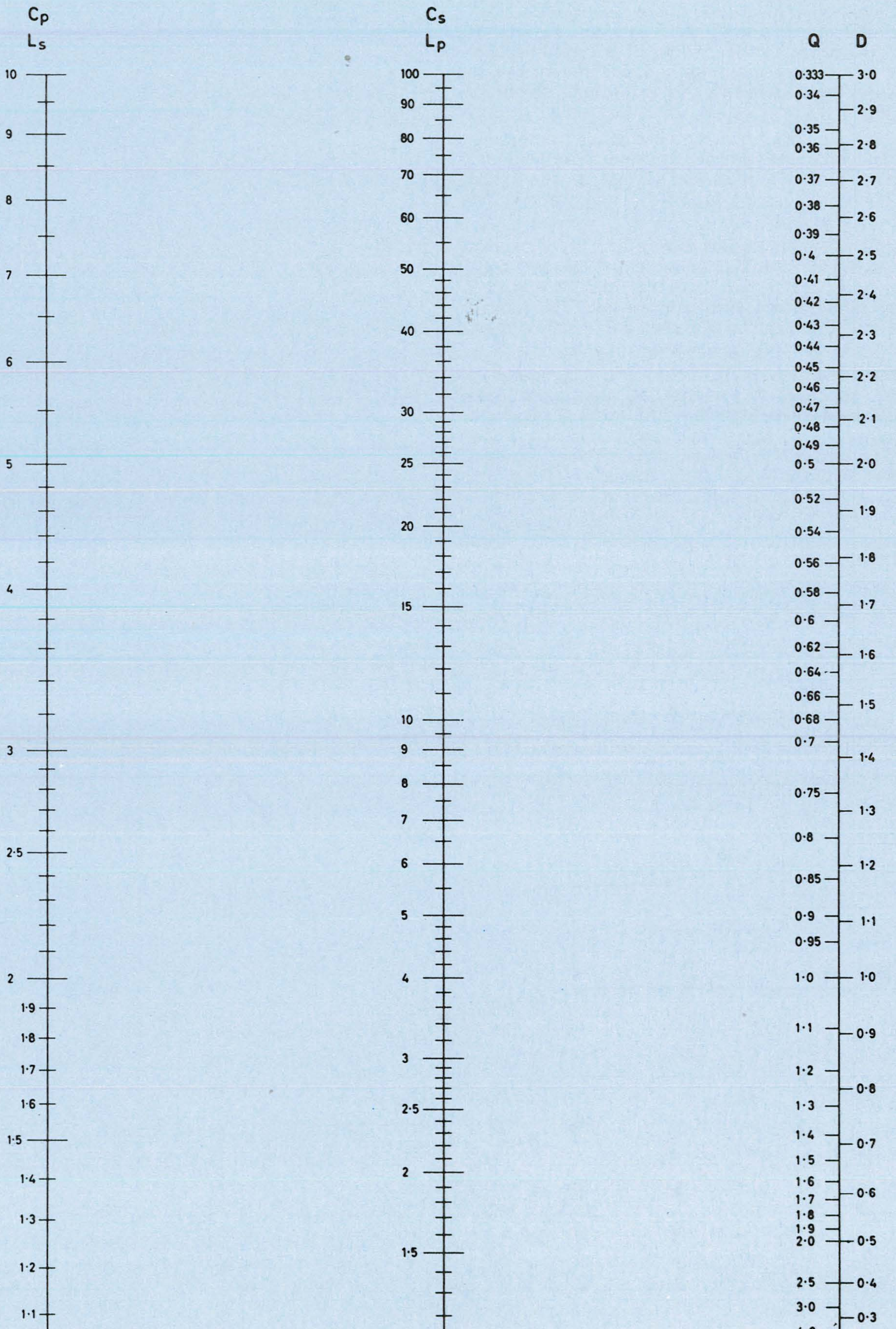


$C_s = C_p\,(1 + D^2)$
$R_p = R_s\,(1 + Q^2)$

The following table gives correction factors for converting L_p to L_s or C_s to C_p and vice versa. Below $D = 0{\cdot}1$ the error is negligible.

D	Multiply by	
	$(1 + D^2)$ — L_P to L_S, C_S to C_P	$\left(\frac{1}{1+D^2}\right)$ — L_S to L_P, C_P to C_S
0·10	1·01	0·99
0·15	1·023	0·98
0·20	1·04	0·962
0·25	1·063	0·943
0·30	1·09	0·917
0·33	1·109	0·901
0·35	1·123	0·893
0·40	1·16	0·862
0·45	1·203	0·833
0·50	1·25	0·8
0·60	1·36	0·735
0·70	1·49	0·671
0·8	1·64	0·610
0·9	1·81	0·553
1·0	2·0	0·5

Alternatively the nomograph opposite may be used for conversion in either direction. To use the nomograph simply lay a straight edge across the three scales so that it coincides with the measured *Q* or *D* marked on scale *C* and the measured inductance or capacitance value on the *A* or *B* scale as appropriate. Then read the converted value at the point where the straight edge crosses the third scale. Any convenient units – e.g. μF, pF, mH, etc. – may be allocated jointly to the *A* and *B* scales, and any convenient multiplying factor may be applied.


Cp
Ls
Cs
Lp
Q
D
SCALE A
SCALE B
SCALE C

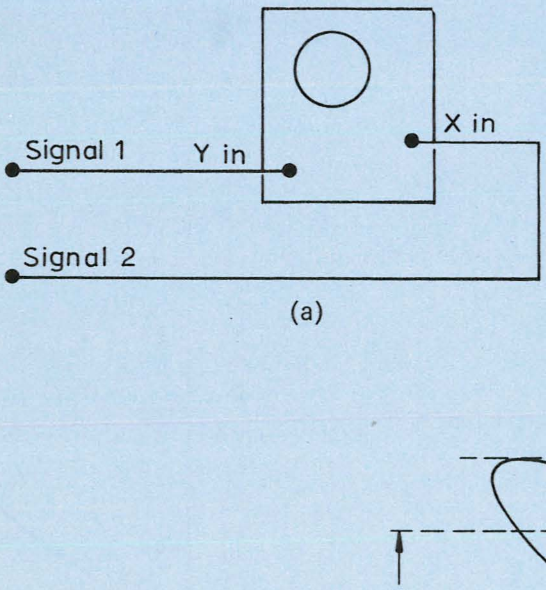
Phase Angle Measurement

A standard method of measuring the phase angle between two equal-frequency sinewaves is shown in Fig. 1. Signal "1" is applied to the Y input of the oscilloscope, and signal "2" to the X input. The phase difference, θ, is assessed from the dimensions of the resulting ellipse as shown in Fig. 1 (b).

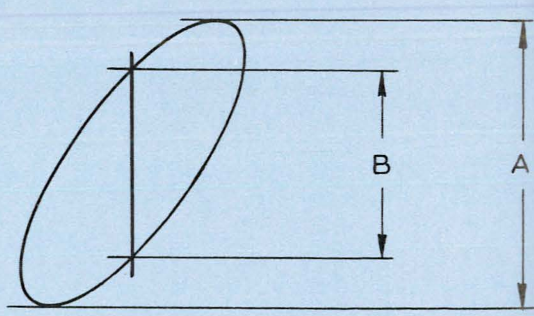
With the single ellipse, however, it is difficult to determine the exact position of the vertical centre line in order to find dimension B. This difficulty can be obviated by the use of a double trace oscilloscope, signal "1" being applied to both Y inputs in parallel.

To obtain the pattern shown in Fig. 2, it is, of course, necessary to switch one Y channel to the "invert" condition. The gains of the two channels must be adjusted for equality before dimension A is measured. The vertical centre line, giving dimension B, is then easily identified by the intersecting points of the ellipses.

The phase angle may be read from the accompanying nomogram (opposite) by connecting the appropriate points on scales A and B, and then reading the phase angle directly from scale C. For measurement of phase angle between 45° and 90° improved discrimination can be obtained by use of the A', B', and C' scales.



(a)



$\sin\theta = B/A$

(b)

Fig. 1

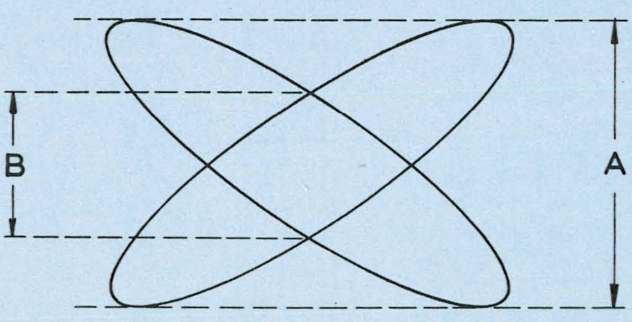
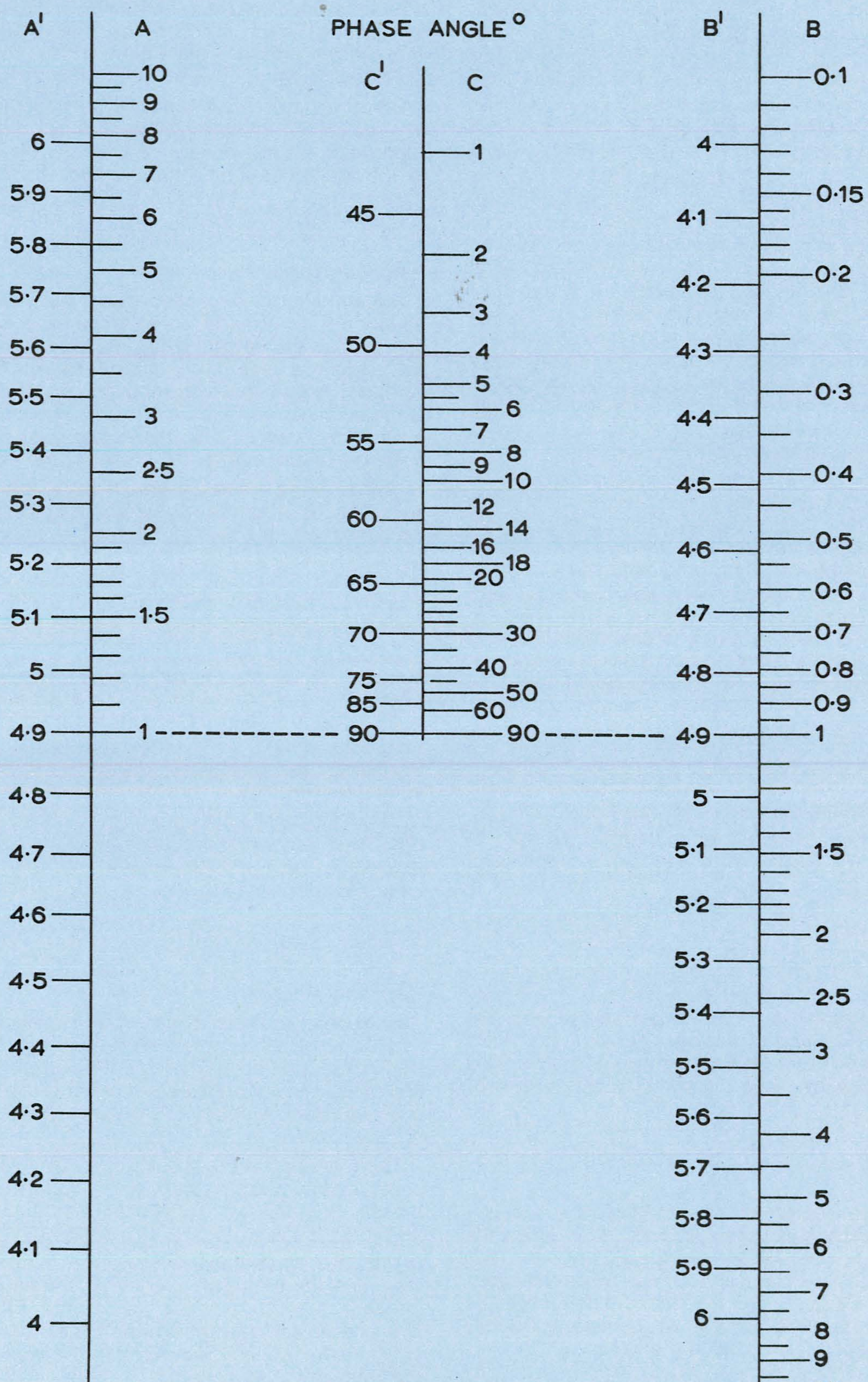


Fig 2


A'
A
PHASE ANGLE °
C'
C
B'
B
10
9
8
7
6
5
4
3
2.5
2
1.5
1
6
5.9
5.8
5.7
5.6
5.5
5.4
5.3
5.2
5.1
5
4.9
4.8
4.7
4.6
4.5
4.4
4.3
4.2
4.1
4
45
50
55
60
65
70
75
85
90
1
2
3
4
5
6
7
8
9
10
12
14
16
18
20
30
40
50
60
90
0.1
0.15
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.5
2
2.5
3
4
5
6
7
8
9
10

The two main applications of audio frequency waveform analysis are (a) measuring purity of the output from sinewave sources and (b) linearity measurements on amplifiers and transmission networks. Providing a low-distortion source is available, the test methods suitable for (a) are also suitable for (b). These are the single frequency methods of distortion factor measurement and harmonic analysis.

Distortion Factor

The r.m.s. voltage of a distorted sinewave multiplied by its distortion factor gives the r.m.s. voltage of the total distortion content. This implies that a true r.m.s. indicator is necessary for the measurement, but the error introduced by the use of the simpler average voltage type of meter is usually negligible for practical purposes. It is important to stress that the term refers only to voltage ratio and not to power ratio, which can seem to be very much better; e.g., with a 10% distortion factor only 1% of the power is in the distortion components of the waveform.

In the distortion factor meter the total voltage of the unwanted frequency components is measured by filtering out the fundamental and measuring the voltage of the residue. This is compared with the total signal voltage in such a way that the instrument indicates the distortion factor directly. If the fundamental component is $\underline{S}$, harmonic distortion is $\underline{D}$, and the noise is $\underline{N}$, the total signal is $(\underline{S}+\underline{D}+\underline{N})$; and when $\underline{S}$ is eliminated $(\underline{D}+\underline{N})$ remains. The distortion, $\underline{D}$, will comprise a number of harmonic components, H_1, H_2, H_3, etc. So, if the final detector is a true r.m.s. indicator, the indicated distortion factor is given by:

$$DF_{r.m.s.} = \frac{\sqrt{H_1^2+H_2^2 \ldots\ldots +N^2}}{\sqrt{S^2+H_1^2+H_2^2 \ldots +N^2}}$$

This is the distortion factor as commonly defined. In a.f. distortion factor meters, however, an average level indicator is used, so that the indicated distortion factor is given by:

$$DF_{av} = \frac{H_1+H_2 \ldots\ldots\ldots +N}{S+H_1+H_2 \ldots\ldots\ldots +N}$$

Both expressions of distortion factor are commonly expressed as percentage. For certain purposes, the distortion factor is defined as the ratio between the noise plus distortion to the fundamental component only. This is occasionally called the true distortion factor, and is, of course, given by:

$$DF_{true} = \frac{\sqrt{H_1^2+H_2^2 \ldots\ldots +N^2}}{S}$$

In normal audio equipment the discrepancy is negligible; with distortion as high as 14%, the difference between DF_{true} and $DF_{r.m.s.}$ is less than 1 part in 100. The difference between DF_{av} and $DF_{r.m.s.}$ depends upon the phase and distribution of the harmonics—especially the third. The greatest difference will be about 1·5 dB, which is barely discernible by the human ear.

Distortion Factor Measurement

For measurement of distortion factor with the Marconi Instruments TF 2331A, the sensitivity of the meter is first standardised to give 100% indication for the total signal. The fundamental component is then rejected by means of a tunable filter, and the instrument indicates the level of the residue directly as distortion factor (DF_{av}). Provision is made for external connection of a true r.m.s. indicator if desired.

When testing an a.f. amplifier or transmission network it is, of course, important that the distortion in the input test signal is small compared with the distortion likely to be introduced by the unit under test.

Amplifier Noise Measurement

For amplifier noise measurement the input test signal is used only to provide a reference level with which to standardise the sensitivity of the distortion factor meter. Once this has been done, the input signal is switched off, so that the residue measured by the distortion factor meter is the amplifier noise. This is likely to be composed of two main components; viz., the mains hum and the white noise generated in the early stages of the amplifier.

If the white noise is heard on a loud speaker, the sensation is that of a predominantly hissing sound, because the human ear is most sensitive to frequencies in the band 3 to 6 kHz. It is thus more realistic to assess the noise after it has been weighted according to the frequency/sensitivity characteristic of the average ear and reproducing device.

The CCIF has decided upon standard response characteristics for what are termed psophometric weighting filters. There are two of these. One is intended for high-quality music transmission (broadcast), and is similar to the characteristic of the human ear alone, while the other represents the combined response of the ear with a telephone earpiece.

The TF 2331A distortion factor meter is fitted with a broadcast type weighting filter (to CCIR Recommendation 468-New Delhi 1970) which can be switched into circuit for noise measurements with the test tone off.

Harmonic Analysers

Harmonic analysis is essentially measurement of the amplitude of each individual frequency component of a waveform separately. The instruments used for isolation and measurement of these components are known alternatively as selective voltmeters or wave analysers, depending on application.

There are two distinct categories of wave analyser—the constant-bandwidth and the proportional-bandwidth types.

The Marconi Instruments TF 2330A is a constant-bandwidth wave analyser; i.e., the bandwidth does not vary with the tuning frequency. The action of this type of instrument is closely analogous to that of a superheterodyne receiver; and it is used mainly for analysis of constant-frequency waveforms in tests on a.f. and communication equipment.

In the proportional bandwidth type instrument the pass band is a constant proportion of the tuning frequency. These instruments are analogous to t.r.f. receivers: and their main applications are generally outside the communications industry, in such fields as vibration analysis.

Waveform Analysis

The wave analyser can be used for measuring the amplitude of a waveform's frequency components either in absolute terms or in terms relative to the amplitude of the fundamental. It is the second of these two ways that is normally used for measurement of distortion.

The instrument is tuned to the fundamental, and its sensitivity is standardised to a reference indication. It is then tuned to each frequency component in turn and the indicated relative level is noted. Thus each harmonic is indicated as H_1/S, H_2/S, etc. The r.m.s. sum of these values is:

$$\frac{\sqrt{H_1^2+H_2^2 \; . \; . \; . \; . \; . \; . \; . \; H_2^2}}{S}$$

which is equal to the true distortion factor (DF_{true}), neglecting the noise component. As each sinusoidal frequency component is measured individually, it makes no difference whether the final indicator responds to the r.m.s., the average, or the peak current or voltage.

Intermodulation Measurement

(Two-Frequency Methods)

The main advantage of two-frequency methods of measuring non-linearity is that distortion in the test signal has far less effect on the measurement than with single-frequency methods. Furthermore the intermodulation measurement usually gives a more realistic assessment of the adverse effects of the non-linearity in an audio system.

Two standard methods are in common use. These are respectively, the method recommended by the CCIF and that recommended by the SMPTE.

The CCIF Method

In this system the test signal consists of two sinewave voltages of equal amplitude, having frequencies P and Q which are relatively close together. A frequency difference of between 10% and 20% is normally used.

This composite signal is applied to the input of the amplifier being tested; and the resulting output is monitored by a peak reading voltmeter (M1) and fed, via a low-pass filter, which rejects frequencies P and Q, to a sensitive voltmeter (M2).

The frequency components reaching M2 are even order intermodulation products having frequencies (P—Q), 2(P—Q), 3(P—Q), etc. Meter M1 indicates the peak voltage of the total output from the amplifier—approximately equal to V_P+V_Q. Meter M2, of course, indicates the peak amplitude of the intermodulation products. The intermodulation distortion is given by the formula:

$$\frac{\text{Intermodulation Product Amplitude}}{V_P+V_Q} \times 100\%$$

This method of measurement gives no indication of the odd order intermodulation products or of the sum components, as these are stopped by the low-pass filter. It is very useful, however, for assessing the effects of non-linearity at the upper end of the amplifier's frequency/response characteristic, where simple harmonic analysis gives misleading results.

The SMPTE Method

For this method, the test signal consists of two tones widely separated in frequency, the amplitude of the low-frequency tone, Q, being four times that of the high-frequency tone, P. The order of frequencies normally used would be 10 kHz for P and 1 kHz for Q, assuming that both of these fall well within the pass band of the amplifier. With the two-tone signal applied to the input of the amplifier, any non-linearity in the transfer characteristic produces intermodulation in the form of sidebands spaced symmetrically about tone P; i.e. ($P \pm Q$), ($P \pm 2Q$), etc.

The high-power low-frequency tone is eliminated from the final output by means of a suitable filter, leaving an a.m. waveform at carrier frequency P. This is passed to a conventional modulation monitor, comprising a carrier level meter (M1) followed by a demodulator and filter feeding a second meter (M2), which indicates the amplitude of the demodulated signal, i.e., the intermodulation products. The intermodulation distortion is equal to:

$$\frac{\text{the sidebands (M2)}}{\text{the carrier (M1)}} \times 100\%.$$

Intermodulation Analysis

More revealing results can be obtained by measuring the amplitude of each of the intermodulation products separately with a wave analyser. A two-tone test signal is applied to the amplifier, and the output is fed to a wave analyser either directly or via a suitable filter depending on the expected intermodulation distortion content. The same test set-up can be used for both CCIF and SMPTE methods of measurement.

Because the wave analyser measures each individual intermodulation product separately, external filtering is no longer a part of the basic measuring equipment. However, it is one of the virtues of the intermodulation method that it can be used for measuring degrees of non-linearity which are small compared with the distortion in the signal source. It follows then that the system is likely to be used for measuring very low distortion levels, and an external filter can extend the range of the wave analyser considerably.

Intermodulation analysis is made in a similar way to that used for harmonic analysis. The sensitivity of the wave analyser is first adjusted to set up a reference level, and then each intermodulation product is measured independently. In this way a measure is made of each order of non-linearity separately.

p

White Noise Testing of F.D.M. Links

In a multi-channel cable or radio link, each telephone channel occupies a frequency band of 300 Hz to 3400 Hz; and in the frequency division multiplex (F.D.M.) system a number of such channels, each channel allocated a bandwidth of 4 kHz, are placed side by side by means of frequency transposition. Twelve channels placed side by side in this manner is called a basic primary group and occupies the band of frequencies 12 kHz to 60 kHz. Secondary groups or supergroups are formed by assembling five such basic groups of twelve channels and transposing them to various positions in the frequency spectrum in the manner shown in Fig. 1.

The frequency spectrum occupied by the transposed channels is referred to as the baseband and is either transmitted direct along cables or used to frequency modulate the carrier in the case of a microwave radio link. The waveform of this total multiplex signal, consisting of the addition of a large number of transposed voice frequencies, closely resembles white noise having the same band of frequencies and distribution of peak amplitudes, i.e. gaussian distribution of peaks. For this reason it is convenient, when testing a link, to simulate fully loaded conditions by applying white noise having the correct level and baseband frequency spectrum.

Good intelligibility is the criterion of performance of a multichannel link system. To secure this, noise, which causes a deterioration in intelligibility, must be kept to a minimum. Main sources of noise are:

1. Intermodulation noise due to amplitude and phase non-linearity throughout the system.
2. Thermal noise generated in amplifiers and receivers.

It is the purpose of a white noise test set to provide a simple and accurate means of comparing the noise produced by the link with the level of an output signal due to the applied white noise. The resulting ratio is called the noise power ratio (N.P.R.) of the system.

A simple understanding of the method of measurement may be obtained if we assume that, say, a 600 channel system is completely loaded with normal speech traffic except for one channel. This channel is used as a listening-post and should be completely silent, but because of non-linearity throughout the link system, intermodulation products occur which are noticeable as noise. It is immaterial which channel is used as the quiet channel although intermodulation will in general be different at different points in the baseband.

These conditions may be simulated by a white noise test set. A white noise generator is used in place of the speech traffic. Its output frequency range, as shown in Fig. 2a, is limited by high- and low-pass filters according to the capacity of the system under test. A quiet channel is produced by switchable band-stop filters, as shown in Fig. 2b. The white noise signal is fed to the baseband input at the sending end of the link, by-passing the channelling equipment.

The second part of the test set is a receiver which is switch-tuned to the frequency of the band-stop filter used to produce the quiet channel. It is connected to the base-band output at the receiving end of the link—again excluding the channelling equipment.

A measurement is made by setting the generator to the correct output level with the band-stop filter out and adjusting the receiver meter to the reference mark. When a band-stop filter is switched in, a narrow band of frequencies is attenuated by about 70 dB and the receiver meter deflection will fall. If there is no noise generated in the link equipment the meter deflection would be restored by reducing the receiver input attenuator by this same amount, i.e., 70 dB. Because of intermodulation and thermal noise it will be found that attenuation will have to be reduced by, perhaps, only 50 dB, as shown in Fig. 2c. This change in attenuation is the noise power ratio of the system.

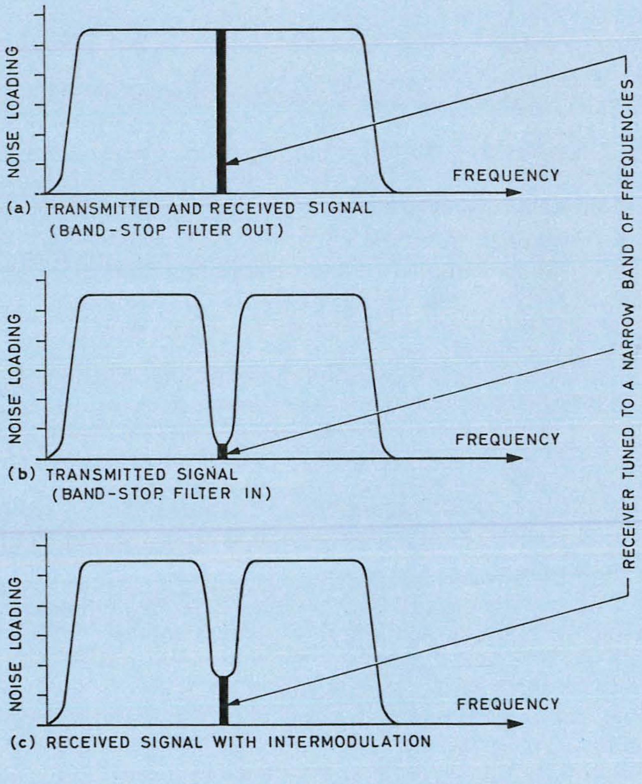


Fig. 2. Principle of operation of white noise test set.

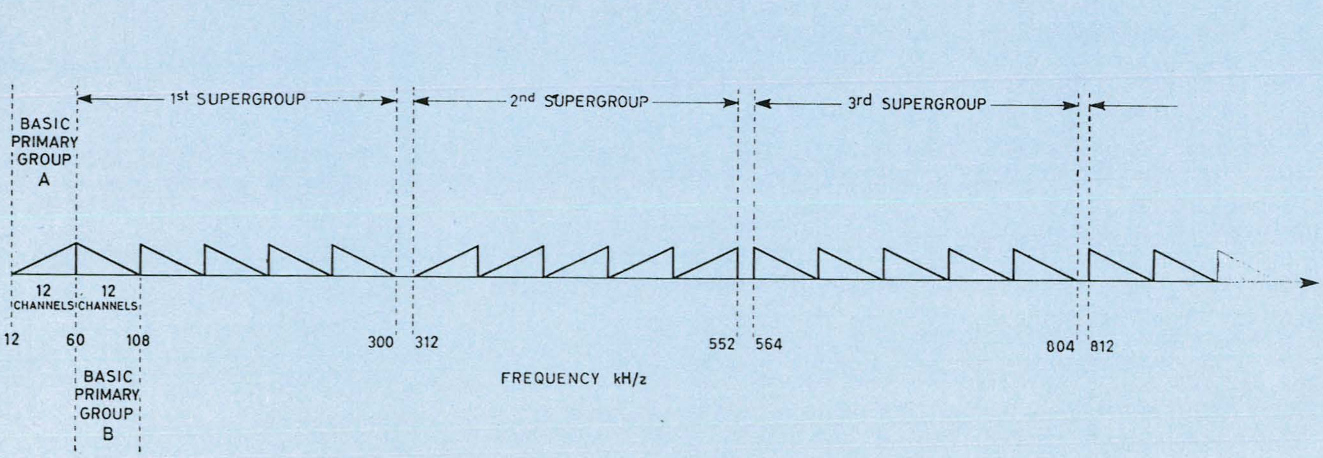


Fig. 1. Formation of the baseband.

With sinewave modulation the sideband distribution depends on the deviation ratio—or modulation index—which is usually signified by the symbol β, and is given by

$$\beta = \delta f / f_{mod},$$

where δf is the peak f.m. deviation and f_{mod} is the modulation frequency. β is also equal to the phase deviation in radians.

Where the modulation frequency is variable and known, f.m. deviation can be accurately measured by setting for deviation ratios at which the carrier or sidebands have zero amplitude as shown in Tables I and II.

Table I. Deviation ratios at which the carrier or sideband components have zero amplitude.

Order of Zero Point	Deviation Ratio			
	Carrier	1st Pair Sidebands	2nd Pair Sidebands	3rd Pair Sidebands
1	2·405	3·832	5·136	6·380
2	5·520	7·016	8·417	9·761
3	8·654	10·173	11·620	13·015
4	11·792	13·324	14·796	16·223
5	14·931	16·471	17·960	19·409

Table II. Modulating frequencies corresponding to deviations at which carrier amplitude is reduced to zero.

Carrier—first disappearance dev. ratio (2·4048)		Carrier—second disappearance dev. ratio (5·5201)	
Freq. Dev. in kHz.	Mod. Freq. in Hz.	Freq. Dev. in kHz.	Mod. Freq. in Hz
1	416	5	907
2	831	10	1,815
3	1,247	15	2,718
4	1,663	20	3,625
5	2,079	25	4,530
6	2,494	30	5,430
7	2,911	35	6,340
8	3,326	40	7,250
9	3,742	45	8,160
10	4,158	50	9,070
15	6,237	55	9,975
20	8,316	60	10,880
25	10,395	65	11,780
30	12,480	70	12,690
35	14,550	75	13,590

F.M. on A.M.

If f.m. and a.m. are applied simultaneously to the carrier, the first order pair of sidebands—as viewed on the spectrum analyser— will be equal to the vector sum of the a.m. and f.m. sidebands. Assuming that peak deviation in the positive direction occurs at the same instant as the a.m. envelope peak—i.e., the f.m. and a.m. modulating waveforms are in phase—the lower sidebands will be equal to the sum and the upper one to the difference of the a.m. and first order f.m. sideband amplitudes.

As a guide to the degree of asymmetry to be expected from a given spurious f.m. deviation, Table III gives the maximum asymmetry that can be produced by various values of spurious f.m. deviation on 30% a.m. Most spectrum analysers are calibrated in decibels; so the apparent sideband amplitudes are given in dB relative to the unmodulated carrier, with the larger sideband amplitude above the smaller.

Table III. Sideband asymmetry caused by spurious f.m. on 30% wanted a.m. (f.m. in phase with a.m.).

F.M. Deviation	Apparent Sideband Amplitudes (dB relative to unmodulated carrier)			
	100 Hz Mod. freq.	400 Hz Mod. freq.	1 kHz Mod. freq.	10 kHz Mod. freq.
0	16·5 dB	16·5 dB	16·5 dB	16·5 dB
5 Hz	15·1 dB 18·1 dB	16·1 dB 16·8 dB	16·3 dB 16·7 dB	
10 Hz	14·0 dB 20·0 dB	15·8 dB 17·2 dB	16·2 dB 16·8 dB	
20 Hz	12·0 dB 26·0 dB	15·1 dB 18·1 dB	15·9 dB 17·1 dB	
40 Hz	9·1 dB 26·0 dB	14·0 dB 20·0 dB	15·4 dB 17·7 dB	
80 Hz	5·7 dB 13·2 dB	12·0 dB 26·0 dB	14·4 dB 18·2 dB	
100 Hz	4·6 dB 10·8 dB	11·4 dB 30·5 dB	14·0 dB 20·0 dB	16·2 dB 16·8 dB
200 Hz		8·2 dB 21·0 dB	12·0 dB 26·0 dB	15·9 dB 17·1 dB
400 Hz		4·6 dB 10·8 dB	9·1 dB 26·0 dB	15·4 dB 17·7 dB
800 Hz			5·7 dB 13·2 dB	14·4 dB 18·2 dB
1 kHz			4·6 dB 10·8 dB	14·0 dB 20·0 dB
2 kHz				12·0 dB 26·0 dB
4 kHz				9·1 dB 26·0 dB
8 kHz				5·7 dB 13·2 dB
10 kHz				4·6 dB 10·8 dB

p

Peak Modulation Measurement

A fundamental method of peak a.m. depth measurement with an oscilloscope is illustrated in Fig. 1. The display in Fig. 1 (a) is obtained with the oscilloscope's internal saw-tooth time base, and for that in Fig. 1 (b) the modulating signal is utilised to produce the horizontal scan. In either case a.m. depth is given by

$$\frac{A-B}{A+B}.100\%$$

Peak modulation depth measurement by the oscilloscope method is limited in accuracy mainly by any non-linearity of the oscilloscope vertical deflection system and by the lack of discrimination resulting from the need to compress the complete peak-to-peak display into the 6 cm window of the c.r.t. screen. The lack of discrimination becomes particularly acute at low modulation depths, where the A and B dimensions are comparable.

Considerably more discrimination is afforded by the standard type of modulation meter (e.g., TF 2300B), which indicates the peak modulation directly. This type of instrument basically comprises a low sensitivity receiver, with a d.c. coupled diode demodulator. The d.c. component of the demodulator output is equal to the carrier voltage, and the l.f. output is equal to the modulation component of the incoming waveform. In use the sensitivity of the instrument is adjusted to bring the carrier level to a reference value, and the amplitude of the l.f. component is monitored by means of a peak-reading diode voltmeter, calibrated directly in % modulation depth. Provision is normally made for reversing the voltmeter diode to permit measurement of the crest/carrier or trough/carrier modulation factor.

Providing the even order harmonic distortion is low (5% or less), obviation of the asymmetry error by taking the average of the positive and negative (crest and trough) peak modulation readings gives the effective modulation depth with negligible error.

Sideband Power Method

With an undistorted sinusoidal envelope, the sideband power would be equal to $M^2/2$ times the carrier power; i.e.

$$M\% = \left[\frac{2P_s}{P_c}\right]^{\frac{1}{2}} \times 100$$

where M is the modulation depth, P_s is the power in the sidebands, and P_c is the carrier power.

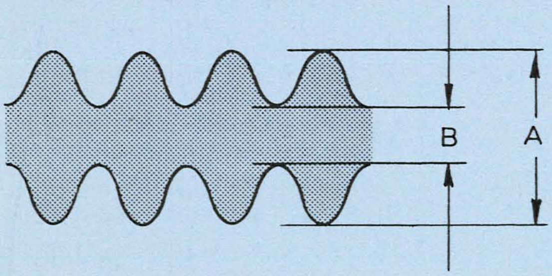
The carrier power can be measured directly by means of a true mean power (thermocouple) meter when no modulation is applied, but there is no direct way of measuring the sideband power separately from the carrier. The standard method is, therefore, as follows.

First measure the r.f. power with no modulation applied, and call this power P_c. Apply the modulation, note the new power reading, and call this P_m. P_s is equal to $P_m - P_c$, so equation (4) can be rewritten.

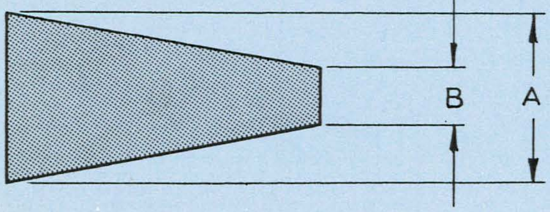
$$M\% = \left[\frac{2P_m}{P_c} - 2\right]^{\frac{1}{2}} \times 100$$

If properly conducted, with suitable measuring instruments, the power-measurement method can give a very accurate assessment of r.m.s. modulation depth. However, it suffers from lack of discrimination when the modulation depth is low. With 30% modulation, for example, the value of P_m/P_c would be 1·045. The utility of this method can, therefore, be realised only for the higher modulation depths; and, for most applications, the methods utilising a modulation meter are generally more suitable.

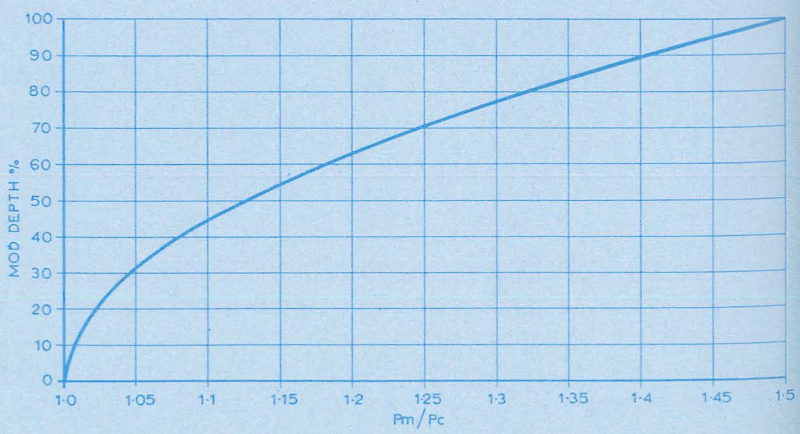
The curve below gives values of P_m/P_c for modulation depths from 0 to 100%.



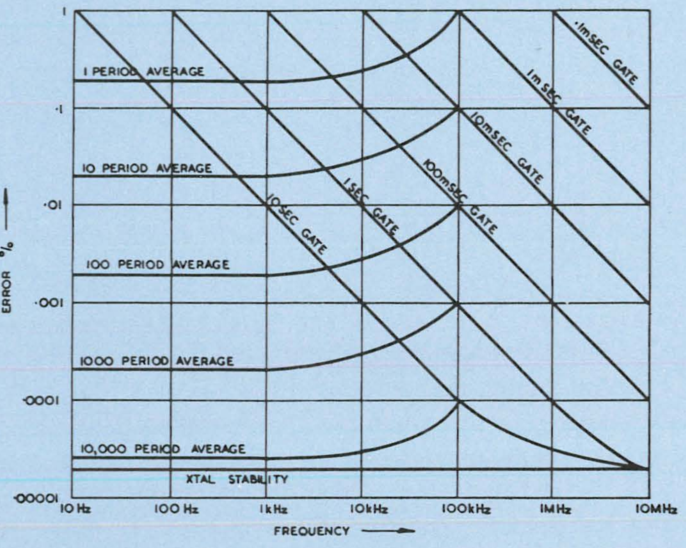
(a)



(b) Fig. 1.



Accuracy of Electronic Counters



Accuracy chart

In general there will always be a possible error of ± 1 count on the least significant digit. This, together with the discrimination required, will determine whether frequency or period measurement is used, see chart

(1) Frequency measurement. Accuracy is dependent on the stability of the internal standard which determines the counting interval. In addition there will be the ± 1 count and thus, for a given gate time, higher frequencies will be displayed with the greatest precision.

(2) Period measurement. The errors in period measurement will be:

(a) ambiguity of gate triggering level,
(b) accuracy of internal timing units, and
(c) the ± 1 count.

For sinewave inputs the total possible error may be expressed as

$$\frac{1}{\pi} \times \frac{En}{Es}$$

where En = total noise, including that due to counter circuitry, and Es = signal level.

Or, for multiple periods,

$$\frac{1}{n\pi} \times \frac{En}{Es}$$

where n is the number of periods.

Nomenclature of Radio Frequency Bands

In accordance with Article 2, Section III, Paragraph 112, § 7 of the Radio Regulations (Geneva, 1959) of the International Telecommunications Union, it is recommended that frequencies shall be expressed:

From 30 kHz to 3,000 kHz in kHz
From 3 MHz to 3,000 MHz in MHz
From 3 GHz to 3,000 GHz in GHz

and that the radio spectrum is divided into nine frequency bands, designated by a Band Number "N", where the band extends from $0{\cdot}3 \times 10^N$ to 3×10^N hertz, the lower limit being excluded, and the upper limit included.

The following table indicates the relationship between this and other systems:

Band No.	Frequency Range	Adjectival Designation		Metric Sub-division
4	3– 30 kHz	Very Low Frequency	V.L.F.	Myriametric
5	30– 300 kHz	Low Frequency	L.F.	Kilometric
6	300–3,000 kHz	Medium Frequency	M.F.	Hectometric
7	3– 30 MHz	High Frequency	H.F.	Decametric
8	30– 300 MHz	Very High Frequency	V.H.F.	Metric
9	300–3,000 MHz	Ultra High Frequency	U.H.F.	Decimetric
10	3– 30 GHz	Super High Frequency	S.H.F.	Centimetric
11	30– 300 GHz	Extra High Frequency	E.H.F.	Millimetric
12	300–3,000 GHz	—		Decimillimetric

Selected Radio Formulæ

CAPACITANCE

Parallel plate capacitor

$$C(\text{in pF}) = \frac{A\varepsilon}{11{\cdot}31d}$$

where A = area of one plate in sq. cms
ε = permittivity
d = dielectric thickness in centimetres.

Plates 1 mm apart in air have a capacitance of 0·884 pF per sq. cm of plate area. Plates 1/10" apart have 2·245 pF per sq. inch.

Reactance of a capacitor

$$X \text{ (in ohms)} = 1/\omega C$$

where C = capacitance in farads
$\omega = 2\pi \times$ frequency in Hz.

Power Factor

$$\cos\varphi = R/Z = R/\sqrt{R^2 + X^2}$$

where R = series resistance
i.e. $\cos\varphi = \omega CR$ when R is small compared with X

Magnification

$$Q = X/R = 1/\omega CR$$

Loss angle

$\delta = \tan\delta$ (when loss is small)
and $\tan\delta = \cos\varphi$ (when loss is small, i.e., capacitor has good power factor)

Therefore, for good capacitors, loss angle = power factor = $1/Q$.

INDUCTANCE

Reactance

$$X \text{ (in ohms)} = \omega L$$

where L = inductance in henries
$\omega = 2\pi \times$ frequency in Hz

Power Factor

$$\cos\varphi = R/Z = R/\sqrt{R^2 + X^2}$$

where R is series resistance
i.e., $\cos\varphi = R/\omega L$ when R is small compared with X

Magnification

$$Q = X/R = \omega L/R$$
$$= 1/\cos\varphi \text{ when } R \text{ is small compared with } X$$

TUNED CIRCUITS

Frequency (in Hz) $= 1/2\pi\sqrt{LC}$

Where L and C are in henries and farads respectively and series resistance can be ignored

Wavelength (in metres) $= 1{,}885\sqrt{LC}$

where L and C are in μH and μF respectively.

For single tuned circuit

$$Q = \frac{f_o}{f_1 - f_2} = \frac{\text{Frequency at resonance}}{\text{Bandwidth at 0·707 of max. response}}$$

Dynamic resistance at resonance

$$R_d = L/CR$$

where R is series resistance.

TRANSMISSION LINES

$$Z_o = \sqrt{L/C}$$

where L and C are inductance and capacitance per unit length.

Parallel Wires in Air

$$Z_o \text{ (in ohms)} = 276 \log_{10} d/r$$

where d = distance between centres in cms
r = radius of wire in cms

Concentric Cables

$$Z_o \text{ (in ohms)} = (138 \log_{10} r_1/r_2)/\sqrt{\varepsilon}$$

where r_1 = inner radius
r_2 = outer radius
ε = permittivity of dielectric between conductors

MAINS TRANSFORMERS

Turns per Volt

$$E \text{ in volts} = 4{\cdot}44BANf \times 10^{-8}$$

where B = flux density
A = cross-sectional area of core
N = number of turns
f = frequency in Hz

Note: B and A must be in corresponding units (lines/sq. in. and sq. ins; gauss and sq. cms).

Since N/E = turns per volt
turns per volt $= 10^8/4{\cdot}44\ BAf$

Selected Mathematical Formulæ

Trigonometrical Functions

$\sin(A+B) = \sin A \cos B + \cos A \sin B$
$\cos(A+B) = \cos A \cos B - \sin A \sin B$
$\sin(A-B) = \sin A \cos B - \cos A \sin B$
$\cos(A-B) = \cos A \cos B + \sin A \sin B$
$\sin 2A = 2 \sin A \cos A$
$\cos 2A = \cos^2 A - \sin^2 A = 1 - 2\sin^2 A = 2\cos^2 A - 1$

$\sin^2 A + \cos^2 A = 1$
$1 + \tan^2 A = \sec^2 A$
$1 + \cot^2 A = \text{cosec}^2 A$

Hyperbolic Functions

$\sinh x = \frac{1}{2}(e^x - e^{-x})$
$\cosh x = \frac{1}{2}(e^x + e^{-x})$
$\tanh x = \dfrac{e^x - e^{-x}}{e^x + e^{-x}}$

Series

Taylor's

$$f(x) = f(a) + (x-a)f'(a) + \frac{(x-a)^2}{2!}f''(a) + \frac{(x-a)^3}{3!}f'''(a) + \dots$$

Maclaurin's

$$f(x) = f(0) + xf'(0) + \frac{x^2}{2!}f''(0) + \frac{x^3}{3!}f'''(0) + \dots$$

Binomial

$$(1+x)^n = 1 + nx + \frac{n(n-1)}{2!}x^2 + \frac{n(n-1)(n-2)}{3!}x^3 + \dots \quad (x<1)$$

$$(1-x)^n = 1 - nx + \frac{n(n-1)}{2!}x^2 - \frac{n(n-1)(n-2)}{3!}x^3 + \dots$$

Logarithmic

$$\log(1+x) = x - \frac{x^2}{2} + \frac{x^3}{3} - \frac{x^4}{4} + \dots \quad (x<1)$$

$$\log(1-x) = -x - \frac{x^2}{2} - \frac{x^3}{3} - \frac{x^4}{4} - \dots$$

Exponential

$$e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \frac{x^4}{4!} + \dots$$

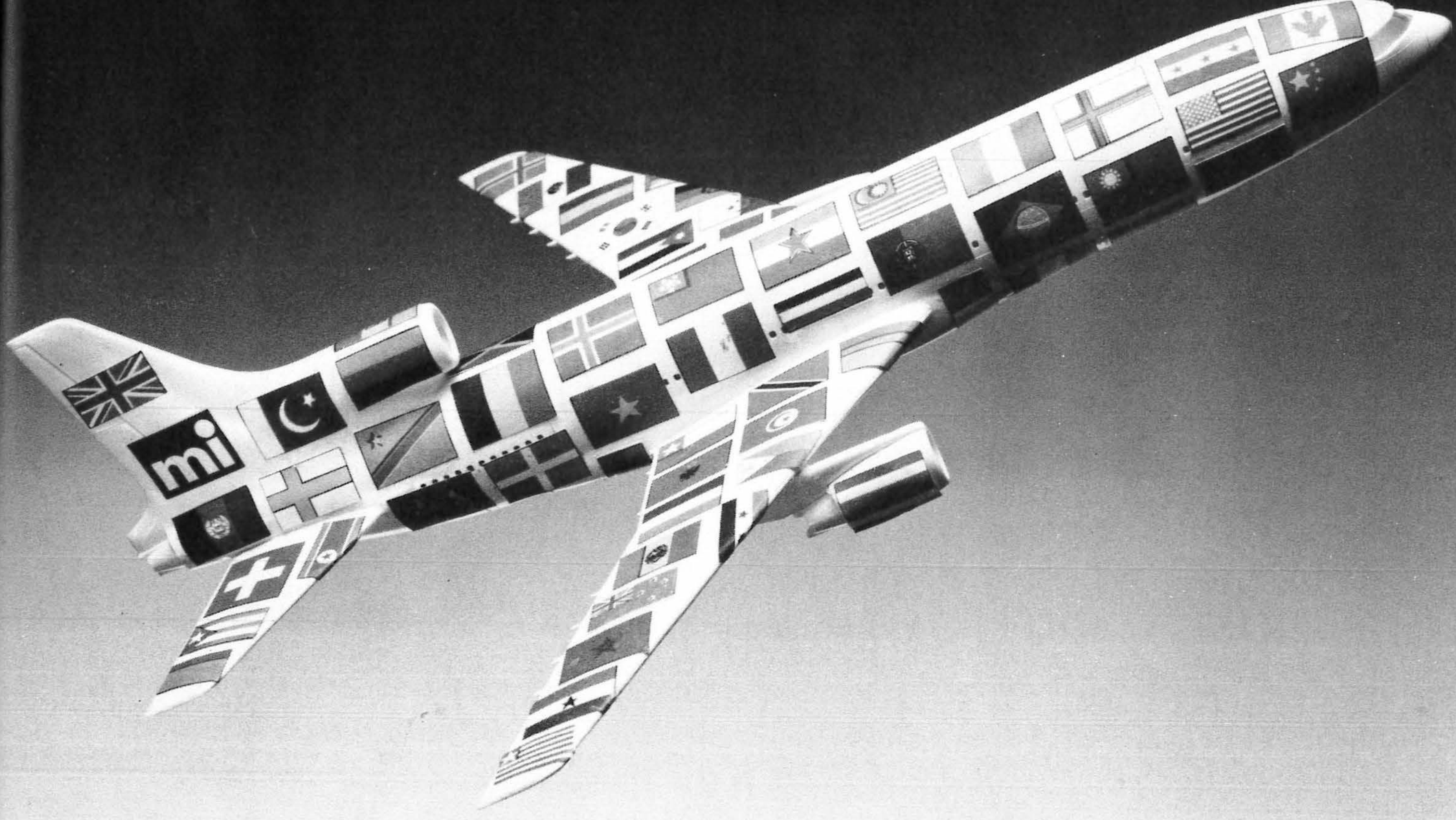
Differentials

$d(ax) = a\,dx$
$d(uv) = u\,dv + v\,du$
$d\dfrac{(u)}{(v)} = \dfrac{v\,du - u\,dv}{v^2}$
$dx^n = nx^{n-1}\,dx$
$de^{ax} = ae^{ax}\,dx$
$da^x = a^x \log a\,dx$
$d(\sin x) = \cos x\,dx$
$d(\cos x) = -\sin x\,dx$
$d(\tan x) = \sec^2 x\,dx$
$d(\cot x) = -\text{cosec}^2 x\,dx$
$d(\sec x) = \tan x \sec x\,dx$
$d(\text{cosec}\,x) = -\cot x\,\text{cosec}\,x\,dx$

Integrals

1. $\int x^n\,dx = \dfrac{x^{n+1}}{n+1} \quad (n \neq -1)$
2. $\int \dfrac{1}{x}\,dx = \log x$
3. $\int e^{ax}\,dx = \dfrac{e^{ax}}{a}$
4. $\int \log x\,dx = x\log x - x$
5. $\int u\dfrac{dv}{dx}\,dx = uv - \int v\dfrac{du}{dx}\,dx$
6. $\int \sin x\,dx = -\cos x$
7. $\int \cos x\,dx = \sin x$
8. $\int \text{sh}\,x\,dx = \text{ch}\,x$
9. $\int \text{ch}\,x\,dx = \text{sh}\,x$
10. $\int \dfrac{1}{a^2+x^2}\,dx = \dfrac{1}{a}\tan^{-1}\dfrac{x}{a}$
11. $\int \dfrac{1}{\sqrt{a^2-x^2}}\,dx = \sin^{-1}\dfrac{x}{a}$
12. $\int \dfrac{1}{\sqrt{(x^2+a^2)}}\,dx = \text{sh}^{-1}\dfrac{x}{a} = \log(x + \sqrt{a^2+x^2})$
13. $\int \dfrac{1}{\sqrt{x^2-a^2}}\,dx = \text{ch}^{-1}\dfrac{x}{a} = \log(x + \sqrt{x^2-a^2}$
14. $\int \dfrac{f'(x)}{f(x)}\,dx = \log f(x)$
15. $\int \tan x\,dx = -\log(\cos x)$
16. $\int \cot x\,dx = \log(\sin x)$
17. $\int \text{cosec}\,x\,dx = \log(\tan \frac{1}{2}x)$
18. $\int \sec x\,dx = \log\left\{\tan\left(\dfrac{\pi}{4} + \frac{1}{2}x\right)\right\} = \log(\sec x + \tan x)$
19. $\int \dfrac{dx}{a+bx} = \dfrac{1}{b}\log(a+bx)$

p



Spairline

We don't claim that **mi** actually runs its own airline, of course. But we do claim to be strategically sited for delivery to a remarkably large number of airports. Which is handy for getting those spares airborne in double-quick time. In fact most of our orders are shipped the day they're received.

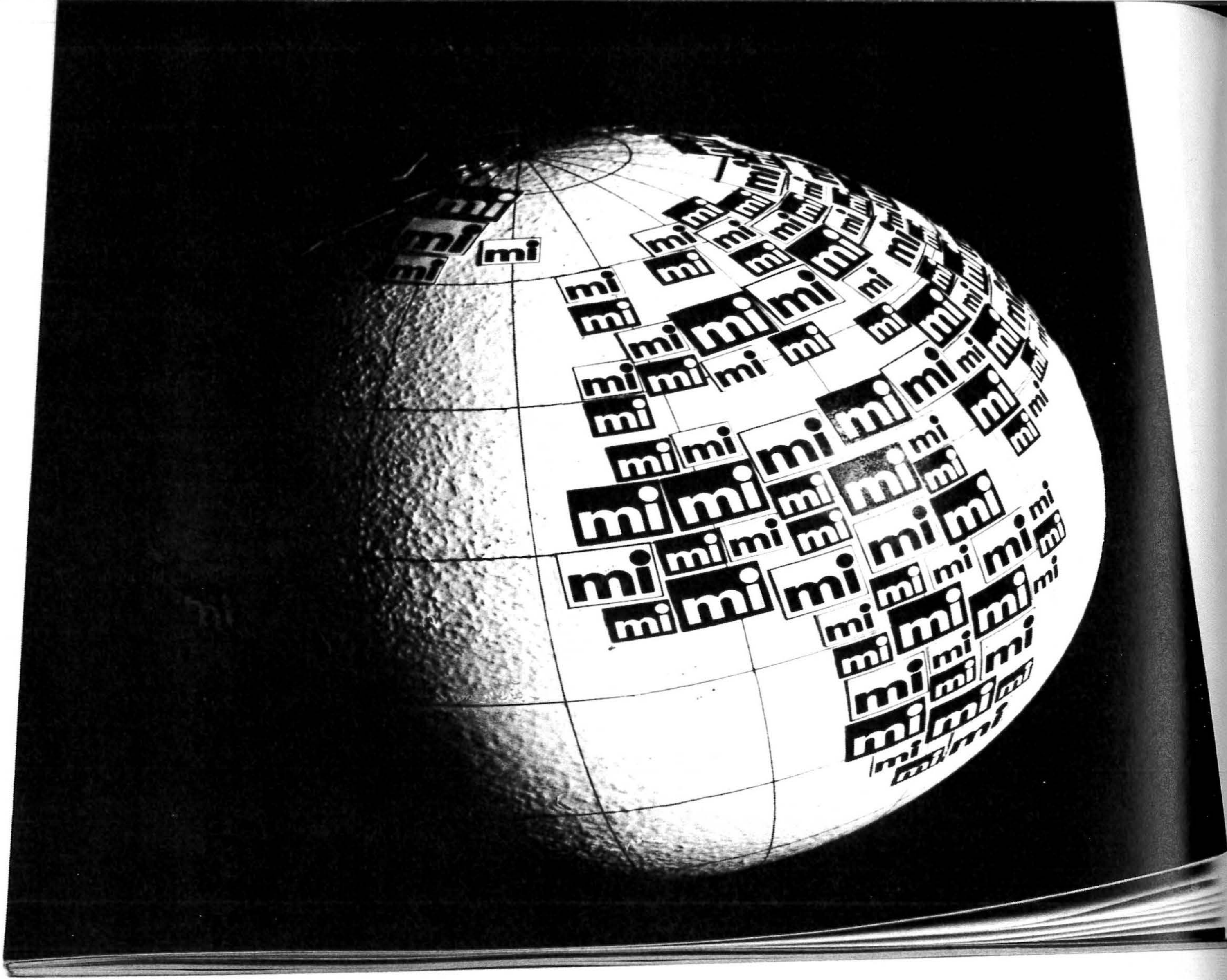
Then, too, our servicing and spares set-up is unusually large. In fact, our three B.C.S.-approved laboratories in the U.K. issue more calibration certificates for electrical measurement than any other organisation in the country. And our Service Division at Luton Airport is the first organisation of its kind to be registered on the M.o.D. defence contractors' list. We run our own sizeable fleet of vans to ensure the minimum of delay in collection and delivery.

Abroad, there are **mi** service operations in, among other places, France, Germany, Australia, U.S.A., Canada and South America.

Put all those facts together and you get what is probably the surest and speediest servicing operation in the business. And that holds good whether you're in Manchester or Marseilles, Sydney or São Paulo.

mi: THE PERFECTIONISTS

MARCONI INSTRUMENTS LIMITED



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Type Numbers—Measuring Instruments

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TF 1246	40 kHz to 50 MHz Oscillator	160
TF 1247	20 to 300 MHz Oscillator	160
TF 1313A	0·1% Universal Bridge	163
TF 2000	AF Signal Source	48
TF 2002B series	MF/HF AM/FM Signal Generator, 10 kHz to 88 MHz	10
TF 2005R	Two-Tone Signal Source	49
TF 2008	FM/AM Signal Generator, 10 kHz to 510 MHz	16
TF 2008/1	FM/AM Signal Generator, digital readout version	16
TF 2015	AM/FM Signal Generator, 10 to 520 MHz	20
TF 2015/1	AM/FM Signal Generator, narrow deviation model	20
TF 2015/2	AM/FM Signal Generator, wide deviation model	20
TF 2016 series	AM/FM Signal Generator, 10 kHz to 120 MHz	26
TF 2020	Synthesized Signal Generator, 50 kHz to 520 MHz	34
TK 2021	GPIB Adapter for TF 2020	34
OA 2090B	White Noise Test Set	60
OA 2090B/4	White Noise Test Set, modified for use with TK 2099AB	60
TK 2099AB	Noise Filter Extension Unit for OA 2090B	64
OA 2090C series	Automatic White Noise Test Set	65
TK 2085	Control Unit for OA 2090C	68
TF 2091B	Noise Generator, part of White Noise Test Set, OA 2090B	61
TF 2091B/4	Noise Generator, modified for use with TK 2099AB	64
TF 2091C	Noise Generator, part of Automatic White Noise Test Set, OA 2090C	66
TF 2092B	Noise Receiver, part of White Noise Test Set, OA 2090B	61
TF 2092B/4	Noise Receiver, modified for use with TK 2099AB	64
TF 2092C series	Noise Receiver, part of Automatic White Noise Test Set, OA 2090C	66
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TF 2155/1	DC Power Supply, centre-tapped version	86
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TF 2213A/1	X-Y Display, dual-trace model with long persistence tube	94
TF 2300B series	FM/AM Modulation Meter	98
TK 2302	Crystal Oscillator for TF 2300B	98
TF 2301A	Programmable FM/AM Modulation Meter	102
TF 2303	FM/AM Modulation Meter, narrow deviation model	104
TF 2304 series	FM/AM Modulation Meter	106
TF 2330A	Wave Analyser	114
TF 2331A series	Distortion Factor Meter	116
TF 2333	MF Transmission Test Set	118
TF 2337A	Automatic Distortion Meter	120
TF 2356	Level Oscillator — Selective Level Measuring Set	76
TF 2357	Selective Level Meter — Selective Level Measuring Set	76
TF 2365	75 Ω Coaxial Switch for SLMS	80
TF 2366	Baseband Filter Unit for SLMS	80
TF 2370	110 MHz Spectrum Analyser, 50 Ω version	122
TF 2370/1	110 MHz Spectrum Analyser, 75 Ω version	122

Note: Indented type numbers refer to major optional accessories or modules associated with the instrument immediately above

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TK 2374	Zero Loss Probe, 50 Ω version, for TF 2370	127
TK 2374/1	Zero Loss Probe, 75 Ω version, for TF 2370/1	
TK 2375	Tracking Generator Amplifier for TF 2370	128
TF 2430	Digital Frequency Meter, 10 Hz to 80 MHz	130
TF 2431 series	Digital Frequency Meter, 10 Hz to 200 MHz	
TF 2432 series	Digital Frequency Meter, 10 Hz to 560 MHz	
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TF 2437	100 MHz Universal Counter/Timer	
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TF 2950/6	Mobile Radio Test Set, alternative frequencies model	
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NATO Catalogue Numbers

(Marconi instruments in this Catalogue which have been allocated NATO Stock Numbers)

M.I. Type No.	*Military Designation*	*NATO Cat. No.*
TF 893A	Wattmeter Absorption Audio Frequency	6625–99–914–9811
TF 1245	Panel Test Electrical	6625–99–103–1083
TF 1246	Oscillator RF	6625–99–103–5187
TF 1247	Oscillator RF	6625–99–103–1073
TF 2000	Oscillator Audio Frequency	5845–99–923–7246
TF 2002B	MF/HF AM/FM Signal Generator Set CT 572A/2	6625–99–628–4711
TF 2005R	Signal Generator Assembly	6625–99–952–0447
TF 2008	Signal Generator Set CT 561/3	6625–99–117–3198
TF 2015	Generator Signal Set CT 584/11	6625–99–529–0130
TF 2016	Signal Generator	6625–99–695–9230
TF 2162	Attenuator Variable CT 532	5905–99–972–0856
TF 2163S	Attenuator Variable CT 553	6625–99–519–9976
TF 2169	Pulse Modulator	6625–99–645–9235
TF 2330A	Analyser, Spectrum	6625–99–525–0653
TF 2331	Indicator Distortion	6625–99–001–2681
TF 2333	Test Set Transmission Line	6625–99–933–3719
TF 2370	Analyser Set Spectrum CT 571/11	6625–99–529–1124
TF 2603 (with standard accessories)	Voltmeter Set, Electronic	6625–99–193–4355
TF 2603 (less accessories)	Voltmeter, Electronic	6625–99–193–3651
TF 2604	Multimeter, Electronic	6625–99–924–5707
TF 2700	Impedance Bridge	6625–99–104–3861

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Type Numbers—Optional Accessories

(Accessories normally supplied with an instrument are not featured in this index)

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TB 39867	43168–009W	Shielded Adapter (Twin Terminals to Type 83)	278
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TB 46843	33631–901J	Grounding Sleeve for TF 2603	149
TJ 230	44811–702G	Series Loss Test Jig for TF 1245A	162
TK 2084 series	–	Out of Band Filters for White Noise Test Set	74
TK 2085	52085–900F	Control Unit for OA 2090C	71
TK 2086	52086–900C	Filter Unit for OA 2090C	
TK 2087	52087–900N	Programmable Filter Unit for OA 2090C	
TK 2087/1	52087–901L	Manual Filter Unit for OA 2090C	
TK 2094 series	–	Noise Measuring Sets for White Noise Test Set	73
TK 2095 series	–	Low-Pass Filters for White Noise Test Set	
TK 2096 series	–	High-Pass Filters for White Noise Test Set	
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TK 2302	52302–900T	Crystal Oscillator for TF 2300B	100
TK 2509	52509–015D	RF Transformer, 75 to 50 Ω	140
TM 1438 series	–	Inductors for TF 1245A	161, 162
TM 4520	46884–013C	Inductors (Set of 18) in case, for TF 1245A	
TM 4726/136	43125–069B	Output Lead, 75 Ω	279
TM 4726/260	54351–011F	Lead for OA 2090B, OA 2090C	
TM 4726/286	43126–026A	RF Connecting Cable, 460 mm long	
TM 4824/1	43125–019F	Output Lead, 50 Ω (1370 mm)	
TM 4916	44411–013U	Matching Unit, 50 to 300 Ω	
TM 4917	44413–007B	DC Isolating Unit	280
TM 4918	44411–004B	Matching Unit, 50 to 75 Ω, with Belling Lee connector	279
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TM 4919/1	44425–503Y	Attenuator Pad, 6 dB, 50 Ω	
TM 4935	41675–003X	Carrying Case for TF 2604 accessories	151
TM 4947/1	44133–033C	Inductor, 2·5 µH for TF 1245A	162
TM 4947/2	44123–202T	Inductor, 0·5 µH for TF 1245A	
TM 4947/3	44114–001U	Inductor, 0·05 µH for TF 1245A	
TM 4969/3	43126–012S	Output Lead	110
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TM 5032	44416–003Z	AC Multiplier for TF 2604	
TM 5033A	44416–037E	DC Multiplier for TF 2604	
TM 5548	44411–002C	Matching Unit, 50 to 75 Ω with PR4D connector	279
TM 5549	44419–003J	Matching Unit, 50 to 75 Ω with Plessey CZ71060 connector	
TM 5569	44411–001M	Matching Pad, 50 to 75 Ω	279
TM 5573	44425–501E	20 dB Attenuator Pad	278
TM 5573/1	44425–002D	6 dB Attenuator Pad	
TM 5573/3	44411–019G	Matching 'T' Pad	279
TM 5582	44411–022G	5-watt Dummy Load for TF 2604	151
TM 5725	43125–010A	Coaxial Lead for TF 1245A	161
TM 5726	44411–009E	50 Ω Matching Unit for TF 1246	
TM 5727	44411–008A	50 Ω Matching Unit for TF 1247	
TM 5728A	43527–001C	600 to 0·5 Ω Transformer for TF 1245A, TF 1246, TF 1247	
TM 5753	43821–001W	Coaxial Fuse	278
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TM 5955/1	54481–021E	75 to 140 Ω unbalanced to balanced Transformer	
TM 5955/5	44412–021C	50 to 300 Ω Matching Transformer	
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TM 6123	44412–023B	Composite Dummy Aerial & DC Isolating Unit	279
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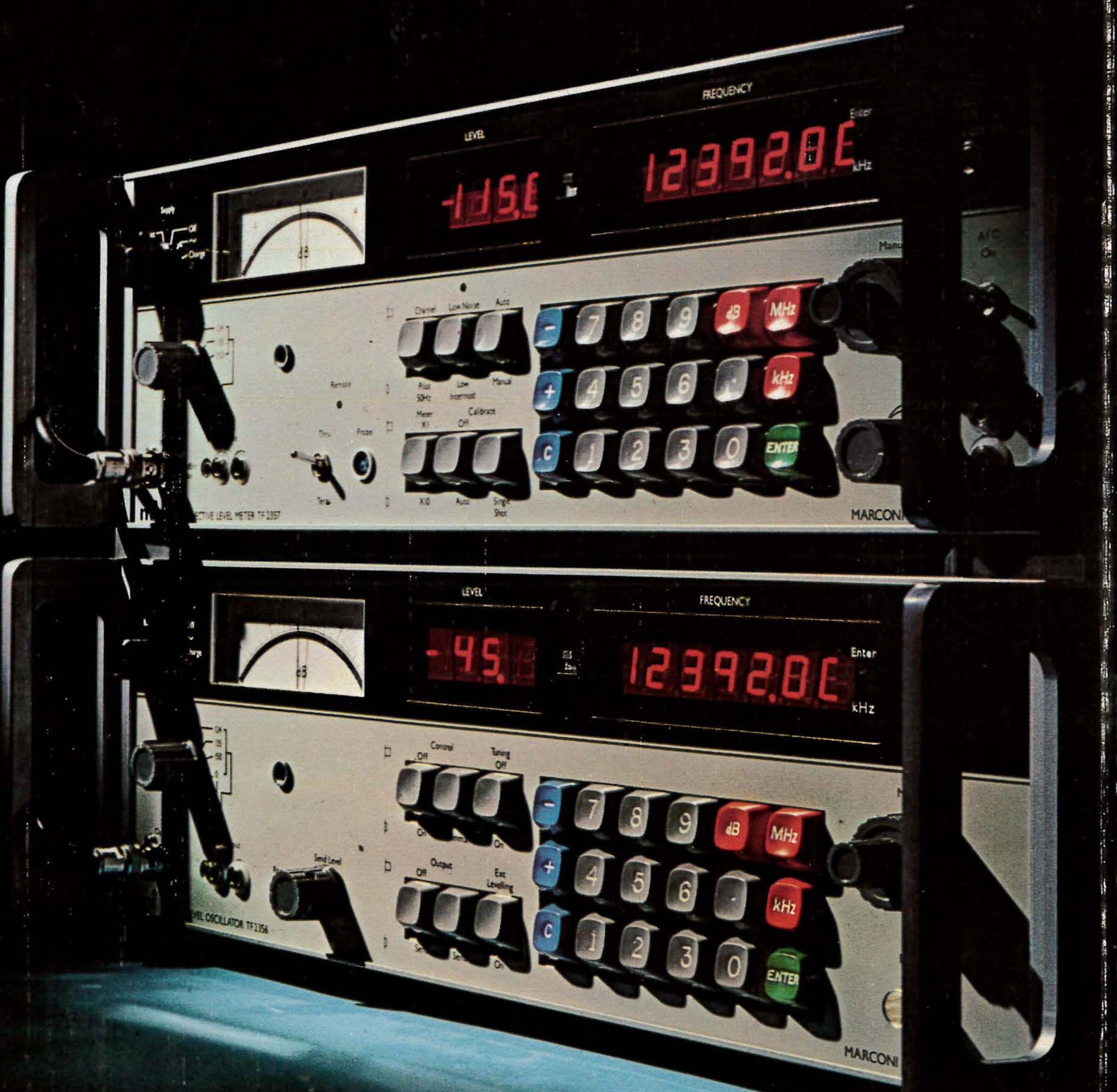

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