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IN THIS ISSUE

ELECTRONIC INSTRUMENTS FOR TELECOMMUNICATIONS AND INDUSTRY

RESUME D'ARTICLES PUBLIES DANS LE PRESENT NUMERO

OSCILLOSCOPE, TYPE TF 2201

C'est un oscilloscope à applications multiples transistorisé, de 30 MHz de bande passante, équipé d'amplificateurs de déviation verticale et horizontale en ensembles enfichables avec 50 mV/cm de sensibilité pour l'amplificateur vertical. Un réticule millimétré et un dispositif de mesure à comparaison permettent d'explorer une image de 6 × 10 cm. Toutes les entrées et sorties de la platine avant sont dotées de sécurités pour éviter tout dégât aux transistors, et les alimentations intérieures sont garanties contre les court-circuits avec le châssis. L'appareil est constitué de sous-ensembles, ce qui facilite à l'utilisateur l'établissement des prévisions de remplacement et de rechanges.

Page 55

GENERATEURS DE SIGNAUX—IMPEDANCE DE SOURCE OU IMPEDANCE DE SORTIE?

On décrit des méthodes de mesure qui démontrent que l'on peut accorder une plus grande confiance à la précision de la valeur de l'impédance d'un générateur de signaux à des puissances de sortie très élevées qu'on ne le pense généralement.

Page 66

TECHNIQUES DE COMPTAGE VHF AVEC LE BLOC DE GAMMES TYPE TM 8267

Le bloc de gammes type TM 8267 est un ensemble enfichable adapté au compteur type TF 2401A. Associé à un ensemble de fonctions approprié, il permet une cadence de comptage dépassant 110 MHz et une résolution dans la mesure des temps de 10 nanosecondes. Certains problèmes de comptage à ces vitesses sont décrits, ainsi que les circuits utilisés dans cet ensemble enfichable.

Page 69

ATTENUATEUR UHF, TYPE TF 2163

Cet atténuateur à plots a une impédance caractéristique de 50 Ω et une capacité de perte atteignant 142 dB par plots de 1 dB. Il fonctionne dans toute la gamme des fréquences de continu à 1 GHz. L'atténuateur se compose de deux pièces coulées, dans un boîtier modulaire, dont les dimensions ont été minutieusement choisies pour conserver l'impédance caractéristique. Il en résulte un rapport d'amplitude de tension au taux d'onde stationnaire supérieur à 1,1:1 jusqu'à 100 MHz, à 1,25 jusqu'à 500 MHz et à 1,50 jusqu'à 1 GHz. La perte par insertion augmente linéairement avec la fréquence et est d'environ 0,35 dB par 100 MHz.

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ZUSAMMENFASSUNG DER IN DIESER NUMMER ERSCHEINENDEN BEITRÄGE

OSZILLOGRAPH TF 2201

Es handelt sich um einen vielseitig verwendbaren transistorisierten 30 MHz Meßoszillographen mit einsteckbaren X und Y-Einschüben und einer Grund-Y-Empfindlichkeit von 50 mV/cm. Ein in cm-Quadrate eingeteilter Raster und eine geeichte Rück-Verschiebespannung ermöglichen Spannungsmessungen der gesamten Schirmfläche von 6 × 10 cm. Alle Ein- und Ausgänge der Frontplatte sind so ausgelegt, daß eine Beschädigung der Halbleiter vermieden wird. Die internen Leitungen sind gegen Kurzschluß zum Gerätegestell geschützt. Das hier verwandte Baukastensystem erleichtert es dem Kunden, den Ersatz von Teilegruppen selbst vorzunehmen.

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MEßSENDER—QUELLWIDERSTAND ODER AUSGANGSIMPEDANZ?

Es werden Meßmethoden nachgewiesen, die klarstellen, daß ein höherer Zuverlässigkeitsgrad bezüglich der Meßsenderimpedanzgenauigkeit bei höchsten Ausgangspegeln erwartet werden kann als gemeinhin angenommen wird.

Seite 66

VHF-ZÄHLTECHNIKEN UNTER VERWENDUNG DES BEREICHZUSATZES TM 8267

Der Bereichzusatz TM 8267 ist als Einschub für den Zähler TF 2401 A gedacht. Wird er zusammen mit einem geeigneten Funktionseinschub verwandt, so läßt er eine maximale Zählfrequenz über 110 MHz und eine Zeitmessungsauflösung von 10 n sec. zu. Es werden einige beim Zählen mit derartigen Geschwindigkeiten auftretende Probleme erörtert und die Schaltungen dieses Einschubes beschrieben.

Seite 69

UHF-EICHLEITUNG TF 2163

Diese Eichleitung hat eine charakteristische Impedanz von 50 Ω bei einem Dämpfungsbereich von 142 dB, unterteilt in Schritte von 1 dB. Der Arbeitsfrequenzbereich erstreckt sich von 0 bis 1 GHz. Der Abschwächer besteht aus zwei Gußteilen in einem Gehäuse für Gestelleinschub, die sorgfältig dimensioniert sind, um die charakteristische Impedanz beizubehalten. Dies führte zu einem Stehwellenverhältnis besser als 1,1:1 bis zu 100 MHz, 1,25 bis zu 500 MHz und 1,5 bis zu 1 GHz. Die Durchgangsdämpfung nimmt linear mit der Frequenz zu und beläuft sich auf etwa 0,35 dB pro 100 MHz.

Seite 73

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ENGLAND

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Return to Step Attenuators

TO BE VERSATILE an instrument must be capable of functioning over a wide range of signal levels. It is not surprising therefore that most instruments incorporate an attenuator, somewhere in the circuit, to reduce the voltage or power by an accurately known ratio. For generators or oscillators it is the output voltage; while for instruments that evaluate signal parameters, such as voltmeters, wave analysers, oscilloscopes, etc., it is the input voltage. Of necessity, the attenuator is frequently the circuit block connected directly to the equipment being tested, so not only does it play an important rôle in defining accuracy, but also in determining the value of the input or output impedance which, if unsuitable, could be a possible source of measurement error.

The piston attenuator is still the primary standard of attenuation. Here the attenuation is constant and independent of frequency provided it is operated much lower than the cut-off frequency of wave propagation. In practice, if the ratio of cut-off to operating frequency is 10:1 the attenuation is reduced by only 0·5% from the theoretical maximum value. This type of attenuator can take several physical forms; the most commonly used is the circular waveguide with inductive coupling. It has the advantage of being simplest to manufacture and is capable of giving a suitable source impedance to match transmission lines. Accuracy depends only upon mechanical tolerances, and the change in attenuation is calculable from a knowledge of the linear movement between source and pick-up. With the circular guide operating in the H_{11} mode, the rate of attenuation is 32 dB/diameter enabling a linear decibel scale to be realised. Piston attenuators have been built with an accuracy of 0·01 dB over a range of 100 dB, but with this degree of precision, even the effects of temperature on the dimensions of the waveguide must be considered. Also, as with all high values of attenuation, great care must be taken in screening the output from the source in order not to invalidate the result.

Although piston attenuators are commonly used in our valve signal generators, with excellent results, there are certain limitations which preclude their general use in other classes of instrument. These are high insertion loss, suitable for transmission line values of impedance only, and a lower practical operating frequency of about 10 Mc/s for a reasonable physical size.

Where any of the above restrictions cannot be tolerated the alternative is some form of lumped circuit step attenuator—either of the constant impedance type or the potential divider configuration. Here the insertion loss can be zero, there are no restrictions on impedance and, provided resistors are used, there is no lower limit of frequency. Now the limitations appear at the higher frequencies, and are most marked as the impedance rises.

A good example of a lumped circuit step attenuator is the one used as the input circuit of the latest Oscilloscope type TF 2201 which is described on page 55 of this issue. Here the requirements are for a high value (1M Ω), constant impedance attenuator which will restrict the level applied to the first stage to 500 mV, but will allow signals having a maximum value of 500 V to be viewed. In terms of attenuation this is not a difficult problem until frequency response is considered. Because of the high impedance any stray capacitance will tend to modify the attenuation at the upper end of the frequency band and, in the limit, will predominate in controlling the value of the insertion loss. To overcome this, capacitance compensation has to be added to the networks which can be adjusted to give an attenuation independent of frequency.

Originally, step attenuators of the constant impedance or ladder type were used to control the output level of signal generators. As frequencies were increased above about 300 Mc/s, the limitations of such devices became prohibitive and piston attenuators were introduced, not just at the higher frequencies, but operating down to the h.f. band. With the change from high impedance, high power output stages provided by valves, to the low impedance, low power available from transistors, the insertion loss of a piston attenuator is no longer acceptable and the change back to step attenuators is under way. Fortunately advances in the state of the art occur simultaneously and, concurrently with the introduction of semiconductors, considerable improvements were being made in the performance of resistors. Both their stability and high frequency characteristics were being upgraded, mainly owing to the adoption of thin film techniques. These advances in component manufacture have assisted in extending the upper frequency limit of constant impedance step attenuators to 1000 Mc/s, as is shown on page 73 of this issue where the Attenuator type TF 2163 is introduced. It has been conveniently designed in two sections—a coarse and a fine—which are both ideal for inclusion in any generator operating up to 1000 Mc/s. At present we use them in the transistorized Signal Generator type TF 2002, and they will no doubt find many applications in our future new designs.

While on this topic, it is worth mentioning the advantages that can be realised by using some of the attenuator-type accessories that are available. Basically, like the built-in attenuator, they are there to extend the operating range of the various instruments. In addition, they can often provide a worth-while improvement in the input or output impedance assuming the loss in sensitivity is tolerable.

For signal generators the fixed pad of 6 dB or more will improve the output impedance, particularly at the higher frequencies. Fixed pads can also be used for the purpose of impedance conversion from, say, 50 Ω to 75 Ω. With voltmeters and oscilloscopes the multipliers, so called because they multiply the instrument range not the signal, will give a large increase in input impedance. Here it is sometimes advantageous to use capacitive attenuators, as in the case of the ×100 multiplier used with our R.F. Electronic Millivoltmeter type TF 2603 where an improvement in input resistance of at least a hundred times results from its use. Another example is the ×10 oscilloscope probe which raises the impedance from 1 M Ω in parallel with 27 pF to 10 M Ω in parallel with 9 pF. There are numerous other attenuator-type accessories which could be quoted, but it is always advisable to study the characteristics with care as their use may offer some definite advantage over and above their ability just to attenuate signals. P.M.R.

Any form of transmission system is subject to unwanted attenuation—not least the National Grid. Power loss is minimized by high voltage transmission as on this section of 275 kV line between Tilbury and Elstree

by courtesy of the Central Electricity Generating Board.

MARCONI INSTRUMENTS NEW DESIGN

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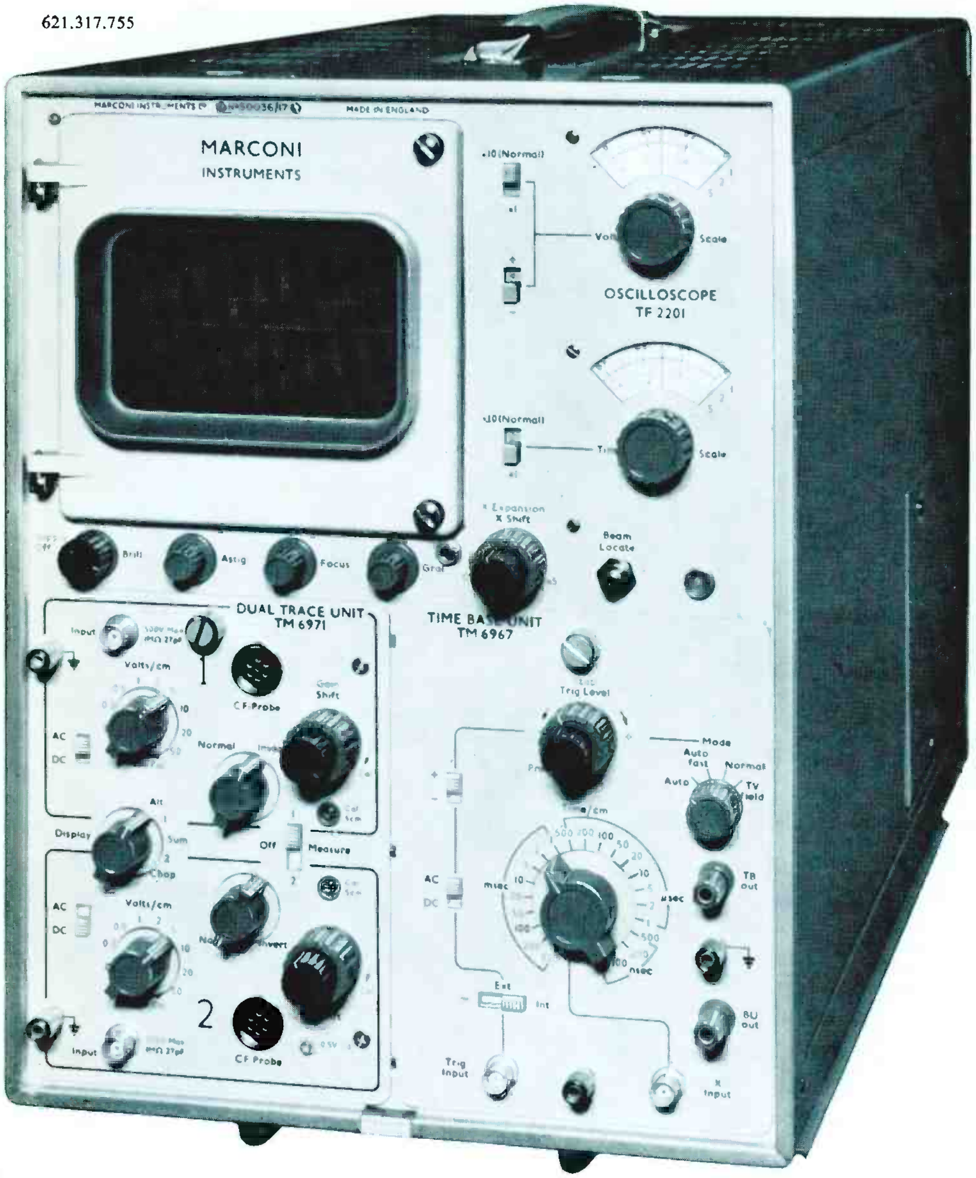


Front panel layout showing well spaced controls. All variable gain potentiometers have a definite indented CAL *position*

D. E. BENNETT, A.M.I.E.E.,
D. A. WHITEMAN, Graduate I.E.E.,
R. J. FRYATT, Graduate I.E.R.E.

Oscilloscope

Type TF 2201

This is a transistorized 30 Mc/s general purpose measuring oscilloscope with X and Y plug-in facilities and a basic Y sensitivity of 50 mV/cm. Both centimetre graticule and slide-back measurement facilities are provided over a 6 × 10 cm picture. All front panel inputs and outputs are protected to prevent damage to semiconductors, and internal supply lines are protected against short circuit to chassis. Sub-unit construction has been employed and facilitates a user replacement servicing scheme.

THE REPLACEMENT of thermionic devices by semiconductors as the active elements in electronic circuitry continues apace. Apart from the benefits of miniaturization, no progressive instrument company can afford to ignore the improvements in performance and reliability resulting from the use of semiconductors in equipment even where size and weight are not primary considerations. Accordingly the TF 2201 Oscilloscope has been designed around what has become almost the standard specification for the general purpose laboratory oscilloscope, i.e. 30 Mc/s bandwidth and 50 mV/cm sensitivity, with a 5 inch c.r.t. giving a 6 × 10 cm display. The difference from its thermionic competitors is virtually complete transistorization of all circuits, including e.h.t. supply.

At the present state of the art the term 'transistorized' as applied to an oscilloscope is still acceptable if the input stages are valves. This is, at present, the most effective method of presenting both a high impedance to the Y input attenuators and protecting the input circuits of the oscilloscope from damaging over-voltages. This practice has been followed in the TF 2201, the valves being used in their most reliable and stable mode of operation, i.e. as cathode followers. The time base and gating waveform outputs are also from cathode followers to protect the transistor circuitry.

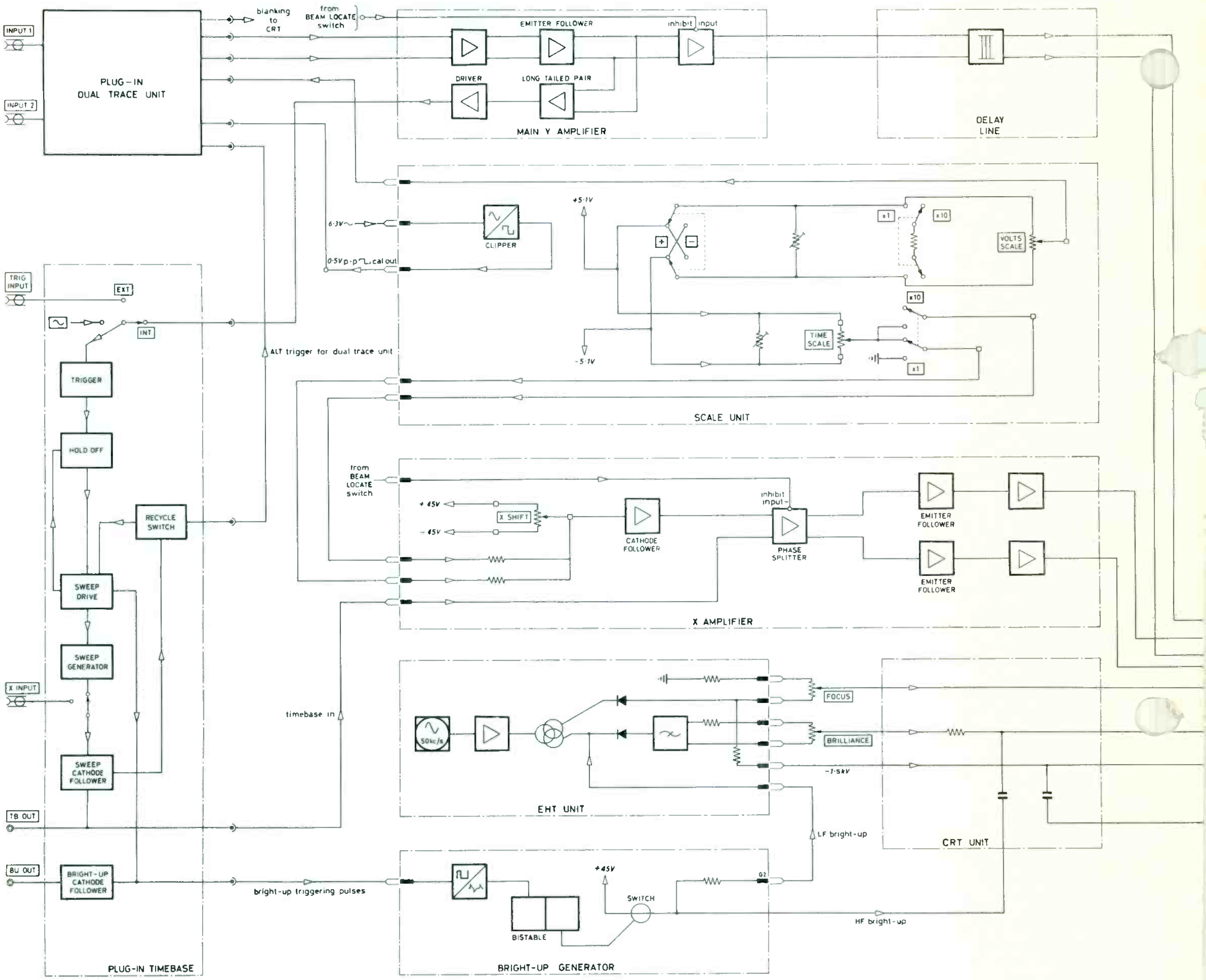


Fig. 1. Schematic diagram of Oscilloscope type TF 2201

Advantages of the transistorized design are as follows:—

1. The performance is achieved with 135 to 150 W mains dissipation as compared with 500 to 600 W for valve oscilloscopes. A reduction of heat of this order results in greater component reliability and stability of performance. Cooling is by convection only, no fan being necessary.
2. Improved reliability because of the much longer life of semiconductor devices.
3. Freedom from drift. This is true for both display position and gain in the Y amplifiers. Improvement in stability of time calibration is also marked. These advantages are apparent over a large ambient temperature range. Triggering and display position are unaffected by mains changes of at least $\pm 10\%$.
4. Improved time base triggering performance to beyond the bandwidth of the instrument. Automatic synchronization is particularly improved.
5. Shorter time base starting time, better linearity at the start of fast sweeps and fast-rise bright-up pulse. These are due to the superior switching performance of transistors.

Some compromise has been made in the size of the instrument in order to keep the price comparable with equivalent valve designs. Miniaturization means higher cost, restricted front panel area and a smaller c.r.t. screen. The larger design also enables the cheaper germanium power transistor to be used; otherwise all transistors used are silicon types.

General construction

The oscilloscope is designed to accept X and Y plug-in units, but the main X and Y deflection amplifiers are housed in the main hulk. Circuits of an oscilloscope fall easily into separate functions—X amplifier, e.h.t. generator, power supplies etc.—and the construction of the TF 2201 Oscilloscope makes each a removable sub-assembly. The reasons for this are three-fold. Firstly, transistors can only be regarded as reliable circuit elements if they are not subjected to damaging voltages due to fault conditions. In order to minimize this risk every sub-unit on the TF 2201, including cableforms, is pre-tested before assembly. Secondly, the sub-units enable easy servicing by isolating faulty stages and allow the user to take advantage of a sub-unit replacement service described later. Thirdly, improvements and changes are easily worked into the instrument during manufacture and may even be passed on to the customer if necessary.

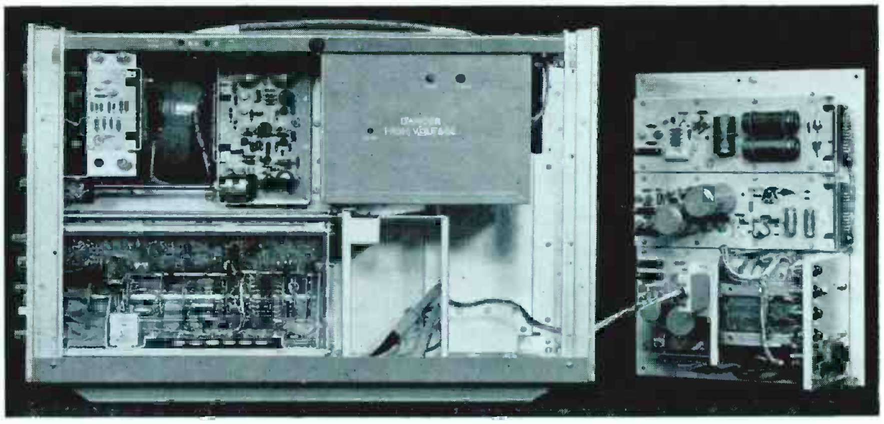
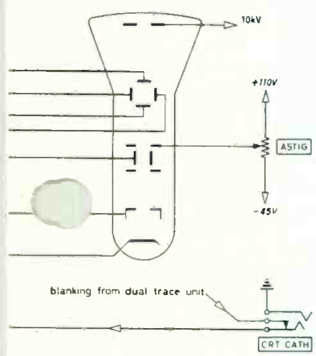


Fig. 2. Side view showing power supplies removed but still connected. Servicing may now proceed on the X amplifier, scale unit and time base. The stowage compartment for probes and leads is behind the time base plug-in unit



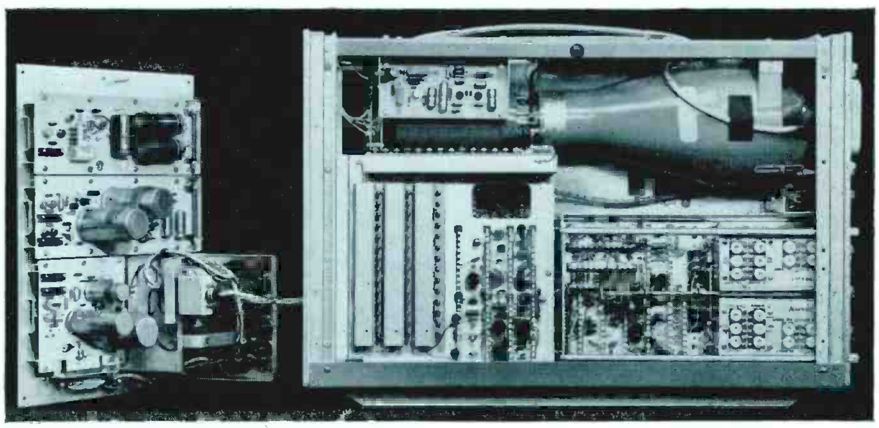


Fig. 3. Side view showing access to Y plug-in unit, main Y amplifier and bright-up generator. The four demountable units of the power supply can be seen. Access to the c.r.t. base is from the rear

Sub-units

These are indicated, enclosed in chain-dotted lines, on the main frame schematic diagram. Fig. 1. Some of these sub-units can be seen in Fig. 23.

Push-pull signals from the Y plug-in unit enter the main Y amplifier at a sensitivity of 100 mV/cm. The amplifier comprises two stages of long tailed pair transistor amplifiers with collector clamps at the input stage to prevent hole storage effects from distorting large signals. A trigger pick-off amplifier provides Y signals to the time base for internal triggering. The Y signal is passed to the c.r.t. Y plates via a 180 nsec lumped constant delay line. As with all the Y amplifier circuits, care has been taken to design out the effects of transistor thermal time constants which can introduce appreciable tilt on low frequency square waves.

Two methods of voltage and time measurement are provided: the usual calibrated graticule method giving accuracies within $\pm 3\%$ of full-scale and a slide-back method of calibrated Y and X shift controls giving greater discrimination and accuracies within $\pm 2\%$. The scale unit provides an accurate 0·5 V square wave Y calibrating signal together with the calibrated 'volts' and 'time' potentials for both methods.

Apart from improved discrimination, an advantage of the slide-back system is that accuracy does not depend on Y or X amplifier gain. Therefore measurements can still be made in the uncalibrated positions of the fine Y or fine X gain controls.

The X amplifier follows the general form of the Y amplifier except that the X shift and time measuring potentials are added at one input to the phase splitter. Saw-tooth waveforms from the time base plug-in unit are injected at the other. The X amplifier is available for external drive and has a maximum sensitivity of 160 mV/cm at a bandwidth of 5 Mc/s.

The BEAM LOCATE button is located on the front panel and, when depressed, limits the swing of both X and Y deflection amplifiers as well as free-running the time base. This has the effect of returning to the 6×10 cm graticule any picture 'lost' by excessive shift or d.c. component of the signal.

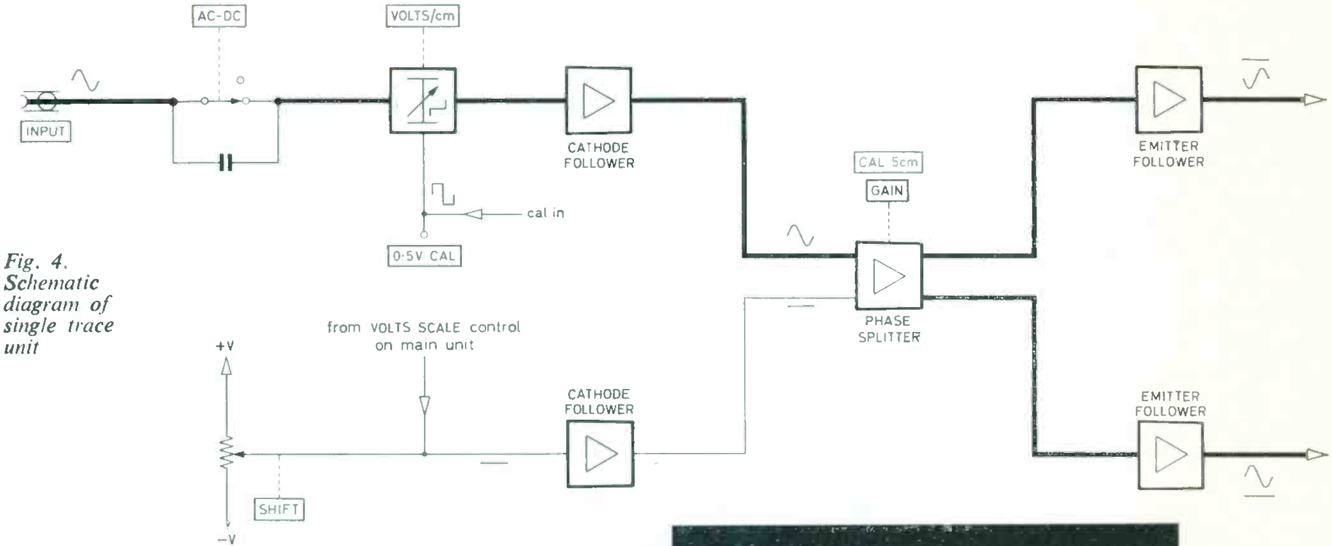


Fig. 4. Schematic diagram of single trace unit

High voltage supplies for the c.r.t. are generated in the e.h.t. unit. This is basically a voltage controlled power oscillator providing a —1·5 kV stabilized cathode line and a +10 kV p.d.a. voltage. A floating winding on the e.h.t. transformer is used to d.c. couple the bright-up waveform to the c.r.t. grid.

Bright-up pulses are generated by a bistable multivibrator driving a high voltage transistor switch. The d.c. component drives the floating winding on the e.h.t. transformer via a capacitor hold-off resistor while the h.f. components are a.c. coupled to the c.r.t. grid via a capacitor.

The 5 inch cathode ray tube has a picture size of 6 × 10 cm and has a mesh type gun structure giving a high Y deflection sensitivity of 3V/cm, a useful feature where direct drive to the Y plates is necessary for frequencies up to at least 100 Mc/s. The X deflection sensitivity is 10 V/cm. Provision is made for externally modulating the c.r.t. cathode via an a.c. coupling, a signal of 2V peak-to-peak being adequate.

Power supplies

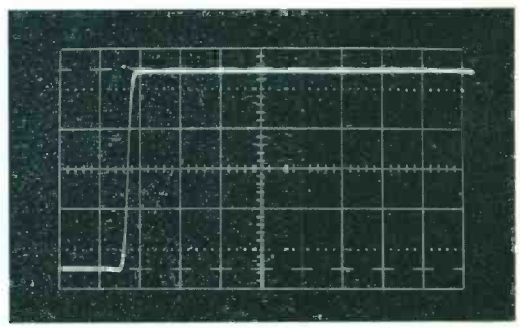
Internal d.c. power supplies are of conventional series regulator design. They are mounted on the back panel which forms a heat sink, and consist of three easily removable sub-chassis. The mains transformer and cableform is also an easily replaceable item.

Supply lines are protected against short circuit to chassis.

Y preamplifiers

Single trace unit

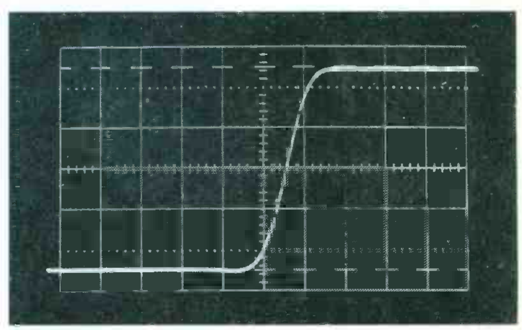
This is the simpler of the two plug-ins and has a single d.c. coupled amplifier giving a maximum sensitivity of 50 mV/cm and a 3 dB bandwidth of at least 30 Mc/s. Its schematic diagram is shown in Fig. 4. A 1–2–5 sequence attenuator gives a range of input sensitivities from 50 mV/cm to 50 V/cm and a variable gain control provides continuous coverage giving a minimum sensitivity of 125 V/cm. A front panel preset CAL control allows the gain to be set such that the internal calibration signal, available by switching the attenuator to the CAL position,



Y=50mV/cm

X=50 nsec/cm

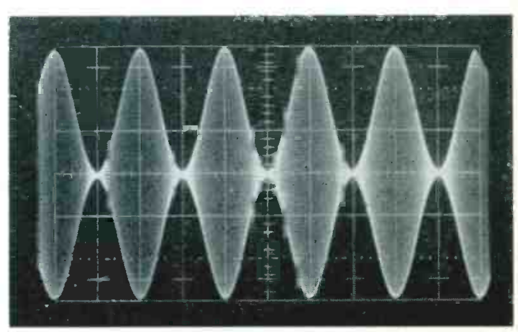
Fig. 5. Clean transient response of TF 2201 to a +ve step of 2·5 nsec rise time. Note that internal Y delay line gives ample time between start of time base and step



Y=50mV/cm

X=10 nsec/cm

Fig. 6. Same step as in Fig. 5 with X expansion of ×5 making time scale 10 nsec/cm. Step is measuring rise time of TF 2201 to be 11 nsec. Dots on 10% and 90% lines are 2 nsec apart



Y=0·1 V/cm

X=500 μsec/cm

Fig. 7. 40 Mc/s sine wave modulated at 1 kc/s showing absence of 'crushing' in Y direction. Waveform from transistorized Signal Generator type TF 2002

gives a 5 cm picture on the screen. Accurate volts/cm readings can then be made on all attenuator ranges. A shift of 12 cm is available at maximum gain decreasing to 4·8 cm at minimum gain.

A signal applied to the unit is fed via a high impedance attenuator and isolating cathode follower to one base of the phase splitter which incorporates the GAIN control. The other base is fed from a complementary cathode follower to which is applied the shift and the measuring voltage. The balanced signal is fed from the phase splitter collectors via emitter followers to the output plug. The overall gain of the unit with the gain control at maximum is $\times 2$.

Dual trace unit

This unit—see Fig. 8—contains two identical amplifiers each giving a sensitivity of 50 mV/cm and a 3 dB bandwidth of at least 30 Mc/s.

The DISPLAY switch selects the following displays:

1: Channel 1
2: Channel 2
ALT: Channels 1 and 2 alternately at time base rate
CHOP: Channels 1 and 2 alternately at unsynchronized 1 μsec intervals
SUM: Algebraic sum of both channels, the polarity of each being determined by individual NORMAL/INVERT switches.

Internal blanking of switching transients is provided by the chop waveform generator. Each channel has its own preset and variable gain, shift, attenuator and calibration facilities. The voltage measuring dial can be switched for use on either channel or can be switched out

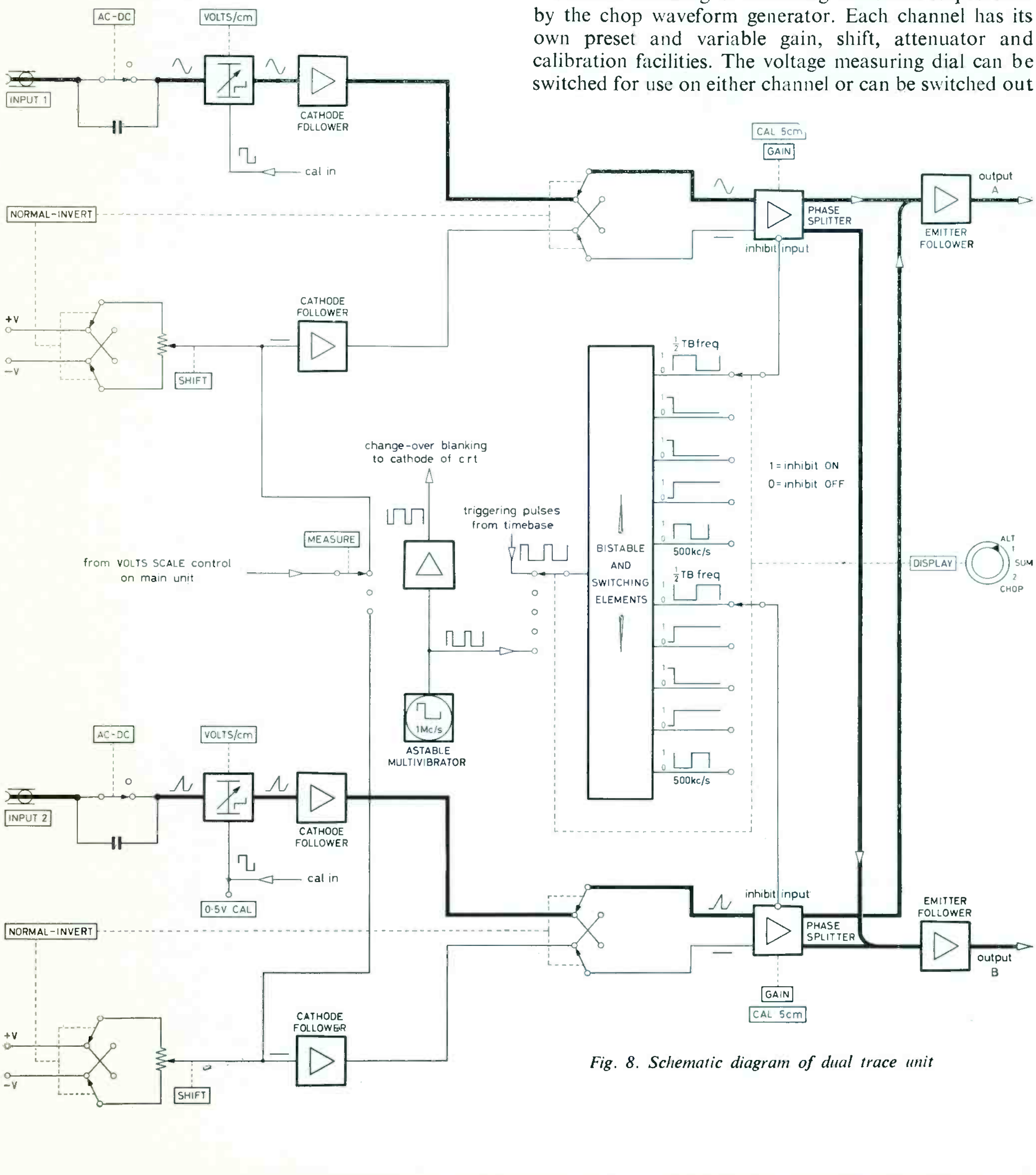
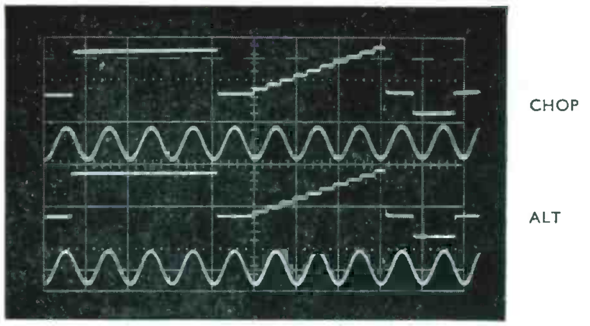
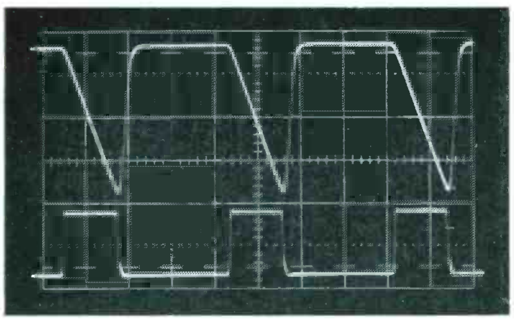


Fig. 8. Schematic diagram of dual trace unit



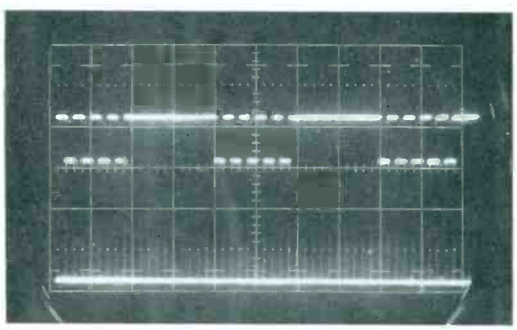
X = 10 μsec/cm

Fig. 9. Double exposure showing dual trace display of same waveforms on both CHOP and ALT. On CHOP switching transients have been effectively blanked



X = 500 nsec/cm

Fig. 10. Dual trace display on ALT mode displaying fastest saw tooth and bright up waveform of TF 2201



X = 500 msec/cm

Fig. 11. Dual trace display in CHOP mode showing good linearity on slowest sweep

as required. The shift control range and attenuator coverage are identical to those of the single trace unit.

A signal applied to either channel is fed via a high impedance attenuator and cathode follower to one base of a phase splitter and mixed with the shift and measuring voltage exactly as in the single trace unit. The NORMAL/INVERT polarity switch enables the inputs to the phase splitter to be reversed and thus positive or negative outputs can be obtained. The phase splitter stages of each channel contain independent variable and preset gain controls but share common collector loads where the output from the phase splitter of one channel is mixed with that of the other channel. The combined balanced signal is fed via emitter followers to the output plug.

The tail of each phase splitter is a common-emitter transistor, these two transistors forming a long tailed pair. Their bases are fed from the beam switch bistable which in one state turns on the emitter current to Channel 1 phase splitter, and in the other state turns on the current to Channel 2 phase splitter. In addition, gating diodes in the collectors of the phase splitters provide additional signal rejection in the 'off' channel. This method of channel switching provides a very high order of isolation between channels; break-through from one channel to the other at 30 Mc/s is better than 40 dB down whilst several screen diameters of low frequency give no visible break-through on the other channel.

Depending on the setting of the DISPLAY switch, the beam switch bistable turns the gates on or off permanently or cyclically. In the ALTernate mode switching is at the time base repetition rate when the bistable is triggered by the time base sweep terminating pulse. In the CHOPped mode the repetition rate is 500 kc/s when the bistable is triggered by the free-running chop multivibrator.

Time base

This unit divides functionally into six parts, each of which is built as a separate sub-assembly. Fig. 12 illustrates how these sub-assemblies are arranged along the time range switch and Fig. 13 is the block schematic diagram.

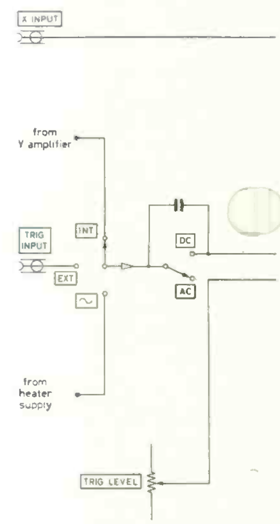


Fig. 13. (right). Block schematic of time base unit

Modes of operation

The time base has four basic modes of operation: AUTO, AUTO FAST, NORMAL and TV FIELD. The trigger source and slope conditions—a.c. and d.c., +ve and −ve —merely modify the way in which the triggering signals are routed to the trigger circuits. These four modes all give triggered operation of the time base, but a sync condition which can be selected on each trigger mode allows the time base to free-run. There are three sources from which the time base can be triggered: the output of the main Y amplifier, an external signal or an internal supply frequency signal.

Trigger function

When switched to AUTO or AUTO FAST mode the trigger level is preset to zero volts and the Schmitt trigger is made to free-run. This is simply achieved by returning both bases of the Schmitt to the same level and a.c. coupling it to the trigger amplifier. This set of conditions ensures that the trigger circuits are biased to their most sensitive condition and that there will always be a trace on the screen, even when no triggering signal is present.

A low frequency of about 45 c/s has been chosen for the AUTO position and a relatively high frequency of about 10 kc/s for the AUTO FAST position, so that a base

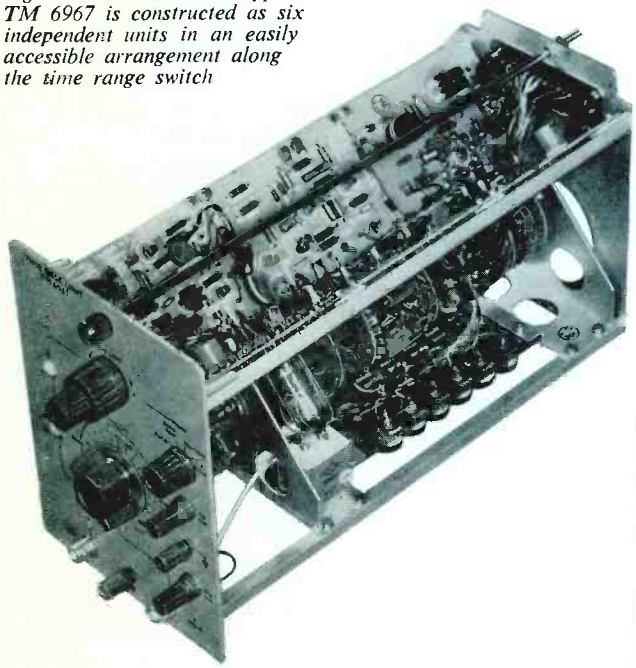
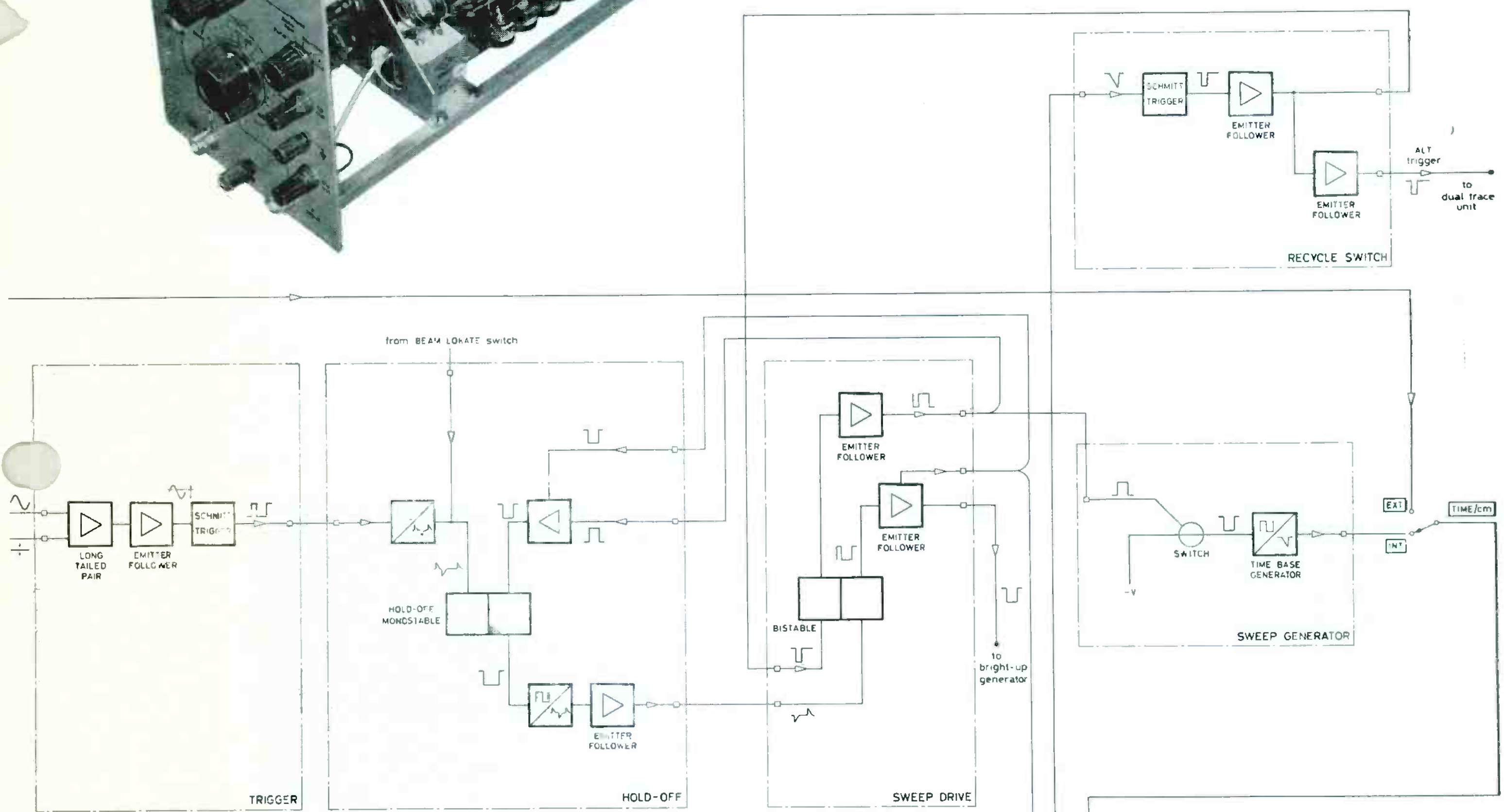
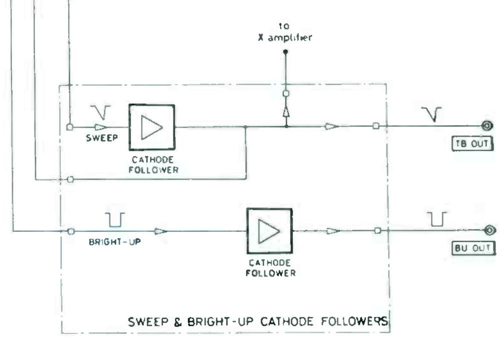
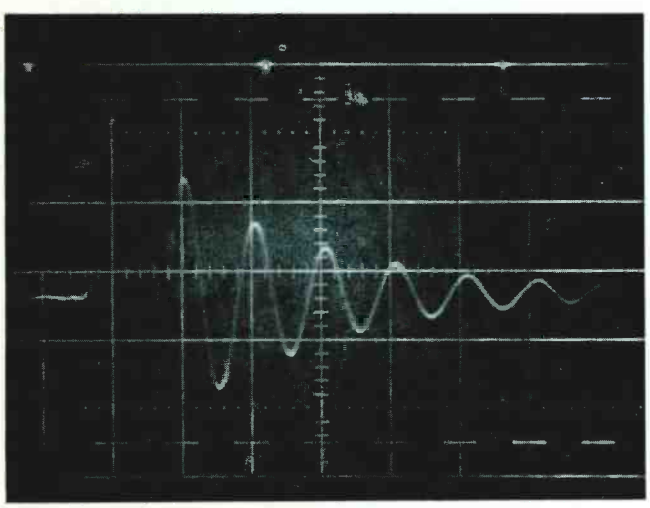


Fig. 12. Time Base Unit type TM 6967 is constructed as six independent units in an easily accessible arrangement along the time range switch

line may be seen even on the shortest time base range when there is no triggering signal present. A.C. signals are coupled directly to the Schmitt trigger which therefore runs at the same frequency as the triggering signal. The level at which the circuit triggers on the triggering waveform is approximately equal to the mean level. The frequency range covered by the AUTO position is at least 45 c/s to 15 Mc/s.

The NORMAL mode of operation should be used when it is necessary to trigger off a precise level on a waveform. Hence the Schmitt trigger is d.c. coupled to the long tailed pair and the TRIG LEVEL control defines the level at which the triggering waveform fires the Schmitt circuit.



X=50 nsec/cm

Fig. 14. Single shot photograph of 20 Mc/s damped oscillation indicating writing speed of 300 cm/µsec obtainable with the D 13-22GH cathode ray tube. Photograph was taken with a Telford type A camera, f1·5 on Polaroid 10,000 ASA film.

TV

In the fourth mode, TV FIELD, the time base can be locked to the field synchronizing pulses of a television signal. The blanking interval in a television signal is defined by a change in mark/space ratio of the synchronizing pulses between fields. It is thus possible to trigger the time base at field frequency by feeding the resultant waveform to

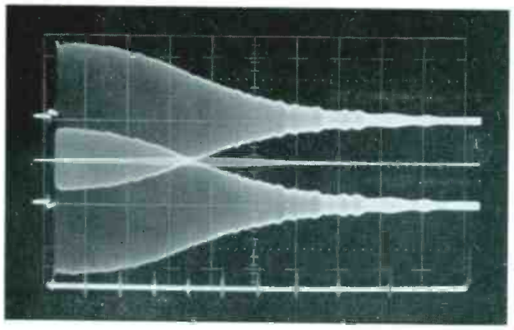


Fig. 15. Double exposure in CHOP *mode of swept frequency display to 100 Mc/s. Centre trace shows algebraic addition of two channels, one inverted. Lowest trace shows 10 Mc/s markers. Channel gain was first equalized at 50 c/s*

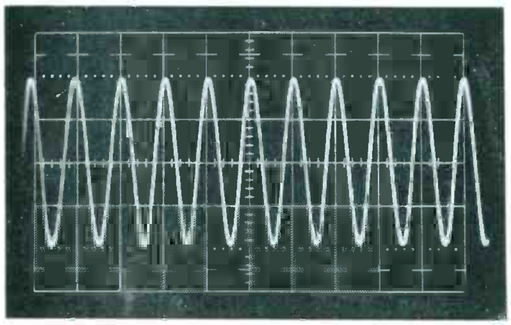


Fig. 16. 20 Mc/s sine wave on fastest time base (unexpanded) showing time base linearity

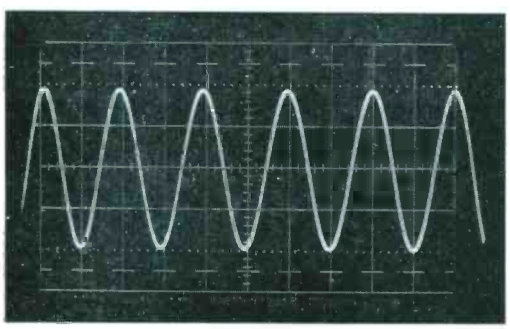


Fig. 17. 50 Mc/s sine wave on fastest time base range, expanded to 10 nsec/cm

the Schmitt trigger. In this case a C-R integrator, formed by the collector load of the long tailed pair and a capacitor, is used. The capacitor is switched to earth by a diode gate controlled from the trigger mode switch to reduce the effects of stray capacitance of the switch on other modes.

Sweep loop

The sweep loop has two modes of operation, monostable and free-running. The monostable state is obtained when the STABility control is set to the preset condition. Rotating the STABility control in a clockwise direction switches in a second bias potentiometer, whose rotation modifies the d.c. level to which the first base of the monostable is returned, so that it becomes astable. When set to this state the hold-off circuit produces trigger pulses of its own volition which drive the sweep drive bistable and hence the loop.

Another way of biasing the hold-off circuit to its astable state is by pressing the BEAM LOCATE button. This adjusts the tube deflection voltages to bring the trace onto the screen of the c.r.t. and, by making the time base free-run, ensures that the trace is visible.

The information progression through the sweep loop is described in the flow diagram, Fig. 19.

One of the aims behind the design of this time base was to make the operation as simple as possible; this meant ensuring that the AUTO and NORMAL trigger modes functioned over the widest possible bandwidth—at least 20 Mc/s on NORMAL and 15 Mc/s on AUTO. Functions at higher frequencies would still be able to be locked to the time base because the STABility control, which is included for this purpose, could be used as an h.f. sync control.

To achieve triggering up to 20 Mc/s means that the rise time of the Schmitt trigger must be less than the period of the triggering function, that is about 10 nsec. The hold-off circuit must also be able to respond in a similar order of time. These performance requirements are obtained by the use of low value collector loads and careful layout to reduce stray capacitance. The resultant triggering performance is in excess of 20 Mc/s, many units producing stable traces on normal trigger up to 30 Mc/s. The high frequency information content in the transient states ensures that an equally satisfying per-

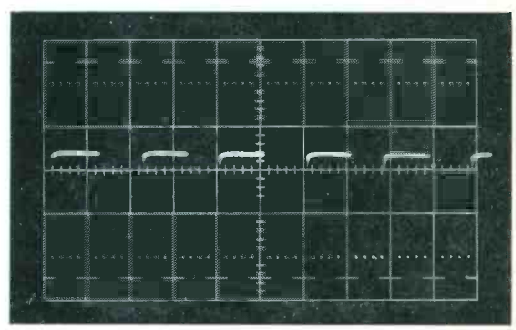


Fig. 18. Excellent recovery time to large amplitude pulses is shown by this photographed response to a 100 V p-p 1 c/s square wave. The waveform is negative going and displayed at maximum Y sensitivity

formance is achieved using the STABility control and free-running the time base loop to synchronize the oscilloscope with a high frequency signal well in excess of the oscilloscope bandwidth.

If high frequencies are to be displayed on the screen a linear sweep of short duration must be provided but the transistor requirements for such a circuit are in direct conflict with the low frequency display. The two requirements are catered for by the choice of a bootstrap saw-tooth generator, the standing currents being adjusted as the sweep range changes so that the high frequency performance of the transistors is maintained for short duration sweeps, and low base current is obtained for 5 sec sweeps.

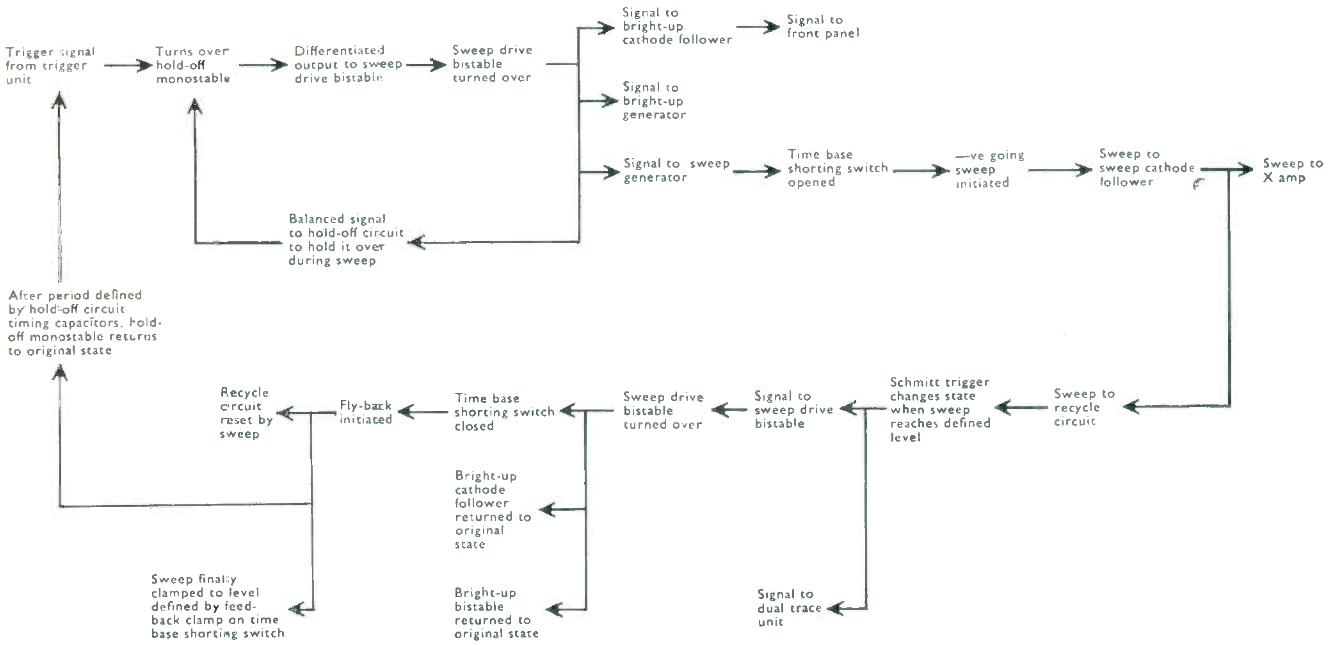
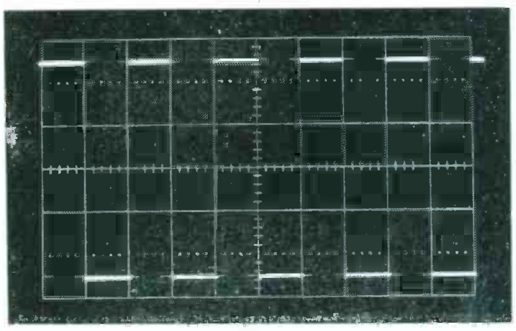
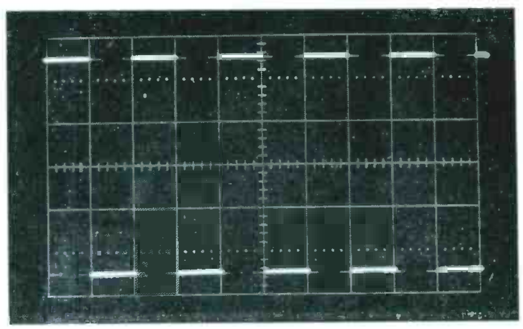


Fig. 19. Time base sweep loop flow diagram



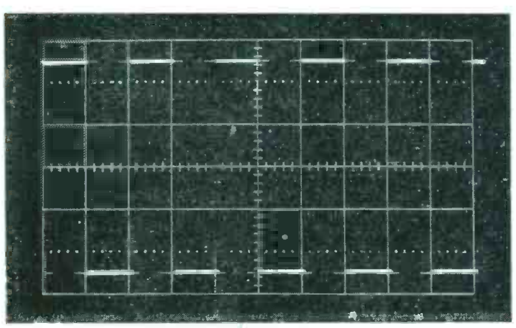
Y=0·2 V/cm

1 c/s X=500 msec/cm

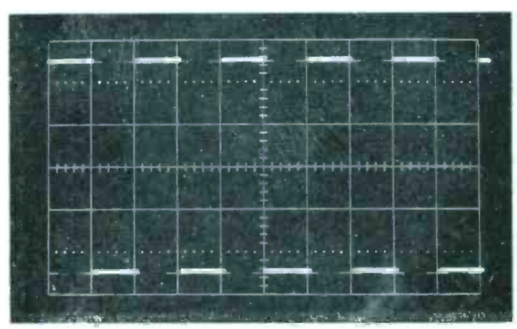


Y=0·2 V/cm

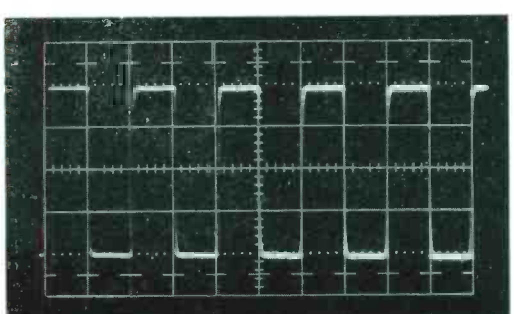
100 c/s X=5 msec/cm



1 kc/s X=500 μsec/cm



10 kc/s X=50 μsec/cm



10 Mc/s X=50 n/sec/cm

Fig. 20.

Transistor Y amplifiers can show waveform distortion of sag or tilt on pulses due to thermal effects in the transistors. The extent to which these and their distortion effects have been designed out are shown in these square wave displays

ABRIDGED SPECIFICATION

Overall performance with:

Single Trace Unit TM 6970 and Dual Trace Unit TM 6971

BANDWIDTH: D.C. to at least 30 Mc/s (—3dB).

RISE TIME: Not greater than 12 nsec.

TRANSIENT RESPONSE: (to an input rise time of 3 nsec). Overshoot not greater than 5% for 6 cm picture.

SENSITIVITY: Ten ranges in 1–2–5 sequence from 50 mV/cm to 50 V/cm. Fine gain control covers greater than 2·5:1.

INPUT IMPEDANCE: 1 MΩ shunted by 27 pF at all sensitivities.

PROBE FACILITIES: Power socket and 0·5 V 1% calibration square wave provided for cathode follower probe.

In addition, the dual trace unit has the following facilities:

POLARITY REVERSAL: To simplify comparison of signals 180° out of phase, the polarity of either channel may be inverted.

DISPLAY SELECTION:

- ALT Channels 1 and 2 displayed on alternate time base sweeps
- 1 Channel 1 only
- SUM Algebraic sum of Channels 1 and 2
- 2 Channel 2 only
- CHOP Chopped display of channels 1 and 2 at 500 kc/s (transients blanked).

Y amplifier

AMPLITUDE MEASUREMENT:

By calibrated Y shift potentiometer to ±2% f.s.d. accuracy.

By calibrated graticule to ±3% f.s.d. accuracy.

SIGNAL DELAY: 180 nsec by lumped constant line. Permits observation of leading edge of waveform that triggers the oscilloscope. Starting time (on screen) greater than 50 nsec.

X amplifier

BANDWIDTH: D.C. to at least 4·5 Mc/s (—3 dB).

SENSITIVITY: 800 mV/cm at ×1 expansion to less than 160 mV/cm at ×5 expansion.

EXTERNAL INPUT IMPEDANCE: 1 MΩ shunted by 60 pF.

Z MODULATION: A.C. coupled to c.r.t. cathode.

Time Base Unit TM 6967

SWEEP VELOCITY: Twenty-two ranges in 1–2–5 sequence from 500 msec/cm to 50 nsec/cm at ×1 expansion. Maximum expansion increases all sweep speeds by at least ×5.

TIME MEASUREMENT:

By calibrated X shift potentiometer to ±2% f.s.d. accuracy.

By calibrated graticule to ±3% f.s.d. accuracy.

TRIGGER FACILITIES:

Input modes: four position switch selects AUTO, AUTO FAST, NORMAL, TV FIELD. Three further switches select inputs from internal, external or supply frequency sources, a.c./d.c. coupling and polarity.

Internal triggering from d.c. to at least 20 Mc/s for 3 mm p–p display.

AUTO operation from 45 c/s to 15 Mc/s for 3 mm p–p display. High frequency synchronization to at least 40 Mc/s by operation of STABILITY control (normally preset for frequencies up to 20 Mc/s).

TV FIELD position integrates composite TV waveform and triggers every field if sync pulses are 5 mm p–p or more.

External triggering. As above but for 600 mV p–p signal. Input impedance: 1 MΩ shunted by 40 pF.

Trigger level control covers 6 cm on internal trigger and ±6V on external. (Inoperative on automatic triggering.)

Accessories supplied

The TF 2201 is normally supplied with the following accessories:—

×1/×10 Attenuator Probe type TM 8110.
Low Capacitance Probe type TM 8120.
Graticule Projector type TM 8098.

The ×1/×10 probe has the unique feature of a switchable tip. In the ×1 position the circuit sees a load consisting of the oscilloscope input impedance of 1 MΩ in parallel with 27 pF, plus an additional shunt 35 pF due to the probe lead. Switched to the ×10 position the load becomes 10 MΩ in parallel with 9 pF.

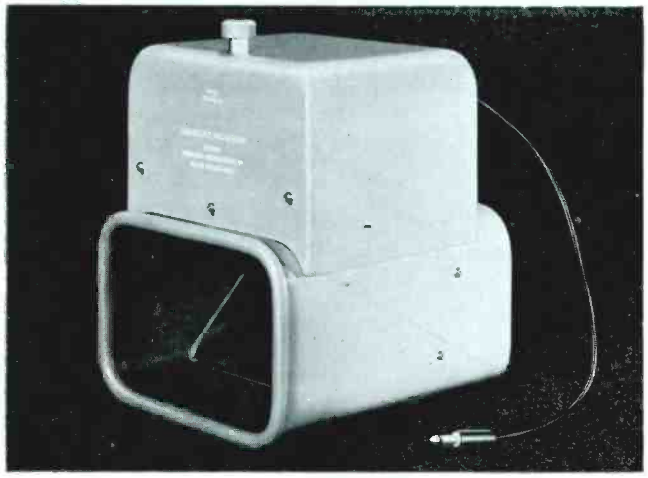


Fig. 21. Graticule projector type TM 8098

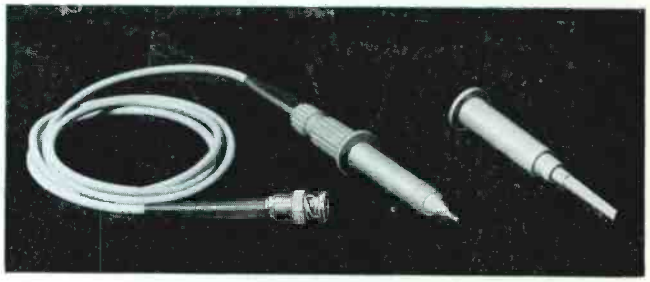


Fig. 22. ×10/×1, Attenuator probe type TM 8110 with Clip-Tip attachment type TM 8189/1 on the right

The primary function of the graticule projector is to eliminate parallax error when making accurate measurements. Some oscilloscopes have cathode ray tubes with internal edge lit graticules. These are not always preferred since they cannot be removed and the edge lighting is not quite so effective as with the older type engraved Perspex graticule. Use of the graticule projector not only displays a perfect parallax free illuminated image but graticules may be rapidly changed.

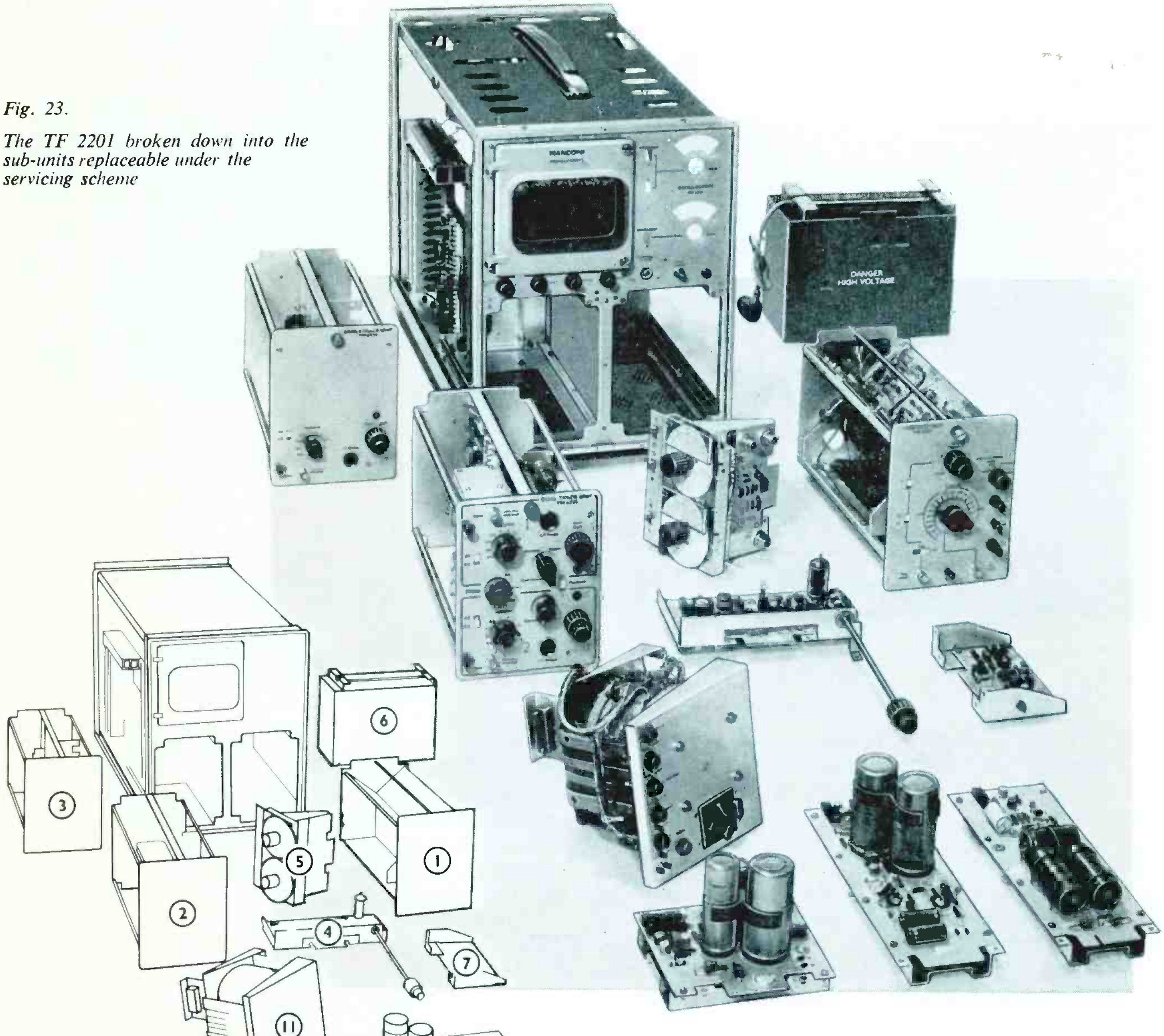
Features of these and other accessories usable with the TF 2201 were described in a previous issue of *Instrumentation*[1].

REFERENCES

1. Murray, J. K.: 'Oscilloscope accessories', *Marconi Instrumentation*, April 1965, 10, p. 2.

Fig. 23.

The TF 2201 broken down into the sub-units replaceable under the servicing scheme



1. Time base X plug-in unit
2. Dual trace Y plug-in amplifier
3. Single trace Y plug-in amplifier
4. X amplifier
5. Scale unit
6. E.H.T. generator unit
7. Bright-up generator
8. +6·3 V/−10 V stabilized power supply
9. +45 V/−45 V stabilized power supply
10. +110 V stabilized power supply
11. Mains transformer assembly.

Servicing scheme

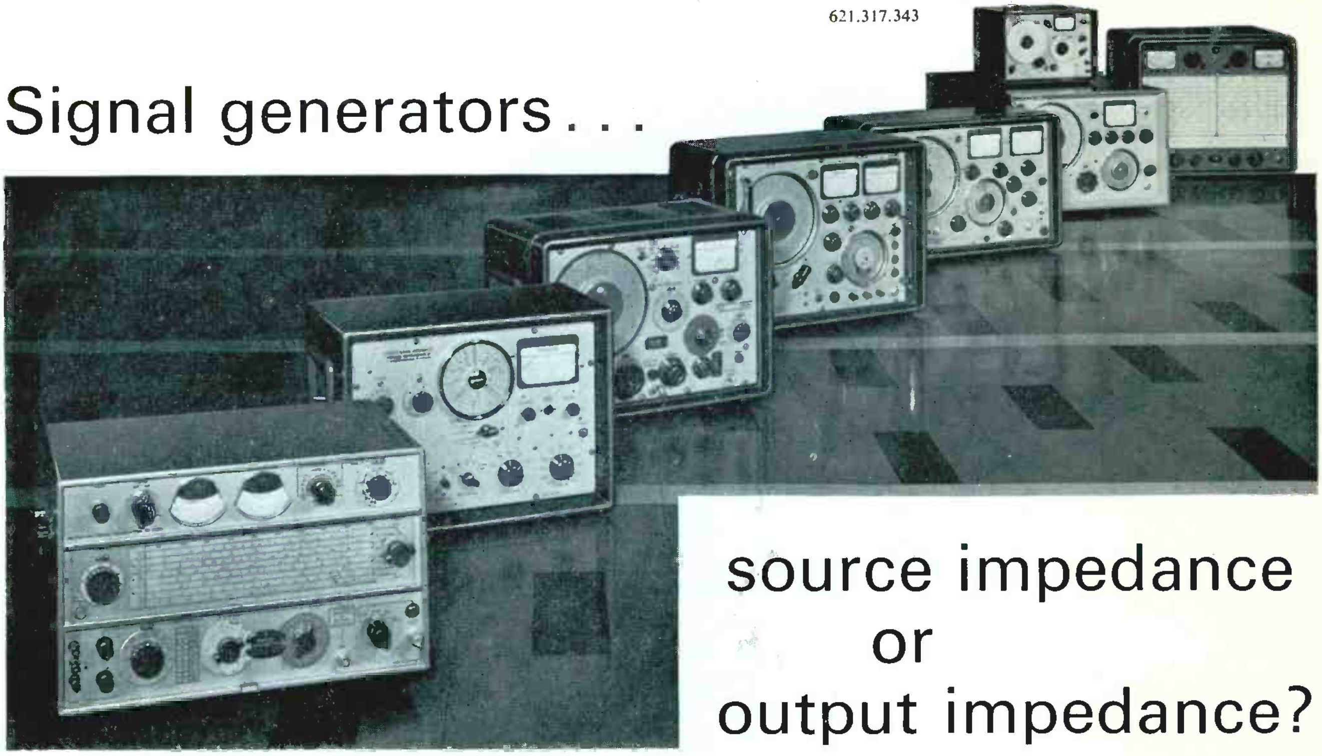
In order to facilitate servicing of the TF 2201 a special service will be operated to reduce the inconvenience and delay caused by an oscilloscope out of action.

Should a fault develop the user has a choice of three remedies:—

1. To return the instrument for servicing in the normal manner. If the repair cannot be made and the TF 2201 returned within 2 days, a replacement oscilloscope will be supplied until the repair is effected.
2. To locate the fault to a sub-unit by the procedure listed in the handbook. A telephone call to Marconi Instruments will result in a replacement sub-unit being dispatched immediately, the faulty unit to be returned by the user in the special pack. For the guarantee period of twelve months after purchase this service will be provided free of charge. Afterwards the usual servicing charges will be made.
   Replacement units are charged for unless the oscilloscope is within its guarantee period, but the user will later receive a credit note for an amount equal to the cost of the replacement unit minus the cost of repairing the faulty one.
3. There is no reason of course why the TF 2201 should not be serviced by the user. If the number of oscilloscopes in use merits the expense a quick turn-round can be assured by keeping a stock of spare replacement units.

621.317.343

Signal generators . . .



source impedance or output impedance?

by
J. M. PARKYN

Methods of measurement are described which show that a higher reliance can be placed on signal generator impedance accuracy at the highest output levels than is generally appreciated.

ONE WAY to assess the progress of the state of the art in electronic measurement instrumentation is by noting the greatly increased detail which has been added to what were once simply defined specification points. The specification for the output level of a signal generator once required only an indication of voltage range with perhaps some mention of accuracy. A statement of the nominal impedance at the signal outlet point usually followed. But rather surprisingly an indication of impedance accuracy or v.s.w.r. took much longer to make a regular appearance in specifications. Then it became apparent that the output impedance v.s.w.r. of a signal generator may be degraded at the high output level settings. This has led to some vagueness in the specification of impedance above a certain level of output. Often a v.s.w.r. figure is given up to, say, 200 mV output e.m.f., but above this level a statement of effective source impedance with no v.s.w.r. figure has to suffice.

The reason for the apparent degrading of the v.s.w.r. figure at high outputs can be seen by reference to Fig. 1 which shows a simplified version of the output circuit of a typical signal generator using a resistive output attenuator.

At the lower output settings sufficient attenuation will be provided by the variable attenuator to ensure that an accurate resistive impedance appears at the output terminals. This output impedance could be measured by an h.f. bridge or slotted line connected to the output terminals. At a 20 dB setting the circuit feeding the attenuator could not degrade the output v.s.w.r. from 1·00 to more than 1·02. At the maximum output setting when the attenuation introduced between the feeding circuit and the output terminals is zero, a bridge measurement of the output v.s.w.r. would inevitably show a poor figure since the total impedance is the sum of a resistance Zo and the complex impedance reflected into the output transformer secondary. If, however, the voltage of the monitor is held constant irrespective of load impedance

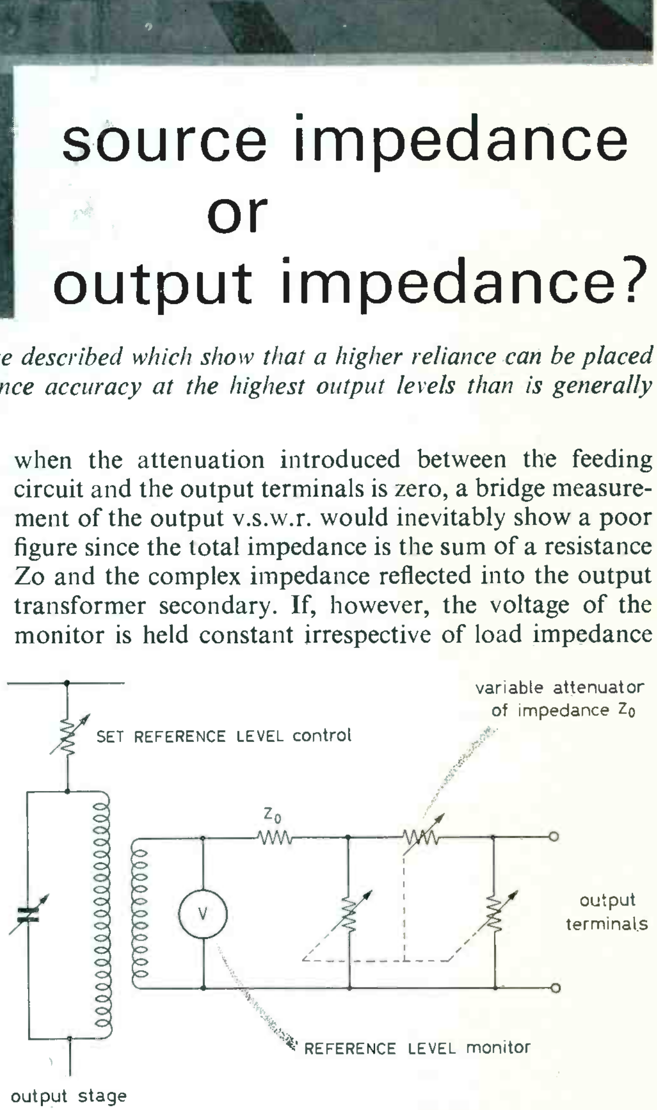


Fig. 1. Simplified signal generator output circuit

changes, then the effective impedance of the source at this point is zero. The addition of the resistance Zo provides a total effective source impedance of good accuracy. Because of the need for clarity on this point a series of experiments was devised in an attempt to show the difference, at the high level settings, between output impedance as seen by external bridges and the effective impedance of the signal generator as a source.

The photograph above shows eight Marconi Instruments signal generators in current production. These provide a.m., f.m. and pulse modulated outputs over a frequency range of 10 kc/s to 1·25 Gc/s

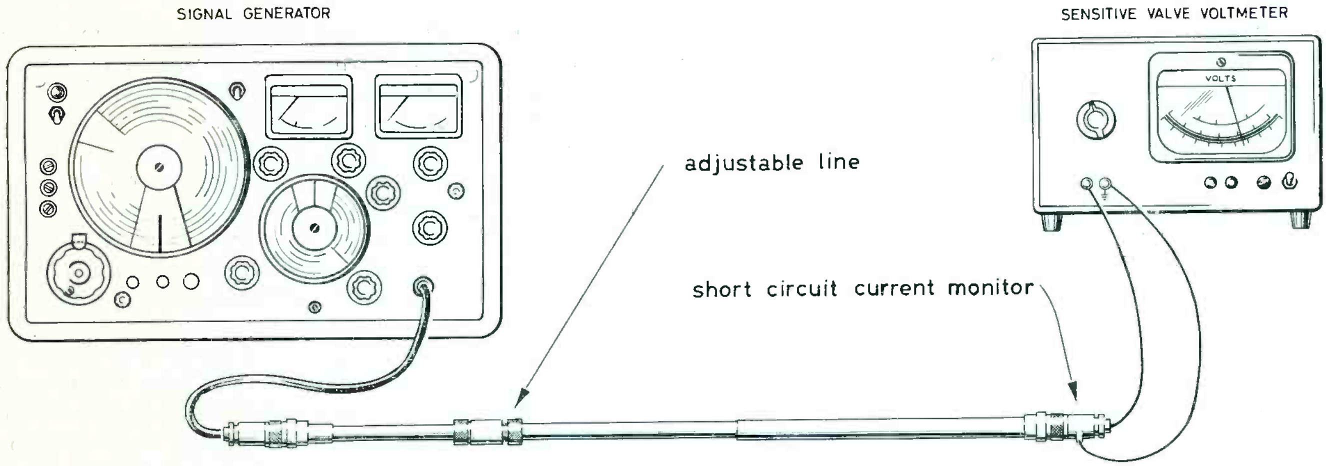


Fig. 2. 'Sliding short' v.s.w.r. measurement

The validity of the first tests depended upon the basic fact that the maximum power is dissipated in a load whose impedance presents a conjugate match to the impedance of the source. A thermistor power meter was connected to the signal generator output via matching stubs. Adjustments were made to give maximum power dissipation in the load. The complete loading assembly, consisting of the power meter and matching stubs, was then disconnected from the signal generator for measurement of the load v.s.w.r. using an h.f. bridge. Figures obtained this way on typical generators were good. However, this type of test is limited in use because the maximum in the power/mismatch curve is very flat. But the system has the merit of basic simplicity.

These matched load tests were carried out on generators having efficient automatic level control although, of course, identical results would have been obtained if manual level control had been used to oppose any change which would have occurred in the signal level at the monitor.

The tests were repeated with the automatic level control immobilised and the level allowed to change due to the loading adjustments. Under these conditions a figure of 1·25 was obtained where previously 1·06 had been achieved.

Because of the considerable care needed to obtain the exact matching point of maximum power output an alternative and more sensitive test was devised. This second series of tests depended upon the fact that a line fed from an impedance equal to its characteristic impedance, Zo, could be misterminated to give a reflection from its far end. The reflected power would then return to the sending end of the line to be absorbed completely in the sending source impedance without further reflection. An extreme condition of far end reflection was used in the form of a short circuit. To show the degree of freedom from secondary reflection from the source impedance back into the line, adjustments were made by inclusion of a sliding section, see Fig. 2. A thermocouple proved generally unsuitable for measuring the far end current because the heater does not approximate to a short circuit and the device is slow reading. Measurements were made using a crystal detector tapped across a thick radial wire fitted into a connector to short circuit the coaxial inner to outer. In this way the small voltage across a near short circuit was measured and the voltage ratios are equal to the current ratios in the short circuit.

While a complete mathematical explanation of this system of measurement is possible the simplified approach which follows may prove to be of more general interest. It provides a very close approximation to the required v.s.w.r. figure with the minimum of calculation.

In Fig. 3, if the line length is half the wavelength, i.e. $l=\lambda/2$, a reflected short circuit will appear at the sending end and a current $I_1 = E/Z_1$ will flow. With a loss-free line an equal current will be measured in the short circuit

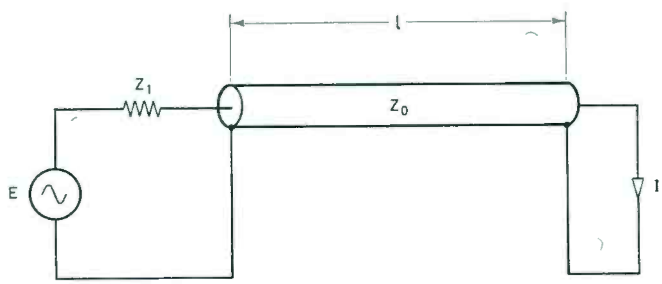


Fig. 3. Equivalent circuit for 'sliding short' v.s.w.r. measurement

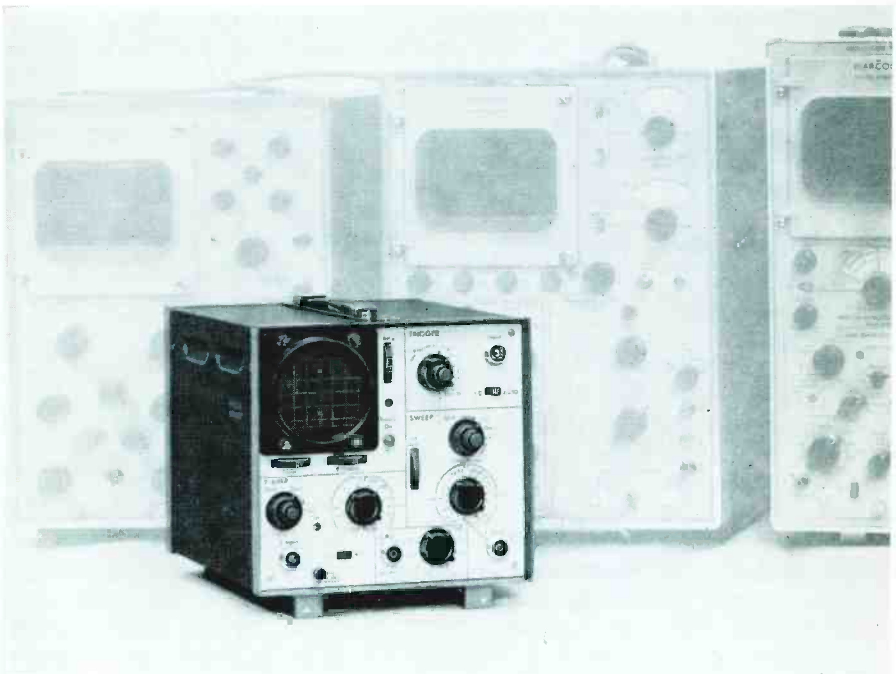
$\lambda/2$ away. With the line readjusted to $\lambda/4$ an open circuit will be reflected from the short circuit to the sending end where voltage E will appear. Assuming a reasonable match at the sending end $E/I = Zo$ and at the short circuit a current $I_2 = E/Zo$ will flow for the $\lambda/4$ line length. Thus $I_1/I_2 = Zo/Z_1$ which is the required v.s.w.r. figure.

Once again, using this different method, measurements were made on signal generators with automatic level control operating to maintain a constant voltage at the monitor point. Good v.s.w.r. figures were obtained, but poor figures were obtained with the automatic level control inoperative. These poor figures closely approximated to those obtained using an external bridge operated at the tuned frequency of the signal generator output circuit and connected directly to the generator output terminals. The good figures could be displayed on an external bridge only when a short circuit was placed exactly at the plane of the signal generator level monitor. The close agreement of the "sliding short" method and the external bridge with a short circuit at the exact monitor point was maintained in practical measurements up to 1 Gc/s.

From the foregoing discussion it appears that a distinction can be made between the effective source impedance of a signal generator and the output impedance looking back into the output terminals. Separate v.s.w.r. figures can be given to these two impedances where they differ at higher output levels. Further evidence obtained from several measurements on signal generators using piston attenuators shows that an identical condition of output impedance exists. This equality may be deduced from the similarity of the equivalent output circuits of the two types of signal generator.

Although it has been shown that signal generators will generally maintain an accurate effective source impedance up to the highest output setting provided the monitor is readjusted as necessary to counteract any load reaction on its reading, certain limitations exist. If a signal generator is fed into a non-linear load such as a heavily driven transistor or diode the load reaction changes throughout the r.f. cycle. It is therefore impossible for a level control to operate at the necessary speed to counteract this, and the effective zero impedance condition at the monitor is lost. In consequence the source impedance is degraded. Another limitation exists when two signal generators are used in a two-signal test at different frequencies; if one signal generator is delivering a high level signal, then the second signal generator will see the total output impedance of the other instrument. This is because the monitor of the high level generator can in no way provide a zero impedance point for a weak signal of another frequency. For this reason of impedance error and—more commonly—to avoid possible intermodulation of the two signals in the signal generator level monitors, a hybrid transformer may be used. It can be concluded from the measurements described that, subject to two limitations, a signal generator specification giving a v.s.w.r. figure up to a certain output level and an effective or nominal impedance figure above will generally maintain an accurate effective source impedance up to the highest output available.

621.317.755



A general purpose oscilloscope

Type TF 2203

AGAINST the familiar background of precision Marconi laboratory oscilloscopes with comprehensive operating and display facilities, the new TF 2203 stands out as a small, simple, portable and inexpensive member of the team. It is, however, a measuring oscilloscope of fully adequate performance for many users' day-to-day requirements. Although measuring only $8\frac{1}{2} \times 9 \times 15$ inches it has the following salient features:

BANDWIDTH: d.c. to 15 Mc/s
RISE TIME: 23 nsec with 1% overshoot
SENSITIVITY: 50 mV/cm
SWEEP SPEED: up to 40 nsec/cm

Voltage and time can be measured to $\pm 5\%$ accuracy against its 6×5 cm graticule, and shift ranges of at least 15 cm vertical and 18 cm horizontal are available. The vertical calibration can be standardized against an internal calibrator producing a 7 kc/s square wave with a rise time of less than 1 μsec at 8 switched levels.

The sweep generator has 18 calibrated ranges from 100 msec/cm to 200 nsec/cm with switched $\times 1/\times 5$ expansion. An external sweep can be applied via the d.c. to 4 Mc/s X amplifier. Trigger facilities are as follows:

SOURCE: external or internal, + or —
MODE: a.c. or auto
BANDWIDTH: 5 c/s to 15 Mc/s
SENSITIVITY: 0·2 cm or 0·2 V

This oscilloscope is transistorized except for the Y input stage and can be operated from 12 V batteries as well as 110/230 V a.c. supplies. Power consumption is only 20 W d.c. J.R.H.

621.317.761

MARCONI INSTRUMENTS

NEW DESIGN

V.H.F. Counting Techniques with Range Unit . . . . . Type TM 8267

by
G. C. HOILE
A.M.E.C., Graduate I.E.E.

Range Unit type TM 8267 is a plug-in unit for Counter type TF 2401A. When used with a suitable function unit it allows a maximum count rate in excess of 110 Mc/s and time measurement resolution of 10 nsec. A few of the problems in counting at these speeds, together with circuits used in this plug-in, are described.

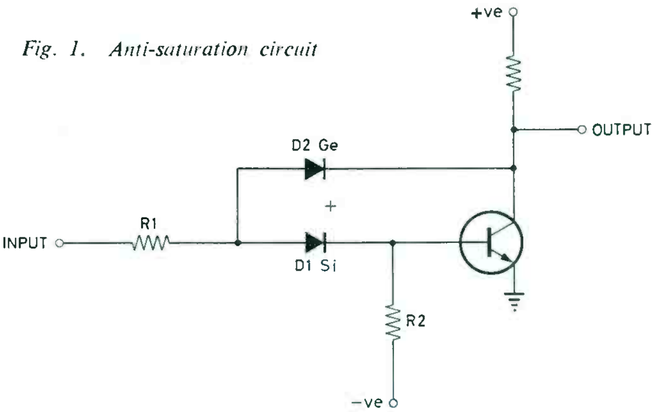
AS COUNTING SPEEDS increase, the problem of switching delays becomes more important. The transistor has certain inherent rise and fall times and produces a storage delay time which is a function of transistor saturation. Saturated switch design has several advantages, namely:

(a) simplicity of design,
(b) well defined voltage levels,
(c) low transistor dissipation when conducting,
(d) good noise immunity
(e) fewer components than in equivalent non-saturating circuits.

Against this, however, must be weighed the reduction in circuit speed owing to the storage delay time. Techniques are now in use where fast switching can be achieved while operating basically in the saturated mode.

Fig. 1 shows how negative feedback has been used to prevent saturation.[1] Resistor R1 is chosen so that sufficient current is available for a fast rise time. The silicon diode, D1, maintains a fairly constant voltage drop of approximately 0·7 V over a wide range of current and hence acts as a constant voltage source holding V_{CE} at 0·7 V. The circuit thus allows a large base drive which increases switching speed but limits the base and collector currents just before saturation. A high conductance germanium diode, D2, has been used to minimize momentary saturation which can be obtained with heavy base drive.

Fig. 1. Anti-saturation circuit



This circuit greatly improves the switching rate of a conventional binary stage, Fig. 2. The basic bistable is formed by transistors VT2 and VT3. Transistors VT1 and VT4 perform the double actions of pulse routing and fast switching. If transistor VT2 is on and VT3 is off then

This new plug-in unit raises the frequency range of the TF 2401A Counter to 110 Mc/s and improves the time measuring resolution to 10 nsec.

there is no collector supply to transistor VT1 and, although positive signals are present at the base, there can be no signals at the collector. Transistor VT4 however will feed a negative pulse to the base of transistor VT2 through capacitor C2, and transistor VT2 will turn off, starting the regenerative change of state of the binary. Increased change-over speed is achieved since the collector current of transistor VT4 will cause the collector voltage of transistor VT3 to fall to earth potential. Some pre-gating and shaping of the input pulses is carried out of these delays has been minimized by shaping the output of the first binary into fast pulses and feeding them in parallel into the remaining three binaries, such that the propagation time delay from the second binary to the fourth binary is eliminated. The scale of ten gating becomes more complex but reference to Fig. 4 and Fig. 5 will give the sequence of events.

It is necessary to drive the first binary with pulses of uniform amplitude and width throughout the full frequency band if reliable operation is to be achieved.

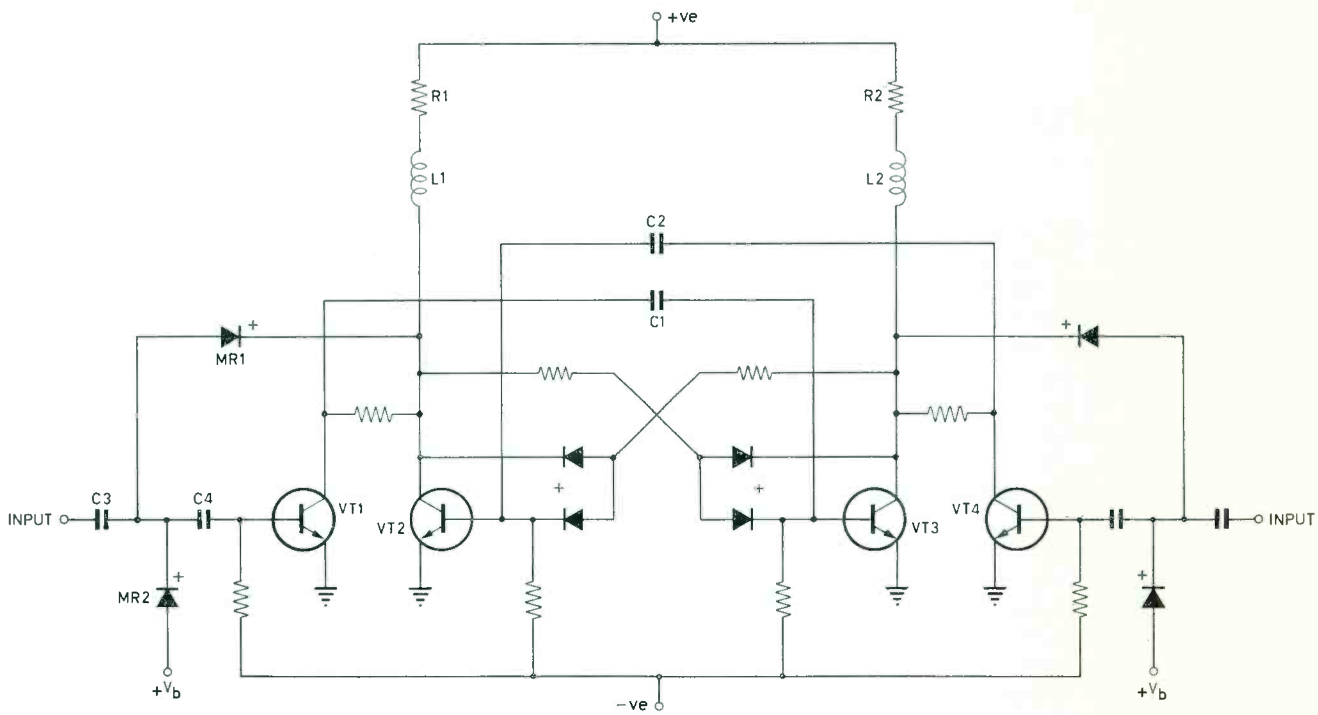


Fig. 2. Simplified diagram of binary stage

in the base drives to transistors VT1 and VT4. Considering the input to VT1, the input waveform is differentiated through capacitor C3 and gating of alternate positive going pulses is achieved with diode MR1. If transistor VT2 is turned off, MR1 will be reverse biased and the full positive going pulse injected into VT1 base. If VT2 is on, it will not be fully saturated and its collector will sit at approximately +0·7 V. Hence, the junction of capacitors C3 and C4 cannot rise more positive than +1·0 V (including the forward drop of MR 1). The amplitude of the unwanted pulse can be reduced even further by pre-biasing the junction of C3 and C4 with diode MR2 to a voltage + Vb. Chokes L1 and L2 resonate with stray capacitance and provide overshoot and hence a faster rise time on the binary output waveform.

A high speed decade counter consists of four series connected binary dividers with feedback connections to alter the natural count of sixteen to a count of ten by omitting six of the stable states of the count. In this type of system the maximum counting rate is usually limited by the time delays involved in the feedback paths of the scale-of-ten system rather than by the counting speed of each individual binary stage. The effect

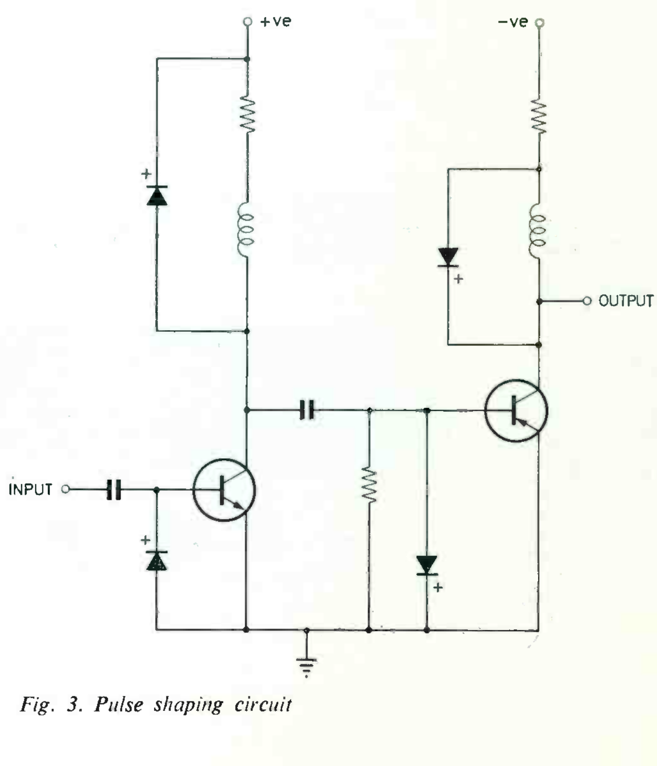


Fig. 3. Pulse shaping circuit

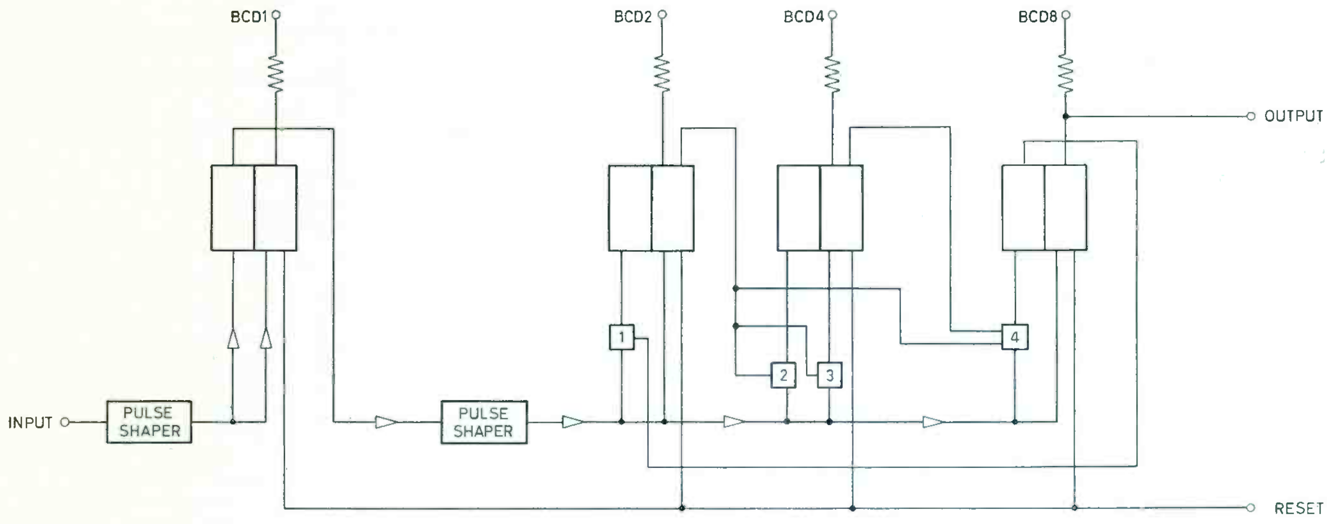


Fig. 4 High speed decade counting unit

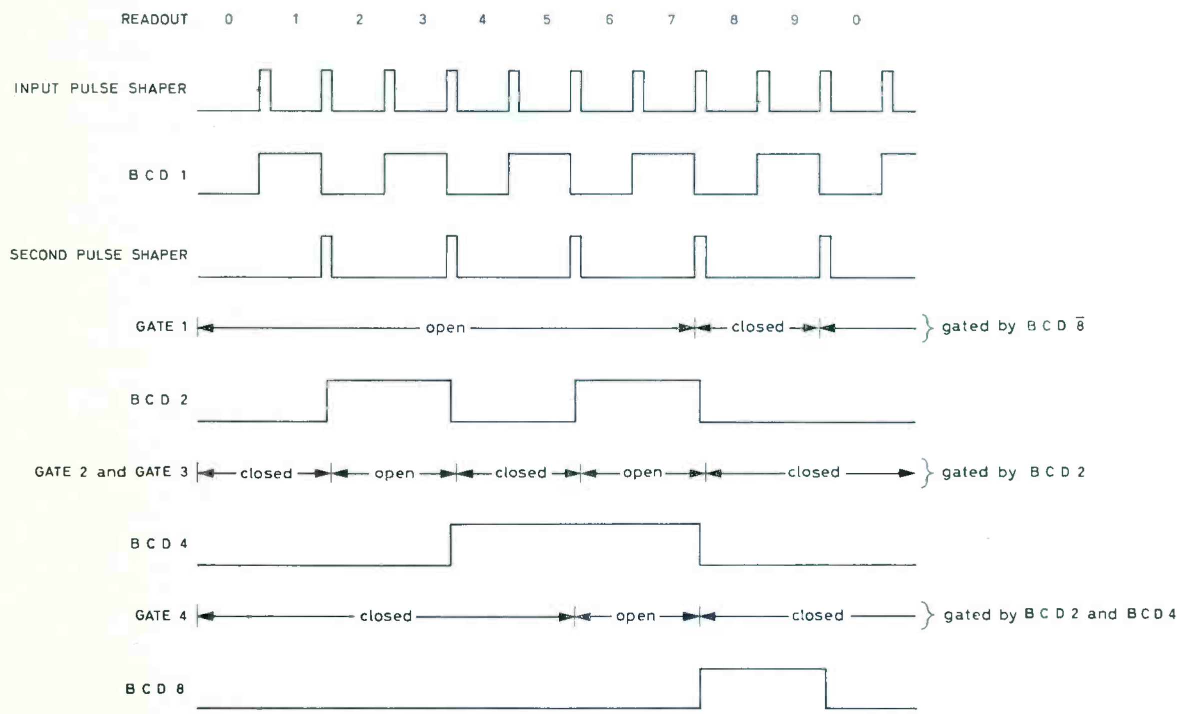


Fig. 5. Waveforms for high speed decade counting unit

The pulse shaper itself must be capable of resolving, from its rest state, the first fast pulse from the main counter gate without excessive overshoot so that the second pulse is not lost. A typical shaping stage is shown in Fig. 3. The collector chokes improve rise time due to a ringing action but collector overshoot is prevented by the clamping diodes.

At counting rates of 100 Mc/s, the gate times generated by the time base in Counter type TF 2401A must be accurate to better than ± 10 nsec. Divider chain propagation delay can in general be ignored since both the beginning and end of the gating waveform are shifted in time by the same amount. However, it has been found that over a divider chain of eight decades a time error, other than that due simply to propagation delay, of approximately 30 to 40 nsec can be obtained. The error is caused by the different conditions which exist in the time base just prior to the first output pulse and the second output pulse. In the former state, all dividers are held in heavy saturation under reset conditions while in the latter, the dividers are in normal saturation or free-running conditions. This error is eliminated by utilizing the output of the first binary of the first divider as the main counter gate drive, and gating out unwanted pulses with the outputs of successive dividers. Fig. 6 is a simplified diagram of the system. The divider output selected by switch SW1 triggers the bistable which opens gate G1. The first output pulse triggers back the bistable and hence closes gate G1 to prevent the flow of any further pulses. The system will then recycle.

A problem often met in counter design is the selection of one of two high speed signals. It is desirable to keep component quantity to a minimum and yet prevent break-through of the unwanted signal. The circuit of Fig. 7 shows a typical two-input gate which also provides some amplification. Selection of input 1 is achieved by reverse biasing diodes MR1 and MR2 with select signal S1 and forward biasing diodes MR3 and MR4 with select signal S2. Thus transistor VT2 may be reverse biased and input signal 2 leaks into the low impedance of diode MR4 in series with decoupling capacitor C2.

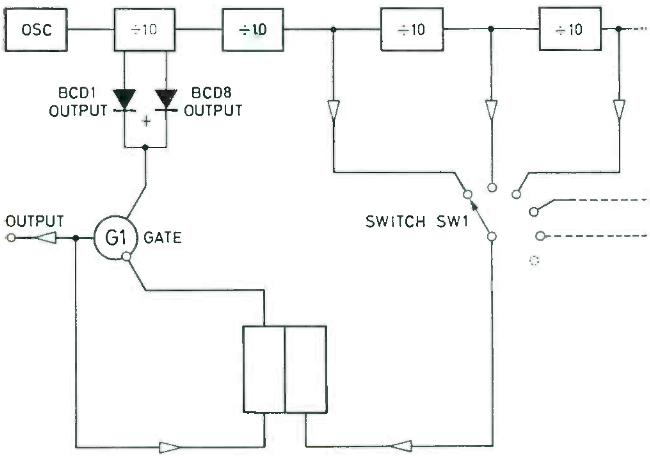


Fig. 6. Simplified synchronized time base system

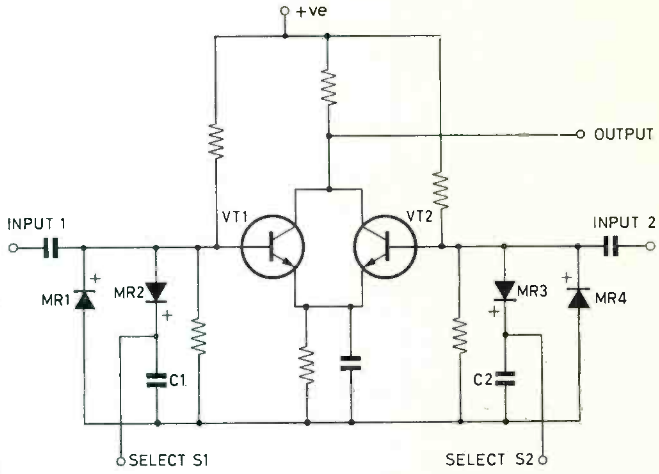


Fig. 7. High speed gate

References.
1. Hoile, G.C. and Ostler, R.I.: "Counter type TF 2401". *Marconi Instrumentation*, June, 1964, **9**, p. 132.

ABRIDGED SPECIFICATION

Range	10 c/s to 110 Mc/s.
Sensitivity	0·1 V r.m.s. sine wave.
Attenuator	Factors of 1, 3, 10, 30 and 100 nominal, switch selected.

Input impedance

Attenuator setting	*Approx. input resistance*	*Shunt capacitance*
×1	10 kΩ	20 pF approx.
×3	30 kΩ	< 10 pF
×10	100 kΩ	< 10 pF
×30	300 kΩ	< 10 pF
×100	1,000 kΩ	< 10 pF

Maximum input ×1 range: 3 V r.m.s. sine wave.
×100 range: 100 V r.m.s. sine wave.

Queen's Award to Industry

MARCONI INSTRUMENTS LIMITED *shared in the award to English Electric in the first list of the Queen's award to Industry announced on April 21st. The other joint recipients were the Aircraft Equipment Division, the Rectifier Division and The Marconi Company Limited.*

The Award signifies recognition by the Sovereign of striking achievement, in the case of Marconi Instruments its considerable export successes. In the last three years, the Company's proportion of export sales to total sales rose from 43% to 58%.

MARCONI INSTRUMENTS NEW DESIGN

U.H.F. Attenuator . . . . . . Type TF 2163

by

J. McHATTIE
B.Sc.

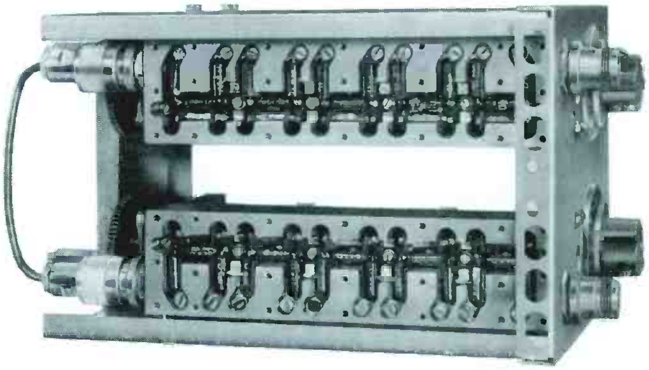
This step attenuator has a characteristic impedance of 50 Ω and a loss range of 142 dB in 1 dB steps. It operates over the frequency range of d.c. to 1 Gc/s. The attenuator consists of two castings, in a module case, which have been carefully dimensioned to maintain the characteristic impedance. This has resulted in a v.s.w.r. better than 1·1:1 up to 100 Mc/s, 1·25 up to 500 Mc/s and 1·5 up to 1 Gc/s. The insertion loss increases linearly with frequency and is approximately 0·35 dB per 100 Mc/s.

WIDE FREQUENCY RANGE, low insertion loss and good v.s.w.r. are the main performance features of this attenuator. Its design is based on the use of switched resistive pads rather than piston attenuators which, although popular above 10 Mc/s, were unsuitable because of their low frequency limit and large insertion loss; this loss is particularly undesirable when considering transistorized equipment with little surplus power at high frequencies. The ladder attenuator was also considered unsuitable because of its impedance change at low loss. A step attenuator switching resistive pads was therefore chosen, this configuration overcoming the above disadvantages. By the choice of pads of certain values a total loss of 142 dB was obtained using only ten π pads in series.

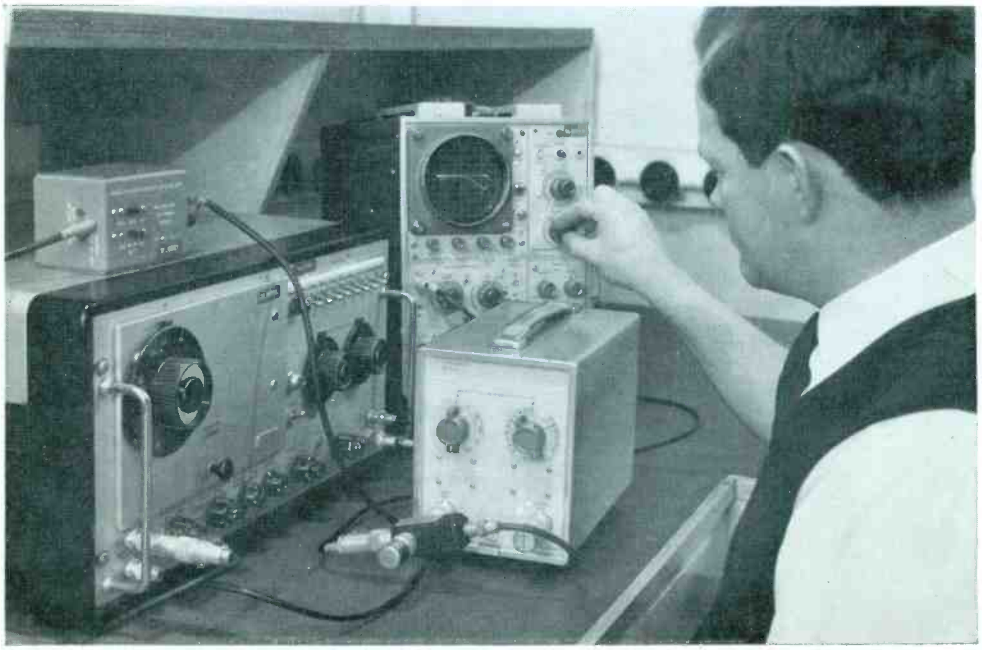
Performance

The attenuator is housed in a standard modular case and is therefore suitable for inclusion in a rack mounting case if required.

Internally two pressure die castings contain the attenuation pads and operating mechanisms which are brought out to the front panel as two rotary switches. One switch enables 120 dB to be obtained in steps of 20 dB and the second switch 22 dB in steps of 1 dB. Each rotary switch is fitted with five cams, each cam controlling the insertion or removal of one attenuation pad. The cam acts through a hinge and two plungers to operate two micro-switches, one at each end of the π pad. A rear link of solid-outer coaxial cable, which has low leakage and good v.s.w.r., joins the rear sockets of the two castings.



With covers removed, this bottom view of the TF 2163 reveals the compartments of the coarse and fine attenuator sections. This precisely engineered construction is responsible for the accuracy of attenuation and the good v.s.w.r. throughout the frequency range.



The author checks the v.s.w.r./frequency characteristic of the TF 2163 Attenuator by using a sweep generator and comparison detector

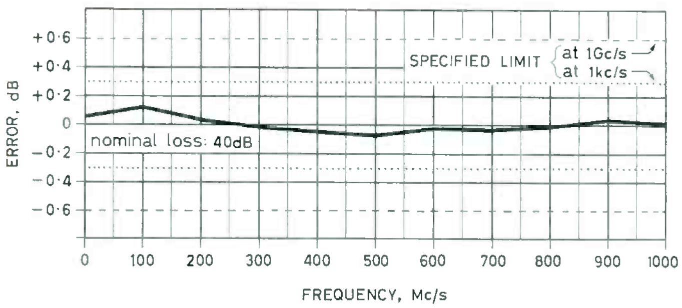


Fig. 1 Typical attenuation performance at 40 dB compared with specification limit

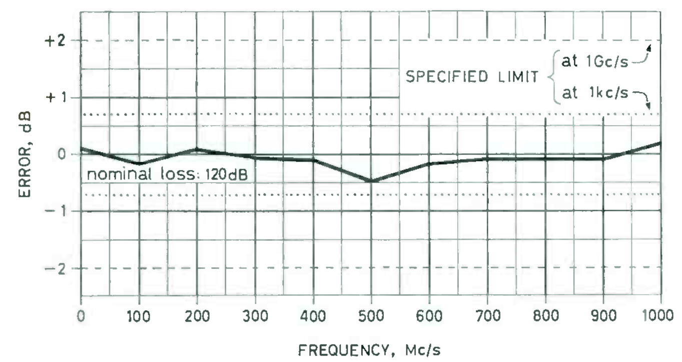


Fig. 2. Typical attenuation performance at 120 dB. The wider claim above 100 dB insertion allows for the progressively worsening discrimination and accuracy of the available test gear rather than any deterioration in the performance of the attenuator itself

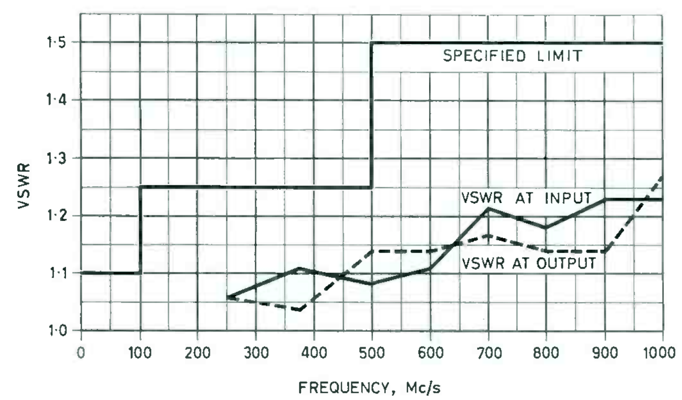


Fig. 3. Worst v.s.w.r. performance of a typical attenuator for any combination of the fine and coarse attenuators

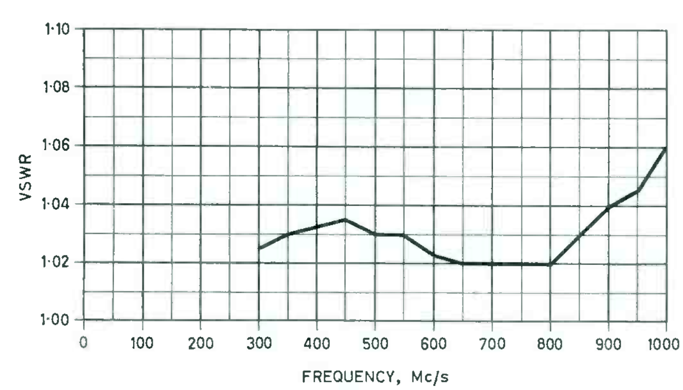


Fig. 4. V.S.W.R. at input of a typical attenuator with 20 dB in the coarse attenuator.

U.H.F. Attenuator type TF 2163

To avoid possible overdrive conditions on equipment driven by the attenuator, the cam profiles have been designed so that, on switching from one position to an adjacent position, any wanted pad is always inserted before the removal of any unwanted pad. As an illustration, 60 dB is made up of three 20 dB pads, but 80 dB is made up of one 20 dB and two 30 dB pads. To switch from 60 to 80 dB the two 30 dB pads are inserted before the two 20 dB pads are removed; thus between 60 and 80 dB the attenuation temporarily reaches 120 dB.

Inside the castings the π pads, shorting links and micro-switches have all been carefully positioned to maintain the characteristic impedance of the attenuator. To adjust the impedance of any particular portion of the attenuator, trimmer 'flags' are provided which are positioned by the calibration engineer during test. The high frequency attenuation of each pad is also adjustable independently of the impedance by one of two means. In the coarse attenuator this is done by spring loaded screws accessible from the side of the casting which control the attenuation by moving a flag towards the centre of the series resistor of the π pad; in the fine attenuator adjustment is made by means of a conductive coating on certain resistors which modifies the capacitance across the resistor and hence the high frequency attenuation.

In the coarse attenuator there are two pads of 30 dB and three of 20dB, and in the fine attenuator the pad values are 1, 2, 3, 6 and 10 dB. The switching sequence on the coarse attenuator has been so arranged that the first 20 dB pad, which is situated directly behind the input socket is always in circuit whenever 20 dB or more is inserted. This pad isolates small unwanted variations in impedance occurring on different positions in the attenuator from the source driving the attenuator, hence avoiding attenuator reaction effects such as frequency shift in an oscillator. The impedance of the attenuator viewed from the output socket is more variable as not only are different pads in circuit on different positions, but each pad in the fine attenuator being of lower value is not as good an isolator as the 20 dB pad in the coarse attenuator. As the attenuator is reversible the user may operate it in reverse of the front panel legend if a constant output impedance is the more important.

Type N sockets are used in preference to type BNC because it was found that the bayonet connection of the BNC type tended on occasion at high frequencies to radiate, giving attenuation errors at large values of attenuation.

The insertion loss of the attenuator may be interpreted in two ways. Firstly it is extra attenuation in circuit above that indicated by the setting of the attenuator and this extra attenuation varies with frequency. Secondly a measurement of the rise time of a pulse which has passed through the attenuator may in fact be used to determine the frequency response and hence the insertion loss. If a pulse of zero rise time were put through this attenuator the rise time of the resultant pulse would be approximately 0·4 nsec.

All components used have been chosen to afford good performance allied with long term reliability. The resistors are close tolerance for accuracy, metal film for stability and axially cut for good high frequency performance. For reasons of long term reliability the micro-switches are fitted with gold contacts.

Precautions

There are certain precautions which should be observed in order to obtain the ultimate performance from the attenuator.

All connections on the system should be tight and care should be taken when using adapters as these may degrade the v.s.w.r.

The maximum input power which may be applied to the attenuator is 0·5 W average. Should this rating be exceeded permanent damage may result due to overheating.

It is most important at high frequencies and large attenuations that all high level signals should be adequately screened. Ordinary double screened cable may not be sufficient under the most severe requirements and for this purpose an optional accessory lead is available which is a coaxial cable 18 inches long fitted with type N plugs, the outer of the cable being a solid aluminium sheath.

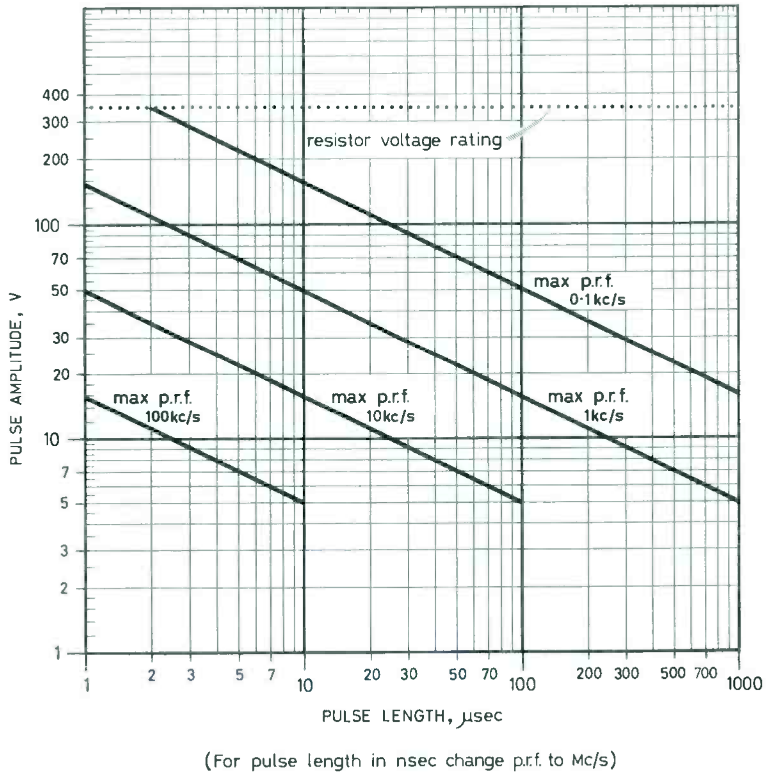


Fig. 5. Pulse parameters shown relative to an average power of 0·5 W. This abac relates pulse amplitude, pulse length and maximum p.r.f. If any two parameters are known, the maximum allowable third parameter can be read off. At a pulse amplitude of 5 V it will be seen that the maximum p.r.f. and pulse length quoted indicate continuous operation

ABRIDGED SPECIFICATION

Frequency range

D.C. to 1 Gc/s.

Attenuation

142 dB in six 20 dB steps and twenty-two 1 dB steps.

ACCURACY AT 1 kc/s: ± 0·5% of attenuation setting ± 0·1 dB up to 120 dB; typically within ± 1 dB at 130 dB.

ACCURACY AT 1 Gc/s: ± 1% of attenuation setting ± 0·2 dB up to 100 dB; ± 1½% of attenuation setting ± 0·2 dB between 101 and 130 dB.

Insertion loss

Approximately 0·35 dB per 100 Mc/s.

Impedance

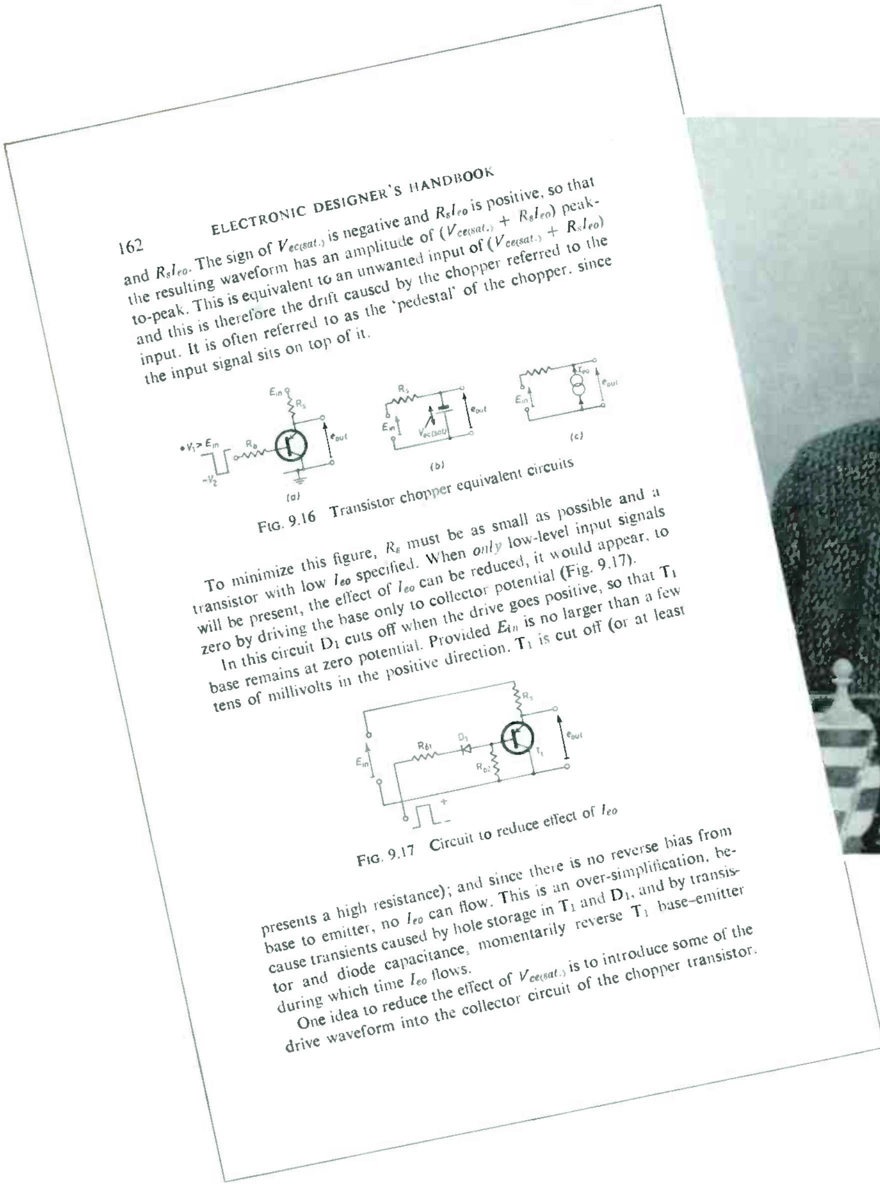
50 Ω for both input and output (type N connectors).

V.S.W.R.

Less than 1·1:1 below 100 Mc/s,
1·25:1 between 100 Mc/s and 500 Mc/s,
1·5:1 between 500 Mc/s and 1 Gc/s.

Maximum input

0·5 W.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and R_sI_{eo}. The sign of $V_{ec(sat.)}$ is negative and R_sI_{eo} is positive, so that the resulting waveform has an amplitude of $(V_{ce(sat.)} + R_sI_{eo})$ peak-to-peak. This is equivalent to an unwanted input of $(V_{ce(sat.)} + R_sI_{eo})$ and this is therefore the drift caused by the chopper referred to the input. It is often referred to as the 'pedestal' of the chopper, since the input signal sits on top of it.

FIG. 9.16 Transistor chopper equivalent circuits

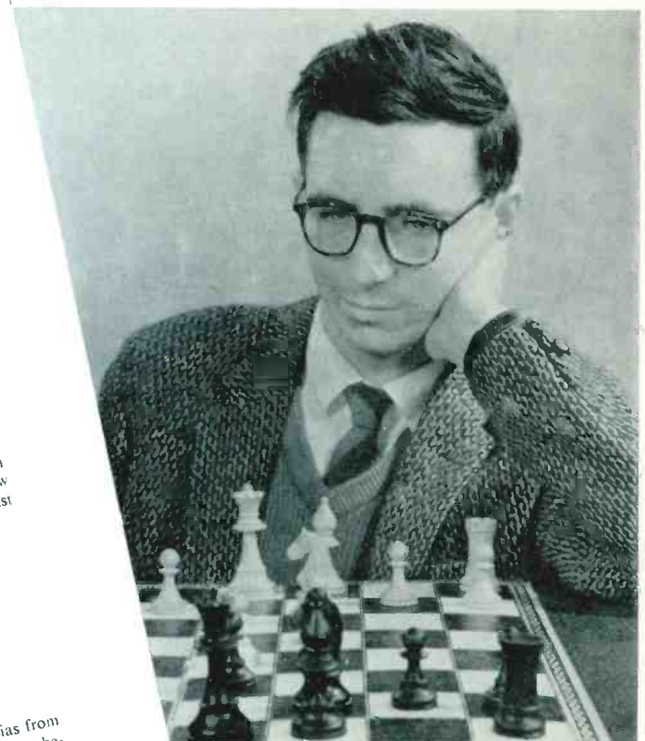
To minimize this figure, R_s must be as small as possible and a transistor with low I_{eo} specified. When *only* low-level input signals will be present, the effect of I_{eo} can be reduced, it would appear, to zero by driving the base only to collector potential (Fig. 9.17).

In this circuit D_1 cuts off when the drive goes positive, so that T_1 base remains at zero potential. Provided E_{in} is no larger than a few tens of millivolts in the positive direction, T_1 is cut off (or at least

FIG. 9.17 Circuit to reduce effect of I_{eo}

presents a high resistance); and since there is no reverse bias from base to emitter, no I_{eo} can flow. This is an over-simplification, because transients caused by hole storage in T_1 and D_1, and by transistor and diode capacitance, momentarily reverse T_1 base-emitter during which time I_{eo} flows.

One idea to reduce the effect of $V_{ce(sat.)}$ is to introduce some of the drive waveform into the collector circuit of the chopper transistor.



As the sample page shows, the technical content of this book has been selected to have the widest appeal to both advanced students and practising electronic engineers.
Author Keith Hemingway, B.Sc. (Hons), Chief of Advanced Circuit Development, Marconi Instruments Limited, also finds time to excel at chess. He is a former chess champion of Hertfordshire

Electronic designer's handbook

THIS BOOK aims to provide the newly qualified electronic engineer or physicist with a working knowledge of transistor circuit design.

The first section describes the properties of the transistor used as a switch and as a small-signal amplifier, followed by examples of the design of useful standard circuits. Since practical designs must function in the presence of ambient temperature and supply voltage variations, these effects are considered in detail for each circuit described.

The next section is concerned with the design of a number of circuits having unusual properties, in order to illustrate the synthesis of novel designs. These chapters will interest both the student and the experienced designer since many of the designs, though little-known, have wide application.

Finally, some useful practical techniques are discussed, which enable the engineer to solve certain problems rarely dealt with in standard text books.

Although the text is largely non-mathematical, derivations of formulae, where necessary for clarification, are given in the Appendixes.

ELECTRONIC DESIGNER'S HANDBOOK

A practical guide to transistor circuit design.

T. K. Hemingway, Business Publications Ltd., 1966, **63s.**

Copies are available at 64/3d, post free, from the Book Sales Manager, Business Book Centre Ltd., Mercury House, Waterloo Road, London, S.E.1, or through your local bookseller.

SOMMARIO DEGLI ARTICOLI PUBBLICATI IN QUESTO NUMERO

OSCILLOGRAFO TIPO TF 2201

Questo è un oscillografo transistorizzato da 30 MHz, d'impiego generale, con unità ad innesto X e Y ed una sensibilità base sullo asse Y di 50 mV/cm. Consente misure su un'immagine di 6 × 10 cm sia mediante il reticolo centimetrato che con il sistema a spostamento. Tutti gli ingressi e le uscite sul frontale dispongono di protezioni per evitare di danneggiare i semiconduttori; le alimentazioni interne sono protette dai cortocircuiti con il telaio. La suddivisione in sub-unità facilita le operazioni sistematiche di manutenzione.

Página 55

GENERATORI DI SEGNALI—IMPEDENZA DI SORGENTE O IMPEDENZA D'USCITA?

Vengono descritti dei metodi di misura che mostrano come si possa fare maggior affidamento sulla precisione d'impedenza dei generatori di segnali, ai livelli d'uscita più alti, più di quanto generalmente si ritiene.

Página 66

TECNICHE DI CONTEGGIO IN VHF CON L'UNITA' DI GAMMA TIPO TM 8267

L'Unità di gamma tipo TM 8267 è una unità ad innesto per il Contatore tipo TF 2401A. Usata con una unità di funzione adatta, consente una velocità massima di conteggio che supera i 110 MHz ed una discriminazione di 10 nsec. nelle misure di tempo. Vengono descritti alcuni dei problemi di conteggio a tali velocità, nonchè i circuiti utilizzati in questa unità ad innesto.

Página 69

ATTENUATORE UHF, TIPO TF 2163

Questo attenuatore a scatti ha un'impedenza caratteristica di 50 Ω ed un campo d'attenuazione di 142 dB in scatti da 1 dB. Funziona su una banda di frequenza che si estende da c.c. a 1 GHz. L'attenuatore è alloggiato in una custodia modulare ed è costituito da due fusioni accuratamente dimensionate per mantenere l'impedenza caratteristica. Ciò consente di ottenere un R.O.S. migliore di 1,1:1 fino a 100 MHz, di 1,25 fino a 500 MHz e di 1,5 fino a 1 GHz. La perdita d'inserzione aumenta linearmente con la frequenza ed è di circa 0,35 dB per 100 MHz.

Página 73

RESUMENES DE ARTICULOS QUE APARECEN EN ESTE NUMERO

OSCILOSCOPIO TIPO TF 2201

Se trata de un osciloscopio a 30 MHz, transistorizado, para medidas de caracter general, al que se pueden conectar unidades de amplificación en "X" y en "Y", esta última con una sensibilidad básica de 50 mV/cm. La gratícula graduada en centímetros, y el dispositivo de "slide-back" tienen una presentación de 6 × 10 cm. Todas las entradas y salidas situadas en el panel frontal, van protegidas para no producir averías en los semiconductores; las líneas de alimentación interna también van protegidas para no producir cortocircuitos en el chasis. La construcción en subunidades facilita su servicio y mantenimiento.

Página 55

GENERADORES DE SEÑAL—¿IMPEDANCIA DE LA FUENTE O IMPEDANCIA DE SALIDA?

Se describen métodos de medida, por los que se comprueba que se debe confiar más de lo que se hace corrientemente, para niveles de salida elevados, en la precisión de la impedancia de los generadores de señal.

Página 66

TECNICAS CONTADORAS EN V.H.F. CON UNIDAD DE MARGEN TIPO TM 8267

Se trata de una unidad enchufable para el contador tipo TF 2401A. Cuando se emplea junto con una unidad de función, permite un ritmo máximo de cuenta superior a 110 MHz, y una resolución en medida de tiempos de 10 nseg. Se detallan algunos de los problemas que surgen a estas velocidades, así como los circuitos empleados en esta unidad enchufable.

Página 69

ATENUADOR EN UHF, TIPO TF 2163

Este atenuador por saltos, tiene una impedancia característica de 50 Ω, un margen de atenuación de 142 dB, en saltos de 1 dB, y un margen de frecuencia de c.c. a 1 GHz. Consta de dos piezas de fundición, en caja modular, de dimensiones apropiadas para mantener la impedancia característica, lo que da como resultado una v.s.w.r. superior a 1,1:1 hasta 100 MHz, a 1,25 hasta 500 MHz, y a 1,5 hasta 1 GHz. Las pérdidas de inserción aumentan linealmente con la frecuencia, y son de 0,35 dB por cada 100 MHz, aproximadamente.

Página 73

SIGNAL GENERATORS

SWEEP GENERATORS

FREQUENCY COUNTERS AND METERS

OSCILLOSCOPES

NOISE GENERATORS

OSCILLATORS

PULSE GENERATORS

MODULATION METERS

DISTORTION ANALYSERS

SPECTRUM ANALYSERS

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