

MARCONI INSTRUMENTATION

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EDITORS

P. M. RATCLIFFE, A.M.I.E.E.

and

J. R. HAYWARD, A.M.I.E.R.E.

Time and Frequency

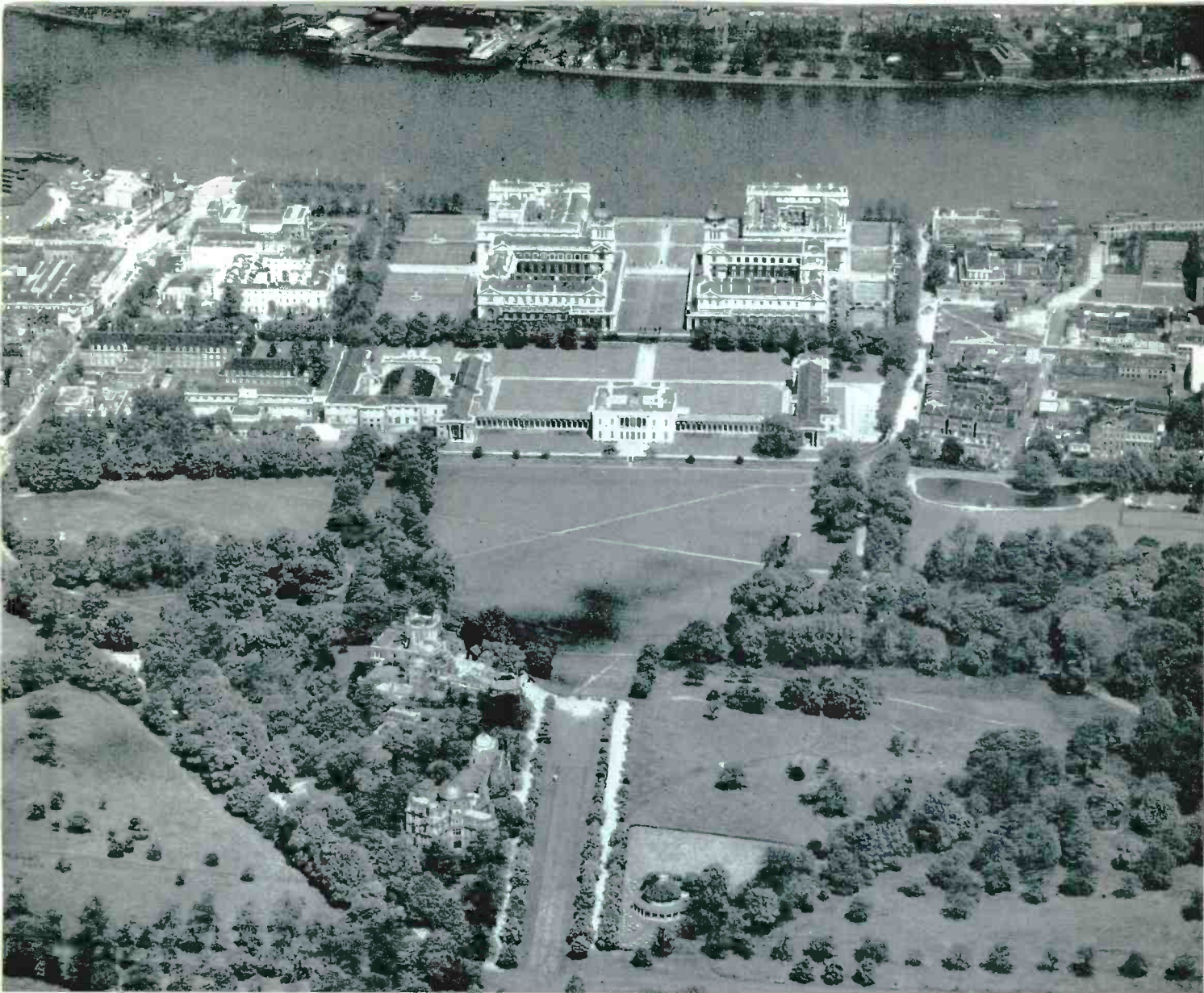
BEING MANUFACTURERS of measuring instruments we are of necessity concerned with 'standards', whether they be components such as resistors and capacitors or quantities such as e.m.f. and frequency. In the limit the ultimate accuracy of our products must be related back to appropriate standards. It is desirable that these standards should be at least one order better than the accuracy claim of the product, so that in the final summation of possible errors their effect is almost negligible. Where this is not possible the instrument performance specification must be downgraded, even though it is capable of precise and repeatable measurements, to include the uncertainty of the standard. This state of affairs occurs more often at the high frequency end of the spectrum except possibly in respect of frequency itself.

Since the introduction of the temperature controlled quartz-crystal oscillator, utilizing the piezo-electric effect, frequency has led the field as the electrical parameter that can be measured with the greatest accuracy. It gained a further lead in the middle of the last decade when a precise caesium beam atomic resonator was constructed. As a primary standard, frequency has the unique advantage over all others that it does not have to be incarcerated in a laboratory, but is universally available for reference purposes by the propagation of standard transmissions. Fundamentally the frequency of a generator is the number of cycles produced in a specified period of time—namely the second. Thus frequency is the inverse of time, and the second must be accurately defined if the exact frequency is to be determined. Prior to the electronics era time measurement was the sole prerogative of the ancient science of astronomy, and as measurement techniques improved and existing standards were found lacking in precision these were discarded for more reliable sources. Fortunately modern changes in time scales do not provoke the unruly scenes of September 1752 when, owing to a surfeit of leap years, a jump of 11 days was required in England to change from the Julian to the more seasonable Gregorian calendar.

Currently there are several time scales in use namely—sidereal, solar, universal (U.T.), ephemeris (E.T.) and, with the introduction of the caesium-beam resonator, atomic time (A.T.). Universal time and the mean of solar time are identical, both being determined by the rotation of the earth on its axis. Due to the non-uniformity of this rotation universal time is adjusted to give U.T. 1, which corrects for polar motion, and U.T. 1 is further modified to give U.T. 2 which corrects for seasonal variations. Even with these two corrections there are still irregularities of an unpredictable nature making the earth's rotation unsuitable as a basis for a modern standard. Thus the current standard of time, adopted in 1956 by the International Committee of Weights and Measures, is the ephemeris second. It is derived from the period of time taken for the earth to make one complete revolution around the sun, although in practice it is determined by observations of the moon's rotation around the earth. Unfortunately to achieve the necessary precision, measurements are required over a protracted period.

Atomic time, which is more readily available, is based on the caesium atomic transition which has a frequency of resonance of $9,192,631,770 \pm 20$ c/s of ephemeris time. Although it is not at present formally accepted as a standard, it has been

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Where time begins—in the foreground the old Royal Observatory Greenwich (1675-1948) containing Airy's transit circle which defines the prime meridian of longitude. Behind the observatory is the National Maritime Museum and, situated on the river bank, the Royal Naval College.

recommended that the 1966 Conference on Weights and Measures consider adopting a unit of time based on an atomic transition. This need not be the caesium beam as research is in progress on other possible standards, such as a thallium beam and a hydrogen maser which may offer even greater precision.

Throughout the world most standard frequency transmissions are now related to atomic time (A.T.) as being the most stable source available. However the actual frequency transmitted is decreased by an internationally agreed amount to give a value based on U.T. 2 as this is the time scale which governs our daily lives. Naturally as A.T. and U.T. 2 are not identical the offset in frequency varies, but is usually kept constant in any one year. The actual value is available in several technical publications such as the 'Radio and Electronic Engineer' and since the beginning of this year has been -150 parts in 10^{10} .

For greatest accuracy of reception low frequency transmissions are preferable to h.f. as the propagation is by ground wave thereby avoiding small frequency shifts due to changes in the ionosphere. In Great Britain this service is provided by the Rugby transmitters working at frequencies of 16 kc/s (G.B.R.) and 60 kc/s (M.S.F.). Such transmissions are immediately available to all standards laboratories so that the local working standard—which is normally still the temperature controlled quartz crystal oscillator—can be readily maintained. By this means, and using the accepted methods of multiplication and division, any standard frequency can be provided. These frequencies can then be distributed by coaxial cables to any number of locations, thereby providing standards where they are most needed which are directly traceable back to the primary standards of either atomic or universal time.

With this progress in the standardization field there have also been similar advances in the ease with which frequency can be measured under normal working conditions. This has been brought about by the electronic counter equipped with a suitable gate and timing generator. Such devices have been commercially available for many years but, due to the complexity of the circuits, it was not until transistors became readily available that their full potential in portability and reliability could be realised. Marconi Instruments introduced their first solid state electronic frequency meter in this journal in December 1961 giving direct counting up to 10 Mc/s with a valve extension unit to increase the range to 220 Mc/s. Since then several articles have appeared detailing various applications and special versions, and December 1963 saw the introduction of a solid state frequency converter to extend the range to 510 Mc/s.

Visitors to the I.E.A. Exhibition at Olympia last month no doubt saw our latest counter, details of which are given on p. 132 of this issue. This is the Counter type TF 2401 which, with the Range Unit type TM 7557 and Counter Timer Function Unit type TM 7558 is capable of direct measurement to over 50 Mc/s. It can also drive a remote readout or, where a permanent record of results is required, a printer. As an optional facility it may be adapted to accept control from a remote source. To avoid any confusion in readout a clear indication of decimal point position, multiplying factor, and units is given in the display. As the photograph on pages 142 and 143 shows, this new counter is no larger than the present 10 Mc/s version, and should not be confused with the king size display which was used at the exhibition for demonstration purposes.

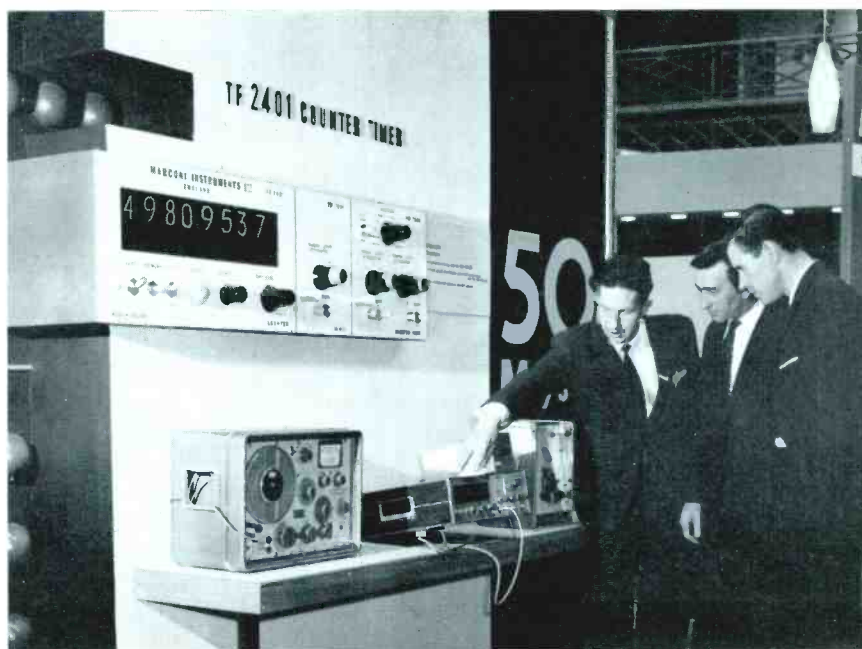
As a counter is only as accurate as its timing waveform a more stable crystal oscillator is provided. In the

eventuality of greater stability being required facilities are available to use an external 1 Mc/s standard frequency source. This can be derived from a working standard quartz oscillator which in turn can be traced back to a standard frequency transmission to give maximum accuracy.

With the increase in popularity of counting devices for electronic instrumentation, owing to the unambiguous form of display, a new terminology is being introduced which has been borrowed from the computer field. To illustrate how some of these terms apply to counter design an introduction to counter logic seemed appropriate for inclusion with the description of this new counter.

Perhaps the poor relation in the standards community is the inductor. No recent improvements seem to be recorded in the state of the art, although present working standards appear to be adequate for most purposes. For us this means the checking and calibration of audio frequency bridges, such as the TF 2700 Universal Bridge or the TF 1313 $\frac{1}{4}\%$ Bridge. At higher frequencies one of the primary functions of the Circuit Magnification Meter is inductance measurement which is calculable from a knowledge of the frequency and tuning capacitance. This method is included in the application report on methods of making measurements on ferrite cores. The author has shown how measurements which are normally considered to be of a complex nature can be performed using a few instruments which are generally readily available in a modern laboratory. It is felt that this article treats, in a down-to-earth manner, what to many electronic engineers is a rather mysterious subject and shows that problems in magnetic materials can be handled with standard electronic techniques.

P.M.R.



A section of our stand at last month's I.E.A. Exhibition showing the king size demonstration counter mounted on the wall. This is giving a remote readout from the genuine counter beneath which is being demonstrated by Mr. Peter Steers—Southern Area Representative.

Counter

TYPE TF 2401



by

G. C. HOILE,
Graduate I.E.E.
andR. I. OSTLER,
B.Sc., D.L.C.,
Graduate I.E.E.

Counter TF 2401 is a completely new design with the novel feature that all input channels are in the form of plug-in units. By this means a wide range of facilities can be achieved using a common basic instrument. The counter, which has an eight decade in-line readout, employs solid state circuitry throughout and makes extensive use of both diode and transistor logic. The Range Unit TM 7557 and Counter-Timer Function Unit TM 7558 allow a maximum count rate in excess of 50 Mc/s and time measurements as short as 0.1 μ sec. Great care has been taken to present an instrument of small size and pleasing appearance, with simplicity of front panel controls.

EASE OF OPERATION, high reliability and inherent high accuracy of digital frequency and time measuring equipment has led to the use of counters in a wide variety of applications. The complexity of such equipment depends upon the type of measurement to be made, and may vary from a simple low frequency instrument, perhaps operated from a transducer, to a high speed multi-purpose instrument for laboratory use. All counters however have certain basic and common features and any differences are mainly in the number and type of input channels and the maximum operating speed. It was with these facts in mind that Counter type TF 2401 was designed. The input channels are so arranged as plug-in units that only new units will be required to keep abreast of latest techniques.

Two types of unit are used, one being a Range unit which determines the maximum operating frequency

and carries the 'A' input channel, the other being the Function unit which determines the number and type of measurements which may be made. The TM 7557 Range Unit operates to a maximum frequency of 50 Mc/s for frequency measurement. Function Unit TM 7558 provides universal counter-timer facilities with input channels 'B' and 'C' and operates with input frequencies up to 10 Mc/s.

Considerable attention has been paid to the mechanical design and overall appearance of the counter and, although about 1,000 semiconductors are employed, an instrument height of only 5¼ inches has been achieved. A pleasing appearance is presented by the use of anodized front panels and cast aluminium side panels with vinyl clad inlays. The plug-in units are easily removable from the front panel of the instrument. Although component density is necessarily very high,

extensive use of printed circuit boards provides good accessibility to circuits. The instrument employs semi-conductors throughout and has no moving parts, the gas filled numeral tubes being transistor driven.

Facilities of Counter TF 2401

This counter has an improved crystal oven to achieve better stability and, since an oven requires a long time to reach its ultimate stability after being switched on, a stand-by facility has been incorporated. This enables the oven power supply to be run without energizing the rest of the counter.

A new feature is that of 'memory'. Normally whilst the signal gate is open the display of a counter follows the counting decades and only during the display period is the reading steady. Thus when using the counter the display time control must be adjusted to allow a display time long enough for the reading to be assimilated, thereby limiting the sampling rate. In the TF 2401 Counter, the previous reading is memorized and displayed whilst counting proceeds, the display changing instantaneously to the new reading when the measurement is complete, so removing the necessity for a long interval between successive counts. A further advantage is that in applications such as drift measurement where only the last few figures of the eight digit display are changing from one measurement to the next, then most of the display will remain steady and the extent of variations can be easily assessed. A front panel switch enables the memory to be switched ON or OFF so that if desired the display can be made to follow the decades as counting proceeds.

The Function Unit TM 7558 enables the following measurements to be made, where A, B and C are the input channels.

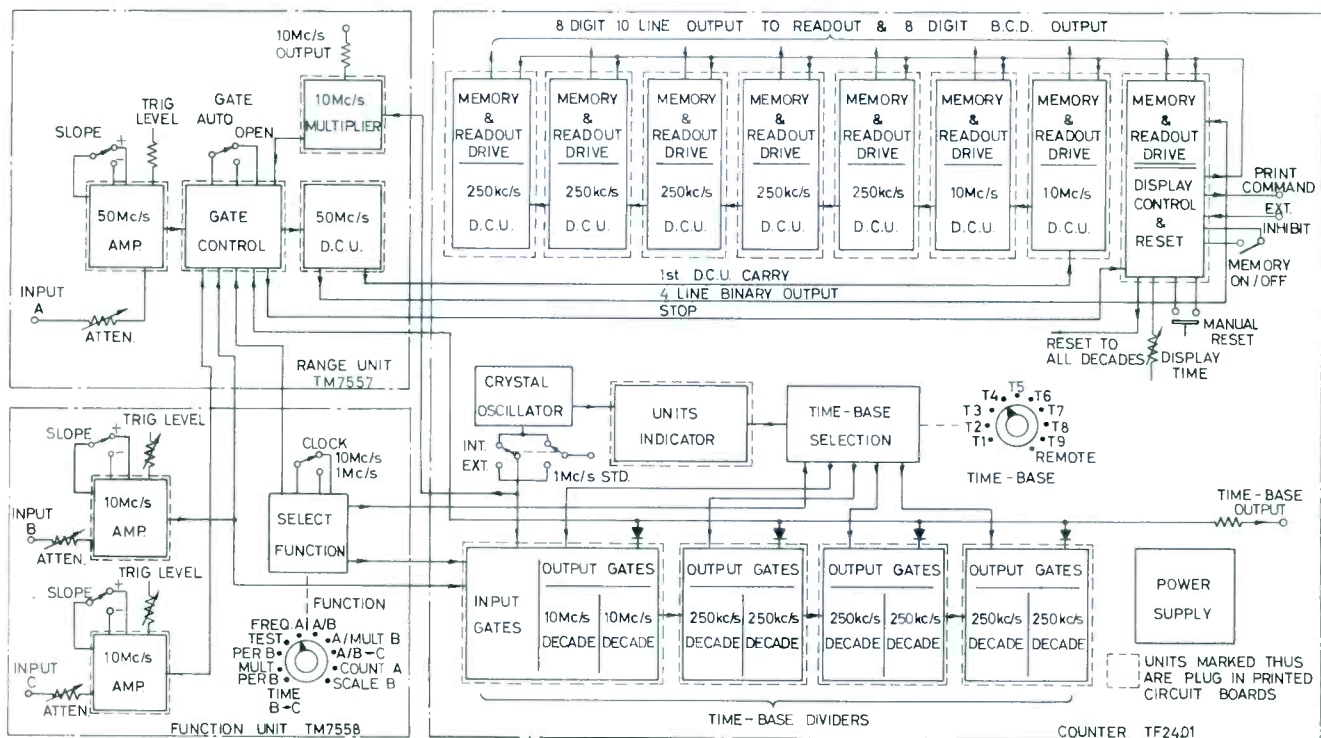
1. Time interval measurement (TIME B→C).
2. Period measurement (PER B).
3. Multiple period measurement (MULT PER B).
A 'clock' switch on the front panel allows selection of 1 Mc/s or 10 Mc/s timing signals.
4. Frequency measurement (FREQ A).
5. Frequency ratio of two applied signals (A/B).
6. Multiple frequency ratio measurement (A/MULT B).
7. Externally applied events during externally applied time interval (A/B→C).
8. Straight or totalizing counting (COUNT A).
9. Scaling down of an applied signal (SCALE B).

For a scaling measurement the signal applied to input B is scaled down through the time-base dividers and then fed to the counting decades, thereby giving a maximum range of 10^{16} events.

In addition to the functions listed above there is a TEST position on the function switch which allows a 10 Mc/s signal derived from the 1 Mc/s standard to be counted for gate times selected by the time-base switch.

A feature of the new counter is the method by which the units of each measurement are displayed. The time base switch which controls gate times, timing units and multiplying factors is also used to switch d.c. signals to lamps in the display window. These lamps illuminate the decimal point, frequency unit (e.g. 'c/s') time unit (e.g. 'μS') and multiplying factor (e.g. '10⁷'), thus presenting the information in a readily acceptable form.

Fig. 2. Basic block diagram of Counter TF 2401 with Range Unit TM 7557 and Function Unit TM 7558. In the photograph opposite these plug-in units are shown in position.



This arrangement greatly simplifies the front panel markings generally associated with the time-base switch.

Sampling is normally automatic but manual operation can be utilized by setting the display time to infinity and operating the reset button. A continuously variable display time from 0.1 sec to 10 sec, which is independent of gate time, is available for automatic sampling. The gate switch provides choice of AUTO or OPEN positions; when in the OPEN position the switch opens the gate and switches off the memory so that the display registers each count for a totalizing measurement.

As with Counter/Frequency Meter type TF 1417¹ each input channel has an input attenuator with trigger level control and can be switched to trigger from either positive or negative going edges of the input signal. The input range is increased, however, being 100 mV to 500 V.

Block Diagram

A simplified block diagram is shown in Fig. 2. In common with TF 1417 all signal switching, with the exception of the input attenuators, is done by AND and OR gating. This enables elaborate switching to be per-

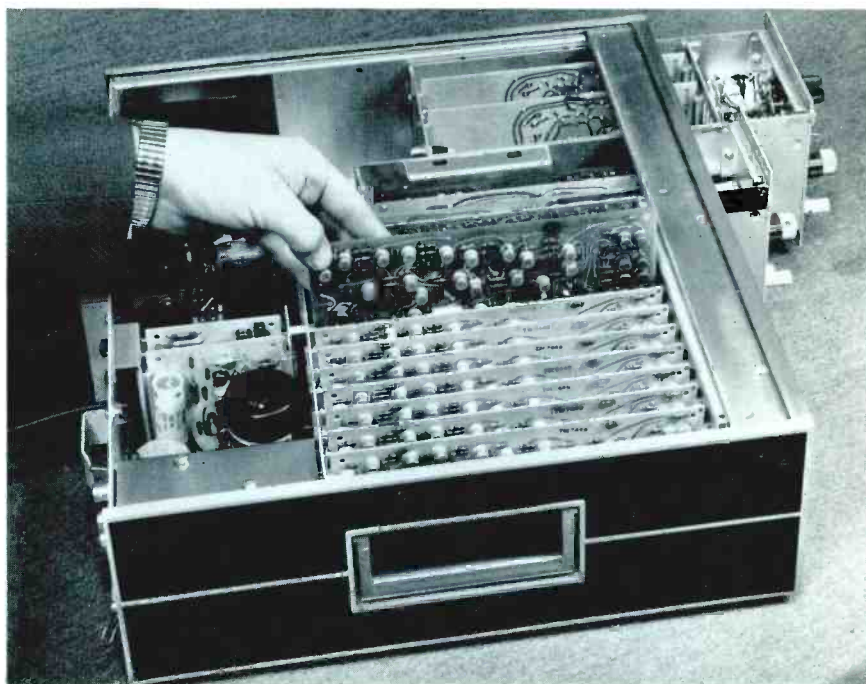
frequency unit. This high speed decade is mounted in the Range unit TM 7557 but has its memory and read-out on the basic chassis.

Time base dividers are arranged in pairs on plug-in printed circuit boards together with the appropriate output AND/OR selection gates for timing units, gate times and multiplying factors. When in the multiple period mode of operation the maximum input frequency to the first time base divider is 10 Mc/s, and in consequence the first double divider board is made capable of operation to this speed. The remaining three boards are capable of operation to at least 250 kc/s.

The decade counters utilize similar circuitry to that of the time base dividers and each decade is arranged on a printed circuit board with its memory, binary to decimal code conversion and numeral display tube drive circuit. Two 10 Mc/s decades and five 250 kc/s decades are employed.

The Range unit contains the 'A' input amplifier, gate control circuitry and high speed decade. The Function unit comprises the 'B' and 'C' input amplifiers and the function switch which controls the d.c. signals fed to the gating in the Range unit and basic instrument.

*Fig. 3
Top view of Counter
showing the two
plug-in units and
the display and reset board
partially withdrawn*



formed without long leads to and from the front panel switches, which would cause deterioration of rise times and pick-up between wires. This system also simplifies the interface connections between the basic instrument and plug-in units.

The diagram shows the breakdown of counter circuitry into the basic instrument and Range and Function units.

On the main chassis are the power supply, crystal oven, time base dividers, display control and reset circuitry and all decade counters, with associated memory and readout, with the exception of the highest

General Layout

Fig. 3 shows the instrument with top cover removed. Running along the whole length of the rear of the counter is the power supply unit. The cooling fan is mounted centrally and is in a box shaped bracket which also serves as a heat sink for the series regulator transistors. The two small printed circuit boards comprise the stabilizing amplifiers. The crystal oven can be seen to the left of these.

To the front and left of the counter are the counting decades which are mounted close to the numerical display to keep the large number of wires to the display

short and tidy. To the right of these seven decades are the display and reset board, which also accommodates the memory and readout drive for the high speed decade, and the four time base dividers. The units indicator is attached to the front panel which can be quickly unscrewed and swung clear to facilitate servicing. To the far right of the counter is the plug-in housing which holds the Range and Function units.

A rigid construction has been achieved by the use of cast side panels and extruded aluminium section. Screw heads in these side panels are covered by the vinyl clad inlays, giving a very clean appearance. The instrument may be rack mounted by attaching brackets to the cast side panels.

In an article of this nature it is impossible to describe the details of all circuits and only those aspects of the design which are new will be mentioned.

Fast Switching Circuits

At counting rates of 50 Mc/s it is necessary to keep switching delays extremely short. The transistor however has certain inherent rise and fall times and produces a storage delay time which is a function of transistor saturation. In low speed switching circuits, where transistor delay time is not critical, it is normal to operate in the saturated mode because of the ease of operation and reliability.

Non-saturated switching, whilst being faster for a given transistor, is in general more complex and difficult to use in conjunction with other circuits. In the new counter several techniques have been used to achieve fast switching whilst operating basically in the saturated mode.

Fig. 4 shows how negative feedback has been used to prevent saturation. Resistor R_1 is chosen so that sufficient current is available for a fast rise time. Diode D_1 is a high

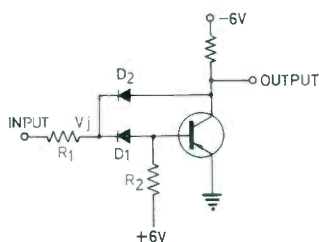


Fig. 4. Basic circuit of high speed inverter

forward voltage drop silicon diode, say 1V at 10 mA current, and diode D_2 a low forward drop germanium diode with say 0.5 V at 10 mA. Initially during the turn on, all current is supplied by the base as the voltage across diode D_2 is in the reverse direction. Thus the voltage at the junction of the diodes (V_j) is given by the base emitter voltage drop plus the forward voltage drop of the diode D_1 . This will be approximately -1.5 V. As the transistor turns on the collector moves positively. When the collector reaches a potential such that diode D_2 begins to conduct, i.e. approximately 0.5 V positive with respect to V_j , some current is supplied to the

resistor R_1 by the collector, thereby reducing the current from the base. The division of current between collector and base is finally governed by transistor gain and diode characteristics but the potentials at the collector and base will be approximately -1 V and -0.5 V respectively. Since the transistor is not saturated, when it is turned off there will be no storage time delay and the reverse bias provided by resistor R_2 will improve the switching-off time.

The generation of a very fast positive going edge can be achieved using the complementary tunnel diode-transistor switch shown in Fig. 5. It is essential for reliable operation that the base to emitter voltage

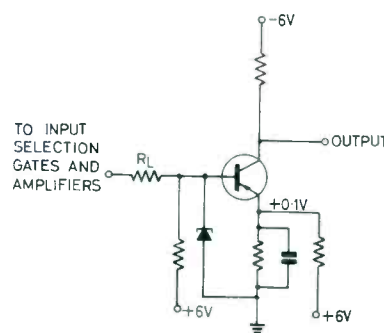
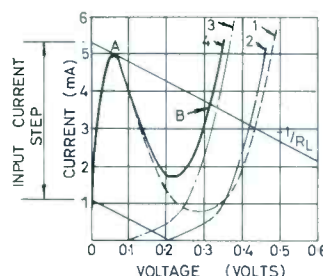


Fig. 5. Basic circuit of tunnel diode-transistor switch

required to turn on the transistor is less than the voltage swing produced by the tunnel diode. A degree of pre-bias is used to ensure this situation at switch on, and in the circuit shown approximately 0.1 V positive bias is applied to the emitter. The curves of Fig. 6 show the tunnel diode characteristic, the base emitter characteristic of the transistor and the combined characteristic. The tunnel diode is biased such that with no input



Curve 1—Tunnel diode
Curve 2—Transistor base
Curve 3—Biased transistor base
Curve 4—Combined tunnel diode and base-emitter diode

Fig. 6. Tunnel diode-transistor switch input characteristics

drive the operating point is very near the origin. As input current rises the diode current rises to point A on the characteristic. Here, however, diode current decreases very rapidly due to the negative resistance and the excess current flows into the junction capacitance. This capacitance is small and a sharp voltage rise across the diode is produced. The voltage will rise rapidly to point B, fixed on the curve by the load line $1/R_L$. This voltage swing will turn on the transistor, causing it to saturate.

Returning the input voltage to zero will trigger a similar sequence of events but in reverse. Storage and fall times are improved since the tunnel diode presents a low impedance during the turn-off.

The main gate of the counter is another good example of high speed switching circuits. Fig. 7(a) is a simplified diagram of this gate, which controls the flow of pulses to the counting decades. Here the requirement is of extremely short delays in the opening and closing of the gate. Since a transistor switches on faster than it switches

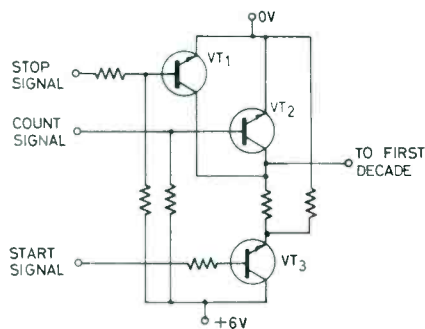


Fig. 7a. Basic circuit of main gate

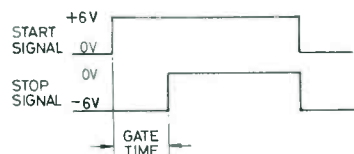


Fig. 7b. Start and stop signal waveforms

off the circuit is arranged so that each operation within the gate is the result of a transistor being switched on.

Switching waveforms are shown in Fig. 7(b) and it can be seen that the start signal causes the emitter of transistor VT₃ to rise to +6 V by emitter follower action. Transistor VT₂ now has a collector supply and can feed the count signals to drive the high speed decade. In this condition the gate is open. The stop signal, which closes the gate, causes transistor VT₁ to switch on, thereby clamping the collector of transistor VT₂ to ground.

Decade Counting Units

The lower speed decades employ standard techniques and will not be described here. The 50 Mc/s high speed decade is more complex however as it is important to keep delays very carefully controlled so that the feedback can successfully permute the four binaries to divide by ten. A simplified arrangement of one binary is shown in Fig. 8. The basic bistable is formed by transistors VT₃ and VT₄, both transistors utilizing the anti-saturation circuit of Fig. 4. Transistors VT₂ and VT₅ perform the double actions of pulse routing and fast switching. If transistor VT₃ is on and transistor VT₄ is off, then there is no collector supply to transistor VT₂ and although negative pulses are present at the base there can be no signals at the collectors. Transistor VT₅

however will feed a positive pulse to the base of transistor VT₃ through capacitor C₂ and transistor VT₃ will turn off, starting the regenerative change of state of the binary. Increased changeover speed is achieved since the collector current of transistor VT₅ will cause the collector voltage of transistor VT₄ to rise towards ground potential.

Transistor VT₁ is a high speed inverter to shape the pulses fed to the next binary.

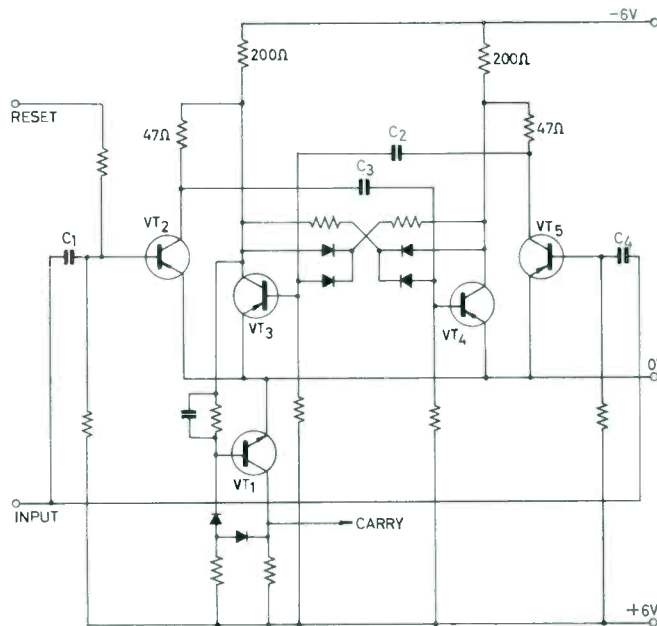


Fig. 8. Simplified circuit of 50 Mc/s binary

Memory

The memory binary and transfer gating system is shown in Fig. 9. Transistors VT₁ and VT₂ form a conventional bistable circuit of the Eccles-Jordan type. The bistable is two line driven through NAND transfer gating from the counting binary. When the memory is not in operation,

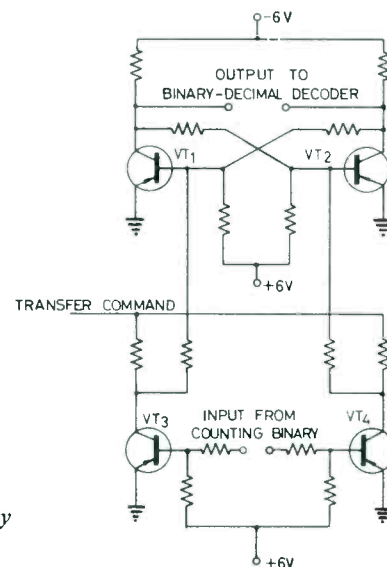


Fig. 9
Basic circuit of memory
binary and transfer
gates

the transfer command line is connected permanently to -6 V, allowing transistors VT_3 and VT_4 to act as simple inverters, one of which is on and the other off according to the state of the counting binary. Thus up to the maximum speed at which the circuits will operate, the memory binary will follow the counting binary.

When the memory is on, a short negative pulse is applied to the transfer command line at the beginning of the display period. This pulse opens the transfer gates for a short time, allowing the memory binary to set up to the same state as the counting binary. At the end of the pulse the collectors of transistor VT_3 and VT_4 are returned to zero potential, closing the gates and thereby preventing any further effect upon the display.

Binary to Decimal Decoding

The system employed in Counter TF 2401 is based on a bi-quinary approach as shown in Fig. 10. The emitters of all 'odd' digit drive transistors are connected together, as are those of the 'even' transistors, and the two lines

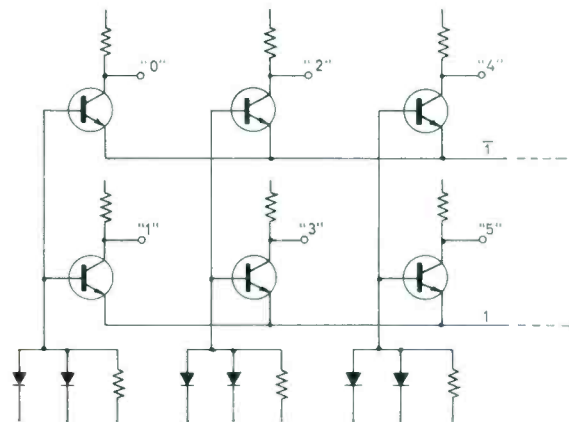


Fig. 10. Binary to decimal decoding schematic diagram

are controlled by the appropriate collectors of the first binary. Final selection is achieved by resistor diode logic at the base of each transistor. This arrangement results in a reduction in the number of components previously associated with the decoding.

Time Base Selection Gating

An elaborate gating system is necessary to select the one time base output required for each measurement, i.e. gate time, timing units and multiplying factor, for each time base position. The gating employs both diode and transistor logic and Fig. 11 shows the principle of operation.

The decade outputs from the time base dividers are taken to the bases of a number of transistor inverters. Collector supplies are controlled by the time base switch so that only certain inverters can operate for a given time base switch position. Further control is effected from the function switch by supplying large d.c. bias currents through resistors to the transistor bases (R_2 in Fig. 11). If no output from the transistor is wanted then -6 V is supplied to R_2 and the current flow is made sufficient to

saturate the transistor and override the time base signal drive. Hence for an inverter to pass a signal to the OR gate formed by the output diodes, its collector must be supplied with -6 V, resistor R_2 must be left floating and tied only to ground via diode D_1 , and a time base signal must be applied via R_1 . Thus the circuit is basically a three input AND gate.

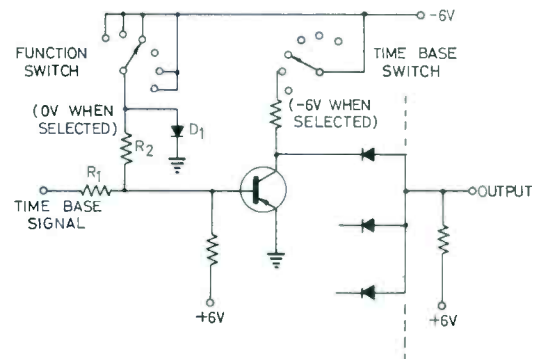


Fig. 11. Basic circuit of time base selection gates

Display Control and Reset

The display control and reset circuitry is completely d.c. coupled. Fig. 12 shows a simplified circuit. Transistor VT_1 , when turned on, prevents capacitor C from charging and so holds off transistors VT_2 and VT_3 . However,

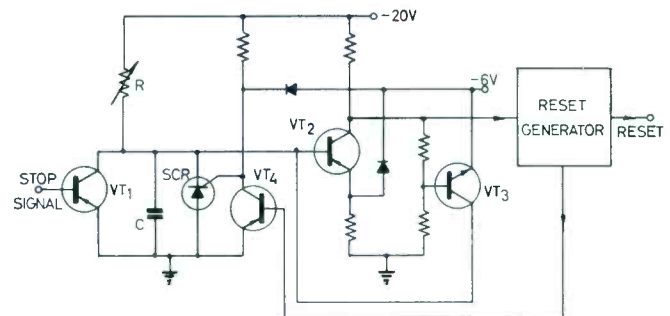


Fig. 12a. Display control schematic diagram

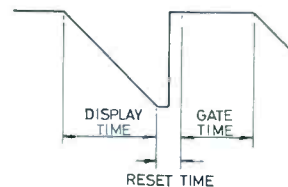


Fig. 12b. Voltage waveform across display timing capacitor

at the end of the count the 'stop' signal is applied to transistor VT_1 turning it off and enabling the capacitor to charge towards -20 V with time constant CR . As the capacitor voltage nears -6 V transistor VT_2 will turn on, turning on transistor VT_3 which clamps the capacitor to -6 V. The turning on of transistor VT_2 also triggers a reset generator which produces the reset pulse required to end the display period. With gate times as

short as 1 μ sec it is desirable that the capacitor discharge time be short otherwise the sampling rate will be needlessly slow. Here a silicon controlled rectifier, triggered during the reset pulse duration, is used to override the clamp provided by transistor VT_3 , and allow the capacitor to discharge rapidly to ground potential. Transistors VT_2 and VT_3 are thus turned off, and also transistor VT_1 is turned on as a result of the reset pulse action on its drive circuitry. The counter is now ready for the main gate to be opened and another measurement started.

Power Supply

The power supply must provide a relatively large amount of power due to the complexity of the instrument and so to safeguard supply components during accidental short circuit or fault conditions, overload protection has been incorporated. Also a thermal cut-out, connected to the transformer primary, is mounted on the heat sink for the power transistors.

REFERENCES

1. Bisset, D. W., 'Counter/Frequency Meter Type TF 1417', *Marconi Instrumentation*, December 1961, 8, p. 80.

ABRIDGED SPECIFICATION

Basic Counter TF 2401

DISPLAY: 8 digit in line, with memory.

GATE TIMES (frequency measurement): 1 μ sec to 100 sec in decade steps, instrument reads in c/s, kc/s or Mc/s, with automatic decimal point indication.

STANDARD FREQUENCY STABILITY:

± 2 parts in 10^9 short term.

± 1 part in 10^8 per day.

50 Mc/s Range Unit TM 7557

(Input Channel A)

RANGE: 1 c/s to 50 Mc/s.

SENSITIVITY: 0.1 V r.m.s., 10 c/s to 50 Mc/s.

INPUT IMPEDANCE: Approximately 500 k Ω shunted by 25 pF.

Counter Timer Unit TM 7558

(Input Channels B and C)

RANGE: 0 to 10 Mc/s.

SENSITIVITY: 0.1 V r.m.s. 1 c/s to 10 Mc/s.

INPUT IMPEDANCE: Approximately 1M Ω shunted by 30 pF.

PERIOD AND TIME INTERVAL MEASUREMENTS:

Timing Signals: 1 c/s to 10 Mc/s in decade steps.

Instrument reads in sec, msec or μ sec, with automatic decimal point indication.

MULTIPLE PERIOD MEASUREMENT:

Timing Signals: 1 Mc/s or 10 Mc/s.

Instrument reads in μ sec with decimal point indication.

MULTIPLYING FACTOR: (Multiple period and multiple frequency ratio measurements) 10 to 10^8 in decade steps.

621.374.32

AN INTRODUCTION TO COUNTER LOGIC

by
J. P. PATRIZIO

Logic techniques, more commonly associated with computer design, have been used in the design of the TF 2401 Counter. A brief description is given of some basic logic elements, and some reference is made to their use in the Counter.

WHENEVER the term 'logic' is used with regard to electronics, the automatic response is 'computer'—the two have become almost synonymous. However, while it is true that logic techniques have been developed to a fine art in the computer field, this is by no means the limit to which these techniques can be employed. The logic of a computer, or instrument, can be broadly defined as its 'thought' processes or, in other words, the way in which it achieves the end for which it was designed. Logic has further come to be applied to the graphical representation of the device's 'thought' processes, and it is the aim of this article to describe some of the fundamental logic elements and principles which have been used in the design of the TF 2401 Counter.

A basic counter is simply a device which accepts pulses, say, and counts and displays the total until the input is stopped and the device reset. This instrument would have very limited use, but it can easily be made

much more powerful a tool by imposing a control on the input (Fig. 1). For signals to pass to the counting unit both A and B must be active; this immediately allows the device to do simple counting, measure frequency by having one input active for a known time, perform period measurements by applying a standard frequency to one input, etc.

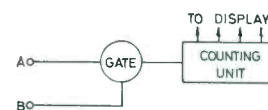
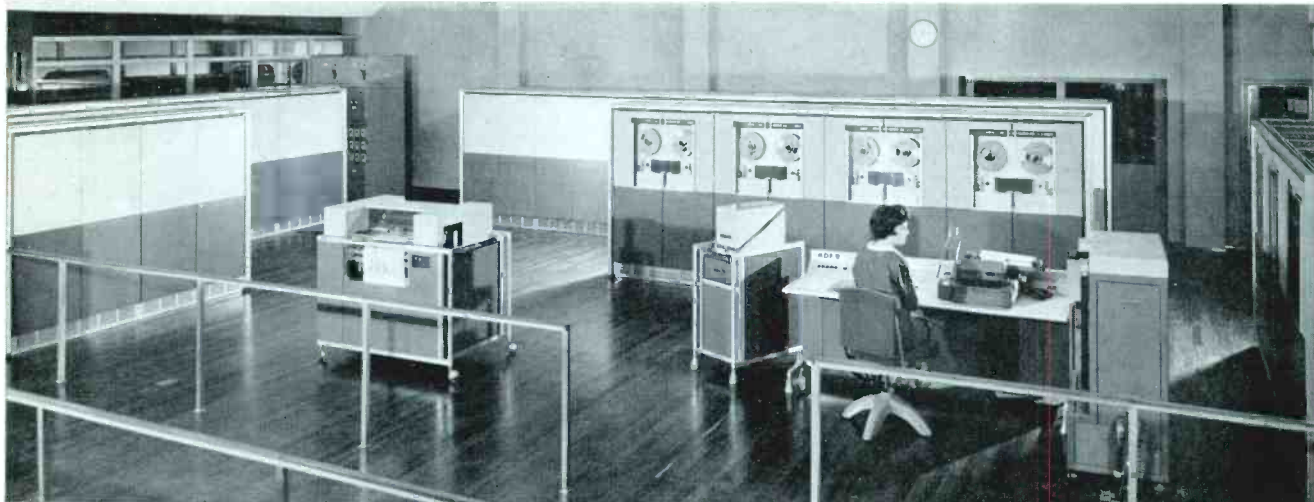


Fig. 1. Basic gated counter

There are many refinements that can be made to this relatively unpretentious device, and each refinement gives increased versatility, until finally a universal counter-timer is obtained as shown in Fig 2. This is the



Part of the KDF 9 data processing system in the English Electric-Leo Bureau at Kids Grove—an example of the application of logic techniques in computer design. KDF 9 is a very high speed computer which in one second can add or subtract one million times, multiply 71,000 times, or sort 6,000 items from random order into any required sequence

(Photograph by courtesy of English Electric-Leo Computers Ltd.)

basic block diagram for the Counter type TF 2401 with the counter-timer plug-in. By activating the appropriate preselector gates with signals from the Function selector, Time Base selector and one or more of the input channels, it can perform a wide variety of measurements.

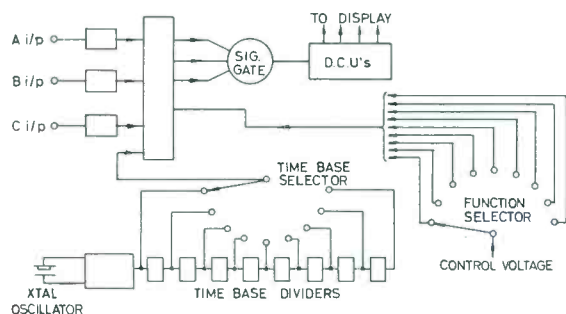


Fig. 2 Block diagram of typical counter

It will be seen from Fig. 2 that some of the blocks are labelled in terms not often used in the general field of measuring instruments—'Gate', 'Time Base Dividers', and 'Decade Counting Units' (D.C.U.). It is in the design of the functions that these units perform that use is made of logic techniques.

There is more than one type of logic used in the design of computers, etc., such as direct-coupled transistor logic, current-switching diode gate logic, transistor-resistor logic, and others. The Counter type TF 2401 does not limit itself to one particular type of logic, using for example, resistor-diode gates, transistor gates, and also achieving a logical end by means of circuitry not normally found in the computer field. In general, the two stable states of the switching circuits used in the TF 2401 correspond to 0 V and -6 V, the -6 V state being the active condition of a signal.

One of the simplest forms of logic element is the diode gate; this may be an OR gate or an AND gate. Fig. 3 shows a three input AND gate, and it is seen that the

output, D, is present when signals A and B and C are in the active state. This is represented by the logic equation

$$A \cdot B \cdot C = D$$

For an OR gate, shown in Fig. 4, an output is produced when an A or B or C signal is present; the logic equation this time is

$$A + B + C = D$$

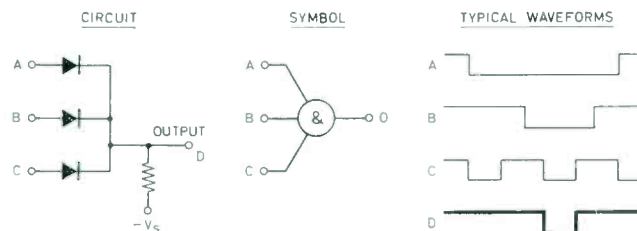


Fig. 3. AND gate

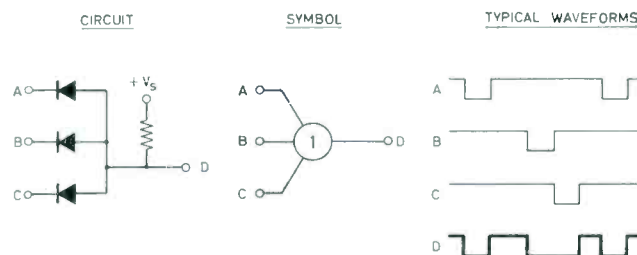


Fig. 4. OR gate

It is obvious, on examination of the two circuits, that if positive going signals are applied to the inputs, each gate will perform the reverse function, i.e. the OR gate will become an AND gate, and vice versa. Diode OR gates (and diode-resistor OR gates) are used as part of the read-out decoding logic of the TF 2401.

A further control which can be imposed on a gate is that of inhibiting. If a gate has an inhibit input, it will not give an output as long as that input is in the active

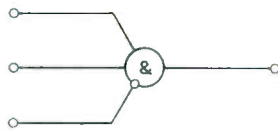


Fig. 5a
Inhibited AND gate

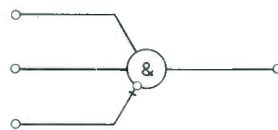


Fig. 5b
AND gate with
negated inhibit

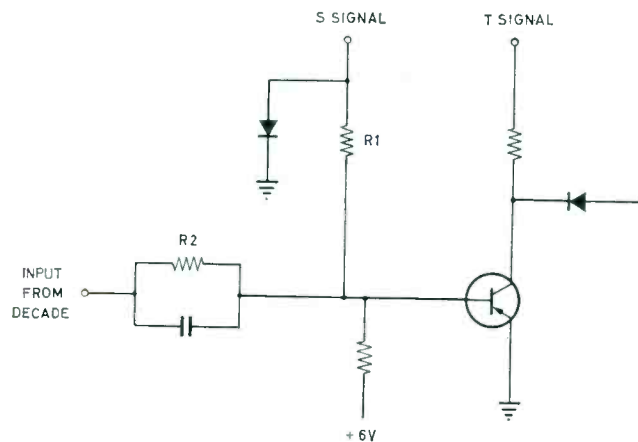


Fig. 6. Time base selection gate

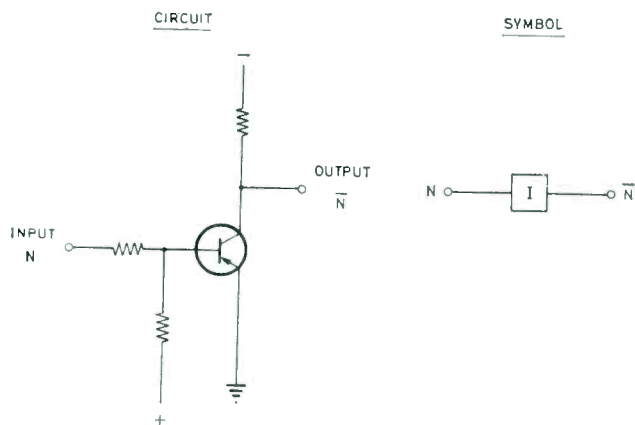


Fig. 7. Inverter

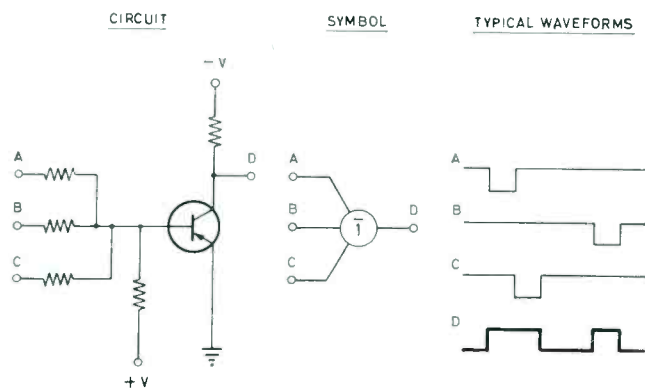


Fig. 8. NOR gate

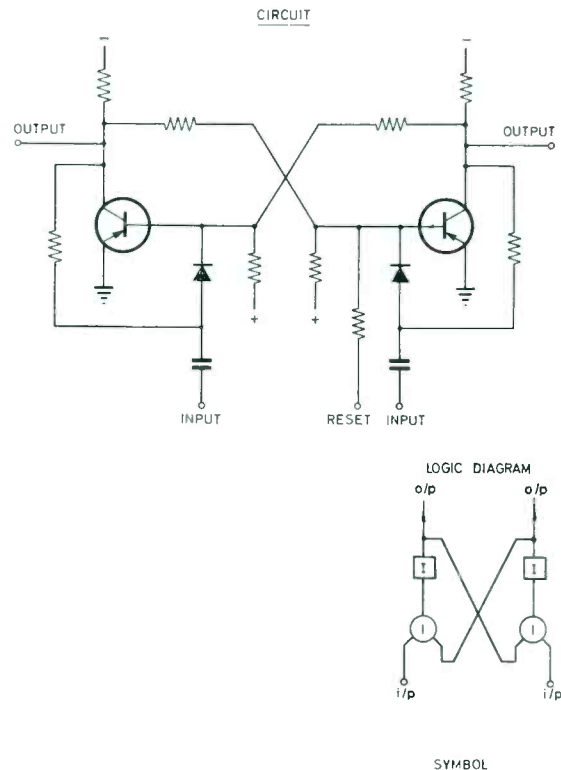
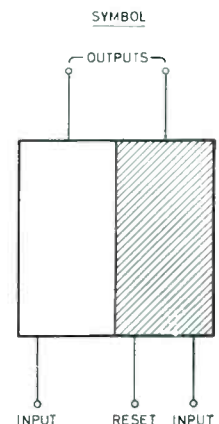


Fig. 9
A '1' input into the right-hand side of the logic and circuit diagrams produces a '1' output from the left-hand side. A '1' signal to the right-hand input of the symbol, however, activates the right-hand output, so avoiding confusion in complicated logic diagrams



state. With a negated inhibit input, the gate is prevented from operating when that input is in the inactive state. Fig. 5 shows the symbols for inhibit gates. The Time Base Selection gate is an example of an inhibited gate and the circuit for this is shown in Fig. 6; the d.c. voltages on the inputs labelled 'S' (select) signal and 'T' (time base) signal are those required to give an output. It will be seen that this gate does not use diode logic, but resistor-transistor logic; two inputs are applied to the base of the transistor and the other, when active, provides the collector current. When the inhibit input is active, i.e. the 'S' signal is a -6 V , the transistor is clamped firmly in the conducting state, thus preventing the time base signal, from the decade, from passing to the output.

Another logic element which is extensively used in one form or another is the inverter. The inverter may be used to invert a signal, improve a rise time, or give power amplification. A simple inverter is shown on Fig. 7; a signal, 'N', applied to the input is delivered at the

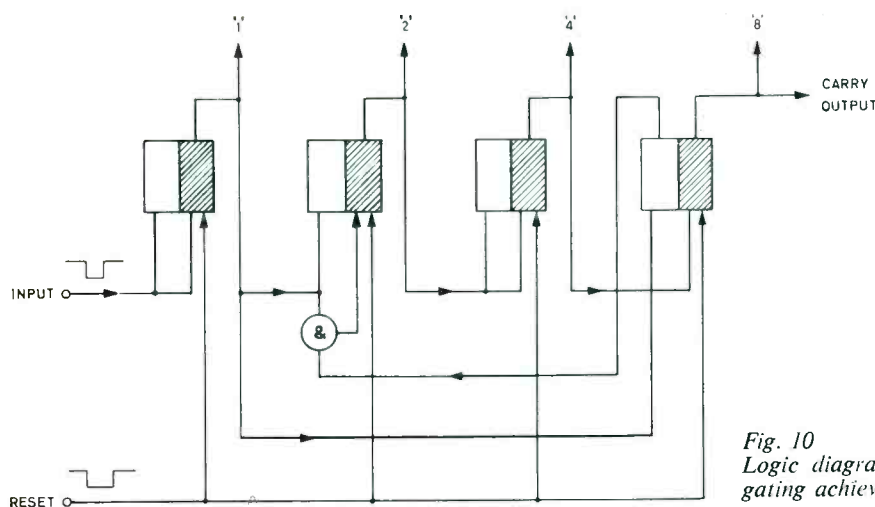


Fig. 10
Logic diagram of decade counting unit, showing how gating achieves a count-to-ten function

output as $\overline{N}$, i.e. 'not N'. The function is expressed by the equation

$$N - I = \overline{N}$$

If an inverter has a number of inputs, as in Fig 8, it will function as a NOR gate, where if any one of the inputs is active, the output will be inactive. The equation for the NOR gate is

$$A + B + C = \overline{D}$$

The NAND gate is similar to the NOR gate except that all inputs must be active before the output is inactive.

An extensively used and very powerful logic element is the bistable, toggle or, in the U.S.A., flip-flop. The most common form of bistable element, of the Eccles-Jordan type, can be considered as two inverter stages resistively coupled via OR gates so that the output of one drives the input of the other. A bistable is shown in Fig. 9; cross-hatching in the logic symbol indicates which transistor is conducting when the circuit is in the reset state.

One use to which the bistable is put is that of memory. When functioning as a memory the circuit is set into one state by the event to be displayed or recorded, and it remains in this state until another pulse cancels the memory by resetting it to the original state.

The bistable circuit can also be used as a counting element. When used as such, the two inputs of the

circuit are connected to form a common input; the first pulse applied to the input switches the bistable into one state, and the second pulse switches it back to the original state, and so on. The bistable therefore completes one cycle for two cycles of the input waveform, and in this manner provides a divide-by-two operation. The cascading of such stages achieves division in binary form and by gating into stages which come early in the sequence, from subsequent stages, division by any number can be accomplished.

The bistable is the basic element in the design of the Time Base Dividers and Decade Counting Units in the new Counter. Fig. 10 shows how four bistables are connected together to form a decade which will count to nine, normally, and set to zero on the tenth count.

All the circuits described above can be considered as basic building blocks which are used to help in the functional design of the instrument. Probably the main difference in the use of logic in the design of computers and counters is in the diversities of the logic used. Computers tend to limit themselves to one particular type of logic, as many factors demand that a few often-used logic set-ups are prefabricated in bulk, and deviously interconnected to achieve the required end. Counters, on the other hand, are so very much smaller that any logic which suits the purpose can be custom built for the particular job under consideration.

BINDER REMINDER

A NEAT BINDER to contain copies of Volumes 8 and 9 of *Marconi Instrumentation* has now been made available so that readers and librarians may keep copies of the bulletin in a convenient form for reference. It is bound in red 'Rexine' and copies can be inserted without punching and opened flat. These binders are available at a cost of 12s. each, post free. To simplify the transaction please send remittances when ordering.

MARCONI INSTRUMENTS LTD.
ENGLAND

TF2

5 1 6 4 7 8 4 2

GATE

OVER

SUPPLY
COUNTER



STANDBY

MEMORY
ON



OFF

GATE
AUTO



OPEN

RESET



DISPLAY



TIME BASE



COL

MADE IN ENGLAND

401

TM7557

TRIGGER LEVEL
ATTENUATOR

X1 X4 X16 X64 X256



A SLOPE



50 MHz

SE

MOTE

COUNTER

FUNCTION TM7558

FREQ A A/B A/MULT E

TEST

CLOCK
FREQ
10 Mc/s

PER B

MULT PER B

TIME B

TRIGGER LEVEL
ATTENUATOR

X1 X4 X16 X64 X256



B SLOPE



SCALE B
TRIGGER LEVEL
ATTENUATOR

X1 X4 X16 X64 X256



C SLOPE



COUNTER-TIMER

VOLTMETER ZERO —ITS SIGNIFICANCE

by

E. C. CRAWFORD,
Graduate I.E.E.

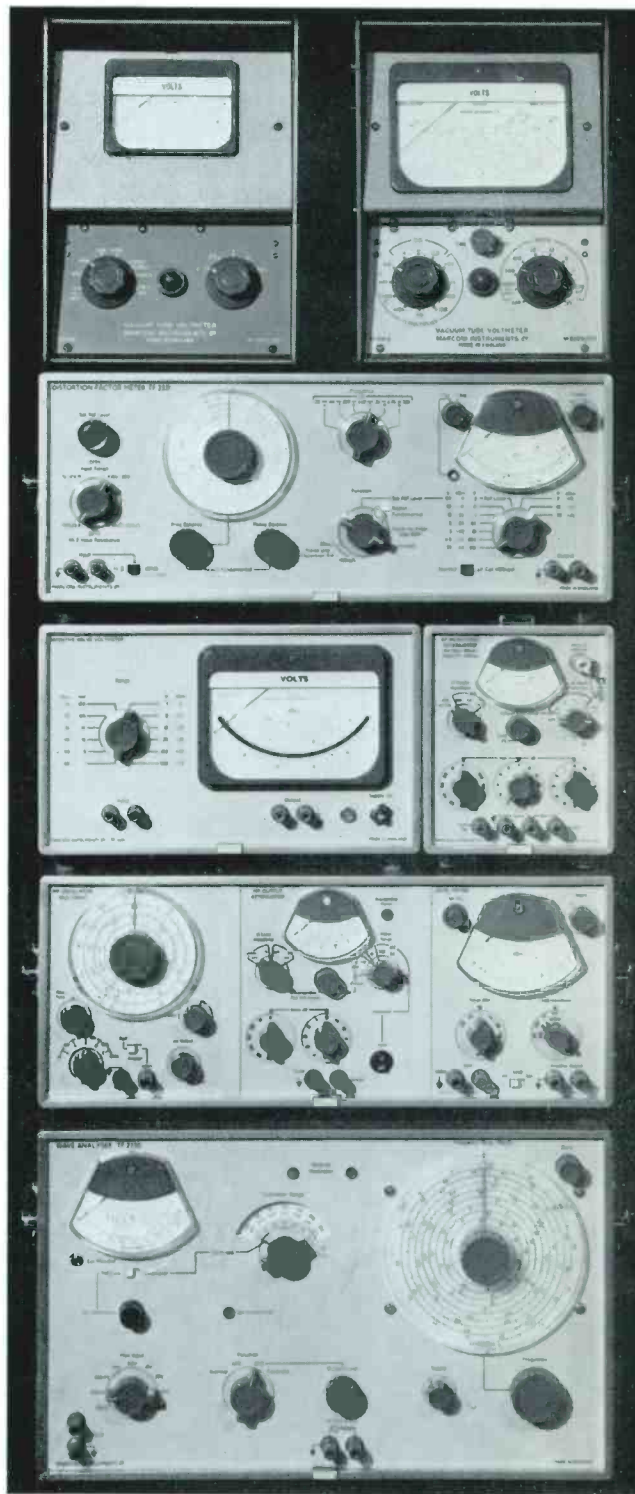
Precautions necessary to obtain maximum reading accuracy with any type of electronic voltmeter are considered. These include correct use of both mechanical and electrical zero controls. Reading error obtained due to an incorrect zero is given for the peak reading diode detector type of voltmeter. The effect of internally generated noise on the sensitive amplifier type a.c. voltmeter is considered in some detail, and a table of errors given for various percentages of full scale deflection.

BEFORE USING any voltmeter it is necessary to observe at least a minimum of technique if the maximum accuracy is to be obtained.

The first operation while the instrument is warm but switched OFF is to check and, if necessary, adjust the mechanical zero of the meter. There is usually a small screwdriver slot adjustment for this purpose and it is a good rule to turn this screw clockwise so that the meter pointer approaches the meter zero mark from the full scale deflection until the correct point is reached. This screw should then be turned back slightly so that the pressure of the adjusting peg is relieved from the internal lever. There is always backlash deliberately left in the mechanism to permit this pressure relief to be easily obtained.

Some instruments with logarithmic meter scales, giving linear dB calibration, do not have any mechanical set zero control as the zero is fixed during manufacture. This type has a non-linear magnetic field so that the mechanical zero deviations are insignificant.

The basic type of electronic voltmeter will also have electrical zero controls. This type of voltmeter, represented by the Vacuum Tube Voltmeters type TF 1041C



Voltmeter zero considerations apply not only to instruments specifically designed to measure voltage but also to any other instrument that uses an electronic voltmeter as its readout. A selection of both categories is shown above

and TF 1300, measures d.c. via a direct coupled amplifier which, for a.c. measurements, is preceded by a diode rectifier to convert the a.c. to d.c. In general it is necessary to adjust the d.c. zero as a preliminary to all measurements and then the a.c. zero for a.c. measurements. It is also advisable to connect the d.c. leads to a resistance equivalent to that of the d.c. source to be measured while the d.c. zero is set, particularly for measurements of less than 1 V. This precaution is only important if the resistance is several megohms or more and if a significant difference in zero is observed with the leads short circuited and then open circuited. The a.c. zero must always be adjusted with the a.c. probe tip either completely shielded or short circuited with a lead arrangement short enough to avoid spurious magnetic pick-up.

With this type of voltmeter any imperfections in zero setting will cause a reading error equivalent to the same displacement—as if the scales had been shifted laterally by a constant amount. The error will obviously be least significant at full scale as a scale shift representing 3% of reading at full scale will represent 30% of reading at one tenth full scale.

Amplifier type A.C. Voltmeters

This type of voltmeter, such as the Sensitive Valve Voltmeter type TF 2600 or the voltmeter section in the new Distortion Factor Meter type TF 2331, has a high input resistance given by a cathode- or emitter-follower; this is followed by a step attenuator and an amplifier of about 1 mV sensitivity whose output is linearly rectified and drives a d.c. microammeter. These amplifiers are wide-band and therefore will have some self-generated noise content in the output, even with short circuited input terminals. The same noise content will tend to be present on all ranges from 1 mV to 300 V full scale as it is convenient to maintain the amplifier at its full 1 mV sensitivity; a 300 V signal, for example, being first attenuated to 300 mV before driving the cathode follower and thereafter being further reduced to 1 mV by the step attenuator. These voltmeters have a mechanical zero only, which should be adjusted with the instrument warmed up to operating temperature but switched off and permitted to stabilize to a discharged state.

The calibration of the meter scale is such that the effect of the small standing reading due to internal amplifier noise has no effect upon the claimed accuracy provided the meter deflection due to the signal is at least 10% of full scale. If the signal deflection is less than 30% of full scale there will, in general, be a more sensitive range that can give better reading accuracy. On the most sensitive range the claimed accuracy will not be impaired down to 10% of full scale.

The theoretical explanation for the absence of significant error is as follows.

Suppose the signal to be measured is $E_s \sin 2\pi f_1 t$ and that the standing noise may be represented by an additional sine wave, $E_n \sin 2\pi f_2 t$. Superimposing these two signals produces a signal which is both frequency and amplitude modulated. In this context frequency

modulation is negligible and the instantaneous amplitude of the envelope is expressed as:—

$$\sqrt{E_s^2 + E_n^2 + 2E_s E_n \cos 2\pi(f_1 - f_2)t}$$

The term $2E_s E_n \cos 2\pi(f_1 - f_2)t$ shows that the signal is now amplitude modulated at the difference frequency between the signal and noise frequencies.

Assuming that m , the signal to noise ratio, is large E_s will be much greater than E_n and the expression simplifies to:—

$$E_s + \frac{E_n}{2m} + E_n \cos 2\pi(f_1 - f_2)t$$

The meter pointer will try but fail to vibrate at the detected modulation frequency $(f_1 - f_2)$, and the indicated value is in error by only $\frac{1}{2m^2} \times 100\%$.

With a ratio m of 20 the error would only be 0.125%. Note that the above calculation assumed that the noise was capable of representation by a single sine wave. Actually of course the noise (excluding hum) consists of an infinite number of indefinitely small random sine wave signals so that the errors are slightly less significant than those indicated by the expression derived above.

It is clear that, whereas with d.c. signals the standing reading is added to the signal direct and gives an obvious error, with a.c. signals the error rapidly diminishes as the signal to noise ratio improves; this is shown in the table for an average-responding voltmeter with a noise signal giving 2% of full-scale deflection.

	Error due to 2% noise					
	100	50	30	10	5	2
Signal (% of full scale)						
Error (% of reading)	0.02	0.08	0.223	2	8	40
Error (% of full scale)	0.02	0.04	0.067	0.2	0.4	0.8

The position is somewhat similar to the familiar behaviour of an r.m.s. meter which rapidly ignores a weak interfering signal as the wanted signal increases beyond a ten to one ratio.

To minimise the noise problem it is advisable to work from the lowest possible signal source impedance, especially on the most sensitive ranges, and to pay careful attention to lead arrangements to avoid the pick-up of extraneous interference.

Biased Voltmeters

Some voltmeters have an introduced meter bias to give a more accurate scale shape. There may or may not be electrical zero controls and, although it can be disconcerting to see the meter pointer obviously off the zero mark on perhaps one or two ranges only, for reasons not associated with noise, it can nevertheless be deliberately arranged thus to improve the accuracy on these ranges. No existing Marconi Instruments voltmeters have this feature.

Tunable Rejection Filter TYPE TF 2334

by

D. E. O'N.
WADDINGTON,
A.M.I.E.R.E.

The limitations of a wave analyser, when used for measuring low levels of harmonic distortion, are discussed and it is shown that the use of a tunable rejection filter would, to a large extent, overcome these difficulties. Requirements of such a filter are given and their bearing upon the design of TF 2334 is described. Methods of using the filter for extending the range of the Wave Analyser Type TF 2330 for measuring both harmonic and intermodulation distortion are suggested.

THE LOWER LIMIT of distortion measurement, when using a wave analyser, is determined by two main factors:—(a) The distortion introduced by the wave analyser input circuits and (b) the bandwidth of the analyser. Noise also has a limiting effect but as the bandwidth is so narrow, particularly in the case of a heterodyne wave analyser, the noise may generally be neglected. If these two main limitations could be eliminated, the useful measuring range of a wave analyser would be considerably extended. The discussion which follows applies particularly to the Marconi Instruments Wave Analyser type TF 2330 but it is equally applicable to any audio frequency wave analyser.

Inherent Distortion

Inherent distortion in a wave analyser is introduced mainly in the input amplifier and the balanced modulator, see Fig. 1. While it is possible to design the input amplifier to have negligible distortion, (i.e. $<0.0001\%$) this is not considered useful as the distortion introduced by the balanced modulator is of the order of 0.003% to 0.001% . However this distortion is amplitude conscious giving less distortion proportionately for lower inputs and thus the only way to make use of any distortion reduction would be to increase the gain in the stages after the narrow band filter. The effect of this would be to increase the noise in the system, thus losing most of the advantages which might have been gained. A further objection to this course of action will become apparent in the discussion of filter response effects. Hence, the most practical way to get added sensitivity would appear to be to reduce the amplitude of the fundamental component of the signal being analysed without altering the harmonic

components in any way. The gain of the input amplifier could then be increased to give the necessary added sensitivity.

Filter Response

In a heterodyne wave analyser there are two effects of filter response which limit its measuring range. The most objectionable of these occurs at the low frequency end of the audio spectrum. This is illustrated in Fig. 2, the worst case, i.e. 20 c/s, being shown. It will be seen that there is no difficulty at all in measuring the fundamental component as the contributions of the harmonics to its average value are insignificant. However, when the second harmonic is measured (in the case shown its level is 55 dB down on the fundamental) it will be seen that the signal due to the fundamental component is 10 dB greater than that due to the second harmonic. Hence the meter reading will not be a true reflection of the second harmonic amplitude. A similar state of affairs obtains when the other components are measured. The obvious methods by which this difficulty may be overcome are either to improve the filter response or to filter out the fundamental component.

At high frequencies the state of affairs is better in that the harmonics will be well out of the normal 6 c/s pass band of the filter. Limitations will still exist, however, as it is not very practical to design a filter with attenuations of greater than 90-100 dB outside the pass band. Increasing the gain of the amplifiers after the filter will result in a standing reading on the meter due to noise. Thus, suppressing the fundamental component of the signal before it reaches the analyser appears to be the most practical answer.

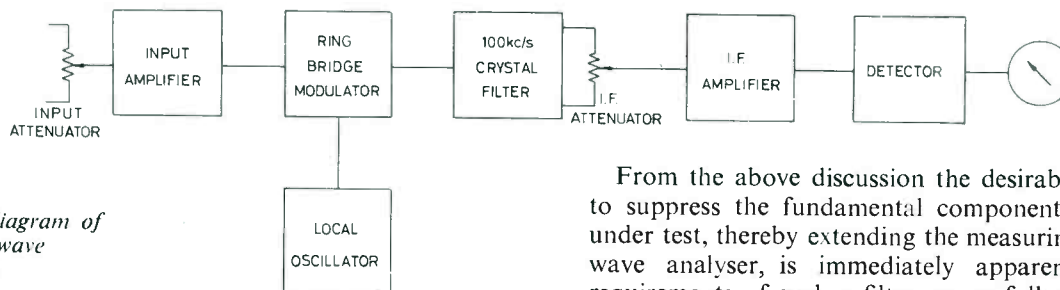
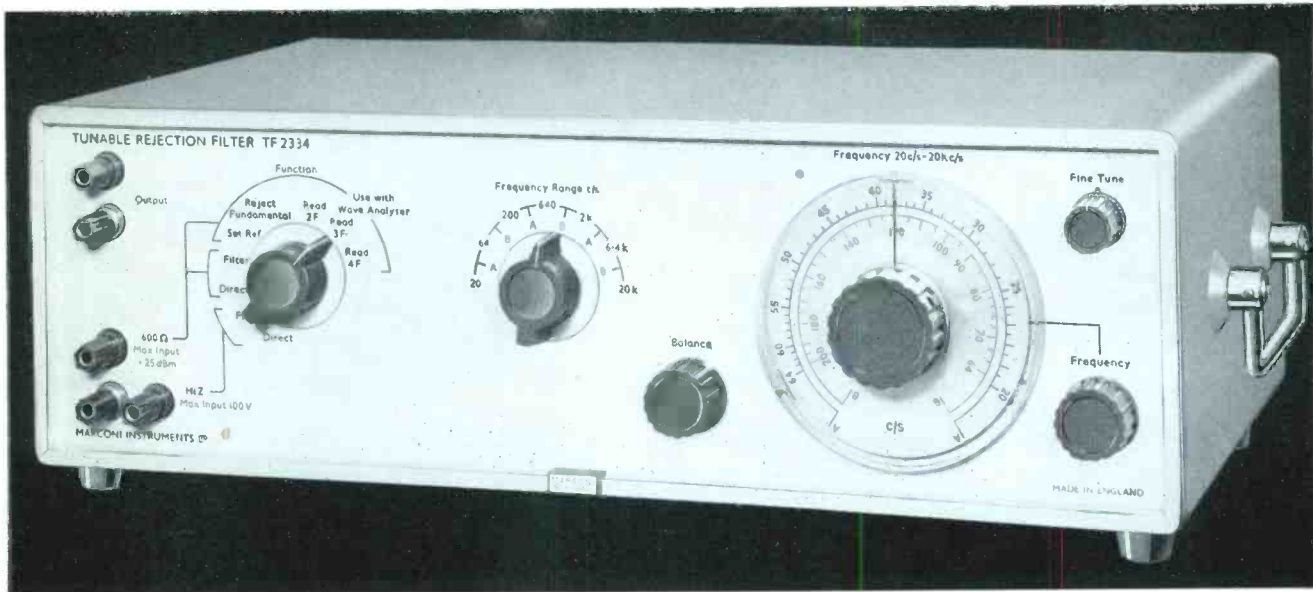


Fig. 1
Block diagram of
typical wave
analyser

From the above discussion the desirability of a filter to suppress the fundamental component of the signal under test, thereby extending the measuring range of the wave analyser, is immediately apparent. The main requirements of such a filter are as follows:



The Marconi Instruments Tunable Rejection Filter type TF 2334. An alternative version is available for rack mounting.

1. It should introduce negligible distortion (i.e. less than 0.00001%).
2. Harmonic attenuation should be as little as possible and should be predictable.
3. Input and output impedances should be suitable for audio circuits.
4. Fundamental rejection should be as high as possible, i.e. 60 dB or greater.
5. It should cover at least the audio range, i.e. from 20 c/s to 20 kc/s.

The first requirement sets the pattern for the design of the filter. Active circuits were ruled out as, although it is possible to design suitable circuits using transistors

or valves, they are very complicated and costly. Tuned LC circuits were also rejected, because inductors, unless air cored, are sources of distortion. Thus it was decided that a passive RC circuit would probably give the best results. Many forms of filter circuit were evaluated and it soon became obvious that the twin-T circuit provided the best results. It may be tuned to give a good null greater than 80 dB; the harmonic attenuation although greater than strictly desirable is predictable, the impedances may be designed to be suitable for audio systems, i.e. 600 Ω input, and it is relatively easy to tune the filter over the required frequency range. The main problem posed by this filter lies in the second requirement.

While the response curve of the filter is predictable—see Fig. 3—the attenuation varies from harmonic to harmonic, i.e. the second harmonic is attenuated by 9.5 dB, the third by 6 dB the fourth by 4 dB, etc. Hence, if the filter is placed in the path of a signal being measured by a

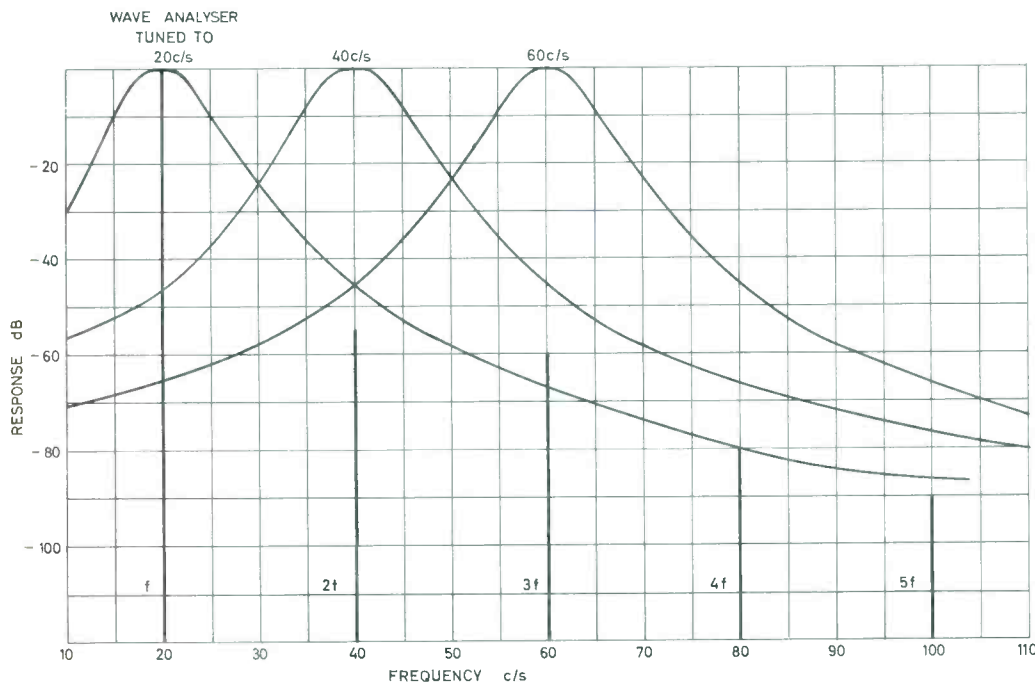


Fig. 2
Filter response limitations in wave analyser at low frequencies

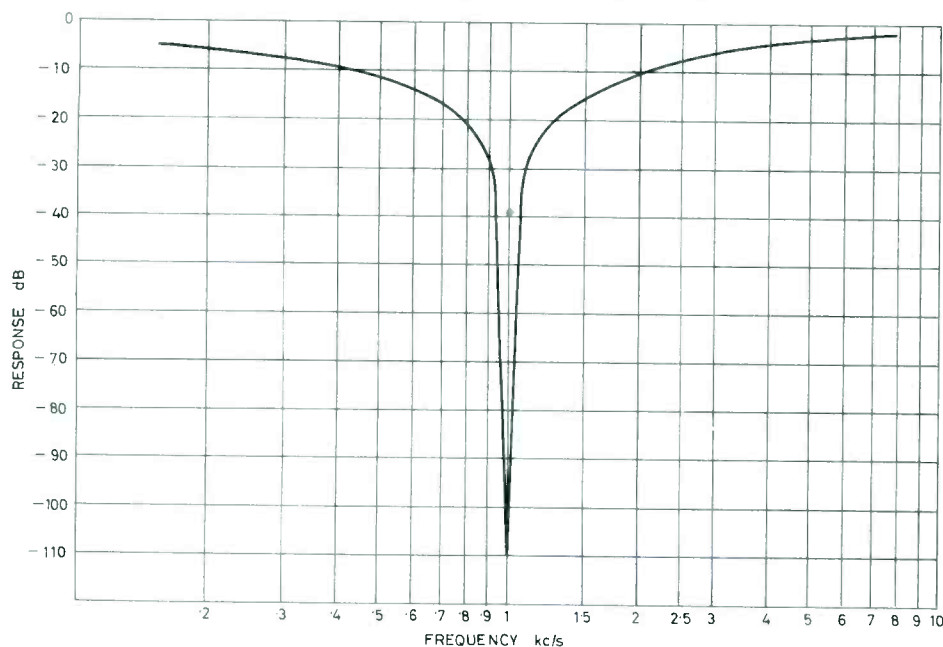


Fig. 3
Response of TF 2334
Twin-T Filter

wave analyser, the harmonics will be attenuated by the above amounts, and it will be necessary to add a correction to each harmonic reading to obtain the true result. While this is very easy to do, it is also very easy to forget, with the result that distortion figures could appear far better than they were in reality. In order to obviate this possibility an attenuator has been fitted between the input terminals and the filter. The degrees of attenuation have been arranged such that the correction factors are automatically included in measurements up to the fourth harmonic. In choosing the fourth harmonic as the upper limit, account was taken of the fact that the whole system is directed at measuring very low levels of distortion. It is thus reasonable to assume that the transfer function of the equipment producing the signal may be treated as a simple power series. It has been shown¹ that the higher order harmonics will be very much smaller than those of lower order. Thus if the low order harmonics are only just measurable using this system, the high order ones should be negligible. If it is still desired to measure the high order components, correction factors may be taken from Fig. 3.

To use the Tunable Rejection Filter it is first connected to the input of the wave analyser. With the FUNCTION switch on the Filter set to SET REF, the twin-T filter is by-passed and the fundamental component of the signal is tuned in on the wave analyser to give a suitable reading. The Filter FUNCTION switch is then set to REJECT FUNDAMENTAL thereby introducing the twin-T filter which is tuned to give minimum reading on the wave analyser, the sensitivity of which may be increased using the RANGE switch. When a sufficient degree of fundamental rejection has been obtained, (greater than 60 dB) the filter FUNCTION switch is set to 2F which compensates for the twin-T filter response and the wave analyser is tuned to the second harmonic frequency. If the second harmonic is too small to be measured when the RANGE switch has been set to maximum sensitivity,

the gain of the wave analyser may be increased by means of the input attenuator; however, the number of 10 dB steps should be carefully noted and added to the 60 dB on the RANGE switch. If difficulty is experienced in finding the second harmonic, a simple way to make it more apparent is to switch the Filter FUNCTION switch to SET REF while searching, thus overloading the input to the wave analyser and introducing extra distortion. The same procedure may be repeated for the third and fourth harmonics.

The minimum distortion which may be measured by this method is limited by the available signal level, and thus the gain which may be switched into the system by means of the wave analyser input attenuator. If this is insufficient, additional gain may be obtained by interposing a low noise amplifier between the Filter and the wave analyser. It is not necessary to know the gain of this amplifier provided that it is capable of handling the fundamental component without overloading during the level setting operation. The distortion characteristic of the amplifier is not very important as, during harmonic measurement, the fundamental component will be attenuated by the Filter to a level comparable with that of the harmonics. Also, the amplifier will be operated at a very low level ($< 10 \mu\text{V}$) where it is unlikely that any distortion will occur.

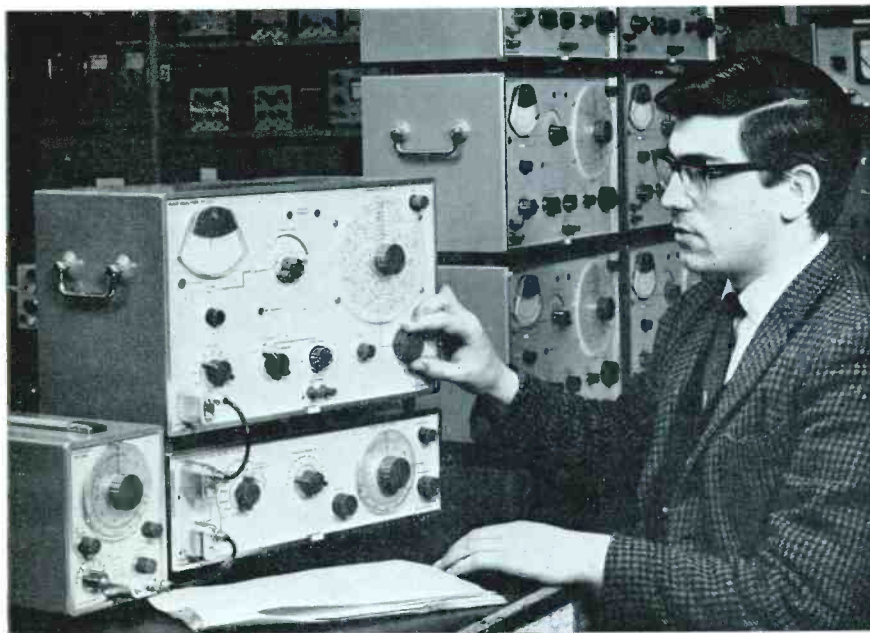
Other uses of the Tunable Rejection Filter are described below.

Frequency Measurement

For this purpose the Filter is connected to a high impedance voltmeter such as Sensitive Valve Voltmeter type TF 2600. An unknown signal is connected to the input of the Filter, the FUNCTION switch of which is set to FILTER. The filter is then tuned to give a minimum reading on the meter and the frequency of the signal may be read directly from the tuning dial.

Distortion Factor Measurements

The Filter is connected as for frequency measurement but with the FUNCTION switch at DIRECT. A signal to be investigated is connected to the input of the Filter and the signal level and the voltmeter range are adjusted to give a suitable meter reading. The FUNCTION switch is then set to FILTER and the filter is tuned to give minimum deflection on the meter, the sensitivity of which is increased by



A Quality Control Engineer uses the TF 2334 in conjunction with the TF 2330 Wave Analyser to measure the very low distortion content of A.F. Oscillator type TF 2100

means of its range switch. Distortion may then be calculated by expressing the residual voltage as a percentage of the initial meter reading. This result will be in error in absolute terms due to the shape of the filter characteristic. However the system is simple and can provide an easy means of making comparison measurements.

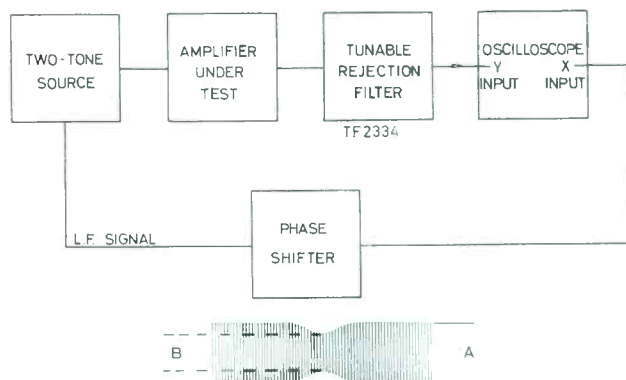


Fig. 4. Circuit arrangement and display obtained when using the TF 2334 in the oscilloscope method of distortion measurement

Intermodulation Distortion² Measurement

As in normal harmonic distortion analysis, the measuring range of the wave analyser is limited by its inherent distortion. This distortion may conveniently be reduced

by attenuating one of the test signals. This is more practical in the S.M.P.T.E. system than on the C.C.I.F. system. However, it may be used to advantage in both.

The Filter may also be used in the oscilloscope^{3, 4} method of distortion measurement, see Fig. 4. Two signals with an amplitude ratio of 10:1, the low frequency signal having the larger amplitude, are fed to the amplifier under test. The output of the amplifier is then fed via the Filter, which is tuned to reject the low frequency signal, to the Y input of the oscilloscope. The X deflection is provided by the l.f. signal. The modulated a.f. signal will then be seen on the oscilloscope and the inter-

modulation is given by $\frac{2(A-B)}{A+B} \times 100\%$, where A and B are the maximum and minimum amplitudes of the display. This method of measurement is particularly useful in setting up audio frequency amplifiers as it is often possible to see, from the oscilloscope display, the nature of the distortion and its source.

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ABRIDGED SPECIFICATION

Frequency Range

20 c/s to 20 kc/s. Accuracy: $\pm 2\%$.

Input Impedance

600 Ω or high impedance.

Maximum Input

+25 dBm at 600 Ω . 100 V r.m.s. at high impedance.

Rejection

Greater than 80 dB.

THE EVALUATION AND TESTING OF FERRITES

by

H. J. HASBROUCK*

Most of the measurements required for the evaluation of ferrites can be done with the TF 1245 Q Meter, TF 1246 Oscillator, TF 1331 Oscilloscope and TF 2600 Voltmeter. After describing the nature, characteristics and many uses of ferrites, the methods of testing important parameters are detailed, for example measuring flux density, permeability and Q/frequency characteristic, checking waveform distortion and displaying hysteresis loops.

VOLUMES have been written on this complex subject. It is hardly within the scope of this article to enumerate the multitude of available types or their characteristics but rather to show how with a few "workhorse" laboratory instruments much knowledge can be obtained concerning the behaviour of a ferrite core material as it is being shaped into a practical and manufacturable instrumentation component. Most of the information needed to determine the choice of material and mechanical dimensions can be acquired through use of the TF 1245 Circuit Magnification Meter with one of its oscillators, the TF 1331 Oscilloscope and the TF 2600 Sensitive Valve Voltmeter. This trio of precision instruments can perform a great many of the measurements required in today's complex electronic activity, and a laboratory without them is like a machine shop without a lathe, drill and vice.

Generally speaking, ferrites are metallic oxides combined in a fantastic array of compositions each for a definite purpose. They have magnetic and mechanical properties interlinked to an extent that has made possible much of this decade's electronic advance. Ferrites have supplanted iron cores in many instances where low loss and special magnetic behaviour are needed more than just high flux carrying capability. Several pages would be required to list all of the possible uses, some of which are modulators, memory cores, discriminators, fractional turn transformers, antenna cores, i.f. and wideband transformers, deflection yokes, recording heads, flyback cores, carrier telephone filters, adjustable inductors, switch cores, magnetic amplifiers, delay lines, oscillators, transducers, loading coils, temperature controls, mechanical to electrical transducers, pulse transformers, etc. Characteristics vary from linear magnetization to moderately non-linear, highly non-linear, rectangular loop, magnetostriction, mechanical resonance, and in microwave applications, use is found of the phenomenon of anisotropic dispersion of permeability or directional resonance losses caused by the combined effects of the high frequency field and the spins at these frequencies.

Ferrites can be furnished for frequency applications ranging from d.c. to 24 Gc/s with varying degrees of behaviour complexity.

Losses in ferrites usually involve a compromise with initial permeability. The higher the permeability the more limited is the upper frequency range. Sometimes six digit permeability of certain metal core materials is considered less important than the mechanical rigidity and simplicity of ferrites of lower permeability, such as cup cores. Initial permeability as high as 5,000 has been developed extending the advantages of ferrites to the lower audio frequencies and broadband communication transformers. Many popular transformer laminations can be replaced by one-piece E cores. On the other hand, ferrites suitable for use at 500 Mc/s may have permeability of only 10.

The three basic losses in ferrite and other magnetic materials are eddy current, hysteresis and residual loss. The two former are widely understood, the latter is believed to be a resonance condition involved in the high frequency limitation of ferrite core materials.

The figure of merit for a ferrite, designated as the product of Q and initial permeability is a determining factor of the upper frequency limit of a material type. The loss factor is defined as the reciprocal of the product of Q and initial permeability.

Basic data is of course available from the manufacturer and may be a primary consideration when a selection is to be made. However, the manufacturer cannot be familiar with the problems of every application and configuration of his product. In the final analysis it behoves the user to study the geometry of his own construction and narrow his choice of materials to the best compromise. In many cases he will find that the published performance data was made on ring samples under ideal conditions. The effective permeability of the type of core used may be considerably lower due to leakage and a less efficient winding in which all of the turns do not link with the core as well as in the case of the ideal toroid upon which the published data had been taken. The practical construction may even contain an

*Mr. Hasbrouck is an Electronic Engineering Consultant in the U.S.A.

air gap or an irregular cross sectional area. Much of the flux may not reach its intended destination; the gap in a recording head, for example, the flux having taken a short cut across the core.

Flux goes through air, electricity doesn't. A crude analog of a magnetic circuit might be stated as the placing of an electrical network into a bath of conductive salt water. The anticipated output terminal voltage no longer exists, having been degraded by many leakage paths. With the three instruments mentioned earlier, the magnetics engineer can determine the permeability, losses and leakage flux performance of a wide range of magnetic materials.

Voltmeter-Oscillator Analysis

Usually the function of a core is to conduct flux from one location to another. If the excitation current and coil turns are maintained it is possible, by means of a search coil, to determine the exact flux passing through any slice of cross section, anywhere in the core, at any frequency. Because of the high sensitivity of the TF 2600 Voltmeter, a very low inductance search coil can be

following formula:—

$$E_{rms} = 4.44 f N \phi_m 10^{-8} \text{ volts}$$

where N = number of turns on search coil

ϕ_m = maximum value of flux in lines or
Maxwells

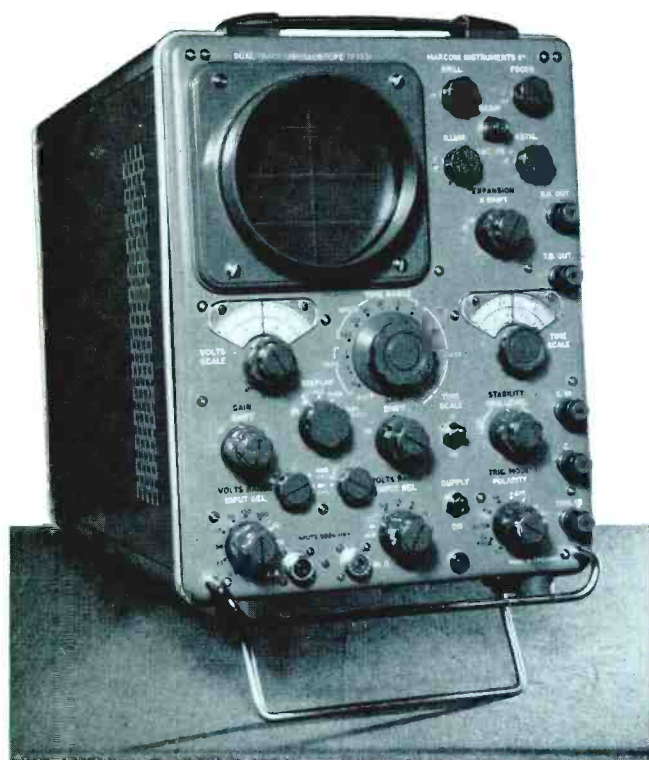
f = frequency in c/s.

From a knowledge of the area within the search coil, the flux density can be determined. This is a valuable attack since no heed need be paid to the configuration of the exciting winding, number of turns, or arrangement of the field generating coil, or short cut leakage paths across the magnetic path before the point of interest in the cores. The only requirement is that exciting ampere-turns remain constant with frequency, that the excitation is sinusoidal and that the flux variation in the core is of sinewave form. To maintain constant exciting current with frequency, sufficient resistance must be placed in series with the exciting field coil so that its rising reactance does not control the current in the core. Or as an alternative, one may monitor the excitation current by observing the voltage across a small non-inductive series resistor, using the TF 2600 Voltmeter. Usually this step can be omitted after it has been established that constant current has been achieved over the bandwidth under investigation.

This voltmeter method not only determines the flux through the area involved at the point of interest, but reveals the behaviour of the core material at various frequencies. If a mid-point frequency is taken for reference and the frequency altered, the output voltage of the search coil, being proportional to the rate of change of flux, will vary 6dB per octave in either direction from reference, provided the flux remains constant. If the output voltage does not follow the 6dB per octave condition as the frequency is raised over the desired bandwidth, the core material is probably inadequate for the job. At low frequencies it may be found that the output voltage from the search coil is lost in noise. If this occurs the voltmeter sensitivity can be extended by means of a well shielded input transformer. The characteristics of the transformer must of course be known.

There is possibility of error in the high frequency region due to resonance caused by the input capacitance of the voltmeter and leads in shunt with the inductance of the search coil. This resonance should be anticipated and investigated in advance, being placed above the range investigated. For this reason, the search coil inductance is made as small as possible. If this precaution is not observed, one may find a rising search coil voltage in excess of 6dB per octave. Even if the rise appears normal and a resonance is beginning it will obscure the true flux existing at the point of interest.

By the method described, core materials have been investigated for video applications from a frequency of 60 c/s to 8 Mc/s with no particular difficulty. The search coil winding was altered three times to cover this range to optimize the signal-to-noise ratio, which otherwise would be insufficient at the low frequency end of the



The TF 1331 Oscilloscope—one of the author's 'workhorses'

used, two or three turns of fine wire usually sufficing. These are wound tightly around the core near the air gap or where the core has been narrowed in a saturable element, or at any location of interest. Due to the high input impedance of the TF 2600 voltmeter the search coil is effectively unloaded and its open circuit voltage can be used to determine the flux according to the

range, with a coil having a suitably high resonant frequency. At the high frequency end, a single turn search coil was adequate and the voltmeter was augmented by the TF 1331 Oscilloscope which had the required extended frequency range. Use of the oscilloscope is suggested at all times as a check on waveform. However, it must be borne in mind that if there is distortion present, the apparent amplitude of harmonics will be exaggerated, second harmonic by a factor of two and third harmonic by a factor of three, because the output from the search coil is proportional to frequency. The voltmeter reading will also be affected by the presence of harmonics for the same reason. If flux waveform is other than a sinewave, at the point of interest, it may be that realistic excitation is not being employed. All measurements suffer when normal operating conditions are not observed. However, as mentioned, the view of the flux waveform at the point of interest may look worse than it really is, due to the differentiating action of the coil. For this reason, if the quality of flux waveform at the realistic excitation level is to be investigated, the oscilloscope and voltmeter should be preceded by an integrating circuit, whereupon they will indicate the true flux without harmonic magnification. When it has been established that the integrating circuit has a 6 dB per octave slope, both flux level and waveform can be observed at the same time, and the voltmeter reading will not change with frequency if the flux is constant. This is a more complicated procedure and may be unjustified for the degree of information sought.

By the 6 dB per octave method the shortcomings of laminated metal cores at once become obvious. A ring sample of Supermalloy tested in this manner failed to deliver flux to the search coil by as much as 10 dB at 8,000 c/s even though its thickness was only .001 inch, whereas a ring sample of ferrite, of a certain type, having the same physical dimensions and configuration of excitation and search coils, was still delivering the correct flux to the measuring area within 0.1 dB at 8 Mc/s. This

is not a criticism of Supermalloy which has, of course, a much higher permeability than the ferrite and serves well in applications where the ferrite could not be used at all.

Q Meter Analysis of Core Behaviour

The TF 1245/TF 1246 Circuit Magnification Meter and Oscillator combination is ideal, among countless other uses, for determining Q/frequency characteristics of coil and core assemblies. Calibrated in Q it is only necessary to connect the device under study to the terminals and, with a suitable value of capacitance as provided by the variable capacitor of the instrument, tune to resonance and note the Q. This is then repeated at other frequencies, and in this manner, a plot can be prepared indicating at what frequency the maximum Q is obtained. This establishes the upper limit of usefulness of the core material with respect to frequency, but not necessarily the lower limit, since if frequency is reduced, the curve will simply lose its flattened top and assume a 6 dB per octave slope downward, because the inductive reactance is diminishing uniformly with frequency and the losses no longer control the circuit Q. It is assumed in Q/frequency tests that the winding form used is sufficiently efficient to render copper losses negligible, leaving the effective increase in coil resistance due mainly to the transformed shunt resistance of the core loss. One can then consider that only the core characteristic is being seen.

In Q/frequency tests of a toroidal core, a single layer winding fully embracing the circle is needed. Since the capacitance and frequency are both known for each point on the curve, the inductance at various frequencies can also be found. As losses increase, the effective inductance will fall.

Permeability (effective at each frequency) can be determined by substituting a similar coil wound on a styrene ring of identical dimensions to the magnetic core to be evaluated and measuring its inductance. The



Mr. A. Spencer, of our U.S.A. Office, and Mr. T. Clarke, Midland Area representative, testing coil characteristics with a Circuit Magnification Meter type TF 1245 (centre) and Sensitive Valve Voltmeter type TF 2600 (top right)

inductance ratio of the air and magnetic cores can be considered as the effective permeability of the magnetic core for the particular construction, although some prefer to simply call this the inductance ratio. By these operations, the frequency limitations of the material become quite obvious. If the core is to be exposed to higher flux densities in use than during measurement, the errors that might occur must be taken into consideration.

When a core material having a rectangular magnetization character is taken to saturation in a cyclic manner the dynamic hysteresis loop can be displayed on the TF 1331 Oscilloscope using a fairly simple circuit. This is shown in Fig. 1 and an oscillogram of the result in Fig. 2.

present, the search coil would indicate true flux, but because the core is driven to saturation, there will be strong odd harmonic frequencies present which will present an erroneous deflection on the oscilloscope due to differentiation. Therefore, it becomes necessary to provide an integrating device in the output circuit so that the vertical deflection on the oscilloscope will indicate flux without harmonic magnification. The capacitor and resistor serve this function. Before displaying the square hysteresis loop, it must be verified that the integrating circuit has a 6 dB per octave slope in the frequency region being investigated. Thus, if the test is to be made at 1 Mc/s the vertical sensitivity of the oscilloscope should drop to half at 2 Mc/s, to one quarter

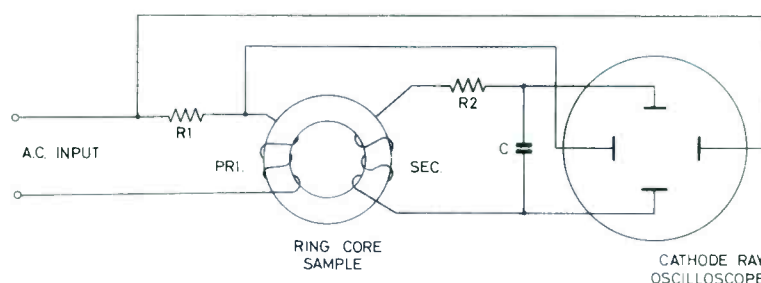


Fig. 1. Circuit arrangement for display of dynamic hysteresis loop on cathode ray oscilloscope. R_1 produces deflection proportional to excitation current. R_2 and C form the integrating network so that vertical deflection is proportional to flux.

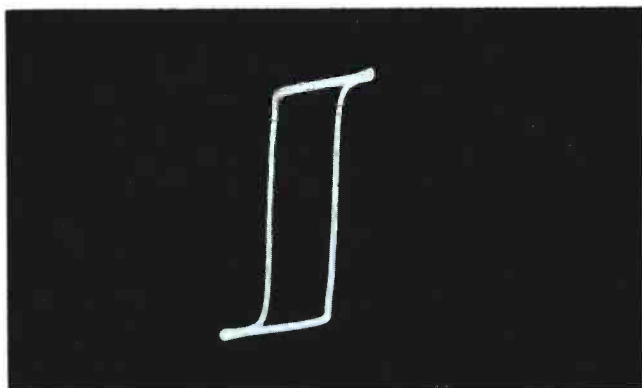


Fig. 2. Oscillogram of hysteresis loop of ferrite material obtained from the circuit of Fig. 1

The core requires two windings, one for excitation and one to indicate resulting flux. Sinewave excitation is employed. The exciting current is applied to the horizontal input of the oscilloscope as a voltage obtained from a resistor in series with the excitation coil. The other oscilloscope input is connected to the search coil, the output voltage of which is proportional to the rate of change and intensity of flux. If only one frequency were

at 4 Mc/s and so forth, although it is unlikely that harmonics beyond the third will cause trouble. Some reversal of leads may be necessary to obtain the conventional form of presentation shown.

The test is not limited to rectangular hysteresis loops and naturally a dynamic loop for any material can be displayed. Or a family of loops may be shown at different degrees of magnetization to study the development of saturation. The cyclic rate can be changed and since circulating currents within the magnetic material dissipate energy, greater magnetizing fields are required as the frequency is increased in order to maintain flux density. Thus it will be observed that the width of the hysteresis loop increases. Eddy current losses in laminated metal cores are quite severe, even in thin materials, compared with ferrites where they occur to a lesser extent within the particles of a high resistance composition. Ferrites of higher permeability do have considerable electrical conductivity but the resistivity is usually greater than in metal laminates. Hysteresis losses, however, being related to the frictional forces opposing the rotation and alignment of magnetic domains, exist in varying amounts in all magnetic materials, and since these must be overcome on each flux reversal, the loss is frequency dependent.

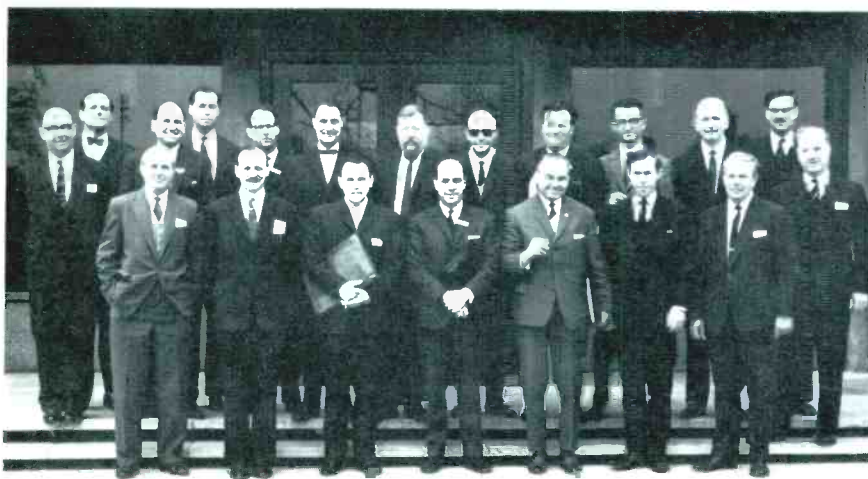


Making Contact

To celebrate the opening of the new Engineering and Administration Building at St. Albans parties of visitors from industrial, educational and government establishments have recently toured the laboratories and works. Here one of the groups finds a new signal generator of interest



While our major mobile unit is touring Great Britain, two Mini-vans will be visiting nine European countries this summer in order to demonstrate Marconi Instruments equipment on the spot. Mr. B. Morris, Export Regional Manager, demonstrates the mobility of the rack mounting instruments prior to loading them together with their trolley



European journalists meet Marconi Instruments executives. One of the five parties of European technical and industrial journalists, who came to England under the auspices of the Electronic Engineering Association and the Foreign Office, found much to interest them at St. Albans. The purpose of the visit was to give European representatives of the press a comprehensive view of the U.K. electronics industry

Summaries of Articles appearing in this issue

RESUME D'ARTICLES PUBLIES DANS LE PRESENT NUMERO

COMPTEUR ELECTRONIQUE TF 2401

Le compteur électronique TF 2401 est une toute nouvelle réalisation, caractérisée par le fait que toutes les voies d'entrée sont réunies en un seul bloc enfichable. Tous les montages du compteur, (à affichage à huit chiffres horizontaux), sont en matières cristallines et comportent de nombreux diodes et de transistors logiques. Le bloc de gamme des valeurs TM 7557 et le bloc compteur/chronoscope fonctionnel TM 7558 permettent une vitesse maximale de comptage pouvant dépasser 50 MHz et des mesures de temps aussi brèves que le dixième de microseconde. Cet appareil a été conçu dès le départ pour présenter le minimum d'encombrement, une vue agréable à l'oeil, et des commandes, montées sur la platine, très simplifiées.

Page 132

QUELQUES MOTS SUR LA LOGIQUE DES COMPTEURS ELECTRONIQUES

Les techniques de la logique, plus généralement appliquées aux calculatrices, ont été mises à profit pour réaliser le compteur, type TF 2401.

On trouvera ici une brève description de certains des éléments logiques ainsi mis en oeuvre et du rôle qu'ils jouent dans ce compteur.

Page 138

L'IMPORTANCE QUE PRESENTE LA LECTURE PRECISE DU ZERO DU VOLTMETRE

L'auteur expose les précautions nécessaires pour obtenir une lecture de précision optimale sur tout modèle de voltmètre à lampe, et plus particulièrement les commandes du zéro tant mécanique qu'électrique. Il indique également l'erreur de lecture

décollant d'un zéro incorrect, obtenue avec un voltmètre électronique à sonde HF et à indication de pointe.

Les effets que produisent les parasites d'origine interne sur les voltmètres à courant alternatif à amplificateur de haute sensibilité sont étudiés avec quelques détails intéressants, et un tableau des erreurs correspondant à différents pourcentages de la déviation à fond d'échelle est également annexé.

Page 144

FILTRE ELIMINATEUR ACCORDABLE, TYPE TF 2334

L'auteur expose les limites des possibilités des analyseurs d'ondes pour la mesure des niveaux de distorsion harmonique et indique que l'utilisation d'un filtre éliminateur accordable pourrait vaincre ces difficultés dans une grande mesure. Il décrit ensuite les caractéristiques que doit présenter un tel filtre et le rôle que celles-ci ont joué dans la conception du TF 2334.

L'auteur propose également une méthode qui permettrait d'accroître les possibilités de l'analyseur d'ondes TF 2330 en mesurant tant la distorsion non linéaire que celle d'intermodulation.

Page 146

EVALUATION ET CONTROLE DES FERRITES

On peut réaliser la plupart des mesures nécessaires pour évaluer les ferrites avec un Q-mètre TF 1245, un oscillateur TF 1246, un oscilloscope TF 1331 et un voltmètre TF 2600. Après avoir décrit la nature, les caractéristiques et cité de nombreuses utilisations des ferrites, on indique aussi, et en détail, les méthodes préconisées pour contrôler d'importants paramètres tels que, par exemple, la mesure de la densité du flux, de la perméabilité, du rapport surtension/fréquence et la vérification de la distorsion de la forme d'onde et l'affichage des boucles d'hystérésis.

Page 150

ZUSAMMENFASSUNG DER IN DIESER NUMMER ERSCHEINENDEN BEITRÄGE

DAS ZÄHLGERÄT TF 2401

Das Zählgerät TF 2401 ist das Ergebnis einer vollständig neuen Entwicklung mit der Neuerung, daß alle Eingangskanäle als Einsteck-Moduln gebaut sind. Auf diese Weise lassen sich bei Benutzung eines gemeinsamen Grundgerätes sehr viele Anwendungsmöglichkeiten erreichen. In dem Zählgerät, welches eine einzeilige Anzeige mit 8 Ziffern besitzt, werden durchweg Halbleiterschaltungen und logische Schaltungen mit Dioden und Transistoren verwendet. Der Bereich-Einschub TM 7557 und der Zähl- und Zeitmeß-Einschub TM 7558 ergeben eine maximale Zählgeschwindigkeit von mehr als 50 MHz und gestatten die Durchführung von Zeitmessungen bis herunter auf 0,1 µs. Es wurde Wert darauf gelegt das Gerät klein zu halten und ihm ein ansprechendes Äußeres mit einfachen Einstellmitteln auf der Vorderseite zu verleihen.

Seite 132

EINE EINFÜHRUNG IN DIE LOGISCHEN SCHALTUNGEN VON ZÄHLGERÄTEN

In dem Zählgerät TF 2401 wurde die häufiger in Verbindung mit elektronischen Rechenanlagen genannte logische Schaltungstechnik angewendet. Einige logische Grundelemente werden kurz beschrieben und auf ihre Anwendung in dem Zählgerät wird Bezug genommen.

Seite 138

DIE BEDEUTUNG EINER GENAUEN NULLPUNKTEINSTELLUNG BEI ELEKTRONISCHEN SPANNUNGSMESSERN

Die notwendigen Schritte zur Erreichung maximaler Anzeigegenauigkeit bei allen elektronischen Spannungsmessern werden untersucht. Hierunter fällt die richtige Bedienung der mechanischen und elektrischen Nullpunkteinstellungen. Der infolge falscher Nullpunkteinstellung gegebene Anzeigefehler bei einem Detektor-

Spannungsmesser mit Spitzenspannungsanzeige wird ermittelt. Die Wirkung des Eigenrauschens in Wechselstrom-Spannungsmesser mit eingebautem empfindlichen Verstärker wird im einzelnen betrachtet und eine Fehlertabelle für verschiedene Prozentsätze des Vollausschlages ist angegeben.

Seite 144

ABSTIMMBARES SPERRFILTER TF 2334

Die bei einem harmonischen Analysator vorhandenen Grenzen bei der Messung kleiner Klirrfaktoren werden besprochen und es wird gezeigt, daß sich diese Schwierigkeiten weitgehend durch die Verwendung eines abstimmbaren Sperrfilters vermeiden lassen. Die an ein solches Sperrfilter zu stellenden Anforderungen und deren Auswirkung auf die Konstruktion des Filters TF 2334 werden beschrieben. Es werden Methoden für die Benutzung des Filters zur Erweiterung des Anwendungsbereiches des harmonischen Analysators TF 2334 bei der Messung von Klirr- und Intermodulationsverzerrungen vorgeschlagen.

Seite 146

DIE BEWERTUNG UND PRÜFUNG VON FERRITEN

Die meisten für die Bewertung von Ferriten erforderlichen Messungen können mit dem Gütefaktormesser TF 1245, dem Oszillator TF 1246, dem Oszillographen TF 1331 und dem Röhrenvoltmeter TF 2600 durchgeführt werden. Nach einer Beschreibung der Arten, Eigenschaften und vielseitigen Anwendungen von Ferriten werden die Methoden der Prüfung von wichtigen Parametern im einzelnen behandelt, wie z.B. die Messung der Flußdichte, der Permeabilität und der Kurven der Kreisgüte als Funktion der Frequenz, sowie die Prüfung auf Verzerrungen und die Anzeige von Hysteresisschleifen.

Seite 150

SOMMARIO DEGLI ARTICOLI PUBBLICATI IN QUESTO NUMERO**CONTATORE TF 2401**

Il contatore TF 2401 è un modello completamente nuovo che ha tutti i canali d'ingresso del tipo modulare a innesto. Ciò permette di ottenere con un unico strumento fondamentale una vasta gamma di prestazioni. Il contatore con lettura allineata a 8 cifre è interamente costruito con circuiti a stato solido e fa largo uso di logiche a diodi e a transistori. Il modulo TM 7557 per la selezione di gamma ed il modulo TM 7558 per la funzione contatore-misuratore di tempi permettono massima velocità di conteggio fino ad oltre 50 MHz e misure di tempi brevissimi fino a 0,1 μ sec. Ci si è molto curati di presentare uno strumento di piccole dimensioni ed elegante, che si distingue per la semplicità dei comandi sul pannello frontale.

Pagina 132

UN' INTRODUZIONE ALLA LOGICA DEI CONTATORI

I metodi logici, che ricorrono più comunemente nel progetto di calcolatrici, sono alla base del progetto del Contatore TF 2401. Si dà una breve descrizione di alcuni elementi logici basilari e si accenna al loro uso nel Contatore.

Pagina 138

LO ZERO DI UN VOLTMETRO E SUA IMPORTANZA

Si considerano le precauzioni necessarie per ottenere una precisione massima di lettura con un qualunque tipo di voltmetro elettronico. Queste presuppongono l'uso corretto delle regolazioni dello zero sia meccaniche che elettriche. Si riporta l'errore di lettura dovuto a imprecisione dello zero quale si riscontra in un voltmetro

del tipo rivelatore al diodo per letture del valore di picco. L'effetto del rumore generato internamente su di un voltmetro c.a. del tipo amplificatore sensibile viene analizzato abbastanza dettagliatamente, e si riporta una tavola di errori per diverse percentuali della deviazione di fondo scala.

Pagina 144

FILTRO SINTONIZZABILE A SOPPRESSIONE TIPO TF 2334

Si discutono le limitazioni di un analizzatore d'onda quando venga adoperato per misurare livelli bassi di distorsione armonica, e si mostra come queste difficoltà potrebbero essere largamente superate adoperando un filtro a soppressione sintonizzabile. Si riportano le specificazioni di un tale filtro e si descrive il loro peso nel progetto del TF 2334. Si suggeriscono modi di adoperare il filtro per estendere la portata dell'Analizzatore d'Onda tipo TF 2330 per misurare sia la distorsione armonica che di intermodulazione.

Pagina 146

LA VALUTAZIONE DI FERRITI E METODI DI PROVA

La maggior parte delle misure che si richiedono per la valutazione di ferriti può effettuarsi con il misuratore del Q TF 1245, l'oscillatore TF 1246, l'oscillografo TF 1331 ed il voltmetro TF 2600. Dopo una descrizione della natura, caratteristiche e usi diversi delle ferriti, si dà una lista dettagliata dei metodi di prova di importanti parametri, ad esempio la misura della densità del flusso, della permeabilità e della caratteristica di frequenza del Q, il controllo delle distorsioni della forma d'onda e la presentazione visuale di cicli d'isteresi.

Pagina 150

RESUMENES DE ARTICULOS QUE APARECEN EN ESTE NUMERO**CONTADOR TF 2401**

El contador TF 2401 es un nuevo modelo con la característica, también nueva, de que todos los canales de entrada tienen técnica modular enchufable. Por ello, se consigue un número considerable de aplicaciones, ya que utiliza un mismo elemento básico. El contador, que tiene lectura en línea, en décadas, de ocho dígitos, emplea todos los circuitos con estado sólido, y hace un gran uso de la lógica con diodos y transistores. Los módulos de margen, TM 7557, y los de función, calculador/contador TM 7558, permiten una operación máxima de cuenta superior a los 50 MHz, y medidas de tiempo tan pequeñas como 0,1 μ seg. Se ha extremado el cuidado en la fabricación para obtener un aparato de tamaño reducido y agradable apariencia, y su panel frontal tiene gran sencillez de mandos.

Pagina 132

INTRODUCCION A LA LOGICA EN LOS CONTADORES

Las técnicas lógicas más comunemente asociadas con los calculadores, se han empleado en el contador TF 2401. Damos una breve descripción de algunos de sus elementos básicos lógicos, haciendo referencia a su empleo en el contador.

Pagina 138

PUESTA A CERO DEL VOLTIMETRO—SU IMPORTANCIA

Se consideran las precauciones necesarias para obtener la precisión máxima de lectura con cualquier tipo de voltmetro electrónico, que comprenden el empleo correcto de controles mecánicos y eléctricos para puesta a cero. El error en la lectura producido por el cero incorrecto se obtiene con el voltmetro de

lectura de pico, tipo detector diodo. Se considera también, con algún detalle, el efecto del ruido engendrado en el amplificador del voltímetro sensible, de c.a. Aparece una tabla de errores en diferentes porcentajes de deflexión a fin de escala.

Pagina 144

FILTRO SINTONIZABLE, ELIMINADOR, TIPO TF 2334

Se estudian las limitaciones del analizador de ondas cuando se emplea para medir niveles bajos de distorsión armónica, y se indica que el uso de un filtro sintonizable, eliminador, resolvería en alto grado las dificultades. Se detallan las razones que aconsejan el empleo de este filtro, así como su repercusión en el proyecto del mismo. Se recomiendan varios métodos de empleo del filtro para ampliar el margen del analizador de ondas tipo TF 2330, en medidas de distorsión de armónicos y de intermodulación.

Pagina 146

VALORACION Y PRUEBA DE FERRITAS

La mayoría de las medidas necesarias para la valoración de ferritas, se pueden realizar con el medidor de "Q" TF 1245, el oscilador TF 1246, el osciloscopio TF 1331 y el voltímetro TF 2600. Después de describir la naturaleza, características y múltiples usos de las ferritas, se detallan los métodos de prueba de sus parámetros importantes, por ejemplo, de densidad de flujo, Q/respuesta de frecuencia, permeabilidad, comprobación de la distorsión en formas de onda, y presentación de ciclos de histéresis.

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MARCONI MESSTECHNIK G.m.b.H.
WOLFRATSHAUSER STRASSE 243, MÜNCHEN-SOLLN
Telephone: 797321 Telex: 524642

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