VOL. 9 NO. 3 SEPTEMBER, 1963

MARCONI INSTRUMENTATION

A Technical Information Bulletin
Issued Quarterly by
Marconi Instruments Limited, St. Albans, England

IN THIS ISSUE

ELECTRONIC INSTRUMENTS FOR TELECOMMUNICATIONS AND INDUSTRY

VOL. 9 NO. 3

SEPTEMBER, 1963

MARCONI
INSTRUMENTATION

Issued with

the compliments of

MARCONI INSTRUMENTS LIMITED

ST. ALBANS

ENGLAND

EDITORS

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What's New?

DURING THE NEXT MONTH or two some 25,000 copies of the new Marconi Instruments catalogue will be distributed. Previous issues of this hardy annual have appeared at the beginning of each year, but now it is to become a biennial publication. Together with this change of recurrence frequency will be a bright new layout and appearance. There is more emphasis on information in diagrammatic form and there are more illustrations, mostly in colour.

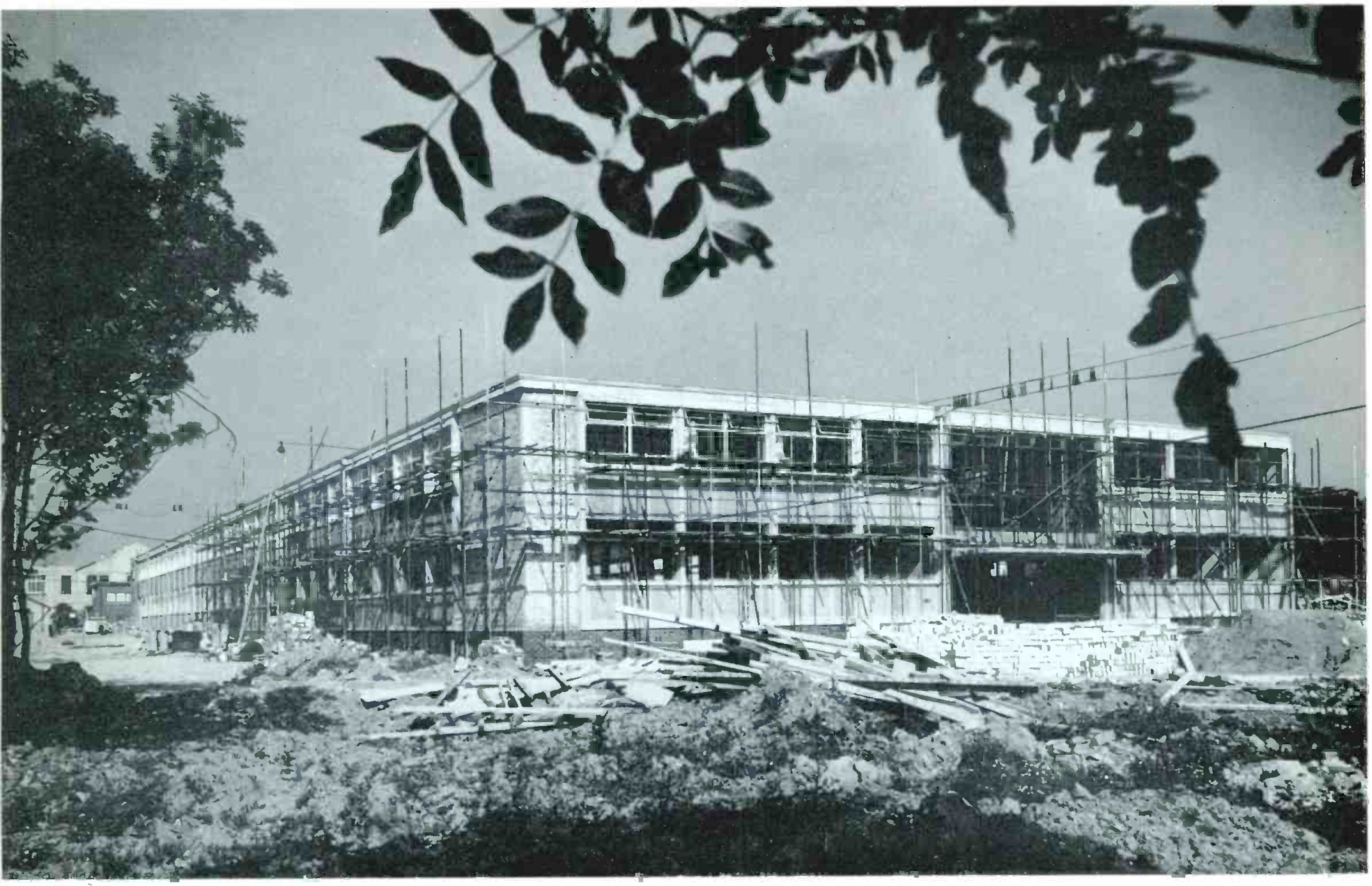
Things have changed a lot in the ten years since we first issued a bound catalogue instead of the previous loose-leaf version. One very noticeable feature is in the field of industrial design—not only of equipment but in typography and packaging—the importance of which has become widely accepted by consumers and producers alike. So much so that an instrument with a 1953 appearance presented in a 1953 catalogue style would have much less appeal today even if its specification was right: technical performance alone is no longer good enough. It does not invariably follow that 'if it *looks* right it *is* right' but there is often much truth in the saying—after all it is reasonable to assume that if effort and care have obviously gone into an instrument's presentation it has probably also gone into its electrical design.

All the 14 new instruments to be featured in the catalogue illustrate the modern trend in industrial design, and most of them are made on the modular principle described in the previous issue of this journal. Altogether about 70 different instruments are to be catalogued, more than 50 of which are manufactured for stock. The remainder are more specialized instruments, or special versions of the standard model which are made to special order; these are given more concise treatment in separate sections of the catalogue. A brief description of instruments that are coming shortly is also included.

Other new designs will, of course, become available before the following catalogue comes out in 1965. These will continue to be described in this journal and will also be featured in brochures and in the concise catalogue, the latter coming out about once a year between the biennial publication of the main catalogue. The concise catalogue is published in six languages—English, French, German, Italian, Russian and Spanish—and there will be French, German and Italian versions of the main catalogue and brochures.

Most of the newly catalogued instruments have already been described in this journal. Just to remind you of them, or to introduce you to the newcomers, here are their summaries together with references to the article in which they were described. They are classified under the main headings as used in the catalogue.

Signal Generators. The range has been broadened by alternative versions of the v.h.f. generator TF 1066B and the u.h.f. generator TF 1060, both now offering wide-deviation frequency modulation. TF 1066B/6, described in this issue, has three deviation ranges giving up to 400 kc/s at modulation frequencies between 30 c/s and 100 kc/s. Although designed to have peak performance between 215 and 265 Mc/s for the benefit of users of telemetry equipment, it provides general-purpose service over the full '1066' range of 10 to 470 Mc/s. Wide deviation over a wide modulation frequency range are also features of the TF 1060/3, a f.m. version of the familiar TF 1060 a.m. generator, with a range of 450 to 960 Mc/s. This new model, which will be described in a future issue of *Instrumentation*, is particularly applicable to the



Another modular design in production at Marconi Instruments. This new building, which will house the engineering staff towards the end of the year, has a floor area of 32,500 square feet and is designed to allow for future expansion

testing of Band IV and V television sound equipment. It provides deviation up to 300 kc/s in three ranges at modulation frequencies from 30 c/s to 100 kc/s, and has very low residual f.m.

Oscillators have been brought up to date with the recent introduction of the transistorized 'modular' range described in Vol. 9, No. 2, June 1963. TF 2100 A.F. Oscillator provides a 600 Ω signal from 20 c/s to 20 kc/s at less than 0·1% distortion—a figure which can be still further reduced by a simple modification described on p. 64 of this issue. Its main applications lie in the testing of high fidelity audio equipment. For higher frequencies such as are used in line transmission there is the M.F. Oscillator TF 2101 with a range of 30 c/s to 550 kc/s.

A.F. and M.F. Signal Sources TF 2000 and TF 2001 comprise the A.F. and M.F. Oscillators with a monitored output level and step attenuator. TF 2000 gives balanced or unbalanced outputs up to +15 dBm at 75, 150 or 600 Ω, and has an attenuation range of 111 dB in 0·1 dB steps. TF 2001 has the same attenuation range and gives up to +3 dBm at 600 Ω or a reduced level at 75 Ω.

Voltmeters are augmented by the TF 2600 Sensitive Valve Voltmeter (see Vol. 8, No. 8, December 1962), an amplifier-rectifier instrument with a range of 10 c/s to 5 Mc/s, a measuring accuracy of 1% of full-scale from 50 c/s to 500 kc/s, and sensitivity ranges from 1 mV to 300 V full-scale.

Attenuators. The 'modular' range of instruments described in Vol. 9, No. 2, June 1963, adds a trio of step attenuators. TF 2162 M.F. Attenuator covers 111 dB in 0·1 dB steps at 600 Ω from d.c. to 1 Mc/s. TF 2161 M.F. Monitored Attenuator, with a range of d.c. to 550 kc/s, is, in effect, a TF 2162 plus a monitor voltmeter and an impedance changer to give a 75 Ω unbalanced output in addition to the normal 600 Ω. TF 2160, the A.F. Monitored Attenuator, has a range of 20 c/s to 20 kc/s with 75, 150 and 600 Ω balanced outputs, or d.c. to 550 kc/s at 600 Ω unbalanced.

Oscilloscopes show a marked expansion with two major newcomers. TF 2200 described in Vol. 8, No. 8, December 1962, is a versatile 35 Mc/s measuring oscilloscope with a rise time of 12 nsec and writing speeds up to 10 nsec/cm. Time and voltage measurements can be made by slideback techniques or centimetre graticule, and delayed sweep facilities enable any portion of a complex waveform to be examined. Y-amplifier plug-ins comprise single-trace and dual-trace units and a TV-differential unit with clamping facilities for television waveform measurements.

TF 2202 Double Beam Oscilloscope is due to appear in the next issue of *Instrumentation*. This measuring oscilloscope has a d.c. to 6 Mc/s bandwidth and a true double beam display is obtained by means of a 4-inch split beam tube. It is almost entirely transistorized and has a rugged panclimatic construction. Bench- or rack-mounting versions are available and it can be powered by a.c. mains or external batteries.

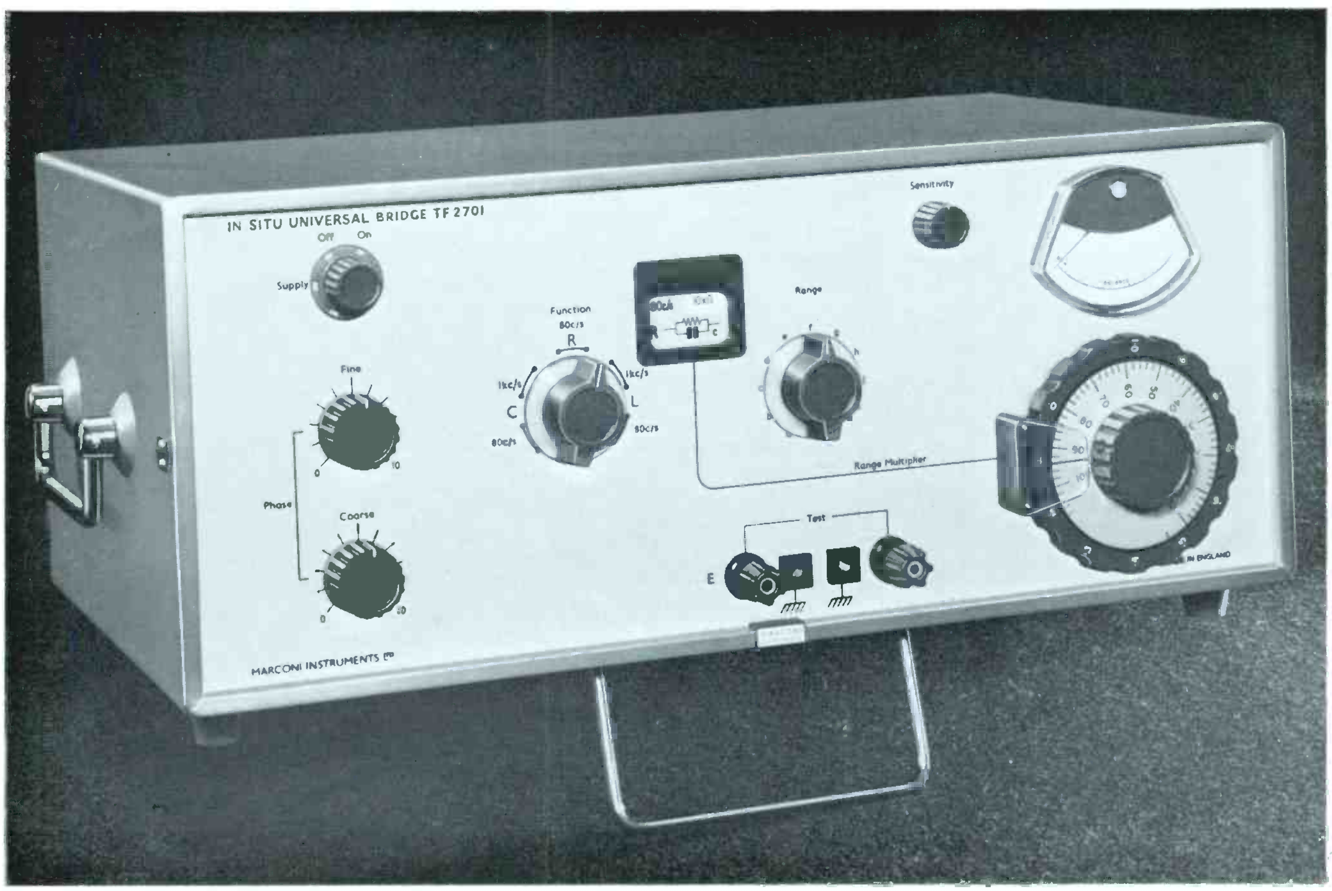
Power Meters. R.F. Radiation Power Meter TF 1396A was described in Vol. 8, No. 7, September 1962. This instrument, together with a set of aerials for X-, S- and L-band use, is designated type OA 1430 and appears as such in the new catalogue. Although the indicating unit can be used as a conventional power meter up to 10 mW between 10 Mc/s and 10 Gc/s, the complete instrument is designed to measure r.f. radiation intensity to ensure that operators or passers-by are not being subjected to a dangerous dose rate near high-power transmitters.

Bridges. Two battery operated transistorized bridges give increased advantages for measurement of inductors, capacitors and resistors to an accuracy of about 1%. TF 2700 Universal Bridge is an economically priced 2-terminal bridge for measurements at 1 kc/s internal with extra facilities such as provision for external a.c. and d.c. drive and d.c. polarizing supply. TF 2701 In-Situ Universal Bridge is a 3-terminal transformer ratio arm bridge capable of measuring components in circuit or with heavy shunting. TF 2700 appeared in Vol. 9, No. 1, March 1963, and TF 2701 in Vol. 9, No. 2, June 1963.

We believe that the catalogue in its new form will be found helpful and informative, and that the new instruments featured in it represent a significant advance in instrument technology.

J. R. H.

In Situ Universal Bridge type TF 2701. High performance in a simple, practical construction



MARCONI INSTRUMENTS NEW DESIGN

621.317.74

Transmission Measurements

AND THE NEW TRANSMISSION MEASURING SET . . *TYPE TF 2333*

by
H. C. GRIBBEN

A transmission measuring set consists of a wide-band signal source and a level meter. Its applications, requirements and possible sources of measurement inaccuracy are discussed, and it is shown how these inaccuracies are avoided or minimized in the design of the TF 2333.

IN THE previous issue of *Instrumentation* a range of new modular instruments was introduced. The basic oscillators and attenuators described, may, it was stated, be combined to produce various types of signal source. If, now, a wide-band level meter is added to a signal source, the combination of the three instruments is a Transmission Measuring Set (T.M.S.).

The purpose of this article is:

(1) to outline the requirements of a Transmission Measuring Set;

(2) to show how these requirements are met in the new instrument.

The Level Meter unit is described briefly since this was not covered in the last issue.

General

A Transmission Measuring Set is used for the measurement of gains, losses, power levels and frequency characteristics. It finds its most important application in the testing of audio and base-band equipment of multi-channel communication systems—in design, production, installation and, most important of all, in the maintenance of such systems. For installation and maintenance in the field the instrument should be portable and complete with interconnecting leads. Alternative mains or battery operation is an advantage.

Level Meter Requirements

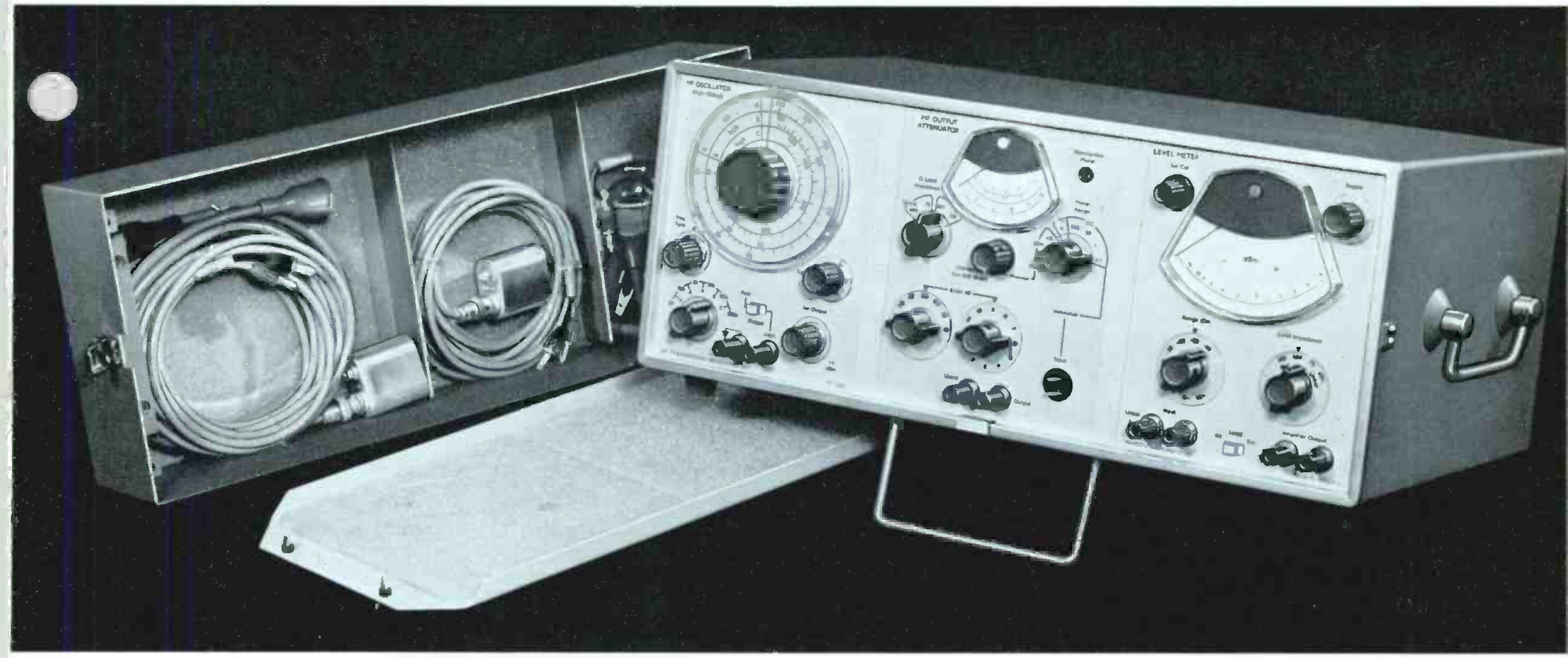
In the telecommunications field, power levels are usually expressed relative to a power level of 1 milliwatt, which is designated 0 dBm. A power level of 1 watt relative to 1 milliwatt is therefore $10 \log_{10} \frac{1000}{1} = 30$ dBm and, similarly, a level of 200 microwatts is -7 dBm.

The power levels developed along a multi-channel telephone cable link are subject to wide variations, due to line attenuation and to the gain produced by repeaters inserted at various points along the line. If the impedance at these points is accurately known, a voltage measurement will give an indication of the power. A level meter suitable for this purpose is a sensitive wide-band voltmeter, calibrated in terms of decibels relative to 1 mW (0 dBm) and capable of measuring levels of the order of -70 dBm to $+25$ dBm.

TABLE 1

Maximum number of telephone traffic channels	*Frequency limits of baseband, kc/s*	*Nominal impedance at baseband*	*Relative power level per channel, dB*	
			Input	*Output*
24	12–108	150 Ω bal.	−52	+4·5
60	12–252	150 Ω bal.	−52	+1·75
	60–300	75 Ω unbal.	−52	−15
120	12–552	150 Ω bal.	−52	+1·75
	60–552	75 Ω unbal.	−52	−15

Reproduced from C.C.I.R. Recommendation No. 189; Documents of the VIIIth Plenary Assembly, Warsaw, 1956, Vol. 1, p. 197.



TF 2333 Transmission Measuring Set comprises (from left to right) an oscillator, a monitored attenuator and a level meter. It is supplied with a splash-proof front-panel lid which also provides neat stowage for a comprehensive set of measuring leads

At speech frequencies the system impedance is usually 600 Ω. A power level of 0 dBm at this impedance corresponds to a voltage of 0·775 V r.m.s. At carrier frequencies the impedance of a link system is either 75 Ω unbalanced or 150 Ω balanced (see Table 1). The voltages developed across these impedances for a power level of 1 mW are 0·274 V and 0·387 V respectively. Consequently the level meter will give different indications for the same power level unless some means of correction is provided or unless impedance matching is accomplished by means of a transformer, in which case the correction is automatic.

There are two conditions under which a level measurement may have to be made:

(1) across a correctly terminated circuit of known impedance;

(2) across an unterminated circuit where it is necessary to provide the terminating load externally.

In the first case, sometimes called a 'bridging measurement', the level meter must have a high input impedance so that it does not affect the conditions in the circuit under test. If, for example, a measuring meter having an input impedance of 6000 Ω is used to measure power in a 600 Ω impedance, an error of −0·4 dB will result. The error will become tolerable if the level meter impedance is greater than 10,000 Ω. For measurements across lower impedances than 600 Ω, say 150 Ω or 75 Ω, the inaccuracies introduced will, of course, be less than in the example given.

In the second case the necessary terminating loads are usually incorporated in the level meter itself and the required impedance selected by means of a switch. (If an internal load of the same impedance as the circuit is switched in when a 'bridging' measurement is being made an error of −3·5 dB will be introduced.)

A level meter will have its greatest accuracy at the frequency and level at which it was standardized. At other frequencies the characteristics of the input transformer—if one is used—and amplifier, introduce errors in measurement. At other levels, the accuracy of the attenuator steps and meter calibration may also lead to a less accurate result. For extreme accuracy the level meter should be standardized at the level and frequency at which the measurement is to be carried out—if the approximate level is known.

Signal Source Requirements

For the measurement of gain, loss and frequency characteristic a variable frequency source of known power output is required in addition to the level meter.

The position in the circuit of the signal source output monitor is of importance because it has a bearing on accuracy of output, particularly at levels and frequencies other than those at which the instrument was calibrated (see Fig. 1). The monitoring meter is used to set up, and to check continuously, the power input to the attenuator. If the monitoring circuit were connected after the attenuator, very little, if any, deflection would indicate on the meter when the attenuation was switched into circuit, and would be useless, therefore, as a continuous monitor.

The transformer shown in Fig. 1 is for the purpose of impedance matching between the attenuator and the load connected to the output terminals. The monitor meter cannot indicate changes in output level due, for instance, to the changing frequency response of the transformer and attenuator over the frequency band. Possible causes of error of this kind are always covered in the specification of the instrument, and this should be studied carefully if the total effect of the various inaccuracies is to be assessed. It is common practice to standardize a signal source at 0 dBm and a frequency of 1 kc/s; the monitoring meter is set to indicate 0 dBm against a standard meter and load connected across the output terminals.

Accuracy of frequency calibration is not of importance and is typically of the order of 2% or 3%. For the measurement of gain, loss and frequency characteristic very low levels of distortion are not essential. The errors introduced into a measurement will be negligible if total harmonic distortion is not greater than about 2%.

directly from the attenuator when the switch is set for 600 Ω unbalanced. The slight additional fall in frequency characteristic, due to the transformer, at both ends of the frequency range is thereby avoided.

The attenuator has a total attenuation of 70 dB—6 steps of 10 dB each and 10 steps of 1 dB. Its input is monitored when the METER RANGE switch is set to the 0 dBm position. Other positions of this switch provide for monitoring voltages up to 0·1 V, 1·0 V, 50 V and 500 V d.c. and 10 V a.c. at the VOLTMETER INPUT front panel plug. The 10 dBm position is not normally used in the T.M.S. application of the M.F. Output Attenuator.

In the STANDARDIZE position of the STANDARDIZE/MONITOR switch, output is disconnected from the front panel terminals and connected across accurate internal load resistances. This ensures that the output power indicated on the meter is accurate for the chosen impedance provided that the meter calibration itself is correct.

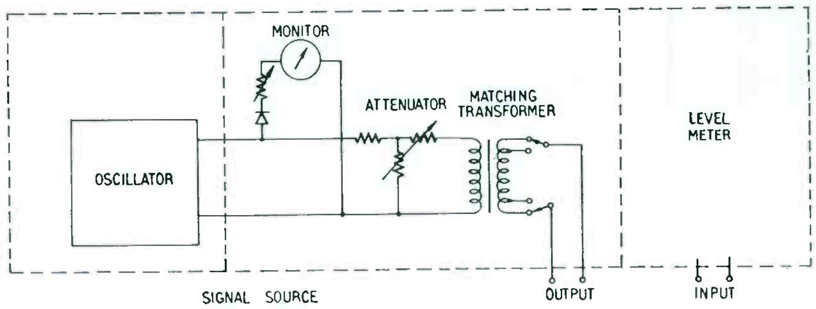


Fig. 1
Output monitoring arrangements of a transmission measuring set

Transmission Test Set TF 2333

TF 2333 consists of the three modules—M.F. Oscillator, M.F. Output Attenuator and Level Meter—mounted together in a single case. The instrument is completely transistorized.

The M.F. Oscillator covers the frequency range 30 c/s to 560 kc/s and it provides an output power, variable up to +3 dBm (2 mW), at an impedance of 600 Ω. A slide switch on the front panel allows the output to be taken from the front panel terminals or from a socket at the rear of the instrument. When the oscillator is used in the Transmission Measuring Set, this switch should be set to the REAR position so that the oscillator output is fed to the second unit, the M.F. Output Attenuator, which has an input socket at the rear, the two units being interconnected by a short length of coaxial cable.

Output from the attenuator unit is taken from terminals on the front panel. In the UNBAL positions of the IMPEDANCE selector switch the left-hand terminal is earthed. This switch is also used for the selection of the required output impedance—75 Ω or 600 Ω unbalanced, and 150 Ω or 600 Ω balanced.

A transformer, following the attenuator itself, and contained in a screening box in the same unit, is used for impedance transformation between the 600 Ω attenuator and output terminals. This transformer is used on three positions of the selector switch—75 Ω unbalanced, 600 Ω and 150 Ω balanced. Output is taken

The latter is standardized before dispatch at 1 kc/s and a level of 0 dBm but can be restandardized from time to time by switching the STANDARDIZE/MONITOR switch to MONITOR, connecting an accurate load resistance to the output terminals and measuring the voltage across the resistance by means of a suitable standard meter. If the internal monitor meter does not indicate 0 dBm when the standard meter indicates the correct voltage for the particular impedance, the front panel preset control labelled STANDARDIZE METER must be adjusted. After such adjustment, the monitoring system of the attenuator unit should remain accurate over a long period of time.

Level Meter

This is a wide-band amplifier designed for use in the frequency band 50 c/s to 560 kc/s (see Fig. 2). It is suitable for level measurements from +25 dBm to −70 dBm. The front panel attenuator RANGE switch is calibrated from +20 dBm through zero to −60 dBm, in 10 dB steps. The remaining +5 dB and −10 dB are covered by the calibration of the meter scale.

In the interests of high input impedance and good signal/noise ratio the attenuator is divided into two parts. One part forms the input circuit, and the second part is connected between the input differential amplifier and the main amplifier. On the final step—between −50 dB and −60 dB—the amplifier gain is changed. The three functions are controlled by the one switch.

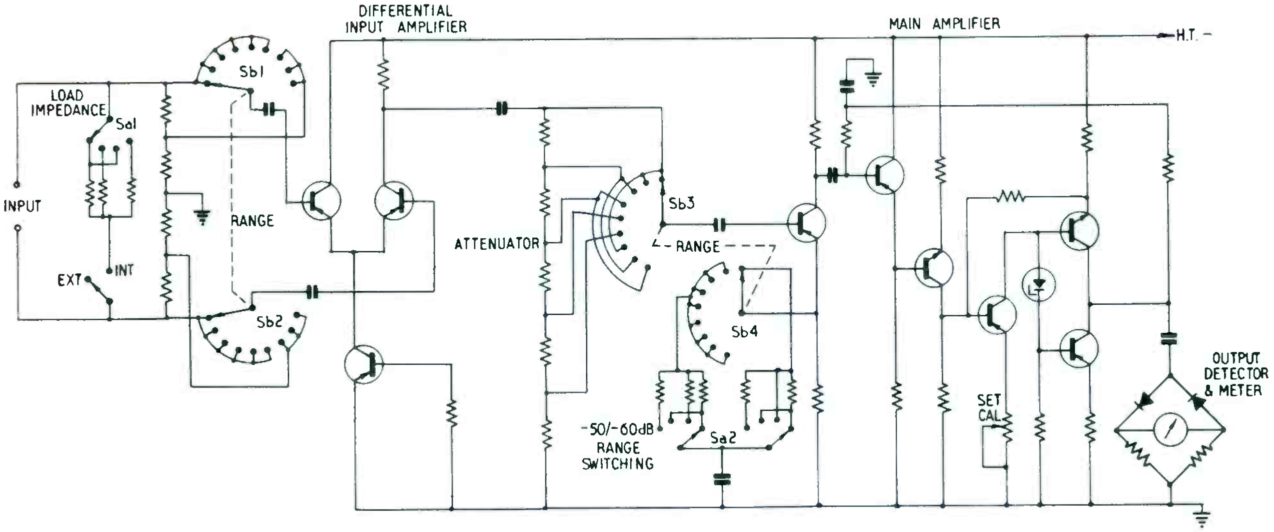


Fig. 2. Simplified circuit of Level Meter

Load impedances of 600 Ω or 75 Ω unbalanced, and 600 Ω or 150 Ω balanced may be selected by a switch. There is also a slide switch designated LOAD which has two positions, INT and EXT. When set to INT an accurate resistive load—selected by the LOAD IMPEDANCE switch—is connected across the INPUT terminals. On EXT the input impedance of the instrument is greater than 15 kΩ on all positions of the attenuator RANGE switch. Consequently, bridging measurements may be made without the introduction of errors due to the shunting effect of the level meter.

Impedance matching is accomplished by switching resistive loads across the input circuit, not by means of an input transformer. Some means must, therefore, be adopted for producing the same meter deflection at all impedances, when the input power is the same in each case. This is carried out in the Level Meter by gain switching. Amplifier gain is changed by means of the LOAD IMPEDANCE switch to that appropriate for the particular impedance. It is maximum on the 75 Ω position, 3 dB less on 150 Ω and 9 dB less on 600 Ω.

This method of impedance selection has a number of advantages compared with the more usual transformer method. The amplitude/frequency characteristic obtainable can be a good deal better than is possible by using a single transformer to cover the wide frequency range necessary. Two transformers would normally be used to give adequate performance, resulting in additional weight and space difficulties. Frequency response specification for the Level Meter is ±0·5 dB at 560 kc/s on the 75 Ω and 150 Ω input impedances—although tests on prototype instruments gave excellent results at 1 Mc/s, a fall in response of less than 1 dB relative to 1 kc/s being recorded for all attenuator positions down to −50 dBm. A second important consideration in favour of the system used in this level meter is that it is not so susceptible to pick-up, particularly hum pick-up from the mains supply.

These are the advantages of the method used for impedance selection; they must, of course, be balanced against the additional inconvenience of switching amplifier gain. (It must be mentioned that this method of providing the appropriate load inside the instrument itself cannot be applied to the output circuit of the signal source as conveniently as with the level meter. It will be remembered that a 600 Ω attenuator and transformer are used between oscillator and output terminals. If the transformer used for impedance matching is replaced by matching pads designed to provide 150 Ω and 75 Ω output impedances, considerable loss of power will result in both cases.)

Level Readings

The algebraic sum of the indications on RANGE switch and meter gives the input level in dBm. If, for instance, the range switch indicates −20 and the meter +3, the level at the input terminals is −17 dBm. The meter can be standardized against the attenuator unit meter by connecting the terminals to those of the signal source using the lead provided; with the signal source output set to read 0 dBm the level meter indication is brought to the same reading by adjusting the SET CAL control. This procedure should be carried out before making a series of measurements.

Amplifier Output

It is sometimes useful to view the level meter signal on an oscilloscope. Terminals marked AMPLIFIER OUTPUT are provided on the front panel for this purpose. The output obtainable is approximately 85 mV when the meter indicates 0 dBm. Output impedance is of the order of 1 kΩ.

Power Supplies

The signal source and level meter have independent internal power units. Mains or battery operation may be selected by means of slide switches on the rear panels of the oscillator and level meter. These panels also carry battery terminals for connection to an external battery having a voltage between 21·5 V and 30 V. The single mains input socket at the rear of the instrument is wired to the power input sockets on the units.

ABRIDGED SPECIFICATION

SIGNAL SOURCE

Oscillator

FREQUENCY RANGE: 30 c/s to 560 kc/s in five ranges.

FREQUENCY ACCURACY: ±3%.

MAXIMUM OUTPUT: At least +3 dBm.

Attenuator

RANGE: 70 dB in 10 dB and 1 dB steps.

ACCURACY: 50 c/s to 20 kc/s: ±1% of dB setting ±0·2 dB.

20 to 560 kc/s: ±2% of dB setting ±0·2 dB.

OUTPUT IMPEDANCE: Unbalanced: 600Ω and 75Ω.

Balanced: 600Ω and 150Ω.

DISTORTION: Less than 1% at 0 dBm.

HUM: Less than —70 dBm.

Output Meter

ACCURACY: Standardized at 0 dBm, 600Ω unbalanced, 1 kc/s.

Panel preset allows re-standardization at any of the other impedances.

FREQUENCY RESPONSE (relative to 1 kc/s): ±1·0 dB from 50 c/s to 560 kc/s.

LEVEL METER

FREQUENCY RANGE: 50 c/s to 560 kc/s.

LEVEL MEASUREMENT RANGE: +25 to —70 dBm.

MEASUREMENT ACCURACY: Can be standardized against signal source at 0 dBm, 1 kc/s.

FREQUENCY RESPONSE (relative to 1 kc/s at 0 dBm): ±1·0 dB from 50 c/s to 560 kc/s.

TERMINATED INPUT RESISTANCE: Balanced: 600Ω and 150Ω.

Unbalanced: 600Ω and 75Ω.

UNTERMINATED INPUT RESISTANCE: At least 15 kΩ on —10 to —60 dBm ranges; 100 kΩ (unbal.) on 0 to +20 dBm ranges; 200 kΩ (bal.) on 0 to +20 dBm ranges.

MARCONI INSTRUMENTS APPLICATION NOTE

621.317.772

MEASUREMENT OF PHASE ANGLE USING A COUNTER

by
A. J. SPENCER

The testing of V.O.R. navigational equipment involves the measurement of the phase angle between two 30 c/s signals to an accuracy of 0·1°—this is equivalent to a time difference of 9·26 μsec. Such a measurement can be made with Counter/Frequency Meter TF 1417 in terms of time difference by feeding one signal into the START *and the other into the* STOP *channel. As the counter will operate over a wide range of input voltages it is essential to present a sharp wavefront to the input circuit to obtain the required accuracy. Details are given of a small battery operated unit TM 7261 which amplifies and squares the signals to provide a suitable waveform at the counter input. By using an external timing unit it is possible to obtain a direct reading in degrees, rather than calculating the phase difference from a time measurement.*

THE USE of the V.O.R. navigational aid involves the measurement of the phase angle between two 30 c/s signals. In testing this equipment, the phase angle must be measured to an accuracy of 0·1°, which is equivalent to a difference in time of 9·26 μsec. If this phase angle is measured as the time interval between the two phases, then a counter such as the TF 1417 or TF 1345 can be used. The method is to measure the time between the phases by letting one start and the other stop the counter; comparing this time with the period of either phase will give the phase shift with a simple computation.

To measure this phase angle accurately requires that the counter shall trigger at the same level on each phase; any difference in level will appear as an error in time.

The error will be dependent on the slope of the waveform causing the triggering, the steeper the slope the less the error. Since the counters mentioned above have a variation in the level at which they trigger, they will need to be presented with a sharp wavefront so that this variation in level will not affect the accuracy. The unit described later has been designed to do just this.

In Fig. 1 the counter is started by phase 'A' and stopped by 'B' t seconds later, corresponding to the phase angle $\phi°$ between them.

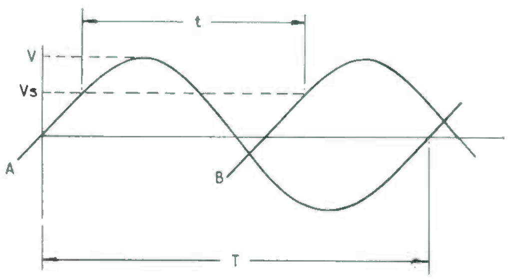


Fig. 1. Phase difference of two sinewaves expressed in time

If T is the period then $\phi = \frac{t}{T} \times 360°$.

In order that the time, t, be measured accurately, both phases must trigger at the same level, V_s. This level must remain constant since any change in V_s would appear as a change in time, and therefore an error in measuring the phase angle. Referring to Fig. 2, if V_s is the triggering voltage and varies by δV_s then the error in phase angle ϕ will be $\delta\phi$. The peak amplitude is V, and triggering occurs $\phi°$ after the zero point.

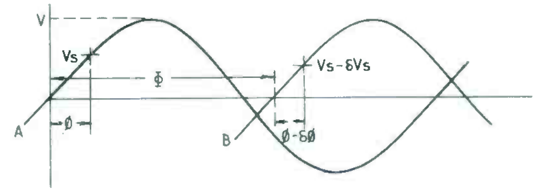


Fig. 2. Effect of variation of triggering level

Since $V \sin \phi = V_s$ and $V \sin (\phi - \delta\phi) = V_s - \delta V_s$,

$$\sin (\phi - \delta\phi) = \frac{V_s - \delta V_s}{V_s} \sin \phi$$

$$= \sin \phi \cos \delta\phi - \cos \phi \sin \delta\phi.$$

When $\delta\phi \to 0$, $\sin \delta\phi \to \delta\phi$ and $\cos \delta\phi \to 1$.

$$\therefore \sin \phi - \delta\phi \cos \phi = \frac{V_s - \delta V_s}{V_s} \sin \phi$$

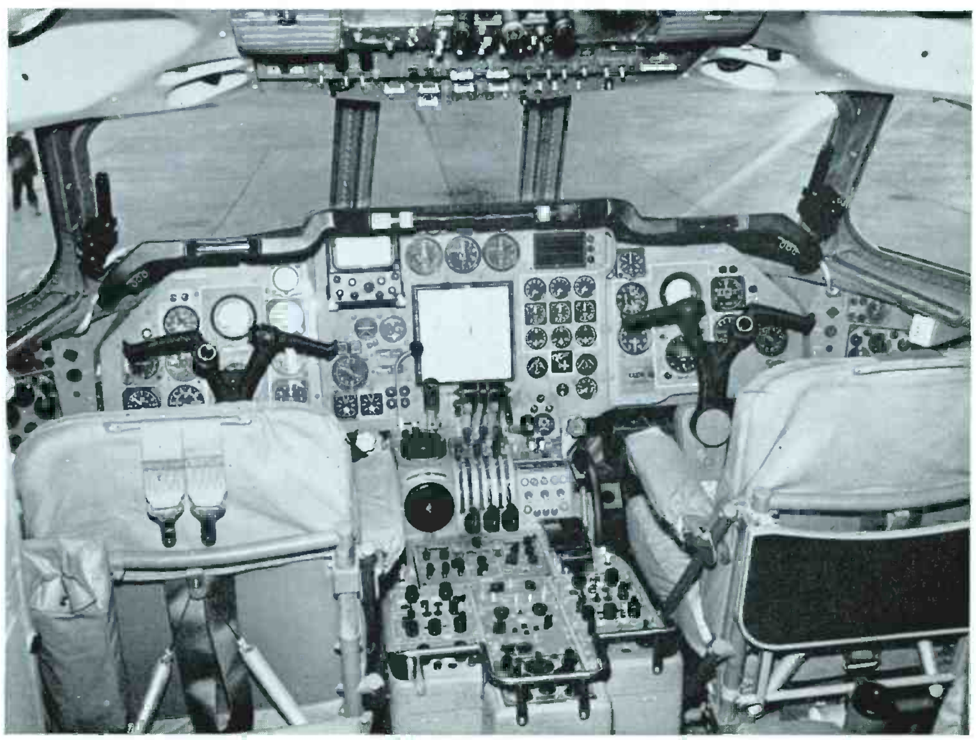
$$\delta\phi \cos \phi = \frac{\delta V_s}{V_s} \sin \phi$$

$$\delta\phi = \frac{\delta V_s}{V_s} \tan \phi \qquad \text{or } \delta\phi = \frac{\delta V_s}{V \cos \phi}$$

$\therefore$ $\delta\phi$ is a minimum when $\cos \phi \to 1$ or $\phi \to 0$.

Therefore for $\delta\phi$ to be a minimum, that is the error to be minimum, the triggering level, V_s, should be as low as possible, the variation in triggering level, δV_s, should be a minimum and the peak amplitude, V, should be as large as possible.

In making a measurement of phase angle, two channels and two triggering circuits are involved; it is necessary to ensure that the triggering level of each be the same.



Flight deck of the Hawker Siddeley 'Trident'. V.O.R. information is presented to the pilot in order that he may read the magnetic bearing of the ground station or select and maintain a V.O.R. radial track

The Marconi Company Ltd.

This can be done by commoning the inputs to one phase supply and adjusting the triggering levels until one channel starts the counter at the same time as the other channel stops it, i.e. measuring zero time between channels. Any change in the triggering levels with respect to each other will now appear as a time measurement on the counter; if the trigger level varies differentially between the channels then this time will change, and will be a measure of the inaccuracy of the measurements.

The TF 1417 counter has a trigger level which can be varied between ± 2 V to enable it to be used with complex waveforms, but it cannot easily be set to a near zero triggering level such as is required for making an accurate phase measurement as described.

If the two phases are amplified before being presented to the counter and the trigger level of the counter is set to, say, 1 V, then the effective triggering level of the phases is 1 V divided by the amount of amplification. The signal can be clipped at some level above 1 V since this will not affect the counter, and the amplifier can be made more simple if it does not have to accommodate large voltage swings; this is the function of the Phase Measuring Unit TM 7261. With this the counter is presented with an amplified and squared sine wave, whose rise time is proportional to the amplification and input level.

Suppose the input signal is 1 V peak at 30 c/s, amplified 50 times and clipped at ± 1 V, then the output will be a square wave with peak-to-peak amplitude of 2 V. 1 V at the output of the amplifier is 20 mV at the input of the amplifier. So the rise time will be the time taken

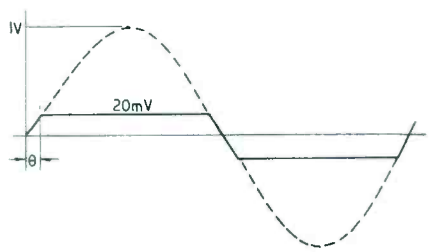


Fig. 3. Clipping of input signal

for the sine wave to reach, from its zero point, a level of 20 mV, which represents an angle of $\Theta°$ as shown in Fig. 3.

$$\text{Sin } \Theta = \frac{20 \times 10^{-3}}{1} = \cdot 02$$

$$\therefore \Theta = 1{\cdot}15°.$$

$$\text{Time} = \frac{\Theta}{360} \times T, \text{ where } T \text{ is the period}$$

$$= \frac{1{\cdot}15}{360} \times \frac{1}{30} = 106\ \mu\text{sec.}$$

The counter has a square wave of 1 V peak amplitude and 106 μsec rise time presented to it. If it is set to a triggering level of $+1$ V ± 50 mV, this instability represents a change in time of about $\frac{50 \times 10^{-3}}{1} \times 106\ \mu$sec, equalling 5·3 μsec, which represents an angle of $5{\cdot}3 \times 10^{-6} \times 30 \times 360°$, that is ·057° at 30 c/s.

Circuit

This consists of two identical clipping amplifiers, the circuit of one being as in Fig. 4.

The amplifier is only required to amplify the portion of the sine wave near the zero point; so, to avoid overloading the amplifier input and also to protect it, the signal is clipped at the input. The larger the input signal, the faster will be the rise time of this clipped portion.

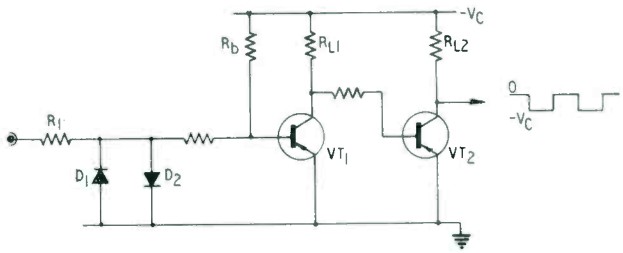


Fig. 4. Basic circuit of clipping amplifier

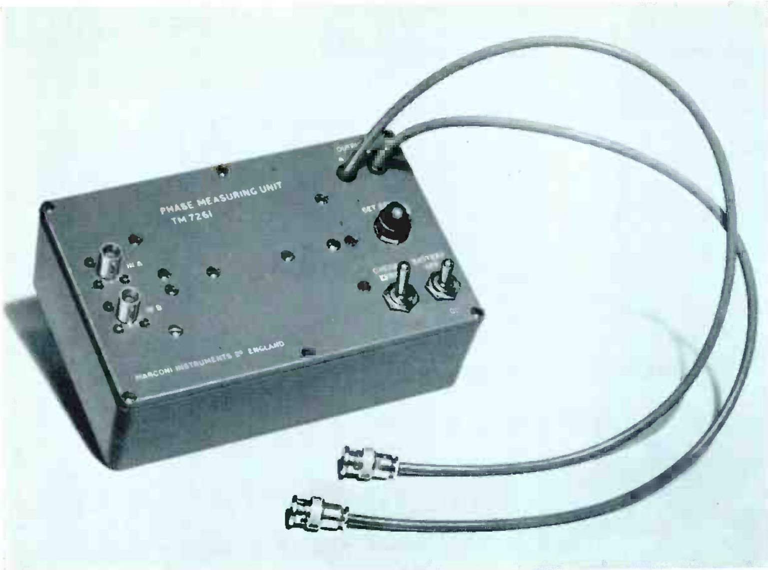
The signal is fed via R_1 to two silicon junction diodes; a type with a very sharp knee in their forward characteristic is used, the knee occurring at a voltage of about 0·6 V. When the signal goes positive by 0·6 V, D_2 will conduct, when negative by 0·6 V, D_1 will conduct, in between neither will conduct and the signal will be unaffected, giving a clipped sine wave of 1·2 V p–p to VT_1. To a large signal at the input, the impedance seen will be very nearly R_1 (4·7 kΩ).

The clipped waveform is amplified by VT_1 and VT_2 to give a square wave output. This output waveform will have a rise time depending upon the input amplitude and the amplifier gain. For a 3 V r.m.s. input the output has a rise time of 20 μsec and an amplitude of 5 V. The maximum change in triggering level of the counter will be ± 50 mV so the time measurement will have an error of 1 μsec minimum, and between the START and STOP channels 2 μsec or ·02°. With 3 V r.m.s. input, the two amplifier channels begin to conduct at -80 mV, that is 110 μsec or 1° (at 30 c/s), after the sine wave has gone through the zero point. These two levels can be quickly checked and equalized for each channel, within limits which, together with the counter error, give a maximum total error not exceeding 0·1°. With higher inputs this error will progressively decrease; at 6 V r.m.s. input, for example, the error due to the amplifier channels will be halved, giving a total error not exceeding ·06°. In general, the basic accuracy will therefore be within 0·1°.

To set the two channels to start at the same level and compensate for the phase errors, it is merely necessary to adjust R_b, with both inputs connected together until the difference, indicated on the counter, is less than 0·1°.

Sources of Error in Measurement

Since the measurement is made over one cycle, if the signal frequency varies from cycle to cycle then there will



The battery operated Phase Measuring Unit, TM 7261, which will present an amplified and squared sine wave to the counter. A picture of the TF 1417 Counter appears on page 67

be a fluctuation of successive readings, which may need to be averaged out. A variation of 0·1% in the frequency could cause an error of 0·3°; at smaller angles the effect will be much less, so it is better to measure smaller angles if possible, which may mean reversing the connections to the STOP and START channels.

Any bias, d.c. or a.c., on either or both phases could cause an error by altering the effective triggering points, as could any distortion of one signal with respect to the other in the region of the zero point.

The input impedance is 5 kΩ; if the amplifier is supplied from a reactive source it is important that this should be the same on each channel, and that this source impedance when loaded with 5 kΩ should produce a phase shift of less than a few degrees to minimize the inter-channel error. The amplitudes of the two phases should be the same to within 0·1 V r.m.s. with 3 V r.m.s. input and within 0·5 V of each other with 6 V r.m.s. input for an accuracy of 0·1°.

Direct read-out in degrees

As described above, to determine the phase angle it is necessary to make a small computation, by measuring the period of one cycle and then the time difference between the two phases. Instead of measuring the period as a time using the counter's internal timing units, external timing units can be supplied from an oscillator whose frequency is adjusted to be such that the counter reads over the one period a count of 3600. Now switching to measure the time between phases will give a direct reading in degrees. At 30 c/s the external oscillator should be set to 108 kc/s or 1·08 Mc/s.

On the counter TF 1417 the inputs are conveniently arranged for making a phase measurement, the external oscillator being fed into the A channel and the outputs of the squaring amplifier into the START and STOP inputs B and C. Using the A/B position the oscillator can be set to give a readout of 360·0 (or 360·00); switching to the A/B–C position gives the required reading. When using the counter TF 1345 it is necessary to use the Time Interval Unit TM 5953 to supply separate START and STOP channels; the external oscillator can be fed into the EXT. TIMING UNITS sockets.

Conclusion

Using a 10 Mc/s counter with separate START and STOP channels for time interval measurement, together with the Phase Measuring Unit TM 7261, it is possible to measure phase angles to within 0·1° with 3 V r.m.s. input giving a direct readout in degrees from 0·1° to 360·0°.

In V.O.R. test equipment two signals are produced, one continuously variable in phase with respect to the other. The standard instrument in use with this equipment merely checks the zero phase shift points, and assumes the scale remains linear at other points. Using the counter and TM 7261 it is possible to check the equipment at all angles. The method can be used at any frequency up to about 1 kc/s, but since at these higher frequencies the times involved are much shorter the accuracy will progressively decrease.

ABRIDGED SPECIFICATION OF TM 7261

PHASE ANGLE RANGE: 0–360°.

FREQUENCY RANGE: below 0·1 c/s to 5 kc/s.

ACCURACY:
- ±0·1° up to 50 c/s.
- ±0·5° from 50 c/s to 500 c/s.
- ±1° from 500 c/s to 2 kc/s.
- ±2° from 2 kc/s to 5 kc/s.

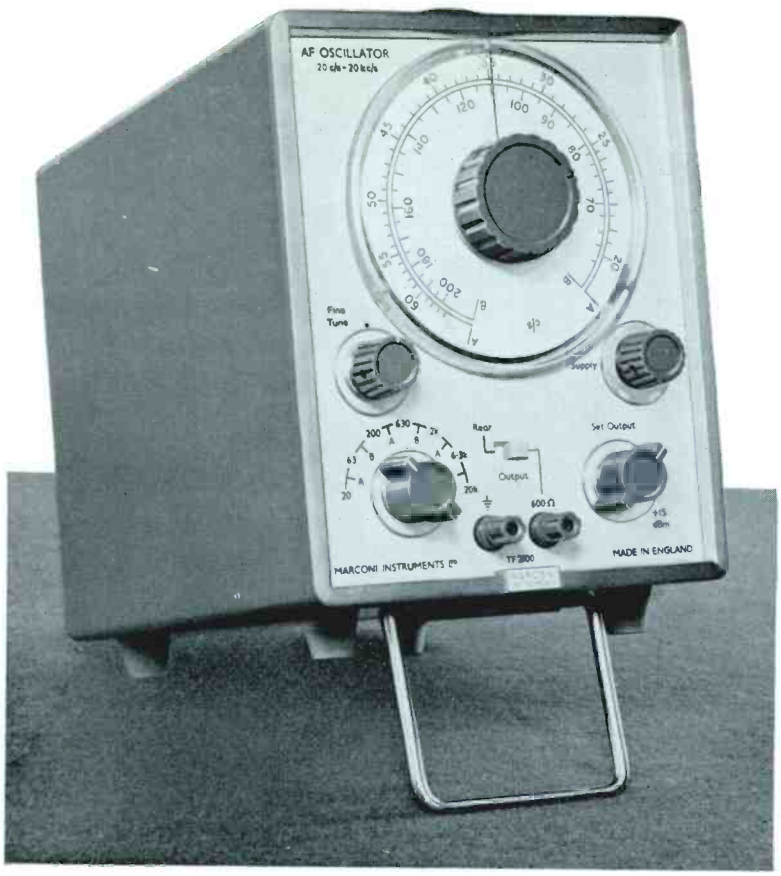
INPUT IMPEDANCE: 5 kΩ.

INPUT LEVEL: 3 V r.m.s. 25 V r.m.s. maximum.

OUTPUT LEVEL: 5 V negative going square wave.

OUTPUT IMPEDANCE: 2·75 kΩ.

POWER CONSUMPTION: 4 mA at 5·4 V from internal battery giving approximately 200 hours working.



MARCONI INSTRUMENTS

621.396.615.11

Still Less Distortion

by
L. M. SARGENT

A simple modification to the A.F. Oscillator type TF 2100 is described, whereby it is possible, with a sacrifice in output level, to reduce the distortion to better than 0·01% over most of the frequency range.

NOTHING is ever quite good enough, so it is not surprising that an application has arisen for an audio signal with less distortion than that to be found in the new A.F. Oscillator TF 2100[1], which is rated as not exceeding 0·05% distortion over the major part of the audio range.

Any user who has special need for a signal with distortion better than 0·01% in general, can sacrifice output power for improved quality in a very simple fashion. The modification to be described reduces the output level from +15 dBm to about +5 dBm (from 4·3 to 1·3 V on a 600 unbalanced load), whilst improving the distortion as shown for a typical instrument in Fig. 1 and Fig. 2. The work consists of replacing the level control element, which is a thermistor type A54 manufactured by Standard Telephones & Cables Ltd., by their thermistor type R15.

Unfortunately, there are various factors leading to 'bouncing' of the output level when switching to frequency ranges below 630 c/s. At the worst, at 20 c/s the signal requires some 45 seconds to settle to a fixed level, but at 200 c/s it only requires 5 seconds. However, assuming one can tolerate a slight delay before low-frequency signals are ready for use, the modification provides very low distortion very simply. The factors causing the 'bouncing' include the low thermal capacity of this type of low-power thermistor, the increased overall feedback which brings the system closer to instability, and the very low amplifier distortion.

To perform the modification, first remove the instrument from its case, slacken the two large shoulder screws at the right-hand rear corner (viewed from the front) and also slacken the two small screws underneath, securing the flange of the rear panel to the side frames.

The rear panel and right-hand side frame can now be pulled apart, and the whole instrument opened out flat. Locate the thermistor TH1 in a glass envelope clipped near the centre of the right-hand board; remove the thermistor and clip. Solder the new thermistor in place. Secure by a cord passed through the clip hole round a short length of insulated rod.

Fig. 1
R.M.S. distortion on load before and after modification

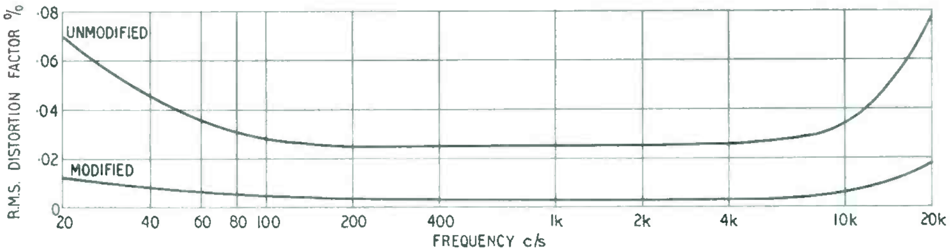
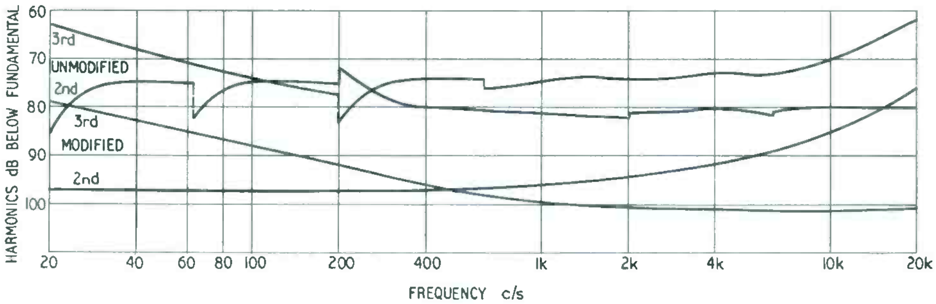


Fig. 2
Harmonics on load before and after modification

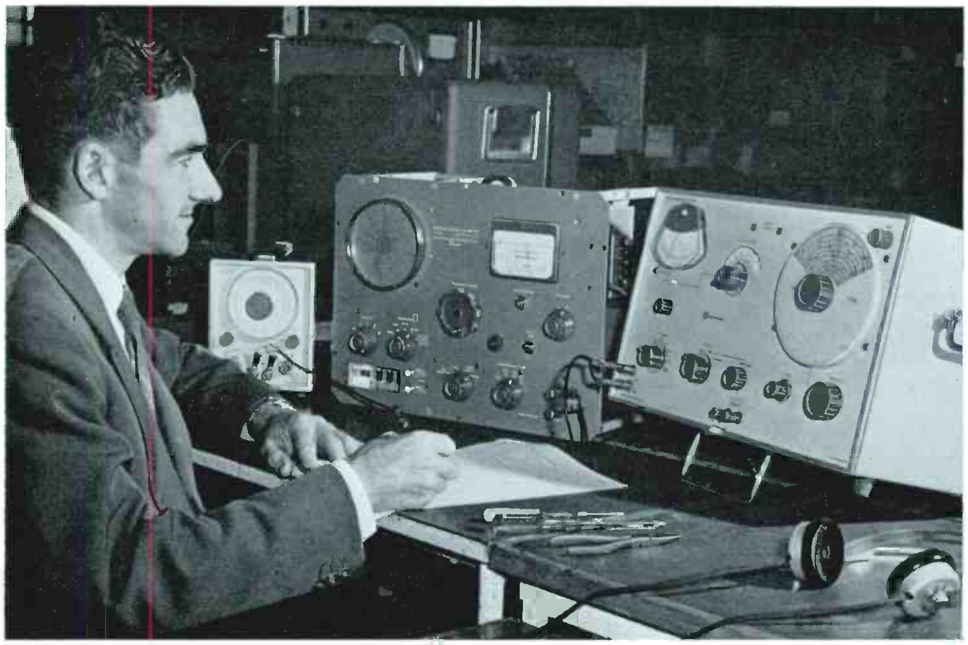


Those who have facilities to measure distortion in the region of 0·01% can achieve the best performance by a slight adjustment of the potentiometer RV4 at about 1 kc/s so as to minimize the second harmonic. This potentiometer is located at the top of the right-hand board. During adjustment, monitor the d.c. voltage between h.t. negative (tag 9) and the amplifier output point (test point TP2). Do not let this stray outside the range 22 to 33 V, to avoid overheating one of the output transistors. It is nominally set for 27·5 V, which is half the h.t. voltage. The best wave analysers can measure 0·01% distortion if they are preceded by a notch filter to reject the fundamental by at least 40 dB.

Instruments modified in this way are designated Type TF 2100/1M1. The same modification can of course be applied to the Oscillator section of the A.F. Signal Source TF 2000 creating a TF 2000/1M1; this low distortion will only be realized when the Attenuator is switched to the 600 Ω UNBAL position and not on the balanced positions where the transformer is switched into the circuit.

REFERENCE

1. Sargent, L. M. 'A.F. Oscillator Type TF 2100'. *Marconi Instrumentation*, June 1963, 9, p. 28.



Utilizing the low distortion output of the A.F. Oscillator to test the l.f. amplifier of Carrier Deviation Meter TF 791D

MARCONI INSTRUMENTS APPLICATION NOTE

621.317.761

FREQUENCY MEASUREMENT OF TRANSMITTED RADIO SIGNALS IN THE RANGE 100 kc/s TO 30 Mc/s

by
J. BREEZE

It is often necessary to measure the frequency of weak r.f. signals, particularly signals from remote transmitters. Counter/Frequency Meter TF 1417 requires a minimum input of 0·25 V for satisfactory operation. However, when used in conjunction with Heterodyne Frequency Meter TF 1067 and a suitable receiver it is possible to measure the frequency of weak signals in the range 100 kc/s to 30 Mc/s to an accuracy of better than 1 part in 10^6. The signal level required will depend only upon the sensitivity of the receiver.

MEASUREMENT IN THE RANGE 2 TO 30 Mc/s

The following instruments are required:

(1) A Heterodyne Frequency Meter, type TF 1067, operated from a constant-voltage supply, to act as a transfer oscillator. This comprises an oscillator with a fundamental range of 2 to 4 Mc/s which is adjusted until a harmonic beats with the unknown signal.

(2) A receiver incorporating an r.f. level meter energized by the 2nd detector current, and driving headphones or loudspeaker to detect the zero beat between the TF 1067 harmonic and the unknown signal. Its indication of the approximate signal frequency serves to identify which harmonic of the TF 1067 is being used.

(3) A Counter/Frequency Meter type TF 1417 to measure the exact fundamental frequency of the TF 1067. This frequency multiplied by the harmonic number determines the signal frequency.

(4) A 1 kΩ resistor and interconnecting leads.

To attain the required accuracy of one part in 10^6, the counter should be allowed 20 minutes warming-up time, and the TF 1067 transfer oscillator a period of one hour.

Method of Measurement

The apparatus is arranged as in Fig. 1 but, should it later prove necessary, the oscillator output to the receiver aerial may be taken through an attenuator.

(1) Disconnect the transfer oscillator and tune the receiver to the incoming signal.

(2) Reconnect the oscillator and tune it to give an audible beat from the loudspeaker or phones.

(3) Using the CORRECTOR fine control on the oscillator, tune to the zero-beat position. Within five cycles either side of the zero beat, the r.f. level meter on the receiver will show a marked beating; this should be reduced until it has a period of more than ½ second.

(4) Measure the oscillator frequency on the counter immediately, using the 10 sec gate time.

(5) The approximate signal frequency appears on the receiver calibration scale. Divide this by the oscillator frequency to find the number of the harmonic of the latter which is beating with the signal. The result will not be an exact integer, but it should be close enough for an estimate to be made. Finally, multiply this integer by the oscillator frequency to give accurately the frequency of the signal.

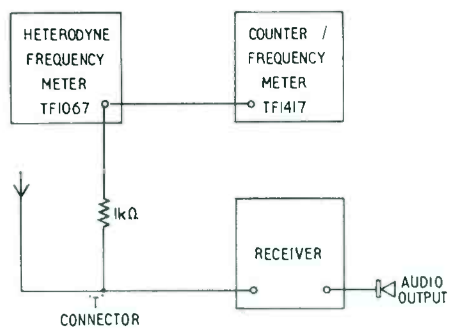


Fig. 1. Arrangement for 2 to 30 Mc/s measurements

Example

When measuring a signal of approximately 28½ Mc/s, zero beat is observed with an oscillator frequency of 2·590130 Mc/s.

Dividing this into 28·5 Mc/s indicates that the 11th harmonic is beating with the signal. Multiplying by the fundamental frequency, gives a signal frequency of 28·491430 Mc/s.

The error will have to be calculated individually for each measurement, but as an illustration, here is the error in the above determination.

Possible oscillator drift was negligible over this short period involved, but as the counter has an accuracy of ±1 count ±3 parts in 10^7 the uncertainty of the funda-

Measuring the frequency of a transmission using A.C. Microvoltmeter TF 1375 as a beat detector for the receiver

mental frequency is 1·78 c/s. This is equivalent to a possible error of 19·58 c/s in the signal frequency. The additional uncertainty of ±1 c/s in observation of the zero beat makes a total of 20·58 c/s. Hence the result of this measurement is that the signal frequency is 28·491430 ±0·000021 Mc/s.

MEASUREMENT IN THE RANGE 100 kc/s TO 2 Mc/s

The procedure has been modified in order that this range may be covered, since TF 1067 only generates signals of 2 to 4 Mc/s. In addition to the instruments used above, the following are also required:

(1) An Oscilloscope type TF 1330 or TF 2200 with a Pre-Amplifier type TM 6591 to give a 'Y' sensitivity of at least 500 μV/cm.

(2) A source of about 5 V p–p at mains supply frequency.

(3) An Attenuator such as type TF 1073A Series or TF 2162, to reduce the signal level from the counter.

(4) A frequency divider for reducing the frequency of the transfer oscillator 100 times. This is conveniently done by the following minor modification to the Counter TF 1417.

Modification to the Counter

The output from the second decade counter unit board is exactly one hundredth the frequency of the incoming signal. The board concerned lies directly behind the second display tube from the right of the readout, and the output is taken from pin 'L' through a simple isolating network as shown in Fig. 2. The counter is operated in the 'Count A' position with the gate open.

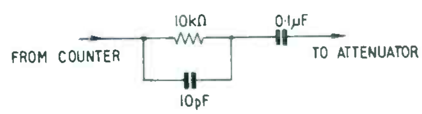


Fig. 2. Counter isolating network

Method of Measurement

The oscillator frequency is reduced by a factor of 100 by the counter. The output from the counter is a rectangular wave with a duty cycle of 25% and is therefore very rich in harmonics. After attenuation, it is combined with the incoming signal to produce audible beats as before.

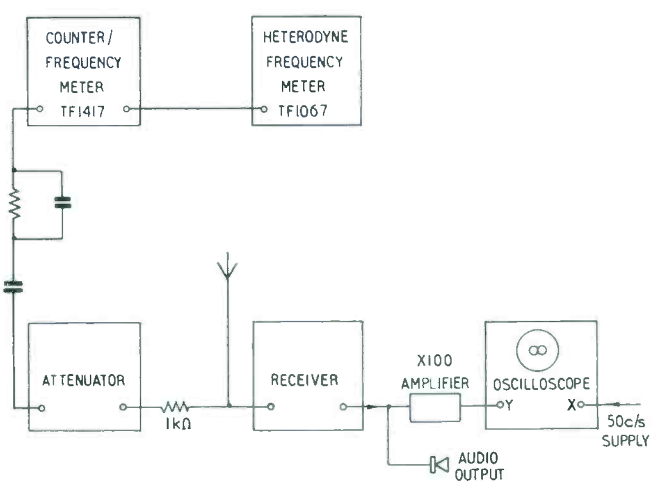


Fig. 3. Arrangement for 100 kc/s to 2 Mc/s measurements

At this point the method differs from the previous one for, if it is desired to measure a 100 kc/s signal with the required accuracy, the zero beat position should be observed within 0·05 c/s, which is extremely difficult.

Consequently, zero beat is no longer obtained and instead the beat note is tuned to 100 c/s and this produces a Lissajous figure on the oscilloscope, using the mains supply frequency as a time base. Not only can the figure be easily and precisely observed, but also, if it has a slow period of oscillation, this period can be measured with a stop-watch and a correction made.

(1) Carry out stages 1 and 2 of the first method and adjust the oscilloscope for roughly equal X and Y deflections.

(2) Tune the oscillator until the oscilloscope shows a 2: 1 figure—this can be done easily by listening to the beat note. At this point it is necessary to check, by using the counter, whether the oscillator frequency is increasing or decreasing as the CORRECTOR knob is rotated in a given direction—it is advisable, though not essential, to tune to the 100 c/s beat where the unknown frequency is lower than the harmonic from the counter.

(3) Obtain a nearly stationary figure on the oscilloscope and measure the oscillator frequency on the counter.

(4) Switch the counter back to continuous running and time the period of oscillation of the Lissajous figure.

(5) Rotate the TF 1067 CORRECTOR control and observe the effect on the figure. There are two possibilities, assuming that the TF 1067 is tuned so that the relevant harmonic is nearly 100 c/s higher than the unknown frequency:

  (a) The figure slows, becomes stationary, then degenerates until the 1: 1 figure is obtained; this means the beat frequency is less than 100 c/s.

  (b) The figure degenerates without becoming stationary, indicating that the beat frequency is greater than 100 c/s.

(6) The oscillator frequency is related to the signal frequency by the same calculation as before, but it must be remembered that the oscillator frequency has been divided by 100, so that an oscillator output of 2·5 Mc/s is reduced to 25 kc/s before the beating occurs.

Having calculated the unknown frequency as before, subtract the correction frequency derived from the Lissajous figure to obtain the final result.

Example

This is the result of an actual measurement of the B.B.C. Home Service frequency (908 kc/s).

A 10-second count of the oscillator frequency was 30269984. Thus the frequency of the fundamental of the heterodyning signal was 30·269984 kc/s.

The 2: 1 Lissajous figure has a period of 6 seconds. Rotating the TF 1067 CORRECTOR control converted this to a 1: 1 figure, without going through the stationary 2: 1 position. Thus the beat note was $(100-\frac{1}{6})$ c/s = 99·83 c/s. Knowing that the Home Service is 908 kc/s, the experiment was clearly using the 30th harmonic of the fundamental oscillator frequency. Hence the observed frequency was

$$30\times\ 30{,}269{\cdot}984-99{\cdot}83\ \text{c/s} = 908{,}099{\cdot}52-99{\cdot}83\ \text{c/s} = 907{\cdot}99969\ \text{kc/s}.$$

As in the previous example the uncertainty of the fundamental frequency is 0·01 c/s, which is equivalent to a possible error of 0·3 c/s in the signal frequency. The additional uncertainty of approximately ±1 second in observing the period of the Lissajous figure adds a further 0·03 c/s, giving a total of 0·33 c/s. Therefore the measured frequency is 907·9997 ± 0·00033 kc/s.

MARCONI INSTRUMENTS FORMS NEW GERMAN COMPANY

From September 1st a new German organization—Marconi Messtechnik G.m.b.H.—with headquarters in Munich, will provide comprehensive sales and service facilities in West Germany for the Company's wide range of electronic measuring instruments.

Mr. T. Broderick has been appointed Manager of Marconi Messtechnik, which will operate from Wolfratshauser Strasse 243, München-Solln. Sales and service will be effected by qualified German engineers in conjunction with regional distributors, offering the West German electronics industry a fully-integrated measurement equipment service. Mr. Broderick is known to many of our readers as a sales engineer for the Company in the United Kingdom until 1959 and subsequently in Western Europe.

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

NEW DESIGN

A Wide Deviation Signal Generator *TYPE TF 1066B/6*

by
J. H. DEICHEN,
A.M.I.E.E.

A new wide deviation signal generator in the familiar TF 1066B series has been specifically designed to meet the requirements for instrumentation of telemetry equipment in the 215 to 265 Mc/s band. However, the instrument covers a continuously variable frequency range from 10 to 470 Mc/s but with less exacting f.m. facilities outside the telemetry band.
This article describes the new instrument, giving special details of the modulating system and the deviation monitor circuitry. Multiple modulating signals and harmonically distorted signals and their associated difficulties in exact monitoring are discussed.

THE F.M. SIGNAL GENERATOR, TF 1066B[1], is a well-established instrument catering for modulation systems such as are used in broadcast and mobile equipment. There is also a special instrument in the same series, TF 1066B/2, which was introduced to provide the wide deviation and high modulating frequency required for the telemetry band of 400 to 550 Mc/s[2]. Since that time the field for instrumentation of telemetry systems in the 215 to 265 Mc/s band has come into being and to give immediate facilities many TF 1066B models were modified to meet the requirements. Now a new version of the series has been specially designed to fulfil the demand, but it also covers the full frequency range of 10 to 470 Mc/s. The new version is the TF 1066B/6 which is housed in a bench-type case. A second version of the same instrument is the TF 1066B/6R which is supplied with a dust cover and is intended for mounting in a standard 19-inch rack. In fact the bench-mounting version can be rack mounted after removal from its case and a few minor alterations to fixing lugs and re-routing of the mains lead. Thus all the description in this article about the TF 1066B/6 applies equally to the TF 1066B/6R.

Special consideration was given to the 215 to 265 Mc/s band by including it in one range having a total cover

F.M. Signal Generator TF 1066B/6. A wide deviation instrument suitable for telemetry applications from 115 to 270 Mc/s. On this range and a lower range of 50 to 115 Mc/s the maximum deviation is 400 kc/s. A special modulation distortion claim of 5% for maximum deviation is made for the 215 to 265 Mc/s band. Over the frequency band of 10 to 50 Mc/s a maximum deviation of 100 kc/s is obtainable and on the top range, 270 to 470 Mc/s, the maximum deviation is 300 kc/s. On all ranges except the special case quoted above, the modulation distortion is not greater than 10% for maximum deviation. However, at the top end of the five ranges the modulation distortion is usually less than the specification and can be as low as 2 or 3%.

F.M. Signal Generator TF 1066B/6R. All the facilities of the B/6 instrument but supplied with a dust cover and intended for mounting in a standard 19-inch rack

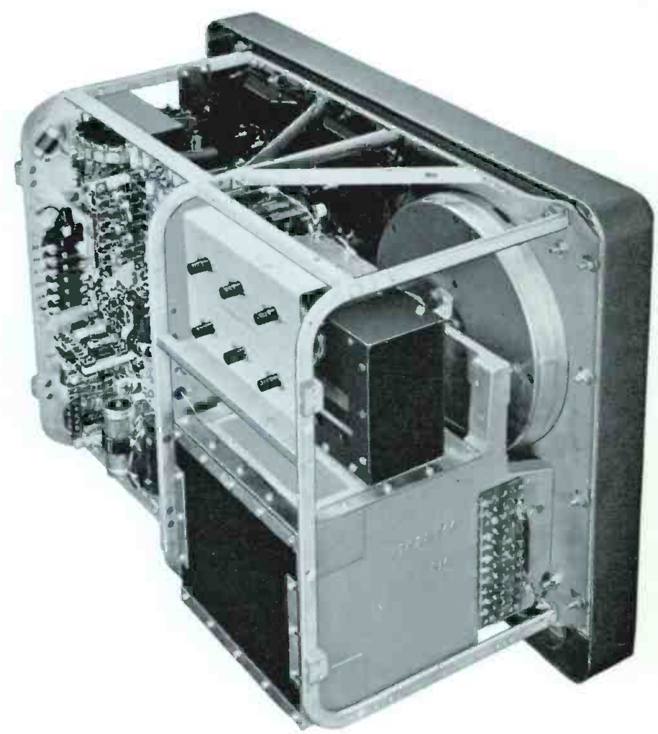
Over the entire r.f. range a modulation frequency range between 30 c/s and 100 kc/s is catered for. Thus the instrument, as well as being suited for r.f. measurements in the special telemetry band, can be useful for i.f. measurements. The modulation is monitored in three ranges as follows: 0 to 20 kc/s, 0 to 100 kc/s and 0 to 400 kc/s. Using the 0 to 20 kc/s range the instrument is suitable for instrumentation in most respects for narrow deviation equipment, being only slightly deteriorated in aspects inherently associated with wide deviation equipment such as stability and noise modulation.

R.F. Oscillator

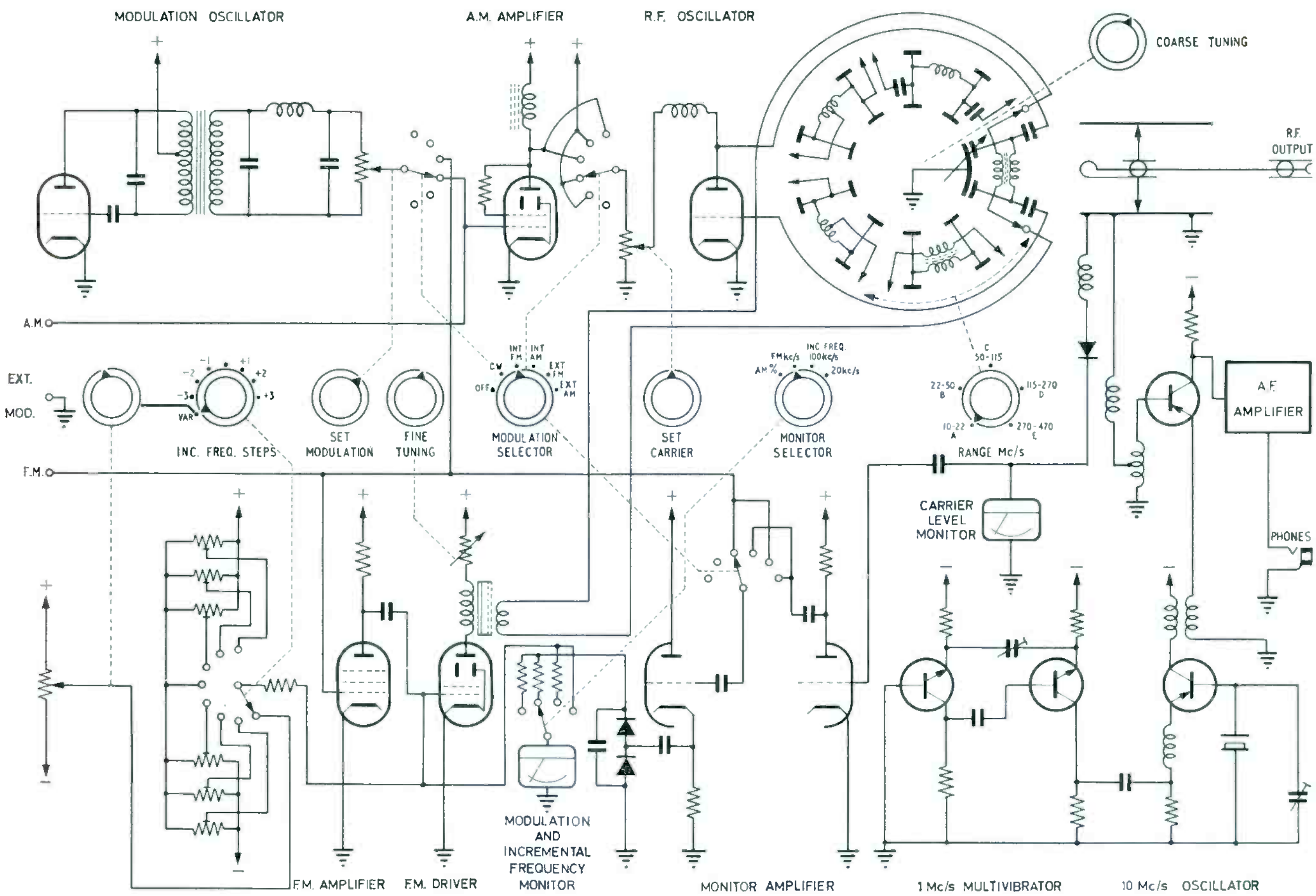
The r.f. oscillator employs the Marconi patented contactless turret which is common to all the TF 1066 series of signal generators which use a multiple range system. The frequency cover is 10 to 470 Mc/s as in the TF 1066B but the five ranges are re-allocated so that the 215 to 265 Mc/s band appears at the upper part of one range. Not only does this eliminate the need for switching in this band, but, as it appears on the upper end of a range, the wide deviation of 400 kc/s is realized with relatively low modulation distortion.

A similar cast r.f. box and attenuator barrel is used on this instrument, thus giving a similar performance to the TF 1066B in respect of microphony and stability other than warm-up drift. The warm-up drift is slightly deteriorated because of the high power requirements of the reactor drive valve and the higher current through the magnetic reactor winding. For wide deviation requirements the stability and microphony features are not so stringent, therefore this instrument's performance is more than ample.

The r.f. circuit employs a disc seal triode in a Colpitts configuration. The r.f. level is monitored by a sampling pick-up loop which feeds a rectifier giving a d.c. component which is monitored on a front panel meter. The output signal from the oscillator is controlled by a piston attenuator giving an output continuously variable between 0·2 μV and 200 mV e.m.f. from a nominal impedance of 50 Ω. R.F. output is indicated by a cursor line on an attenuator dial calibrated in e.m.f. and decibels relative to 1 μV. A second line on the cursor gives a 6 dB down indication which represents the voltage across a matched 50 Ω load, or the e.m.f. using a 6 dB pad. By reversing the cursor the centre cursor line indicates the p.d. across a 50 Ω load and is variable between 0·1 μV and 100 mV, a -6 dB line indicates the p.d. when using a 6 dB pad.



Rear view, with case removed. The crystal calibrator is the black box mounted on the cast r.f. box shown in the front of the picture. The six preset potentiometers seen on the separate chassis are used for setting the stepped incremental frequencies



Simplified diagram of Signal Generator type TF 1066B/6

Crystal Calibrator

The frequency of the r.f. oscillator is indicated to an accuracy of 1% by a cursor line indication on an 8-inch diameter dial. A greater accuracy of 0·02% is obtained by setting the cursor at 1 Mc/s check points from the transistorized crystal calibrator. Marker points at 10 Mc/s intervals ensures absolute frequency when used in conjunction with the 1% direct accuracy of the calibration.

The crystal calibrator uses a 10 Mc/s crystal oscillator for the 10 Mc/s marker points and a 1 Mc/s multivibrator to modulate the crystal oscillator, thus giving 1 Mc/s check points. Precise frequency of the multivibrator is obtained by feeding a signal from the 10 Mc/s crystal oscillator to trigger the multivibrator. Indiscriminate triggering is avoided by using a low mark to space ratio so that the mark pulse is comparable in time to one cycle of the crystal oscillator frequency.

The 10 Mc/s signal from the oscillator is mixed with the r.f. signal of the generator and the resultant zero beat note is amplified and fed to a front panel phone jack via a volume control.

Modulation and Incremental Frequency

Frequency modulation and incremental frequency shift are obtained by a magnetic reactor coupled into the r.f. tank circuits. Three methods of coupling are employed, depending on the frequency range. The two lower ranges use mutual inductance and are loosely coupled to prevent excessive loading of the oscillator. The next two ranges are coupled by tapping into the oscillator coil. This gives tight coupling and hence wide deviations with small signal on the reactor network. At these frequencies the reactor can be tightly coupled without overloading the oscillator as the reactor ferrite core possesses a high Q. On the top frequency range the reactor is capacitance coupled thus giving loose coupling which is necessary as the Q of the material falls off at these high frequencies.

The modulation frequency winding of the reactor must necessarily contain a low number of turns to give a flat response up to 100 kc/s compared with only 15 kc/s on the TF 1066B. However, the sensitivity must be greater to obtain a very wide deviation. Thus to meet the sensitivity requirement another means is necessary. The coupling between the reactor and the tank circuit is a maximum on the top and the two lower ranges so the only other alternative is to increase the drive current through the a.f. winding and eliminate the usual permanent magnet.

Increasing the drive current through the a.f. winding of the reactor is limited by the output characteristic of the reactor drive valve and the linearity of the B/H characteristic of the reactor. By using a sufficiently high

ABRIDGED SPECIFICATION

Frequency

RANGE: 10 to 470 Mc/s in five bands.

CALIBRATION ACCURACY: Direct accuracy $\pm 1\%$. Using inbuilt crystal calibrator the frequency accuracy can be set to within $\pm 0{\cdot}02\%$.

FREQUENCY STABILITY: Within 0·015% in any 10 minute period after 1 hour warm up.

INCREMENTAL FREQUENCY CONTROL: -100 to $+100$ kc/s by continuous and stepped controls.

R.F. Output

LEVEL: Continuously variable from 0·2 μV to 200 mV e.m.f.

OUTPUT ACCURACY: Incremental, 0·2 dB; overall, 2 dB.

SOURCE IMPEDANCE: 50Ω; v.s.w.r. 1·25:1 using the 20 dB pad TM 4919, 1·6:1 using the 6 dB pad, TM 4919/1.

Frequency Modulation

INTERNAL: Modulation frequencies: 1 and 5 kc/s. Deviation variable to 100 kc/s between 22 and 50 Mc/s; 400 kc/s between 50 and 270 Mc/s; 300 kc/s between 270 and 470 Mc/s.

EXTERNAL: Modulation frequency range: 30 c/s to 100 kc/s. Input requirements: 25 V across 5 kΩ.

DEVIATION ACCURACY: Direct accuracy for internal modulation varies with carrier frequency from within $\pm 7\%$ to 20% of full-scale. Using correction chart supplied, accuracy at all carrier frequencies is within $\pm 7\%$ of full-scale. Accuracy over external modulation frequency range is within $\pm 12\%$ of accuracy at 1 kc/s.

MODULATION DISTORTION: Not greater than 10% at the maximum deviations, or 5% over the r.f. range 215 to 265 Mc/s.

RESIDUAL F.M.: The f.m. due to hum and noise is less than 100 c/s deviation.

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nominal current through the reactor modulation winding the operating point on the B/H curve is positioned above the knee without the aid of the permanent magnet as used on other models of the TF 1066B series. However, as the minor hysteresis loop which is followed during a cycling of modulation signals is confined to the narrow part of the major hysteresis loop of the material, the linearity and hysteresis effect is not greatly different on this instrument compared with models designed for lower deviations.

To keep the deviation the same at all carrier frequencies a compensating network is used which applies a lower modulating signal at the high end of an r.f. range: this greatly reduces the distortion at these frequencies. Therefore, the specification for distortion which is stated for the worst condition is usually much better at the high frequency end of the ranges.

Use is made of the nominal current through the reactor modulation winding to produce the incremental frequency shift. This feature is obtained by connecting the modulation winding in series with a reactor drive valve of comparatively low output impedance. By shifting the d.c. bias on the valve the current in the winding is changed, thus producing a change in flux. As the output impedance of the driver valve is low the reactor is current fed and hence gives a flat response between d.c. and 100 kc/s.

As well as the usual continuously variable incremental frequency control giving shifts of -100 kc/s up to $+100$ kc/s, there are seven step incremental frequency positions on the control switch. Three of the steps are for positive frequency shifts, three are for negative shifts and the seventh is a zero shift position. Each of the six steps is continuously variable up to 100 kc/s and can be preset against the front panel meter reading. This facility is particularly useful in bandwidth measurements of receivers. The steps can be previously adjusted and response measurements quickly taken by simple operation of the switch. Access to the presets is made through a small door at the back of the instrument case.

The instrument contains an L-C oscillator which can give an internal modulating signal of either 1 kc/s or 5 kc/s. The level of the modulation is controlled by a front panel control and the sensitivity of the control is changed with the F.M. RANGE switch. Thus the control is suited to the meter range, making small deviations as easily adjusted as large deviations. When on the INT. A.M. position of the instrument function switch the output from the oscillator is reduced to maintain the full control discrimination.

Provision is made on the instrument for both external f.m. and a.m. The modulating frequency suitable for f.m. is from 30 c/s to 100 kc/s while for a.m. it is 30 c/s to 15 kc/s. Multiple signal frequency modulation is possible; however, care must be taken in interpreting the monitor reading as discussed in the following paragraphs.

Monitor

A common meter is used to monitor the f.m., the a.m. and the incremental frequency shift. In the last case the meter is biased to centre zero so that indications of both positive and negative shifts are possible in two ranges.

For deviation measurements the monitor responds to the peak to peak amplitude of the modulating signal, but is calibrated to indicate the mean peak deviation. This feature of the instrument is of particular importance when modulating with signals rich in harmonics or using multiple signals as in the case of telemetry equipment. However, if asymmetrical signals are used the deviation indication will give the peak deviation if one were to assume the signal peaks were equal but the carrier frequency was shifted to half-way between the positive and the negative peaks. Furthermore, if multiple signals are used errors in the monitoring can occur if the signals are such that the maximum peaks of the composite signal are spaced in time by more than the period equivalent of

30 c/s or if the maximum peak amplitudes are so very narrow that the power contained in the peak is insufficient to fully charge the capacitors of the monitor circuit.

The f.m. monitor has three ranges, 0 to 20 kc/s, 0 to 100 kc/s and 0 to 400 kc/s, which apply to the five r.f. ranges of the instrument, even though the high deviation of 400 kc/s cannot be obtained over part of the band of some of the r.f. ranges. Thus the maximum deviation obtainable at these frequencies is limited by the distortion introduced by the modulating system and not by the monitor. Therefore if the instrument is used for higher deviations than that given in the specification, care must be taken to ensure distortion is not introduced by limiting of the modulating circuitry.

The a.m. monitor has one range only of up to 50% modulation and operates from the rectified r.f. which feeds the r.f. level monitor.

As the f.m. and a.m. monitor is common over part of the circuit the meter will read when the function switch is set to either f.m. or a.m. But for correct monitoring the monitor range switch must be set to the same condition as the function switch.

Power Supply

Although the instrument is designed primarily for wide deviation as associated with multichannel telemetry equipment, special care has been taken to ensure good short-term stability. This is important for telemetry because of the exact frequency requirements of the sub-carriers and the carrier. Therefore, in keeping with the TF 1066B, stabilized h.t. and d.c. heater supplies are used.

The heater regulator is independent of the h.t. and, when switching on, the heater supply comes into operation prior to the h.t. supply.

REFERENCES

1. Deichen, J. H., 'F.M. Signal Generator types TF 1066B and B/1'. *Marconi Instrumentation*, December 1960, 7, p. 242.
2. Deichen, J. H., 'F.M. Signal Generator type TF 1066B/2'. *Ibid*, March 1961, 8, p. 18.

ACCURACY OF ELECTRONIC COUNTERS

IN GENERAL there will always be a possible error of ± 1 count on the least significant digit. This, together with the discrimination required, will determine whether Frequency or Period measurement is used, see graph.

1. **Frequency Measurement.** Accuracy is determined by the stability of the internal standard which provides the accurate counting interval. In addition there will be the ± 1 count and thus for a given gate time higher frequencies will be displayed with the greatest discrimination and accuracy.

2. **Period Measurement.** The errors in period measurement will be: (a) Ambiguity of gate triggering level. (b) Accuracy of internal timing units. (c) The ± 1 count.

For sine wave inputs the total possible error may be expressed as $\frac{1}{\pi}\frac{E_n}{E_s}$, where

E_n = total noise, including that due to counter circuitry

E_s = signal level

or $\frac{1}{n\pi}\frac{E_n}{E_s}$ where n is the number of periods in multi-period average measurements.

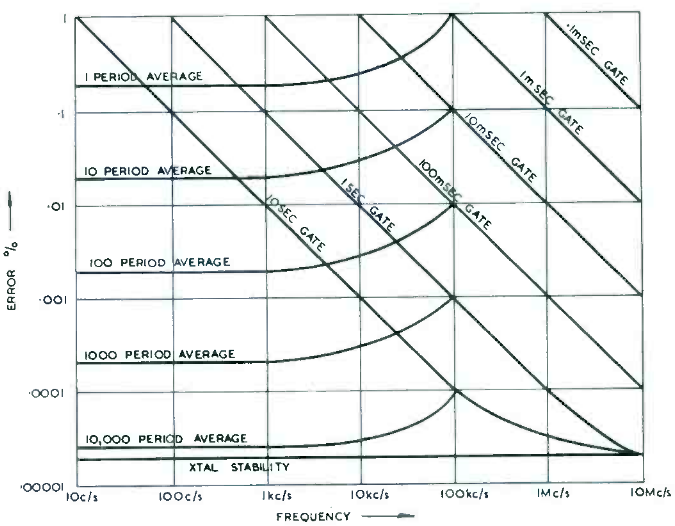
3. **Phase Measurement.** The reference and out-of-phase signals are used to start and stop the counter, the latter being arranged for period measurement and time interval measurement:

$$\theta = 360\,\frac{t}{T}.$$

Where θ = phase difference in degrees

t = phase difference in counter timing units

T = period of signal in counter timing units.



Accuracy chart TF 1417 series

Thus if the counter is to read directly in degrees external timing units must be provided of a frequency $n.360\,f_s$ where n is an integer determining the discrimination desired and f_s is the frequency of the signal to be measured.

The accuracy obtained is a function of the ambiguity of the triggering level, and is considered in detail in the article appearing on page 60 of this issue.

M. W. G. H.

Summaries of Articles appearing in this issue

RESUME D'ARTICLES PUBLIES DANS LE PRESENT NUMERO

MESURE D'ÉMISSION ET LE NOUVEL APPAREIL DE MESURE D'ÉMISSION TF 2333

Un appareil de mesure d'émission se compose d'une source de signaux à large bande et d'un mesureur de niveau. Ses applications, ses exigences et les sources possibles d'inéxactitude à la mesure sont discutées, et il est démontré comment ces inéxactitudes sont évitées ou réduites dans la conception du TF 2333. Page 56

UTILISATION D'UN COMPTEUR POUR LA MESURE DE L'ANGLE DE PHASE

Les essais associés aux équipements de navigation V.O.R. impliquent la mesure de l'angle de phase entre deux signaux de 30 Hz. avec une précision de 0,1 %, correspondant à une différence de temps de 9,26 µsec. Ces mesures peuvent être effectuées avec le compteur fréquencemètre TF 1417 en termes de différences de temps, en alimentant un signal dans le 'START' et l'autre dans le canal 'STOP'. Comme le compteur fonctionne avec une gamme étendue de tensions d'alimentation il est essentiel que le voltage alimentant le circuit d'alimentation, ait une courbe de tension frontale pointue pour obtenir la précision désirée. Des détails sont donnés, concernant l'appareil TM 7261 fonctionnant sur piles, appareil amplifiant et équarrissant les signaux pour alimenter le compteur avec une courbe de tension appropriée. En utilisant un appareil extérieur de minutage il est possible d'obtenir une lecture directe en degrés, de preférence aux méthodes de calcul de la différence de phase en partant d'une mesure de temps. Page 60

ENCORE MOINS DE DISTORSION

Une description est donnée, d'une modification simple appliquée à l'oscillateur AF du type TF 2100, permettant, avec un sacrifice sur le niveau de sortie, de réduire la distorsion à un pourcentage inférieur à 0,01 % sur la presque totalité de la gamme de fréquence. Page 64

MESURE DE LA FRÉQUENCE DE SIGNAUX RADIOS ÉMIS DANS LA GAMME DE 100 kHz à 30 MHz

Il est souvent nécessaire de mesurer la fréquence de signaux de radio faibles, en particulier les signaux venant d'émetteurs éloignés. Le compteur fréquencemètre TF 1417 nécessite une entrée minimum de 0.25 volt pour un fonctionnement satisfaisant. Néanmoins, lorsqu'il est utilisé en conjonction avec un fréquencemètre Hétérodyne TF 1067 et un récepteur approprié il est possible de mesurer la fréquence de signaux faibles dans la gamme de 100 kHz à 30 MHz. avec une précision supérieure à 0,0001 %.

Le niveau du signal requis dépend uniquement de la sensitivité du récepteur. Page 66

GÉNÉRATEUR À DÉVIATION À LARGE BANDE

Un nouveau générateur de signaux à déviation à large bande, dans la série familière des TF 1066B, a été spécifiquement conçu pour répondre aux exigences des instruments d'equipement de télémesure dans les bandes de 215 à 265 MHz.

Néanmoins, cet instrument couvre une gamme de fréquence continuellement variable de 10 à 470 MHz mais avec moins de facilité d'exploitation de modulation de fréquence dans certaines parties de la gamme, comparée à la bande comprenant les fréquences ci-dessus.

Cet article décrit le nouvel instrument et donne les détails spéciaux du système de modulation et du circuit du moniteur de déviation. Les signaux de modulation multiples et les signaux à distorsion harmoniques ainsi que les difficultés qui leur sont associées pour une monitorisation exacte sont discutés dans cet article. Page 69

ZUSAMMENFASSUNG DER IN DIESER NUMMER ERSCHEINENDEN BEITRAGE

ÜBERTRAGUNGSMESSUNGEN UND DAS NEUE ÜBERTRAGUNGSMESSGERÄT TF 2333

Das Übertragungsmessgerät besteht aus einem breitbandigen Generator und einem Pegelmesser. Anwendungsgebiete, Anforderungen und mögliche Ursachen von Messungenauigkeiten werden behandelt. Die Vermeidung oder Verringerung dieser Ungenauigkeiten auf ein Minimum in dem Gerät TF 2333 wird ebenfalls aufgezeigt. Seite 56

DIE MESSUNG DES PHASENWINKELS MIT EINEM ZÄHLGERÄT

Bei der Prüfung von VOR-Navigationseinrichtungen muss der Phasenwinkel zwischen zwei 30 Hz-Signalen mit einer Genauigkeit von 0,1° bestimmt werden. Dies entspricht einem Zeitunterschied von 9,26 µs. Eine solche Messung kann mit dem Zähl- und Frequenzmessgerät TF 1417 durch Bestimmung des Zeitunterschiedes durchgeführt werden, wobei ein Signal an den 'Start'-Kanal und das andere an den 'Stop'-Kanal gelegt wird. Da das Zählgerät über einen grossen Spannungsbereich am Eingang arbeitet, muss zur Erzielung der geforderten Genauigkeit eine scharfe Impulsfront an den Eingang gelegt werden. Einzelheiten über ein kleines batteriebetriebenes Gerät TM 7261 werden berichtet, mit dessen Hilfe die Signale verstärkt und in Rechteckimpulse umgewandelt werden, um eine für den Eingang des Zählgerätes günstige Schwingung zu bilden. Durch Benutzung einer anzuschliessenden Zeitbestimmungseinheit ist es möglich eine direkte Ablesung in Graden zu erhalten, anstatt den Phasenunterschied aus einer Zeitmessung errechnen zu müssen. Seite 60

NOCH WENIGER VERZERRUNG

Eine einfache Änderung an dem Tonfrequenzoszillator TF 2100 wird beschrieben, mit deren Hilfe es bei einer geringfügigen Verringerung des Ausgangspegels möglich ist, die Verzerrung im grössten Teil des Frequenzbereiches unter 0,01 % herunterzudrücken. Seite 64

DIE FREQUENZMESSUNG VON ABGESTRAHLTEN FUNKSIGNALEN IM BEREICH VON 100 kHz BIS 30 MHz

Häufig muss die Frequenz von schwachen Hochfrequenzsignalen, besonders von entfernten Sendern, bestimmt werden. Das Zähl- und Frequenzmessgerät TF 1417 benötigt eine minimale Eingangsspannung von 0,25 Volt für einen zufriedenstellenden Betrieb. Bei Benutzung dieses Gerätes in Verbindung mit dem Heterodyn-Frequenzmesser TF 1067 und einem geeigneten Empfänger kann jedoch die Frequenz schwacher Signale im Bereich von 100 kHz bis 30 MHz mit einer Genauigkeit von besser als 10^{-6} gemessen werden. Der erforderliche Signalpegel hängt nur von der Empfindlichkeit des Empfängers ab. Seite 66

DER MEBSENDER TF 1066B/6 MIT GROSSEM FREQUENZHUB

Der neue Messender mit grossem Frequenzhub in der bekannten Geräteserie TF 1066B wurde besonders zur Erfüllung der an Einrichtungen für Fernmessanlagen im Band 215 bis 265 MHz gestellten Anforderungen entwickelt. Das Gerät überdeckt einen kontinuierlich veränderlichen Frequenzbereich von 10 bis 470 MHz, aber mit weniger genauen FM-Einrichtungen über einen Teil des Bereiches im Vergleich zum Frequenzband, welches die oben erwähnten Frequenzen umfasst.

Der Aufsatz beschreibt das neue Gerät mit Einzelheiten über Schaltungen für die Modulation und Messung des Frequenzhubes. Mehrfachmodulation und harmonisch verzerrte Signale, sowie die daraus entstehenden Schwierigkeiten bei genauen Messungen werden behandelt. Seite 69

SOMMARIO DEGLI ARTICOLI PUBBLICATI IN QUESTO NUMERO

MISURE DI TRASMISSIONE ED IL NUOVO COMPLESSO PER MISURE DI TRASMISSIONE TF 2333

Un complesso per misure di trasmissione consiste di una sorgente di segnali a larga banda e di uno strumento per la misura del livello. Ne vengono discusse le applicazioni, i requisiti e le fonti possibili di inesattezze nelle misure, e si indica come queste inesattezze sono evitate o ridotte al minimo nel TF 2333 con opportuni accorgimenti costruttivi.

Pagina 56

MISURA DI UN ANGOLO DI FASE MEDIANTE UN CONTATORE

Il collaudo di apparecchiature di navigazione V.O.R. (radiofari omnidirezionali ad onde ultracorte) comporta la misura dell'angolo di fase tra due segnali di 30 Hz con una precisione di 0,1°, equivalente ad un intervallo di tempo di 9,26 μsec. Tale misura può essere effettuata con un contatore/frequenzimetro TF 1417 in termini di un intervallo di tempo, applicando uno dei segnali al canale di sgancio (start) e l'altro segnale al canale di arresto (stop). Dato che segnali di ingresso aventi valori di tensione compresi entro limiti molto vasti sono in grado di far funzionare il contatore, è essenziale di presentare al circuito di entrata un fronte d'onda ripido per poter ottenere la precisione richiesta. Vengono forniti particolari di una piccola unità con alimentazione a pile, TM 7261, che amplifica e squadra i segnali in modo da provvedere una forma d'onda adatta all'ingresso del contatore. Con l'uso di un cadenzatore esterno si può ottenere una lettura diretta in gradi, piuttosto che dover calcolare la differenza di fase dalla misura di un intervallo di tempo.

Pagina 60

ANCORA MENO DISTORSIONE

Viene descritta una semplice modifica apportabile all'oscillatore a bassa frequenza TF 2100, mediante la quale è possibile, con sacrificio del livello di uscita, di ridurre la distorsione ad un valore inferiore a 0,01 % sulla maggior parte del campo di frequenza.

Pagina 64

MISURE DI FREQUENZA DI SEGNALI RADIOTRASMESSI NEL CAMPO DA 100 kHz A 30 MHz

Succede spesso di dover misurare la frequenza di segnali a radiofrequenza di debole intensità, particolarmente nel caso di segnali provenienti da trasmettitori lontani. Il contatore/frequenzimetro TF 1417, per funzionare in modo soddisfacente, richiede un minimo di 0,25 volt all'ingresso. Usandolo però in unione al frequenzimetro ad eterodina TF 1067 e ad un ricevitore adatto, consente di misurare la frequenza di segnali deboli nel campo da 100 kHz a 30 MHz con precisione superiore ad una parte su 10^6. Quale dovrà essere il livello del segnale dipenderà soltanto dalla sensibilità del ricevitore.

Pagina 66

UN GENERATORE DI SEGNALI A FORTE DEVIAZIONE TIPO TF 1066B/6

Un nuovo generatore di segnali nella nota serie TF 1066B, con una forte deviazione di frequenza, è stato specificamente studiato per soddisfare le esigenze di strumentazione per apparecchiature di telemetria nella banda 215–265 MHz. Lo strumento è però in grado di funzionare entro un campo di frequenza variabile con continuità da 10 a 470 MHz, sebbene nella parte del campo all'infuori della suddetta banda offra possibilità meno rigorose di modulazione di frequenza.

Questo articolo descrive il nuovo strumento fornendo minuti particolari del sistema di modulazione e dei circuiti di controllo della deviazione. In esso sono discussi i casi di segnali modulanti multipli e di segnali affetti da distorsione armonica e le relative difficoltà di esatto controllo.

Pagina 69

RESUMENES DE ARTICULOS QUE APARECEN EN ESTE NUMERO

EL NUEVO EQUIPO PARA MEDIDAS DE TRANSMISIÓN

El equipo para medidas de transmisión consiste en un generador de señales de banda ancha y un medidor de nivel. En este artículo se describen sus aplicaciones, requisitos y las posibles causas de inexactitud de medidas. A continuación, el autor demuestra como estas inexactitudes se pueden evitar o reducir en el diseño del TF 2333.

Página 56

MEDIDAS DEL ANGULO DE FASE CON EL USO DE UN CONTADOR

Las pruebas de los equipos de navegación V.O.R. deben ser capaces de medir el ángulo de fase de dos señales de 30 Hz con una precisión de 0,1° y esto es equivalente a una diferencia de tiempo de 9,26 useg.

Tales medidas pueden hacerse con el Medidor Contador/Frecuencia TF 1417 en términos de diferencia de tiempo, alimentando una de las señales al canal de arranque y la otra al canal de parada. Como el contador puede operar sobre un ancho margen de tensión de entrada, es esencial que se presente al circuito de entrada una fuente de onda aguda para obtener la precisión requerida.

Se dan detalles de una unidad pequeña alimentada por batería TM 7261 que amplifica y cuadra las señales para poder proveer una forma de onda adecuada a la entrada del contador. Con el uso de una unidad externa de regulación, es posible obtener una medida directa en grados en lugar del cálculo de la diferencia en fase de una medida de tiempo.

Página 60

AUN MENOS DISTORSION

Se describe una modificación sencilla del oscilador de AF tipo TF 2100 con la que es posible reducir la distorsión con una pérdida en el nivel de salida, menor del 0,01 % en casi todo el margen de la frecuencia.

Página 64

MEDIDAS DE FRECUENCIA DE SEÑALES DE RADIO EN EL MARGEN DE 100 kHz A 30 MHz

A menudo es necesario medir la frecuencia de señales débiles de radio, particularmente las señales de emisoras remotas. El medidor Contador/Frecuencia TF 1417 requiere una entrada mínima de 0,25 V para su operación satisfactoria. Pero, cuando este se usa con el medidor Heterodino de Frecuencia TF 1067 y un receptor adecuado, es posible medir entonces la frecuencia de señales débiles en el margen de frecuencias de 100 kHz a 30 MHz con una precisión que es mejor de 1 parte en 10^6.

El nivel de señales requerido depende solamente de la sensitividad del receptor.

Página 66

UN GENERADOR DE SEÑALES DE AMPLIA DESVIACION TF 1066B/6

Un nuevo generador de señales de amplia desviación en la serie TF 1066B ha sido estudiado especialmente para los requisitos de equipos telemétricos en el margen de frecuencias de 215 a 265 MHz. No obstante, el instrumento cubre un margen de frecuencias continuamente variable desde 10 a 470 MHz si bien las facilidades de modulación de frecuencia son menores en la parte exterior al mencionado margen.

En este artículo se dan detalles especiales del sistema de modulación y de los circuitos de control de desviación.

Se discuten señales moduladas múltiples y señales con deformación ármonica y las dificultades a ellas asociadas.

Página 69

SIGNAL GENERATORS

NOISE GENERATORS

OSCILLATORS

OSCILLOSCOPES

PULSE GENERATORS

MODULATION METERS

DISTORTION ANALYSERS

SPECTRUM ANALYSERS

FREQUENCY COUNTERS AND METERS

POWER METERS

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Printed in England by The Campfield Press St. Albans