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MARCONI INSTRUMENTATION

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MARCONI INSTRUMENTS LIMITED

ST. ALBANS

ENGLAND

EDITORS

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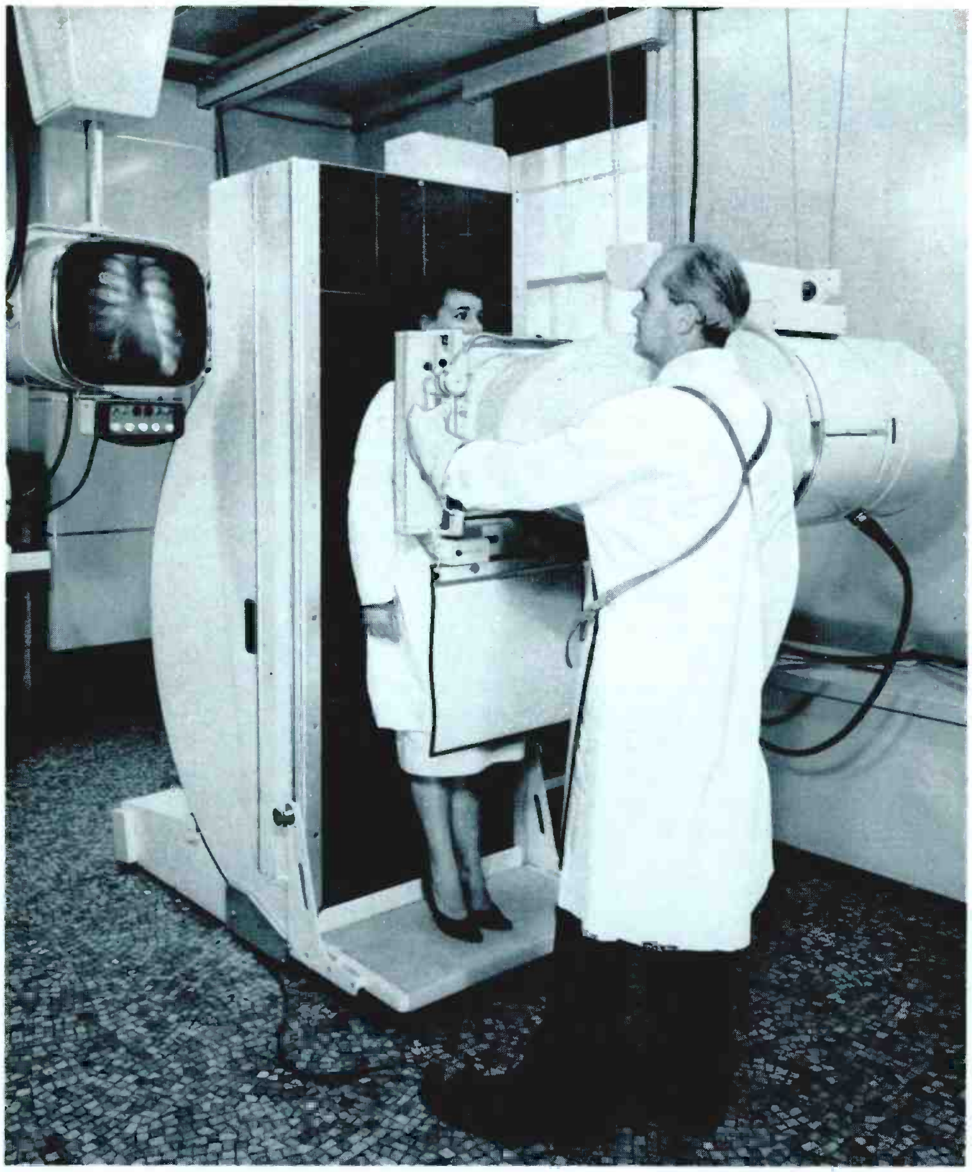
Finger on the Pulse

A CONTINUOUS STRUGGLE to increase the purity of sinusoidal waveforms, by the reduction of harmonic content, engages the attention of many designers in all branches of electrical engineering. At times they must envy their colleagues working on equipments involving the various forms of pulse techniques—but of course they also have their problems. As the success of the former is measured in the deficiency of the harmonics, so might the achievements of the latter be expressed in the richness of harmonic content. However, because of the complex relationship required of the amplitude and phase of individual sinusoidal waves to produce a pulse of acceptable standards, it is preferred, for simplicity, to introduce new concepts of performance in such terms as rise-time, sag and overshoot to define the quality of a pulse.

The link between the pure sinewave and the pulse was first propounded as a mathematical series by the eminent French scientist Fourier in the early nineteenth century, when he was investigating the mathematical theory of the conduction of heat, long before the science of electronics, which was to bring him everlasting fame, was known. His theorem basically relates to any periodic function, but in terms of electronics it states that a train of pulses having zero rise-time is equivalent to a sum of continuous sinewaves of frequencies harmonically related extending from zero to infinity and of suitable relative amplitudes and phase. Therefore for perfect production or transmission of such a pulse train, an infinite bandwidth is required. In practice, of course, this demand on bandwidth is limited at the lower end by the recurrence frequency, while the upper limit is set by the finite rise and fall times of the individual pulses.

Compared with c.w. or amplitude- and frequency-modulated systems, pulse techniques offer the great advantage that considerable power can be obtained for a short length of time which, depending upon the ratio of ON to OFF period, will result in a low average power. This fact is admirably illustrated in radar transmitters where, for example, it is possible to obtain a peak power output of one megawatt for the expenditure of an average power which with a low duty cycle could be as small as 100 watts. Provided that the necessary information is obtained under these conditions, then a very high efficiency can be realized. Although this is a good example of the application of pulse techniques, they are not confined to transmission systems alone. A rapidly growing field is in the testing of components such as transistors and ferrite cores, beyond their steady state dissipation limits. Also, using suitable generators it is possible to study the transient response and bandwidth of amplifiers, transmission lines, magnetic delay lines; switching speeds of relays and semiconductors; resolution time of counters—to mention but a few.

Each year sees an increase in the number of instruments listed in our catalogue employing either directly or indirectly pulse and kindred waveforms. On the one hand are the pulse generators, oscilloscopes and counters where the emphasis is predominantly pulse operation, although in their application the oscilloscopes and counters are frequently used for sinewave measurements. At the other end of the scale are the signal generators which, although essentially sinewave devices, often have facilities to apply pulse modulation to simulate transmission systems; in this respect a modified U.H.F. Signal Generator TF 1060/2 was introduced last year to give improved rise and fall times under modulation conditions. In between these two extremes we have the hybrid type of instrument such as the Wide Range R-C Oscillator



Many of our readers will be unfamiliar with this particular product of Marconi Instruments. It is a large screen X-ray image amplifier, in which television pulse techniques are utilized to reproduce a fluoroscopic image on monitor screens. The installation shown here is in use at Guy's Hospital, London

TF 1370. Basically this instrument is a sinewave generator, of the Wien-bridge type, but with the use of squaring circuits can produce from its sinusoidal waveform a square wave having rise-times considerably less than 1 μsec. The converse is true of another hybrid, namely the Low-Frequency Generator TF 1382, where the basic waveform is a sawtooth or ramp from which a sinewave is electronically synthesized.

The major contributions to this issue are devoted to instruments using pulse circuits. Two new pulse generators are introduced which employ vastly different methods for the production of their outputs. First there is the versatile Double Pulse Generator TF 1400, with its accessories, which uses what may be considered as conventional circuits such as various forms of multivibrators and phantastrons. It is in fact an extension of the TF 675 series which in its many guises, with various improvements, has done yeoman service for a considerable number of years. Our records show that the original version was first produced as a modulation generator in 1941. Secondly, and in contrast, we have the Nanosecond Pulse Generator TF 1389 which relies upon discharging various lengths of coaxial line by electromechanical means to produce a very short pulse.

On the same topic of pulse production is a novel application report by one of our representatives on the construction of a do-it-yourself double pulse generator using two type TF 1330 or 1331 Oscilloscopes. Although we do not consider this a serious competitor to the TF 1400, the arrangement described can form a useful generator particularly as oscilloscopes are usually readily available. As an exercise for his ingenuity, he has been asked to do a further report on using two Double Pulse Generators TF 1400 to produce an oscilloscope—we await the result with interest.

In the oscilloscope field is an article describing the Delay Generator TF 1415 which provides sweep delaying facilities to extend the usefulness of oscilloscopes, or it can be used independently as a general purpose delay generator.

In introducing these three types of pulse generator in this issue, and giving some of the possible applications, it would perhaps have been more correct to have used the title *The Generation and Utilization of Non-Sinusoidal Recurrent Waveforms.* Instead we have borrowed a phrase from the medical world because we hope that all our new instruments, which are duly presented in this journal irrespective of waveform, show that we have our finger on the pulse of our customers' requirements. P. M. R.

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MARCONI INSTRUMENTS

Double Pulse Generator . . . . . TYPE TF 1400

by J. W. MACFARLANE,
B.Sc. (Hons.),
Graduate I.E.E.

This instrument provides high quality single or double pulses up to 200 volts with a maximum jitter-free delay of 3000 µsec. The addition of the TM 6600 Secondary Pulse Generator provides a second output of comparable pulses and extends the usefulness for systems which require three-pulse testing. The further addition of the 50 Ω Combining Unit TM 6666 increases the versatility of the instrument by providing at a single socket two pulses independently variable in width, amplitude and delay.

THIS DOUBLE PULSE GENERATOR was designed to be a versatile instrument for the testing of systems where a maximum of three separate pulse outputs may be required. For example, with a radar system, one could be used to trigger an oscilloscope, one to operate the transmitter, and a third to simulate an echo pulse to the receiver, double pulse operation being provided on one output to facilitate the testing of systems using a simple two pulse code. It was, however, felt that there was considerable scope for a simpler instrument providing only a sync pulse to trigger an oscilloscope with a single main output channel on which double pulse working was available. To meet this dual requirement, the TF 1400 Double Pulse Generator was constructed as a general-purpose instrument with sync and one main output only, but with provision for an optional plug-in unit to provide the third output.

The main output provides large amplitude pulses with good rise times, having many applications such as testing of radar and television circuits, response testing of oscilloscopes, amplifiers and filters with bandwidths up to 10 Mc/s, or modulating signal generators. The jitter free delay and double pulse facility provided on the main channel extend the usefulness of the instrument to the field of time measurement, enabling time bases of oscilloscopes and time interval meters to be rapidly checked. It is also very useful for checking the resolution of counters.

When double pulse operation is employed, using only the basic TF 1400, the two pulses appearing at the main output are identical in width and amplitude, the optional pulse being coincident with the sync output pulse.

The sync output provides a single pulse of adequate amplitude for satisfactory trigger operation of most modern oscilloscopes. The leading edge of this pulse at

Marconi Instruments Double Pulse Generator, Type TF 1400, with the Secondary Pulse Generator, TM 6600, plugged in half amplitude is the datum for delay calibration, and its good rise time maintains the calibration accuracy in spite of variations in the triggering level.

The time relationship between the outputs when using the TF 1400 alone are illustrated diagrammatically in Fig. 1a.

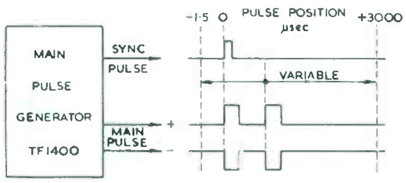


Fig. 1a. Outputs from TF 1400. First pulse of main output present in 'Double Pulse' working only

The plug-in unit is known as the TM 6600 Secondary Pulse Generator. It provides a second output of comparable pulses independently variable in amplitude, width, and delay. The repetition frequency, however, is that of the main instrument with which it is operated. This unit fits into a space provided in the front panel of the TF 1400 Double Pulse Generator. All the necessary electrical connections between the two are made by means of a 16-way plug on the rear of the Secondary Pulse Generator which mates automatically with a socket inside the main instrument when the unit is pushed into place. As in the case of the main output from the TF 1400, the delay is calibrated with respect to the half amplitude point on the leading edge of the sync output from the TF 1400.

When the main output of a TF 1400 fitted with a TM 6600 is used under double pulse conditions, the two pulses are identical in amplitude and width, but the optional pulse is now coincident with the secondary output from the TM 6600, instead of with the sync output from the TF 1400. Although the pulses are independently delayed, the amount of jitter present is small enough for the pulses to be used as a pair with a short interval between them, even when the pair is delayed up to the maximum available. The time relationship between the various outputs when a TM 6600 Secondary Pulse Generator is used are shown in Fig. 1b.

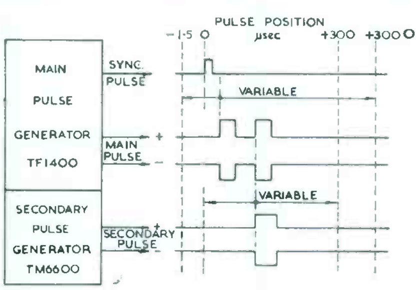
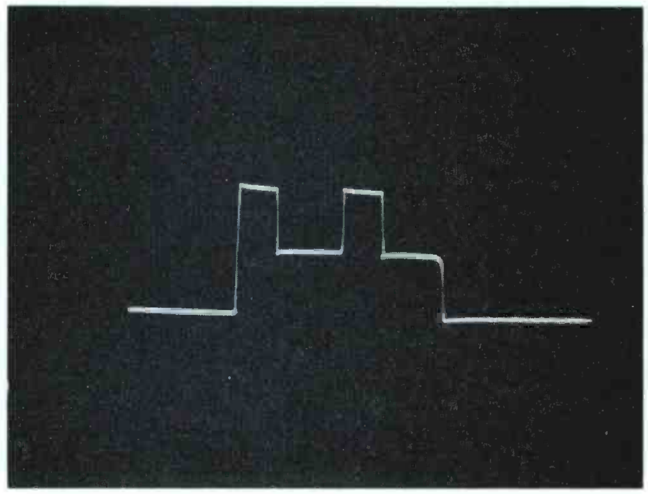


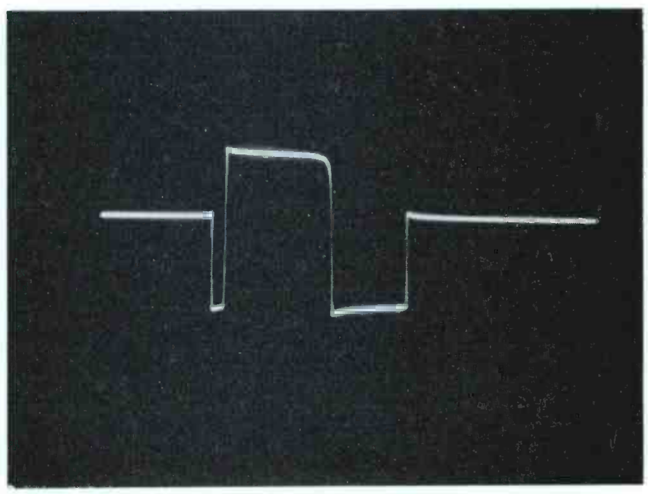
Fig. 1b. Outputs from TF 1400 with TM 6600. Second pulse of main output present in 'Double Pulse' working only

When the TM 6600 is not used, the space in the front panel is covered by a clip-on blank panel. Once a TM 6600 is fitted, it is unnecessary to change back to a blank panel, as all conditions obtainable with only the TF 1400 are also obtainable when the TM 6600 is added.

The repetition frequency common to all outputs may be generated internally or an external source may be used. Provision is made for trigger operation from either



(a) Wide secondary +ve pulse provides a pedestal for double shorter pulses from main output



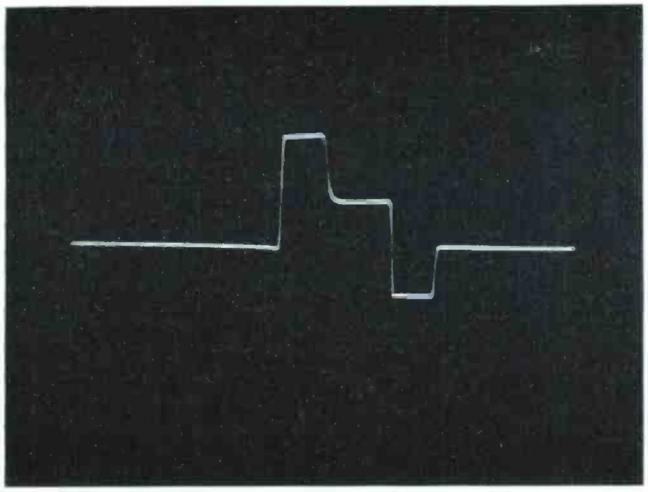
(b) Large amplitude +ve secondary pulse superimposed on smaller amplitude wide −ve main pulse

Fig. 2. Typical waveforms obtained from TF 1400 with accessories TM 6600 and TM 6666

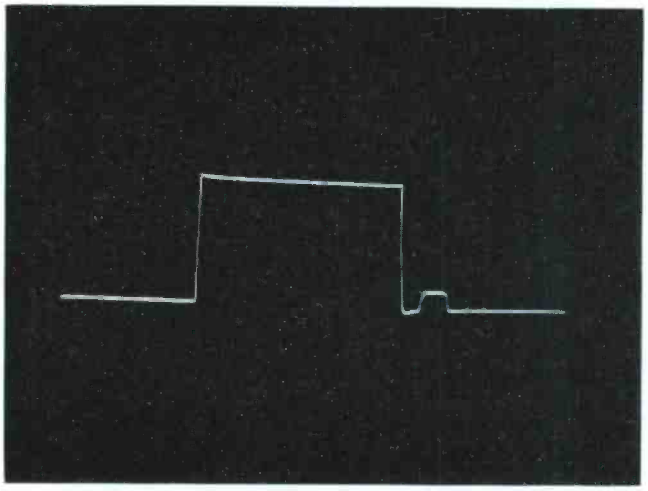
positive or negative going pulse trains or from the positive or negative going slopes of sinusoidal inputs. Sync operation is possible from either positive or negative going pulse trains, where the repetition frequency of the input is any integral multiple up to 10 of the desired output p.r.f. Internal trigger operation at mains frequency is also provided. The front panel sensitivity control allows satisfactory trigger or sync operation from a very wide amplitude range of input signals.

To increase the versatility of the combined instrument formed by the TF 1400 Double Pulse Generator and TM 6600 Secondary Pulse Generator, a second accessory —the TM 6666 50 Ω Combining Unit—has been designed.

As its name implies this unit is intended for working with the 50 Ω, i.e. 20 volt e.m.f., output ranges of the pulse generators. It is designed to accept two inputs from 50 Ω sources and to combine these two input signals in a single 50 Ω output. The circuit is a simple resistive



(*c*) *—ve main pulse starting during larger amplitude +ve secondary pulse*



(*d*) *Large amplitude wide +ve main pulse followed by smaller amplitude narrow secondary pulse*

network which performs this function with a loss of half amplitude for each of the two signals. It is provided with two leads for connecting to the outputs of the pulse generators, these leads being fixed to the small box containing the resistors. A 50 Ω BNC socket similar to those on the main instrument is provided as the outlet.

One of the inputs is intended to be taken from the TF 1400 and one from the TM 6600. The 50 Ω Combining Unit then provides at a single socket a signal comprising two pulses which are independently variable in amplitude, width and delay, and which can be the same or reversed polarity. As different generators are used for the two pulses there is no limitation, due to recovery time, on the spacing, and the pulses can if required be coincident to provide, say, a short pulse on a wider pedestal.

This feature greatly increases the usefulness of the instrument for testing high resolution counting circuits, and the different characteristics available for the two pulses make it ideal for the measurement of amplifier paralysis time. In addition it provides a signal source of great versatility for rapid testing of trigger circuits on a GO—NO GO basis.

CIRCUIT DETAILS

TF 1400 Double Pulse Generator

A block schematic diagram of the TF 1400 is shown in Fig. 3. For operation using the internally generated p.r.f. the p.r.f. generator is connected as a free running multivibrator which generates a square wave at the output repetition frequency. The range covered is from 10 c/s to 100 kc/s in four decade ranges selected by setting the P.R.F. SELECTOR switch to positions 2 to 5. A calibrated control gives continuous coverage within each range.

At these settings of the P.R.F. SELECTOR, the p.r.f. generator will synchronize to a train of pulses applied to the EXT. P.R.F. socket. A single socket is used for all input signals which are fed through a two-stage amplifier to the p.r.f. generator. The amplifier's first stage is a phase splitter whose correct output is selected by setting the TRIG/SYNC switch to position + or — to correspond with the polarity of the input signal. The remaining stage of the amplifier has sufficient gain to give the required sensitivity. For sync operation it also limits the maximum output to the p.r.f. generator to a level which permits satisfactory working with an input repetition frequency up to 10 times that of the output with no danger of breakthrough of the input frequency. For this mode of operation, position 3 of the TRIG/SYNC switch is SYNC OFF which disconnects the external signal.

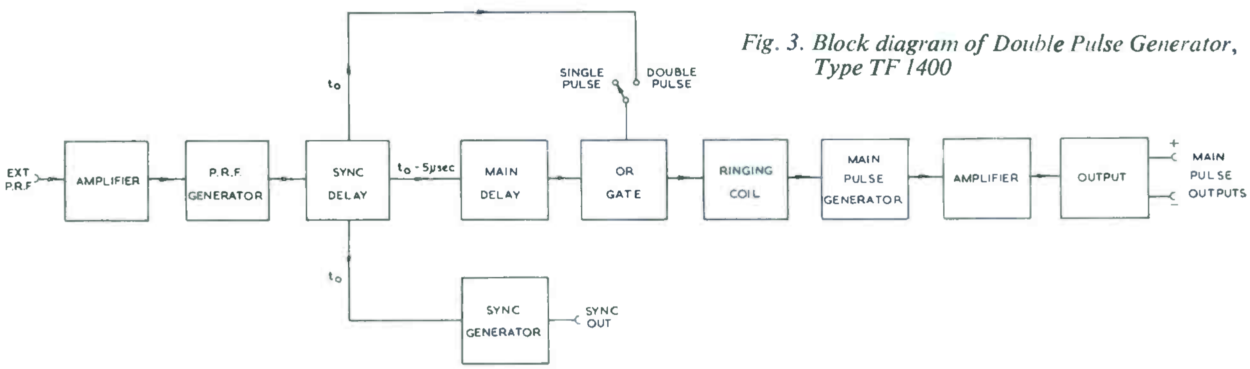


Fig. 3. Block diagram of Double Pulse Generator, Type TF 1400

For trigger operation, the P.R.F. SELECTOR is set to TRIG. The p.r.f. generator is now connected as a Schmitt circuit which changes from one stable state to the other on the positive going part of the waveform from the amplifier, reverting to its original state on the negative going part of the waveform. An external pulse train or sinusoidal input may be used, the polarity being selected as before by means of the TRIG/SYNC switch. The circuit will respond to a random train of pulses as well as to an evenly spaced train, provided that the pulses are not closer than 10 μsec. With input pulses of large amplitude, or where the waveform tends towards a square wave, it is possible to trigger the instrument from the rear edge of a negative going pulse by setting the TRIG/SYNC switch to + and vice versa.

With the P.R.F. SELECTOR set to TRIG., position 3 of the TRIG/SYNC switch is INT. MAINS. TRIG. The EXT. P.R.F. socket is disconnected and the input to the amplifier is taken from one of the secondaries of the mains transformer, causing the p.r.f. generator to run at mains frequency.

In every case, the rectangular waveform from the p.r.f. generator is differentiated, the negative going edge providing a short pulse whose shape is nearly independent of frequency and method of operation. This pulse is used to drive the remainder of the instrument.

To enable the main output pulse to precede the sync output pulse, it is necessary to delay the latter. The sync delay circuit is formed by a flip-flop which is triggered by the pulse from the p.r.f. generator to form a rectangular pulse with a fixed duration of 5 μsec. This is differentiated and the short pulse from the rear edge is squared and amplified in the sync output stage to provide the sync output pulse. The short pulse from the front edge of the sync delay waveform is used to trigger the main delay circuit.

The switching of polarity in the p.r.f. circuits ensures that the sync output pulse occurs not more than 8 μsec after the desired operating point on an external trigger or sync waveform.

The main delay is obtained by using a phantastron circuit to generate a jitter free rectangular pulse whose duration is equal to 5 μsec plus the required delay. The rear edge of this pulse is thus delayed on the sync output pulse by the required amount. The total delay coverage is from −1·5 μsec to +3000 μsec relative to the sync output pulse, in four ranges. Continuous variation within each range is provided by a calibrated front panel control. The output from the phantastron is squared by a bistable multivibrator whose output is differentiated. The resulting spike from the rear edge is applied to an 'or' gate.

When the SINGLE PULSE/DOUBLE PULSE switch is set to DOUBLE PULSE, a second spike is applied to the 'or' gate. This spike is obtained by differentiation of the rear edge of the sync delay waveform, and so coincides with the front edge of the sync output pulse.

The 'or' gate comprises a diode network which combines the spikes from the two delay circuits in a single channel and feeds them to a stage incorporating a ringing coil. The 'or' gate network also prevents the output from each delay circuit from affecting the other, permitting close pulse spacing to be used.

The ringing coil forms the anode load of a high gain pentode amplifier. Each spike from the 'or' gate causes it to ring, but a diode circuit removes all but the first half cycle to give a short pulse used to trigger the main pulse generator.

The main output pulses are formed by a high-speed flip-flop circuit. It generates pulses with widths ranging from 0·1 to 100 μsec in three decade ranges, and again a calibrated control is provided to give continuous variation in each range. For double pulse working, the minimum pulse spacing is determined by the recovery time of this flip-flop, but it will respond satisfactorily to a pair of trigger pulses spaced by twice the output pulse width.

The output from this flip-flop is at a fairly low level, and a two-stage pulse amplifier is used to increase the pulse amplitude to that required to drive the output stages. Shunt peaking in the second stage and limiting at each grid help to maintain good rise and fall times.

The amplifier feeds a cathode follower which provides a low impedance signal to drive the final output stage through an amplitude control. The anode circuit of the cathode follower incorporates an integrator which produces a d.c. voltage proportional to the duty cycle of the main pulse generator. This voltage is applied to a small neon which is thus caused to glow when the maximum permissible duty cycle is exceeded. The limitation on duty cycle is imposed by the maximum ratings of the valves used, and the neon is mounted on the front panel to give visual warning to the user.

The final output stage is connected differently for each of the output ranges. On the ±20 volt range, it is connected as a phase splitter to supply peak pulses of +20 volts and −20 volts e.m.f. maximum simultaneously from two sockets, each having a source impedance of 50 Ω. The circuit is designed to operate correctly when each output feeds a resistive load of 50 Ω, and the calibration of the amplitude control is not valid nor will the outputs be equal for any other load conditions.

An internal termination is provided which can be switched to either of the two outputs enabling the other alone to be used with correct calibration. This is done on the +20 volt and −20 volt ranges. In each of these cases, the internally terminated output has its socket disconnected.

On the +60 volt range the output stage forms a simple cathode follower, and on the −200 volt range it is connected as an amplifier. Again in each of these cases the unwanted output socket is disconnected.

In all cases the same output amplitude control is used, and as it is the input to the final stage which is controlled, the output impedance is maintained constant on any one range.

TM 6600 Secondary Pulse Generator

Fig. 4 shows a block schematic diagram of the TM 6600 Secondary Pulse Generator, showing its connections to the TF 1400. Not shown are the power supplies which are obtained from the power unit of the TF 1400.

The secondary delay circuit is similar to that of the main delay of the TF 1400. It covers the range of 0–300 μsec relative to the TF 1400 sync output pulse in two ranges. As in the TF 1400 a single calibrated dial is

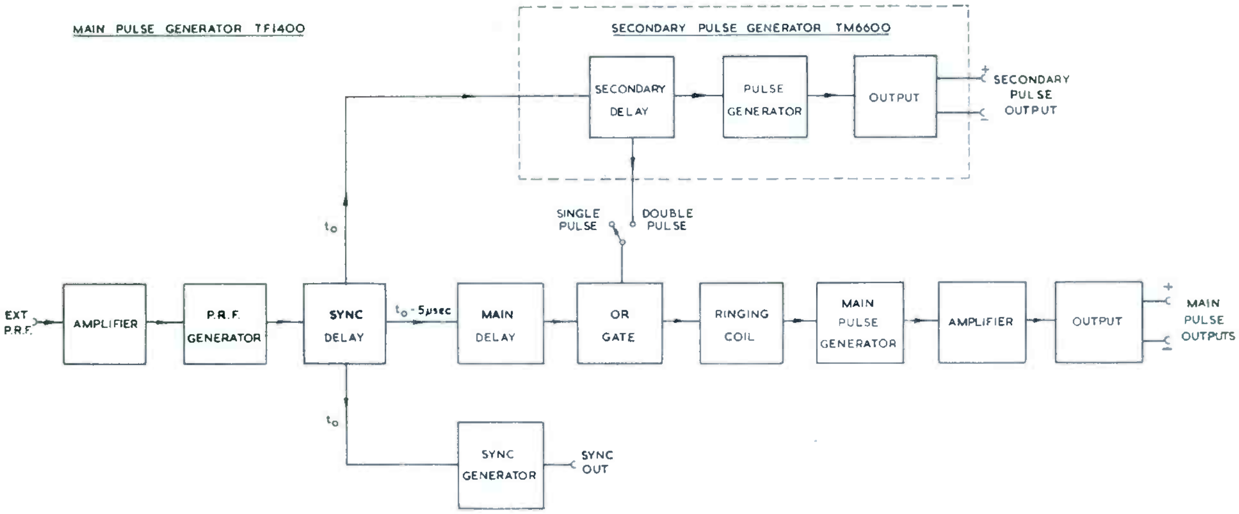


Fig. 4. Block diagram of TF 1400 complete with Secondary Pulse Generator, Type TM 6600

used to give continuous variation within each range. The delay pulse is differentiated, and the short pulse obtained from its rear edge is used to drive the secondary pulse generator.

The output pulses are generated by a flip-flop, a single width range from 0·5 to 25 μsec being used. The calibrated control is non-linear, giving a wide range with good discrimination at short pulse lengths. The pulses generated by this circuit are fed directly to output stages similar to those of the main pulse generator of the TF 1400. These stages incorporate identical systems for amplitude control and warning of excessive duty cycle.

On comparing Figs. 3 and 4, it will be noticed that when a TM 6600 Secondary Pulse Generator is used with a TF 1400, the feed to the 'or' gate of the TF 1400 from its sync delay is removed, and replaced by a signal from the secondary delay. When double pulse operation is used on the main outputs, both pulses are thus variable in delay, the optional pulse being coincident with the secondary output pulse. Both pulses are still identical in width and amplitude to that obtained in single pulse operation.

General Construction

To ease assembly, and reduce wiring time in production, printed wiring is used for the pulse circuitry on both the main instrument and the plug-in unit. This has the added advantage of maintaining stray capacitances and inductances more constant, giving a high degree of repeatability. To reduce the time required for calibration and setting up both initially and at any subsequent time, preset components have been used wherever necessary. The circuitry was designed specifically to suit pre-calibrated dials which are used wherever possible, and also to minimize the amount of resetting to be done in the event of replacement of any valve or other component.

All necessary adjustments to the Secondary Pulse Generator can be carried out with the TM 6600 in its normal position in the instrument provided that the case of the TF 1400 is removed. Studs have been provided on swivel arms at the rear of the TM 6600 so that it can be mounted outside the front panel of the TF 1400, and an extension lead is provided so that it can be operated in this position for setting up. This avoids the necessity of removing the TF 1400 case to adjust only the TM 6600.

The design of the mounting for the plug-in unit is such that units are interchangeable mechanically and a preset is provided to set the sync delay of the TF 1400 accurately to 5 μsec to ensure accurate delay calibration and electrical interchangeability.

The fuses and mains tap changing panel are situated at the rear of the instrument, and are readily accessible through a detachable panel in the rear of the case. In addition to the normal h.t. and mains fuses, the heater supply to each of the printed boards is individually fused to prevent damage to the printed wiring in the event of excess current being drawn in a fault condition.

Forced air cooling is necessary to remove the 300 watts dissipated in the instrument. Air is drawn in through a filter mounted in the left-hand side of the case and exhausted through an open grille at the right-hand side. The power supply valve chassis and the printed boards have been arranged to form a tunnel through which the air can flow with the minimum of unnecessary obstruction. All the valves and high wattage components are situated in the air stream to obtain the maximum cooling effect, and to prevent as far as possible the formation of local hot spots.

The design is such that the circuitry of the TF 1400 and TM 6600 lends itself to a considerable amount of fault localization from the front panel. In the event of failure of either the main or secondary output pulses, for example, the double pulse facility provides a simple means of checking whether the fault lies in the delay or pulse generator concerned. The operation of the duty cycle warning light, the sync pulse and the internal mains trigger facility can also be employed to help localize the fault.

ALTERNATIVE MILITARY VERSION

In addition to the instrument described above, a slightly modified version—Type TF 1400/S—has been designed to meet the needs of the armed services. The major differences from the commercial version are that the TF 1400/S will operate from various mains supply voltages at frequencies up to 500 c/s and, unlike the TF 1400, is supplied complete with the Secondary Pulse Generator as standard. The overall equipment has been allocated the Joint-Service Reference No. CT 434 and the NATO designation 6625-99-580-1364.

ABRIDGED SPECIFICATION FOR TF 1400 AND TM 6600

Repetition frequency
10 c/s to 100 kc/s; by internal control, external trigger or external sync.

Pulse length
0·1 to 100 μsec.

Rise time
Less than 30 nsec on the 20-volt ranges.

Amplitude
Five ranges:
0 to −20 volts,
0 to +20 volts,
0 to ±20 volts at separate outlets,
0 to +60 volts,
0 to −200 volts.

Source impedance
50 Ω on the 20 volt ranges.

Sync output
10 volt positive pulses, between 0·5 and 1 μsec.

Delay
−1·5 to +3000 μsec relative to sync output.

Double pulsing
Additional pulse is coincident with sync output.

SECONDARY PULSE GENERATOR

Repetition frequency
As for main pulse.

Pulse length
0·5 to 25 μsec.

Rise time
Less than 90 nsec on the 20 volt ranges.

Amplitude and impedance
As for main pulse.

Delay
0 to +300 μsec relative to sync output.

Double pulsing
Secondary Pulse Generator triggers the additional pulse at the main pulse output

For A. G. W. read P. M. R.

Readers of *Instrumentation* will have become accustomed to seeing editorials signed off with the initials of A. G. Wray, joint editor since February 1952. With the completion of the December 1961 issue, Mr. Wray has relinquished his editorship and P. M. Ratcliffe has been appointed in his place. Mr. Wray is now Deputy Chief Engineer of this Company; Mr. Ratcliffe is Assistant Chief Development Engineer, having responsibilities for signal sources and frequency measuring equipment.

Looking back to that editorial of February 1952, we find that it dealt with f.m. test gear in relation to the proposed setting up of v.h.f. f.m. broadcasting services by the B.B.C. Then as now f.m. instrumentation was one of our major activities, and it is interesting to note that two of the instruments mentioned at that time were Deviation Meter TF 791B and F.M. Signal Generator TF 995. Later versions of both these instruments are still available today in a highly developed form suitable for modern close-channel systems of f.m. communications.

Readership of *Instrumentation* has also developed during these ten years, and in fact has increased tenfold. The policy, however, remains the same—to present articles written by engineers for engineers in order to advance the science of electronic measurement.

. . . and for Arabs read Hindus

In letters to the editors, readers in Hatfield and Munich pointed out that in the caption of last issue's editorial picture we had attributed the invention of our numbering system to the Arabs instead of the Hindus. Turning to Encyclopaedia Britannica for some guidance in this unfamiliar subject for *Instrumentation*, we find that, as far as is known, it was indeed the Hindus who first used the largest number of our present numeral forms.

Their system originally lacked two vital features: a zero and the concept of place value by which the same set of symbols can represent not only units but tens, hundreds or, in fact, any power of ten. But the Hindus are also credited by many authorities with the eventual introduction of these most important advantages which gave the system its unique flexibility. About 800 A.D. these numerals became known to the Arabs who set out their value and use, modified the symbols, and introduced the system into Europe. Despite initial reaction against this 'infidel' invention, the Hindu-Arabic numerals began to be used in Europe about the twelfth century and attained their present form about the fourteenth.

A concluding thought—what a pity the early Hindus didn't have twelve fingers or we might have had the advantage of a duodecimal system today.

J. R. H.

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Fig. 1

Nanosecond Pulse Generator

TYPE TF 1389

by D. E. BENNETT, A.M.I.E.E.

A discharge-line type of pulse generator using a coaxially mounted mercury-wetted switch is the most versatile method of generating nanosecond (10^{-9} sec) pulses. The TF 1389 uses this principle to generate positive or negative pulses of good waveform and accurate amplitude continuously variable from 0·2 mV to 200 volts. The use of an improved mercury switch of small dimensions permits a variable repetition rate up to 350 c/s and the pulse risetime is less than 0·5 nsec. Pulse durations of 2·5, 5, 25, 50 and 100 nsec are provided by internal lengths of 75 Ω coaxial line although a pulse of any required duration may be generated by using an external line of convenient impedance.

RECENT PROGRESS in many branches of electronics has been dependent on the ability of switching circuits to perform at increasingly high speeds. The need for accurate display and measurement of fast transient waveforms has stimulated the development of commercial wideband oscilloscopes with risetimes in the nanosecond (10^{-9} sec) region.

To test adequately both the switching of high-speed devices and the fidelity of display apparatus requires a test waveform considerably faster than the equipment under test. The problem of generating pulses of less than 1 nsec risetime, good waveform, and accurate amplitude and duration has not yet been satisfactorily solved by purely electronic means. A solution does exist, however, in the well-known principle of the discharge line pulse generator using a coaxially mounted mercury-wetted contact switch.[1] This principle is used in the TF 1389 Nanosecond Pulse Generator.

Principle of Operation

Essentially the generator consists of a stable source of variable d.c. supply, a switch driven by a variable-frequency oscillator, and a length of coaxial cable open circuit at the far end.

Referring to Fig. 2, S is an oscillator-driven relay with mercury-wetted contacts. The armature is magnetically biased and operated by the alternating flux from the winding W; hence the relay makes one operation per cycle of the driving waveform. A potentiometer across the stabilized d.c. supply gives an adjustable voltage E. The pulse forming coaxial cable is L_1 while L_2 is a short length of output cable terminated by Z_0. The switch S is mounted coaxially inside a tube in order to match the cable impedance of 75 Ω as nearly as possible.

Fig. 3 shows the waveforms during one cycle of operation. Between pulses the cable L_1 will be charged to potential E via the charging resistor R_1 which is of high value

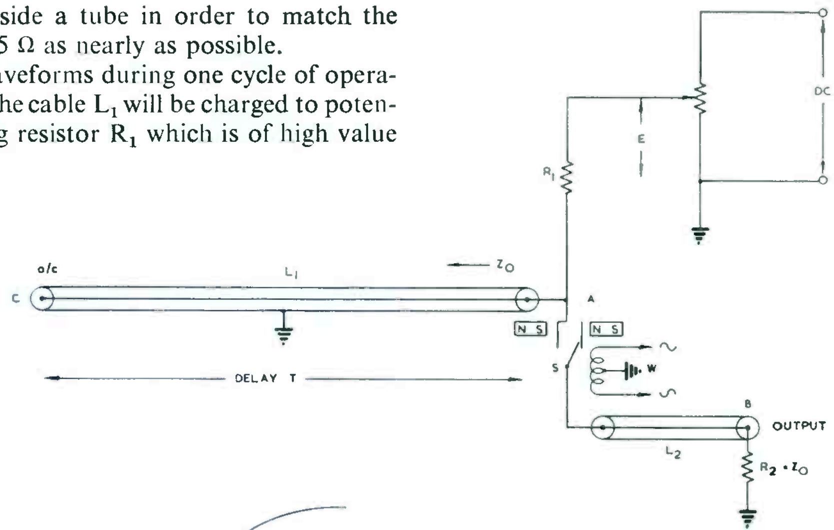


Fig. 2. Basic circuit arrangement of TF 1389

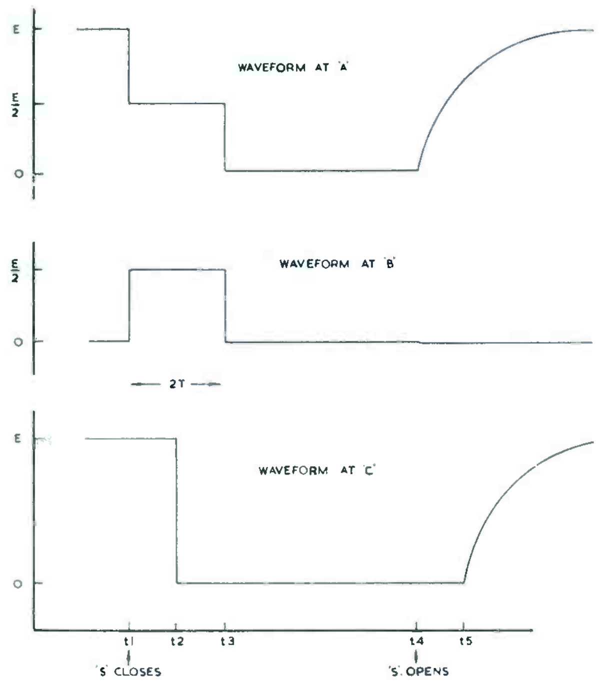


Fig. 3. Idealized waveforms

(100 kΩ). At instant t_1 the switch S closes and the line (which may be considered as a generator of potential E and internal impedance 75 Ω) is discharged by the 75 Ω terminating resistor at the end of L_2. Since L_1 is of equal impedance to its load, R_2, the potential at A falls from E to E/2 and that of B rises from 0 to E/2. This transient occurs very rapidly and is slowed only by small stray capacitances and the making time of S, the latter being less than one nanosecond. The voltage step E/2 so formed travels down L_1 taking time T to do so. The line is open circuit and hence reflection occurs without inversion. At instant t_3 (after twice the delay time of L_1) the waveform step at B is cancelled, making a pulse of duration twice the delay time of L_1 and of amplitude E/2. Actually the cable does not discharge to zero but to a potential determined by R_1 and the terminating resistor, R_2, in this case negligibly small. At instant t_4, determined by the period of the driving waveform, S opens allowing L_1 to charge exponentially to potential E.

Requirements for a Nanosecond Pulse Generator

A versatile instrument would be expected to cover the following applications:

1. Transient tests on wideband oscilloscopes and pulse amplifiers.
2. Switching measurements on semiconductor devices and circuits.
3. Extremely short pulses of accurately known amplitude and duration often required in nuclear physics.

Essential requirements for these applications might then be listed as follows:

(*a*) Fastest risetime possible with minimum overshoot.
(*b*) Good and stable waveform independent of pulse duration or polarity.
(*c*) Variable amplitude over a wide range accurately calibrated and capable of being varied by small increments.
(*d*) The minimum pulse length to be as short as possible. Apart from internal pulse lines provided, the user should be able to easily attach his own pulse lines to suit the impedance and duration required.

Performance

The TF 1389 has been designed with these requirements in mind. The switch used is an improved version of a unique device due to Brown and Pollard.[2] The use of mercury-wetting by capillary action prevents the contact from breaking due to 'bounce' when the armature makes contact. Use of a 'dry' switch would produce multiple pulses. The switch is contained in a hydrogen filled pressurized capsule to quench arcing right up to the instant of making and allow dissipation of heat from the contacts. The small dimensions of the device (4 cm) permit mounting in a short coaxial housing designed to minimize overshoot and reflections and produce a short minimum pulse duration (about 0·5 nsec). The risetime (less than 0·5 nsec) is independent of the pulse length generated or the cable used. Early versions of this switch were limited in repetition rate to 100 c/s, but the improved switch used in the TF 1389 may be operated to 350 c/s resulting in increased oscilloscope trace brightness. Being an electro-mechanical device some jitter is inevitable, the worst being at 350 c/s. This is usually not important for triggered displays but, when using sampling oscilloscopes, if displacement of the samples becomes excessive, adjustment of the variable frequency control on the TF 1389 will enable a stable display to be obtained.

Changes in the waveform and pulse duration depend only on changes in the characteristics of the charging line which are negligible in the case of coaxial cable. Since the pulse can be inverted by simply changing the polarity of the charging voltage, positive and negative pulses are identical. The photograph of Fig. 4 shows a double exposure of 5 nsec positive and negative pulses taken on a 1,000 Mc/s sampling oscilloscope. The repetition rate was 300 c/s and the time base 1 nsec/cm.

Disconnecting the pulse cable and loading the output socket with a high impedance results in a low frequency square wave output of about 100 kΩ internal impedance entirely free from sag—a useful facility for low frequency tests.

A potentiometer network presenting a constant load to a stabilized d.c. supply and incorporating a 10-turn helipot provides accurate adjustment of charging voltage

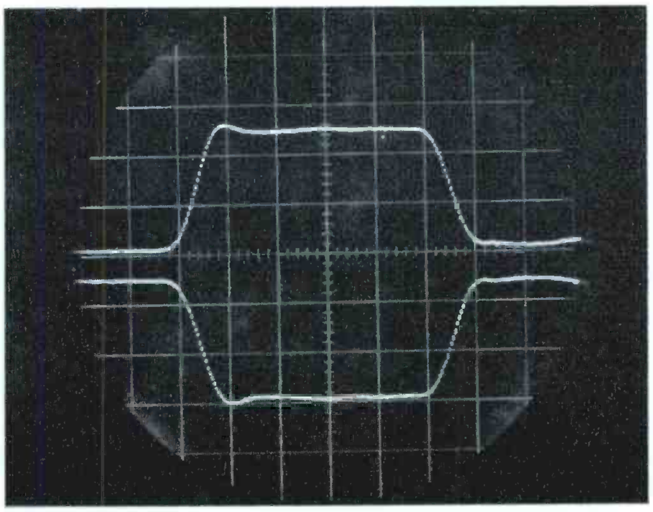


Fig. 4. Positive and negative 5 nsec pulses

and hence pulse amplitude from a few millivolts to 200 volts peak.

Circuit Description

Fig. 5 shows a simplified circuit diagram of the instrument. A push-pull amplifier which provides the relay operating current is driven from a multivibrator whose frequency can be continuously varied from 35 to 350 c/s. A jack is provided to allow external drive when required,

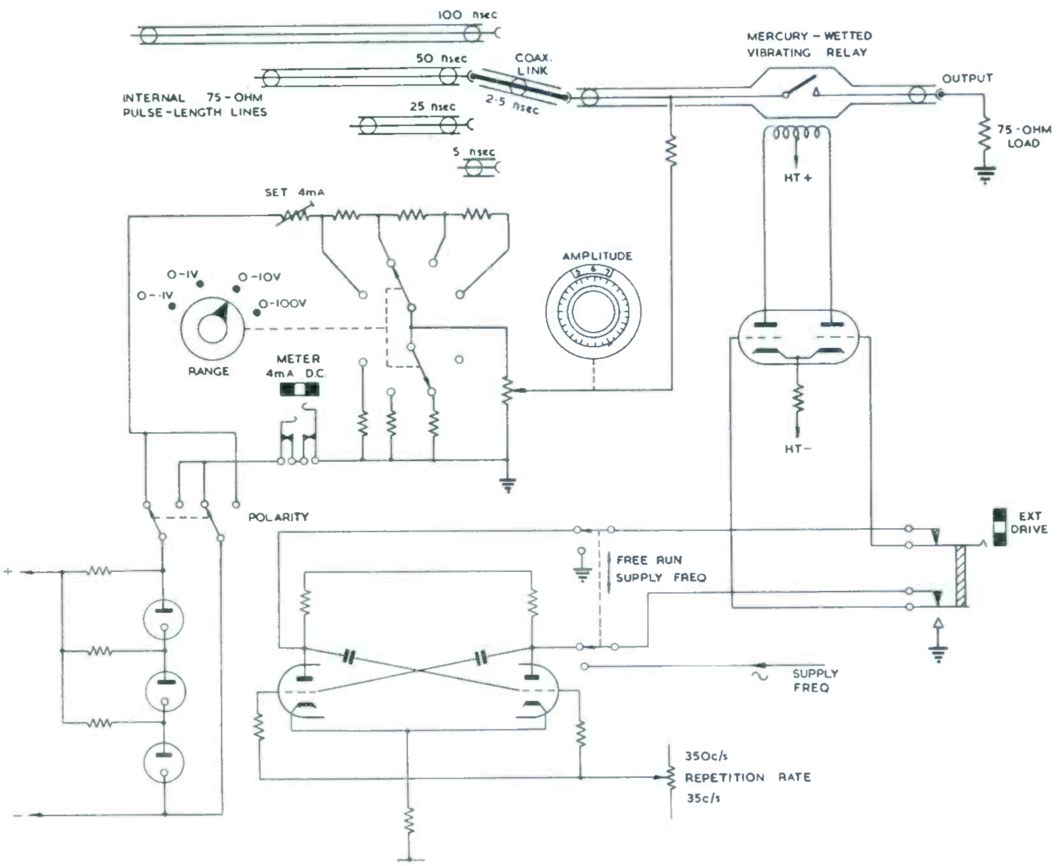


Fig. 5. Simplified circuit diagram of TF 1389

although single shot operation has been found to give erratic results and is not recommended. When using pulses in amplitude sensitive circuits where mains ripple may be present a constant pulse height can be ensured by switching the input of the amplifier to be driven at supply frequency.

A conventional power supply is stabilized by three neon reference tubes, and is shunted by a precise constant impedance network of which the amplitude control forms part. A current of 4 mA is supplied to the network and may be checked by plugging a standard milliammeter into the jack socket provided. The pulse forming line is charged from the voltage adjusted on the amplitude control, which is a 10-turn helical potentiometer across which is developed full-scale voltages of 0·4 volt, 4 volts, 40 volts and 400 volts. One-half of the voltage of the slider of the helical potentiometer is developed as peak pulse amplitude across the termination at the output socket. The charging voltage may be adjusted to an accuracy of better than 2% and the helical potentiometer allows incremental adjustment of less than 0·1% of full scale.

Resistive 'T' Network TM 6459

Most applications of the generator will require the output to be divided into trigger and signal pulses. The TM 6459 is available as an optional accessory for this purpose; it contains three 25 Ω non-spiralled metal film resistors mounted coaxially in a housing with BNC output sockets—see Fig. 6. The network must be terminated by 75 Ω on each of the two outputs and has an attenuation of 6 dB.

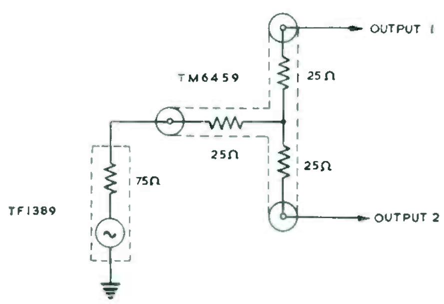


Fig. 6. Resistive 'T' Network TM 6459

Amplitude calibration of the TF 1389 assumes the use of this network and readings must be doubled when the accessory is not in use.

Amplitude Errors

When voltages greater than 100 are developed across the switch contacts ionization occurs causing amplitude jitter but only over a limited range. This effect introduces an additional error not exceeding −10% above a safe limit of 50 volts of pulse amplitude. The facility of increasing amplitude above this figure has been retained because it is frequently useful to generate large pulses particularly when testing attenuators.

Amplitude accuracy is also dependent on how closely the terminating resistor matches the impedance of the lines used. Commercial coaxial cables can vary in impedance by ±10% from nominal, although precise types to ±1% can be supplied by manufacturers to special order. The internal lines used in the TF 1389 have a tolerance of ±1 Ω.

Internal and External Pulse Line

Internal 75 Ω lines are provided for generating pulses of 100, 50, 25, 5 and 2·5 nsec, the last being twice the delay time of the link used to connect a line to the switch.

The switch housing has been designed to minimize reflections in a 75 Ω system. When some mismatch can be tolerated, external cables of other impedance may be used. Provided the output is accurately terminated to suit the cable the amplitude calibration is unaffected. Calculation of a required pulse duration is made knowing the velocity ratio (U) of the cable used.

Velocity of propagation in air $= 300 \times 10^6$ m/sec.

Velocity of propagation in cable $= U \times 300 \times 10^6$ m/sec $= 30U$ cm/nsec.

$\therefore$ Cable length for pulse t nsec $= 15U$ cm

because of the double transition in the cable.

The most commonly used coaxial cables have a solid polythene dielectric. The velocity ratio is 0·67 and this is subject to the same tolerance as Z_0. 'Air dielectric' types in which the conductors are spaced by a thin helical membrane have a velocity ratio of over 0·9. A variety of semi-air spaced and cellular types exist with velocity ratios between these values. The longest pulse to be generated is limited by the necessity for the cable to recharge between pulses after the switch has opened. Assuming a 50% duty cycle of the switch the cable may be considered as a capacitor recharging to potential E (= twice pulse amplitude) via 100 kΩ in time $t = 0{\cdot}5/f$ where f = repetition rate.

Replacing the cable by a non-inductive capacitor of suitable value simulates the fast rise and exponential decay of the pulse from a scintillation counter. An integrating network at the output in conjunction with a required pulse line can generate a fast exponential time base for a transient oscilloscope.

The Shortest Pulse

Disconnecting the link from the input socket of the switch leaves a pulse line consisting of a BNC socket and a short tube containing the relay capsule. Assuming air dielectric the calculated pulse duration is 0·3 nsec.

An estimation of the risetime and duration can be made from Fig. 7 which shows the pulse displayed on a travelling wave oscilloscope with a bandwidth of 2000 Mc/s. The 60 nsec signal delay necessary to allow the time base to trigger before the signal arrived at the Y system was provided by a ⅞-inch dia helical membrane coaxial cable. A 20 cm constant impedance adjustable air dielectric line was inserted in the trigger circuit and a double exposure taken with a 0·6 nsec interval between pulses. The photograph shows the rise and fall times to be under 0·5 nsec.

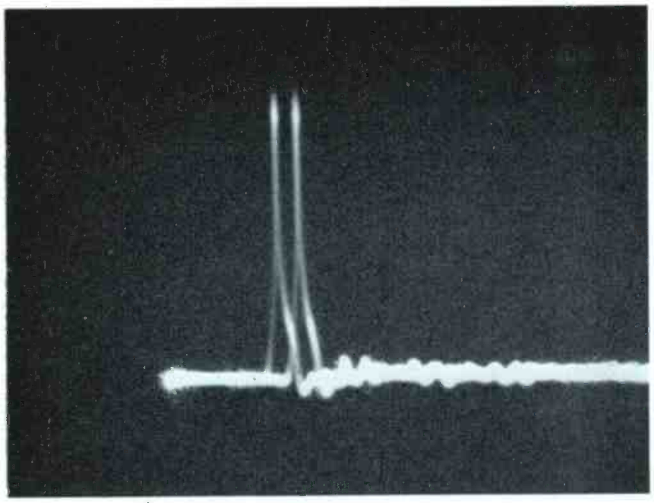


Fig. 7. 0·3 nsec pulse with second exposure after 0·6 nsec

The −3 dB point of the spectrum of a short triangular pulse whose base duration, t, is short compared with the pulse separation is given by f = 650/t Mc/s, when t is in nsec. The frequency spectrum of the shortest pulse therefore extends to over 1000 Mc/s.

Short pulses thus generated are stable in amplitude and duration. Accurate amplitude calibration enables them to be used as wide band noise sources for tests on receivers and for calibrating noise measuring equipment.

Precautions when using Nanosecond Pulses

PULSE DISTORTION IN CABLES

Fast transients in coaxial cables show a characteristic form of distortion consisting of a rapid start followed by a more slowly rising top.[3] This effect is seen in the photographs of Fig. 8 taken on a 1000 Mc/s sampling oscilloscope. The upper trace shows the leading edge of a pulse from TF 1389 after passing through 125 nsec of $\frac{3}{8}$-inch dia

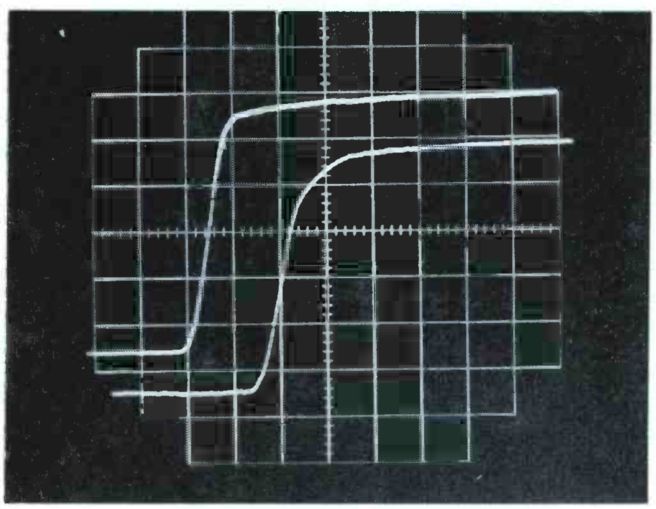
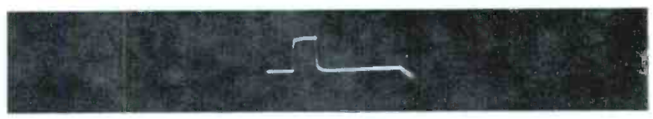


Fig. 8. Transient distortion of pulse with air spaced (upper trace) and polythene dielectric cable

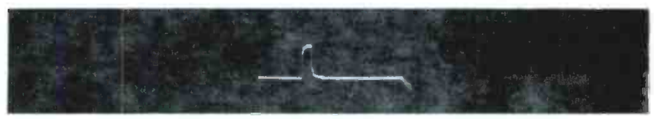
'air-spaced' delay line, the outer conductor being a seamless aluminium tube. The lower trace shows the pulse after the same delay using a solid polythene dielectric braided cable of comparable diameter. The advantages of using the air-spaced line are somewhat reduced by the necessity of using a 40% greater length of the air line to obtain the same delay due to the difference in velocity ratios.

Risetime measurements from 10 to 90% amplitude are often made after delaying signals in long coaxial cables and can be in error if allowance is not made for the cable distortion. The formula f = 0·35/t where f is −3 dB point of the frequency response and t the risetime between 10 and 90% points is frequently used to estimate risetime from a stated bandwidth and cannot be applied to cable attenuation figures. It is possible to partially equalize this effect for short pulses by enclosing a small 'H' attenuator pad made of miniature resistors in a screened box and shunting the series arm with a small capacitance adjusted empirically for best pulse response.

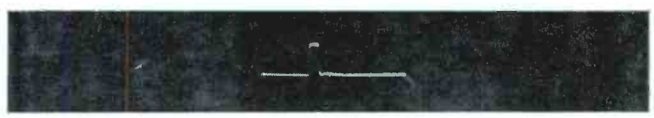
100 nsec pulse



25 nsec pulse



5 nsec pulse



5 nsec pulse after equalization

Fig. 9

The photographs of Fig. 9 show pulses of 100, 25 and 5 nsec from the TF 1389 displayed on a travelling wave oscilloscope. Rounding of the leading edges is due to the delay cable and that of the trailing edge to both the pulse forming line and the delay cable. The second 5 nsec pulse has been equalized in the manner described.

REFLECTIONS

Careful attention to impedance matching is necessary if reflections and transient distortion are to be minimized. All connections must be made with properly terminated coaxial cables correctly matched to the system in use. Impedance mismatches appear as pips or steps after the transient, of amplitude proportional to the degree of mismatch and duration proportional to the physical length of the mismatched section. The source of reflection may be localized by calculation, knowing the physical lengths of lines involved, or by adding capacitance at significant points in order to worsen the effect. Reflections from reactive loads, such as the trigger inputs to oscilloscopes, can be reduced by resistive pads. Ideally rod and disc resistors are best for all matching pads, attenuators and terminations, and should be mounted in matched coaxial fittings. Coaxial connectors cause reflections and can vary considerably in impedance from their nominal values unless precise types are specified.

Double Pulse 'T' Junction TM 6460

Double pulses of nanosecond duration spaced by known intervals are used to measure the resolution of fast counters. Fig. 10 shows a well-known method of producing such pulses by using a length of open circuit line

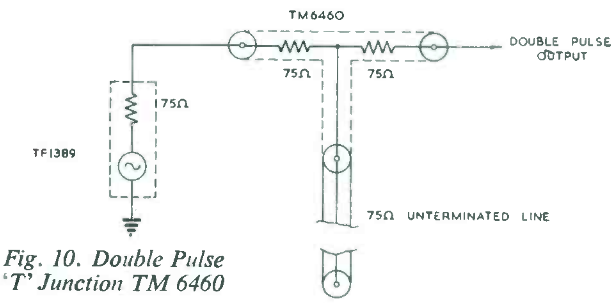


Fig. 10. Double Pulse 'T' Junction TM 6460

to produce the second pulse after an interval equal to twice the delay of the open circuit line.

The accessory TM 6460 supplies this facility and is plugged in to the output socket of the TF 1389. The length of the open circuit 75 Ω line can then be adjusted (or calculated) to obtain the pulse spacing required.

The photograph of Fig. 11 shows two 1 nsec pulses 5·0 nsec apart displayed on a 1000 Mc/s sampling oscilloscope. The 1 nsec pulse was generated by a short open circuit stub of 75 Ω line on the TF 1389. The spacing was obtained by using an appropriate length of RG 59A/U cable plugged into the pulse interval socket on the TM 6460. Rise and fall times of the pulses are degraded by the oscilloscope and associated delay line. Short circuiting the stub line inverts the second pulse.

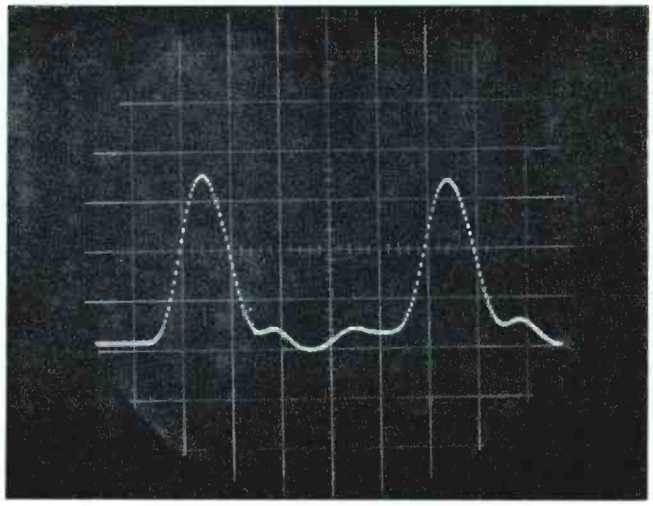


Fig. 11. Two 1-nsec pulses, 5 nsec apart, obtained by using Double Pulse 'T' Junction

The minimum spacing possible is a nanosecond or less. Attenuation is 12 dB.

REFERENCES
1. Garwin, R. L. 'A pulse generator for the millimicrosecond range.' *Rev. Sci. Inst.* 1950, 21, p. 903.
2. Brown and Pollard. 'Mercury Contact Relays.' *Electrical Engineering*. 1947, 66, p. 1106.
3. Lewis and Wells. 'Millimicrosecond pulse techniques.' p. 44.

ABRIDGED SPECIFICATION

Repetition frequency
INTERNAL: 35 to 350 c/s, or mains supply frequency.
EXTERNAL: 5 to 350 c/s.

Pulse amplitude
Continuously variable in four ranges:
0·2 mV–200 mV
2·0 mV–2·0 V
20 mV–20 V
200 mV–200 V
Positive or negative polarity.
Accuracy ±3% to 50 volts out, using internal cables and 75 Ω ±1% termination; additional error not exceeding −10% up to 200 volts out. Independent of ±10% mains variation.

Pulse risetime
Leading edge is less than 0·5 nsec. Back edge is dependent on cable.

Pulse length
Internal cables give 100, 50, 25, 5 and 2·5 nsec. Basic pulse is 0·5 nsec. Any suitable external cable may be used to give a desired pulse.

Output impedance
75 Ω using internal cables. Other impedance by using an external cable.

Optional accessories
75 Ω 'TEE' Junction, TM 6459, for deriving trigger and signal pulse; divides input pulse by two; attenuation, 6 dB.
75 Ω Double Pulse 'TEE', TM 6460, for generating double pulses down to a nanosecond or less using open or short circuit cable techniques; attenuation, 12 dB.

Mainly of Interest to our Southern Readers

Since 1956 Mr. E. A. Rea-Palmer has become a familiar figure to our customers in the south of England as the Southern Area Sales Manager, operating from English Electric House, London. He has now been appointed Home Sales Manager and will be residing once again at the Head Office in St. Albans. Mr. Rea-Palmer has had many years' experience in the application of measurement techniques since he first joined our Engineering Department in 1939 as a designer. His new post covers the sale of the Company's products to all our customers in the United Kingdom.

The position now vacated in London will be filled by Mr. G. C. Briggs, who will already be known to some of our customers through his work as a member of the Technical Sales Department during the past eighteen months. He first joined the Company in May 1959 from the Royal Navy, and served first with the Production Department before transferring to commercial work.

MARCONI INSTRUMENTS

TRANSFORMER TESTING FOR INSTRUMENT RELIABILITY

by W. J. SOUTHAM

THE NEED for quality control is of the utmost importance in the manufacture of complex apparatus such as electronic instruments. Thorough testing of an instrument after assembly is an obvious precaution but, since reliability depends largely on its hundreds of electrical components, it is good production practice to ensure that these are satisfactory before assembly; this helps to avoid wasted time and effort caused by faulty components during overall testing.

Arumugan Suppiah, of Marconi Instruments' Component Test Department, uses the transformer test equipment to check mains transformers for Standard Signal Generator TF 867

One of the major components is the mains transformer; we make virtually all the ones that are used in our instruments, and each is thoroughly tested under full load conditions before use. This exposes any faults due to shorted turns, wrong number of turns, poor insulation, or even tappings brought out to the wrong tags—any of which could cause confusion or damage when the transformer was fitted in an instrument.

Increased production of instruments means more transformers to be tested, and the present trend in our instruments is towards more elaborate transformers with considerably heavier h.t. loading and more and varied l.t. windings. This situation is unlikely to change in the near future, or indeed to any great extent until the performance of semiconductors can match in all respects that of the wide range of thermionic devices at present used in our instruments. This has brought about the need for more comprehensive and efficient transformer testing facilities, which has led to the installation of a new transformer test equipment in our Component Test Department.

In the original equipment the external loads which were used to supplement the built-in devices were easily damaged, not always immediately available, and sometimes hazardous to the operator. The new test gear was therefore designed to cope in itself with all types of mains transformer likely to be encountered in the next five to eight years. The general design requirements were as follows:

(1) To load all windings of a transformer simultaneously without resort to external attachments.

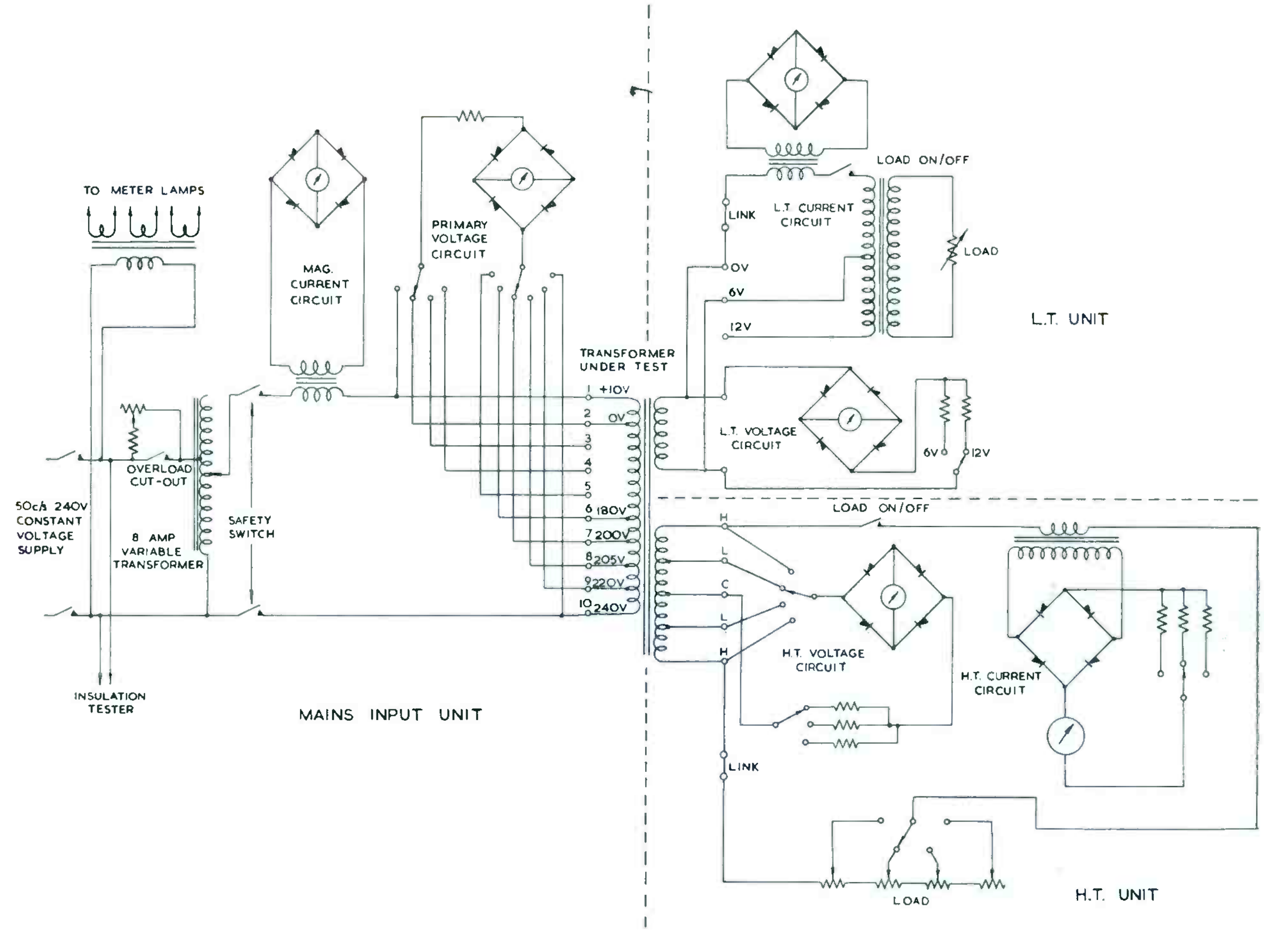
(2) To enable voltage and current readings to be simultaneously displayed and easily read.

(3) To provide means of testing insulation without removing the transformer from the test gear.

(4) To be completely safe, simple, and reliable in operation.

These considerations determined the size, shape and scope of the gear, the design of which was finalized and built by our Test Equipment Department.

The finished product is in console form; it consists of a mains unit centrally disposed with side units set at an angle of about 30° on both sides of the operating position, and with a desk or bench with drawers running its whole length. The centre unit houses the test bed, giving generous room for positioning the transformer under



Functional diagram of Marconi Instruments' Transformer Test Equipment

test adjacent to three sets of connectors, these being grouped as 'Input', 'H.T.', and 'L.T.' With one exception no electrical circuit can be completed until a transparent safety cover (counter-balanced for ease of action) is lowered to completely enclose the transformer and all connections.

Above the test bed is the Mains Input panel. A 240 volt 50 c/s constant voltage supply is fed through an overload cut-out device to an 8 amp variable transformer, thus providing a steady input to the transformer under test at anything from a few volts to about 270 volts. The on/off switch is a heavy-duty twin-button type, permitting emergency 'bang off' if necessary, and this is supplemented by the switch built into the overload cut-out. The input voltage to the test bed is monitored by a moving coil meter adjacent to the variable transformer, and input current by a similar instrument just below it. Remaining controls on this panel are, a switch to allow reading of voltages at any of the primary taps on the transformer under test, and the controls of the built-in insulation tester, this last being the only part of the test gear usable with the safety cover raised, since it is necessary to provide access to the transformer for the two test prods.

The left-hand section of the console comprises eight L.T. Units, capable of loading windings of up to 15 volts with currents variable from 0·3 to 12 amps, and two 'Bias' units with provision for voltages up to 100, with loads up to 500 mA. Each unit has its own voltage and current meters paired one above the other, together with load setting and voltage range controls immediately beneath. The two 'Bias' units are placed on the extreme left as they are not so frequently used, and since the extra lead length does not cause a significant voltage drop with the small currents involved. In order to avoid very heavy currents in the l.t. loads, each unit is provided with a 25:1 step-up current transformer, the secondaries being loaded with heavy-duty ceramic cored rheostats, vertically mounted for optimum cooling and driven from the front panel via bevel gears. As can be seen from the schematic diagram all loading circuits can be individually broken without disconnecting the high-impedance voltage monitoring circuits. (In this respect it had been hoped to incorporate a master switch controlling all loads simultaneously; the practical difficulties, however, of providing such a heavy-duty, multi-way switch within the console out-weighed the advantages to be gained.) A link is brought to the front panel in the form of two coupled adjacent terminals to provide access for monitoring and calibrating individual internal ammeters; pairs of terminals give the same facilities for the voltmeters.

The right-hand console section houses five H.T. Units, all capable of accommodating voltages of 0 to 1000, in ranges of 150 volts, 450 volts and 1000 volts maximum. Three of these provide for loads up to 500 mA and the remaining two for loads up to 1 amp. Metering and positioning of controls is similar to that of the L.T. Units already described. Each H.T. Unit caters for transformers with either 'straight' or centre-tapped windings or for those with additional tapping points. Voltage measurements are normally taken from the centre tap, as shown in the diagram, with loading across the outside taps, but in the case of an untapped winding the normal centre tap point must be cross-connected to one of the outer points. Once again the loading circuits can be broken, leaving the voltage monitoring circuits unaffected, and external current and voltage monitoring facilities are provided.

The current and voltage meters in every unit may be illuminated if required, one advantage of this being that when some sections only of the instrument are in use the remainder, being unlit, may be much more easily ignored, thus decreasing operator fatigue.

The instrument has already proved extremely useful, and its ability to accommodate any of our variety of transformers has led to considerable time saving during 'setting up' operations. Although it is not designed for testing more than one transformer at a time, its general layout and convenience is such that large batches may be tested in very good time.

MARCONI INSTRUMENTS APPLICATION NOTE

621.396.615.17

A Wide Range Double Pulse Generator

by A. B. RETTIE, Grad.Brit.I.R.E.

THE FOLLOWING ARTICLE describes a method by which two oscilloscopes, such as the Marconi TF 1330 or TF 1331, can be used as a simple double pulse generator. It is an extension of an earlier article[1] in *Instrumentation* describing a method of interconnecting two oscilloscopes to provide a delayed trigger facility.

There are a number of occasions when two pulses, one delayed with respect to the other, may be required; for example, as 'run' and 'stop' pulses for a digital counter. Although this method may seem to be an expensive way of doing the job, the probability would seem to be in favour of finding two oscilloscopes in a small laboratory rather than one double pulse generator. The system has its limitations, but for many applications it would be adequate.

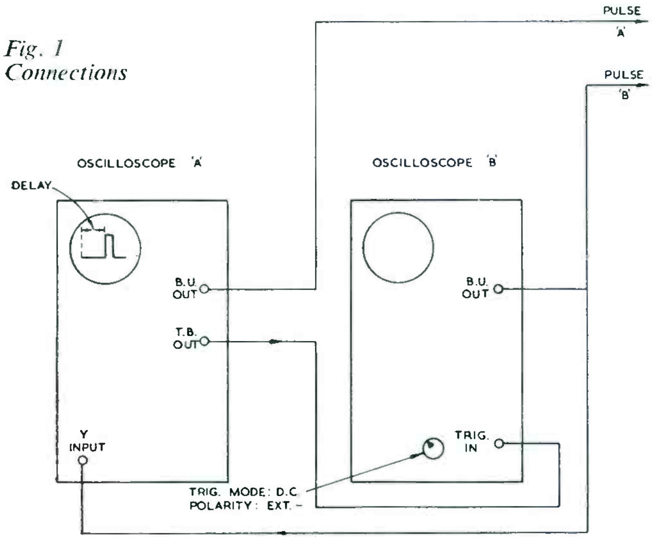


Fig. 1
Connections

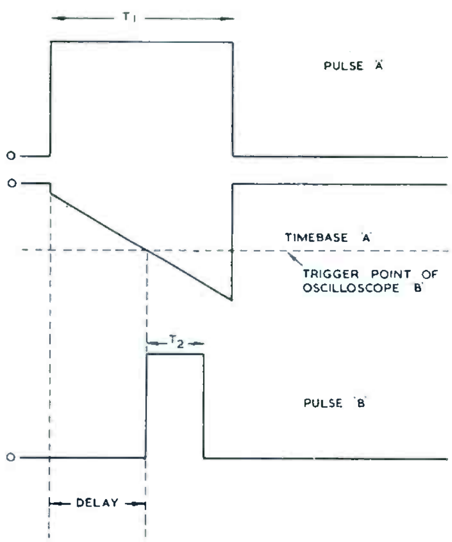
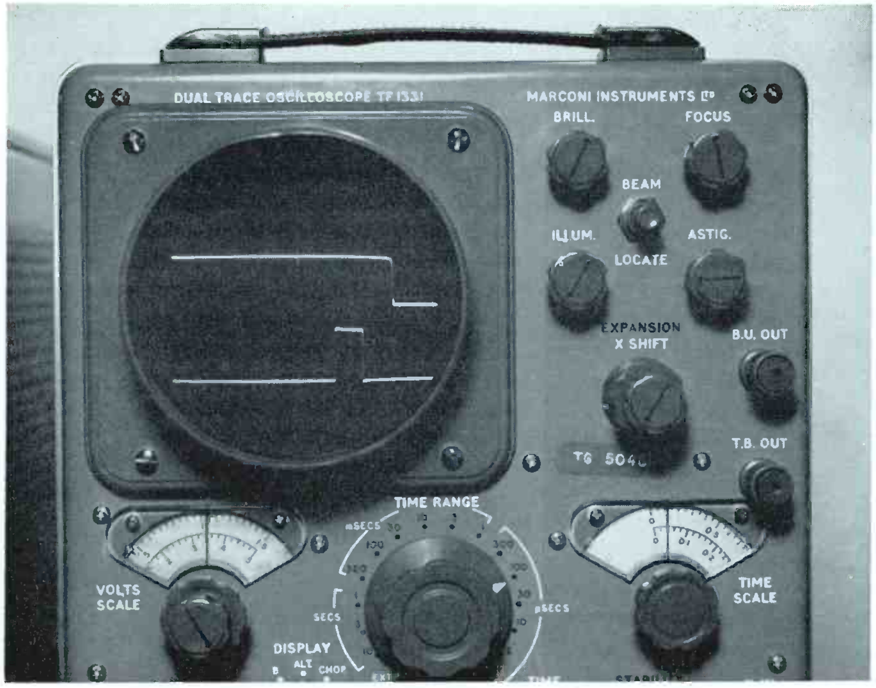


Fig. 2
Waveforms

Fig. 1 indicates the necessary connections, and Fig. 2 the relevant waveforms. It will be seen that the time-base output from Oscilloscope 'A' is used to trigger Oscilloscope 'B' and that the two pulses are, in fact, the bright-up outputs. The p.r.f. can be controlled internally, by free-running Oscilloscope 'A', but it is probably preferable to trigger it from an external source. The pulse



Double pulse waveform displayed on a dual-trace oscilloscope

widths, T1 and T2, are variable in steps from 10 seconds to 1 μsec duration by means of the time-base range controls on Oscilloscopes 'A' and 'B'. The second-pulse delay is continuously variable from 10 seconds to about 0·5 μsec, but it should be noted that the leading edge of the 'B' pulse will always precede the trailing edge of the 'A' pulse. The 'B' pulse jitter can be expected to be less than 0·2% of the total delay.

The actual delay is controlled by the setting of the trigger level of Oscilloscope 'B', and the delay range by the setting of the Oscilloscope 'A' time-base switch. If the 'B' pulse is applied to the 'A' oscilloscope input, a trace showing the delay is displayed and this can be measured to the accuracy of the oscilloscope.

The system does enable one to provide a much wider range of pulse delay, at a much wider p.r.f. range, than is available with most conventional double pulse generators. The abridged specification is given below:

P.R.F. range
0 to 900 kc/s.

Main pulse width
Equal to the time delay range selected: 10 seconds to 1 μsec.

Second pulse width
Must be shorter than main pulse width: 10 seconds to 1 μsec.

Delay range
10 seconds to about 0·5 μsec.

Pulse amplitude
Nominally 8 volts, positive.

This method of delayed pulse generation can be employed as an accurate means of calibrating the time-base of Oscilloscope 'A'. The 'B' pulse is adjusted so that the delay is just equal to the width of the 'A' pulse. The two pulses are then arranged to gate a counter set for time interval measurement. The resultant counter display will indicate the time-base duration. No reliance is placed on the accuracy of Oscilloscope 'B', it is merely required to produce the counter 'stop' pulse.

An alternative method, illustrated in Fig. 3, which produces two non-overlapping pulses, is to trigger the two oscilloscopes from the positive and negative slopes, respectively, of a mains-frequency sinewave or other waveform.

The delay can be varied by adjustment of the trigger levels, and delay and p.r.f. by altering the frequency of the sinewave. Pulse widths are determined by the oscilloscope time-base settings.

The delay can be measured by connecting pulse 'B' to the Y input of Oscilloscope 'A' and increasing the 'A' time-base duration until the 'B' pulse appears as in Fig. 1.

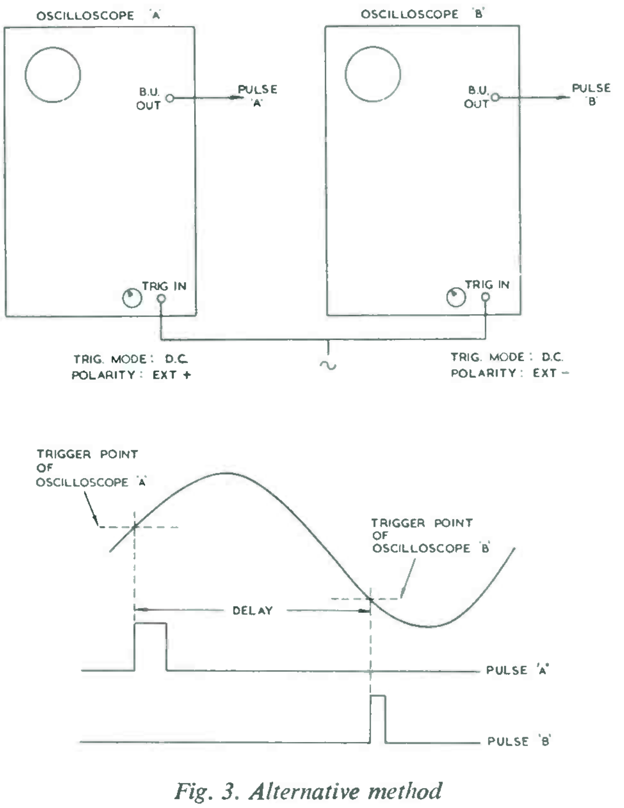


Fig. 3. Alternative method

REFERENCE

1. Application Note. 'Delayed Triggering Operation using Two Standard TF 1330 Oscilloscopes.' *Marconi Instrumentation* 7, 222, September 1960.

MARCONI INSTRUMENTS

Delay Generator . . . . TYPE TF 1415

by J. F. GOLDING
and J. D. JULIAN

This Delay Generator can be used in conjunction with most measuring oscilloscopes to produce a delayed sweep display; alternatively it may be used as a general-purpose delay generator. It generates a sweep voltage commencing at a selected point on an applied waveform, a trigger pulse delayed by up to 500 msec, and a bright-up pulse coincident with the trigger pulse.
The sweep voltage is used to drive the oscilloscope X amplifier and the delayed bright-up pulse to locate the point on the oscilloscope display at which the delay sweep is required to start. The oscilloscope timebase is then switched to internal control and triggered by the trigger pulse from the Delay Generator.

ALTHOUGH it was originally designed as a companion instrument to the Marconi TF 1330 series of oscilloscopes, the TF 1415 can be used in conjunction with most measuring oscilloscopes to provide delayed sweep displays. The delayed sweep is actually produced by the oscilloscope's own timebase generator, which is triggered by a delayed pulse output from the TF 1415. Thus, the instrument can also be used as a general-purpose variable delay generator.

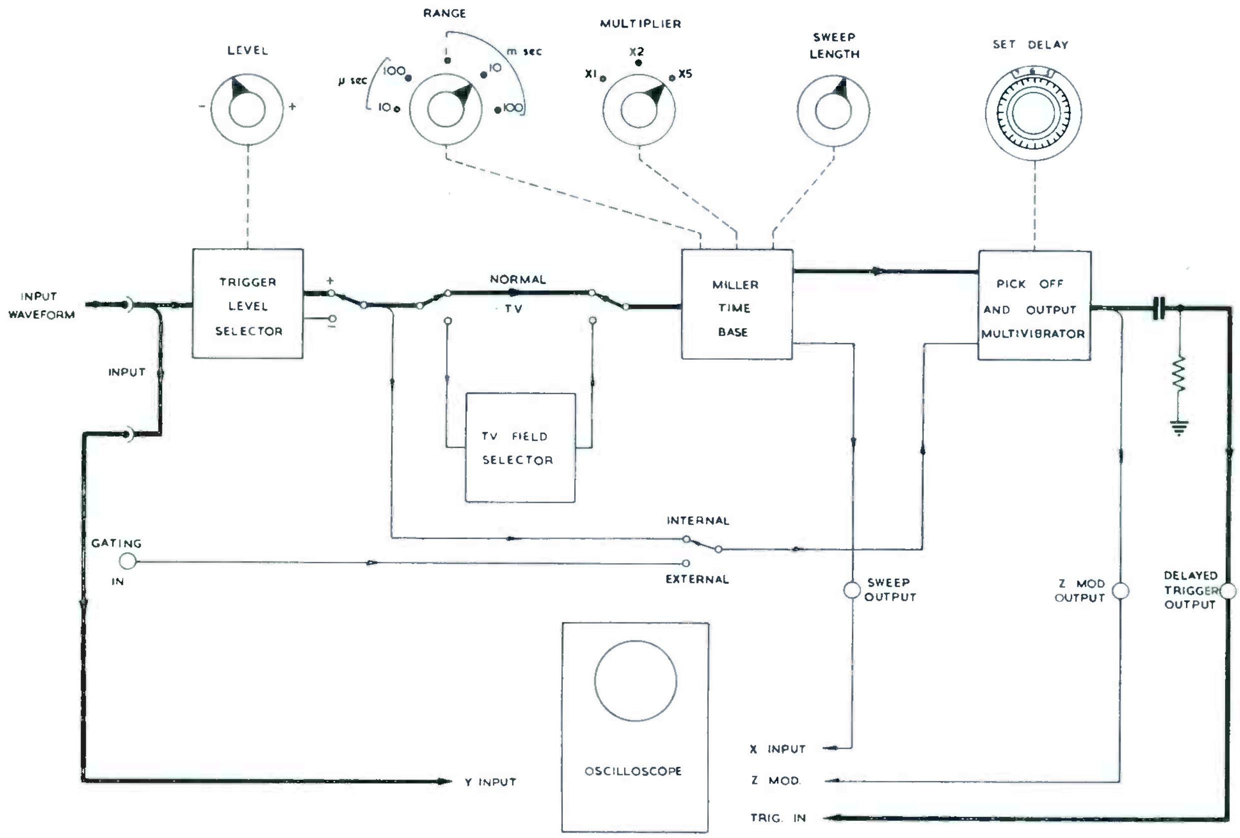


Fig. 1. Functional diagram of Delay Generator, Type TF 1415

General Arrangement

The design is based on conventional principles of operation. A sawtooth waveform, produced by an internal generator, is started by the normal trigger signal. At a selected voltage on this sawtooth, a pulse generator is triggered, producing an output pulse having a known delay relative to the incoming trigger signal. The sawtooth waveform is also brought to a front-panel outlet so that it can be applied as a sweep voltage to the

X amplifier of an oscilloscope; the importance of this feature will become apparent later.

The functional arrangement of the delay generator is shown in Fig. 1.

The input-trigger waveform goes first to a level-selector stage. As this waveform is usually the one being examined, there are two INPUT sockets in parallel so that the waveform can conveniently be routed to the Y input of the oscilloscope.

The level-selector stage is adjusted by the TRIG. LEVEL control to trigger the sawtooth generator at any selected point on a positive-going or negative-going slope of the input waveform. Its circuit arrangement is the subject of a Marconi patent and is shown in simplified form in Fig. 2. It comprises a pentode and triode in a Schmitt-trigger circuit with a second pentode acting as the common-cathode resistance. Use of a pentode valve in this position gives a very high effective resistance without the large p.d. that would be present across a resistor of equivalent value. The cross coupling of the Schmitt trigger is taken from the screen of the first pentode to the grid of the triode. The anodes of both the pentode and the triode are then available as electron-coupled output electrodes. Selection of the appropriate anode output by means of a switch provides for triggering from the positive- or negative-going slope of the incoming waveform.

This circuit fills the roles of trigger amplifier, level selector, and pulse-shaping multivibrator combined. It provides constant-amplitude trigger pulses to the sawtooth generator irrespective of incoming signal polarity or level.

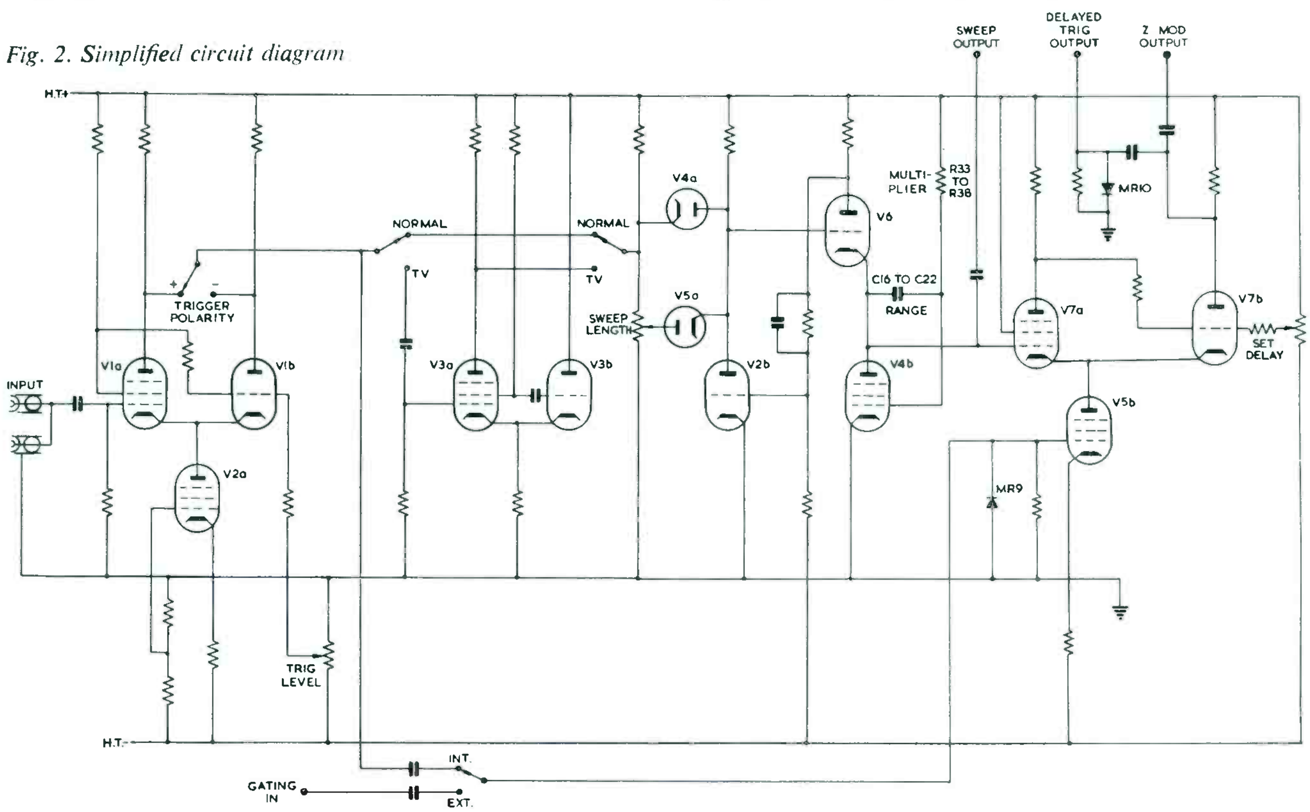
The sawtooth generator is a simple Miller timebase which forms part of a flip-flop—see Fig. 2. Valve V4b is the Miller valve. The slope of the sawtooth run-down is set by selecting appropriate values of the Miller capacitor (C16–C22) and the discharging resistor (R33–R38) by means of the RANGE and MULTIPLIER switches respectively.

Valves V2b and V6 form a flip-flop controlling the fly-back of the sawtooth. Diodes V4a and V5a, which are actually diode-strapped triodes, function as clamps. In the stable condition of the circuit, V2b is cut off; V6 and V4b are in the conducting condition, the grid — and thus the cathode — of V6 being held at a constant voltage by diode V4a. V6 also forms a low-value charging impedance for the Miller capacitor giving a fast fly-back. Normally the sweep is triggered by a negative pulse from the level selector, via diode V4a, to the grid of V6. The positive pulse produced at the anode of V6 is applied to the grid of V2b, bringing this valve into conduction, and by cumulative action V6 rapidly runs to cut off, keeping V2b conducting.

This flip-flop action causes a brief negative step in the output voltage from the anode of V4b; then, as the Miller capacitor discharges through this valve, the sawtooth sweep voltage is produced. The voltage runs down until V6 is brought into conduction; the flip-flop action then returns the circuit to its stable condition, producing the fly-back as the Miller capacitor charges via V6 and V4b grid current.

This sawtooth output from the timebase generator goes to a front-panel terminal at a normal level of about 8 volts peak-to-peak. It also goes to the pick-off and output-pulse circuit. This is a modified Schmitt-trigger

Fig. 2. Simplified circuit diagram



arrangement similar to the level selector circuit. The triggering level, or pick-off voltage, is determined by the grid voltage of valve V7b, which is adjusted by means of the SET DELAY control—a 10-turn helical potentiometer calibrated in units of time.

A pulse from the anode of V7b, coincident in time with the pick-off voltage on the sawtooth, is taken to a Z MODULATION terminal outlet, and is also differentiated and taken to the DELAYED TRIGGER OUTPUT terminal. A diode, inserted between this terminal and earth, eliminates the negative part of the differentiated waveform.

There are some refinements to the basic arrangement described so far, but, before going into these, it would be useful to digress to the operating procedure.

With the sawtooth output from the Delay Generator applied as an external sweep-voltage to an oscilloscope, the pulse from the Z MODULATION OUTPUT terminal can be used as an accurate time marker. The waveform being examined is applied to the Y input of the oscilloscope, via the Delay Generator's bridged input sockets, and displayed with the Delay Generator adjusted to a suitable timebase setting. The bright spot produced by the Z modulation pulse can then be shifted along the display by means of the accurately calibrated SET DELAY control. This bright spot marks the point on the waveform at which the delayed trigger pulse is occurring. So, by adjustment of the SET DELAY control, the delayed trigger pulse may be set to the exact starting position on the part of the waveform that is to be examined in more detail.

The operating condition is then changed. The oscilloscope's internal timebase generator is triggered by the delayed pulse and adjusted for an appropriate sweep speed to give the desired display detail.

Delay Generator, Type TF 1415

Television Waveform Measurements

One of the commonest uses for a delayed-sweep display is that of examining selected parts of a television waveform; for example, it may be desirable to isolate and display one particular line of a complete raster.

With normal triggering arrangements, however, the selection of the trigger point depends only on the direction of the transient and the triggering-voltage level; this makes it impossible to discriminate between line and field synchronizing pulses. A special circuit, which responds only to field sync pulses, has therefore been incorporated. This circuit can be introduced between the level-selector stage and the sawtooth generator by operation of a switch.

Variable Sweep Length

The repetition rate of the internal sawtooth generator is obviously limited by the duration of the sweep. And it is often desirable to examine a part of a waveform that occurs late in its repetitive cycle. The situation can, thus, easily occur where the sweep length necessary to accommodate the required part of the waveform does not permit triggering at its full repetition rate. Furthermore, as the sweep duration switches follow a 1, 2, 5, 10 sequence, waveforms such as television rasters, which contain two similar synchronizing pulses, could be very difficult to display.

For example; suppose the display is to consist of a selected line from a complete television raster (two fields). The total duration of one raster is 40 msec. The nearest sweep RANGE setting that will accommodate the whole raster is $10 \times 5 = 50$ msec. With the television field selector switched into circuit, the sawtooth generator would trigger at the start of field No. 1; would be near the middle of its sweep at the start of field No. 2; and would not have completed its sweep at the start of field No. 3. It would then trigger for the second time at the start of field No. 4. This would result in triggering from both odd and even fields on alternate sweeps, and result in a blurred display every 60 msec. Similarly, the next faster sweep RANGE setting is $10 \times 2 = 20$ msec; so there would be a sweep for every field pulse.

A SWEEP LENGTH control is, therefore, incorporated in the sawtooth generator circuit, enabling the sweep to be shortened to a minimum of 0·6 of its normal duration. The action of this control does not alter the slope of the run-down, and thus it has no effect on the calibration accuracy of the SET DELAY control. Stable trigger on alternate television field sync pulses can therefore easily by obtained by adjusting the control for rather less than $\times 0{\cdot}8$, giving a sweep duration of just under 40 msec.

The action of the SWEEP LENGTH control is to carry the voltage applied to the anode of diode V5a in the positive direction. This clamps the grid voltage of valve V6 at a predetermined minimum and thus limits the sawtooth amplitude by bringing V6 into conduction and initiating the fly-back.

Fig. 3 illustrates the action of the sweep RANGE switches, the SWEEP LENGTH control, and the SET DELAY control.

Gating

The jitter on the delayed trigger pulse is less than 1 part in 10^4, but even this can be virtually eliminated if the waveform under observation is such that the portion being examined contains a suitable transient.

The previous example of a single line from a television raster begins with the line sync pulse which can be used for gating the delayed trigger pulse.

The Delay Generator is normally used with internal gating. The output from the level-selector stage is fed via a differentiating circuit to the grid of the cathode-impedance valve (V5b) of the pick-off flip-flop. A diode (MR9) eliminates the negative-going pulse of the differentiated waveform. Each positive pulse at the grid of V5b produces a corresponding negative pulse on the cathodes of the Schmitt-trigger valves. These pulses have no effect until the sawtooth voltage at the grid of V7a approaches the triggering level. The gating pulse that occurs at this instant brings V7b into conduction and produces the trigger action. The delayed trigger pulse is then locked positively to the appropriate positive-going transient of the waveform.

Provision is also made for gating externally when a waveform under examination does not contain suitable transients, but a separate related waveform of suitable shape is available. An example of this occurs when viewing a noncomposite video waveform, with the field and line sync pulses available separately. Here the video signal would be applied directly to the Y-input terminal of the oscilloscope; the field sync pulses go to the INPUT socket of the Delay Generator to trigger the internal sawtooth generator; and the line sync pulses should be fed in via a GATING IN terminal on the front panel of the Delay Generator, which is set for EXTERNAL gating. There is no provision for inverting the pulses applied on external gating; so the delayed pulse will be locked to the positive-going transient of the gating waveform.

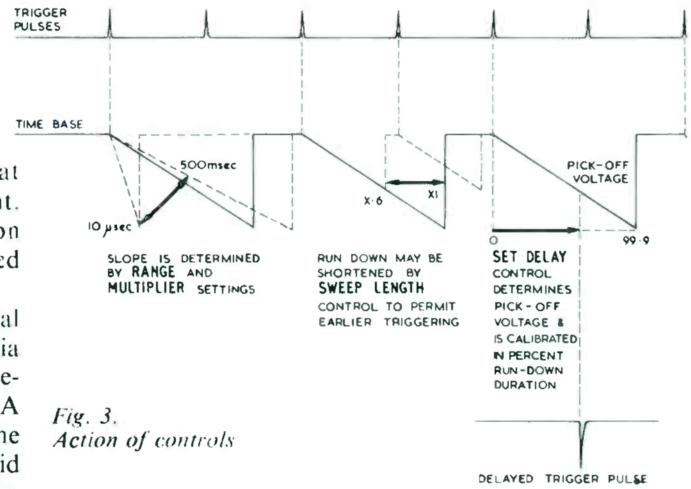


Fig. 3. Action of controls

Power Supplies

The h.t. is fully stabilized, a conventional series regulator system controlling the positive rail, and a simple gas-filled stabilizer tube shunt-regulating the negative rail. The positive and negative supplies are derived via full-wave silicon rectifiers from a single centre-tapped winding on the mains transformer.

Two heater windings are provided, one of which is held at about 130 volts positive with respect to earth. This supplies the heater current to those valves whose cathodes are positive, thus maintaining a safe heater-cathode potential.

ABRIDGED SPECIFICATION

Inputs

SIGNAL INPUT

Level: 0·5 to 25 volts.

Triggering: 0·5 to 25 volts, positive or negative polarity.

Impedance: 1 MΩ shunted by 30 µµF.

GATING INPUT

Level: 2 to 20 volts; positive going.

Impedance: 5 kΩ.

Time-of-rise: Not greater than 1 µsec.

Outputs

DELAYED TRIGGER PULSE

Level: 20 volts; negative going.

Pulse Duration: Approx. 25 µsec h.a.d.

Time-of-rise: Approx. 0·25 µsec.

Delay Ranges: 10 µsec to 500 msec in 1–2–5 sequence. Continuously variable by 10-turn helipot; minimum delay 1 µsec.

Accuracy: ±5% of delay range ±1 µsec.

Impedance: 3·5 kΩ.

Jitter: Approximately 1 part in 10^4; negligible when gated.

SWEEP (SAWTOOTH)

Level: 8 volts p–p.

Impedance: 90 kΩ.

Duration: 10 µsec to 500 msec in 1–2–5 sequence.

Z MODULATION

Level: 20 volts; negative going.

Impedance: 3·5 kΩ.

Summaries of Articles appearing in this issue

RESUME D'ARTICLES PUBLIES DANS LE PRESENT NUMERO

GENERATEUR D'IMPULSIONS DOUBLES, TYPE TF 1400

Cet appareil fournit des impulsions de haute qualité, simples ou doubles, dont la crête s'étend jusqu'à 200 V, avec un retard de 3000 microsecondes sans vacillement. On peut aussi employer le Générateur d'Impulsions Secondaires TM 6600 pour donner une sortie supplémentaire d'impulsions comparables; de cette façon il est possible d'examiner des systèmes pour lesquels il faut des impulsions triples. Muni en outre du Tiroir de Combinaison 50-ohm TM 6666, on peut produir deux impulsions en même douille dont la largeur, l'amplitude, et le retard sont variables indépendemment.

Page 99

GENERATEUR D'IMPULSIONS NANOSECONDES, TYPE TF 1389

Le TF 1389 est un générateur d'impulsions à décharge de ligne coaxiale qui produit des impulsions positives ou négatives dont la forme d'onde est bonne et l'amplitude peut être varié continueusement et avec précision depuis 0,2 mV jusqu'à 200 V. Ce générateur utilise un commutateur mouillé de mercure, ce qui est la méthode la plus versatile de produir les impulsions nanosecondes (10^{-9} seconde). L'utilisation d'un commutateur à mercure amelioré, d'encombrement réduit, permet de varier la fréquence de répétition dans une plage qui monte jusqu'à 350 impulsions par seconde, avec un temps de montée inférieur à 0,5 nanosecondes. Des valeurs de largeur d'impulsion qui égalent 2,5, 5, 25, 50, et 100 nanosecondes sont fournis par des sections internes de ligne coaxiale 75 ohm, bien qu'il soit possible de générer une impulsion de durée quelconque en utilisant une ligne externe d'une impédance convenable.

Page 105

UN GENERATEUR D'IMPULSIONS DOUBLES A LARGE ETENDUE

Une méthode est présenté pour employer deux oscilloscopes, telles que la Marconi TF 1330 ou TF 1331, comme simple générateur d'impulsions doubles, dont la gamme de valeurs de la fréquence de répétition des impulsions est de zéro jusqu'à 900 kHz et la gamme de valeurs de retard est de 0,5 microsecondes jusqu'à 10 secondes.

Page 113

GENERATEUR DE RETARD, TYPE TF 1415

Ce générateur de retard peut être employé avec la plupart des oscilloscopes pour présenter l'information cathodique à balayage retardé; d'autre part, il peut etre utilisé isolément comme générateur à usage général. Il fournit une tension balayée commençant à un point bien determiné d'une onde, une impulsion de déclenchement retardé jusqu'à 500 msec., et une impulsion de luminosité coincidant avec l'impulsion de déclenchement.

La tension de balayage contrôle la base de temps de l'oscilloscope et l'impulsion de luminosité retardé pour localiser le point de l'information cathodique où on veut faire commencer le balayage de retard. Ensuite, on tourne le commutateur de la base de temps de l'oscilloscope sur la commande interne, dans laquelle condition c'est le Générateur de Retard qui fournit l'impulsion de déclenchement pour déclencher la base de temps.

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ZUSAMMENFASSUNG DER IN DIESER NUMMER ERSCHEINENDEN BEITRÄGE

DOPPELIMPULS-GENERATOR TYP TF 1400

Dieses Gerät liefert einwandfreie Einzel-und Doppelimpulse mit einer Amplitude bis zu 200 V und einer maximalen schwankungsfreien Verzögerung von 3000 µsec. Durch Zusatz eines Sekundärimpuls-Generators TM 6600 lässt sich ein zweites Ausgangssignal von ähnlichen Impulsen erzeugen und der Anwendungsbereich auf Anordnungen ausdehnen, die mit Dreifachimpulsen geprüft werden müssen. Durch weiteren Zusatz einer 50 Ohm Kombinationseinheit TM 6666 kann die Vielseitigkeit des Gerätes noch mehr erweitert werden, denn damit stehen an einer einzigen Buchse zwei Impulse zur Verfügung, deren Dauer, Amplitude und Verzögerung sich unabhängig voneinander verändern lassen.

Seite 99

NANOSEKUNDENIMPULS-GENERATOR TYP TF 1389

Ein Impulsgenerator mit einer Verzögerungsleitung zur Impulsformierung und einem koaxial angeordneten Schaltkontakt mit Quecksilberbenetzung ist das vielseitigste Gerät zur Erzeugung von Nanosekunden-(10^{-9} sek)-Impulsen. Das Gerät TF 1389 benutzt dieses Prinzip zur Erzeugung positiver und negativer Impulse mit guter Form und genauer Amplitude, die sich von 0,2 mV bis 200 V einstellen lässt. Durch Verwendung eines verbesserten Quecksilber-Schaltkontaktes kleiner Abmessungen kann die Impulsfrequenz bis auf 350 Imp./Sek. verändert werden. Die Anstiegzeit konnte auf einem Wert unter 0,5 nsek gehalten werden. Impulslängen von 2,5, 5, 25, 50 und 100 nsek können mit Hilfe der eingebauten 75 Ohm-Koaxialkabellängen abgegeben werden, was die Erzeugung eines Impulses anderer Länge durch Verwendung einer anzuschliessenden Leitung beliebigen Scheinwiderstandes nicht ausschliesst.

Seite 105

EIN WEITGEHEND VERÄNDERLICHER DOPPELIMPULS-GENERATOR

Der Aufsatz beschreibt eine Methode bei der zwei Oszillographen, wie die Marconi-Typen TF 1330 und TF 1331, als einfacher Doppelimpuls-Generator geschaltet werden, der einen Impulsfrequenz-Bereich von 0-900 Imp./Sek. und einen Verzögerungsbereich von 0,5 µsek bis 10 sek hat.

Seite 113

VERZÖGERUNGSIMPULS-GENERATOR TYP TF 1415

Dieser Verzögerungsimpuls-Generator kann in Verbindung mit den meisten Mess-Oszillographen zur Erzeugung einer Anzeige mit verzögerter Ablenkung benutzt werden. Andererseits kann er als allgemein verwendbarer Verzögerungsimpuls-Generator verwendet werden. Er erzeugt eine Ablenkspannung, die an einem gewünschten Punkt auf einer angelegten Schwingung beginnt. Ferner erzeugt er einen Auslöseimpuls nach einer Verzögerung bis zu 500 msek und einen Helltastimpuls, der mit dem Auslöseimpuls zeitlich zusammenfällt.

Die Ablenkspannung dient als Steuerspannung für die Ablenkung in dem Oszillograph und der Helltastimpuls wird zur Bestimmung des Punktes auf dem Bildschirm benutzt, bei dem die Ablenkung beginnen soll. Der Ablenkteil des Oszillographen wird dann auf eigene Ablenkung umgeschaltet und durch den Auslöseimpuls aus dem Verzögerungsimpuls-Generator ausgelöst.

Seite 115

SOMMARIO DEGLI ARTICOLI PUBBLICATI IN QUESTO NUMERO

GENERATORE D'IMPULSI DOPPI TIPO TF 1400

Questo strumento fornisce impulsi di alta qualità semplici o doppi, di ampiezza fino a 200 V, con un ritardo massimo ed esente da sfarfallamento tra gli impulsi doppi di 3000 µsec.

Con l'aggiunta di un generatore di impulsi secondari tipo TM 6600, si ottiene una seconda uscita di impulsi e si estende la possibilità di impiego a quei sistemi che richiedono la prova con tre impulsi. L'ulteriore aggiunta dell'unità combinatrice a 50 Ohm tipo TM 6666 aumenta la versatilità dello strumento, fornendo su di un unico connettore due impulsi indipendentemente variabili in durata, ampiezza e ritardo.

Pagina 99

GENERATORE DI IMPULSI DI DURATA NELLA GAMMA DEI NANOSECONDI TIPO TF 1389

Un generatore di impulsi del tipo a linea di scarica, che usi un interruttore a bagno di mercurio montato coassialmente, costituisce il metodo più versatile per la produzione di impulsi di durata dell'ordine dei nanosecondi (10^{-9} sec.).

Il TF 1389 impiega questo principio per generare impulsi positivi o negativi di buona forma d'onda ed ampiezza variabile con continuità e precisione da 0,2 mV a 200 V. L'uso di un perfezionato interruttore a mercurio di piccole dimensioni permette di ottenere una cadenza di ripetizione fino a 350 impulsi al secondo ed un tempo di salita degli impulsi minore di 0,5 nanosecondi.

Mediante le linee coassiali da 75 Ohm di impedenza caratteristica contenute nello strumento si ottengono durate di impulso di 2,5; 5; 25; 50 e 100 nanosecondi. E' inoltre possibile ottenere impulsi di durata desiderata con l'impiego di una linea esterna di conveniente impedenza.

Pagina 105

UN GENERATORE DI IMPULSI DOPPI A VASTA GAMMA

L'articolo descrive un metodo mediante il quale due oscilloscopi, come i Marconi **TF** 1330 o **TF** 1331, possono essere usati come un semplice generatore di impulsi doppi con una gamma di frequenza di ripetizione da 0 a 900 Kc/s ed una gamma di ritardo da 0,5 µsec. a 10 sec.

Pagina 113

GENERATORE DI RITARDO TIPO TF 1415

Questo generatore di ritardo può essere impiegato unitamente alla maggior parte degli oscilloscopi di misura per produrre una rappresentazione con base dei tempi ritardata. Può inoltre essere impiegato come generatore di ritardo per uso generale.

Il generatore produce una tensione a dente di sega che inizia in un punto scelto sulla forma d'onda d'ingresso, un impulso di comando ritardato fino a 500 msec. ed un impulso di intensificazione di traccia coincidente con l'impulso di comando.

La tensione a dente di sega è usata per pilotare l'amplificatore orizzontale dell'oscillografo, mentre l'impulso di intensificazione ritardato serve ad individuare, sulla forma d'onda rappresentata sull'oscillografo, il punto da cui si vuol far partire la base dei tempi ritardata. Effettuata questa operazione, il circuito di base dei tempi dell'oscillografo viene commutato per il funzionamento normale ed è comandato dall'impulso di comando prodotto dal generatore di ritardo.

Pagina 115

RESUMENES DE ARTICULOS QUE APARECEN EN ESTE NUMERO

GENERADOR DE DOBLE IMPULSO TIPO TF 1400

Este instrumento provee inpulsos sencillos o dobles de alta calidad hasta de 200 voltios con un retardo libre de vacilaciones de un máximo de 3.000 µseg. Añadiéndole el generador de impulsos secundarios TM 6600, puede dar una segunda salida de impulsos comparables y esto extiende su utilidad para sistemas que necesiten pruebas de tres impulsos. Además, la Unidad Combinadora TM 6666 de 50 ohmios aumenta su versatilidad con la provisión en una sola salida de dos impulsos variables e independientes en anchura, amplitud y retardo.

Página 99

GENERADOR DE IMPULSOS DE NANOSEGUNDO TIPO TF 1389

El método mas versátil para generar impulsos de nanosegundo (10^{-9} seg.) es por medio del generador de impulsos del tipo de linea de descarga que emplea un conmutador especial de mercurio.

El TF 1389 utiliza este modo de generación para impulsos positivos y negativos con buena forma de onda y correcta amplitud, variable continuamente desde 0,2 mV hasta 200 V. El uso de un conmutador de mercurio mejorado y de tamaño reducido permite una repetición variable de hasta 350 c/s y la subida del impulso es de menos de 0,5 nseg. Impulsos con duraciones de 2,5. 5. 25. 50 y 100 nseg. son provistos por diferentes líneas coaxiles aunque un impulso de duración requerida puede ser generado con el uso de una línea externa de conveniente impedancia.

Página 105

UN GENERADOR DE DOBLE IMPULSO CON MARGEN SUPERIOR

Este artículo describe un método por medio de que dos osciladores tales como los Marconi **TF** 1330/0/TF 1331 pueden usarse como un generador sencillo de doble impulso con un margen de repetición de frecuencias de impulsos desde 0 hasta 900 kc/s y un margen de retardo de 0,5 µseg. hasta 10 seg.

Página 113

GENERADOR DE RETARDO TIPO TF 1415

Este generador de retardo puede usarse con casi todos los osciloscopios de medición para dar en la pantalla una presentación de la respuesta de un barrido retardado. Genera una tensión de barrido empezando en cualquier punto elegido de la onda aplicada, un impulso de disparo con retardo de hasta 500 mseg., y un impulso brillante que coincide con el impulso de disparo.

La tensión de barrido se usa para controlar la base de tiempo del osciloscopio y el impulso brillante retardado así fijando el punto en la presentación del barrido retardado donde es requerido de empezar. La base de tiempo del osciloscopio se pone entonces al control externo y es disparado por el impulso de disparo del generador de retardo.

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SIGNAL GENERATORS

NOISE GENERATORS

OSCILLATORS

OSCILLOSCOPES

PULSE GENERATORS

MODULATION METERS

DISTORTION ANALYSERS

SPECTRUM ANALYSERS

FREQUENCY COUNTERS AND METERS

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