the GENERAL RADIO Experimenter

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Since 1915 – Manufacturers of Electronic Apparatus for Science and Industry

VOLUME 30 No. 12 MAY, 1956

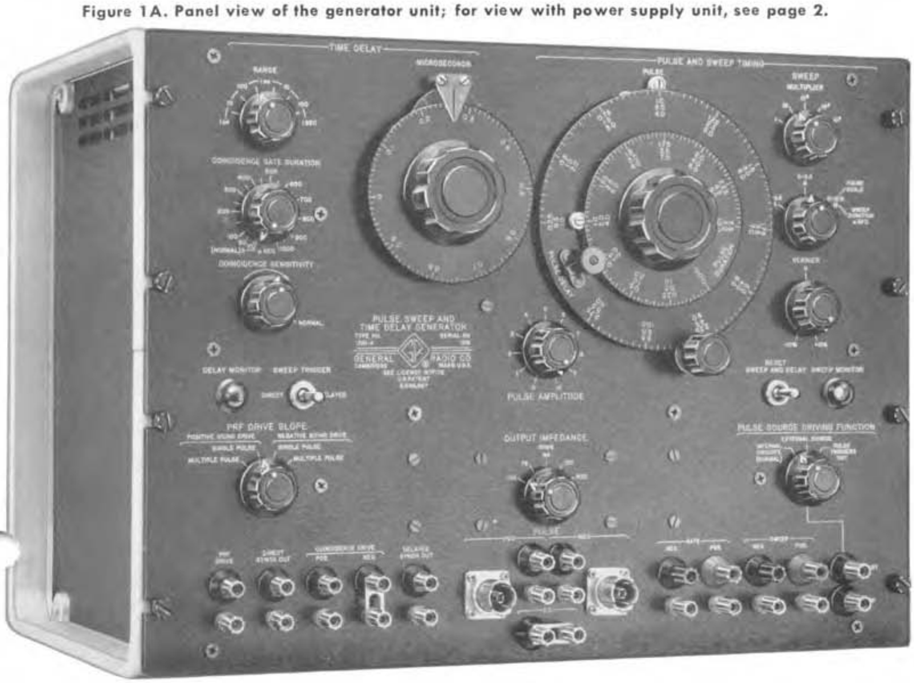
A VERSATILE GENERATOR FOR TIME-DOMAIN MEASUREMENTS

Also IN THIS ISSUE

The new TYPE 1391-A Pulse, Sweep, and Time-Delay Generator is a pulse source and measuring device designed to meet the diverse requirements of laboratories engaged in time-domain measurements.[1] It produces pulses of medium power and good rise-time, over an extremely wide range of durations and repetition rates, and it generates time delays and saw-tooth sweeps over comparably wide time intervals.

[1] Frank, R. W., "A Wide Range Pulse Generator for Laboratory Applications," *Proceedings of the National Electronic Conference*, Vol. 8, Jan. 1953.

Figure 1A. Panel view of the generator unit; for view with power supply unit, see page 2.



This instrument contains, in a single assembly, (1) a pulse generator, (2) a time-delay generator, and (3) a linear saw-tooth sweep generator. The time-delay generator has a calibrated range from one microsecond to 1.1 seconds; the linear sweep generator produces saw-tooth waveforms ranging in duration from 3.0 microseconds to 0.12 second. The start and stop times of pulses continuously adjustable in duration from 0.05 microsecond to 0.1 second can be precisely set at any point along this sweep by amplitude comparators.[2] The pulse repetition rate is set by an external generator, which may have almost any waveform.

The generator not only covers wide ranges, but it produces its time delays, pulses, and sweeps with high accuracy and stability. Its over-all usefulness is greatly enhanced by its many terminals, which permit access to the various basic circuit groups that perform the sequential operations involved; and by its internal switching, which permits the user to obtain many different combinations for optimum solutions to particular problems.

[2] The amplitude comparators used throughout this instrument are Schmitt trigger circuits. (Note 3) For a complete discussion, including a circuit for a sensitive comparator, see M. C. Holtje, "A New Circuit for Amplitude Comparison," *General Radio Experimenter*, Vol. 30, No. 6, November, 1955, p. 1.

Throughout this instrument timing is accomplished by the combination of R-C integrator sweep circuits and amplitude comparators. The application of these simple, fundamental timing systems leads to circuits that are practically independent of tube characteristics, have fast recovery times, and good signal-to-noise ratios. Additional dividends are linear dial scales and absolute accuracies dependent only upon the stability of the resistors and capacitors of the integrator circuits.

In addition to accuracy and reliability, this instrument provides the user with conveniences and effects not previously available in other pulse generators. For example, a completely new type of push-pull, bistable pulse-output circuit was incorporated. This output circuit provides a moderately high current (150 ma) into a number of internally contained, switched, source impedances. This balanced system has no limit on duty ratio, and, since the output is fed directly to the pulse output terminals, pulses of any duration can be produced without ramp-off effects.

BASIC CIRCUITS

The basic circuit groups shown in Fig. 2 perform the necessary timing and shaping operations. The groups consist of:

(1) Input synchronizing circuits that produce a single trigger pulse per cycle from *any* timing waveform. This trigger pulse, referred to hereafter as the direct trigger, serves as the basic timing signal. It drives

(2) Delay circuits capable of produc-

Figure 1B. View of the complete Pulse, Sweep, and Time-Delay Generator, with power supply.

ing an accurately timed delayed trigger pulse over the range 1 μsec to 1.1 sec after the direct trigger. These delay circuits comprise: (a.) a main delay-circuit group producing a delayed pulse of 1 μsec to 1 sec, and, (b.) a coincidence system consisting of a monostable gate, a coincidence circuit, and pulse-forming circuits to produce a delayed synchronizing pulse. This coincidence system permits such operations, as television-line selection, stabilized delays, and multiple pulsing of the pulse generator.

(3) A linear sweep circuit, producing a 250-volt push-pull sawtooth available at panel terminals and variable in steps of 3, 6, and 12 μsec, with a 5-decade multiplier to provide for a maximum sweep duration of 0.12 sec. The sweep duration is continuously adjustable over a range of ± 10% so that any repetition frequency can be used. In addition to the sweep voltage, push-pull 40-volt gate pulses of sweep duration are provided at front-panel terminals.

(4) Pulse generating circuits whose timing is controlled by trigger pulses derived by amplitude comparison from

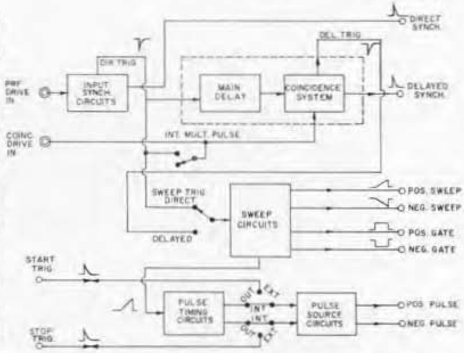


Figure 2A. System block diagram, showing major circuit groups and their interconnections.

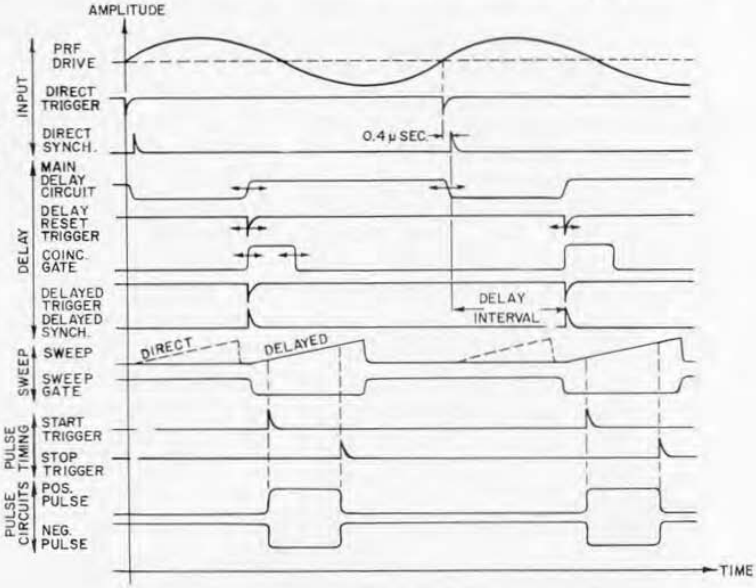
the sweep voltage. The pulse duration is continuously and accurately adjustable over a gamut of 0.05 μsec to 100,000 μsec by this method of timing. A switch on the front panel

(a) provides normal operation as described,

(b) connects the input of the pulse-generating circuits to panel terminals for external control of start and stop times, or

(c) makes available at panel terminals the start-and-stop trigger pulses that normally time the main pulse.

Figure 2B. Timing diagram for the complete system.



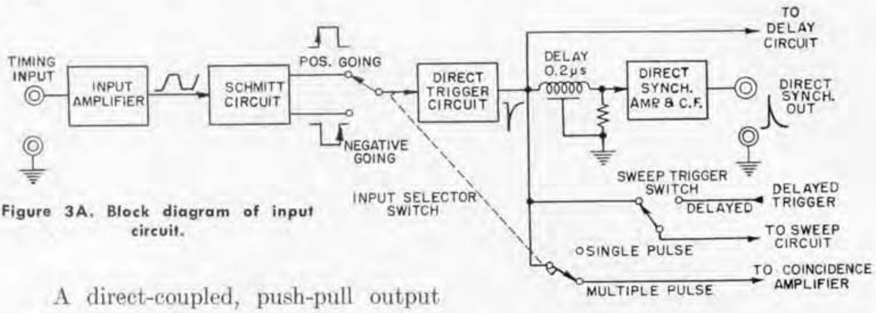


Figure 3A. Block diagram of input circuit.

A direct-coupled, push-pull output system makes the output pulses useful over their large range of durations. The output impedance can be set at values of 50, 75, 100, 300, and 600 ohms with a rotary switch.

Throughout the system no circuits have been used that must be restricted in duty ratio, so that there is no limit except recovery time on the maximum duration of sweep or pulses. The maximum duty ratio is limited by recovery-time to approximately 90% of the period set by repetition rate.

CIRCUITS, CONTROLS, AND INTERCONNECTIONS

Input Circuits. (Figure 3) The input circuits consist of an input amplifier, Schmitt circuit,[3] pulse-forming circuit, amplifier, and output cathode follower. The Schmitt circuit, driven by the direct-coupled amplifier, in turn drives the direct-trigger pulse-forming circuit to produce the direct-trigger pulses at prf's between about 3 cycles and 500 kilocycles. This direct-trigger pulse is used to synchronize the rest of the circuit groups within the instrument. It can be formed on whichever zero crossing the user selects. For sine-wave and square-wave inputs, the trigger-generating system requires approximately 0.5 volt peak; for brief pulses of either polarity, approximately 10 volts.

The panel switch that selects positive-going or negative-going voltages has positions in which the direct-trigger pulse is fed to the coincidence circuit to provide for multiple pulsing.

The sweep circuit and the delay circuit can be triggered simultaneously by the direct-trigger pulse, or the sweep circuit can be triggered by the delayed synchronizing pulse. These two modes of operation, selectable by a panel toggle switch, make available the delayed synchronizing pulse during the sweep time, or, alternatively, make use of the delay circuit to delay the sweep with respect to the direct-trigger pulse.

The direct synchronizing pulse is a 100-volt, 1.5 μsec, positive pulse fed from a cathode follower to a pair of binding posts on the front panel. Lagging slightly behind the direct-trigger pulse, it can be used to trigger auxiliary equipment such as oscilloscopes and

[3] Schmitt, Otto F., "A Thermionic Trigger," *Jour. Sci. Insts.*, 1938, XV, p. 24.

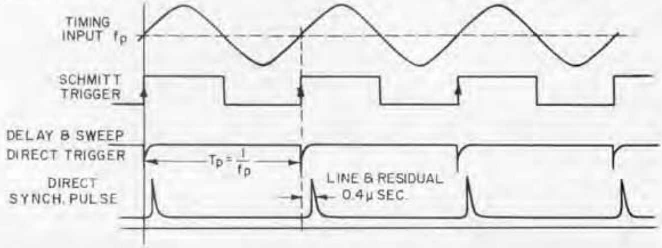


Figure 3B. Time relationships in input circuit.

counters. It can also be used to initiate the main pulse when the pulse duration is to be determined by the delay circuit.

Except for an input-coupling capacitor, the input amplifier and the Schmitt circuit are d-c stable. If it is desired to trigger the generator at very low rates of change of input voltage, the input capacitor can be shorted out. The Schmitt circuit is adjusted in the laboratory for maximum sensitivity for sine-wave and square-wave inputs. If the particular application of the pulser requires that it be sensitive to either a positive or negative pulse of low amplitude (less than 10 volts) an internal screw-driver adjustment permits setting the circuit to be more sensitive to one or the other pulse polarities. This control can also be adjusted so that the Schmitt circuit will trigger precisely at either positive or negative zero crossing.

When the generator is driven by a brief, rapidly rising, input pulse, there is a time delay of 0.4 μsec between the input pulse and the direct-synchronizing pulse. This time delay permits: (a.) the establishment of an accurately predetermined minimum delay and, (b.) the observation of the direct synchronizing pulse on almost any oscilloscope triggered by the input pulse.

Delay Circuits. (Figure 4) The direct-trigger pulse starts the delay circuit by opening a bistable gate. The opening of the gate starts a sweep, which produces a rising voltage whose slope is determined by an R-C circuit. The delay control, a ten-turn potentiometer, provides a voltage reference for an amplitude comparator. When the sweep voltage reaches the level set by the delay control, the amplitude comparator operates to form a trigger pulse that closes the bistable gate, ending the sweep and returning the loop to its original state.

The dial for the ten-turn potentiometer is calibrated linearly in 1000 divisions and provides an accurate reading of the delay with high incremental resolution. Delay is direct reading in microseconds, the basic range being from 1 to 11 microseconds with a six-decade range switch, which changes the R-C circuit constants.

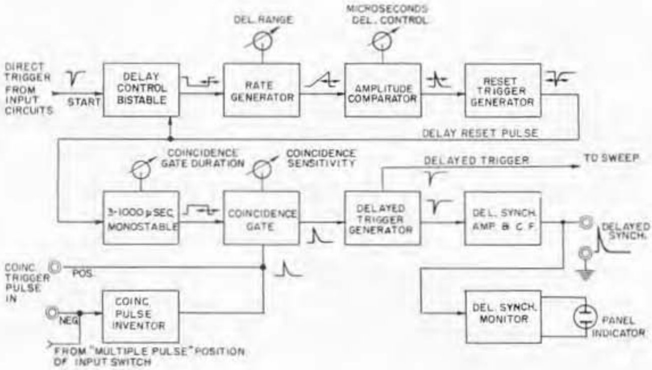
This form of delay circuit, where the basic R-C timing circuit is an integrator, has lower noise than the simpler forms of monostable circuits. Careful measurement shows time jitters caused by circuit noise to be as low as 1 part in 50,000. Care has been taken in the design of the circuit to minimize drifts and transients resulting from line-voltage variations, and all timing errors caused by a $\pm$ 10% change in line voltage have been reduced to less than 0.01% of the dial reading.

Coincidence Circuit. A monostable coincidence gate, adjustable from approximately 3 to 1000 μsec, is a part of the delay circuit. This gate is opened by the trigger pulse produced by the main delay circuit, 1 μsec to 1.1 sec after the direct-trigger pulse. The coincidence gate permits many useful time-selection operations.[4] (See Figure 4C, and D).

In normal operation, the opening of the coincidence gate produces the delayed synchronizing pulse (Fig. 4B). If, however, the sensitivity of the coincidence amplifier is reduced, it can no longer be switched by the opening of the coincidence gate and the circuits are prepared for coincidence operation. The injection of a positive or negative pulse at the coincidence-drive terminals during the time that the gate is open will cause the coincidence amplifier to operate, and a delayed synchronizing pulse to be produced. While the coincidence

[4] Chance, B., etal., *Waveforms, Radiation Laboratory Series*, Vol. 19, McGraw Hill, New York, 1949. (Chapter 10 contains an excellent discussion of time selection and coincidence systems.)

Figure 4A. Block diagram of delay circuits.



gate is open, as many delayed synchronizing pulses will be produced as there are input pulses to the coincidence circuit.

Provisions have been made for producing multiple-pulse groups internally by proper use of the main delay circuit and coincidence system. An illustrative timing diagram is shown in Figure 4D. In this mode of operation, the main delay circuit is used to "count-down" the input prf by any desired number up to about 20 by appropriate setting of the delay controls. The direct-trigger pulses, which occur at the input prf, are fed to the coincidence amplifier. All of the direct-trigger pulses that exist during the time the coincidence gate is

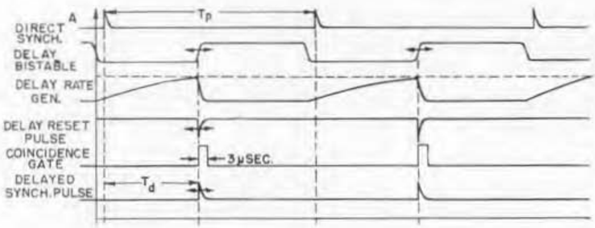


Figure 4B. Delay-circuit timing; coincidence circuit set for normal operation.

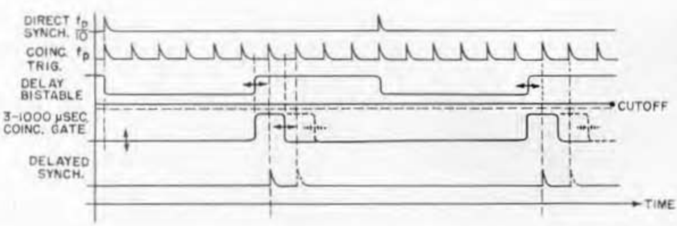


Figure 4C. Timing of multiple pulses when delay circuit is connected for multiple-pulse operation.

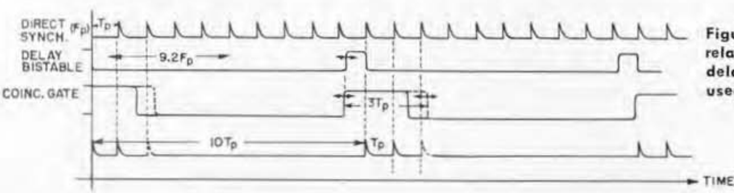


Figure 4D. Time relationships when delay circuit is used as a prf divider.

open will operate the delayed-trigger pulse-forming circuit to produce a group of pulses.

Let us assume that the input frequency setting the basic prf is 100 kc. The main delay circuit is set between 90 and 100 μsec to divide this input frequency by ten. Let it be set to 92 μsec. The coincidence gate is set for 20 microseconds, and coincidences are established by the 10th and 11th direct-trigger pulses to produce a pair of delayed synchronizing pulses separated by 10 μsec at a 10 kc rate. Increasing the coincidence-gate duration to 30 μsec will add a third pulse to this pair and so on. Since delayed synchronizing pulses can always be used to start the action of the pulse generator, groups of output pulses or sweeps can be produced (See Figure 9).

To illustrate a use of the coincidence circuits with an external associated timing generator, consider the example shown in Figure 4C. Here the basic repetition rate, f, is set by the timing generator. Additional outputs at 10 f, $10^2 f$ . . . $10^n f$ are also available from the timing generator. Any of these higher-frequency pulses can be fed into the coincidence input terminals. The timing diagram of Figure 4C shows how multiple pulses, precise delays and standardization of the time-delay circuits can be obtained.

To produce a group of pulses, the delay controls are first set to open the coincidence gate at the desired point in time. The coincidence-gate duration is then adjusted to an interval appropriate to produce the desired pulse group.

When the coincidence-gate duration is less than the time interval between input pulses to the coincidence circuit, only one delayed-trigger pulse (or none) will be produced. The timing of this delayed-trigger pulse relative to the direct-trigger pulse is precisely controlled by the timing generator.

The delay-circuit calibration can be checked by determining the point at which coincidence is just established by the opening of the coincidence gate. This method is accurate to only ± 0.2 μsec owing to the finite rise-time of the gate.

When the coincidence circuits are driven by externally generated trigger pulses, the delayed synchronizing pulse always occurs when, and only when, the pulse occurs at the coincidence input. Thus, the delayed synchronizing pulse will move step-wise in time as the main delay controls are operated, and the delay interval has the same accuracy as the timing generator.

The frequency dividers in the timing generator are usually much more stable in phase than R-C timed monostable circuits, and the selection of delayed pulses as described reduces the jitter present in the delayed output to that inherent in the timing generator.

Sweep Circuit. The sweep circuit is similar in form to the main delay generator, consisting of a bistable gate, a "bootstrap"[5] linear sweep circuit, an amplitude comparator fixed to trigger at 135 volts, and a reset trigger generator (Figure 5). The sweep timing is accomplished by the setting of R-C time constants to produce the basic 3, 6, and 12 μsec ranges and their decade multipliers. The push-pull sweep is fed from two cathode followers to two pairs of binding posts at which negative-going or positive-going sweeps are available. In addition, sweep-gate pulses are fed in push-pull to front-panel terminals where they are available, positive or negative, as a gate or for intensifying the trace on a cathode-ray oscilloscope.

The most obvious use of the sweep is

[5] *Waveforms*, p. 267

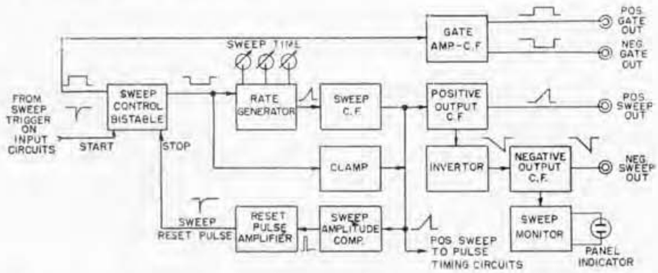


Figure 5A. Block diagram of the sweep circuits.

to provide a simple means for viewing the output pulse on any oscilloscope capable of being deflected by direct connection to the horizontal deflection plates. In addition, the sweep can be used to drive external amplitude comparators to generate additional pulses or delays.[6] The main pulse circuits can be started and stopped by external triggering pulses obtained from pairs of such amplitude comparators, to provide many pulses of independently controlled duration and delay. With their 40-volt amplitudes, sweep gates are adequate pulses for many testing purposes. The Type 1219-A Unit Pulse Amplifier, for instance, can be driven by these gates to produce excellent pulses for use as pedestals for the main output pulse. Since the main pulse always occurs during the time interval in which the sweep gate is open, this gate can be used to operate a keyed clamp[7] to restore d-c level for the main pulse anywhere in the external system.

Pulse Timing System. The positive-going sweep is used to time the main pulse generator. The linearly rising voltage operates two amplitude comparators, one to start and one to stop the pulse-generating circuits. The start and stop reference voltages can be independently set by front-panel controls (Figure 7). The start voltage sets the position of the "leading edge" of the pulse along the sweep, and the stop voltage sets the "trailing edge." The stop-voltage (or pulse duration) dial reads against an index carried by the start-voltage (or pulse-delay) dial and, therefore, reads directly in pulse duration. The excellent timing accuracy of this system results from the good linearity of the sweep as a function of time and of the voltage-setting potentiometers as a function of angle.

With this type of delay and duration control for the timing of the pulse relative to the start of the sweep, the sum of the pulse delay and pulse duration times must be equal to or less than 2.75, 5.5, or 11 μsec on the 3, 6, or 12 μsec sweep-duration control settings. On the 3 microsecond sweep, for example, a maximum pulse duration of 0–2.5 μsec can be set on the 100-division dial. Maximum pulse durations of 5 and 10 μsec, respectively, can be similarly

[6] Holtje, *op. cit.*
[7] Wendt, K. R., "Television D. C. Component," *R.C.A. Review*, Vol. IX, No. 1, March 1948, p. 100 ff.

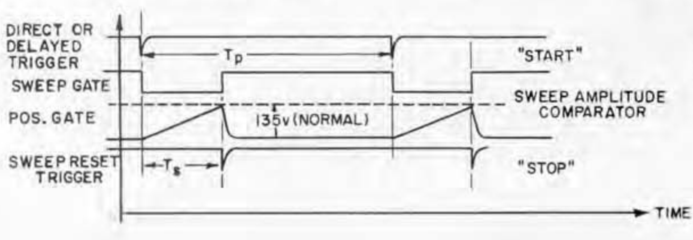


Figure 5B. Time relationships in the sweep circuit.

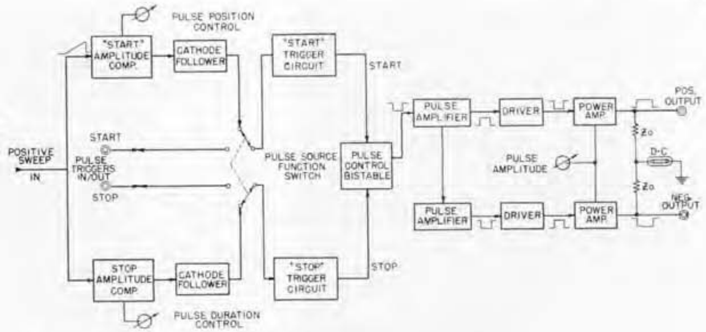


Figure 6A. Block diagram of pulse-timing and output circuits.

set on the 6 and 12 μsec ranges. The position of pulses of shorter duration than these maxima can be set within the stated limits. For instance, on a 12-μsec sweep, a 5-μsec pulse can be positioned over a range of 5 μsec. For highest accuracy and resolution the shortest sweep that will accommodate the desired pulse should be used. (See Figure 6)

Care in the circuit design and component choice equal to that in the delay circuits discussed previously leads to low jitter figures and a high degree of reliability. The extremely high resolution of the delay circuit is not provided in the pulse-timing system and is not usually needed. The delay circuit, however, can be used to control pulses of duration greater than 1 μsec if extremely high resolution should be needed.

The trigger-pulses for the pulse-generating circuits are fed through a switch to start and to stop a bistable pulse-controlling gate. This switch permits the operator:

(1) to start and stop the pulse with the internally generated triggers from the circuits just described.

(2) to start and to stop the pulse with triggers generated externally.

(3) to obtain the internally generated start-and-stop trigger pulses at individual binding posts on the panel. These positive-going pulses are obtained from cathode followers and can be used to control external circuits. They can, for example, be used to measure flip-flop resolution, since they can be set to occur simultaneously. In this switch position the main pulse is not generated.

Main Pulse-Generating Circuits. (Figure 8) The start-and-stop-trigger pulses operate a high-speed, bistable gate circuit. This circuit drives a pair of pulse amplifiers which, in turn, operate a pair of buffers for the output stage. The push-pull pulse-output stage is a single, 40-watt, 5894 dual beam-tetrode tube operated as a current source with switched load resistors across which the voltage

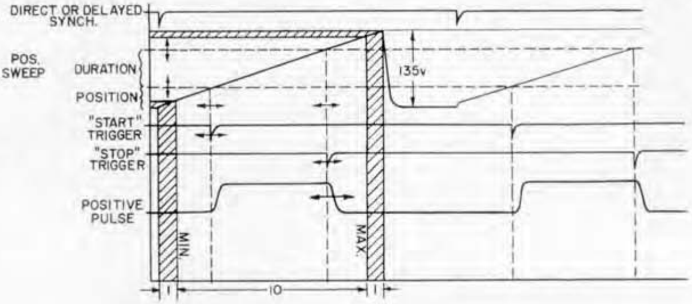
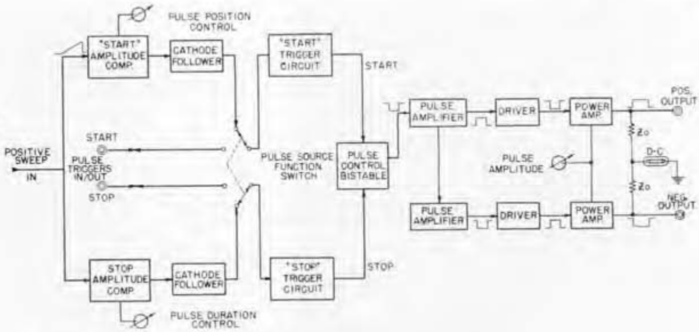


Figure 6B. Pulse timing diagram.



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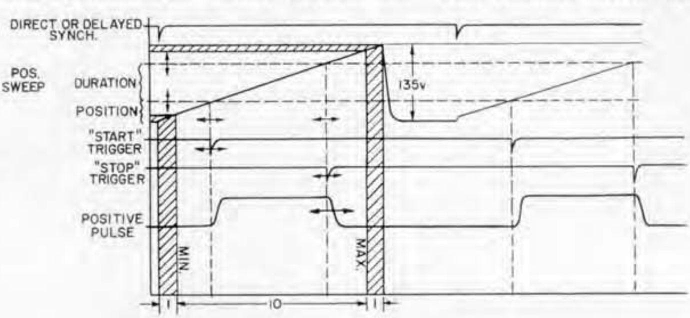


Figure 6B. Pulse timing diagram.

Figure 9. Sweep, sweep gate, and pulse.

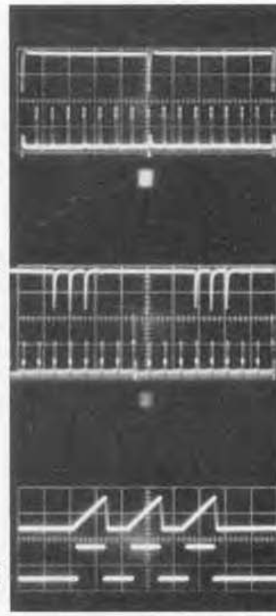


Figure 10. Time selection to produce a multiple pulse.

nium units are carefully located for maximum cooling and are derated by about 2:1. Although rectifier life expectancy is over 20,000 hours, they have been made readily accessible for ease in replacement.

The main unit has also been carefully designed for both cooling and accessibility of components. Forced-air cooling using a quiet 3-inch squirrel-cage blower maintains the hottest point of the cabinet at a safe 20°C above ambient.

Many features to aid in maintenance have been included. The multiplicity of input and output binding-post connections to the various circuit groups within the instrument makes it simple to isolate a trouble. In addition, every stage that does not have a front panel connection is provided with a clearly labeled and numbered test point, and all vacuum tubes are marked by type, V-number, and circuit function. All screwdriver adjustments are likewise numbered and labeled to show their circuit function.

As with all General Radio designs, great care has been taken to make the operating circuits independent of the characteristics of vacuum tubes and as reliable as possible, consistent with the high performance requirements. All panel-mounted variable resistors are precision, wire-wound potentiometers and, wherever possible, computer-type vacuum tubes have been used. Etched circuits are used wherever circuit capacitance is critical in order to insure maximum reproducibility of characteristics.

— R. W. FRANK

The author wishes to acknowledge the many helpful suggestions and criticisms made during the course of this development by M. C. Holtje, W. F. Byers, D. B. Sinclair, and W. P. Buuck; and, in addition, the contributions of W. P. Buuck in the establishment of test and calibration procedures. — R. W. F.

SPECIFICATIONS

Pulse Generating Circuit:

Pulse Duration: (Timed by sweep) 0.05 to 2.5, 0.05 to 5.0 and 0.05 to 10.0 between half amplitude points, with decade multipliers to a maximum of 100,000 μsec. Pulse length can be extended to 1.1 seconds if pulse is timed by delay circuit.

Pulse Duration Accuracy: After sweep calibration, ± (1% + 0.05 μsec).

Pulse Position Accuracy: 0.5 μsec ± 1% of dial reading.

Pulse Rise Time: Depends on output impedance chosen. Into a terminated 50-ohm coaxial line, it can vary from 0.025 μsec by ±0.01 μsec. The following are typical (0.1 μsec pulse as measured on oscilloscope; rise time of vertical amplifier 0.006 μsec):

Impedance	*Positive Pulse*		*Negative Pulse*	
	Rise μsec	*Decay μsec*	*Rise μsec*	*Decay μsec*
Terminated Coax 50 ohms	0.03	0.015	0.02	0.03
15 μμf Probe 72 ohms	0.03	0.025	0.02	0.03
95 ohms	0.03	0.025	0.025	0.03
150 ohms	0.03	0.03	0.025	0.03
600 ohms	0.05	0.05	0.04	0.05

Pulse Shape: Overshoots and other defects are less than 5% of pulse amplitude when the pulse generator is correctly terminated. Pulse rampoff does not exist, owing to direct coupling of output circuits.

Pulse Duty Ratio: Push-pull circuit with unity duty ratio possible.

Output Impedance, Z_0: 50, 72, 94, 150, 600 ohms, all ±10%.

Output Pulse Amplitude: 150-ma current source; voltage from each phase of push-pull channel, 0.15 Z_0 ±20%.

Typical nominal amplitudes, 50 ohms, 7.5v; 72 ohms, 10v; 94 ohms, 14v; 150 ohms, 22v; 600 ohms, 90v.

D-C Component Insertion: Binding posts provided for this purpose. DC can be moved ±25 volts for all output impedances except 600 ohms.

Input Synchronizing Signal: Signals of almost any shape will trigger the input timing circuits. Average value must be approximately 0.2 volt, minimum.

Typical input signal minimum amplitudes are:

(1) Sine wave, 0.2 volt, rms.

(2) Square waves, 0.5 volt, peak-to-peak.

(3) Brief positive pulse, 10 volts, peak-to-peak.

(4) Brief negative pulse, 10 volts, peak-to-peak.

Internal screwdriver adjustment permits increasing trigger-circuit sensitivity for either positive or negative pulses.

Direct Synchronizing Pulse:

Polarity-positive amplitude: 75 volts peak-to-peak.

Duration: (½ amplitude) 1 μsec.

Output Impedance: 600 ohms.

Repetition Rate: Amplitude constant to 300 kc; down 20% at 500 kc.

Time-Delay Circuits:

Range: 1.0 μsec to 1.1 sec in six ranges.

Delay Dial Calibration: 1.00 to 11.00 in 1000 divisions.

Delay Dial Resolution: 1 part in 8800.

Accuracy: Absolute, ±2% of full scale, or ±3% of scale reading + .005 μsec, whichever is smaller; incremental delay, ± (1% + .05 μsec).

Maximum PRF: 400 kc.

Duty Ratio Effects: Less than 2% error in delay for duty ratios up to 60%, at the low end of each range, and up to 90% at the high end of each range; proportional effects between.

Delayed Synchronizing Pulse Characteristics: Positive, 60 v, 1.0-μsec half-amplitude duration, 600 ohm cathode-follower output.

Stability:

	Low End of Dial	*High End of Dial*
Time Jitter	1:10,000	1:50,000
10% Line Change	2:1000	2:10,000
Sudden 10% Line Transient	3:1000	3:10,000

Coincidence Circuits:

Gate Duration: 3 to 1000 μsec.

Gate Accuracy: ±15% or ±1 μsec, whichever is larger.

Coincidence driving circuit will accept either positive or negative input pulses. Source impedance should be low, have rise time less than 0.2 μsec. Amplitudes between 5 and 20 volts are acceptable for negative pulses, and between 10 and 100 for positive pulses.

Sweep Circuit:

Sweep Duration: 3, 6, 12 μsec with 5-decade multiplier.

Sweep Linearity: Determined by the accuracy of pulse timing. On longer ranges, where time delay effects are absent, the linearity is better than 1%.

Sweep Amplitude: Push-pull, each phase, 135 volts ±10%.

Sweep Gate Amplitude: Push-pull, each phase 40 volts ±10%. Negative and positive sweeps and the positive sweep gate are cathode-follower output circuits with a 1-μf coupling capacitor.

Duty Ratio and Repetition Rate Effects: Maximum repetition rate, 3 μsec sweep, 250 kc.

Range	*Maximum Frequency for 5% Error in Sweep Slope*		
Sweep Time	*3 μsec*	*6 μsec*	*12 μsec*
x 1	150 kc	100 kc	60 kc
x 10	160 kc	12 kc	7 kc
x 10^2	1.6 kc	1.2 kc	700 c
x 10^3	160 c	120 c	70 c
x 10^5	16 c	12 c	7 c

Tube Complement: Generator:

8 — 6485		1 — 5894
5 — 5965	2 — 6AN8	1 — 6AW8
4 — 12AX7	2 — 12BY7	1 — 6BQ7A
5 — 6AN5	2 — NE51	1 — 12BH7
2 — 5963	1 — 5687	1 — 6U8

Power Supply, 1 — 0C3, 1 — 6AK5, 1 — 6AS7.

Accessories Supplied: Interconnecting cables, Type CAP-35 Power Cord, 2 Type 874-C58 Cable Connectors, spare fuses.

Other Accessories Available: Type 1219-A Unit Pulse Amplifier* for higher power output.

Accessories Required: Trigger source; practically any laboratory oscillator of the appropriate frequency range is adequate; the Type 1210-B Unit R-C Oscillator† is recommended.

Power Supply Input: 105 to 125 (or 210 to 250) volts, 50 to 60 cycles, 385 watts.

Dimensions: Generator, 19 (width) x 14 (height) x 12½ inches (depth) over-all; Power supply, 19 (width) x 10½ (height) x 12½ inches (depth) over-all.

Net Weight: Generator, 30 pounds; power supply, 40 pounds.

Type		*Code Word*	*Price*
1391-AM‡	Cabinet Model (incl. Power Supply)	EDIFY	$1745.00
1391-AR‡	Relay-Rack Model (incl. Power Supply)	EBONY	1745.00

* See *Experimenter* for July, 1955, pp. 9–15.
† See *Experimenter* for May, 1955, pp. 1–11.

‡ U. S. Patent No. 2, 548,457.
Licensed under patents of the Radio Corporation of America.

MORE NEW VARIACS®

The new W2-series Variacs are 2-ampere counterparts of the W5 series, previously announced.[1] The new W2-series Variacs are identical in design, construction and appearance to their W5 brothers, differing from the latter only in electrical rating, size, and weight. All current and kva ratings are 40% of the W5 ratings. Panel mounting area, volume, and weight are each about 50% of the measurements of equivalent W5 series models. Figure 1 shows the basic model, Type W2.

The basic, uncased model carries a 2.4-ampere rating, an increase of 20% over the Type V2 which it supersedes. Other features include Duratrak brush track, unit brush, captive counterbalanced radiator assembly and square flange mounting. Mounting holes matching those of the V2 and the earlier Type 200-B are also provided, so that the new unit directly replaces these models in practically all cases.

Entirely new in this size Variac are cased models for fixed installations as well as for portable and bench use. The totally enclosed Type W2M can be wall- or panel-mounted. Standard ⅞ in. diam. knockouts are provided for ½ in. conduit or cable connectors. Portable models include line cord, convenience outlet, line switch, and carrying handle, plus resettable overload protector, first introduced in the W5 series. W2MT is provided with two-wire cord and outlet; the W2MT3 has the new standard three-wire fittings which ground the equipment.

The square-base design makes ganging simple, and assemblies are available both with and without enclosure. A number of variations of the standard design are also possible. For example,

[1] *Experimenter*, December, 1955.

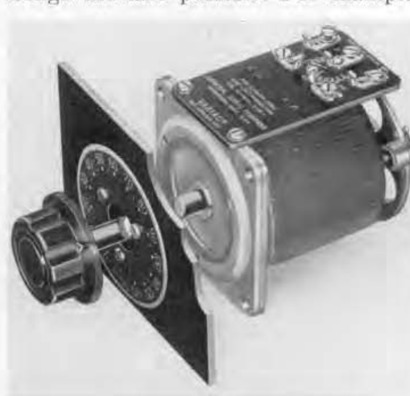


Figure 1. View of Type W2 Variac. Mounting holes are on a 2¾-inch square. Depth behind panel is 3 15/16 inches.

Case dimensions, both types are (width) 4⅛ x (height) 5 $\frac{9}{16}$ x (depth) 4¼ inches, over-all

Figure 2. Type W2MT, with overload protector.

Figure 3. Type W2M, with conduit knockouts.

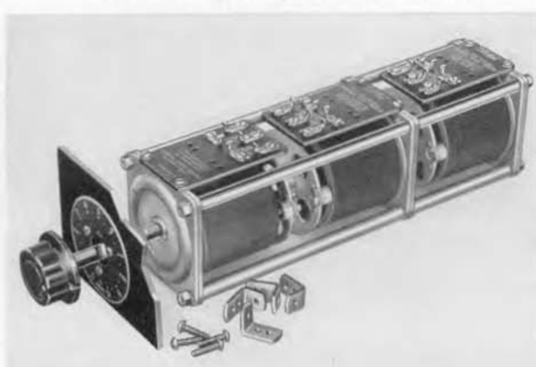
units for 360° rotation and two-brush models are available on special order. Motor-driven assemblies will be announced in a future issue of the *Experimenter*, as will the stock availability of units equipped with ball bearings.

NEW 400-CYCLE MODELS

The construction of the two-ampere and five-ampere 400-cycle models, Types M2 and M5, have been revised to include all the features of the 60-cycle models. These 400-cycle models are now identical to the 60-cycle models except for the obvious difference in vertical dimension, made possible by the lower stack height of the high-frequency units.

Fungus-resistant treatment has been added as standard and stock units now pass most commonly encountered military corrosion, salt-spray and fungus specifications, as well as shock, vibration and humidity requirements. Manufacturing economies resulting from the use of parts common to the 60-cycle (W-series) units permit a significant reduction in price, as shown in the following table:

Figure 5 (left) Type W2G2M; (right) Type W2G3



	Old Style	New Design
Type M5	$22.50	$18.50
Type M2	15.50	14.50

Even more striking is the comparison with the Type 60-AU, predecessor of the M5, which listed five years ago at $28. These lower prices, accompanied by substantially improved performance, have been accomplished in a period of rising material and labor costs and are the result of a continuous program of careful attention to design, tooling and production methods.

SPECIFICATIONS FOR W2-SERIES VARIACS

			Line-Voltage Connection				Overvoltage Connection						
Type	*Mounting*	*Input Voltage*	*Rated Output Current — amp.*	*Output Voltage*	*Maximum Current — amp.*	*Output kva*	*Output Voltage*	*Rated Output Current — amp.*	*60-cps no-load loss — watts*	*Driving torque ounce-inches*	*Net Weight — pounds*	*Code Word*	*Price*
W2	Uncased	115	2.4	0–115	3.1	0.36	0–135	2.4	3.5	5–10	3⅝	BAGAL	**$13.50**
W2M	With case	115	2	0–115	2.6	0.30	0–135	2	3.5	5–10	4⅛	BAGER	**18.00**
W2MT	Portable 2-wire	115	*See Note Below*				0–135	2	3.5	5–10	4¾	BAGIC	**24.00**
W2MT3	Portable 3-wire	115	*See Note Below*				0–135	2	3.5	5–10	4¾	BAGOM	**26.00**

Note 1. MT models are shipped with overvoltage connections and corresponding dial scales, but can be supplied on special order with line-voltage connections and dial scales.
Note 2. The Type W2 dial plate is reversible, with 0–115 on one side, and 0–135 on the other. Angle of rotation is 320 degrees.
Note 3. Replacement brushes for Type W2 Variacs are Type VB-1, 55¢ each.
Note 4. Complete dimension drawings furnished on request.

TYPE M2 AND TYPE M5 VARIACS

	Output Current					
Type	*Rated*	*Max.*	*Depth Behind Panel*	*Net Weight*	*Code Word*	*Price*
M2	**2**	**3**	**2½ inches**	**1⅞ pounds**	BAGGY	**$14.50**
M5	**5**	**7.5**	**2⅝ inches**	**3¼ pounds**	CANNY	**18.50**

GANGED MODELS

Type	*Description*	*Net Weight*	*Code Word*	*Price*
W2G2	**Two-gang**	**7 pounds**	BAGALGANDU	**$32.00**
W2G2M	**Two-gang with case**	**8 pounds**	BAGALBONDU	**40.00**
W2G3	**Three-gang**	**11 pounds**	BAGALGANTY	**48.00**
W2G3M	**Three-gang with case**	**12 pounds**	BAGALBONTY	**56.00**
M2G2	**2-gang M2**	**3⅜ pounds**	BAGGYGANDU	**33.00**
M2G3	**3-gang M2**	**5½ pounds**	BAGGYGANTY	**49.50**
M5G2	**2-gang M5**	**6¾ pounds**	CANNYGANDU	**41.00**
M5G3	**3-gang M5**	**10¼ pounds**	CANNYGANTY	**61.50**

SECOND INTERNATIONAL CONGRESS ON ACOUSTICS

Cambridge, Mass **June 17-23, 1956**

General Radio acoustical apparatus will be on display at the exhibit held in Memorial Hall, Harvard University, June 20 and 21, in connection with this Congress.

PRESIDENTS—OLD AND NEW

Errol H. Locke

Charles C. Carey

On December 31, 1955, Errol H. Locke retired as President of the General Radio Company and, on February 16, 1956, Charles C. Carey was elected to succeed him.

Mr. Locke came to the General Radio Company in 1918, three years after its founding, and became Vice-President in 1920. His first association was with commercial and sales matters; later, as Vice-President, his main concern was with production. He was elected President in 1944 and held that post continuously until his retirement. As President, one of his primary interests was personnel policies, a field in which his long experience and deep human sympathies were particularly effective.

Mr. Carey's association with the General Radio Company began in 1927 in the production department. In that same year he became foreman of the winding department. He was appointed assistant to the Vice-President for Production in 1931 and Production Superintendent in 1934. When Errol H. Locke became President in 1944, Mr. Carey succeeded him as Vice-President for Manufacturing and continued in this office until 1956.

CHAIRMAN HONORED

At the annual meeting of the Scientific Apparatus Makers Association in Belleaire, Florida, April 11, Harold B. Richmond, Chairman of the Board of Directors of the General Radio Company received the Scientific Apparatus Makers Award "in recognition of his leadership, vision, and devotion to the growth and progress of the scientific instrument industry." Mr. Richmond's record of service to the Association dates from 1938. He was chairman of its board of directors in 1947, its president in 1938, and is at present a director-at-large. He is the first person in the history of the association to receive this award before retirement.

Harold B. Richmond

AMERICAN SOCIETY FOR TESTING MATERIALS

59th Annual Meeting — Chalfonte-Haddon Hall — Atlantic City, N. J. — June 18–21, 1956

At the apparatus exhibit held in conjunction with this meeting, General Radio will exhibit some of the new items recently announced in the *Experimenter*. Among these are the TYPE 1605-A Impedance Comparator, the TYPE 1230-A D-C Amplifier and Electrometer, and the W-model Variacs. Other equipment in the exhibit includes bridges for measuring impedance, power factor, and insulation resistance; stroboscopes; polariscope; sound- and noise-measuring instruments, and voltage regulators.

Plan to visit the General Radio exhibit in booths 48 and 49. Our engineers will be on hand to discuss your measurement problems with you.

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PRINTED IN U.S.A.