INSTRUCTION MANUAL

Serial Number _____

114

PULSE GENERATOR

Tektronix, Inc.
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070-465


114 PULSE GENERATOR
PERIOD
100 µS
10 µS
1 mS
1 µS
10 mS
100 mS
EXTERNAL TRIGGER
WIDTH > PERIOD
WIDTH
10 µS
1 µS
100 µS
100 nS
1 mS
10 mS
SQUARE WAVE
AMPLITUDE
1 TO 3V
1 TO 3V
3 TO 10V
3 TO 10V
INPUT
+2V MIN
POWER
TRIGGER
LEADING EDGE
OUTPUT
TRAILING EDGE
OUTPUT
TEKTRONIX, INC., PORTLAND, OREGON, U.S.A.

SECTION 1
CHARACTERISTICS

Introduction

The Type 114 Pulse Generator is a general purpose pulse generator. Transistorized circuitry is used throughout, with most of the components being mounted on an etched circuit board.

The Type 114 Pulse Generator is versatile. The repetition rate, width, and amplitude of the output pulse are individually selectable by range and by variable control within each range. Front-panel connectors are provided for the pulse output, trigger output, and external trigger input. A single front-panel switch selects both the amplitude range and polarity of the output pulse. The trigger output pulse is set by a front-panel switch to occur on the desired edge (leading or trailing) of the output pulse. In cases where the Type 114 is set for a pulse width longer than the pulse repetition period, a built-in feature automatically counts down the repetition rate to permit the width of the output pulse to remain at the value selected (such operation is indicated by a Width > Period light). In addition, two Type 114's can be connected together so that the output pulse of the second unit is delayed by the pulse width (up to 10 ms) of the first unit.

Electrical

Pulse Period. The PERIOD switch and associated VARIABLE control provide continuously variable pulse periods from 1 μsec to 100 msec (pulse repetition rates from one million pulses per second to 10 pulses per second). An EXTERNAL TRIGGER position on the PERIOD switch permits external control of the pulse period. With the VARIABLE control at the CAL end of its range and the WIDTH > PERIOD light unlit, the period accuracy is within $\pm 3\%$ of the indicated value. Jitter is typically less than 0.05% of pulse period +2 ms.

Pulse Width. The WIDTH switch and associated VARIABLE control provide continuously variable pulse widths from 100 nsec to 10 msec. With the width VARIABLE control at the CAL end of its range, the width accuracy is within $\pm 3\%$ of indicated value. Jitter is typically less than 0.05% plus $\frac{1}{2}$ nsec. An additional SQUARE WAVE position on the WIDTH switch disables the variable width feature and changes the output to a square wave whose repetition rate is determined by the PERIOD controls. Period error in the square wave mode is $\leq \pm 5\%$.

Output Polarity and Amplitude. The AMPLITUDE switch provides for either polarity output with two amplitude ranges (1 V to 3 V and 3 V to 10 V). The VARIABLE control permits the output to be varied within the voltage ranges. Aberrations (overshoot, rolloff, preshoot, or ringing) amount to less than 5% at maximum amplitude.

Output Impedance. The output impedance of the Type 114 is given in Table 1-1. The figures given are typical and are dependent upon the setting of the AMPLITUDE—VARIABLE control. Load impedance is not critical. Temporarily short circuiting the OUTPUT connector will not damage the instrument.

WARNING

The Type 114 should never be connected to an inductive load, or any load that will produce a current which will feed back into the instrument.

TABLE 1-1

Amplitude Range	Pulse on	Pulse off
± 1 to 3 V	$\approx 20\,\Omega$	19 Ω to 22 Ω
± 3 to 10 V	28 Ω to 48 Ω	30 Ω to 95 Ω

External Trigger Input. External triggering requires a positive trigger signal of 2 to 20 volts and having a risetime of 1 μsec or less. Triggering signals up to 2 Mc may be used.

Trigger Output. The trigger output pulse into an open circuit is approximately 3 volts; into a 50 Ω termination, the trigger output pulse is approximately $\frac{1}{2}$ volt. A front-panel switch allows the output trigger pulse to be set to occur at the leading edge or the trailing edge of the main pulse.

Input Power Requirements. $\approx$ 15 watts; 50 to 400 cps, 94.5- to 137.5- or 189- to 275-volts, ac.

Warm-up Time at +25°C $\pm$5°C. Five minutes for rated accuracies.

Environmental

Operating

Temperature	0°C to +50°C
Altitude	15,000 feet maximum

Non-Operating

Temperature	—40°C to +65°C
Altitude	50,000 feet maximum

Mechanical

Dimensions	Approximately 9" × 6" × 12½" overall
Connectors	Front-panel connectors are BNC type.

Accessories

See standard accessory lists in this manual for accessories supplied with each instrument. For optional accessories, see the current Tektronix, Inc. catalog.

GLOSSARY OF TERMS

Bistable (multivibrator)	A circuit that has two stable states and requires two input pulses to complete a cycle.
Calibrate	To check or correct the graduation accuracy of quantitative indicators.
CAL (calibrated) position	An index position to which an otherwise ungraduated control is set when a quantitative measurement must be made.
Catching or clamping diode	Establishes the + or — extremity of a voltage excursion.
Count-down (of pulses) circuit	A circuit, such as a bistable, whose output consists of pulses fewer in number (usually a submultiple) than the pulses applied to the input(s).
Delayed pulse	A pulse occurring after a preselected interval following an event used as a time reference point.
Delayed trigger	Generally, a narrow, delayed pulse.
Duty factor (of pulses)	For periodic pulses, the duty factor (often called duty cycle) is equal to the duration (width) of a pulse divided by the pulse period.
Enabling pulse	A pulse which opens a normally closed electric gate, or otherwise permits an operation for which a pulse input is a necessary condition.
External trigger (pulse)	An enabling pulse derived from a source external to the circuit or equipment where a particular operation requires an enabling pulse with certain characteristics (time delayed, duration, etc.).
Falltime	The time required by pulse waveform to fall from 90% of its maximum value to 10% of its maximum value. Not necessarily equal to risetime.
Jitter	Short-duration instability (of a signal); random small departures from regularity.
KPPS	Kilopulses per second.
Monostable (multivibrator)	A circuit having one stable and one semistable state. A trigger pulse drives the circuit into the semistable state, where it remains for a predetermined time before returning to the stable condition.
MPPS	Megapulses per second.
Overshoot	When changing from one voltage level to another, a momentary excursion greater than the change desired.
PPS	Pulses per second.
Preshoot	A small negative excursion immediately preceding a positive-going pulse, or vice versa.
Pulse amplitude	The amplitude of a pulse is any term indicating the magnitude of the pulse.
Pulse duration	The time interval between the first and last instants at which the pulse voltage (or current) reaches some specified percentage of the peak voltage (or current) of the pulse.
Pulse period	The pulse period in a sequence of periodic pulses is the elapsed time between any given point on one of the pulse waveforms and the same point on the following pulse.
Pulse Repetition Frequency	The number of periodic pulses that occur in a given unit of time. Also expressed as pulse repetition rate.
Pulse width	See pulse duration.
Quiescent	At rest—specifically, the condition of a circuit when no input signal is being applied and/or no change is taking place.
Ramp voltage	A voltage waveform that rises at a steady rate. For example, at 10 volts per second.
Ringing	High-frequency damped oscillations caused by shock excitation of high-frequency resonances, or, a damped oscillation in the output signal of a system as a result of a sudden change in the input signal.
Risetime	The risetime of a pulse is taken as the time required for the leading edge of the pulse to increase from 10% of its maximum value to 90% of its maximum value.
Sampling system	A method that takes amplitude samples from a repetitive input signal with each sample at a progressively later time, then reconstructs these samples into a replica of the original waveform at a much lower frequency.
Trigger	A signal that starts action in another circuit.

SECTION 3

CIRCUIT DESCRIPTION

Introduction

This section contains the theory of operation of the various circuits in the Type 114. The text is supplemented by two block diagrams inserted in the text and by schematics in Section 5. The reader should follow the circuits on the diagrams as they are presented in the text.

CAUTION

There is no fixed chassis ground for the circuit board used in the Type 114. A common negative point is used instead. This permits changing the polarity of the output by grounding the appropriate side of the power supply. For this reason, always connect probe grounds to the main chassis rather than to a point on the circuit board.

Period Generator

The Period Generator (see Fig. 3-1) supplies the trigger pulse which activates the Width Generator. The trigger pulse is generated internally, or is derived from an externally generated triggering signal, depending upon the setting of the PERIOD switch.

Internal Operation. When the Type 114 is operating in the internally triggered modes, the operation of the Period Generator is as follows:

Transistors Q115 and Q125 in conjunction with the appropriate RC timing combination form a free running oscillator. At the start of a cycle of operation, Q115 is biased off and Q125 is biased slightly on. The charge on timing capacitor C115 has been removed by the preceding cycle and now starts charging toward a common point voltage at an RC rate. As the timing capacitor charges, the voltage across it reaches a point where it turns on diode D114 and transistor Q115. At this instant the circuit becomes regenerative with Q115 turning Q125 on hard, which in turn biases Q115 into heavy conduction. The heavy conduction of Q115 removes the charge accumulated on timing capacitor C115 and ends the cycle.

At the instant Q125 is turned on hard by Q115, the steep wave-front is coupled through R131 and C131 to the base of Q134, and thence to pulse transformer T131. The pulse output of T131 is in the order of 20 nanoseconds in width.

External Trigger Operation. When the Type 114 is operating in the externally triggered mode, the Pulse Generator functions as a pulse shaper. Period switch SW120 disconnects the base of Q115 from the collector of Q125 and reconnects it to the external trigger input circuit. SW120 also connects the base of Q125 to +25 volts through R121 and disconnects the timing capacitor from the circuit. Under these conditions none of the transistors in the Period Generator are conducting. A positive pulse of 2 to 20 volts in amplitude and having a risetime of 1 microsecond or less is required at the EXTERNAL TRIGGER—INPUT connector in order to make the transistors conduct and deliver the proper pulse to the Width Generator.

When a pulse having the proper amplitude and risetime is applied to the EXTERNAL TRIGGER—INPUT connector, Q115 is biased into conduction and in turn biases Q125 and Q134 into conduction. The resulting pulse at the primary of T131 has a risetime of about 10 nanoseconds.

Width Generator

The Width Generator receives the trigger pulses from T131 and generates pulses of the desired width. The output of the width generator is applied to the Trigger Out Circuit and to the Output Amplifier. Except when operating in the square wave mode, the Width Generator operates as a monostable multivibrator; in the square wave mode the Width Generator functions as a bistable.

Normal Operation. In normal operation transistors Q205 and Q215 form a bistable network whose output drives ramp transistor Q224, trigger output transistor Q234, and the output amplifier. Q205 is the normally "on" transistor. The arrival of a negative trigger pulse from T131 cuts off Q205. Q215 now conducts and cuts off Q224, permitting the voltage at the collector of Q224 to start charging ramp capacitor C195. When the selected ramp capacitor reaches the desired voltage, D193 is forward biased and transistor Q194 is biased into conduction. The conduction of Q194 increases the conduction of Q184 and thereby biases Q205 back into conduction. The conduction of Q205 ends the output pulse. Turning on Q205 turns off Q215 and turns on Q224. The conduction of Q224 discharges the ramp capacitor.

When the ramp capacitor is discharged down to about 0.3 volt, Q174 turns off and Q164 is turned on. Transistors Q164 and Q174, diodes D136 and D161, and pulse transformer T131 function as a pulse steering circuit. With Q164 on, the pulse from the Period Generator via T131 triggers the width monostable circuit on, generating an output pulse. As soon as the ramp capacitor reaches approximately 0.3 volt, Q174 conducts and turns Q164 off. Turning off Q164 reverse biases D161, while turning on Q174 biases D136 near zero. If the Period Generator produces a pulse while these conditions exist, that is, whenever the ramp capacitor has a charge above approximately 0.3 volt, the pulse is steered to the WIDTH > PERIOD light circuit. This monostable circuit is actuated by the pulse from T131, turning off Q145 and turning Q155 on, lighting the WIDTH > PERIOD light. Turning on Q155 causes C155 to discharge through T131 and R136. When C155 is discharged, D141 and Q145 conduct and reset the circuit, making it ready for another pulse.

Square Wave Mode. When the Type 114 is operated in the Square Wave Mode (see Fig. 3-2), the Width Generator operates as a bistable and requires two trigger pulses from the Period Generator for each cycle of operation. Consequently, the RC network in the Period Generator is

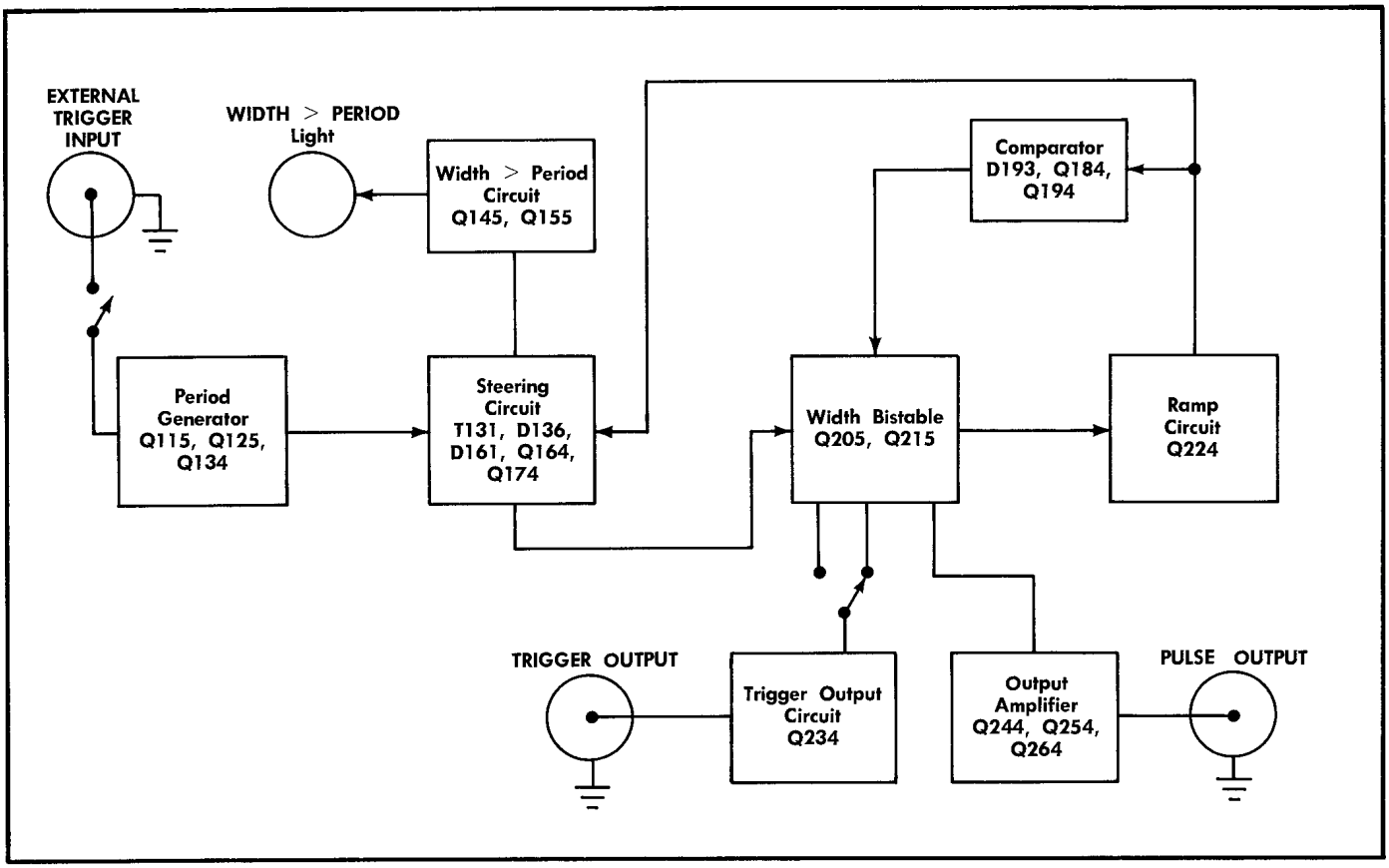


Fig. 3-1. Type 114 block configuration for pulse output.

reduced to half its normal value so that the Period Generator can deliver twice the usual number of output pulses. This procedure ensures that the period indicated by the PERIOD switch remains valid for square-wave operation. (When external triggering is used, the period of the square wave is twice that of the triggering signal, since the Width Generator is functioning as a bistable and requires two pulses for each cycle of operation.)

In the Width Generator, the ramp circuit is disabled by D196, which means that the comparator consisting of D193, Q194, and Q184 is not used. Resetting of the width bistable is accomplished by applying the output of WIDTH > PERIOD light driver transistor Q155 to the base of Q125.

At the instant of turn on when operating in the square-wave mode, D177 reverse biases and Q174 is biased on. Q174 turns off Q164 and zero biases steering diode D136. Under these conditions, the first pulse from the Period Generator forward biases D136 and turns off Q145. Turning off Q145 turns on Q155, which in turn cuts off Q215 and makes Q205 the conducting transistor in the bistable. Turning off Q215 also biases Q224 into conduction which switches the steering circuit so that D161 becomes zero biased. The second pulse from the Period Generator is steered to Q205, switching the bistable and the steering circuit. Thus the output of the bistable is a symmetrical square wave.

Trigger Output Circuit

Trigger output transistor Q234 normally operates in saturation due to the current through R232. Whenever the signal selected by the TRIGGER switch goes negative, the voltage change is coupled through C231 to the base of Q234 and momentarily takes it out of saturation. When this happens, the collector voltage of Q234 rises sharply until it reaches $\approx 3\frac{1}{2}$ volts and forward biases catcher diode D236. The resulting trigger output through C236 is about 80 nanoseconds wide and is limited to $\approx +3$ volts into an open circuit, or to 10 ma into a short circuit.

The TRIGGER switch permits selecting the edge of the output waveform at which the trigger occurs. By setting the switch to TRAILING EDGE, the Type 114 may be used as a delay generator with the WIDTH controls setting the amount of delay.

Output Amplifier

The two-stage output amplifier consists of driver transistor Q244 and the parallel-connected output transistors Q254 and Q264. When negative output pulses are desired, the output transistors are connected common emitter and the +25-volt supply is connected to chassis ground displacing the circuit board common ground 25 volts negative. When positive output pulses are desired, the output transistors are connected as an emitter follower and the common point is connected to chassis ground. Polarity switching of the output is accomplished by the AMPLITUDE switch.

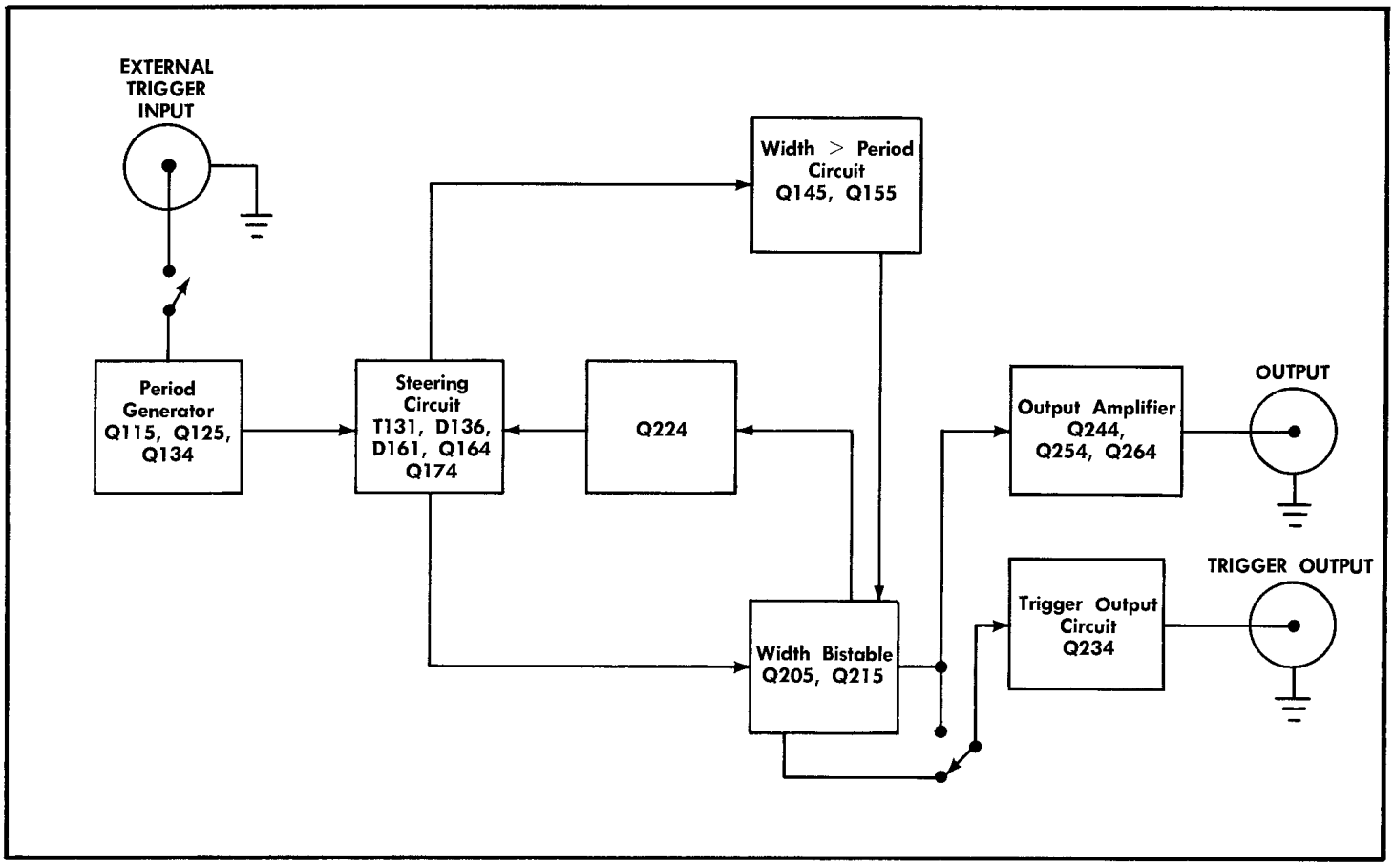


Fig. 3-2. Type 114 block configuration for square-wave output.

CAUTION

Do not connect test probe ground clips to the common point of the circuit board while the AMPLITUDE switch is in either of the negative positions. The best procedure is to always connect the test probe ground clip to the main chassis and leave the AMPLITUDE switch in the positive output positions.

The VARIABLE control associated with the AMPLITUDE switch provides continuously variable voltage amplitude within the ranges of the AMPLITUDE switch.

Power Supply

The power supply consists of a regulated 25-volt supply and an unregulated 35-volt supply. The 25-volt supply and a 10-volt supply are stacked to obtain the 35-volt supply. A rear-panel switch is provided to change transformer primary connections when switching from 115- to 230-volt operation.

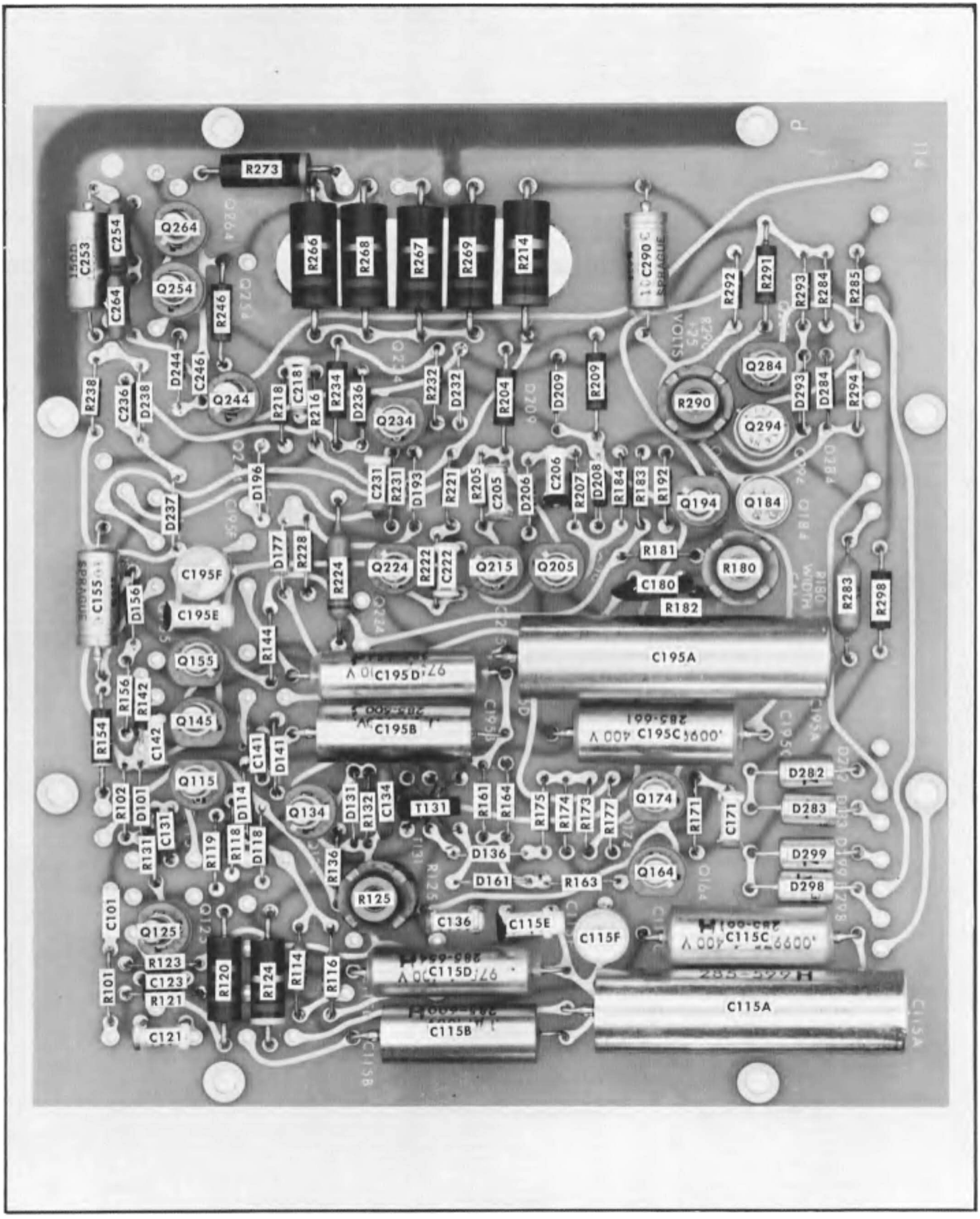
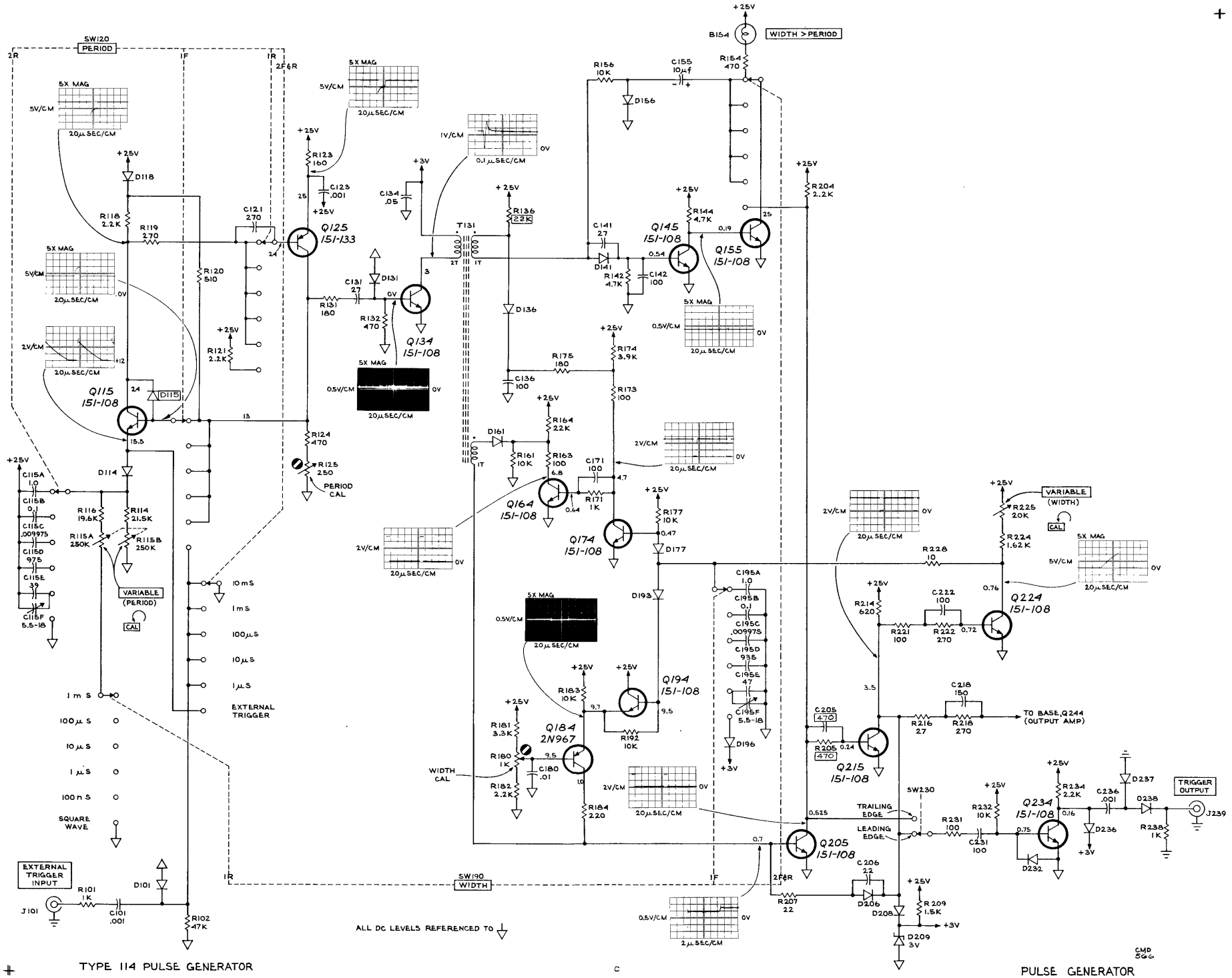


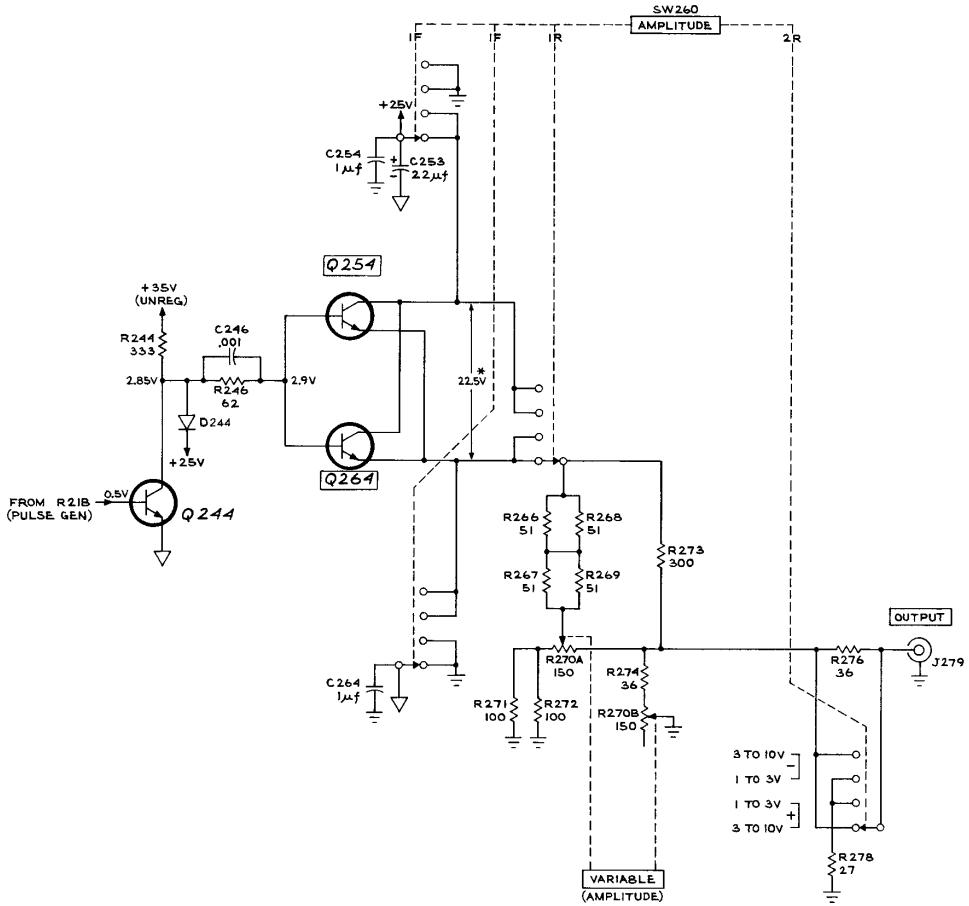
Fig. 4-20. Locations of electrical components.



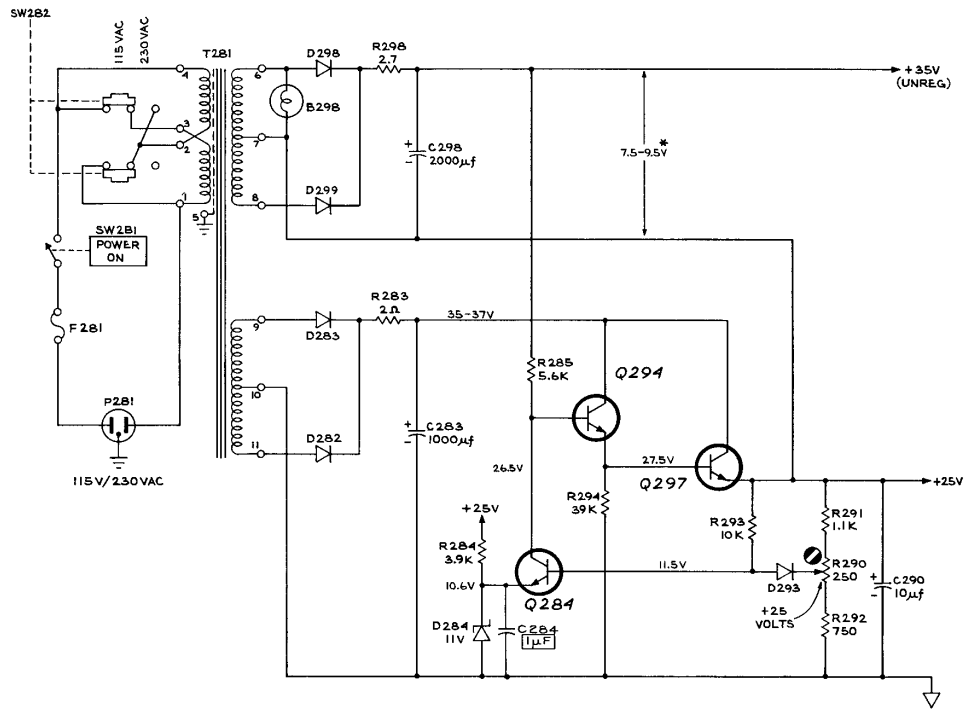
TYPE 114 PULSE GENERATOR

C

PULSE GENERATOR



OUTPUT AMPLIFIER



POWER SUPPLY

NOTE: ALL VOLTAGES REFERENCED TO COMMON POINT ⏚ EXCEPT AS INDICATED *.

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

CMD 566

TYPE 114 PULSE GENERATOR

OUTPUT AMPLIFIER & POWER SUPPLY

TYPE 114

TEXT CORRECTION

Section 1 Characteristics

Page 1-1, 1st column, Pulse Width

CHANGE: 2nd sentence to read:

With the width VARIABLE control at the CAL end of its range, the width accuracy is within ±3% (+10 ns on negative pulse) of indicated value at 10 ns through 1 µs positions. At the 100 ns position, accuracy is within ±5% (+10 ns on negative pulse).

TYPE 114

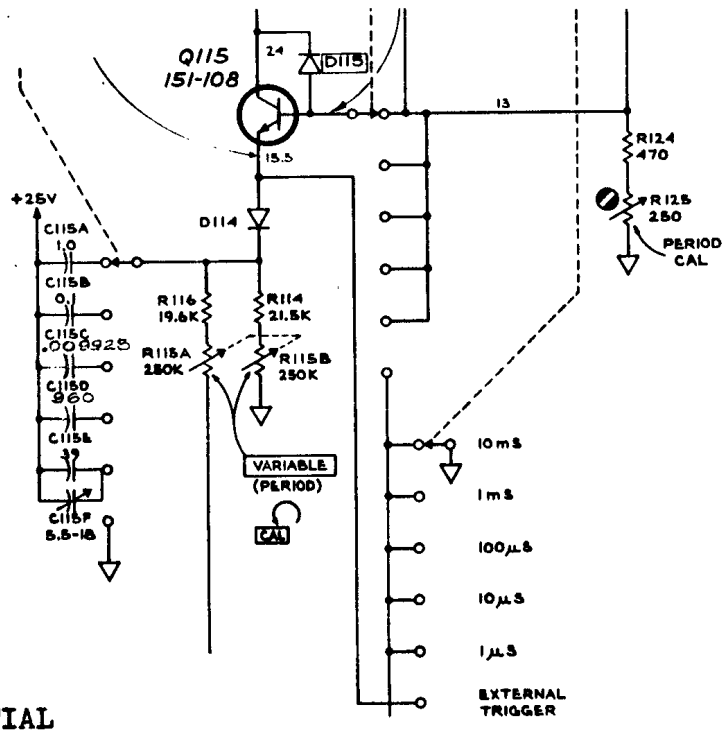
PARTS LIST CORRECTION

CHANGE TO:

C115A	*295-0108-00	1.0 µF	Timing Capacitor (PERIOD)
C115B		0.1 µF	
C115C		0.009925 µF	
C115D		960 pF	

* Checked assembly

SCHEMATIC CORRECTION



PARTIAL

PULSE GENERATOR

M10,952/667