

INSTRUCTION MANUAL

Serial Number _____

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TYPE 115
**PULSE
GENERATOR**

Tektronix, Inc.

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070-0786-00

868



WARRANTY

All Tektronix instruments are warranted against defective materials and workmanship for one year. Tektronix transformers, manufactured in our plant, are warranted for the life of the instrument.

Any questions with respect to the warranty mentioned above should be taken up with your Tektronix Field Engineer.

Tektronix repair and replacement-part service is geared directly to the field, therefore all requests for repairs and replacement parts should be directed to the Tektronix Field Office or representative in your area. This procedure will assure you the fastest possible service. Please include the instrument Type and Serial or Model Number with all requests for parts or service.

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Abbreviations and symbols used in this manual are based on, or taken directly from, IEEE Standard 260 "Standard Symbols for Units", MIL-STD-12B and other standards of the electronics industry. Change information, if any, is located at the rear of this manual.

SEE PARTS LIST FOR
SEMICONDUCTOR SYMBOLS

SEE THE REAR COVER FOR
SERIES W SYMBOLS

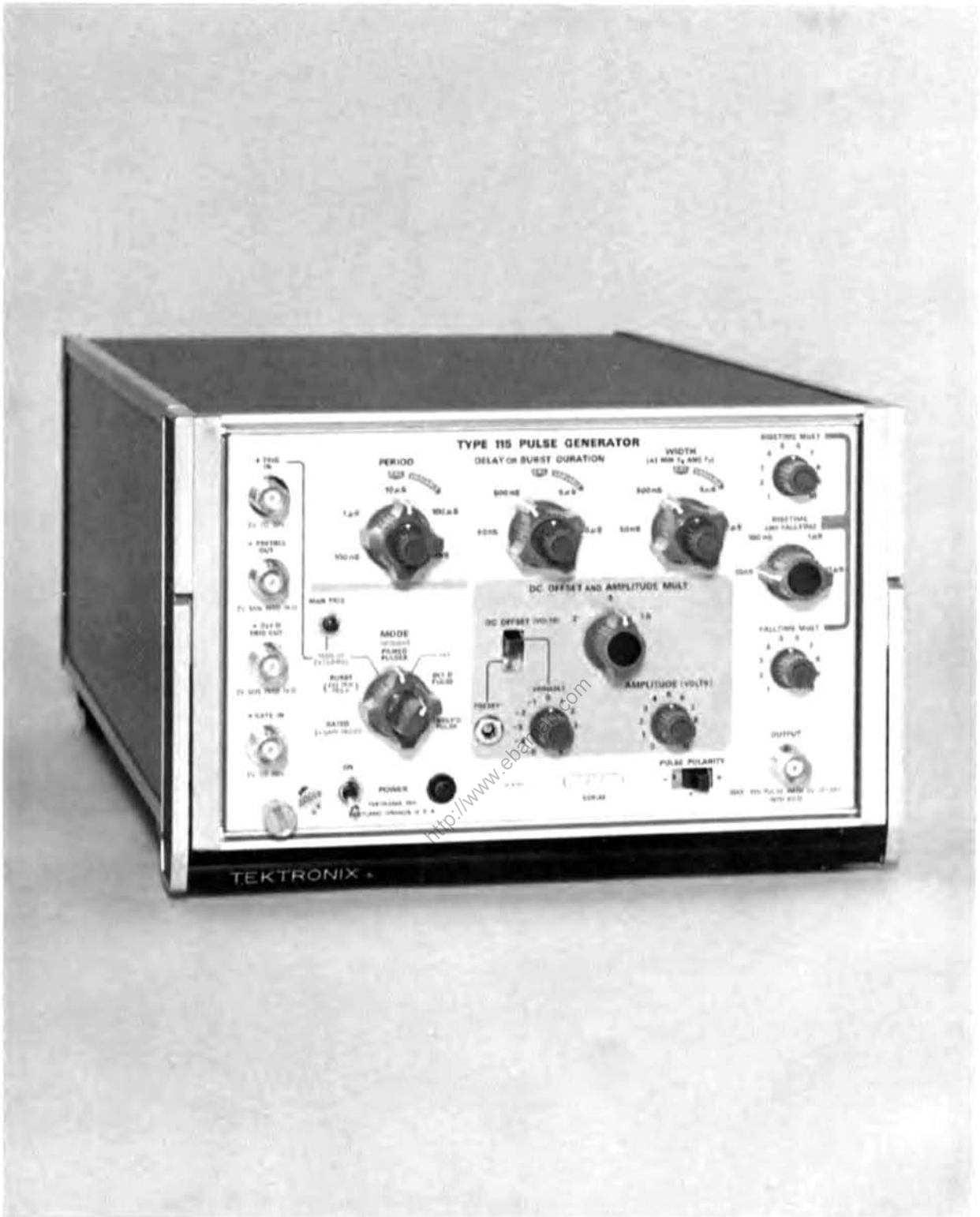


Fig. 1-1. Type 115 Pulse Generator.

SECTION 1

SPECIFICATION

Change information, if any, affecting this section will be found at the rear of this manual.

General

The Type 115 Pulse Generator is a multi-purpose instrument which generates pulses with a variety of controllable characteristics. It has a maximum repetition rate of 10 MHz, a maximum amplitude of ± 10 volts and a minimum risetime and falltime of 10 ns. Those pulse characteristics which are controllable are: the repetition rate, width, amplitude, risetime, falltime, DC offset and polarity. Its five modes of operation include an undelayed pulse, a delayed pulse (with a calibrated delay), paired pulses, an externally triggered burst of pulses and an externally gated burst of pulses. In addition to the output pulse, there is an undelayed and a delayed trigger output.

The following specifications are valid for instruments operated at an ambient temperature of from 0°C to +50°C after an initial warm-up period of 20 minutes, when previously calibrated at a temperature of +25°C ± 5 °C. Section 5, Performance Check and Calibration Procedure, gives a procedure for checking and adjusting the Type 115 with respect to the following specification.

Type 115 Mod 146B

This manual also pertains to the Type 115 Mod 146B. The Type 115 Mod 146B is identical to the standard Type 115 except that it is shipped without a cabinet and with a coiled, detachable power cord (Tektronix Part No. 161-0031-00) and power cord connector receptacle (Tektronix Part No. 331-0102-00). See Section 9 for rackmounting instructions.

TABLE 1-1

ELECTRICAL CHARACTERISTICS

Pulse Output

Characteristic	Performance
Pulse Period (TRIGGER switch set to INT)	100 ns to 1 ms in 5 steps; continuously variable between calibrated steps. PERIOD VARIABLE extends maximum period to at least 10 ms.
Period Accuracy	Within 3% of PERIOD switch setting (PERIOD VARIABLE set to CAL); Within 5% in 100 ns position.
Pulse Delay or Burst Duration	50 ns to 50 μ s in 4 steps; continuously variable between calibrated

	steps. DELAY OR BURST DURATION VARIABLE extends maximum delay to at least 500 μ s.
Delay Accuracy	Within 3% of DELAY OR BURST DURATION switch setting ± 10 ns (DELAY OR BURST DURATION VARIABLE set to CAL).
Pulse Width	50 ns to 50 μ s in 4 steps; continuously variable between calibrated steps. WIDTH VARIABLE extends maximum width to at least 500 μ s.
Width Accuracy	Within 3% of WIDTH switch setting (WIDTH VARIABLE set to CAL); Within 5% in 50 ns position.
Pulse Risetime (10% to 90%)	10 ns to 10 μ s in 4 steps; continuously variable between calibrated steps. RISETIME MULT extends maximum risetime to 100 μ s.
Risetime Accuracy	Within 5% ± 1 ns of RISETIME AND FALLTIME switch setting (RISETIME MULT set to 1).
Pulse Falltime (90% to 10%)	10 ns to 10 μ s in 4 steps; continuously variable between calibrated steps. FALLTIME MULT extends maximum risetime to 100 μ s.
Falltime Accuracy	Within 5% ± 1 ns of RISETIME AND FALLTIME switch setting (FALLTIME MULT set to 1).
Pulse Amplitude	3 ranges, continuously variable, with DC OFFSET AND AMPLITUDE MULT set to: (a) 1 from less than ± 100 mV to at least ± 10 V. (b) .5 within 5% of 0.5 times pulse amplitude in (a). (c) .2 within 5% of 0.2 times pulse amplitude in (a).
Pulse DC Offset	0 V to at least ± 5 V in 3 ranges; continuously variable.
Pulse Aberrations	No more than +3%, -3% or 3% peak-to-peak of the pulse amplitude or 200 mV, times the DC OFF-

¹As measured with a Tektronix Type 351 Vertical Sampling Unit.

ELECTRICAL CHARACTERISTICS

	SET AND AMPLITUDE MULT switch (whichever is greater) in either pulse polarity. ¹
Minimum Pulse Separation	50 ns, or less, between 50% amplitude points of any two adjacent pulses, with risetime and falltime set to minimum.
Maximum Duty Factor	At least 75% (limited by minimum pulse separation).

Additional Output Signals

Pretrigger Output	At least +2 V into 1 k Ω
Delayed Trigger Output	At least +2 V into 1 k Ω

Input Signal Requirements

External Trigger Input Frequency	Pulse: At least 0.5 V/ μ s rate of rise. Sinewave: From 1 kHz to 10 MHz.
External Trigger Input Amplitude	Pulse: Between +2 V and +20 V, maximum decreasing to +4 V at 10 MHz. Sinewave: Between 2 V and 20 V peak-to-peak, maximum decreasing to 4 V peak-to-peak at 10 MHz.
Gate Pulse Input	Between +2 V and +20 V.

Power Requirements

Line Voltage Range (AC, RMS) 115 V	Low	90 V to 110 V
	Medium	104 V to 126 V
	High	112 V to 136 V
Line Voltage Range	Low	180 V to 220 V

Power Requirements

(AC, RMS) 230 V	Medium 208 V to 252 V High 224 V to 272 V
Line Frequency	From 48 Hz to 66 Hz
Maximum Power Consumption	115 watts, 1 A at 115 V, 60 Hz

TABLE 1-2

ENVIRONMENTAL CHARACTERISTICS

Characteristic	Information
Operating Temperature Specified	+20°C to +30°C
	Useful 0°C to +50°C
Non-operating	-40°C to +65°C
Altitude	Operating Up to 10,000 feet
	Non-operating Up to 50,000 feet
Transportation	Qualified under National Safe Transit Committee Test Procedure 1A, Category 11 (24 inch drop).

TABLE 1-3

MECHANICAL CHARACTERISTICS

Characteristic	Description	
	With Cabinet	Without cabinet Mod 146B
Dimensions		
Height	6 inches	4 $\frac{7}{8}$ inches
Width	9 inches	8 inches
Length	15 $\frac{7}{8}$ inches	14 $\frac{3}{4}$ inches
Weight	15 lbs.	11 lbs.
Finish		
Cabinet	Blue vinyl painted aluminum	
Front Panel	Anodized Aluminum	

SECTION 2

OPERATING INSTRUCTIONS

Change information, if any, affecting this section will be found at the rear of this manual.

General

This section of the instruction manual provides information necessary for operating the Type 115 and using it in various applications. Included are handling and setup procedures, a description of the Type 115 controls and connectors, a first time operation procedure, definitions of pulse characteristics, a discussion of output pulse selection, and a discussion of the use of the Type 115 with other instruments.

INITIAL CONSIDERATIONS

Handle and Stand

The handle of the Type 115 can be pulled out for convenient carrying of the instrument. When not in use, the handle folds out of the way, into the trim of the instrument cabinet (see Fig. 2-1).

A bail-type stand is mounted beneath the cabinet. When folded out it provides a convenient operating position for the Type 115 (see Fig. 2-1). The instrument may also be set on feet mounted on the rear, for either operation or storage.

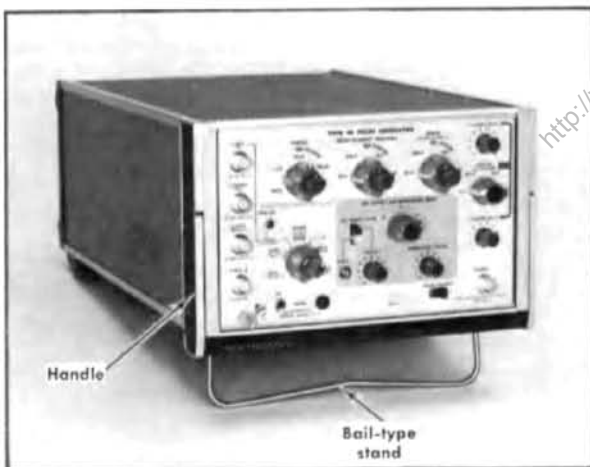


Fig. 2-1. Handle and bail-type stand.

Cooling

The Type 115 maintains a safe operating temperature by drawing air in at the rear and blowing it out through ventilation holes in the left side of the instrument. The ambient temperature of the operating environment should be from 0° C (32° F) to 50° C (122° F) for proper operation. Ade-

quate clearance on the left side of the instrument must be provided to allow free air flow and dissipation of heat from the instrument.

TABLE 2-1
Regulating Ranges

Range Selector Switch Position	Regulating Range	
	115 volts	230 volts
LO (Switch bar in left holes)	90 to 110 volts	180 to 220 volts
M (Switch bar in middle holes)	104 to 126 volts	208 to 252 volts
HI (Switch bar in right holes)	112 to 136 volts	224 to 272 volts

A thermal cutout in the instrument provides thermal protection by disconnecting the power to the instrument if the internal temperature exceeds a safe operating level. Power is automatically restored when the temperature returns to a safe level. The cabinet is designed to distribute air flow throughout the instrument for efficient cooling. Operation of the instrument for extended periods without the cabinet may cause it to overheat and the thermal cutout to open.

Operating Voltage

The Type 115 can be operated from either a 115-volt or a 230-volt line voltage source. The LINE VOLTAGE SELECTOR assembly, located on the rear panel, allows conversion of the instrument so that it may be operated from one line voltage or the other. In addition, this assembly changes the connections of the power transformer primary to allow selection of one of three regulating ranges (see Table 2-1). The assembly also includes the two line fuses. When the instrument is converted from 115-volt to 230-volt operation or vice versa, the assembly selects the proper fuse to provide the correct protection for the instrument.

Use the following procedure to convert this instrument between line voltages or regulating ranges.

1. Disconnect the instrument from the power source.
2. Loosen the two captive screws which hold the cover onto the voltage selector assembly then pull to remove the cover.
3. To convert from 115-volt to 230-volt line voltage or vice versa, pull out the Voltage Selector switch bar (see Fig. 2-2); turn it 180° and plug it back into the remaining holes. Change the line-cord power plug to match the power-source receptacle or use a 115-to-230-volt adapter.

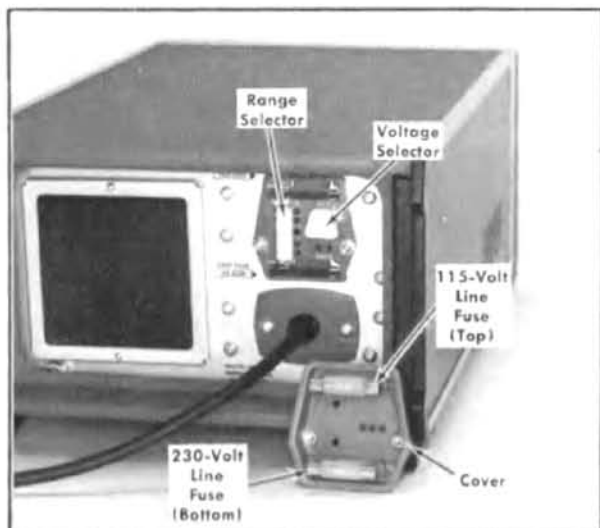


Fig. 2-2. Line Voltage Selector assembly on the rear panel (shown with cover removed).

4. To change regulating ranges, pull out the Range Selector switch bar (see Fig. 2-2) slide it to the desired position and plug it back in. Select a range which is centered about the average line voltage to which the instrument is to be connected (see Table 2-1).

5. Re-install the cover and tighten the two captive screws.

6. Before applying power to the instrument, check that the indicating tabs on the switch bars are protruding through the correct holes in voltage selector assembly cover for the desired line voltage and regulating range.

CAUTION

The Type 115 should not be operated with the Voltage Selector or Range Selector switch in the wrong position for the line voltage applied. Operation of the instrument with either switch in the wrong position will either provide incorrect operation or damage the instrument.

CONTROLS AND CONNECTORS

All controls and connectors required for the normal operation of the Type 115 are located on the front and rear panels of the instrument (see Fig. 2-3). Familiarity with the function and use of each of these controls is necessary for effective operation of the instrument. These functions are described briefly in the following table and in more detail later in this section.

Controls

MODE switch Selects mode of operation of instrument to produce different types of outputs at OUTPUT connector.

UNDLY'D PULSE—Identical, equally-spaced output pulses with no delay.

DLY'D PULSE—Identical, equally-spaced output pulses with adjustable delay with respect to start of undelayed output pulse.

PAIRED PULSES—Identical, equally-spaced pairs of output pulses, second pulse of each pair having adjustable delay time with respect to start of first pulse of pair.

BURST—Identical, equally-spaced bursts of output pulses. Each burst is started by external trigger applied to + TRIG IN connector or by pressing MANUAL TRIG button and duration of burst is controlled by DELAY OR BURST DURATION controls.

GATED—Identical, equally-spaced bursts of output pulses. Start and duration of each burst is controlled by external gate applied to +GATE IN connector.

TRIGGER switch Selects how output pulses will be triggered in undelayed, delayed and paired pulses modes.

INT—Output pulses triggered by internal, free-running period generator.

MAN OR EXTERNAL—Output pulses triggered by external triggers applied to + TRIG IN connector or by MANUAL TRIG button.

MANUAL TRIG button Pressed—Triggers one output pulse cycle (undelayed, delayed, paired or burst) when TRIGGER switch is in MAN OR EXTERNAL. Release—Re-arms.

PERIOD switch Selects time from beginning of one cycle to start of next in undelayed, delayed and paired pulses modes when TRIGGER switch is set to INT. Selects period of individual output pulses within each burst or gated burst. Five calibrated positions (VARIABLE control set to CAL position).

VARIABLE control Provides continuously variable pulse periods between calibrated settings of PERIOD switch.

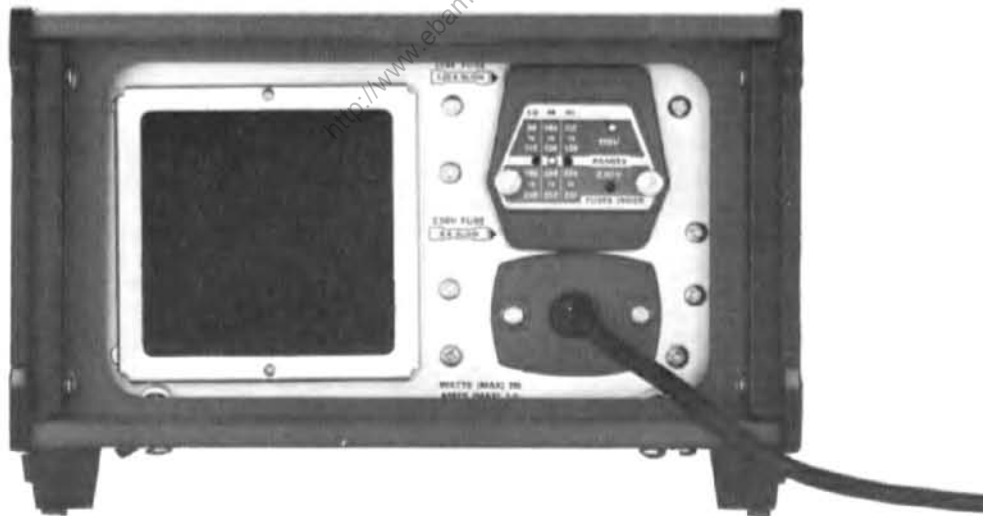
DELAY OR BURST DURATION switch Selects time delay between start of undelayed pulse and start of delayed pulse and selects duration of burst in BURST mode. Four calibrated positions (VARIABLE control set to CAL position).

VARIABLE control Provides continuously variable pulse delay or burst duration between calibrated settings of DELAY OR BURST DURATION switch.

WIDTH switch Selects width of individual pulses generated in undelayed, delayed and paired pulses modes. Selects width of individual pulses within burst or gated output. Width is measured at 50% amplitude level with risetime and falltime at minimum. Four calibrated positions (VARIABLE control set to CAL position).



A. Front Panel.



B. Rear Panel.

Fig. 2-3. Front-and rear-panel controls and connectors.

Operating Instructions—Type 115

VARIABLE control	Provides continuously variable pulse width between calibrated settings of WIDTH switch.	in undelayed, delayed, paired pulses and burst modes with TRIGGER switch set to MAN OR EXTERNAL.
RISETIME AND FALLTIME switch	Selects risetime and falltime of individual pulses from 10% to 90% amplitude level and from 90% to 10% level respectively, in undelayed, delayed and paired pulses modes. Selects risetime and falltime of individual output pulses in each burst or gated burst output. Four calibrated positions (RISETIME MULT and FALLTIME MULT controls set to 1).	+ PRETRIG OUT connector Provides approximately +2 volts trigger pulse into 1 k Ω load, preceding undelayed pulse (or first pulse of paired pulses) and each individual pulse of burst or gated burst output for triggering external equipment. Pretrigger precedes output pulse by lead time ranging from approximately 30 ns to 45 μ s depending on pulse risetime.
RISETIME MULT control	Provides continuously variable pulse risetime between calibrated settings of RISETIME AND FALLTIME switch, independent of FALLTIME MULT control.	+ DLY'D TRIG OUT connector Provides approximate +2-volt trigger pulse into 1 k Ω load preceding delayed pulse (or second pulse of paired pulses) and at approximately the end of each burst in burst mode, for triggering external equipment. Delayed trigger is delayed with respect to pretrigger by approximately the delay time set by DELAY OR BURST DURATION controls. Delayed trigger precedes delayed output pulse by lead time from approximately 30 ns to 45 μ s depending on pulse risetime.
FALLTIME MULT control	Provides continuously variable pulse falltime between calibrated settings of RISETIME AND FALLTIME switch, independent of RISETIME MULT control.	+ GATE IN connector Permits application of external DC-coupled gate signal having an amplitude between +2 and +20 volts for determining start and duration of gated burst output. With risetime set to minimum, output burst starts within 100 ns after gate exceeds +2-volt level (above chassis ground) and continues until gate drops below +2-volt level. Input impedance is approximately 1 k Ω .
DC OFFSET AND AMPLITUDE MULT	Selects one of three multiplication factors to be multiplied by settings of AMPLITUDE (VOLTS) and DC OFFSET (VOLTS) controls.	OUTPUT connector Provides DC-coupled output pulse signal. Characteristics determined by front-panel controls when applied to a 50 Ω load.
AMPLITUDE (VOLTS) control	Provides continuously variable pulse or burst amplitude from approximately 0 volts to at least 10 volts multiplied by DC OFFSET AND AMPLITUDE MULT switch setting. Risetime and falltime unaffected.	
DC OFFSET (VOLTS) VARIABLE control	Provides continuously variable DC level of output pulse or burst baseline from 0 volts to approximately ± 5 volts multiplied by DC OFFSET AND AMPLITUDE MULT switch setting.	
DC OFFSET (VOLTS) PRESET adjustment	Provides continuously variable DC level of output pulse or burst baseline from 0 volts to approximately ± 3 volts.	
DC OFFSET PRESET-VARIABLE switch	Selects whether DC OFFSET (VOLTS) is controlled by VARIABLE or PRESET control.	
PULSE POLARITY switch	Selects either positive-going or negative-going output pulse or burst.	
POWER switch	Controls power to instrument (ON or off).	
Power Light	Lights when power is on.	
Line Voltage Selector (Rear Panel)	Switch assembly selects operating voltage and line voltage range. Also includes line fuses. Voltage Selector—Selects operating voltage (115 V or 230 V). Range Selector—Selects line voltage range (low, medium, high).	
Connectors		
+ TRIG IN connector	Permits application of external DC-coupled signal having an amplitude between +2 and +20 volts for triggering output pulses	

FIRST TIME OPERATION

When the Type 115 is received, it is calibrated and should be performing within the specification shown in Section 1 of this manual. The following procedure allows the operator to become familiar with the front panel controls and their functions as well as some of the problems involved in selecting desired output pulse characteristics. This procedure may also be used as a general check of the instruments performance. For a check of the instruments operation with respect to the specification given in Section 1, the Performance Check and Calibration Procedure in Section 5 must be used.

1. Apply power to the Type 115 and a 15-MHz test oscilloscope.
2. Allow the instrument to warm up for a few minutes. (For instrument to operate within tolerances stated in Section 1, the instrument must warm up for 20 minutes.)
3. Install a 50- Ω 5 watt termination on the vertical input of the test oscilloscope. (Tektronix Part No. 011-0099-00)
4. Connect a coaxial cable between the Type 115 OUTPUT connector and the termination on the test oscilloscope input.
5. Connect a 50- Ω coaxial cable between the Type 115 + PRETRIG OUT connector and the test oscilloscope External Trigger Input.

6. Set the Type 115 and oscilloscope controls as follows:*

Type 115	
MODE	UNDLY'D PULSE
TRIGGER	INT
PERIOD	1 ms
VARIABLE	CAL
DELAY OR BURST DURATION	50 μ s
VARIABLE	CAL
WIDTH	50 μ s
VARIABLE	CAL
RISETIME AND FALLTIME	10 μ s
RISETIME MULT	1
FALLTIME MULT	1
DC OFFSET AND AMPLITUDE MULT	1
AMPLITUDE (VOLTS)	10
DC OFFSET VARIABLE	0
DC OFFSET PRESET-VARIABLE	VARIABLE
PULSE POLARITY	+

Oscilloscope

Sweep Rate	20 μ s/cm
Vertical Deflection	2 V/cm
Input Coupling	DC
Triggering	+ External
Amplitude Calibrator	Off

7. Adjust the test oscilloscope triggering, positioning and CRT controls to obtain a stable display of the output pulse (see Fig. 2-4A).

8. Turn the AMPLITUDE (VOLTS) control throughout its range and note that the pulse amplitude goes from 10 volts to approximately zero volts with no change in risetime or falltime.

9. Reset the AMPLITUDE (VOLTS) control to 10.

10. With the test oscilloscope vertical position control, position the pulse baseline to the test oscilloscope center horizontal line.

11. Turn the DC OFFSET VARIABLE control throughout its range and note an approximate ± 5 volts displacement of the baseline from the test oscilloscope center horizontal line.

12. Set the DC OFFSET PRESET-VARIABLE switch to the PRESET position.

13. With a small screwdriver turn the DC OFFSET PRESET screwdriver adjustment throughout its range and note both + and - DC offset about the center horizontal line.

14. Set the DC OFFSET PRESET adjustment for a 2-volt DC offset as measured on the test oscilloscope CRT.

15. Set the AMPLITUDE AND DC OFFSET RANGE switch to .5V and note both a decrease in pulse amplitude to 5 volts and a decrease in DC offset to 1 volt.

*This setup will always yield a pulse when the instrument is operating correctly.

16. Set the DC OFFSET PRESET-VARIABLE switch to VARIABLE.

17. Turn the DC OFFSET VARIABLE control throughout its range and note an approximate ± 2.5 volts displacement of the pulse baseline from the test oscilloscope center horizontal line.

18. Set the Type 115 PULSE POLARITY switch to - and note the inversion of the pulse (see Fig. 2-4B).

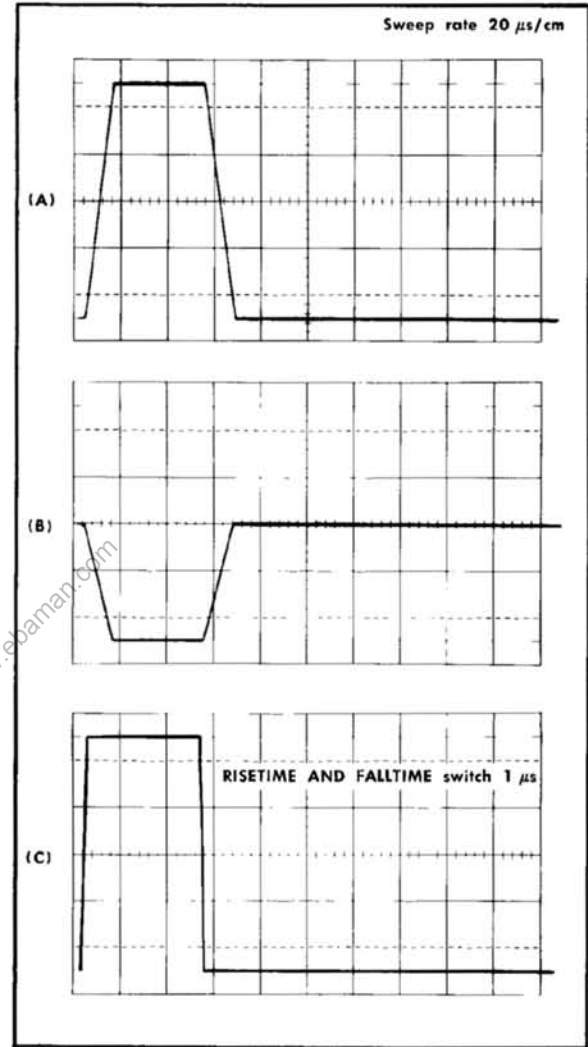


Fig. 2-4. Test oscilloscope displays obtained during first-time operation: (A) Initial pulse (step 7); (B) Inverted pulse (step 18); (C) Effect of RISETIME AND FALLTIME switch (step 21).

19. Reset the following Type 115 controls:

DC OFFSET AND AMPLITUDE MULT	1
DC OFFSET VARIABLE	0
PULSE POLARITY	+

Operating Instructions—Type 115

20. Position the pulse on the test oscilloscope CRT so that both the baseline and the pulse top are visible.

21. Switch the RISETIME AND FALLTIME switch throughout its range and note the changes in risetime and falltime. Fig. 2-4C shows an example of a display with the RISETIME AND FALLTIME switch set to $1 \mu\text{s}$.

22. Reset the RISETIME and FALLTIME switch to $10 \mu\text{s}$.

22. Reset the WIDTH switch to $5 \mu\text{s}$ and note the near disappearance of the pulse (see Fig. 2-5A). The pulse will begin to disappear when its width becomes less than its risetime as determined by the positions of the front-panel controls.

24. Turn the WIDTH VARIABLE switch fully clockwise and note the reappearance of the pulse shape observed in step 22.

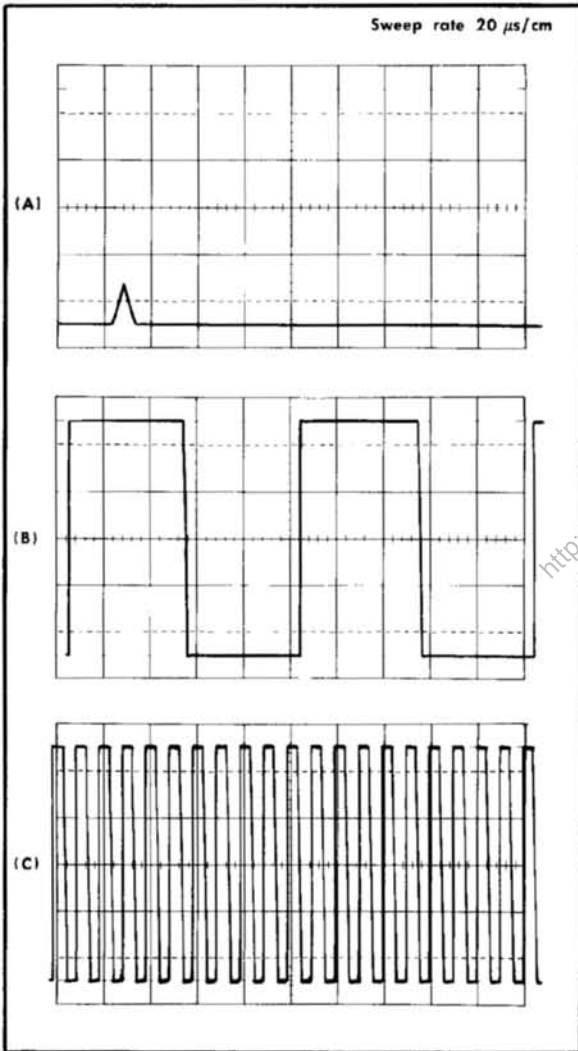


Fig. 2-5. Test oscilloscope displays obtained during first-time operation: (A) Risetime greater than pulse width (step 23); (B) Decrease in pulse period (step 30); (C) Decrease in pulse period (step 34).

25. Set the RISETIME AND FALLTIME switch to $1 \mu\text{s}$.

26. Turn the WIDTH VARIABLE control to the CAL position and note that the pulse does not disappear as it did in Step 23.

27. Set the WIDTH switch to $50 \mu\text{s}$.

28. Turn the RISETIME MULT and FALLTIME MULT controls to 10 and note the increase in both the risetime and the falltime.

29. Set the RISETIME MULT and FALLTIME MULT controls to 1.

30. Set the PERIOD switch to $100 \mu\text{s}$ and note the decrease in pulse period (see Fig. 2-5B).

31. Turn the PERIOD VARIABLE control fully clockwise and set the PERIOD switch to $10 \mu\text{s}$. Note approximately the same display as observed in Step 30.

32. Turn the PERIOD VARIABLE toward the CAL position and note that as the pulse period becomes less than the pulse width the test oscilloscope display exhibits countdown (width generator triggered before end of cycle).

33. Turn the PERIOD VARIABLE fully clockwise and set the WIDTH switch to $5 \mu\text{s}$.

34. Turn the PERIOD VARIABLE control to the CAL position and note the decrease in pulse period with no countdown (see Fig. 2-5C).

35. RESET the following Type 115 controls:

PERIOD	1 ms
WIDTH	$50 \mu\text{s}$

36. Set the test oscilloscope sweep rate to $0.2 \text{ ms}/\text{cm}$.

37. With the test oscilloscope horizontal position control, position the leading edge of the first pulse on the 1-cm vertical line of the CRT graticule (see Fig. 2-6A).

38. Set the Type 115 MODE switch to DLY'D PULSE and note the appearance of a pulse, delayed with respect to the start of the undelayed pulse (in this case delayed with respect to the start of the trace).

39. Turn the DELAY OR BURST DURATION VARIABLE control throughout its range and note the variation in delay time (see Fig. 2-6B).

40. With the DELAY OR BURST DURATION control, position the start of the first pulse about 1.5 cm from the beginning of the trace.

41. Set the Type 115 MODE switch to PAIRED PULSES and note the appearance of paired pulses (see Fig. 2-6C).

42. Turn the DELAY OR BURST DURATION VARIABLE control throughout its range and note the movement of the second pulse of each pair relative to the first. Note that when the delay interval becomes equal to the pulse width the display begins to exhibit countdown.

43. Connect a BNC T-connector to the test oscilloscope Amplitude Calibrator. Disconnect the coaxial cable from the Type 115 + PRETRIG OUT connector and connect it to one arm of the T-connector. Connect another coaxial cable from the other arm of the T-connector to the Type 115 + TRIG IN connector.

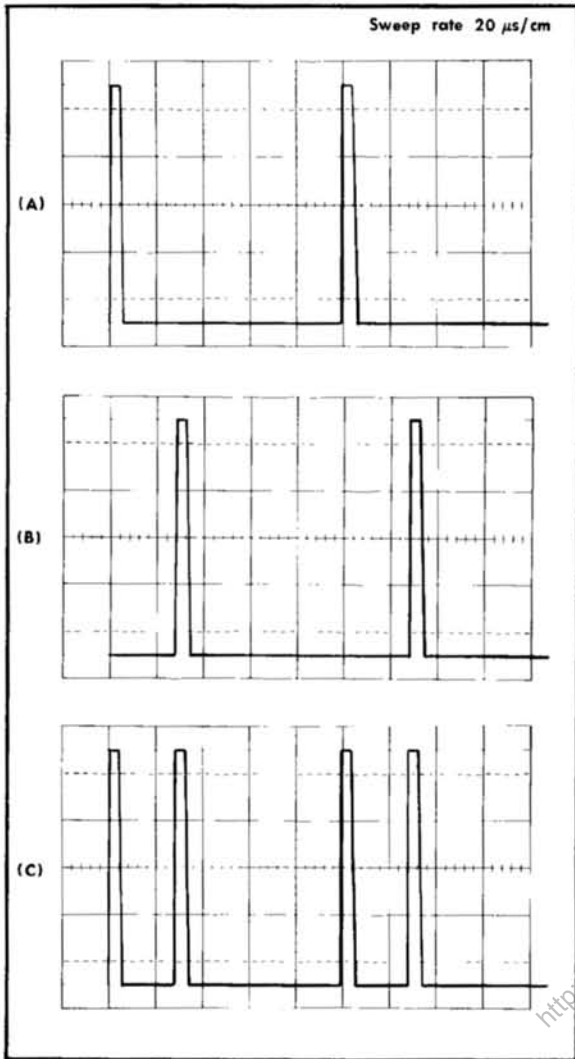


Fig. 2-6. Time comparisons of output signals in three modes of operation: (A) Undelayed pulse (step 37); (B) Delayed pulse (step 39); (C) Paired pulses (step 41).

44. Reset the following Type 115 controls:

MODE	UNDLY'D PULSE
TRIGGER	MAN OR EXTERNAL
DELAY OR BURST	Midrange
DURATION VARIABLE	

45. Set the test oscilloscope amplitude calibrator to 10 volts and note the undelayed output pulses on the CRT.

46. Turn the PERIOD VARIABLE control throughout its range and note that the PERIOD controls do not affect the pulse period. The pulse period is determined by the repetition rate of the external trigger. Reset the PERIOD VARIABLE to CAL.

47. Set the MODE switch to DLY'D PULSE and then to PAIRED PULSES and note that the pulses behave the same as in Steps 38 through 42.

48. Reset the following Type 115 controls.

MODE	BURST
PERIOD	100 μs
DELAY OR BURST	Fully clockwise
DURATION VARIABLE	

49. Note the bursts of output pulses on the test oscilloscope CRT (see Fig. 2-7A). Turn the DELAY OR BURST DURATION VARIABLE to the CAL position and note the decrease in the burst duration or number of pulses per burst.

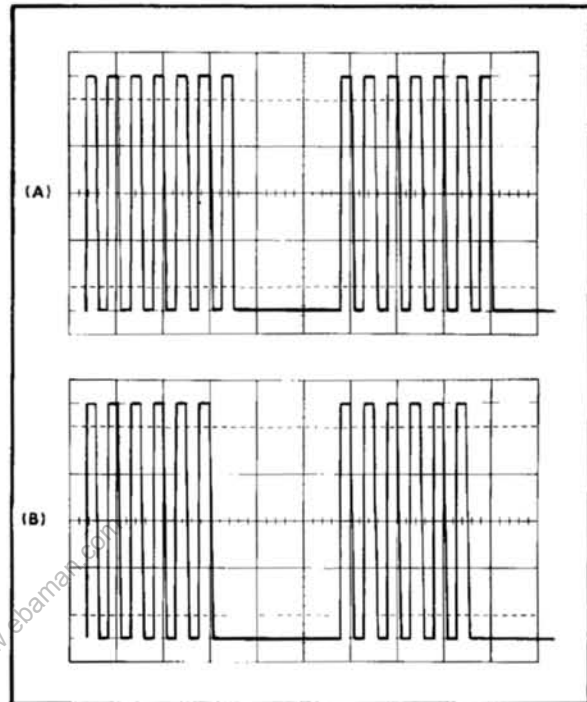


Fig. 2-7. Output pulse bursts: (A) Burst mode (Step 49); (B) Gated burst mode (step 51).

50. Disconnect the coaxial cable from the + TRIG IN connector and connect it to the + GATE IN connector.

51. Set the Type 115 TRIGGER switch to INT and the MODE switch to GATED and note the bursts of output pulses (see Fig. 2-7B). Note that the duration of the burst is controlled by the width of the positive-going input gate and is unaffected by the DELAY OR BURST DURATION controls.

52. Reset the following Type 115 controls:

PERIOD	10 μs
WIDTH	5 μs
RISETIME AND FALLTIME	1 μs

53. Note a gated burst where the individual pulses within the burst are narrower and have a shorter period.

54. Disconnect the coaxial cable (between the test oscilloscope External Trigger Input and the Amplitude Calibrator) from the T-connector and reconnect it to the Type 115 +

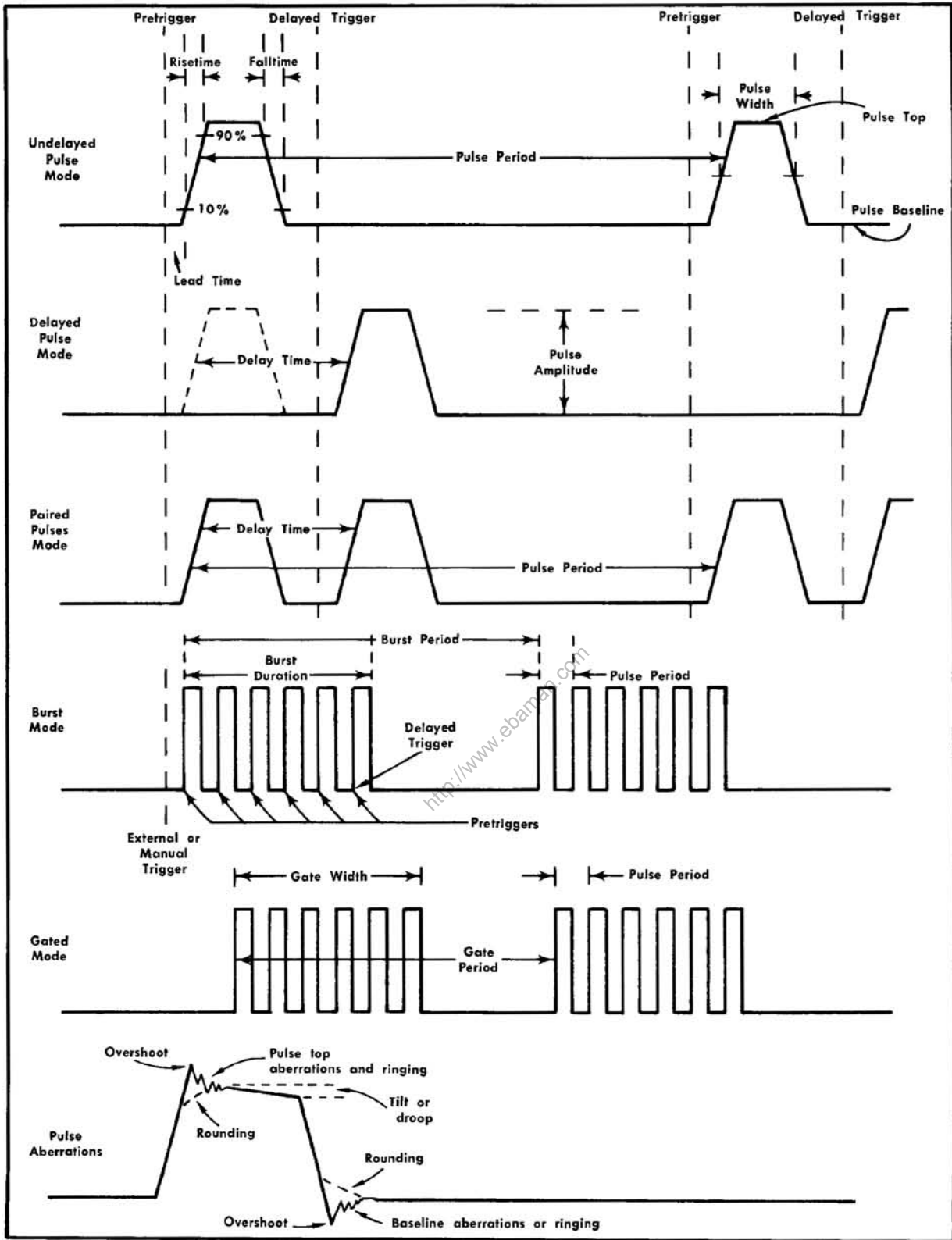


Fig. 2-8. Pulse waveforms illustrating the different pulse characteristics.

PRETRIG OUT connector. Disconnect the coaxial cable from the Type 115 + GATE IN connector and turn off the test oscilloscope Amplitude Calibrator.

55. Reset the following Type 115 controls:

MODE	UNDLY'D PULSE
PERIOD	1 ms
WIDTH	50 μ s
RISETIME AND FALLTIME	10 μ s
DC OFFSET AND AMPLITUDE MULT	.5 V

56. Position the pulse baseline to the center horizontal line of the CRT graticule with the test oscilloscope vertical position control.

57. Observe on the test oscilloscope CRT graticule an undelayed output pulse with the following characteristics:

Amplitude	5 volts
Period	1 ms
Width	50 μ s
Risetime and Faltime	10 μ s
DC Offset	0
Polarity	+

58. This completes the basic operating procedure for the Type 115. Instrument operations not explained here, or operations which need further explanations are discussed under selecting output pulse characteristics.

DEFINITIONS OF PULSE CHARACTERISTICS

In the following discussion the various characteristics of a Type 115 output pulse are defined and illustrated (see Fig. 2-8) as they are used in this manual.

Period—The time interval between the start of one cycle and the start of the next cycle. In the case of a burst, both the burst and the individual pulses within the burst have periods.

Delay Time—The time interval between the start of the undelayed pulse and the start of the delayed pulse. Also the approximate interval of time between the pretrigger and the delayed trigger.

Lead Time—The time interval between the output of a pretrigger (delayed trigger) and the start of an undelayed (delayed) output pulse. Lead time is dependent on pulse risetime.

Burst—A group of undelayed pulses followed by a pause when no pulses are generated.

Burst Duration—The time duration from the start of the first individual pulse of a burst to the fall of the last individual pulse of the burst.

Burst Period—The time interval between the start of one burst and the start of the next. In burst mode the burst period is the same as the period of the externally applied trigger. In gated mode the burst period is the same as the period of the externally applied positive-going gate.

Width—The time duration from the 50% amplitude level of the leading edge of a pulse to the 50% level of the trailing edge.

Amplitude—The voltage difference between the pulse baseline and the pulse top.

Baseline—The quiescent DC voltage level (including DC offset) at the output when no pulse has been generated.

Pulse Top—The constant voltage level to which the pulse rises from the baseline.

Polarity—The direction of the initial pulse excursion from the baseline, either positive-going (+) or negative-going (−).

Risetime—The amount of time required for the pulse amplitude to move from the 10% to the 90% level of the leading edge of a pulse.

Falltime—The amount of time required for the pulse amplitude to move from the 90% to the 10% level of the trailing edge of the pulse.

Aberration—Deviations by the actual pulse from an ideal square-cornered pulse shape, i.e., overshoot, undershoot or rounding, ringing and tilt or droop.

Overshoot—The part of a pulse rise extending above the normal amplitude, or the part of a pulse fall extending below the baseline.

Undershoot or Rounding—The part of a pulse rise rounding off before it reaches normal amplitude or the part of the pulse fall rounding off before it reaches the baseline.

Tilt or Droop—A long-term aberration in which the pulse top changes amplitude between the end of the pulse rise and the start of the pulse fall.

SELECTION OF OUTPUT PULSE CHARACTERISTICS

The versatility provided by the Type 115 controls allow pulses with a wide variety of characteristics to be obtained. As has been noted in the first-time operating procedure, however, some undesirable pulse characteristics are also obtainable. There are many combinations of front-panel control settings which yield no pulse at all. The following discussion has been provided to help obtain only desired pulse characteristics. These general rules should be kept in mind whenever setting up a pulse.

1. The pulse risetime must be less than the pulse width.
2. The pulse falltime must be at least 50 ns less than the interval between pulses, period minus width (assuming equal risetime and falltime).
3. The pulse width at the baseline must be at least 50 ns less than the period.
4. In the delayed pulse or paired pulses modes, the pulse period must be 50 ns greater than the delay time.
5. In the paired pulses mode the delay time must be 100 ns greater than the baseline pulse width.

When setting up an output pulse on the CRT of an oscilloscope, it is often easiest to set the Type 115 for minimum risetime and falltime until the rest of the output pulse char-

Operating Instructions—Type 115

acteristics have been established. This will eliminate the problem of obtaining no output pulse because of a slow risetime and/or falltime.

Mode

The MODE switch determines what type of output pulse will appear at the OUTPUT connector. The undelayed output pulse is the basic of each of the Type 115 Modes of operation. Its amplitude, width, period, risetime, falltime, delay, DC offset and polarity can all be determined by front-panel controls. The 5 different modes of operation are obtained by generating the undelayed pulse in various arrangements.

Undelayed Pulse. Identical, equally-spaced pulses with no delay appear at the OUTPUT connector.

Delayed Pulse. Identical, equally-spaced pulses with an adjustable delay appear at the OUTPUT connector. The delay is determined by the DELAY OR BURST DURATION controls and is referenced to the start of the undelayed pulse.

Paired Pulses. Identical, equally-spaced pairs of output pulses appear at the OUTPUT connector. The second pulse of each pair is delayed with respect to the first by an adjustable delay time determined by the DELAY OR BURST DURATION controls. The paired pulses mode is actually a combination of the undelayed and the delayed pulse modes.

Burst of Pulses. Equal-duration, equally-spaced bursts of output pulses appear at the OUTPUT connector. Each burst cycle consists of a group of undelayed pulses followed by a pause. Each burst is triggered by an external trigger pulse applied to the + TRIG IN connector or a manual trigger and the duration of each burst is determined by the DELAY OR BURST DURATION switch. The characteristics of the individual pulses within the burst and thus the number of output pulses which can be generated for a given burst duration are determined by the Type 115 front-panel controls.

Gated Burst of Pulses. Bursts of output pulses time-coincident with an input gate appear at the OUTPUT connector. Each gated burst cycle consists of a group of undelayed pulses followed by a pause. The triggering of the gated burst, the burst duration and the burst period are determined by the characteristics of a positive-going gate signal applied to the + GATE IN connector. The characteristics of the individual pulses within the gated burst and thus the number of output pulses which can be generated for a given gated burst duration are determined by the Type 115 front-panel controls.

Trigger Source

The TRIGGER switch determines whether the repetition rate of the output pulse is to be controlled internally by the free-running period generator or externally by an external trigger applied to the + TRIG IN connector. Also a single cycle may be obtained when the TRIGGER switch is set to MAN OR EXTERNAL by pressing the MANUAL TRIG button.

In the undelayed pulse, delayed pulse or paired pulses modes of operation, the TRIGGER switch may be set to either INT or MAN OR EXTERNAL allowing any of the methods of triggering.

In the burst mode, the TRIGGER switch may be set to either INT or MAN or EXTERNAL. The burst must be triggered either by an externally applied trigger or a manual trigger.

In the gated burst mode the TRIGGER switch must be set to INT to ensure that no trigger from the external trigger amplifier influences the display.

Polarity

The PULSE POLARITY switch determines whether the output pulse will be positive-going or negative-going. In either polarity the pulse characteristics are identical and switching polarity does not change the baseline level.

Amplitude

The output pulse amplitude is controlled by the DC OFFSET AND AMPLITUDE MULT switch and the AMPLITUDE (VOLTS) control. The AMPLITUDE (VOLTS) control provides a variable pulse amplitude ranging from approximately zero to 10 volts which is attenuated by the DC OFFSET AND AMPLITUDE MULT switch. The numbers on the Type 115 front-panel, which accompany the AMPLITUDE (VOLTS) control, are approximate voltages. Since they are not exact, they should be used only for reference. The numbers associated with the DC OFFSET AND AMPLITUDE MULT switch are multiplication factors, which when multiplied by the setting of the AMPLITUDE (VOLTS) control, give the approximate amplitude of the output pulse. It should be noted that when the AMPLITUDE (VOLTS) control is fully counterclockwise the pulse amplitude is approximately zero volts.

The amplitude controls are related to the DC offset, through the DC OFFSET and AMPLITUDE MULT switch, and affect no other pulse characteristics. The effect of the DC OFFSET AND AMPLITUDE MULT switch is to vary the range of the DC OFFSET (VOLTS) controls and the AMPLITUDE (VOLTS) control. The greatest range is obtained when the DC OFFSET AND AMPLITUDE MULT switch is in the 1 position and the greatest resolution is obtained when the switch is in the .2 position.

DC Offset

The output pulse DC offset is controlled by the DC OFFSET AND AMPLITUDE MULT switch and the DC OFFSET (VOLTS) controls. When the DC OFFSET PRESET-VARIABLE switch is in the VARIABLE position, the output pulse DC offset can vary from 0 to ± 5 volts. The numbers on the Type 115 front-panel accompanying the DC OFFSET VARIABLE control are approximate voltages. These numbers, when multiplied by the setting of the DC OFFSET AND AMPLITUDE MULT switch, give the approximate DC offset of the output pulse.

When the DC OFFSET PRESET-VARIABLE switch is in the PRESET position, the DC offset is controlled by the front-panel PRESET screwdriver adjustment. This adjustment allows the DC offset to be set at a fixed value of from 0 to ± 3 volts. Whenever the DC OFFSET PRESET-VARIABLE switch is set to the PRESET position, the output pulse will be offset by the preset value.

The DC offset controls are affected only by the amplitude controls. No setting of the DC offset controls can, by itself, cause an undesirable output pulse characteristic. Table 2-2

shows the typical baseline stability of the Type 115 for various settings of the DC OFFSET AND AMPLITUDE MULT switch.

Width

The output pulse width is controlled by the WIDTH switch and the WIDTH VARIABLE control. A calibrated output pulse width can be obtained only when the WIDTH VARIABLE control is in the CAL position and the risetime and falltime are equal. The WIDTH VARIABLE control provides a continuously variable pulse width between the WIDTH switch settings and extends the maximum width to approximately 500 μ s.

The width jitter is typically 0.05% or less of the pulse width plus 2 ns regardless of the mode of operation, except when the DELAY OR BURST DURATION control settings exceeds the PERIOD control settings.

TABLE 2-2
Baseline Stability

DC OFFSET AND AMPLITUDE MULT	Baseline Stability
1	± 500 mV
.5	± 250 mV
.2	± 100 mV

Although the width controls have been calibrated for minimum risetime and falltime (see Fig. 2-9A), the calibrated width readings will remain approximately correct as long as the risetime and falltime are equal (see Fig. 2-9D). If the risetime and falltime are not equal, the output pulse width can be determined approximately as follows:

1. If the risetime is longer than the falltime, the pulse width is decreased by an amount equal to $\frac{1}{2}$ the difference between the risetime and the falltime.
2. If the risetime is shorter than the falltime, the pulse width is increased by an amount equal to $\frac{1}{2}$ the difference between the risetime and the falltime.

The variation in pulse width, when the risetime and falltime are unequal, is caused by interaction between the risetime and falltime controls and the width gate, as shown in Fig. 2-9B. As described in the Circuit Description, the output pulse is generated when a fast-rising, fast-falling width gate enters the pulse shaper. The initial rise of the width gate causes a linear ramp to rise from the baseline to an amplitude determined by the amplitude controls. The fall of the width gate causes a linear ramp to fall from the given amplitude back to the baseline. Fig. 2-9B shows that when the risetime exceeds the falltime, the pulse width decreases and Fig. 2-9C shows that when the risetime is less than the falltime, the pulse width increases.

Fig. 2-9 also helps explain the first three general rules listed at the beginning of this discussion on selecting pulse characteristics. Fig. 2-9E exemplifies the fact that when the

risetime exceeds the duration of the width gate the pulse never reaches full amplitude before it begins to fall. Fig. 2-9F shows that when the falltime exceeds the interval between the fall of the width gate and the end of the period, the pulse never reaches the baseline before it starts rising again. It is also shown in Fig. 2-9F, that the baseline width of the pulse must not exceed the period.

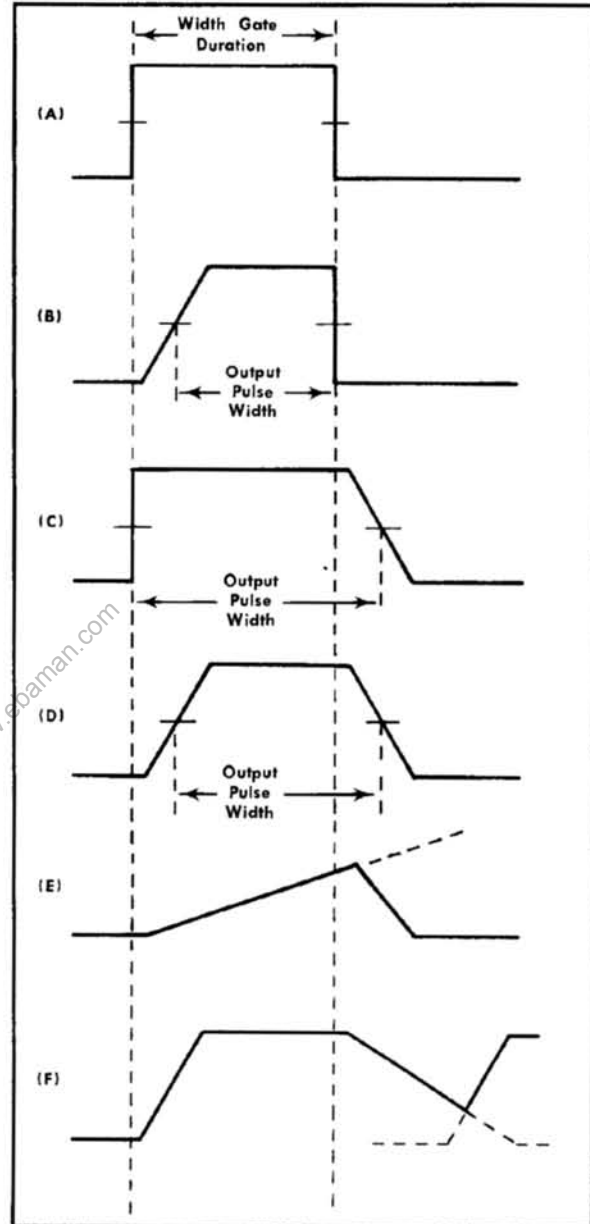


Fig. 2-9. Effects of risetime and falltime on pulse width; (A) pulse with minimum risetime and falltime; (B) pulse width is decreased by increase in risetime; (C) width is increased by increase in falltime; (D) width is approximately equal to initial pulse width when the risetime and falltime are equal; (E) risetime exceeds duration of width gate; (F) falltime exceeds interval between the fall of the width gate and the start of the next pulse.

Period

The output pulse period is controlled by the PERIOD switch and the PERIOD VARIABLE control. For a calibrated pulse period, the PERIOD VARIABLE control must be in the CAL position. The PERIOD VARIABLE control provides a continuously variable period between the PERIOD switch settings and extends the maximum period to approximately 10 ms.

The period jitter is typically 0.05% or less of the pulse period plus 2 ns except when the DELAY OR BURST DURATION control settings exceed the PERIOD control settings, regardless of the mode of operation.

The most important rules to remember in setting the period controls is that the duty factor must be no greater than 75% and the period must be 50 ns greater than the pulse width (with risetime and falltime set to minimum).

Delay or Burst Duration

The delay or burst duration controls affect the output pulse only when the Type 115 is operating in the delayed pulse, paired pulses or burst modes.

In the delayed pulse or paired pulses modes, the DELAY OR BURST DURATION switch and the DELAY OR BURST DURATION VARIABLE control determine the delay time between the start of the delayed pulse (or the second pulse of paired pulses) and the start of the undelayed pulse. A calibrated delay can be obtained whenever the DELAY OR BURST DURATION VARIABLE control is in the CAL position. The DELAY OR BURST DURATION VARIABLE control provides a continuously variable delay between the DELAY OR BURST DURATION switch settings and extends the maximum delay to approximately 500 μ s. The delay jitter is typically 0.05% or less of the pulse delay plus 2 ns.

When in the delayed pulse mode, the delay time must be 50 ns less than the pulse period. When in the paired pulses mode, this condition holds true and in addition the delay must be greater than the baseline pulse width plus 50 ns.

In the burst mode the duration of the burst of output pulses is determined by the delay or burst duration controls as discussed above. It is important to remember that the burst duration must be longer than the period of the individual pulses within the burst and the burst period minus the burst duration must exceed the baseline width of the individual pulses within the burst.

Risetime and Falltime

The output pulse risetime and falltime are determined by the RISETIME AND FALLTIME switch and the RISETIME MULT and FALLTIME MULT controls. To obtain a calibrated risetime and falltime the RISETIME MULT and FALLTIME MULT controls must be set to the 1 position. The RISETIME MULT and FALLTIME MULT controls allow independent and continuous variation of the pulse risetime and falltime between the RISETIME AND FALLTIME switch settings. The numbers on the Type 115 front-panel accompanying the RISETIME MULT and FALLTIME MULT controls are approximate multiplication factors of the RISETIME AND FALLTIME switch settings. Since they are not exact, they should be used only for reference.

It is important to remember that the risetime must be less than the duration of the width gate and the falltime must be less than the pulse period minus the duration of the width gate, as was illustrated in Fig 2-9. The linearity of the rise rate and fall rate is typically within 2% of an ideal ramp, except when the RISETIME AND FALLTIME switch is set to 10 ns.

TRIGGERING THE TYPE 115

The Type 115 can be triggered either by the internal, free-running period generator; an external trigger applied to the + TRIG IN connector or a manual trigger; or by a positive-going gate applied to the + GATE IN connector. The mode of operation determines which methods of triggering are possible and the TRIGGER switch allows the choice of the method to be used.

When the MODE switch is set to either UNDY'D PULSE, DLY'D PULSE or PAIRED PULSES, the Type 115 may be triggered either by the internal trigger, the external trigger or the manual trigger. For internal triggering, the TRIGGER switch must be in the INT position; for manual or external triggering the TRIGGER switch must be in the MAN OR EXTERNAL position. The external trigger signal must be applied at the + TRIG IN connector.

When the MODE switch is set to BURST, the Type 115 must be triggered either by an external trigger applied to the + TRIG IN connector or by a manual trigger applied by pressing the MANUAL TRIG button. In the burst mode the TRIGGER Switch may be set to either INT or MAN OR EXTERNAL.

When the MODE switch is set to GATED, the Type 115 must be triggered by a positive-going gate applied to the + GATE IN connector. The TRIGGER switch must be set to INT to ensure that no triggers from the external trigger amplifier interrupt the output pulse.

External Trigger Input

To trigger the Type 115 through the + TRIG IN connector a signal having an amplitude between +2 and +20 volts is required. If the input signal has a DC component which prevents it from moving into the +2 to +20-volt range, it should be capacitively coupled. The time constant of the coupling should be very short if the full repetition rate of the instrument is to be used. See Section 1 for characteristics of signals which are suitable for input at the + TRIG IN connector.

The most desirable way to connect a trigger signal to the + TRIG IN connector is through a 50 Ω coaxial cable with BNC-connectors and suitable attenuators to bring the signal amplitude within the +2 to +20-volt range. For some applications, a trigger probe can be connected to a desired trigger source. A 1 \times probe should be used for triggering signals from +2 volts to +20 volts and a 10 \times probe for signals from +2 volts to +200 volts in amplitude. For best results, a 10 \times probe should be compensated after installation. (This may be done by connecting the probe tip to a 20-volt square wave source and adjusting the probe compensation while monitoring the signal with another probe connected just inside the TRIG IN connector).

+ Gate Input

To generate a gated burst when the Type 115 is in the gated mode of operation, a gate pulse having an amplitude between +2 and +20 volts must be applied to the + GATE IN connector. Each burst begins after the gate signal exceeds the 2-volt level and ends after the gate returns below the +2-volt level.

The most desirable way to connect a gate signal to the + GATE IN connector is through a coaxial cable with BNC connectors and appropriate attenuators to ensure that the gate is within the +2 to +20-volt range. If the gate signal has a DC component which shifts the pulse out of the +2 to +20-volt range, the signal will have to be applied through a coupling capacitor. The time constant of the coupling must be long enough to keep the signal above +2 volts for the duration of the gate. The input impedance of the + GATE IN connector is 1 k Ω or more.

Manual Trigger

When the TRIGGER switch is set to MAN OR EXTERNAL and no signal is applied to the + TRIG IN connector, the Type 115 can be triggered by pressing the MANUAL TRIG button. Each time the button is pressed, a single cycle is generated in either the undelayed pulse, delayed pulse, paired pulses or burst mode.

TRIGGERING EXTERNAL EQUIPMENT WITH THE TYPE 115

General

The positive-going triggers appearing at the + PRETRIG OUT and the + DLY'D TRIG OUT connectors of the Type 115 allow a test oscilloscope or other external device to be time-referenced to the output pulse. In the case of an oscilloscope, these trigger pulses allow the oscilloscope sweep to be started before the Type 115 output pulse arrives, as well as allowing time-positioning of the output pulse on the oscilloscope CRT with the Type 115 delay controls. These trigger pulses also provide the convenience of a constant-amplitude triggering signal that eliminates the need for adjusting triggering controls.

When the Type 115 pretrigger is connected to a test oscilloscope external trigger input, the oscilloscope sweep is time-referenced to the beginning of the undelayed output pulse. If the MODE switch is set to DLY'D PULSE, the delayed output pulse displayed on the test oscilloscope CRT will move back and forth when the DELAY OR BURST DURATION VARIABLE control is turned.

When the Type 115 delayed trigger is connected to the test oscilloscope, the sweep will be time referenced to the beginning of the delayed output pulse. If the MODE switch is set to UNDELAYED PULSE, the undelayed output pulse will move back and forth across the test oscilloscope CRT when the DELAY OR BURST DURATION VARIABLE control is turned.

Pretrigger Output

The pretrigger output pulse which appears at the + PRETRIG OUT connector is a positive-going pulse which precedes

by 30 ns or more the undelayed output pulse, the first pulse of paired pulses and each individual pulse in a burst or gated burst. The pretrigger precedes the delayed pulse in the delayed pulse mode by approximately the delay time and also precedes the delayed trigger appearing at the + DLY'D TRIG OUT connector by approximately the delay time. The amplitude of the pretrigger is 2 volts or more into 1 k Ω and the risetime is typically 10 ns. The pretrigger serves as a good time reference for all the output pulses of the Type 115 and also the internal signals of the instrument.

Delayed Trigger Output

The delayed trigger output pulse which appears at the + DLY'D TRIG OUT connector is a positive-going pulse which precedes by 30 ns or more the delayed pulse and the second pulse of paired pulses. In the burst mode, the delayed trigger appears at approximately the end of each burst. It also appears approximately the delay time after the pretrigger. The amplitude of the delayed trigger is 2 volts or more into 1 k Ω and the risetime is typically 10 ns. The delayed trigger signal provides a convenient time reference for viewing delayed output pulses from the Type 115 and for time-positioning undelayed output pulses on the test oscilloscope CRT graticule.

The Type 115 as a Test Device

A common use of the Type 115 is in testing external equipment or electronic components. A sample setup of this type is shown in Fig. 2-10. In the usual application, the Type 115 pretrigger is used to trigger a test oscilloscope sweep and the Type 115 output pulse is applied to a device under test. An output signal from the device under test is then connected to the vertical input of the test oscilloscope allowing it to be monitored on the CRT.

OUTPUT PULSE CONNECTIONS

The output stage of the Type 115 has been designed to work into a 50- Ω load and is calibrated in amplitude and DC offset only when working into a 50 Ω load. Higher impedances will produce higher voltage amplitudes and greater DC offset, but may also cause reflections and ringing in the output connecting cables. Lower impedances will produce lower amplitudes and less offset, but will not overload the output circuit of the Type 115.

Basic Precautions

Certain precautions should always be observed when connecting the Type 115 output signal to a device under test or when connecting the output of a device under test to a display oscilloscope.

1. Use high-quality coaxial cables and connectors for all signal connections.
2. Make sure that all connections are tight and that all connectors are tightly assembled.
3. Keep signal cables as short as possible to preserve the signal quality.

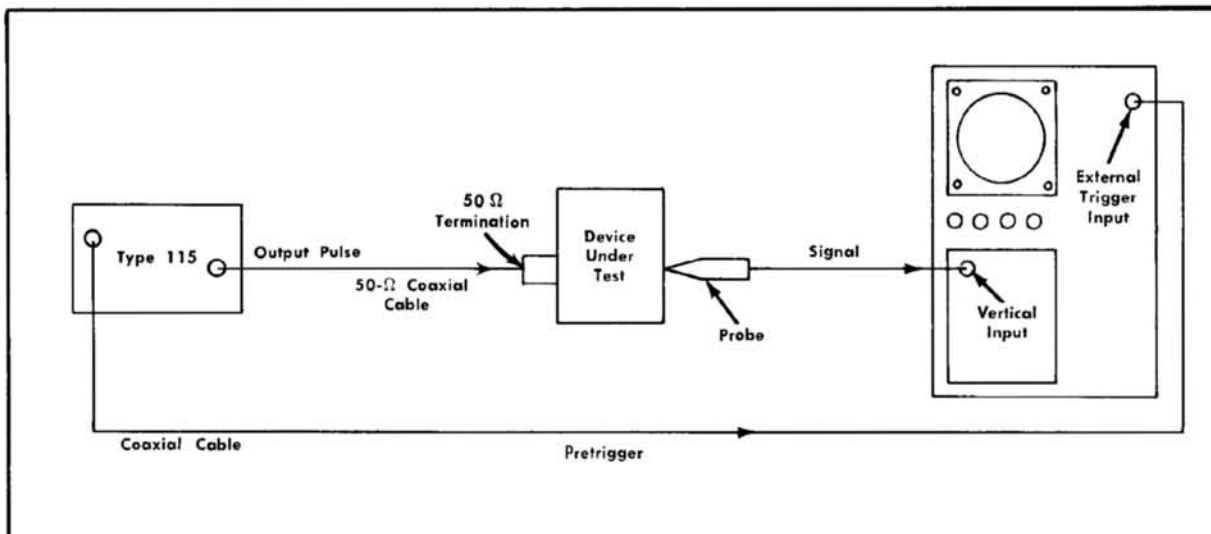


Fig. 2-10. Normal test setup using the pretrigger pulse for triggering the display oscilloscope.

4. Use attenuators as needed to limit the signal amplitude applied to sensitive circuits.
5. Use terminations and impedance-matching devices to suit the application.
6. Use only attenuators, terminations, etc., that have power ratings suitable for the 5 watts maximum output from the Type 115. (Power output is determined by offset current and duty factor of output pulse current.)

Risetime Considerations

If the output pulse signal from the Type 115 is to be used for determining the risetime of a device under test, the risetime of the Type 115 output pulse may have to be taken into consideration.

In general, if the risetime of the device under test is at least 10 times as long as the combined risetimes of the Type 115 and the monitoring oscilloscope and cables, the error introduced into the measurement will not be more than about 1%, and therefore can be considered negligible.

However, if the risetime of the test device is less than 10 times as long as the combined risetime of the testing system, the observed risetime will not give a true measurement of the test device. In this case, the risetime of the test device will have to be determined from the risetimes of the various components making up the system.

Normally the overall risetime of the system is equal to the square root of the sum of the squares of the individual risetimes. Thus the risetime of the test device can be determined if the risetime of all of the other components are known. Since the minimum risetime of the Type 115 is 10 ns, the practical lower limit of risetime measurements is 10 ns.

Cabling Considerations

The cables that conduct the output pulse of the device under test should be low-loss 50 ohm coaxial cables to ensure

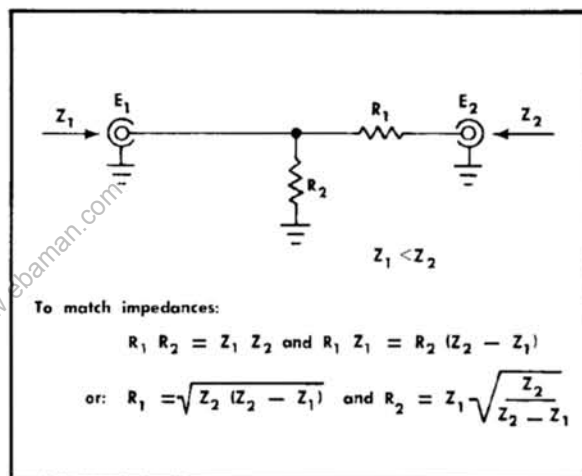


Fig. 2-11. Simple impedance-matching network providing minimum attenuation.

that all information contained in the pulse will be delivered to the test point without distortion. The physical and electrical characteristics of the cable determine the characteristic impedance, velocity of propagation and nature of signal loss. Since the signal losses caused by energy dissipation in the dielectric are proportional to the signal frequency, any very high frequency information in a fast-rise pulse will be lost in a very few feet of cable. Therefore it is important to use cables that are as short as possible.

When making signal-comparison measurements or time difference determinations, the two response signals from the test device should travel through coaxial cables that have identical loss characteristics and identical time delay.

If there is a DC voltage across the output load, a coupling capacitor should be used to prevent the DC offset compres-

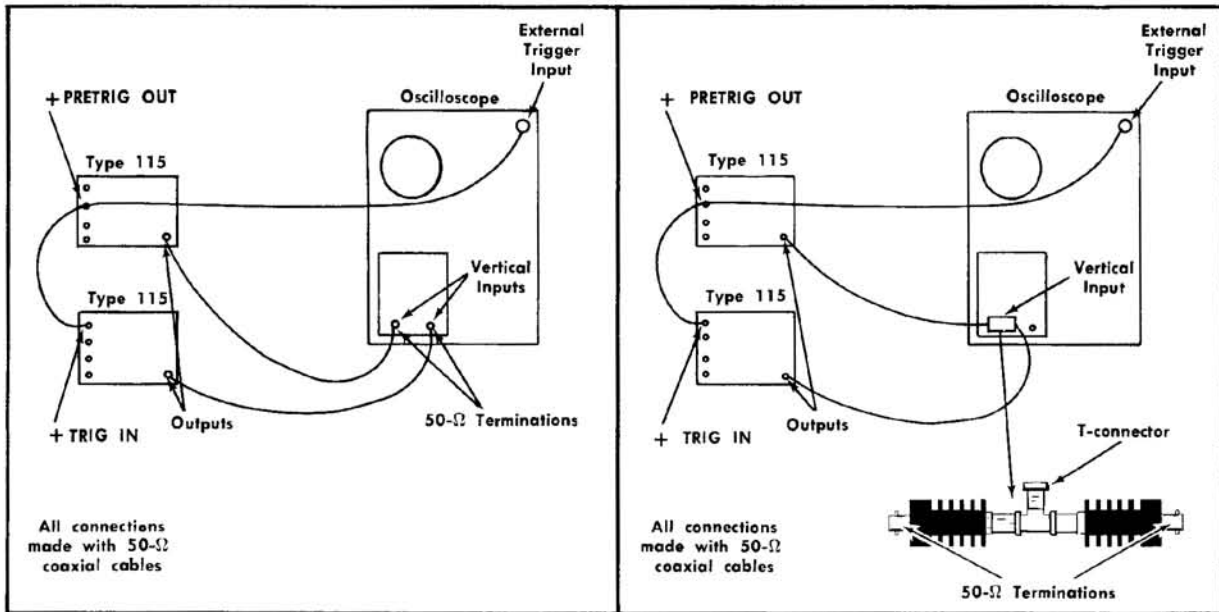


Fig. 2-12. Possible connection using two Type 115 simultaneously: (A) using vertical plug-in unit with an add made (B) using a T-connector.

sion of the Type 115 output pulse. The choice of time constant of the coupling will be dependent on the duty cycle of the pulse output. The time constant must be long enough to assure minimum decay of the pulse top but short enough to allow adequate recovery time before the start of the next pulse. If a coupling capacitor is not used, when there is a DC voltage across the load, the output pulse amplitude will be compressed if the DC voltage is less than ± 10 volts and will possibly be shorted out if the voltage present exceeds ± 10 volts.

Impedance Matching

To provide a smooth transition between devices of different characteristic impedances, each device must encounter a total impedance that is equal to its own characteristic impedance at the input or output point. The following discussion provides a method for matching impedance networks with relatively low impedances. If the Type 115 is operating into a high impedance system such as the $1\text{ M}\Omega$ input of an oscilloscope, this type of impedance matching is not necessary as long as the $50\ \Omega$ termination is connected very close to the high impedances.

A simple resistive impedance-matching network that provides minimum attenuation is illustrated in Fig. 2-11. To match impedances with the illustrated network, the following conditions must exist:

$$\frac{(R_1 + Z_2) R_2}{(R_1 + Z_2) R_2} \text{ must equal } Z_1^2$$

and

$$R_1 + \frac{Z_1 R_2}{Z_1 + R_2} \text{ must equal } Z_2$$

Therefore:

$$R_1 R_2 = Z_1 Z_2; \text{ and } R_1 Z_1 = R_2 (Z_2 - Z_1)$$

$$\text{or } R_1 = \sqrt{Z_2 (Z_2 - Z_1)}$$

$$\text{and } R_2 = Z_1 \sqrt{\frac{Z_2}{Z_2 - Z_1}}$$

As an example, to match a $50\text{-}\Omega$ system to a $125\text{-}\Omega$ system, Z_1 equals $50\ \Omega$ and Z_2 equals $125\ \Omega$.

Therefore:

$$R_1 = \sqrt{125 (125 - 50)} = 96.8 \text{ ohms}$$

$$\text{and } R_2 = 50 \sqrt{\frac{125}{125 - 50}} = 64.6 \text{ ohms}$$

When constructing such a device, the environment surrounding the components should also be designed to provide a transition between the impedances. Keep in mind that the characteristic impedance of a coaxial device is determined by the ratio between the outside diameter of the inner conductor and the inside diameter of the outer conductor ($Z_c = 138 \log_{10} D_1/D_2$).

Though the network in Fig. 2-11 provides minimum attenuation for a purely resistive impedance-matching device, the attenuation as seen from one end does not equal that seen from the other end. A signal applied from the lower impedance source (E_1) encounters a voltage attenuation (A_1) which is greater than 1 and less than 2, as follows:

$$A_1 = \frac{E_1}{E_2} = \frac{R_1}{Z_2} + 1$$

²In the case of the Type 115, Z_1 is the source impedance which varies with respect to the position on the DC OFFSET AND AMPLITUDE MULT. It varies as follows: 1 position—at least $500\ \Omega$; .5 position— $50\ \Omega$, within 5%; .2 position— $50\ \Omega$ within 5%.

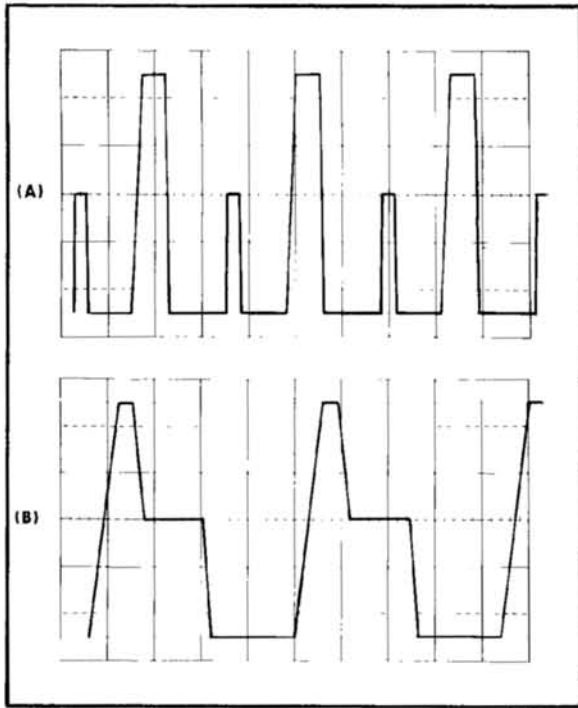


Fig. 2-13. Examples of output pulses obtained using the outputs of two Type 115 pulse generators.

A signal applied from the higher impedance source (Z_2) encounter a greater voltage attenuation (A_2) which is greater than 1 and less than $2 Z_2/Z_1$:

$$A_2 = \frac{E_2}{E_1} = \frac{R_2}{R_1} + \frac{R_1}{Z_1} + 1$$

In the example of matching 50Ω to 125Ω ,

$$A_1 = \frac{96.8}{125} + 1 = 1.77$$

$$\text{and } A_2 = \frac{96.8}{64.6} + \frac{96.8}{50} + 1 = 4.44$$

The illustrated network can be modified to provide different attenuation ratios by adding another resistor (less than R_1) between Z_1 and the junction of R_1 and R_2 .

USE OF MORE THAN ONE TYPE 115

If the output pulses of two Type 115 pulse generators are combined, an interesting variation of outputs can be obtained. Fig. 2-12A shows a possible setup using two Type 115's connected to the vertical inputs of an oscilloscope. This method can be used only if the oscilloscope (or plug-in

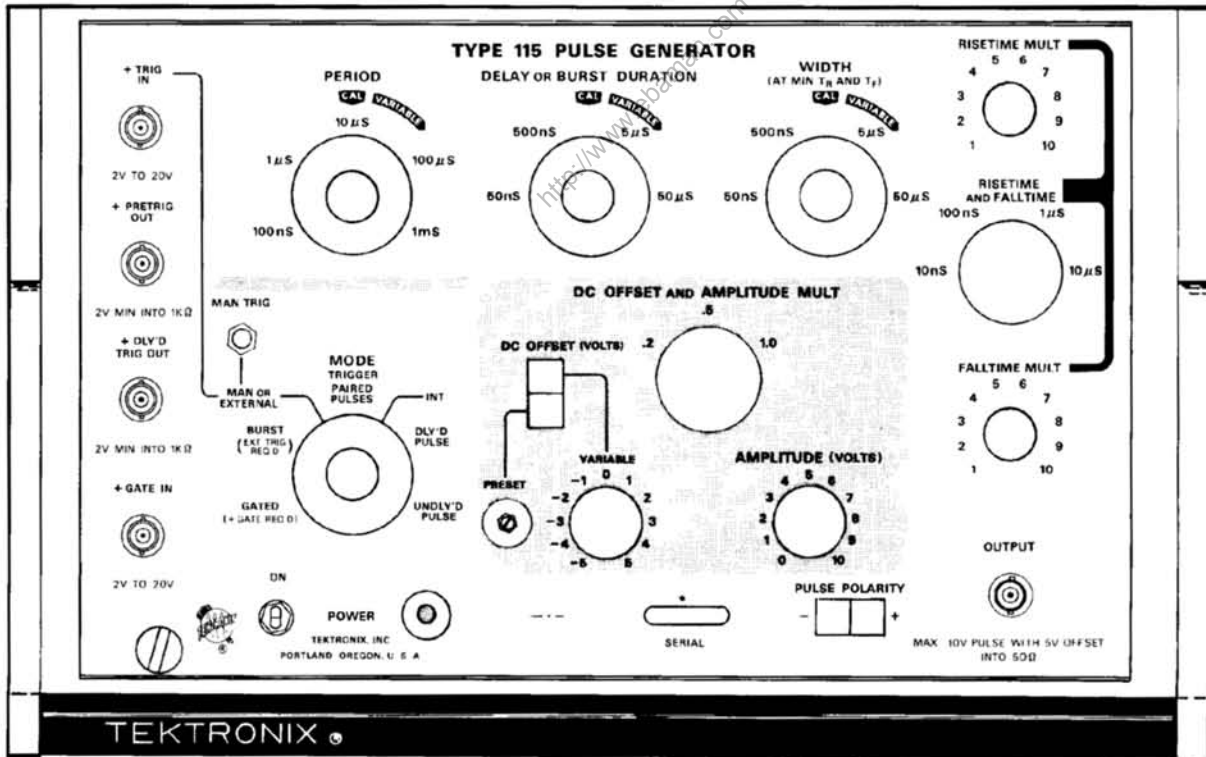


Fig. 2-14. Control setup chart for the Type 115 front-panel.

unit) has a mode where the inputs of both channels are added. Note that one Type 115 triggers both the display oscilloscope and the other Type 115. Fig. 2-12B shows a possible connection between the two pulse generators and the oscilloscope using a T-connector and two 50- Ω terminations. Fig. 2-13A and B shows two examples of outputs obtained using two Type 115 pulse generators.

CONTROL SETUP CHART

Fig. 2-14 shows the front-panel controls and connectors of the Type 115. This chart may be reproduced and used as a test-setup record for special measurements, applications or procedures or may be used as a training aid for familiarization with the Type 115.

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SECTION 3

CIRCUIT DESCRIPTION

Change information, if any, affecting this section will be found at the rear of this manual.

General

This circuit description has been written in two parts: the Block Diagram Description and the Circuit Description. The block diagram description discusses briefly the generation of the undelayed output pulse and the effect of each major circuit on its characteristics. Also described are the five modes of operation and the input and output pulses related to them. The circuit description gives a more precise discussion of the operation of each major circuit.

An overall block diagram of the Type 115 circuitry can be found at the beginning of Section 8. Detailed block diagrams of the major circuits are included within the text of the circuit description. These block diagrams along with the Section 8 schematics will greatly aid in the reading and understanding of the circuit description.

BLOCK DIAGRAM DESCRIPTION

The Undelayed Output Pulse

The undelayed output pulse is the basis of any output pulse obtained at the OUTPUT connector. The period, width, amplitude, risetime, falltime, polarity and the DC offset of the undelayed pulse are determined by the front-panel controls. The output pulses related to the five different modes of operation are produced simply by causing the Type 115, by means of the MODE switch, to generate the undelayed pulse in various time arrangements.

The undelayed pulse (see Fig. 3-1) begins at the period generator which free runs at a calibrated repetition rate set by the PERIOD switch. The period generator produces a positive-going trigger at the end of each cycle which

appears at the + PRETRIG OUT connector and a negative-going trigger which goes to the width generator.

The width generator when triggered by the negative-going period trigger produces a fast rising and falling gate of calibrated width which is transmitted to the pulse shaper circuit. The width of this gate is set by the WIDTH switch.

The pulse shaper, when triggered by the rise of the width gate, starts the rise of the output pulse. The rate of rise is regulated by the RISETIME AND FALLTIME switch and the RISETIME MULT control. The pulse rises to an amplitude of about 5 volts where it is clamped until the pulse begins to fall. The fall of the width gate triggers the fall of the output pulse, the rate of which is controlled by the RISETIME AND FALLTIME switch and the FALLTIME MULT control.

The shaped pulse is transmitted through a variable attenuator, the AMPLITUDE (VOLTS) control. The AMPLITUDE control can attenuate the pulse to as low as approximately zero volts and transmits the attenuated pulse into the output stage. In the output stage it is amplified by the output amplifier and is offset by current supplied by the offset current generator. The DC OFFSET (VOLTS) controls determine the amount of offset current to be added. If the PULSE POLARITY switch is in the minus position, the pulse is inverted by the inverter circuit of the output stage before it enters the output amplifier. The final shaped output pulse passes through attenuators, controlled by the DC OFFSET AND AMPLITUDE MULT switch, and appears at the OUTPUT connector. The DC OFFSET AND AMPLITUDE MULT switch attenuates both the pulse amplitude and DC offset.

Modes of Operation

The MODE switch determines the type of output pulse which appears at the OUTPUT connector. The five modes

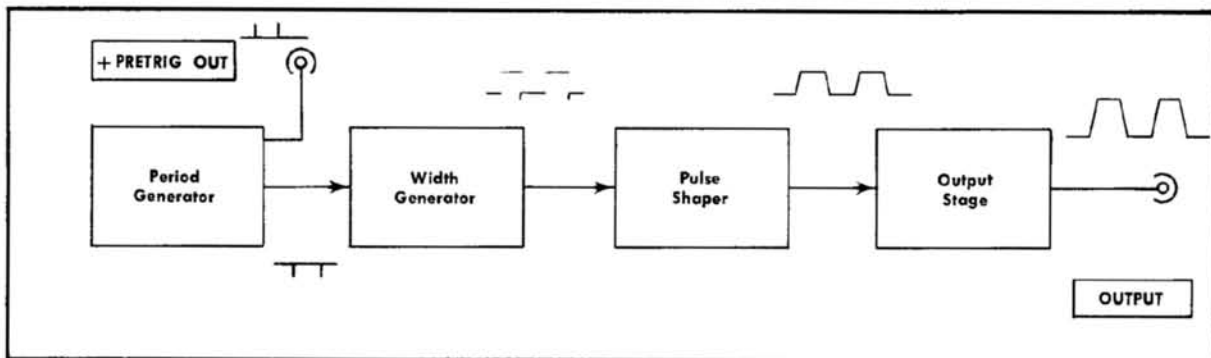


Fig. 3-1. Simplified block diagram of the generation of an undelayed pulse.

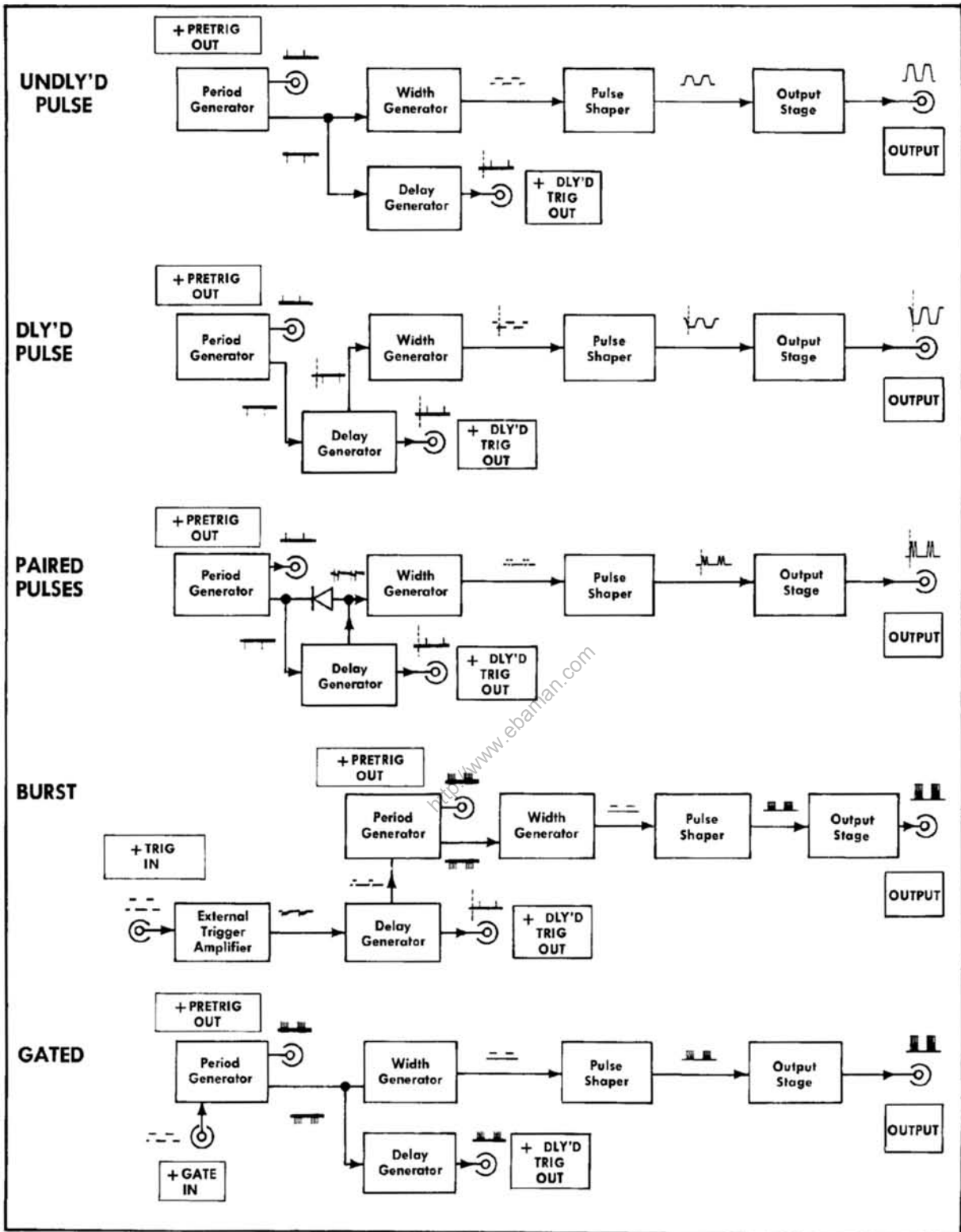


Fig. 3-2. Simplified block diagrams illustrating the generation of the five basic outputs.

of operation are: UNDLY'D PULSE, DLY'D PULSE, PAIRED PULSES, BURST and GATED (see Fig. 3-2).

Undelayed Pulse. In the undelayed mode the undelayed pulse is generated as has been previously described.

Delayed Pulse. When the mode switch is in the DLY'D PULSE position, the negative-going period trigger goes to the delay generator rather than the width generator. A calibrated delay time after it is triggered by the period trigger, the delay generator produces a delayed trigger pulse which is transmitted to the width generator. The delay time is determined by the DELAY OR BURST DURATION switch. The delay generator also produces a positive-going delayed trigger, which appears at the + DLY'D TRIG OUT connector. The delayed output pulse is delayed with respect to the undelayed output pulse by the delay time set by the DELAY OR BURST DURATION switch.

Paired Pulses. When the mode switch is set to PAIRED PULSES both the period trigger and the delayed trigger are transmitted to the width generator. The result is two output pulses occurring within the period set by the PERIOD switch, separated by the delay time set by the DELAY OR BURST DURATION switch.

Burst of Pulses. When the MODE switch is set to BURST, the period generator is inhibited. When an external trigger, either from the + TRIG IN connector or from the manual trigger button, is applied to the delay generator, a period generator is gated on by the burst gate. The resulting output delay generator. The duration of the gate is determined by the DELAY OR BURST DURATION switch. Period triggers are therefore applied to the width generator whenever the period generator is gated on by the burst gate. The resulting output is groups of undelayed pulses, called bursts, each burst being followed by a pause or period of time during which the period generator is disabled. The duration of each burst is set, approximately, by the DELAY OR BURST DURATION switch and the period of each burst cycle is determined by the repetition rate of the externally applied triggers. The characteristics of each pulse within a burst are determined by the front-panel controls. When the burst gate falls a positive-going delayed trigger appears at the + DLY'D TRIG OUT connector.

Gated Burst of Pulses. When the MODE switch is set to GATED, the output is again bursts of pulses. The duration and period of each gated burst is in this case determined by an external, positive-going gate applied to the + GATE IN connector. This external gate enables the period generator as the burst gate does in the burst mode. Also, as in the burst mode, the characteristics of the individual pulses within each gated burst are set by the Type 115 front-panel controls.

CIRCUIT DESCRIPTION

This circuit description discusses each major circuit within the instrument. It is assumed that the reader has a knowledge of basic electronics; therefore, any section of the circuitry which can be considered basic electronics is discussed only briefly. It is suggested that the pull-out schematics in the rear of the manual as well as the block diagrams within this section be referred to while reading the descriptions.

All the circuitry in this instrument is referenced to a floating common which is referred to as signal ground. Signal ground

is displaced from chassis ground by an amount varying from 0 to +18 volts, depending on the pulse polarity and DC offset. Further discussion of the relationship between signal and chassis ground is found in the Output Stage and Power Supply sections of this circuit description.

Throughout this discussion references to current are in terms of electron flow; that is, current flowing from a negative potential to a positive potential.

Pulse Timing and Mode Switching

Period Generator. The period generator consists of multivibrator Q226 and Q233 (see Fig. 3-3), current source Q244, enabling circuit Q224, clamping circuit Q253, timing capacitors, tunnel diode D235 and trigger amplifier stage Q264, Q266, Q274, and Q276. Transistors Q226 and Q233 (see the Delay and Period Generators schematic) form an astable unsymmetrical multivibrator. It is unsymmetrical in the sense that Q226 is turned on and Q233 is turned off the majority of the time. The cycle of the multivibrator, and thus the period of the output pulse, is dependent on the capacitance of the timing capacitor switched into the circuit by the PERIOD switch and the amount of current conducted by Q244.

When Q224 is turned on, the period generator is enabled. Initially Q233 and D254 are off and Q226, referenced to the +25-volt Supply through D234 and D235, is on. The emitter of Q226, connected to one end of the timing capacitor, is held at a constant voltage by the R225-R226 voltage divider. With Q233 off, Q244 charges the other side of the timing capacitor with constant current set by PERIOD TIMING adjustment R241, VAR PERIOD CAL adjustment R245 and the PERIOD VARIABLE control, R246. The capacitor charges until the voltage at the junction of R236 and R247 is low enough to turn on Q233. When Q233 begins conducting, the voltage at its collector drops rapidly, forward biases D254 and clamps the collector voltage of Q233 at approximately +19 volts as set by Q253. The rapid transition of the Q233 collector voltage causes tunnel diode D235 to change states and generate a period trigger pulse at the base of Q264.

The voltage drop at the collector of Q233 also is felt at the emitter of Q226 as it tries to follow the base down. The constant voltage at the emitter of Q226, however, does not allow the emitter to go down more than about 0.5 volt and Q226 becomes reverse biased and turns off. The voltage at the junction of R236 and R247 is now held constant by Q233 which acts as a constant voltage source. With Q226 now turned off, the current conducted by Q224 charges the timing capacitor in the opposite direction. The charging in this case is rapid and the voltage at the emitter of Q226 drops until Q226 is again turned on. With Q226 conducting, the voltage at its emitter starts to go up. This change in voltage is coupled through the timing capacitor, raising the voltage at the emitter of Q233 until it turns off. The voltage at the emitter of Q226 now is free to go to its stable conducting voltage of about 17 volts, the tunnel diode resets and the circuit begins another cycle. R233 assures that D235 returns to its low state by conducting part of the base current necessary to keep Q226 turned on.

The negative-going period trigger generated by D235 is amplified and shaped by Q264 and Q266 and transmitted to the width and/or delay generator (depending on the posi-

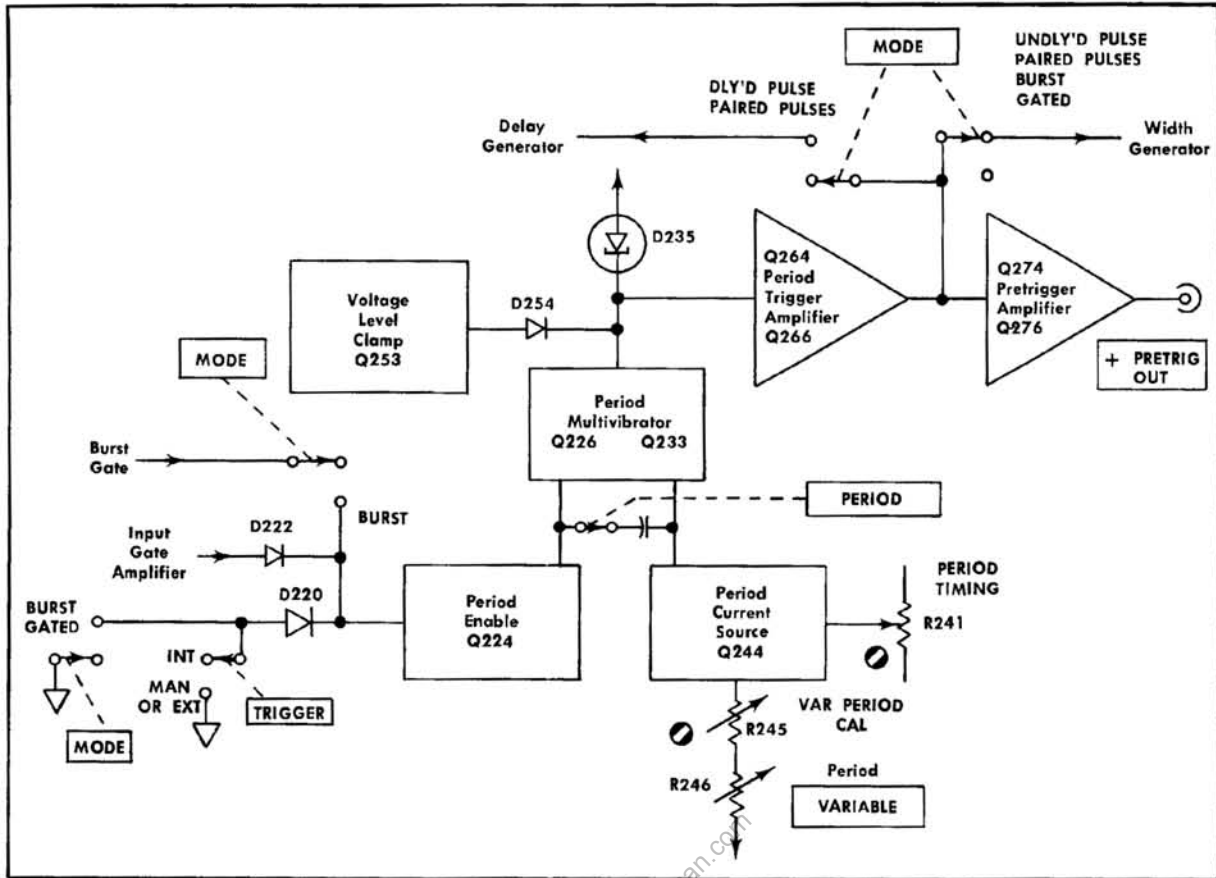


Fig. 3-3. Block diagram of the period generator circuit.

tion of the mode switch) and the base of pretrigger amplifier Q274. Through Q274 and Q276 the period trigger is inverted shaped, and further amplified, and appears as a positive-going trigger at the + PRETRIG OUT connector. The repetition rate of the period generator ranges from 100 Hz to 10 MHz.

External Trigger Amplifier. The external trigger amplifier allows the output pulse period or burst period to be controlled externally. A pulse having an amplitude between +2 volts and +20 volts, when applied to the + TRIG IN connector, is shaped and amplified by the external trigger amplifier circuit. The resulting trigger is transmitted to the delay and/or width generators according to the position of the MODE switch. This circuit can also receive a pulse from the MANUAL TRIG button, SW20.

The circuit consists of input pulse amplifier Q14 and Q18 (see the External Trigger Amplifier schematic), tunnel diode D25, output amplifier Q32 and output complementary emitter follower circuit Q36 and Q38. When the TRIGGER switch is set to MAN OR EXTERNAL, the period generator is disabled and the emitter of Q32 is connected to signal ground thereby enabling the external trigger amplifier. Quiescently, both Q14 and Q18 are off, D18 is reverse-biased and D17 is conducting, setting the voltage at its anode at about +7.6 volts. A trigger having an amplitude between +2 and +20

volts applied to the + TRIG IN connector, turns on Q14 which begins conducting current through D18, setting the voltage at the collector of Q14 to about +6.4 volts. Current through Q14 also is conducted by R13 which turns on Q18 and turns off D17. When Q18 begins conducting, the current through D25 increases, causing it to switch to its high state, creating a pulse which is presented to the base of Q32. The tunnel diode may also be triggered by the manual trigger button, SW20, which when pushed connects the +25-volt supply to the anode of D25 through R20 and R21. This trigger is also presented to Q32. Inductor L25 momentarily blocks the external or manual trigger from shunting D25 thus allowing the total pulse voltage to trigger the tunnel diode. Resistor R26 sets the voltage level at the cathode of D25 so that the voltage at the high state of D25 is high enough to cause Q38 to conduct.

The pulse from D25 is amplified and inverted by Q32 and applied to the complementary emitter followers Q36 and Q38. Q36 and Q38 act in a push-pull manner and produce a negative-going pulse at their emitters, which is differentiated into a negative-going trigger by C38 and transmitted to the width and/or the delay generator.

Delay Generator. The delay generator consists of input amplifier Q102 (see Fig. 3-4), multivibrator Q106, Q114 and Q124, current source Q138, timing capacitors, burst gate

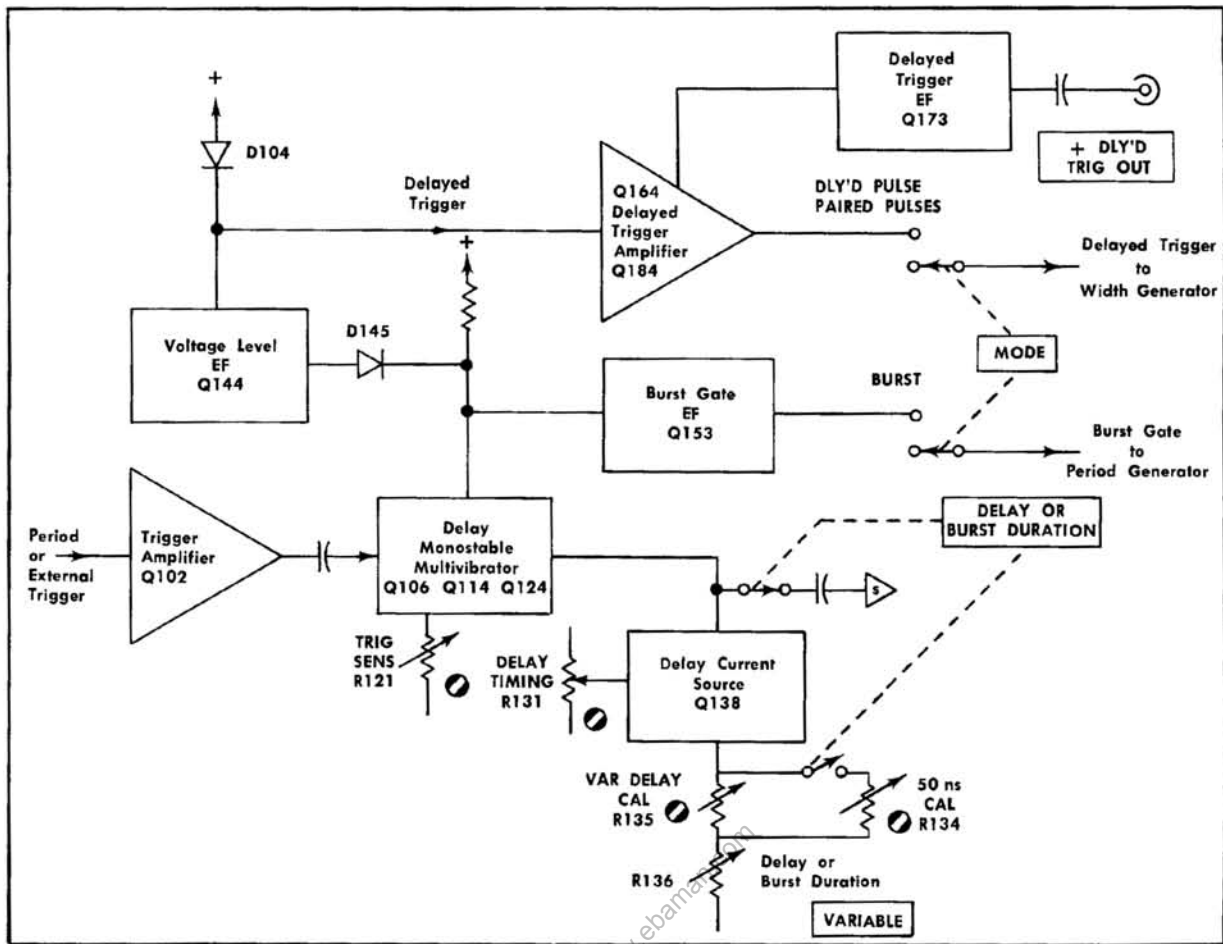


Fig. 3-4. Block diagram of the delay generator circuit.

amplifier Q153, clamping circuit Q144 and output stage Q164, Q184 and Q173. Transistors Q106, Q114 and Q124 (see Delay and Period Generator schematic) form a monostable multivibrator with Q114 and Q124 conducting and Q106 turned off in the quiescent condition. The delay time from the initial triggering of the delay generator to the output of a delayed trigger, is dependent on the capacitance of the timing capacitor switched into the circuit by the DELAY OR BURST DURATION switch and the amount of current conducted by Q138.

When Q114 is conducting, D145 is forward biased and the voltage at the collector of Q114 is set by Q144. Q114 conducts current from both Q124 and Q138. The timing capacitor switched into the circuit is charged to the voltage at the junction of R115 and R124. TRIG SENS adjustment R121 sets the quiescent base voltage of Q114 and Q124 so that the multivibrator will be monostable and switch whenever a negative-going trigger is applied to Q102. A negative-going trigger applied to the delay generator turns on Q102 and applies a 2-volt negative-going trigger to the bases of Q124 and Q114, turning them off. When Q114 turns off, the voltage at its collector rises, and reverse biases D145 allowing Q106 to begin conducting. Current through

Q106 pulls the voltage at its collector down and keeps Q114 and Q124 off by holding down the voltage at their bases. Current source Q138 now charges the timing capacitor with constant current determined by DELAY TIMING adjustment R131, VAR DELAY CAL adjustment R135 and the DELAY OR BURST DURATION VARIABLE control, R136. When the DELAY OR BURST DURATION switch is in the 50 ns position, the delay timing is also influenced by C138 and 50 ns CAL adjustment R134.

As the timing capacitor charges, the voltage at the emitter of Q114 goes down until Q114 again turns on. With Q114 on, Q106 turns off, releasing the bases of Q114 and Q124 and turning on Q124. When Q114 turns on, D145 again becomes forward biased and the voltage at the collector of Q114 is clamped to about +2.4 volts by Q144. The delay generator is now in its quiescent state and is ready for another period or external trigger.

As Q114 turns on after the charging of the timing capacitor, Q144 begins conducting more heavily. The resulting negative gate is applied to the base of Q164 where it is transmitted to Q184 causing it to conduct more heavily. The negative-going pulse appearing at the collector of Q184 is differentiated by C184 and the resulting negative-going

Circuit Description—Type 115

delayed trigger is applied to the width generator. The positive-going pulse at the collector of Q164 is transmitted by emitter follower Q173 and differentiated by C175. The resulting positive-going trigger appears at the + DLY'D TRIG OUT connector.

When Q114 is turned off at the beginning of the delay cycle, the base of Q153 rises approximately 4 volts. In the burst mode this positive gate, called the burst gate, is transmitted by emitter follower Q153 through the MODE switch to the base of Q224 enabling the period generator. When Q114 again turns on, the burst gate falls, disabling the period generator. The period generator, in burst mode, is thus enabled for the duration of the delay time.

Input Gate Amplifier. The purpose of the input gate amplifier is to change the reference of an input gate from chassis ground to signal ground and to produce a gate of large enough amplitude to enable the period generator. When the MODE switch is set to GATED, the emitter of Q204 (see the Delay and Period Generators schematic) is connected to chassis ground, thus enabling the input gate amplifier. When a positive-going gate pulse having an amplitude between +2 and +20 volts is applied to the + GATE IN connector, Q204 and Q214 are turned on and go into saturation. As Q204 and Q214 turn on, a 10-volt positive-going gate pulse is generated, forward biasing D222 and enabling the period generator. The period generator then remains enabled until the input gate falls, turning off Q204 and Q214.

Mode and Trigger Switching. The preceding discussion has described the formation of various timing triggers and gates. The period trigger is produced either by the free-running period generator or the external trigger amplifier; the delayed trigger and burst gate are produced by the delay generator and the gated mode gate is produced by the input gate amplifier. The MODE and TRIGGER switches determine how these various circuits are enabled to produce these triggers and gates and also determines when and where these assorted signals are applied. See Fig. 3-2, Fig. 3-3 and Fig. 3-4 and the schematics for the External Trigger Amplifier and the Period and Delay Generators while reading the following.

When the MODE switch is in the UNPLY'D PULSE position and the TRIGGER switch is set to INTERNAL, the period generator is enabled and transmits negative-going period triggers directly to the width generator and positive-going period triggers to the + PRETRIG OUT connector. (Positive-going period triggers always appear at the + PRETRIG OUT connector when the period generator is operating.) When the MODE switch is reset to DLY'D PULSE, period triggers are applied to the delay generator and the resulting negative-going delayed triggers are applied to the width generator. Whenever a delayed trigger is generated, a positive-going delayed trigger appears at the + DLY'D TRIG OUT connector. When the mode of operation is switched to PAIRED PULSES, period triggers are applied to both the delay and width generators and the width generator receives triggers from both the period and delay generators. When the TRIGGER switch is set to MAN OR EXTERNAL for the three previous modes of operation, the period generator is disabled and negative-going external triggers originate at the external trigger amplifier output. These triggers are applied to the delay and width generators according to the mode of operation, as if they had

originated from the period generator. These triggers are also applied to the base of Q274 to produce positive-going triggers at the + PRETRIG OUT connector.

In burst mode the TRIGGER switch may be in either the INT or the MAN OR EXTERNAL position. The period generator is inhibited by the MODE switch. Triggers from the external trigger amplifier are applied to the delay generator producing a burst gate which is used to enable the period generator. The enabled period generator then applies triggers to the width generator for the duration of the burst gate.

The gated mode is identical to the burst mode except that the period generator enabling gate comes from the input gate amplifier rather than from the delay generator.

Pulse Shaping

Width Generator. The width generator is identical in operation to the delay generator except that it has no trigger amplifier stage. The only output of the width generator is a width gate. The width generator consists of input amplifier Q302 (see Fig. 3-5), multivibrator Q306, Q314 and Q324, current source, Q338, clamp circuit Q343 and width gate amplifier Q353.

Quiescently Q314 and Q324 are on and Q306 is off (see the Width Generator and Pulse Shaper schematic). The quiescent voltage levels at the bases of Q314 and Q324 are set by TRIG SENS adjustment R321. When a negative-going trigger is applied to the bases of Q314 and Q324, they turn off and Q306 turns on. With Q314 turned off the voltage at its collector rises, reverse biasing D345 and producing a fast rising transition, the start of the width gate, at the base of Q353. The width gate is transmitted through emitter follower Q353 and applied to the pulse shaper circuit where it determines the width of the output pulse. The duration of the width gate is determined by the charge time of the timing capacitor switched into the circuit by the WIDTH switch and ranges from 50 ns to 500 μ s. With Q314 and Q324 off, the timing capacitor charges until the voltage at the junction of R315 and R324 has gone low enough to turn on Q314 and causes the width gate to fall. The rate of charge is dependent on the current conducted by Q338 which is controlled by WIDTH TIMING adjustment R331, VAR WIDTH CAL adjustment R335 and the WIDTH VARIABLE control, R336.

Pulse Shaper. It is in the pulse shaper circuit where the shape of the output pulse is formed. The width and period of the pulse are determined by the preceding circuitry, but its risetime, falltime and amplitude are formed by the pulse shaper. This circuit can be divided into two sections: the risetime-falltime generator and the amplitude clamp. The risetime-falltime generator consists of current steering transistors Q384, Q394, Q404 and Q414 (see Fig. 3-6) current sources Q374 and Q424, and the timing capacitors switched into the circuit by the RISETIME AND FALLTIME switch. The amplitude section consists of voltage reference Q434, unity-gain feedback amplifier Q443 and Q444, emitter followers Q453, Q463 and Q473, amplitude clamp D445 and baseline clamp Q483. The pulse shaper circuit shapes a pulse by charging a timing capacitor with constant current until the pulse voltage reaches the clamp voltage, and then discharging the capacitor with constant current until the voltage returns to the baseline. This process forms the voltage rise, amplitude and fall of the pulse.

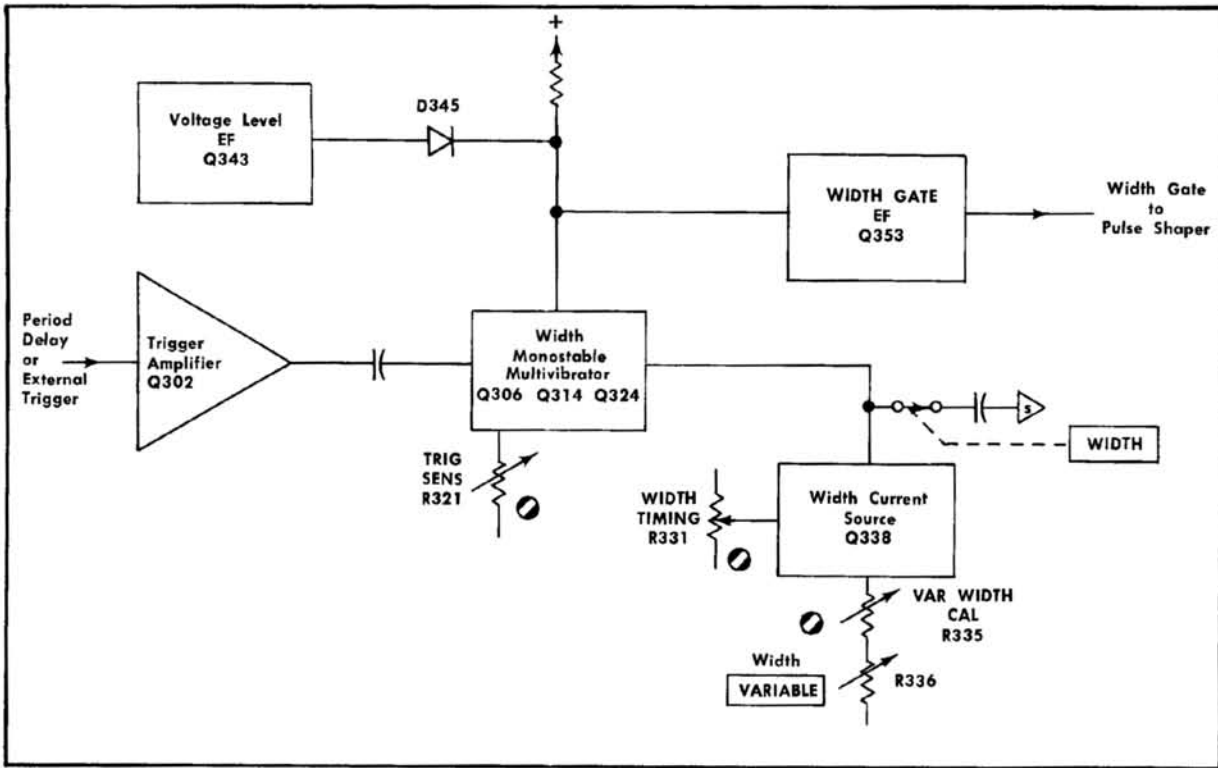


Fig. 3-5. Block Diagram of the width generator circuit.

Quiescently, Q384 and Q414 are conducting and Q394 and Q404 are off (see Width Generator and Pulse Shaper schematic). A fast rising width gate from the width generator raises the voltage at the base of Q384 to about 12 volts which turns off Q384 and turns on Q394. At the same time the voltage at the base of Q404 is raised to about 5 volts, turning on Q404 and switching current from Q414 into Q404. T_r CENTERING adjustment R391 and T_f CENTERING adjustment R411, by setting the base voltage on Q394 and Q414 respectively, determine the voltage levels on the bases of Q384 and Q404 necessary to cause the transistors to switch. The amount of current conducted by Q394 is determined by T_r TIMING adjustment R371, RISETIME CAL adjustment R375, 10 ns T_r CAL adjustment R376 (when the RISETIME AND FALLTIME switch is set to 10 ns) and the RISETIME MULT control, R376. The current through Q394 charges the timing capacitor switched into the circuit by the RISETIME AND FALLTIME switch at a constant rate. The charging of the timing capacitor forms the leading edge of the pulse shaper output pulse (at the emitter of Q473). The pulse rises until D445 is forward biased and the pulse amplitude is clamped by the amplitude clamp circuitry. The pulse will remain at its clamped amplitude until the width gate falls.

As the width gate falls, the voltage goes negative at the base of Q404 turning it off and turning on Q414. At the same time the voltage at the base of Q384 goes negative, turning on Q384 and causing Q394 to turn off. As Q414 begins conducting, the timing capacitor starts discharging at a constant current rate as determined by T_f TIMING

adjustment R421, FALLTIME CAL adjustment R423, 10 ns T_f CAL adjustment R426 (when the RISETIME AND FALLTIME switch is set to 10 ns), and the FALLTIME MULT control, R428. The pulse at the emitter of Q473 falls until it forward biases D483 and is clamped at a predetermined baseline voltage. The pulse shaper is now in its quiescent state and is ready for another width gate.

The amplitude of the pulse shaper output pulse at which D445 becomes forward biased is determined by PULSE AMPL RANGE adjustment R431. R431 determines the collector voltage of Q434 which is coupled through Q443 and D443 and sets the voltage at the cathode of D445. Q443 and Q444 form a feedback amplifier with a gain of 1. Any increase in current through D445 increases current through Q443 and causes Q444 to conduct more heavily. The extra current conducted through Q444 flows through D445 and allows the voltage at the cathode of D445 to remain constant. After D445 has been forward biased the pulse amplitude will remain at 0.6 volt above the voltage set at the collector of Q444. As the voltage continues to rise at the base of Q463, Q463 turns off and disconnects the risetime-falltime generator circuitry from the output pulse. With Q463 off, a constant current is conducted through D445 which helps create a flat output pulse top. When the voltage at the base of Q463 rises more than 1.8 volts above the pulse amplitude voltage, D453 becomes forward biased protecting Q463 from base-emitter breakdown. Q453 provides current when D453 is forward biased.

As the pulse begins its fall, D453 becomes reverse biased, Q463 again begins to conduct and D445 becomes reverse

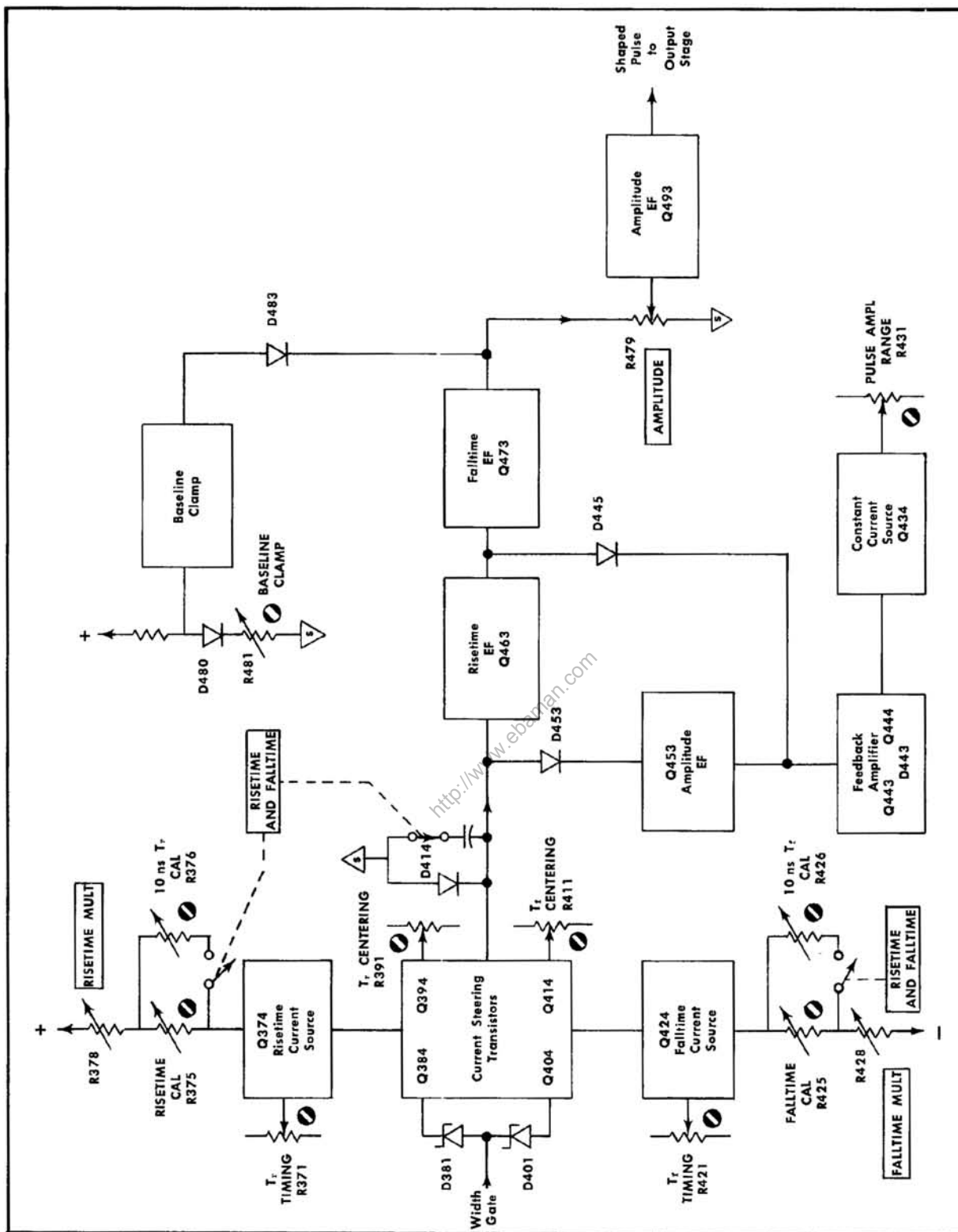


Fig. 3-6. Block diagram of the pulse shaper circuit.

biased. As the voltage falls low enough to forward bias D483, the pulse will be clamped to a baseline voltage set by BASELINE CLAMP adjustment R481. As the pulse continues to fall, Q473 becomes reverse biased, which disconnects the risetime-falltime generator from the pulse shaper output pulse. When the voltage at the base of Q473 falls more than 1.6 volts below the pulse baseline, D414 turns on and protects Q473.

When a pulse has been formed by the pulse shaper, it is transmitter to the output stage through the AMPLITUDE control, R479. The AMPLITUDE control is a variable attenuator which presents a pulse ranging from approximately zero to +5 volts to the output stage. R471 and C471 are pulse aberrations adjustments.

It should be noted that due to the turning on and off of Q463 and D453, and Q473 and D414, the pulse appearing at the junction of R394 and R414 is approximately 3.4 volts higher in overall amplitude than the pulse applied to the output stage (see Fig. 3-7). As shown in Fig. 3-7, this 3.4 volts is distributed both above and below the pulse applied to the output stage. The effect of this amplitude difference is that when D483 reverse biases and the pulse begin to rise at the beginning of the output stage, it has already risen 1.6 volts above the quiescent voltage at the junction of R394 and R414 and is already on a linear portion of the rising ramp. This method of starting pulses ensures fewer aberrations and a more linear pulse rise (see linearity specification Selection 1). When the pulse applied to the output stage reaches its maximum amplitude and forward biases D445, the rising ramp continues rising 1.8 volts higher at the junction of R394 and R414. This continuation of the pulse rise causes a sharper cutoff of the rising ramp when D445 forward biases, and therefore minimizes front-corner aberrations of the output pulse. The same reasoning applies to the falling edge of the pulse.

It should be noticed from the above discussion that there is a varying time delay between the start of the pulse at the

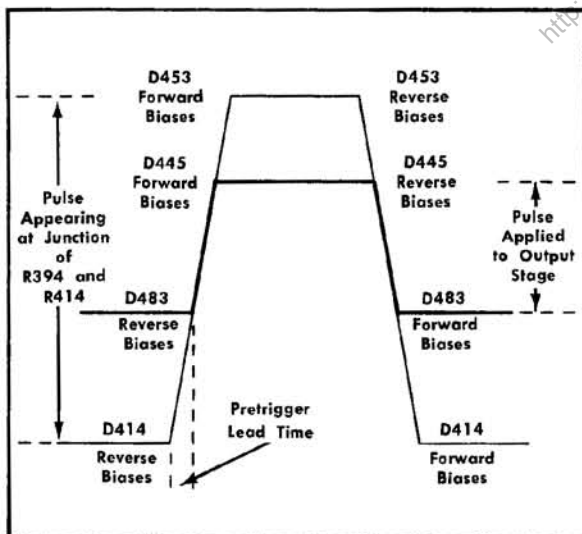


Fig. 3-7. Relationship between various amplitude and baseline clamps and varying time delay between the start of the output pulse and the pretrigger.

R394-R414 junction and the start of the pulse applied to the output stage (which is also the pulse appearing at the OUTPUT connector). The delay is varying because it is dependent on the risetime of the pulse. The pulse rise will always have to travel 1.6 volts from the quiescent voltage at the R394-R414 junction before a pulse is seen at the output connector. The time required for the rise to travel the 1.6 volts will depend on the pulse risetime.

Output Stage

General. When the shaped pulse has been generated by the pulse shaper circuit it is applied to the output stage. The output stage consists of an inverter, an output amplifier, an offset current generator and the attenuators.

The output stage operates in a current mode, generating a current pulse and DC offset current to be applied to a 50 Ω load. The output amplifier current amplifies the shaped pulse to as high as 200 mA. The offset current generator supplies from -85 mA to $+315$ mA of offset current to the output amplifier and output load, which offsets the output pulse from -5 volts to $+5$ volts in both polarities.

All the internal circuitry of the Type 115 is referenced to signal ground and the output pulse is referenced to chassis ground (see Fig. 3-8). The variable power supply is the circuit which controls the referencing of an internal pulse to the outside world. Understanding the interrelationship of the output stage to the variable supply is basic to understanding how the Type 115 generates an output pulse. The variable supply controls the voltage separation between signal ground (common) and chassis ground and varies this voltage from zero to ± 18 volts. Both the variable supply and the offset current generator are controlled by the DC OFFSET (VOLTS) controls and the PULSE POLARITY switch.

The existence of a variable voltage separation between the internal circuitry common (signal ground) and the chassis ground performs two functions. It allows pulse polarity switching with no change in the DC level of the output pulse baseline (discussed later in the section on the output amplifier) and it maintains a consistent output pulse shape in both polarities and for all levels of DC offset.

This consistent output pulse shape is obtained by maintaining a constant V_{CB} on output transistors Q564, Q574 and Q584 for all values of DC offset (see Fig. 3-9). The base voltage of each output transistor is held at signal ground, while the DC level of the output pulse determines the collector voltage. For a positive pulse with zero DC offset the variable supply causes a 15-volt voltage separation between signal ground and chassis ground, causing a V_{CB} of 15 volts to occur quiescently (at the pulse baseline). If the output pulse is given $+5$ volts of DC offset, the variable supply separates signal ground from chassis ground by 20 volts, thus keeping the V_{CB} at 15 volts. When an output pulse is generated, it decreases the V_{CB} (to as low as 5 volts on a 10-volt pulse). The V_{CB} for a 10-volt pulse, however, will be 5 volts (when the pulse has reached 10 volts) for any value of DC offset. The same process occurs in negative polarity, except that the quiescent V_{CB} is 5 volts and it increases to 15 volts for a 10-volt pulse. Having a constant V_{CB} vs. pulse amplitude relationship for all values of DC offset and pulse polarity, ensures a consistent pulse shape over the ranges of the DC OFFSET (VOLTS) controls.

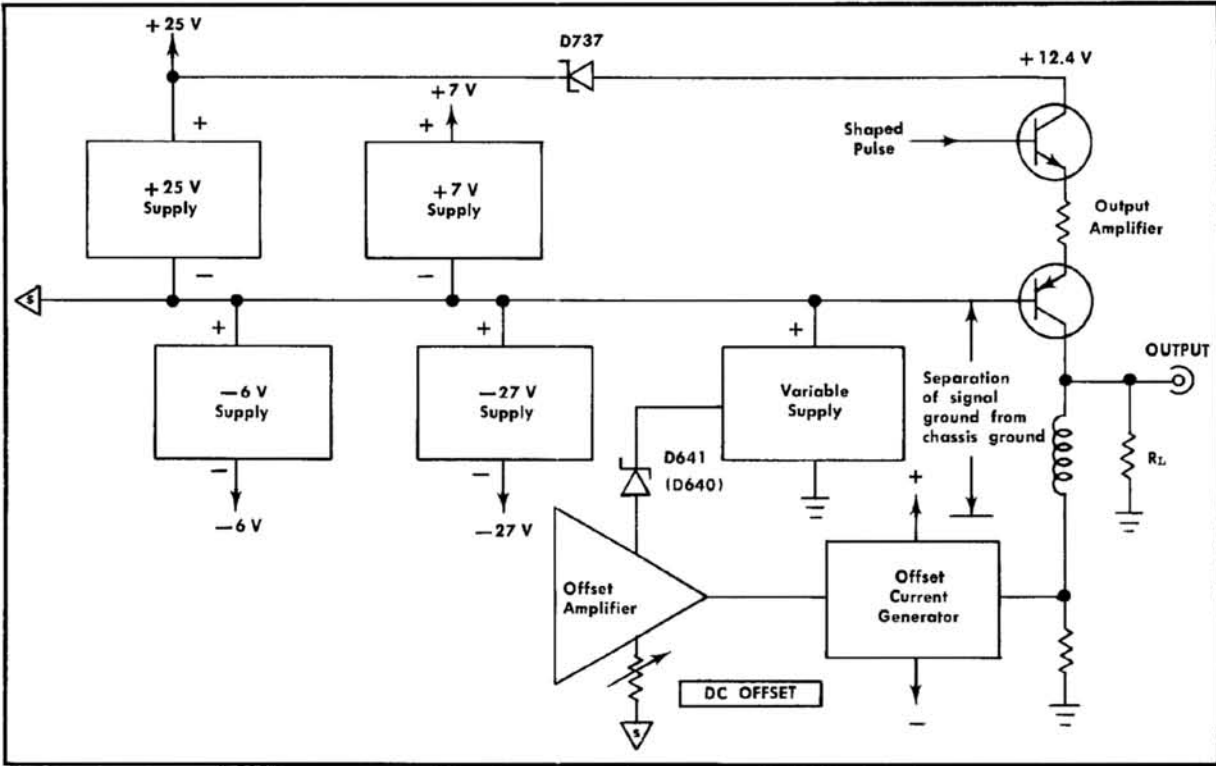


Fig. 3-8. Block diagram of the relationship of the variable supply to the output stage and to the floating power supply.

Inverter. The inverter circuit receives the positive-going shaped pulse from the pulse shaper circuit and inverts it, while maintaining the original pulse amplitude. This circuit consists of inverting amplifier Q534 (see the Output Stage schematic) amplitude and DC level setting circuit Q523 and Q513, and output emitter follower Q543.

When K500 and K505 are in their actuated position (PULSE POLARITY switch set to —) the shaped pulse is applied to the base of Q534. The inverted pulse at the collector of Q534 is transmitted through emitter follower Q543 and applied to the output amplifier. NEG AMPL adjustment R523 controls the amplitude of the negative-going pulse by regulating the gain of Q534. NEG DC LEVEL adjustment R551, through emitter follower Q513 sets the DC level of the output pulse by setting the voltage at the base of Q523.

Output Amplifier. The output amplifier consists of input transistor Q553, three parallel-connected emitter followers Q563, Q573 and Q583, and three parallel-connected common base amplifiers Q564, Q574 and Q584.

The positive or negative-going shaped pulse is transmitted to the emitter followers Q563, Q573 and Q583 by emitter follower Q553. PULSE OVERSHOOT adjustment C551 regulates the front corner of the pulse and is adjusted for the squarest possible corner. C563 regulates the tilt of the pulse top. Transistors Q563, Q573 and Q583 apply the pulse to the emitters of Q564, Q574 and Q584. Each emitter follower common-base amplifier combination, current amplifies the pulse by an amount equal to the load impedance divided by 75 Ω, or by 2/3. The total current gain of the output amplifier

into a 50 Ω load is therefore 2. As mentioned in the preceding section, the V_{CB} of the common base amplifiers is the same over all DC levels of operation of the instrument.

When the PULSE POLARITY switch is in the + position the output amplifier is conducting about 15 mA of quiescent current from the offset current generator. When a positive-going pulse is applied to the emitter followers, the circuit conducts as much as 215 mA in order to get a 200 mA (10 volt) output pulse. If a negative-going pulse were applied to the circuit while it was quiescently conducting only 15 mA, the output transistors would turn off. To get a negative-going pulse, therefore, 200 mA of additional offset current is switched into the output amplifier when the PULSE POLARITY switch is switched to the — position. As a result the total quiescent current conducted by the output amplifier is about 215 mA and a negative-going pulse applied to the emitter followers reduces current conducted by the output stage by as much as 200 mA (10 volt negative-going pulse). The baseline of the negative pulse is held at the same DC level as that of the positive pulse by reducing the separation between signal ground and chassis ground. The separation is reduced by 10 volts when the polarity is switched to the — position.

Offset Current Generator. The offset current generator produces DC current varying from —85 mA to +315 mA, part of which provides quiescent operating levels for the output amplifier and part of which causes varying shifts in the DC level of the output pulse. This current generator consists of variable voltage reference circuit Q614 (see Fig. 3-10), unity-gain feedback amplifier Q623 and Q624, variable cur-

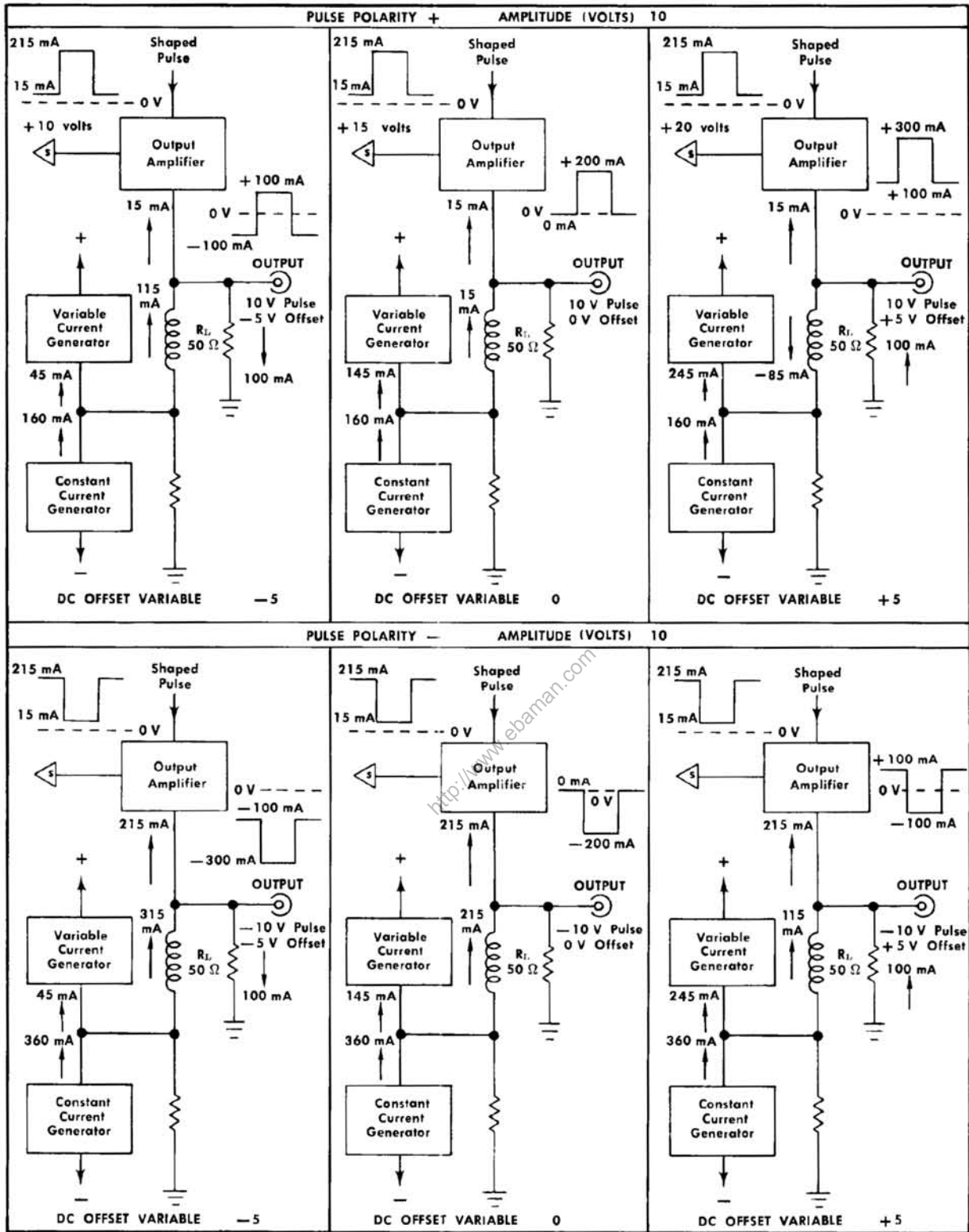


Fig. 3-9. Block diagram of the output amplifier and the offset current generator showing the DC currents and the pulse currents due to different conditions of the PULSE POLARITY switch and the DC OFFSET (VOLTS) controls.

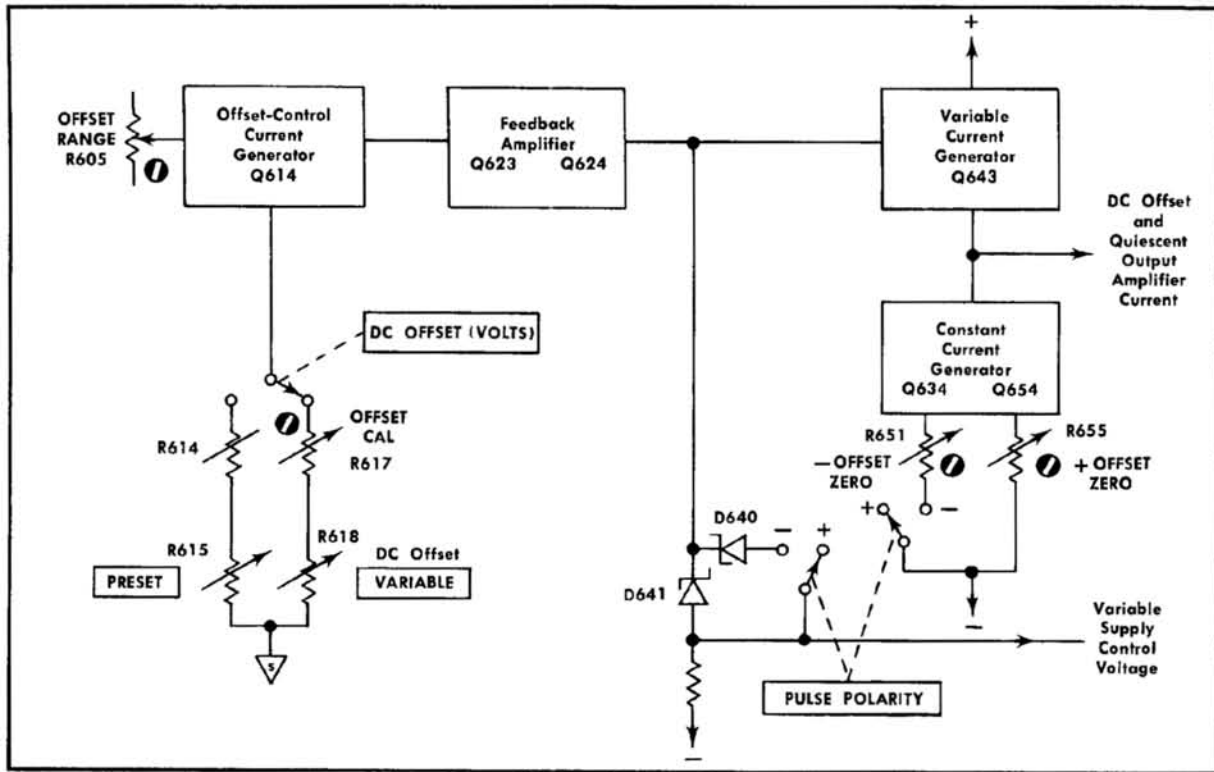


Fig. 3-10. Block diagram of the Offset current generator.

rent generator Q643 and constant current generator Q634 and Q654.

The offset current generator consists of a constant current generator which supplies constant DC current plus a variable current generator which regulates the flow of this constant current into, and, in some cases, out of the output amplifier and output load (see Fig. 3-9). The constant current generator supplies two different amounts of constant current: 160 mA in + polarity and an additional 200 mA when in - polarity. + OFFSET ZERO adjustment R655 (see the output stage schematic) sets the constant current through Q654 in + polarity and - OFFSET ZERO adjustment R651 (which is only in the circuit when the PULSE POLARITY switch is in the - position) in conjunction with R655 sets the current in - polarity. Q634 provides feedback control of the current through Q654, by opposing any current change.

The amount of current drawn by Q643, the variable current generator, is determined by the voltage level at its base. The base voltage of Q643 is set by the collector voltage of Q614 which is coupled through Q623 and D623. The DC OFFSET (VOLTS) controls, by varying the collector series resistance of Q614 controls its collector voltage, and OFFSET RANGE adjustment R605 determines the range of the DC OFFSET (VOLTS) controls. When the DC OFFSET PRESET-VARIABLE switch is in the VARIABLE position, OFFSET CAL adjustment R617 and the DC OFFSET VARIABLE control, R618, determine the variable collector voltage level of Q614; when the switch is in the PRESET position the PRESET front-panel screwdriver adjustment R615 controls the collector voltage.

Transistors Q623 and Q624 form a feedback amplifier with a gain of one, which helps keep the voltage constant at the base of Q643. When the PULSE POLARITY switch is in the - position, D640 is switched into the circuit causing additional current to flow through R641. Q624 compensates for this increase in current to hold the current through R623 and thus the base voltage of Q643 essentially constant.

DC Offset in + Polarity. See Fig. 3-9 while reading the following. In + Polarity and zero DC offset, the constant current generator conducts 160 mA, 145 mA of which is conducted by the variable current generator and the remaining 15 mA is conducted by the output amplifier as quiescent current. No offset current is conducted by the 50 Ω output load; therefore, there is zero DC offset. For + offset the variable current source conducts as much as 245 mA, thus drawing as much as 100 mA from the output load. 100 mA through the output load produces a +5-volt DC offset. For - offset (in + polarity) as little as 45 mA of current may be conducted by the variable current generator and up to 100 mA may be drawn by the output load. A -100 mA current through the output load produces a -5-volts DC offset. In all the preceding cases the output amplifier conducts approximately 15 mA of quiescent current.

DC Offset in - Polarity. In - polarity the output amplifier requires about 215 mA of quiescent current as explained in the description of the output amplifier circuit. The additional 200 mA of quiescent current is supplied by the constant current generator which conducts about 360 mA in - polarity. For zero DC offset about 145 mA is conducted by the variable current source and 215 mA is con-

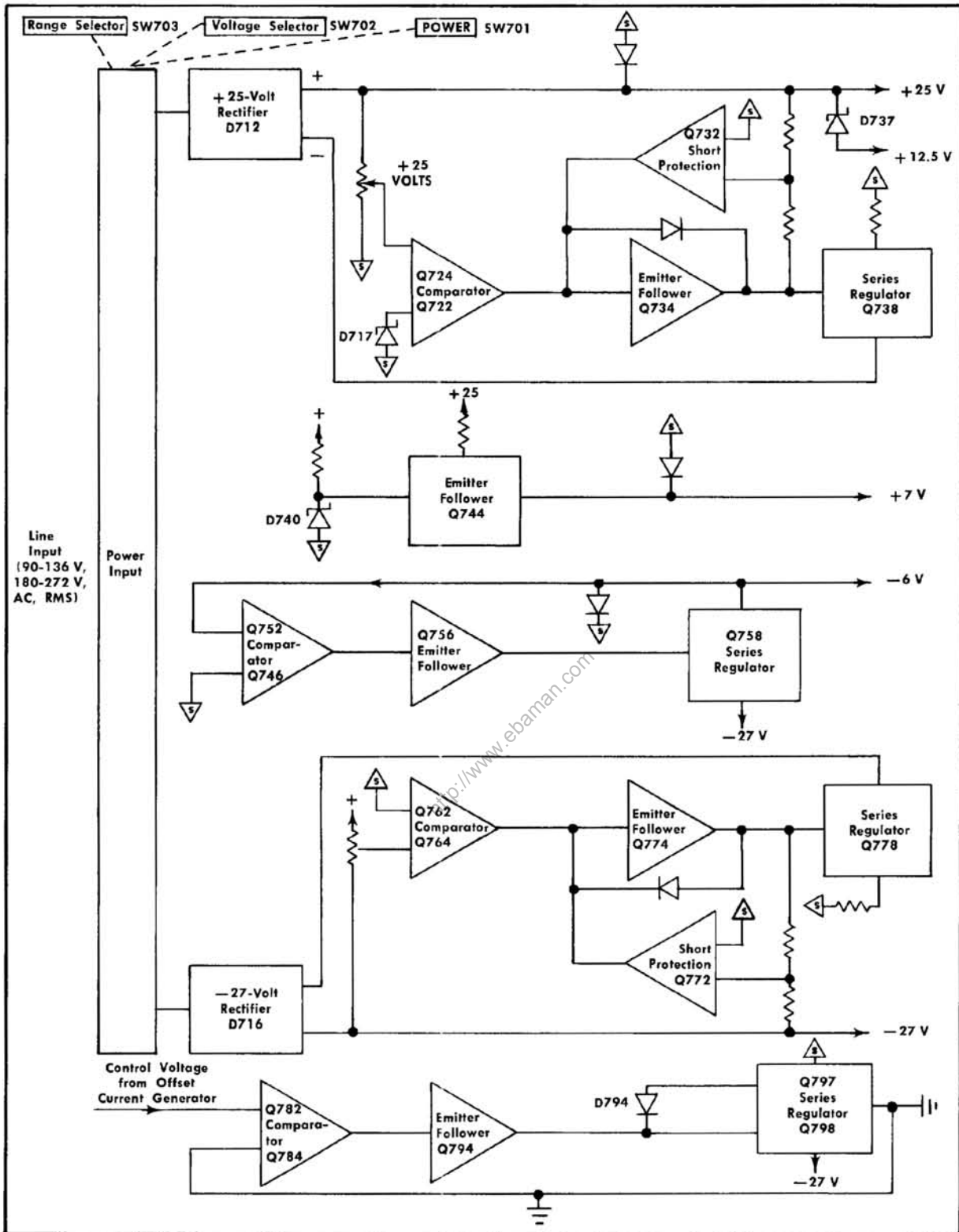


Fig. 3-11. Power Supply Block Diagram.

Circuit Description—Type 115

ducted by the output amplifier. No offset current is conducted by the output load, producing zero DC offset. For + offset (in — polarity) as much as 245 mA may be conducted by the variable current generator and up to 100 mA may be drawn from the output load producing up to +5 volts DC offset. For — DC offset as little as 45 mA may be conducted by the variable current generator and as much as 100 mA may be drawn by the output load. 100 mA of DC offset current produces a —5-volt DC offset. In all levels of DC offset the quiescent current of the output amplifier is 215 mA.

Attenuators. When the final pulse (with offset) has been generated it may pass through an attenuator before appearing at the pulse output connector. The DC OFFSET AND AMPLITUDE MULT switch transmits the pulse straight through to the OUTPUT connector when the switch is in the 1.0 position. When the switch is in either the .5 or .2 positions, the pulse goes through either a $\div 2$ or a $\div 5$ attenuator, respectively, before it appears at the OUTPUT connector. It should be noted that these attenuators attenuate the pulse offset as well as the pulse amplitude.

Floating Power Supply

General. The Type 115 can be operated either from a 115-volt or a 230-volt line voltage source. The power supply (see Fig. 3-11) consists of a single transformer which has two secondaries and produces 5 regulated, short-proof voltages: +25 volts, +12.5 volts +7 volts, —27 volts and — 6 volts. As discussed in the description of the output stage, the power supply is floating in the sense that all the voltages produced are referenced to signal ground which moves up and down with respect to chassis ground. Also included in the floating power supply is the variable supply which is referenced to chassis ground and provides variable separation between signal ground and chassis ground.

Input Circuit. When the POWER switch is switched to ON, line current flows from the input, P701 (see the Floating Power Supply schematic), through fuses F700 and F701, LINE FILTER FL701, power switch SW701, fuse F702, thermal cutout TK701 and into the primary windings. For 115-volt operation, the LINE SELECTOR switch connects the two primaries in parallel and for 230-volt operation connects them in series. For 230-volt operation F703 is connected into the circuit. The RANGE SELECTOR plug determines how many turns of each primary winding are utilized to compensate for variations in line voltage. The fan is connected between terminals 1 and 3 on the transformer primary.

+25-volt Supply. The 25-volt supply is a short-protected and regulated supply. It consists of diode bridge D712A, B, C and D, filter capacitor C712, comparator circuit Q722 and Q724, emitter follower Q734, short circuit protection circuit Q732 and series regulator Q738.

9-volt Zener diode D717 sets the base voltage of comparator transistor Q722 while the quiescent voltage at the base of Q724 is set by the +25 VOLTS adjustment R727. Any variation in the +25-volt supply is compared by Q722 and Q724. The resulting rise or fall in voltage across R722 is transmitted by Q734 to the base of series regulator Q738. Any change in voltage of the +25-volt supply will be opposed by a change in current through the series regulator.

If the +25-volt supply is shorted to one of the supplies or to chassis ground, D736 and Q732 will protect the supply. D736 prevents the supply from going more than 0.6 volt

below signal ground. Q732 will turn on when its base voltage is low enough to forward bias it. When Q732 turns on, its collector voltage rises, turns off Q734 turns on D734 and limits current flow through Q738. The + 25-volt supply voltage will thus remain at about signal ground until the source of the short is removed.

+7-Volt Supply. Zener diode D740 sets the voltage at the base of Q744 at about 7.5 volts and holds its emitter at about 6.9 volts. The current through R743 is relatively constant. Any change in supply voltage will change the base-emitter voltage of Q744 and more or less current will be conducted to the +7-volt supply as needed. D744 protects the supply from a short to a potential that is below signal ground.

—27-Volt Supply. The —27-volt supply consists of diode bridge D716A, B, C and D, filter capacitor C716, comparator Q762 and Q764, emitter follower Q774, short-circuit protection circuit Q772 and series regulator Q778. The circuit regulates the —27-volt supply in essentially the same manner as the +25-volt supply circuit operates.

—6-Volt Supply. The —6-volt supply consists of comparator Q746 and Q752, emitter follower Q756 and series regulator Q758. The base of Q746 is connected to signal ground through R746 and the voltage at the base of Q752 is set by the R750-R751 divider. Any variation in the —6-volt supply is compared by Q746 and Q752 and transmitted by Q756 to the base of Q758. D751 protects the supply from a short to a potential that is above signal ground.

Variable Supply. As has been stated previously, the variable supply provides a means of varying the voltage separation between signal ground and chassis ground. This separation will vary from approximately +1 volt to +18 volts with respect to chassis ground: +8 to +18 volts in + polarity and +1 to +10 volts in — polarity. When the DC OFFSET (VOLTS) controls are set for zero offset, the output voltage of the variable supply is about 13.5 volts in + polarity and +6 volts in — polarity.

The variable supply consists of comparator circuit Q782 and Q784, emitter follower Q794 and series regulators Q797 and Q798. Control current from the offset current generator is conducted through R780 and R781 to the base of Q782. Through the operation of Q782 and Q784 as a comparator, variations in current at the base of Q782 cause changes in the collector current of Q784. Variations in Q784 collector current determine the base voltage of Q794, which when coupled through to its emitter, sets the voltage at the bases of series regulators Q797 and Q798. As this voltage moves up or down with respect to chassis ground, as determined by the DC OFFSET (VOLTS) controls, Q797 and Q798 will turn on and off, one or the other always being on. They are never both on except at approximately the zero DC offset level when crossover occurs. D794 helps keep both Q797 and Q798 conducting slightly at this crossover point.

As the voltage at the bases of the series regulators rises above the crossover level (chassis ground), Q798 turns off and Q797 turns on. Any rise in voltage at the base of Q797 while it is on, causes an increase in conduction of the transistor and a decrease in the voltage separation between signal ground and chassis ground (i.e., between the collector and the emitter of Q797). As the voltage moves in a negative direction at the bases of the series regulators and passes through the crossover level, Q797 turns off and Q798 turns

on. Any additional downward movement of voltage at the base of Q798 while it is on causes an increase in conduction of the transistor and a decrease in voltage separation between chassis ground and the -27-volt supply. The -27-volt regulator circuitry provides a constant voltage separation of 27 volts between the -27-volt supply and signal ground. Any decrease in voltage separation between chassis ground and the -27-volt supply, therefore, causes an in-

crease in voltage separation between signal ground and chassis ground. Considering chassis ground as reference, the action of the series regulators moves signal ground and the -27-volt supply up and down with respect to chassis ground while maintaining 27 volts separation between signal ground and the -27-volt supply. D786 protects the circuit from a short to a voltage that is more than 0.6 volt above signal ground.

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SECTION 4

MAINTENANCE

Change information, if any, affecting this section will be found at the rear of this manual.

Introduction

This section of the manual provides information for use in preventive maintenance, troubleshooting and corrective maintenance of the Type 115.

PREVENTIVE MAINTENANCE

General

Preventive maintenance consists of cleaning, visual inspection, lubrication, etc. Preventive maintenance performed on a regular basis may prevent instrument breakdown and will improve the reliability of this instrument. The severity of the environment to which the Type 115 is subjected determines the frequency of maintenance.

Cabinet Removal

The cabinet of the Type 115 consists of an open-ended box which the Type 115 chassis slides into. To remove the chassis from the cabinet, loosen the slotted thumb-screw located below the + GATE IN connector on the front-panel and pull the chassis out of the cabinet. The cabinet protects the instrument from dust in the interior and directs the flow of cooling air.

Cleaning

The Type 115 should be cleaned as often as operating conditions require. Accumulation of dirt in the instrument can cause overheating and component breakdown. Dirt on components acts as an insulating blanket and prevents efficient heat dissipation. It can also provide an electrical conduction path.

Air Filter. The air filter should be visually checked every few weeks and cleaned or replaced if dirty. More frequent inspections are required under severe operating conditions. If the filter is to be replaced, order new air filters from your local Tektronix Field Office or representative. The following procedure is suggested for cleaning the filter:

1. Remove the filter by pulling it out of the retaining frame on the rear panel. Be careful not to drop any of the accumulated dirt into the instrument.
2. Flush the loose dirt from the filter with a stream of hot water.
3. Place the filter in a solution of mild detergent and hot water and let it soak for several minutes.
4. Squeeze the filter to wash out any dirt which remains.

5. Rinse the filter in clear water and allow it to dry.
6. Re-install the filter in the retaining frame.

Exterior. Loose dust accumulated on the outside of the Type 115 can be removed with a soft cloth or small paint brush. The paint brush is particularly useful for dislodging dirt on and around the front-panel controls. Dirt which remains can be removed with a soft cloth dampened in a mild detergent and water solution. Abrasive cleaners should not be used.

Interior. Dust in the interior of the instrument should be removed occasionally to prevent electrical conductivity under high-humidity conditions. The best way to clean the interior is to blow out the accumulated dust with dry, low-velocity air. Remove any dirt which remains with a soft paint brush or a cloth dampened with a mild detergent and water solution. A cotton-tipped applicator is useful for cleaning in narrow spaces or for cleaning ceramic terminal strips and circuit boards.

CAUTION

Avoid the use of chemical cleaning agents which might damage the plastics used in this instrument. Avoid chemicals which contain benzene, toluene, xylene, acetone or similar solvents.

Lubrication

General. The reliability of potentiometers, rotary switches, and other moving parts can be maintained if they are kept properly lubricated. Use a cleaning-type lubricant (such as Tektronix Part No. 006-0218-00) on shaft bushings and switch contacts. Lubricate switch detents with a heavier grease (such as Tektronix Part No. 006-0219-00). Potentiometers that are not sealed, should be lubricated with a lubricant which will not affect electrical characteristics (such as Tektronix Part No. 006-0220-00). Do not use excessive lubrication. A lubrication kit containing the necessary lubricants and instructions is available from Tektronix, Inc. Order Tektronix Part No. 003-0342-00.

Fan. It is recommended that the fan-motor bearings be lubricated every 1000 hours. Fig. 4-1 shows the lubrication holes in the fan. Place a few drops of light machine oil in the holes. Remember that too much lubrication is as harmful to the fan motor as too little lubrication.

Visual Inspection

The Type 115 should be inspected occasionally for such defects as broken connections, loose pin connections, broken or damaged ceramic strips, improperly seated transistors, damaged circuit boards and heat-damaged parts.

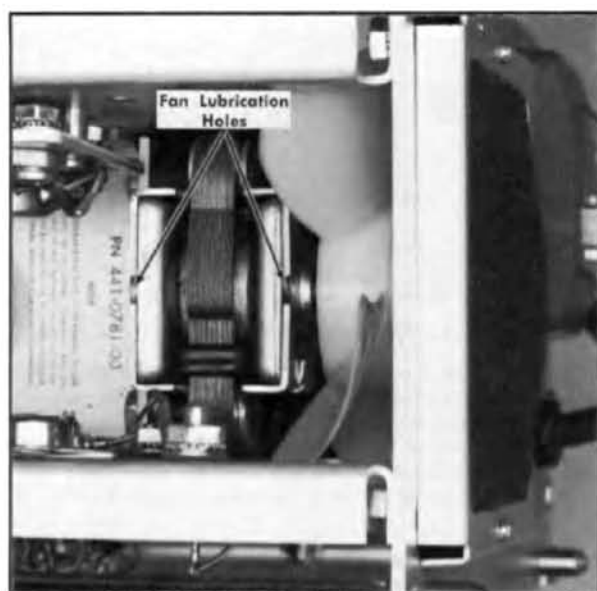


Fig. 4-1. Location of lubrication holes in fan (right side).

The corrective procedures for most visible defects is obvious; however, particular care must be taken if heat-damaged components are found. Overheating usually indicates other trouble in the instrument; therefore, it is important that the cause of overheating be corrected to prevent recurrence of the damage.

Transistor Checks

Periodic checks of the transistors in the Type 115 are not recommended. The best check of transistor performance is its actual operation in the instrument. More details on checking transistor operation are given under Troubleshooting.

Recalibration

To ensure accurate measurements, check the calibration of this instrument after each 1000 hours of operation or, if used infrequently, every 6 months. In addition, replacement of components may necessitate recalibration of the affected circuits. Complete calibration instructions are given in the Performance Check and Calibration section. This procedure may also be helpful in localizing certain troubles in the instrument. In some cases, minor troubles may be revealed and/or corrected by recalibration.

TROUBLESHOOTING

Introduction

The following information is provided for use with the other sections of this manual to facilitate troubleshooting of the Type 115 if trouble develops. An understanding of the operation of the Type 115 circuitry is also helpful for locating troubles. See the Circuit Description section for complete information.

Troubleshooting Aids

Diagrams. A complete set of circuit diagrams is given on foldout pages in Section 8. The circuit number and electrical value of each component in this instrument is shown on the appropriate diagram. Each main circuit is assigned a series of circuit numbers. Table 4-1 lists the main circuits in the Type 115 and the series of circuit numbers assigned to each. The portions of the circuit which are mounted on a circuit board are enclosed with a blue line on the circuit diagram.

TABLE 4-1
Component Numbers

Component Numbers on Diagrams	Diagram Number	Circuit
1-99	1	External Trigger Amplifier
100-199	2	Delay Generator
200-299	2	Period Generator
300-399	3	Width Generator and Pulse Shaper-Risetime
400-499	3	Pulse Shaper-Falltime and Amplitude Reference
500-599	4	Output Amplifier and Inverter
600-699	4	Offset Current Generator
700-799	5	Power Supply

Also included on the circuit diagrams are voltages and waveforms which can be expected at various points in the circuitry. A list of front-panel control settings which must be used to obtain the given voltages and waveforms is shown on the apron of circuit diagram number one.

Switch Wafer Identification. Switch wafers shown on the diagrams are coded to indicate the position of each wafer in the complete switch assembly. The numbered portion of the code refers to the wafer number counting from the front, or mounting end of the switch, toward the rear. The letters F and R indicate whether the front or rear of the wafer performs the particular switching function. For example, a wafer designated by 2R indicates that the rear of the second wafer (from the front) is used for this particular switching function.

Circuit Boards. Figs. 4-7 and 4-8 show the circuit boards used in the Type 115. On each of these pictures each electrical component on the board is identified by its circuit number. These pictures, used along with the circuit diagrams, aid in locating the components mounted on the circuit boards.

Wiring Color-Code. All insulated wire and cable used in the Type 115 is color-coded to facilitate circuit tracing. Signal carrying leads are identified with one or two colored stripes. Voltage supply leads are identified with three stripes to indicate the approximate voltage using the EIA resistor color code. A white background color indicates a positive voltage and a tan background indicates a negative voltage. The widest color stripe identifies the first color of the code. Table 4-2 gives the wiring color-code for the power-supply voltages used in the Type 115. The signal carrying wires color-codes are given in Fig. 4-7 and 4-8 with the appropriate pin connection.

TABLE 4-2
Power Supply Wiring Color Code

Supply	Back-Ground Color	1st Stripe	2nd Stripe	3rd Stripe
+25 volt	White	Red	Red	Brown
+7 volt	White	Violet	Green	Black
-27 volt	Tan	Brown	Red	Black
-6 volt	Tan	Black	Blue	Black
Signal Ground	White	Brown		

Resistor Color Code. In addition to the brown composition resistors, some metal-film resistors (identifiable by their gray body color) and some wire-wound resistors (usually light blue or gray-green) are used in the Type 115. The resistance value of a wire-wound resistor is printed on the body of the component. The resistance value of a composition resistor or metal-film resistor is color-coded on the component with EIA color-code (some metal-film resistors may have the value printed on the body). The color-code is read starting with the stripe nearest the end of the resistor. Composition resistors have four stripes which consist of two significant figures, a multiplier and a tolerance value (see Fig. 4-2). Metal-film resistors have five stripes consisting of three significant figures, a multiplier and a tolerance value.

Capacitor Marking. The capacitance value of a common disc capacitor or small electrolytic is marked in microfarads on the side of the component body. The white ceramic capacitors used in the Type 115 are color coded in picofarads using a modified EIA code (see Fig. 4-2).

Diode Color Code. The cathode end of each glass encased diode is indicated by a stripe, a series of stripes or a dot. For most silicon or germanium diodes with a series of stripes, the color-code identifies the Tektronix Part Number using the resistor color-code system (e.g., a diode color-coded blue or pink-brown-grey indicates Tektronix Part Number 152-0185-00). The cathode and anode ends of metal-encased diodes can be identified by the diode symbol marked on the body.

Transistor Lead Configuration. Fig. 4-3 shows the lead configurations of the transistors used in this instrument. This view is as seen from the bottom of the transistor.

Troubleshooting Equipment

The following equipment is useful for troubleshooting the Type 115:

1. Transistor Tester—Some means of testing the semiconductors used in the instrument is helpful. A transistor-curve tracer such as the Tektronix Type 575 will give the most complete information.

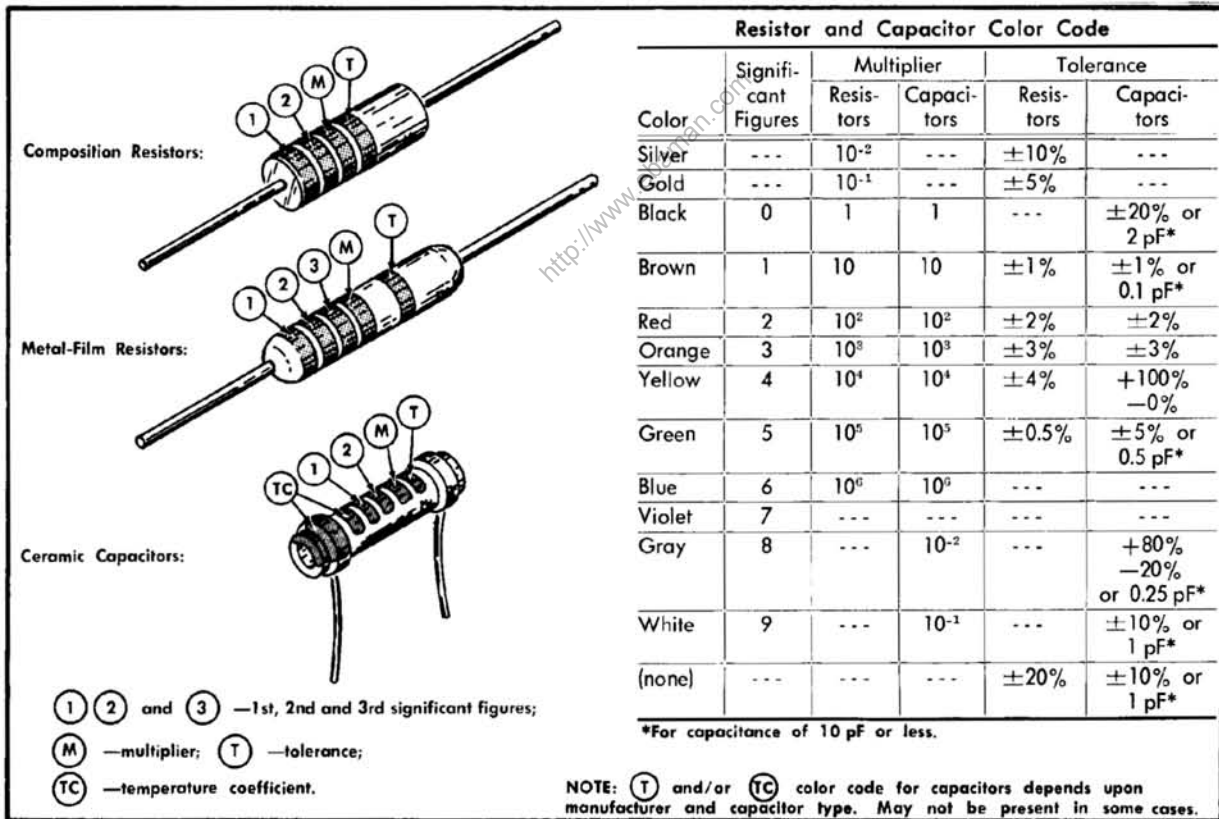


Fig. 4-2. Color-code for resistors and ceramic capacitors.

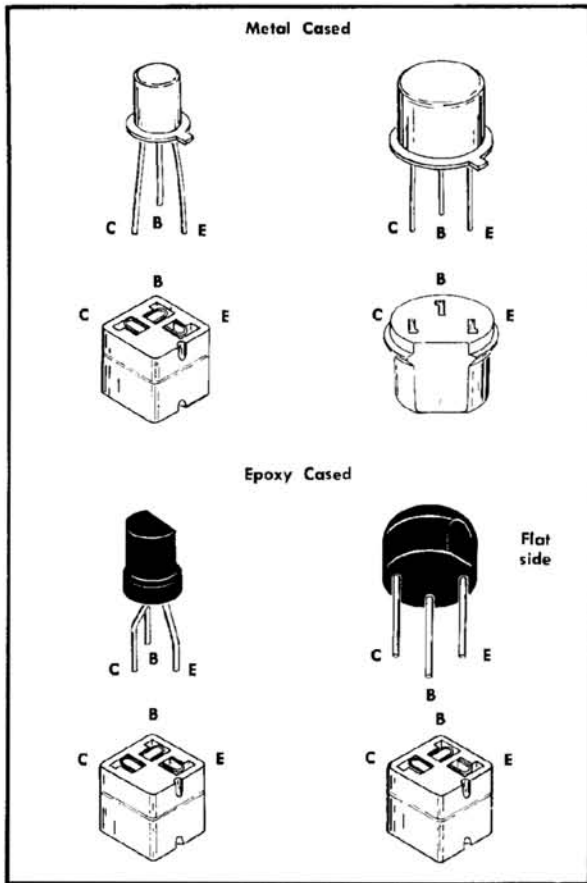


Fig. 4-3. Electrode configurations for socket-mounted transistors: Top View.

2. DC Voltmeter and Ohmmeter—A voltmeter for checking voltages within the circuit and an ohmmeter for checking resistors and diodes are required. A VTVM with a 10 megohm input impedance and 0 to 50 volts range, and an ohmmeter with a 0 to 20 megohm range are suggested. A 20,000 ohm/volt VOM can be used to check voltages, if allowances are made for the circuit loading of a VOM at high-impedance points.

3. Test Oscilloscope—A test oscilloscope is required to view waveforms at different points in the circuit. An oscilloscope with DC to 20 MHz frequency response and 100 millivolts to 10 volts/division vertical deflection factor is suggested. A 10X probe should be used to reduce circuit loading.

Troubleshooting Techniques

This troubleshooting procedure is arranged in an order which checks the simple trouble possibilities before proceeding with extensive troubleshooting. The first few checks ensure proper connection, operation and calibration. If the trouble is not located by these checks, the remaining steps aid in locating the defective component. When the detec-

tive component is located, it should be replaced following the replacement procedure given under Corrective Maintenance.

1. Check Control Settings. Incorrect control settings can indicate a trouble that does not exist. If there is any question about the correct function or operation of any control, see the Operating Instructions section of this manual.

2. Check Associated Equipment. Before proceeding with the troubleshooting of the Type 115, check that the equipment used with this instrument is operating correctly. Check that the signals are properly connected and that the interconnecting cables are not defective. Also, check the power source.

3. Check Instrument Calibration. Check the calibration of this instrument or of the affected circuit if the trouble is known to exist in one particular circuit. The apparent trouble may be only a result of misadjustment and may be corrected by calibration. Complete calibration instructions are given in the Performance Check and Calibration section of this manual.

4. Pin point Malfunctioning Circuits. To pinpoint the source of a malfunction in instrument operation, the trouble symptom will often indicate the identity of the faulty circuit(s). For example, if a proper output pulse appears in the undelayed pulse mode but not in the delayed pulse mode, the fault is probably in the delay generator.

If the trouble symptom does not indicate which circuit(s) is causing problems, as would be the case if no pulse appeared at the output connector in any mode, a more systematic troubleshooting procedure is necessary. Fig. 4-4 provides a general guide for pinpointing circuits and the troubles within them which are causing instrument malfunctions.

The chart first covers the circuits which affect the generation of an internally-triggered undelayed pulse: The power supply, the internal pulse and trigger generators and the output stage. A further extension of the chart provides a troubleshooting method for determining trouble spots when the problem lies in obtaining pulses in different modes of operation or in obtaining proper external triggering.

The following preliminary procedure ensures that the instrument malfunction is not caused by improper control settings and helps determine where to begin on the troubleshooting chart:

A. Set the Type 115 controls as given under First Time Operation Instructions in Section 2.

B. Connect the Type 115 OUTPUT through a coaxial cable terminated in 50-Ω to the vertical input of the oscilloscope.

C. Turn on the Type 115 power switch and observe the oscilloscope display of the pulse:

a. If no pulse appears, start at the beginning of troubleshooting chart point (A).

b. If a pulse appears but is improperly shaped (compared to Fig. 4-5), start at point (B) on the troubleshooting chart.

c. If the undelayed pulse is similar to the pulse seen in Fig. 4-5 but a problem arises in other modes of operation or in external triggering, start at point (C) on the troubleshooting chart according to the trouble symptom.

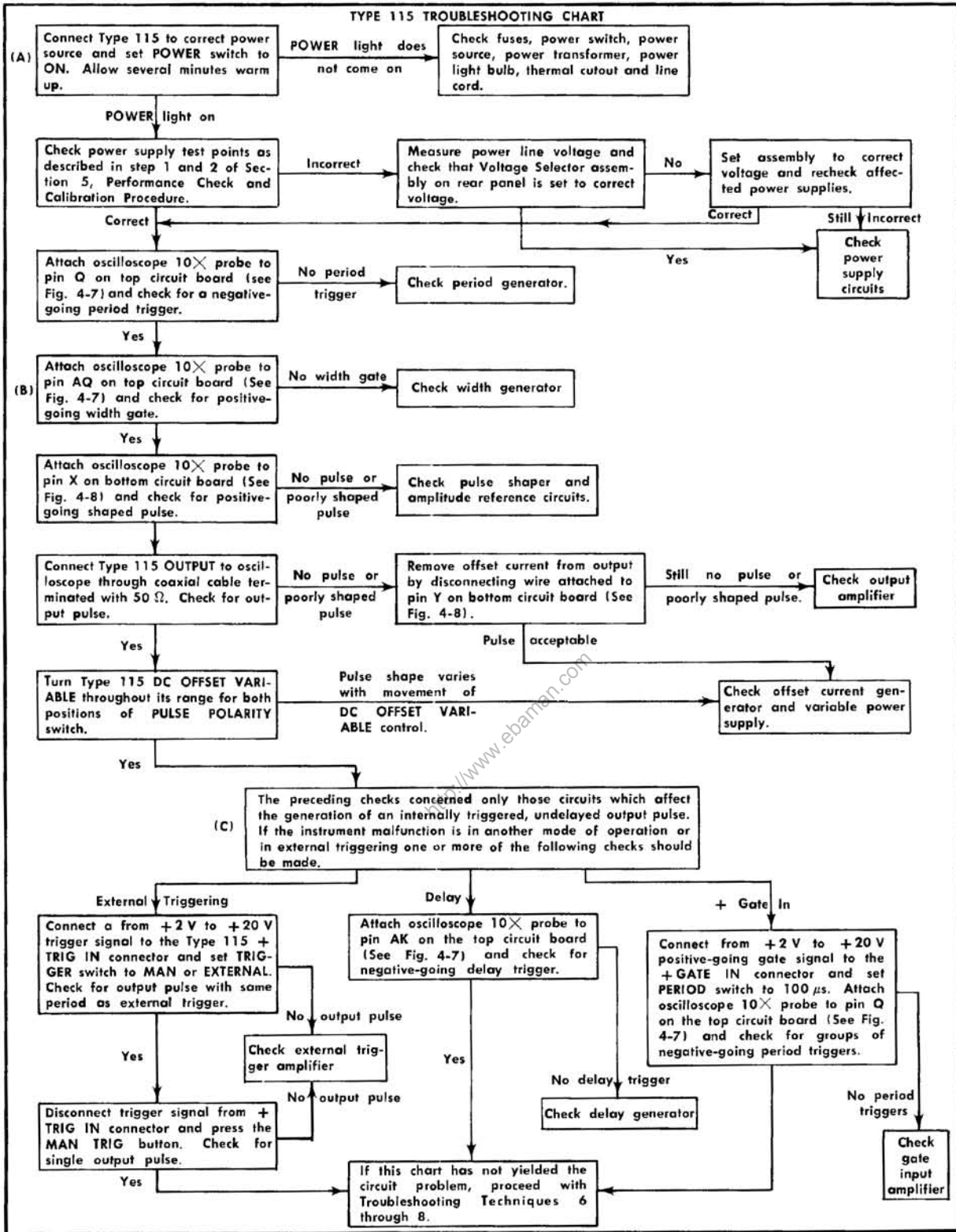


Fig. 4-4. Troubleshooting chart.

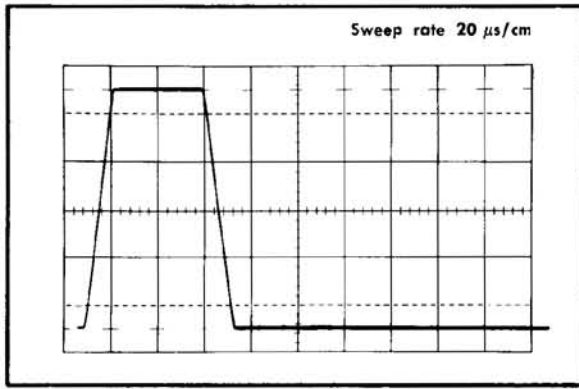


Fig. 4-5. Type 115 Output pulse which should be obtained if instrument is operating properly.

After the defective circuit has been located, proceed with steps 5 through 9 to locate and repair the faulty components.

5. **Visual Check.** Visually check the portion of the instrument in which the trouble is located. Many troubles can be located by visual indications such as unsoldered connections, broken wires, damaged circuit boards, damaged components, etc.

6. **Check Circuit Board Interconnections.** After the trouble has been isolated to a particular circuit, check the pin connectors on the circuit board for correct connection. Fig. 4-7 and 4-8 show the correct connections of each board.

The pin connectors used in this instrument also provide a convenient means of circuit isolation. For example, if the power supply is shorted, the defective circuit can be isolated by disconnecting the pin connectors at the boards until the shorting condition is removed.

7. **Check Voltages and Waveforms.** Often the defective component can be located by checking for the correct voltage or waveforms as given on the circuit diagrams on fold-out pages in the back of this manual.

NOTE

Voltages and waveforms given on the diagrams are not absolute and may vary slightly between instruments. To obtain operating conditions similar to those used to take these readings, see the first diagram page.

8. **Check Individual Components.** The following procedures describe methods of checking individual components in the Type 115. Components which are soldered in place are best checked by disconnecting one end. This isolates the measurement from the effects of surrounding circuitry.

A. **TRANSISTORS.** The best check of transistor operation is actual performance under operating conditions. If a transistor is suspected of being defective, it can best be checked by substituting a new component or one which has been checked previously. However, be sure that circuit conditions are not such that a replacement transistor might also be damaged. If substitute transistors are not available, use a dynamic tester (such as Tektronix Type 575). Static-type

testers are not recommended, since they do not check operation under simulated operating conditions.

CAUTION

The **POWER** switch must be turned off before removing or replacing transistors.

B. **DIODES.** A diode can be checked for an open or shorted condition by measuring the resistance between terminals. With an ohmmeter scale having an internal source of between 800 millivolts and 3 volts, the resistance should be very high in one direction and very low when the leads are reversed. To measure reverse leakage, a dynamic tester is necessary. When unsoldering leads, be sure to provide a heat shunt so that the diode is not damaged.

CAUTION

Do not use an ohmmeter that has a high internal current. High currents may damage the diode. Do not measure tunnel diodes with an ohmmeter; use a dynamic tester.

C. **RESISTORS.** Resistors can be checked with an ohmmeter. Check the Electrical Parts List for the tolerance of the resistors used in this instrument. Resistors normally do not need to be replaced unless the measured value varies widely from the specified value.

D. **INDUCTORS.** Check for open inductors by checking continuity with an ohmmeter. Shorted or partially shorted inductors can usually be found by checking the waveform response when high-frequency signals are passed through the circuit. Partial shorting often reduces high-frequency response causing rounding. Check toroids and Ferrite beads for cracks.

E. **CAPACITORS.** A leaky or shorted capacitor can best be detected by checking resistance with an ohmmeter on the highest scale. Do not exceed the voltage rating of the capacitor. The resistance reading should be high after the capacitor has charged. An open capacitor can best be detected with a capacitance meter or by checking to see if the capacitor passes AC signals.

F. **REED SWITCHES.** Check the reed switches with a voltmeter when the instrument is operating, to be sure that the reed is closed when actuated and open when not actuated.

G. **REED-DRIVE COILS.** The reed-drive coils can be checked for correct operation as follows (coil has four mounting leads for rigidity; make measurements between the two leads on either end of the coil): 1) With the instrument power off, check the DC resistance of the coil with an ohmmeter; typical resistance values are given in the electrical parts list. 2) With the instrument power on, check the DC voltage drop across the coil when the actuating level is applied. 3) If both the resistance and voltage are correct, the coil can be assumed to be correct; 4) If the resistance is incorrect (take into account surrounding circuitry), disconnect the coil and check the resistance again. 5) If the voltage across the coil is incorrect but the coil resistance is correct check the circuit originating the actuating level.

9. **Repair and Readjust the Circuit.** If any defective parts are located, follow the replacement procedures given in this section. Be sure to check the performance of any circuit that

has been repaired or that has had any electrical components replaced. If a component has been replaced, recalibration is usually necessary.

CORRECTIVE MAINTENANCE

General

Corrective maintenance consists of component replacement and instrument repair. Special techniques required to replace components in this instrument are given here.

Obtaining Replacement Parts

Standard Parts. All electrical and mechanical part replacements for the Type 115 can be obtained through your local Tektronix Field Office or representative. However, many of the standard electronic components can be obtained locally in less time than is required to order them from Tektronix, Inc. Before purchasing or ordering replacement parts, check the parts list for value, tolerance, rating and description.

NOTE

When selecting replacement parts, it is important to remember that the physical size and shape of a component may affect its performance, particularly at the upper frequency limits of the instrument. All replacement parts should be direct replacements unless it is known that a different component will not adversely affect instrument performance.

Special Parts. In addition to the standard electronic components, some special parts are used in the Type 115. These parts are manufactured or selected by Tektronix, Inc. to meet specific performance requirements, or are manufactured for Tektronix, Inc. in accordance with our specifications. Each special part is indicated in the electrical parts list by an asterisk preceding the part number. Most of the mechanical parts used in this instrument have been manufactured by Tektronix, Inc. Order all special parts directly from your local Tektronix Field Office or representative.

Ordering Parts. When ordering replacement parts from Tektronix, Inc., include the following information.

1. Instrument Type.
2. Instrument Serial Number.
3. A description of the part (if electrical, include circuit number).
4. Tektronix-Part Number.

Soldering Techniques

WARNING

Disconnect the instrument from the power source before soldering.

Circuit Boards. Use ordinary 60/40 solder and a 35- to 40-watt pencil type soldering iron on the circuit boards. The tip of the iron should be clean and properly tinned for best heat transfer to the solder joint. A higher wattage soldering iron may separate the wiring from the base material.

The following technique should be used to replace a component on a circuit board. Most components can be replaced without removing the boards from the instrument.

1. Grip the component lead with long-nose pliers. Touch the soldering iron to the lead at the solder connection. Do not lay the iron directly on the board, as it may damage the board.

2. When the solder begins to melt, pull the lead out gently. This should leave a clean hole in the board. If not, the hole can be cleaned by reheating the solder and placing a sharp object such as a toothpick into the hole to clean it out. A vacuum-type desoldering tool can also be used for this purpose.

3. Bend the leads of the new component to fit the holes in the board. If the component is replaced while the board is mounted in the instrument, cut the leads so they will just protrude through the board. Insert the leads into the holes in the board so the component is firmly seated against the board (or as positioned originally). If it does not seat properly, heat the solder and gently press the component into place.

4. Touch the iron to the connection and apply a small amount of solder to make a firm solder joint. To protect heat-sensitive components, hold the lead between the component body and the solder joint with a pair of long-nose pliers or other heat sink.

5. Clip off the excess lead that protrudes through the board (if not clipped in step 3).

6. Clean the area around the solder connection with a flux-remover solvent. Be careful not to remove information printed on the board.

Ceramic Terminal Strips. Solder used on the ceramic terminal strips should contain about 3% silver. Use a 40- to 75-watt soldering iron with a 1/8-inch wide wedge-shaped tip. Ordinary solder can be used occasionally without damage to the ceramic terminal strips. However, if ordinary solder is used repeatedly or if excessive heat is applied, the solder-to-ceramic bond may be broken.

A sample roll of solder containing about 3% silver is mounted on the chassis of this instrument next to L664. Additional solder of the same type should be available locally, or it can be purchased from Tektronix, Inc. in one-pound rolls; order by Tektronix Part No. 251-0514-00.

Observe the following precautions when soldering to a ceramic terminal strip:

1. Use a hot iron for a short time. Apply only enough heat to make the solder flow freely.
2. Maintain a clean, properly tinned tip.
3. Avoid putting pressure on the ceramic terminal strip.
4. Do not attempt to fill the terminal-strip notch with solder; use only enough solder to cover the wires adequately.
5. Clean the flux from the terminal strip with a flux-remover solvent.

Metal Terminals. When soldering to metal terminals (e.g., switch terminals, potentiometers, etc.), ordinary 60/40 solder can be used. Use a soldering iron with a 40- to 75-watt rating and a 1/8-inch wide wedge-shaped tip.

Maintenance—Type 115

Observe the following precautions when soldering to a metal terminal:

1. Apply only enough heat to make the solder flow freely.
2. Apply only enough solder to form a solid connection. Excess solder may impair the function of the part.
3. If a wire extends beyond the solder joint, clip off the excess.
4. Clean the flux from the solder joint with a flux-remover solvent.

Component Replacement

WARNING

Disconnect the instrument from the power source before replacing components.

Ceramic Terminal Strip Replacement. A complete ceramic terminal strip assembly is shown in Fig. 4-6. Replacement strips (including studs) and spacers are supplied under separate part numbers. However, the old spacers may be reused if they are not damaged. The applicable Tektronix Part Numbers for the ceramic strips and spacers used in this instrument are given in the Mechanical Part List.

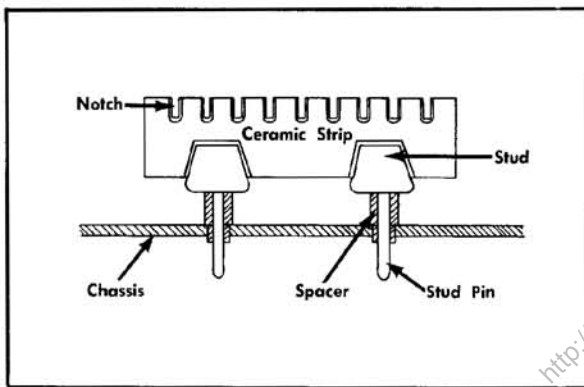


Fig. 4-6. Ceramic terminal strip assembly.

To replace a ceramic terminal strip, use the following procedure.

REMOVAL:

1. Unsolder all components and connections on the strip. To aid in replacing the strip, it may be advisable to mark each lead or draw a sketch showing the location of the components and connections.
2. Pry or pull the damaged strip from the chassis.
3. If the spacers come out with the strip, remove them from the stud pins for use on the new strip (spacers should be replaced if they are damaged).

REPLACEMENT:

1. Place the spacers in the chassis holes.
2. Carefully press the studs of the strip into the spacers until they are completely seated. If necessary, use a soft

mallet and tap lightly, directly over the stud, to seat the strip completely.

3. If the studs on the new ceramic strip are longer than those on the old one, cut off the excess length before the new strip is put in place.

4. Replace all components and connections. Observe the soldering precautions given under soldering Techniques in this section.

Circuit Board Replacement. If a circuit board is damaged beyond repair, either the entire assembly including all soldered-on components, or the board only, can be replaced. Part numbers are given in the Mechanical Parts List for either the completely wired or the unwired board. Most of the components mounted on the circuit boards can be replaced without removing the boards from the instrument. Observe the soldering precautions given under Soldering Techniques in this section.

Use the following procedure to remove a circuit board.

1a. To lift the board for maintenance or access to areas beneath the board, disconnect the pin connectors which might impair lifting.

1b. To completely remove the board; disconnect all the remaining pin connectors.

2. Remove all screws holding the board to the chassis.

3. Lift the circuit board partially or all the way out of the instrument. Do not force or bend the board.

4. To replace the board, reverse the order of removal. Correct location of the pin connectors is shown in Figs. 4-7 and 4-8. Replace the pin connectors carefully so they mate correctly with the pins. If forced into place incorrectly the pin connectors may be damaged.

Transistor Replacement. Transistors should not be replaced unless they are actually defective. If removed from their sockets during routine maintenance, return them to their original sockets. Unnecessary replacement or exchange of transistors may affect the calibration of this instrument. When transistors are replaced, check the operation of that part of the instrument which may be affected.

CAUTION

POWER switch must be turned off before removing or replacing transistors.

Replacement transistors should be of the original type or a direct replacement. Fig. 4-3 shows the lead configuration of the transistors used in this instrument. Some plastic case transistors have lead configurations which do not agree with those shown here. If a transistor is replaced by one which is made by a different manufacturer than the original, check the manufacturer's basing diagram for correct basing. All transistor sockets in this instrument are wired for the basing used for metal-case transistors. Use silicone grease when replacing transistors which have heat radiators or are mounted on the chassis. Replace the silicone grease when replacing these transistors.

WARNING

Handle silicone grease with care. Avoid getting silicone grease in the eyes. Wash hands thoroughly after use.

Fuse Replacement. The power-line fuses are located on the rear panel in the Voltage Selector Assembly. Power-supply fuses are located beside the power transformer. See the electrical parts list for the values of the fuses.

Glass Reed-Switch Replacement. The glass reed-switches used in this instrument are pressurized and can easily be broken. To avoid damage to the reed-switch, do not apply stress to the metal-glass bond. When it is necessary to bend a lead, use two pair of long-nose pliers one next to the glass to hold the lead and one to bend the lead. Before replacing a reed-switch, be sure the actuating circuitry is not at fault. See Troubleshooting procedure for methods of checking the circuit. It is important that the replacement reed-switch be correctly positioned within the drive-coil assembly with the same lead length as the original to provide similar magnetic characteristics.

REMOVAL:

1. Observe the physical position of the glass bulb and the leads of the old reed-switch.
2. Unsolder the leads of the old reed-switch from the solder posts.
3. Pull the old reed-switch out of the drive-coil.

REPLACEMENT:

1. Bend and clip the leads of the new reed-switch to duplicate those of the old one. Be careful not to stress the glass.
2. Slip the new reed-switch into the drive-coil.
3. Position the new reed-switch in exactly the same physical position as the old one.
4. Position the leads correctly and solder the new reed-switch to the solder posts. Avoid excessive heat on the reed-switch; use a heat sink on the leads.

Rotary Switches. Individual wafers or mechanical parts of rotary switches are normally not replaceable. If a switch is defective, replace the entire assembly. Replacement switches can be ordered either wired or unwired; refer to the Electrical Parts List for the applicable part number.

When replacing a switch, tag the leads and switch terminals with corresponding identification tags as the leads are disconnected. Then, use the old switch as a guide for installing the new one. An alternative method is to draw a sketch of the switch layout and record the wire color at each terminal. When soldering to the new switch, be careful that the solder does not flow beyond the rivets of the switch terminals. Spring tension of the switch contact can be destroyed by excessive solder.

To gain access to the switches attached to the front-panel, use the following procedure:

1. Remove the screws on the rear panel which hold the spacer bars in place.

2. Loosen the screws in the spacer bar clamps.
3. Pull the front panel forward until the switches are accessible.
4. When putting the front-panel back in its proper position, be sure to re-tighten the spacer bar clamp screws.

Power Transformer Replacement. The power transformer in this instrument is warranted for the life of the instrument. If the power transformer becomes defective, contact your local Tektronix Field Office or representative for a warranty replacement (see the Warranty note in the front of this manual). Be sure to replace only with a direct replacement Tektronix transformer.

To replace the power transformer the bottom chassis plate to which the power transformer is bolted must be lowered as follows:

1. Lift the bottom circuit board(as described in the part titled Circuit Board Replacement) enough to gain access to the screws which hold the bottom chassis plate in place.
2. Remove the screws which secure the bottom chassis plate to the rear panel and front bulkhead.
3. Lower the bottom chassis plate until the power transformer can be removed.
4. Be sure to label the leads before unsoldering them from the power transformer.

Miscellaneous Maintenance Information

TK701—If the thermal cutout is replaced, be sure the nuts and screws used to hold it in place are tight before turning on the instrument.

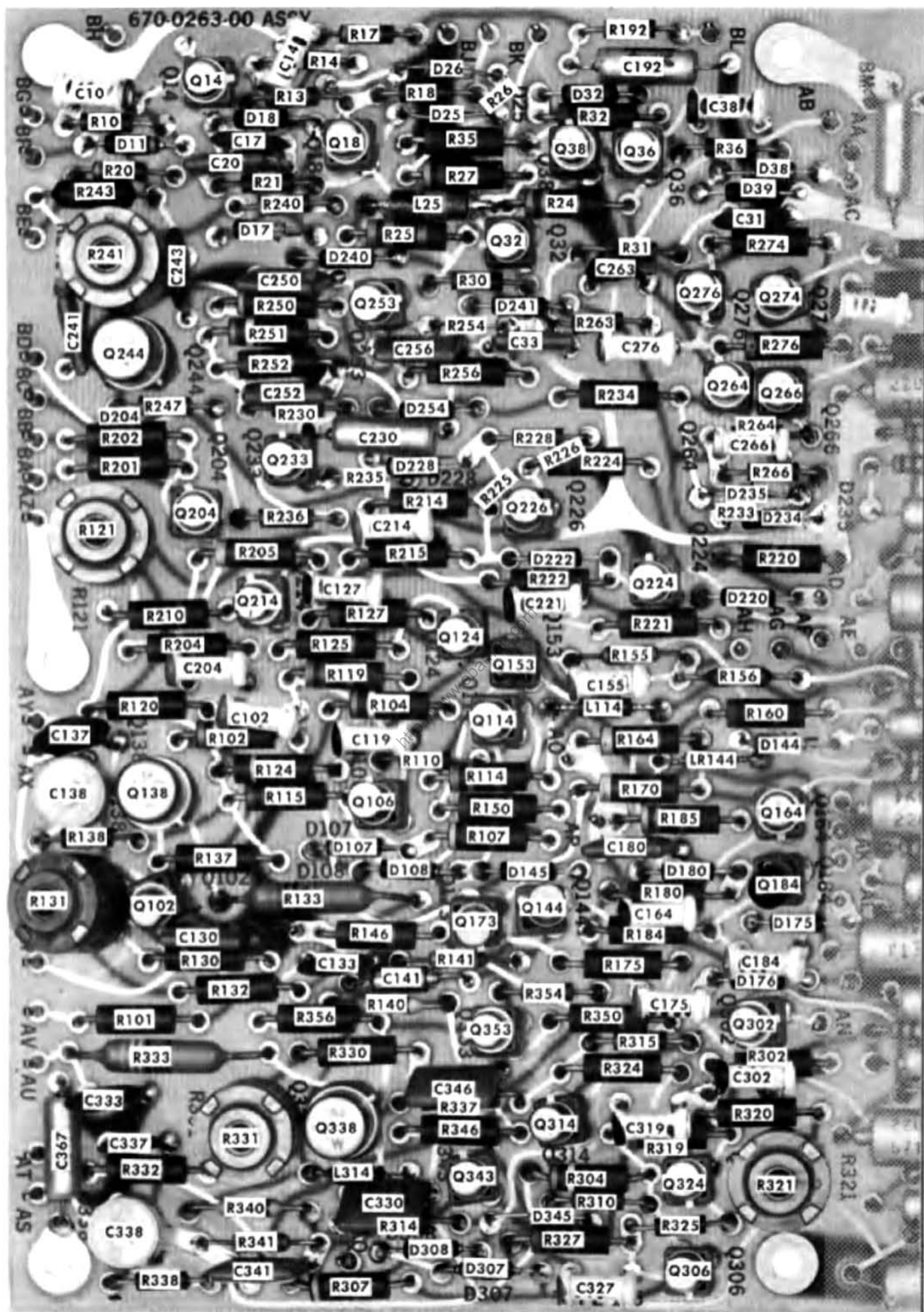
C716 and C717—The filter capacitors can be removed without lowering the bottom chassis plate.

R615—The PRESET control can be disconnected from the front-panel with an Allen wrench.

L668—When removing then replacing the bottom circuit board, be sure that L668 (mounted on the back side of the circuit board), is not touching the chassis.

Recalibration After Repair

After any electrical component has been replaced, the calibration of the associated circuit should be checked, as well as the calibration of other closely related circuits. Since the Power supply affects all circuits, calibration of the entire instrument should be checked if work has been done in the Power supply or if the power transformer has been replaced. The Performance Check and Calibration Procedure in Section 5 provides a means of checking instrument operation and making necessary adjustments.



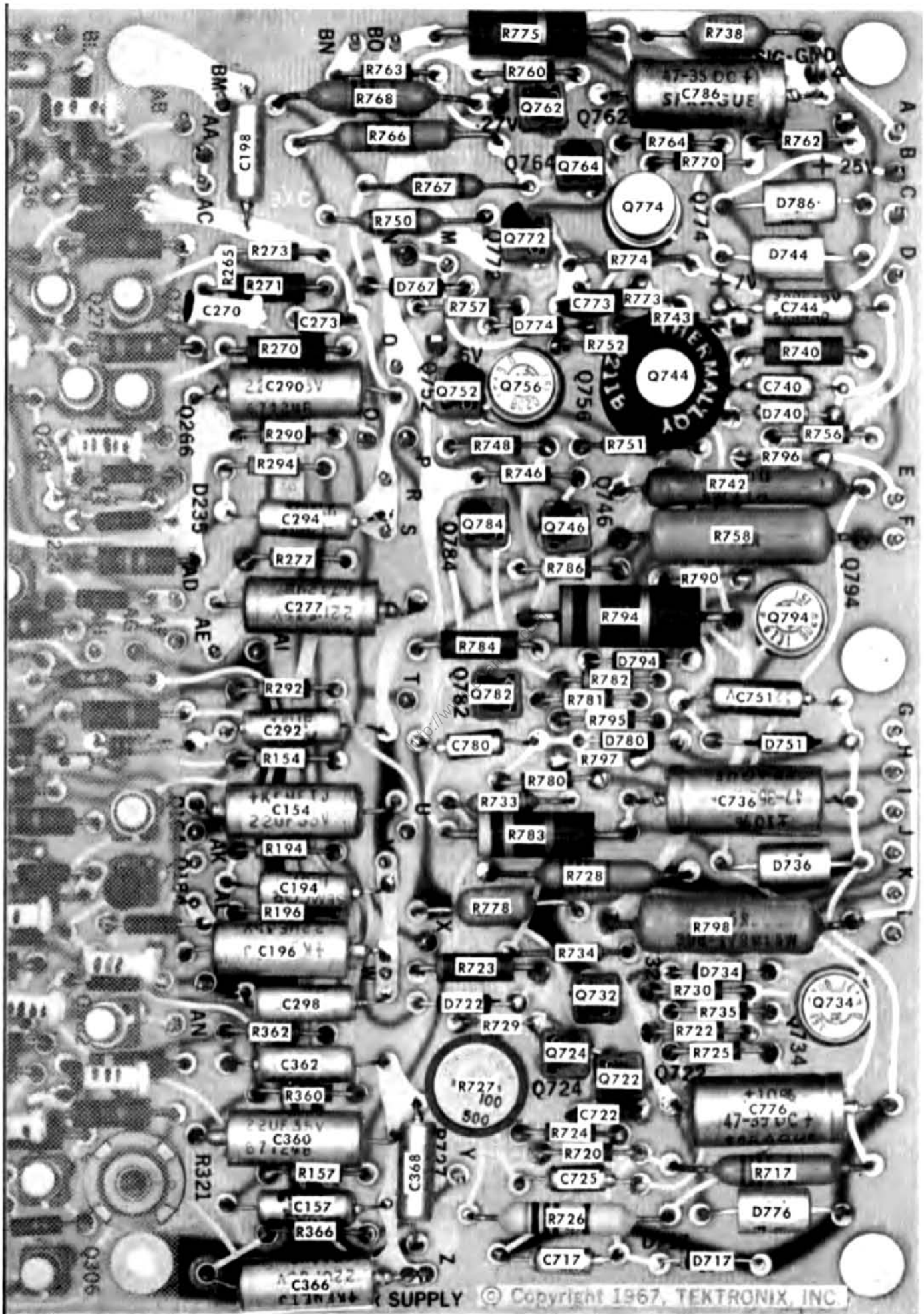


Fig. 4-7B. Component locations on top circuit board.

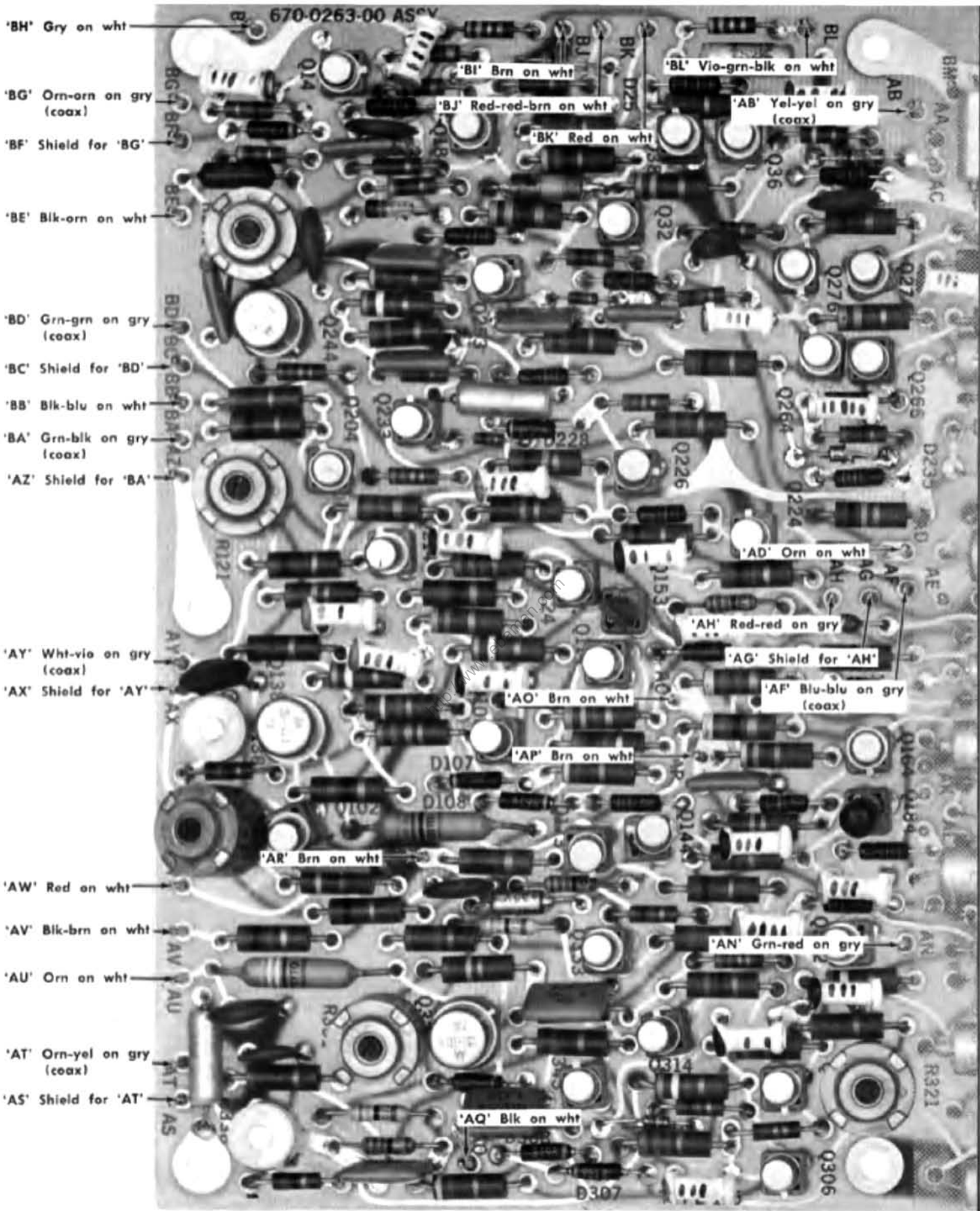


Fig. 4-7C. Wiring color code on top circuit board.

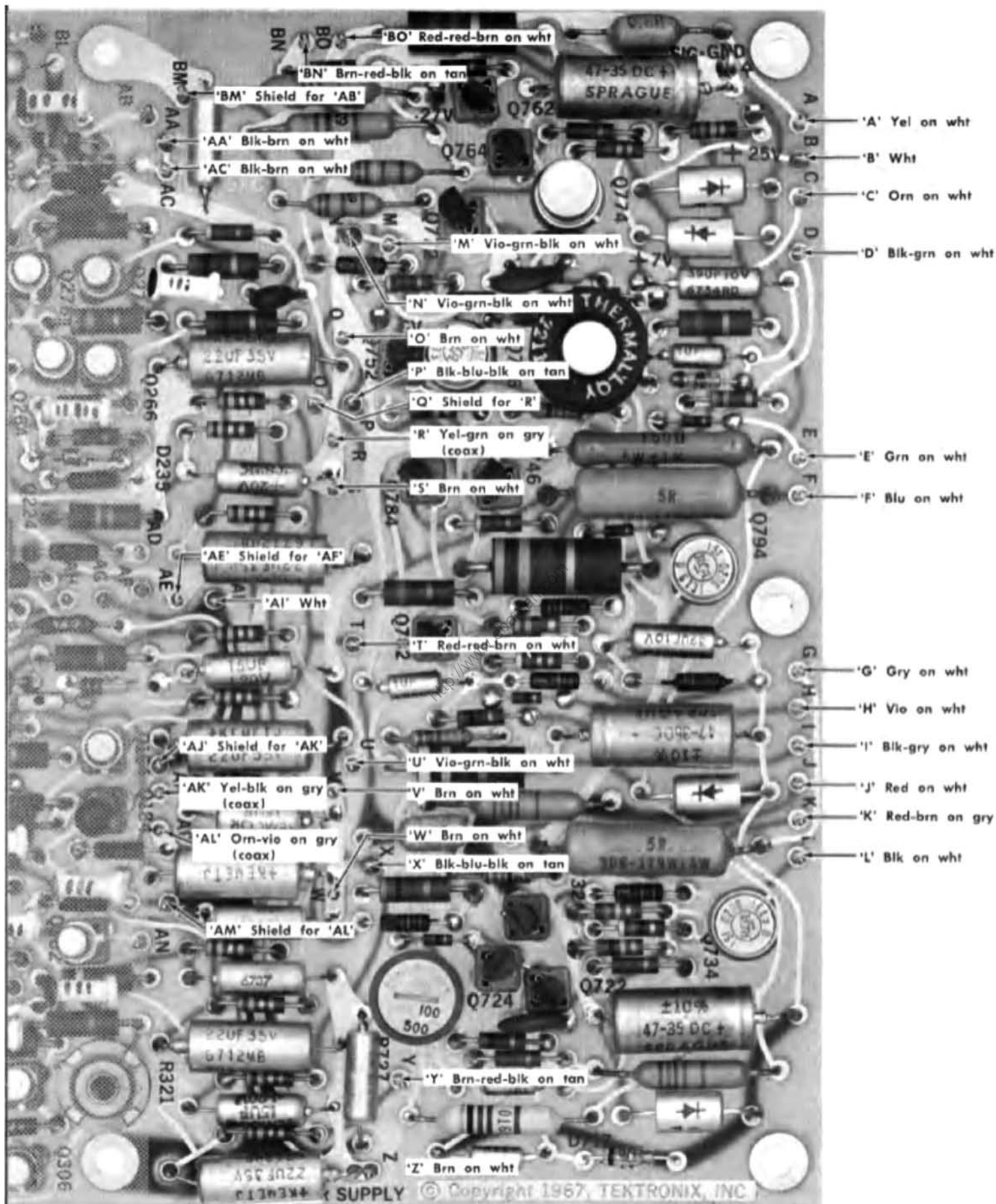


Fig. 4-7D. Wiring color code on top circuit board.

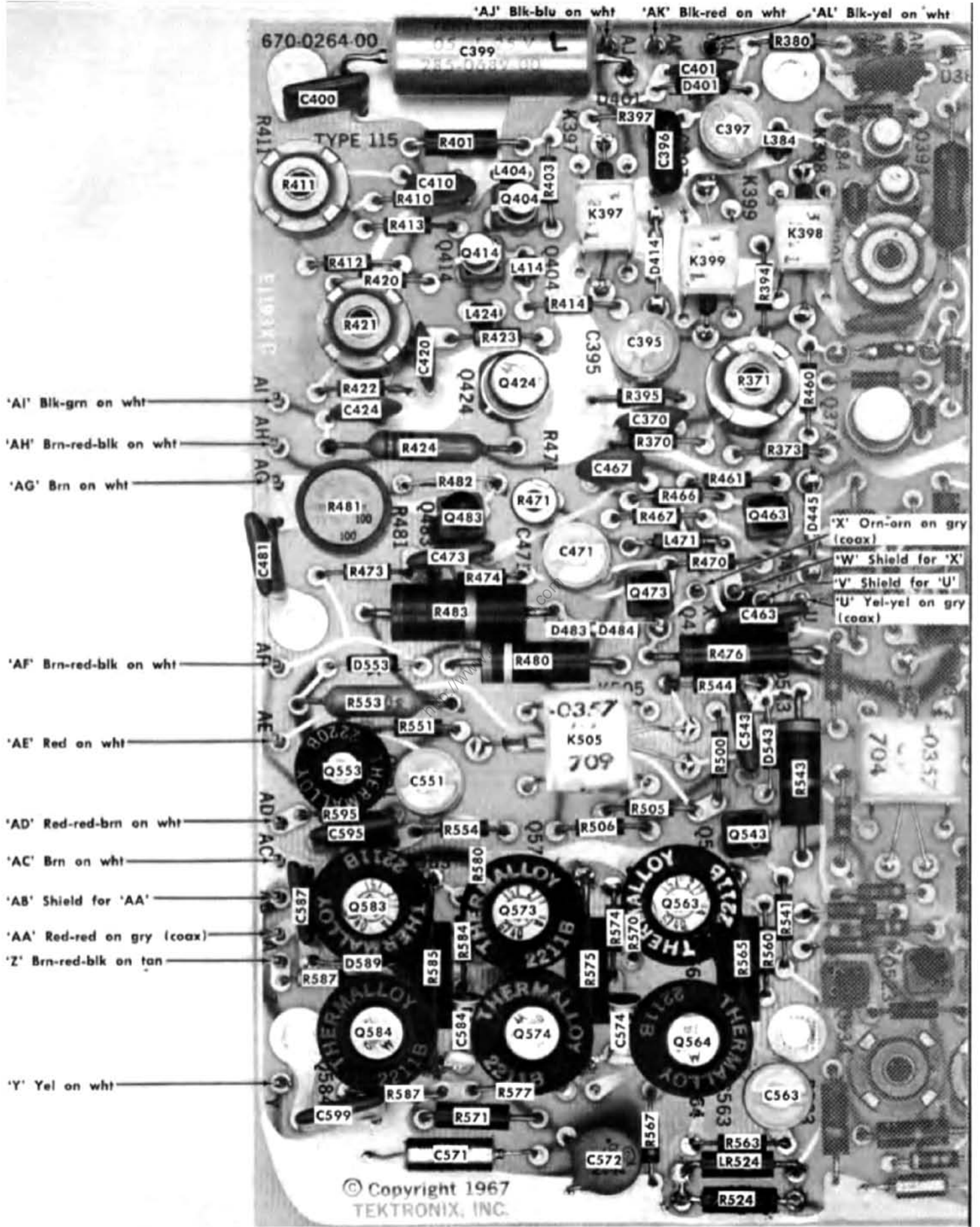


Fig. 4-8A. Component locations and wiring color code on bottom circuit board.

'AM' Blk on wht 'AN' Blk-vio on wht

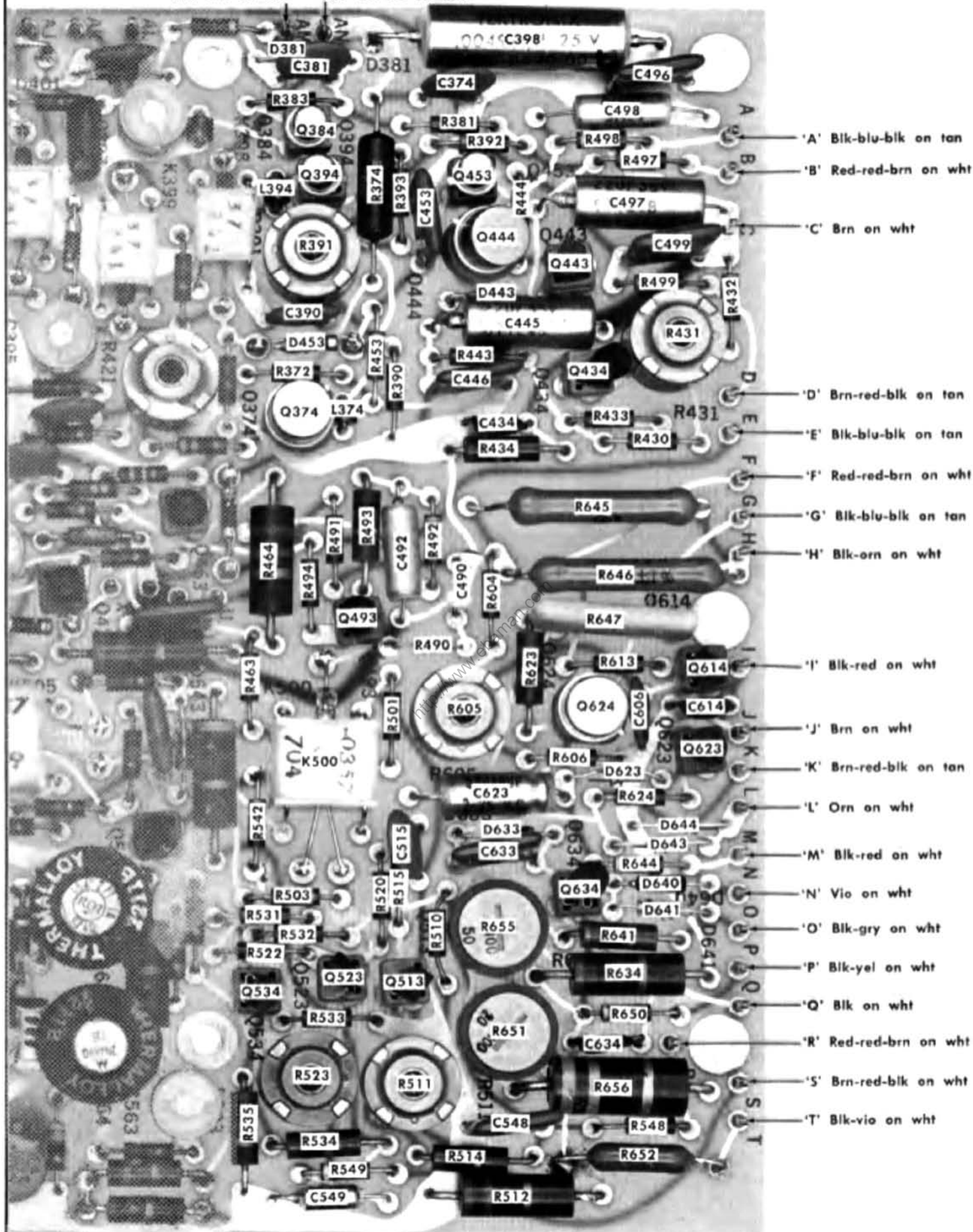


Fig. 4-8B. Component locations and wiring color code on bottom circuit board.

SECTION 5

PERFORMANCE CHECK AND CALIBRATION PROCEDURE

Change information, if any, affecting this section will be found at the rear of the manual.

General

This combined performance check and calibration procedure provides both a method of comparing the instrument to performance requirements given in the Specification section and a method of adjusting any instrument characteristics which do not meet this specification. A performance check and calibration record is included at the beginning of the procedure for use as a check list to verify correct calibration and operation of the Type 115 or as a guide for quick calibration by an experienced calibrator.

The Type 115 should be checked and recalibrated after each 1000 hours of operation or at least once every 6 months to ensure that it is operating properly. In addition, portions of the instrument will require recalibration if components are replaced or other electrical repairs are made.

The step by step instructions in this procedure furnish an orderly approach to the isolation of possible malfunctions and thus serve as an aid in troubleshooting the instrument. Any maintenance that is known to be needed should be performed before starting the calibration procedure. If any troubles become apparent during calibration, these also should be corrected before proceeding. Repair and servicing information is given in the Maintenance section of this manual.

EQUIPMENT REQUIRED

The following (or equivalent) items of equipment are required for a complete calibration of the Type 115. The equipment is illustrated in Fig. 5-1. If substitute equipment is used, its accuracy must exceed the tolerances to be measured by at least 4 times in order to make an accurate measurement.

1. Test oscilloscope, Tektronix Type 547 with Type 1A1 wideband Dual-Trace Amplifier Plug-In Unit. Minimum alternate requirements: Bandwidth from DC to 40 MHz; sweep rate from 10 ms/cm to 10 ns/cm (0.1 μ s/cm magnified by 10); internal and external triggering; amplitude calibrator output available (approximately 1 kHz); vertical deflection factors from 5 mV/cm to 5 V/cm; voltage accuracy of the display within 3%; alternate-trace switching.

2. Time-mark generator, Tektronix Type 184. Minimum alternate requirements: Time-mark outputs from 0.1 μ s to 10 ms; sine wave output of 10 ns; accuracy within 0.75%.

3. Variable autotransformer [e.g., General Radio, Variac Type W10MT3W]. Minimum requirements: Output voltage variable from 90 volts to 136 volts AC RMS for 115-volt operation

or from 180 volts to 272 volts AC RMS for 230-volt operation; output power rating at least 0.1 KVA. If monitor voltmeter is not included, separate AC voltmeter is required.

4. DC Voltmeter. Minimum suggested requirements: Voltage range 6 volts to 27 volts; basic accuracy within 3%; accuracy within 1% at 25 volts and 27 volts; sensitivity 20,000 ohms per volt.

5. Two 1 \times test probes, Tektronix P6011, with BNC connectors. Tektronix Part Number 010-0192-00.

6. Three 42 inch coaxial cables. Characteristic impedance approximately 50 Ω ; BNC connectors. Tektronix Part Number 012-0057-01. (One of these cables is included with the Type 115).

7. 50 Ω in-line termination with BNC connectors, 5 watt. Tektronix Part Number 011-0099-00. (Included with the Type 115).

8. 50 Ω in-line termination with BNC connectors. Tektronix Part Number 011-0049-00.

9. Coaxial T connector with BNC connectors. Tektronix Part Number 103-0030-00.

10. Plastic screwdriver-type adjustment tool. Tektronix Part Number 003-0000-00.

NOTE

The following equipment is needed only to perform steps 17 through 20 of this section. If the accuracy of the pulse characteristics adjusted and checked in these steps is not critical, these items of equipment may be omitted.

11. Sampling Oscilloscope, Tektronix Type 561A with Type 3S1 Dual-Trace Sampling Unit and Type 3T77A Sampling Sweep Unit. Minimum alternate requirements: Risetime of 2.5 ns; equivalent sweep rates of 0.2 μ s/cm to 2 ns/cm; vertical deflection factors from 1 mV/cm to 200 mV/cm; front-corner aberrations of $\pm 2\%$, and 2% peak-to-peak; external triggering, time-positioning capability (time delay); voltage accuracy within 3%.

12. 5-ns coaxial cable. Characteristic impedance approximately 50- Ω ; GR connectors. Tektronix Part Number 017-0502-00.

13. 50 Ω 10 \times attenuator with GR connectors. Tektronix Part Number 017-0078-00.

14. 50- Ω 5 \times attenuator with GR connectors. Tektronix Part Number 017-0079-00.

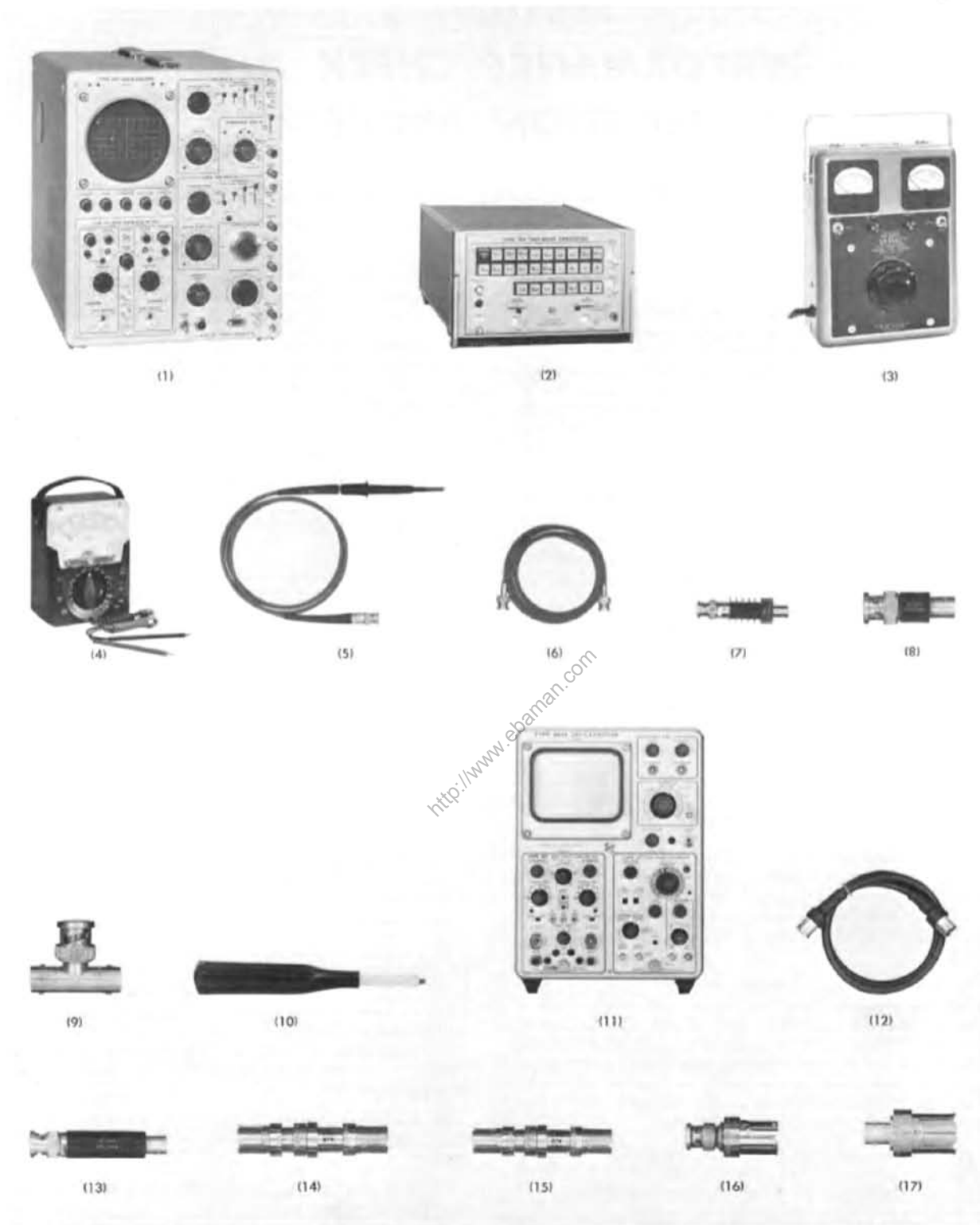


Fig. 5-1. Recommended test equipment.

15. 50- Ω 10 \times attenuator with BNC connectors. Tektronix Part Number 011-0059-00.

16. BNC female to GR connector adapter. Tektronix Part Number 017-0063-00.

17. BNC male to GR connector adapter. Tektronix Part Number 017-0064-00.

PERFORMANCE CHECK/CALIBRATION RECORD AND INDEX

The following abridged performance check and calibration procedure has been provided for use as a record of performance check and/or calibration or as a guide for an experienced calibrator. It may also serve as an index to locate a particular step in the procedure. Performance requirements given in the following correspond to those given in Section 1 of this manual.

Type 115, Serial No.

Performance Check/Calibration Date =

Checked/Calibrated by

POWER SUPPLY

- 1. Adjust +25-volt Supply (Page 5-7)
Adjust R727 for +25 volts with respect to signal ground.
- 2. Check Other Power Supply Voltages (Page 5-8)
-27 volts with respect to signal ground.
-6 volts with respect to signal ground.
+7 volts with respect to signal ground.
Chassis ground (while varying DC offset controls) with respect to signal ground.
- 3. Check Regulation (Page 5-8)
 \geq 15 mV ripple on +25-volt supply.
 \geq 50 mV ripple on +7-volt supply.
 \geq 30 mV ripple on -6-volt supply.
 \geq 15 mV ripple on -27-volt supply.
 \geq 20 mV ripple on chassis ground.
Measured differentially with respect to signal ground.

PRELIMINARY PULSE CIRCUIT ADJUSTMENTS

- 4. Adjust Risetime Centering (Page 5-10)
Adjust R391 for 0 volt between base of Q384 and base of Q394.
- 5. Adjust Falltime Centering (Page 5-11)
Adjust R411 for 0 volt between base of Q404 and base of Q414.
- 6. Adjust Width and Delay Trigger (Page 5-11)
Adjust R321 and R121 for stable delayed output pulse throughout range of DELAY OR BURST DURATION VARIABLE and WIDTH VARIABLE controls.
- 7. Adjust Offset Zero Level—Preliminary (Page 5-12)
Adjust R655 for zero offset with DC OFFSET (VOLTS) VARIABLE control set to 0 in + polarity.
- 8. Adjust Baseline Clamp (Page 5-12)
Adjust R481 for stable baseline throughout range of AMPLITUDE (VOLTS) control.

PULSE OFFSET AND AMPLITUDE

- 9. Adjust Offset Range (Page 5-14)
Adjust R605 for 10-volt DC offset with DC OFFSET AND AMPLITUDE MULT switch set to 1.0 and with DC OFFSET (VOLTS) VARIABLE control turned from +5 to -5.
- 10. Adjust DC Offset (+ Polarity) (Page 5-14)
Adjust R655 for zero DC offset with DC OFFSET (VOLTS) VARIABLE control set to 0.
- 11. Adjust + Amplitude (Page 5-15)
Adjust R431 for 10 volts amplitude of the positive-going pulse with AMPLITUDE (VOLTS) control set to 10 and DC OFFSET AND AMPLITUDE MULT switch set to 1.0.
- 12. Adjust Amplitude and DC Offset (—Polarity) Page 5-15
Adjust R523 for 10 volts amplitude of the negative-going pulse with the AMPLITUDE (VOLTS) control set to 10 and the DC OFFSET AND AMPLITUDE MULT switch set to 1.0. Adjust R511 and R561 for zero offset with DC OFFSET (VOLTS) VARIABLE control set to 0.
- 13. Check Offset Accuracy (Page 5-16)
10 volt range of DC OFFSET (VOLTS) VARIABLE control with DC OFFSET AND AMPLITUDE MULT switch set to 1.0, zero volts with control set to 0. 6 volt range of PRESET screwdriver adjustment.
- 14. Check Amplitude Accuracy (Page 5-16)
Amplitude of 10 volts, 5 volts \pm 5% and 2 volts \pm 5% with DC OFFSET AND AMPLITUDE MULT switch set to 1.0, .5 and .2 respectively and the AMPLITUDE (VOLTS) control set to 10 in both polarities.

RISETIME AND FALLTIME

- 15. Adjust Risetime and Falltime (Page 5-18)
Risetime and Falltime within 5% \pm 1 ns with RISE-TIME MULT and FALLTIME MULT controls set to 1. Adjust R371 and R421 for a risetime-falltime of 100 μ s. Adjust R375 and R425 for a risetime-falltime of 10 μ s. Adjust C397 for a risetime-falltime of 100 ns.
- 16. Check Risetime and Falltime Accuracy (Page 5-19)
Risetime and Falltime within 5% \pm 1 ns with RISE-TIME MULT and FALLTIME MULT controls set to 1.

PULSE SHAPE, FAST RISETIME AND FALLTIME

- 17. Adjust Pulse for Minimum Aberrations (Page 5-21)
Aberrations of less than \pm 3%, 3% peak-to-peak times the setting of the DC OFFSET AND AMPLITUDE MULT switch setting, whichever is greater. Adjust C551 and C563 while viewing pulse fall. Adjust C471 and R471 while viewing pulse top.
- 18. Check Pulse Aberrations (Page 5-21)
Aberrations of less than \pm 3%, 3% peak-to-peak times the setting of the DC OFFSET AMPLITUDE MULT switch setting, whichever is greater.

Performance Check/Calibration—Type 115

19. Adjust 10 ns and 100 ns Risetime and Falltime (Page 5-23)
Risetime and Falltime within 5% ± 1 ns with the RISETIME MULT and FALLTIME MULT controls set to 1. Adjust R376, R426 and C395 for a risetime and falltime of 10 ns. Adjust C397 for a risetime-falltime of 100 ns.

20. Check 10 ns Risetime and Falltime Accuracy (Page 5-23)
Risetime and Falltime within 5% ± 1 ns with the RISE-TIME AND FALTIME switch set to 10 ns and the RISE-TIME MULT and FALLTIME MULT controls set to 1

WIDTH GENERATOR

21. Adjust Pulse Width Timing (Page 5-26)
Width timing within 3% with WIDTH VARIABLE in CAL position (within 5% with WIDTH switch in the 50 ns position). Adjust R331 for a width of 550 μ s. Adjust R335 for a width of 50 μ s. Adjust C338 for a width of 50 ns.

22. Check Width Accuracy (Page 5-26)
Width timing within 3% with WIDTH VARIABLE in CAL position (within 5% with WIDTH switch in the 50 ns position).

DELAY GENERATOR

23. Adjust Pulse Delay Timing (Page 5-26)
Delay timing within 3% ± 10 ns with DELAY OR BURST DURATION VARIABLE control in the CAL position. Adjust R131 for a delay time of 550 μ s. Adjust R135 for a delay of 50 μ s. Adjust R134 and C138 for a delay of 50 ns.

24. Check Pulse Delay Timing (Page 5-28)
Delay timing within 3% ± 10 ns with the DELAY OR BURST DURATION VARIABLE control in the CAL position.

PERIOD GENERATOR

25. Adjust Pulse Period Timing (Page 5-29)
Period timing within 3% with the PERIOD VARIABLE control set to CAL (within 5% with the PERIOD switch set to 100 ns). Adjust R241 for a period of 11 ms. Adjust R245 for a period of 1 ms. Adjust C249C for a period of 1 μ s. Adjust C249A for a period of 100 ns.

26. Check Pulse Period Accuracy (Page 5-30)
Period timing within 3% with the PERIOD VARIABLE control set to CAL (within 5% with the PERIOD switch set to 100 ns).

MODES OF OPERATION, TRIGGERS AND TRIGGERING

27. Check Pretrigger and Delayed Trigger (Page 5-33)
Pretrigger and delayed trigger pulse amplitudes of greater than 2 volts into 1 k Ω .

28. Check Undelayed Pulse, Delayed Pulse and Paired Pulses (Page 5-33)
Correct selection of undelayed pulse, delayed pulse and paired pulses with the MODE switch.

29. Check External and Manual Triggering (Page 5-34)
Correct triggering of output pulse with externally applied trigger at the + TRIG IN connector (see Section 1 trigger specification). Correct triggering of output pulse with trigger received from MANUAL TRIG button.

30. Check Burst Mode (Page 5-34)
Correct output pulse when MODE switch is set to BURST.

31. Check Gated Output Mode (Page 5-35)
Correct output pulse when MODE switch is set to GATED.

PERFORMANCE CHECK AND CALIBRATION PROCEDURE

The following procedure is arranged to allow: (1) Checking of the performance of the Type 115 with respect to tolerances given in Section 1; (2) complete or partial adjustment of the Type 115 internal controls without a complete performance check; or (3) a complete recalibration of the Type 115, which includes adjustment of internal controls as well as a complete performance check. To perform any of the above operations, use one of the following methods:

Performance Check Only. Start with the PRELIMINARY PROCEDURE—Performance Check Only and perform only those steps with titles printed in Baskerville type throughout the main procedure. An example of this type can be seen in Step 13 on page 5-16.

Adjustment Only. Start with the PRELIMINARY PROCEDURE—Calibration Only and perform only those steps with titles followed by the adjustment symbol throughout the main procedure and the Calibration and Performance Check Procedure. An example of the heading and symbol can be seen in Step 1 on page 5-7.

Calibration. Start with the PRELIMINARY PROCEDURE—Calibration Only and perform all the steps throughout the main procedure.

When doing a complete calibration or a complete adjustment of internal controls of the instrument, the best overall performance will be obtained if each adjustment is made to the exact setting, even if the observed performance is within tolerance. When doing only a partial adjustment, however, do not readjust any controls unless the observed performance is not within tolerance. In either case, do not preset any adjustments unless they are known to be significantly out of adjustment or unless repairs have been made in the circuit. In these instances, set the particular controls to midrange.

A picture of the initial setup of the Type 115 and related test equipment is shown for each major group of adjustments and/or checks. Beneath each setup picture is a complete list of front-panel control settings of the Type 115, plus significant control settings of the test instruments. Any control that has been changed from the setting at the end of the preceding step is given in boldface type. These control settings can be used no matter which of the three procedures is to be used. If adjustments and/or checks are made without following one of the three procedures, start with the nearest initial setup preceding the desired adjustment or check and follow the sequence up to the desired step, making changes in control setting as indicated.

PRELIMINARY PROCEDURE

Performance Check Only

1. Set the line voltage selector switch on the Type 115 rear panel in accordance with the line voltage source to be used.

2. Connect the Type 115 to the line voltage source.

3. Install the Type 1A1 Plug-In Unit in the Type 547 Oscilloscope and connect the instrument to a suitable power source.

4. Connect a 50- Ω coaxial cable, terminated with a 5 watt 50- Ω termination, (Tektronix Part No. 011-0099-00) from the Type 115 OUTPUT connector to the Channel 1 vertical input of the test oscilloscope.

5. Turn on the Type 115 and the test oscilloscope. Allow at least 20 minutes warm-up at an ambient temperature of between 0° C and +50° C (+32° F and +122° F) before making any checks.

6. Set the instrument controls as shown in Fig. 5-7 and start the performance check procedure with step 13 on page 5-16.

Calibration Only

1. Remove the Type 115 from its cabinet.

2. Set the line voltage selector assembly on the Type 115 rear panel in accordance with the line voltage source to be used.

3. Connect the autotransformer and other test instruments to a suitable power source.

4. Connect the Type 115 to the autotransformer output.

5. Set the autotransformer for the line voltage and range chosen on the Type 115 line voltage selector.

6. Install the Type 1A1 Plug-In Unit in the Type 547 Oscilloscope.

7. Connect a 50- Ω coaxial cable terminated with a 5-watt, 50- Ω termination (Tektronix Part No. 011-0099-00), to the Type 115 OUTPUT connector.

8. Check that the seven variable controls on the front panel of the Type 115 are correctly aligned: Variables at the CAL position when fully counterclockwise, RISE TIME MULT and FALL TIME MULT controls at the 1 position when fully counterclockwise, AMPLITUDE (VOLTS) control at the 10 position when fully clockwise and DC OFFSET VARIABLE at the 0 position when it is in the center of its range of rotation. Realign any knob that is not correctly positioned.

9. Turn on the autotransformer, the Type 115 and the test instruments.

10. Allow at least 20 minutes warm-up at an ambient temperature of +25° C \pm 5° C (+77° F \pm 9° F) before making any checks or adjustments.

11. Connect the two 1 \times test probes to the vertical inputs of the test oscilloscope.

12. Set the instrument controls as given following Fig. 5-2 and start the adjustment or calibration procedure with step 1 on page 5-7.

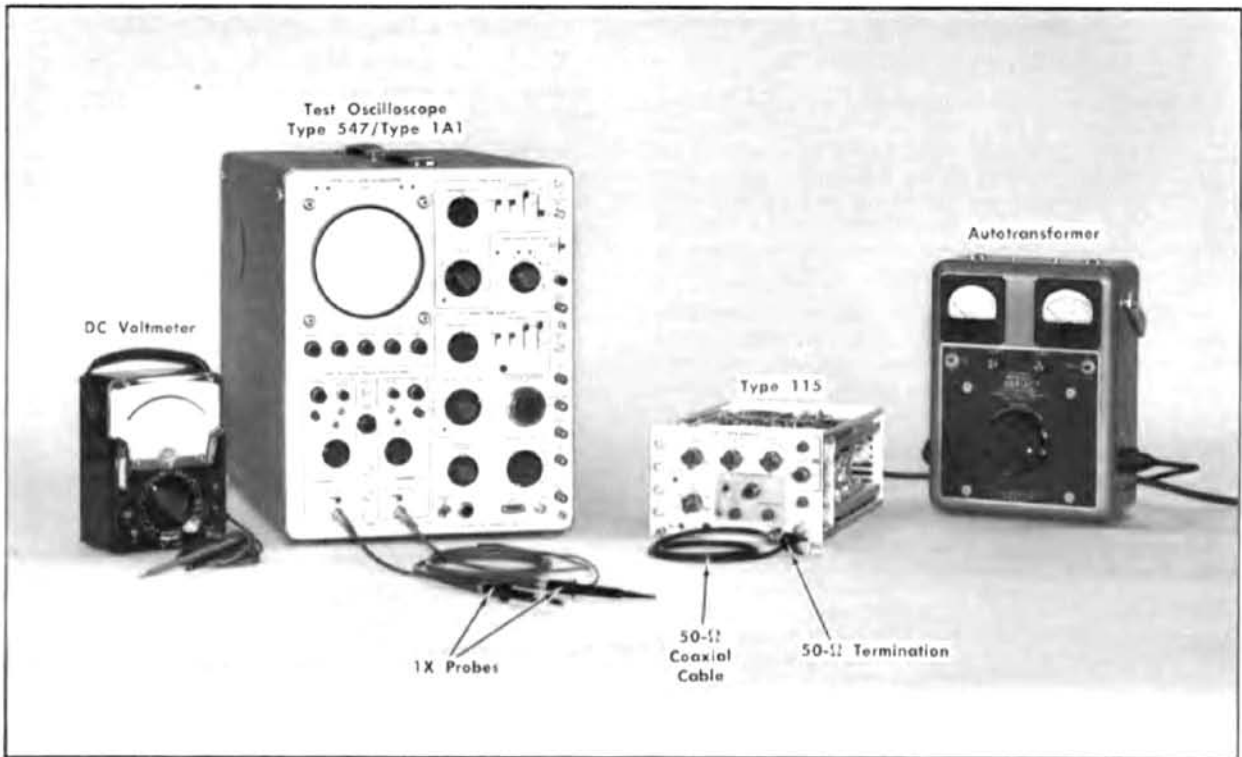


Fig. 5-2. Initial test equipment setup for steps 1 through 3.

Control Settings

	Type 115	AMPLITUDE (VOLTS)	10
		DC OFFSET PRESET-VARIABLE switch	VARIABLE
MODE	UNCLY'D PULSE	DC OFFSET (VOLTS) VARIABLE	0
TRIGGER	MAN OR EXTERNAL	PULSE POLARITY	+
PERIOD	10 μ s		
VARIABLE	CAL	Test Oscilloscope	
DELAY OR BURST DURATION	50 nS	Time/cm	5 ms (Calibrated)
VARIABLE	CAL	Sweep Magnifier	Off
WIDTH	5 μ s	Triggering	+, AC, Line
VARIABLE	CAL	Vertical Mode	Add
RISETIME AND FALLTIME	10 ns	Volts/Cm (Channel 1)	0.01
RISETIME MULT	1	Volts/Cm (Channel 2)	0.01
FALLTIME MULT	1	Invert (Channel 2)	Invert
DC OFFSET AND AMPLITUDE MULT	1	Input Selector	AC
		Amplitude Calibrator	Off

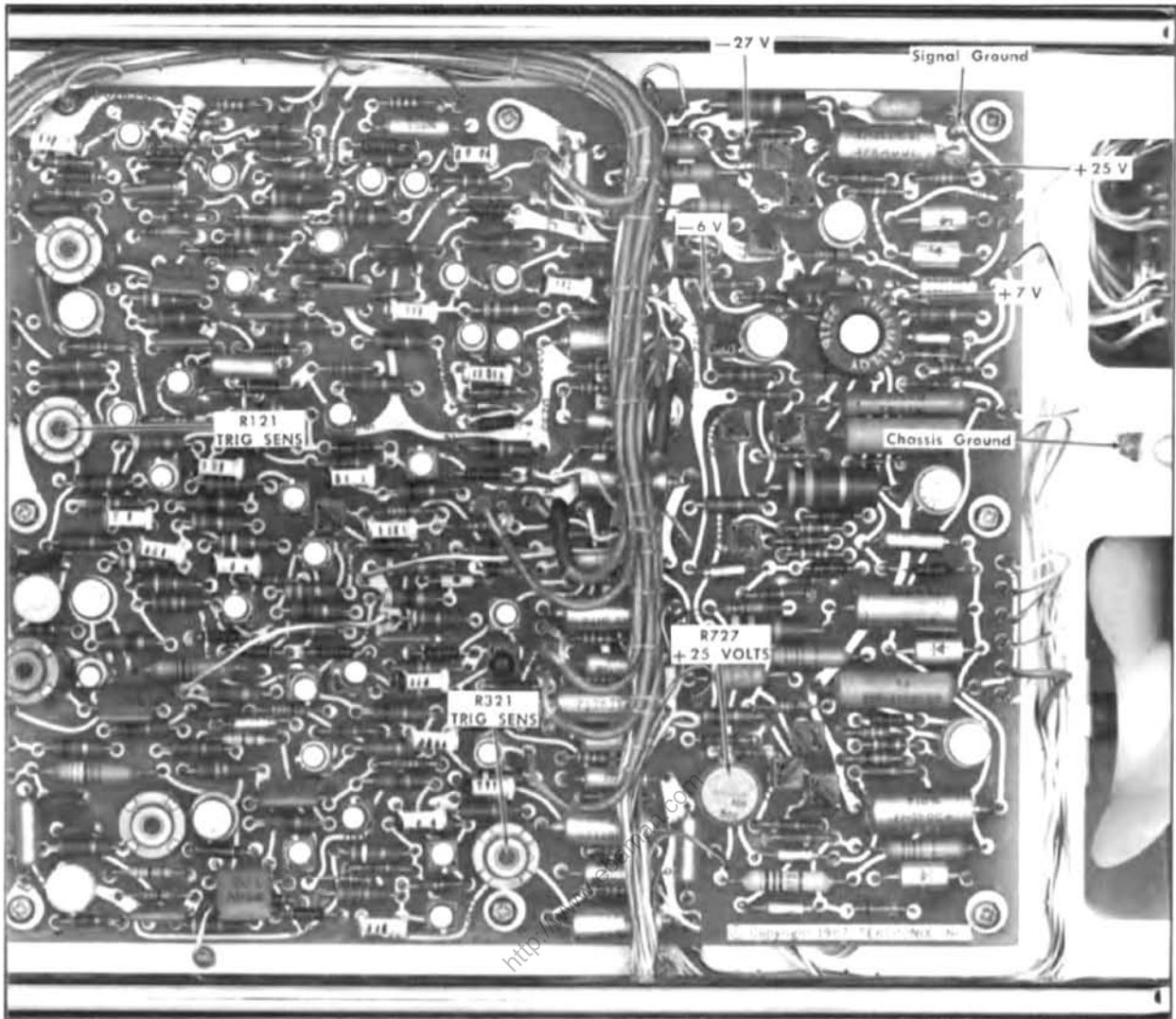


Fig. 5-3. Top circuit board: Location of adjustments and test points in steps 1, 2 and 6.

POWER SUPPLY

NOTE

The power supply voltages and the ripple tolerances listed in the following 3 steps are guides to correct instrument operation; not instrument performance requirements. Actual measured values may vary from the listed voltages with no loss in pulse accuracy, providing the instrument meets the performance requirements in Section 1 as tested in this procedure.

1. Adjust +25-volt Supply

- a. Test equipment setup is shown in Fig. 5-2.
- b. Position the Type 115 so that the top circuit board is visible.
- c. Connect the negative lead of the DC voltmeter to the signal ground test point (see Fig. 5-3) and the positive lead to the +25-V test point.
- d. CHECK FOR—DC voltmeter reading of +25 volts with respect to signal ground.
- e. ADJUST—R727, +25-VOLTS adjustment, (see Fig. 5-3) if the voltage is not correct.

Performance Check/Calibration—Type 115

NOTE

The voltage level of the +25-volt supply affects the calibration of the entire instrument. Any adjustment of R727 will probably require the readjustment of all other instrument adjustments as well.

f. (If doing only the Adjust steps, disconnect the meter leads and go to Step 4).

2. Check Other Power Supply Voltages

NOTE

All voltages are measured with respect to signal or common ground.

a. Move the positive lead of the DC voltmeter to the +7-V point (see Fig. 5-3).

b. CHECK FOR—Meter reading of approximately +7 volts with respect to signal ground.

c. Move the positive lead of the DC voltmeter to the signal ground test point (or reverse the polarity of the meter).

d. Move the negative lead to the -27-V test point (see Fig. 5-3).

e. CHECK FOR—Meter reading of approximately -27 volts with respect to signal ground.

f. Move the negative lead to the -6-V test point (see Fig. 5-3).

g. CHECK FOR—Meter reading of approximately -6 volts with respect to signal ground.

h. Move the negative lead to the chassis ground test point (see Fig. 5-3).

i. While observing the DC voltmeter reading, turn the Type 115 DC OFFSET VARIABLE control throughout its range, then set the PULSE POLARITY switch to — and again turn the DC OFFSET VARIABLE control throughout its range.

j. CHECK FOR—Meter reading ranging from approximately +8 volts to +18 volts in + polarity and from +1 volt to +10 volts in — polarity.

k. Reset the following Type 115 controls:

DC OFFSET VARIABLE 0
PULSE POLARITY +

l. Disconnect the DC voltmeter leads from the Type 115.

3. Check Regulation

a. Trigger the test oscilloscope on the internal line signal.

b. Connect the Channel 2 1× probe to the Type 115 signal ground test point.

c. Connect the ground clips of both 1× test probes to chassis ground.

CAUTION

Do not connect the probe ground clip to signal ground. This will ground the power supply causing incorrect operation and possible damage of the instrument.

d. Connect the Channel 1 1× test probe tip to the test points of each of the power supplies given in Table 5-1.

e. With the probe connected to each test point, observe the test oscilloscope display while varying the autotransformer output voltage over the regulating range selected by the Line Voltage Selector assembly on the rear panel.

f. CHECK FOR—Test oscilloscope display of power supply ripple with the line frequency ripple amplitude not exceeding the maximum value given in Table 5-1.

g. Disconnect the probe tips and ground clips from the Type 115.

h. Remove the 1× probes from the test oscilloscope vertical inputs.

i. Disconnect the Type 115 from the autotransformer and connect it directly to the power source, or set the autotransformer output voltage to the center of the regulated range selected by the Line Voltage selector assembly.

TABLE 5-1

POWER SUPPLY REGULATION CHECKS

Voltage Test Point (Fig. 5-3)	Ripple (60 Hz or 120 Hz Component)	
	Voltage (peak-to-peak)	Display Amplitude
+25 V	15 mV	1.5 cm
+ 7 V	50 mV	5 cm
- 6 V	30 mV	3 cm
-27 V	15 mV	1.5 cm
Chassis Ground	20 mV	2 cm

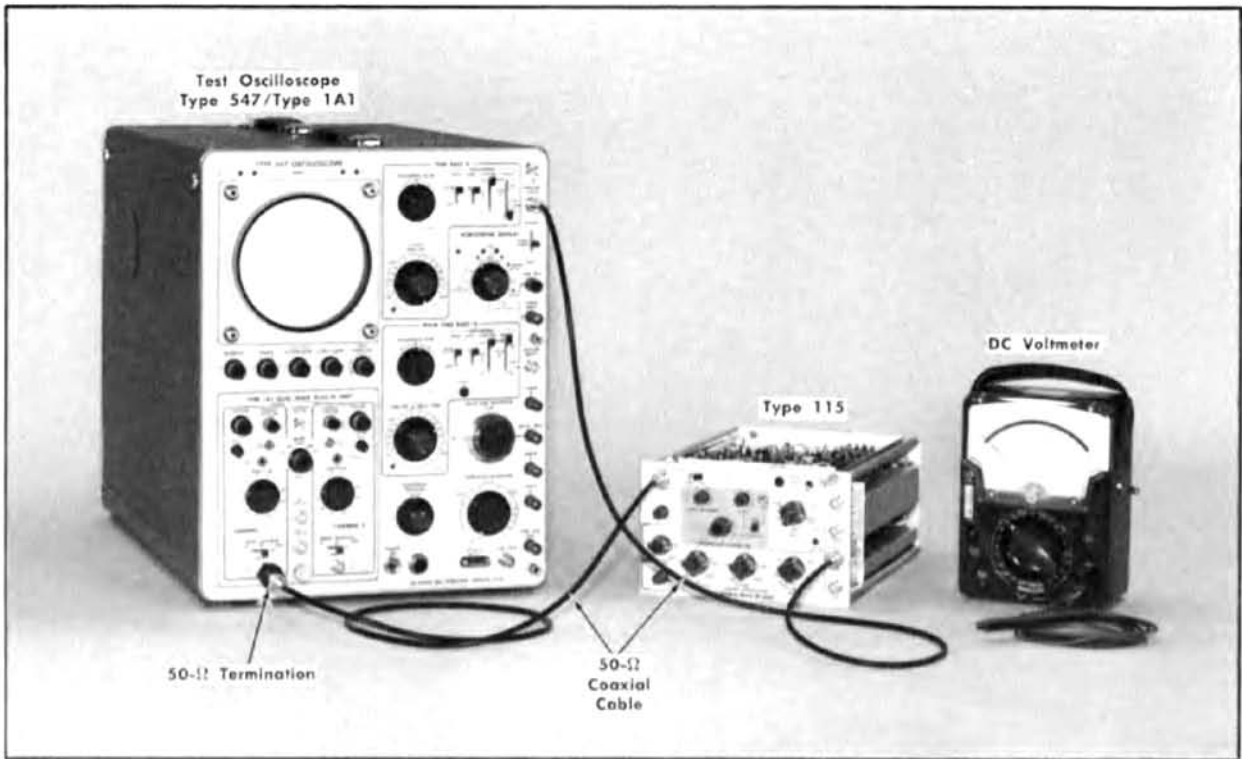


Fig. 5-4. Initial test equipment setup for steps 4 through 8.

Control Settings

	Type 115	
MODE	UNDLY'D PULSE	
TRIGGER	INT	
PERIOD	10 μ S	
VARIABLE	CAL	
DELAY OR BURST DURATION	50 ns	
VARIABLE	CAL	
WIDTH	5 μ s	
VARIABLE	CAL	
RISETIME AND FALLTIME	10 ns	
RISETIME MULT	1	
FALLTIME MULT	1	
DC OFFSET AND AMPLITUDE MULT	1	

AMPLITUDE (VOLTS)	10
DC OFFSET PRESET-VARIABLE switch	VARIABLE
DC OFFSET (VOLTS) VARIABLE	0
PULSE POLARITY	+

Test Oscilloscope

Time/cm	2 μs
Triggering	Trig, +, AC, Norm
Vertical Mode	Channel 1
Volts/cm (Channel 1)	2
Invert (Channel 2)	Normal
Input Selector	DC

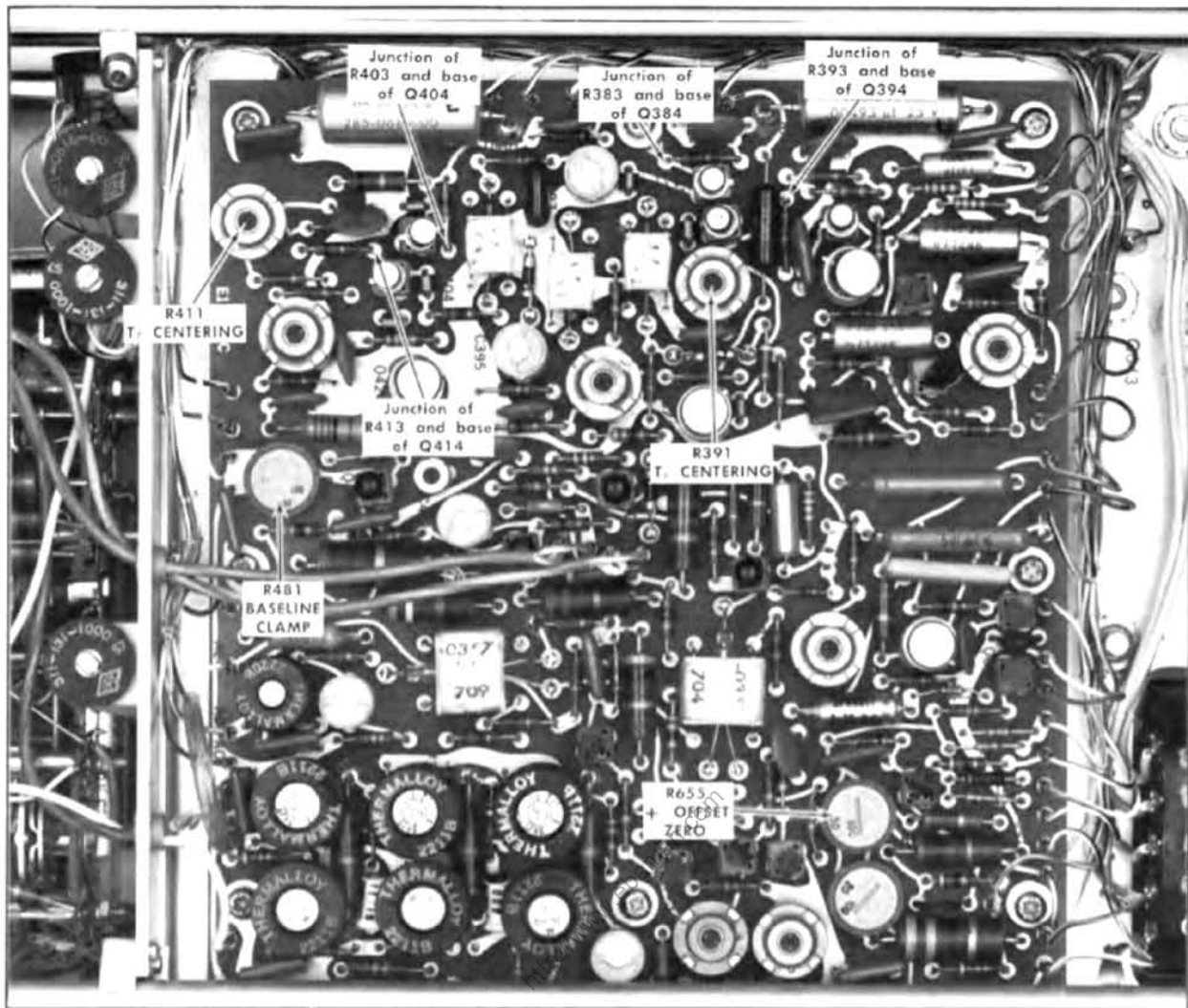


Fig. 5-5. Bottom circuit board: Location of test points and adjustments in steps 4 through 8.

PRELIMINARY PULSE CIRCUIT ADJUSTMENTS

4. Adjust Risetime Centering



- a. Test equipment setup is shown in Fig. 5-4.
- b. Connect the Type 115 output pulse through the terminated 50-Ω coaxial cable to the Channel 1 vertical input of the test oscilloscope.
- c. Trigger the test oscilloscope display.
- d. If a stable pulse display appears, adjustment of the risetime and falltime centering is probably not necessary. Proceed to step 6.
- e. Position the Type 115 so that the bottom circuit board is visible.
- f. Connect the negative lead of the voltmeter to the junction of R383 and the base of Q384 (see Fig. 5-5).
- g. Connect the positive lead of the voltmeter to the junction of R393 and the base of Q394 (see Fig. 5-5).
- h. CHECK FOR—Meter reading of approximately 0 volts.
- i. ADJUST—R391, T_r CENTERING adjustment, (see Fig. 5-5) if the voltage is not correct.

5. Adjust Falltime Centering

- Connect the negative lead of the voltmeter to the junction of R403 and the base of Q404 (see Fig. 5-5).
- Connect the positive lead of the voltmeter to the junction of R413 and the base of Q414 (see Fig. 5-5).
- CHECK FOR—Meter reading of approximately 0 volts.
- ADJUST—R411, T, CENTERING adjustment, (see Fig. 5-5) if the voltage is not correct.
- Disconnect the voltmeter from the Type 115.
- Position the Type 115 so that the top circuit board is visible.

6. Adjust Width and Delay Trigger

- Set the test oscilloscope Trigger Source switch to External and the Time/Cm switch to $0.2 \mu\text{s}$.
- Connect a $50\text{-}\Omega$ coaxial cable between the Type 115 + PRETRIG OUT connector and the test oscilloscope External Trigger Input.
- Trigger the test oscilloscope display.
- Set the Type 115 MODE switch to DLY'D PULSE and the WIDTH switch to 50 ns.
- Observe the test oscilloscope display (see Fig. 5-6) while performing the following four operations:
 - Turn the DELAY OR BURST DURATION VARIABLE control slowly clockwise to the fully clockwise position (B).
 - Turn the WIDTH VARIABLE control slowly clockwise to the fully clockwise position (C).
 - Turn the DELAY OR BURST DURATION VARIABLE control slowly counterclockwise back to the CAL position (D).
 - Turn the WIDTH VARIABLE control slowly counterclockwise back to the CAL position (E).
- CHECK FOR—Stable test oscilloscope display of the Type 115 delayed output pulse throughout the preceding checks.
- Reset the following Type 115 controls:

PERIOD	1 ms
VARIABLE	Fully clockwise
DELAY OR BURST	
DURATION	$50 \mu\text{s}$
WIDTH	$50 \mu\text{s}$
- Set the test oscilloscope sweep rate to 0.2 ms/cm .
- Repeat steps e and f at these control settings.
- ADJUST—R321, TRIG SENS Adjustment, (see Fig. 5-3) in the width generator circuit, according to the following procedure, if the pulse is not present, is unstable or disappears during steps e through i.
 - Set the Oscilloscope sweep rate to $0.2 \mu\text{s/cm}$.

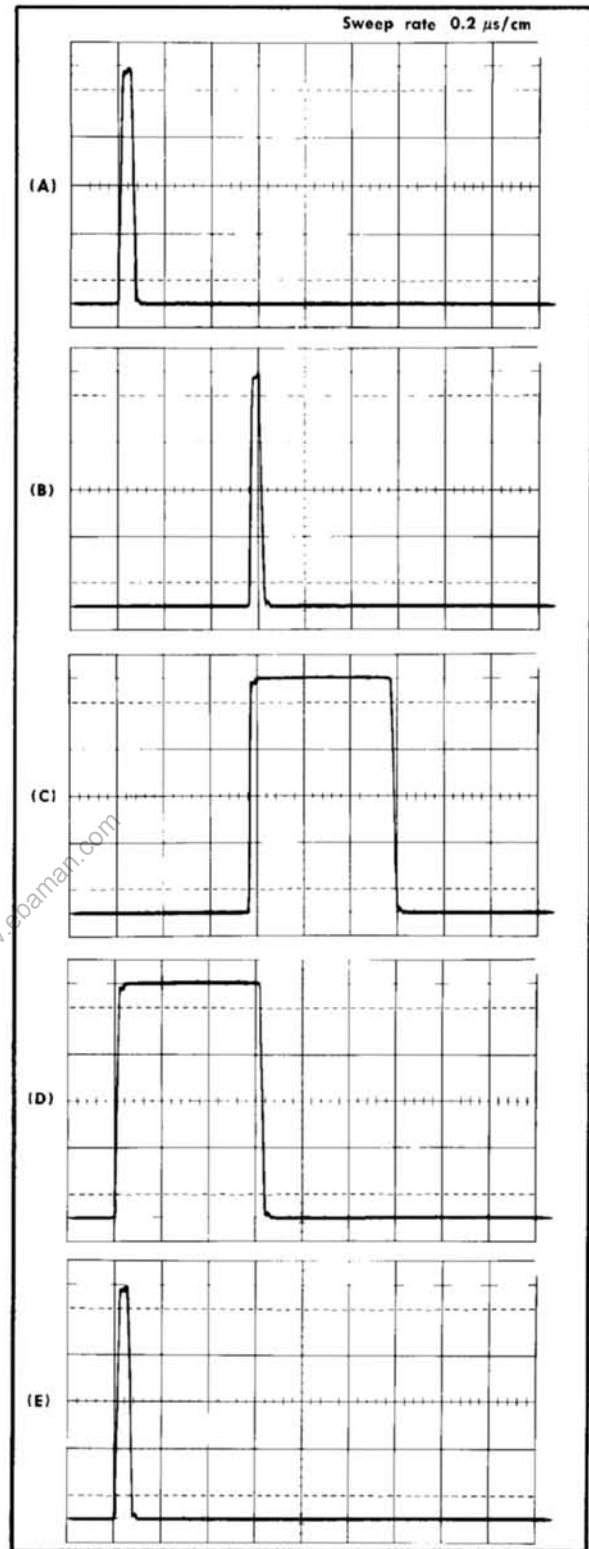


Fig. 5-6. Typical test oscilloscope displays obtained during check of width and delay trigger sensitivity adjustments (step 6e).

Performance Check/Calibration—Type 115

2. Reset the following Type 115 controls:

MODE	UNDLY'D PULSE
PERIOD	10 μ S
VARIABLE	CAL
DELAY OR BURST DURATION	50 ns
VARIABLE	CAL
WIDTH	50 ns
VARIABLE	Fully clockwise

3. Turn R321 (TRIG SENS) through its range of rotation and observe the region over which the Type 115 output pulse is present and stable.

4. Turn R321 slowly counterclockwise through the stable pulse region and note the position of the falling edge of the pulse when the width generator starts to free run.

5. Set R321 slightly clockwise from the free-run position. The pulse width should just start to decrease from the maximum width present before free-run, but should not decrease by more than 1 mm.

6. Turn the WIDTH VARIABLE to the CAL position. The pulse should still be present if the adjustment is correct.

7. Recheck the width and delay trigger sensitivity as given in steps d through j.

k. ADJUST—R121, TRIG SENS adjustment, (see Fig. 5-3) in the delay generator circuit, according to the following procedure, if the delayed output pulse is still not stable after the width trigger sensitivity has been adjusted.

1. Set the test oscilloscope sweep rate to 0.2 μ s/cm.

2. Reset the following Type 115 controls:

MODE	DLY'D PULSE
PERIOD	10 μ S
VARIABLE	CAL
DELAY OR BURST DURATION	50 ns
VARIABLE	Fully clockwise
WIDTH	50 ns
VARIABLE	CAL

3. Turn R121 through its range of rotation and note the region over which the pulse remains present and stable.

4. Set R121 as far clockwise as possible without causing the pulse to disappear.

5. Turn the Type 115 DELAY OR BURST DURATION VARIABLE control slowly counterclockwise until the pulse becomes unstable.

6. Turn R121 slightly counterclockwise until the pulse again becomes stable.

7. Repeat parts 5 and 6 until the DELAY OR BURST DURATION VARIABLE is in the CAL position.

8. Turn the DELAY OR BURST DURATION VARIABLE control throughout its range while checking for a stable pulse.

9. Recheck the width and delay trigger sensitivity as in steps e through i.

7. Adjust Offset Zero Level—Preliminary ①

a. Position the Type 115 so that the bottom circuit board is visible.

b. Reset the following Type 115 controls:

MODE	UNDLY'D PULSE
PERIOD	10 μ S
VARIABLE	CAL
WIDTH	500 ns
VARIABLE	CAL

c. Reset the following test oscilloscope controls:

Time/cm	2 μ s
Volts/cm	0.5
Input	Gnd

d. Free run the trace and position it to the center horizontal line of the CRT graticule.

e. Set the test oscilloscope Input Selector switch to DC.

f. CHECK FOR—Test oscilloscope display with the pulse baseline at the center horizontal line with the DC OFFSET control set exactly to 0.

g. ADJUST—R655, +OFFSET ZERO adjustment, (see Fig. 5-5) if the offset zero level is not correct.

8. Adjust Baseline Clamp ①

a. Check to be sure the Type 115 DC OFFSET VARIABLE control is exactly on 0.

b. Set the Type 115 AMPLITUDE (VOLTS) control to 0.

c. Position the pulse baseline to the center horizontal line of the CRT graticule.

d. Set the Type 115 AMPLITUDE (VOLTS) control to 10.

e. CHECK FOR—Test oscilloscope display of the pulse baseline at the center horizontal line.

f. ADJUST—R481, BASELINE CLAMP adjustment, (see Fig. 5-5) if the baseline level is not correct.

g. Turn the AMPLITUDE (VOLTS) control throughout its range and check that the baseline does not move up or down on the CRT with changes in pulse amplitude.

h. If the baseline still does not remain constant, readjust R481.

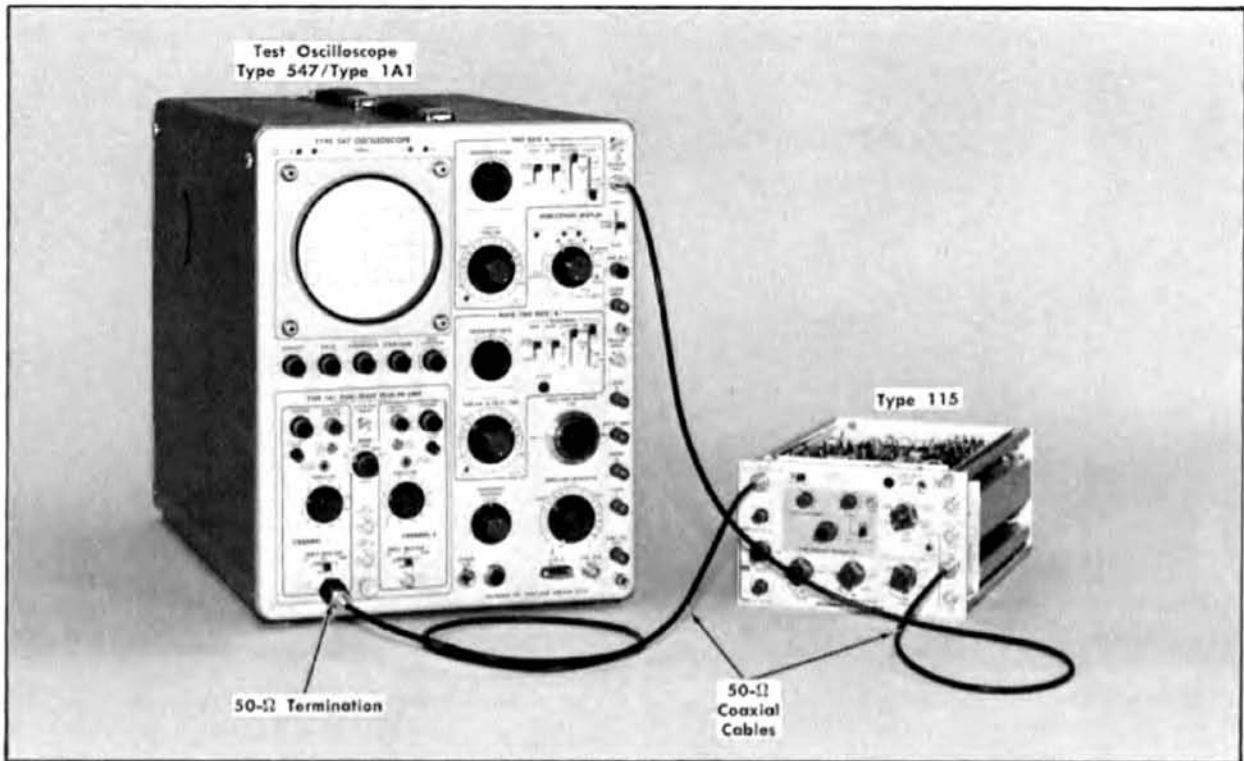


Fig. 5-7. Initial test equipment setup for steps 9 through 14.

Control Settings

	Type 115
MODE	UNDLY'D PULSE
TRIGGER	INT
PERIOD	100 μ S
VARIABLE	CAL
DELAY OR BURST DURATION	50 μ S
VARIABLE	CAL
WIDTH	50 μ S
VARIABLE	CAL
RISETIME AND FALLTIME	1 μ S
RISETIME MULT	1
FALLTIME MULT	1

DC OFFSET AND AMPLITUDE MULT	1
AMPLITUDE (VOLTS)	10
DC OFFSET PRESET-VARIABLE switch	VARIABLE
DC OFFSET (VOLTS) VARIABLE	+5
PULSE POLARITY	+
	Test Oscilloscope
Time/cm	20 μS
Triggering	External
Vertical Mode	Channel 1
Volts/Cm (Channel 1)	2
Volts/Cm (Channel 2)	2
Invert (Channel 2)	Normal
Input Selector	DC

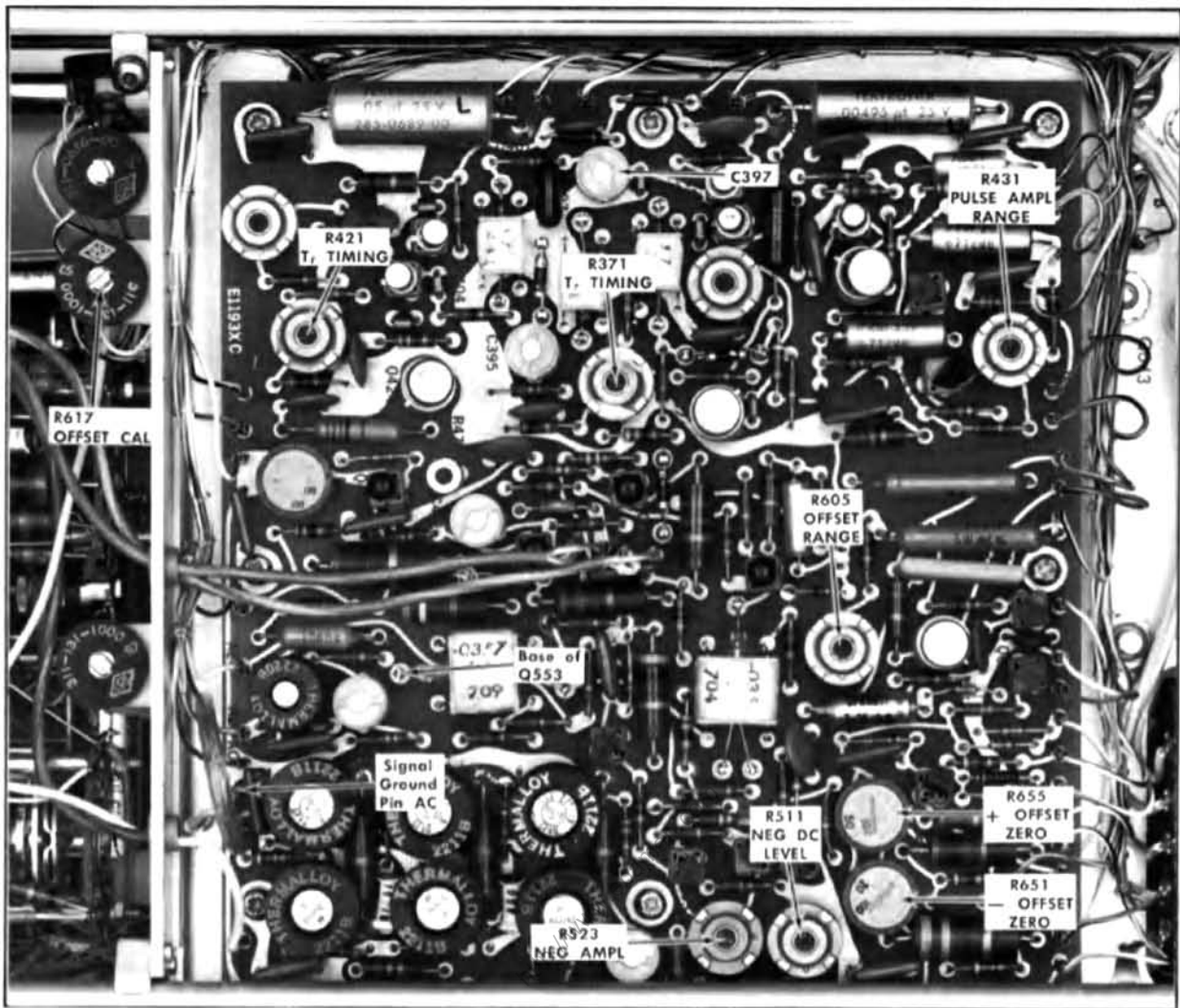


Fig. 5-8. Bottom circuit board: Location of adjustments in steps 9 through 15.

PULSE OFFSET AND AMPLITUDE

9. Adjust Offset Range

- Test equipment setup is shown in Fig. 5-7.
- Position the pulse baseline 2.5 cm above the center horizontal line of the CRT graticule.
- Set the DC OFFSET VARIABLE control to -5 .
- CHECK FOR—Test oscilloscope display with the pulse baseline 2.5 cm below the center horizontal line (10 volts offset).
- ADJUST—R605, OFFSET RANGE adjustment, (see Fig. 5-8) if the pulse baseline is not correct.
- If R605 requires adjustment reset the DC OFFSET

VARIABLE to $+5$ and recheck the offset range as in parts b through e.

10. Adjust DC Offset (+ Polarity)

- Set the Type 115 DC OFFSET VARIABLE control to -5 .
- Set the test oscilloscope Input Selector switch to Gnd.
- Free run the trace and position it to the center horizontal line of the CRT graticule.
- Set the test oscilloscope Input Selector switch to DC.
- CHECK FOR—Test oscilloscope display with the pulse baseline 2.5 cm below the center horizontal line.
- ADJUST—R655, + OFFSET ZERO adjustment, (see Fig. 5-8) if the baseline level is not correct.

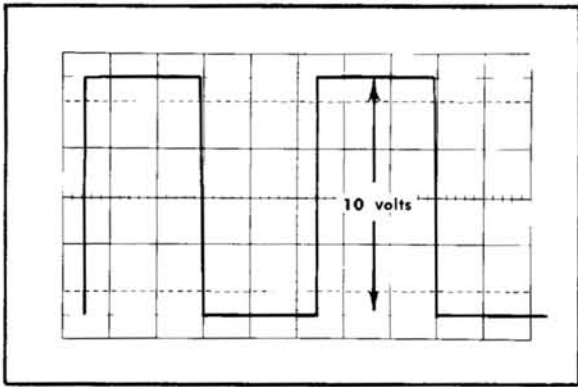


Fig. 5-9. Test oscilloscope display for checking amplitude adjustment.

g. Turn the Type 115 DC OFFSET VARIABLE control clockwise until the pulse baseline is on the center horizontal line of the CRT graticule.

h. CHECK FOR—Index dot on the Type 115 DC OFFSET VARIABLE control knob aligned with the 0 on the front-panel.

i. If the dot position is not correct, loosen the Allen screw on the DC OFFSET VARIABLE control-knob and realign the knob so that the dot coincides with the 0 on the Type 115 front-panel when the pulse baseline is on the center horizontal line of the CRT graticule.

11. Adjust + Amplitude

a. Position the pulse with the test oscilloscope vertical position control so that it is centered on the CRT (see Fig. 5-9).

b. CHECK FOR—Test oscilloscope display of the pulse with an amplitude of 5 cm (10 volts).

c. ADJUST—R431, PULSE AMPL RANGE adjustment, (see Fig. 5-8) for a pulse amplitude of 10 volts.

12. Adjust Amplitude and DC Offset (— Polarity)

a. Set the Type 115 PULSE POLARITY switch to —.

b. Position the pulse so that it is centered on the CRT with the test oscilloscope Vertical Position control.

c. CHECK FOR—Test oscilloscope display of the negative-going pulse with an amplitude of 5 cm (10 volts).

d. ADJUST—R523, NEG AMPL adjustment, (see Fig. 5-8) for an amplitude of the negative-going pulse of 10 volts.

e. Disconnect the Type 115 output pulse from the test oscilloscope vertical input.

f. Connect two 1X test probes to the vertical inputs of the test oscilloscope.

NOTE

Be sure that the gain of each channel is the same. Check with the amplitude calibrator.

- g. Set the Type 115 PULSE POLARITY switch to +.
- h. Reset the following test oscilloscope controls:

Vertical Mode	Add
Channel 2 Invert	Invert
- i. Connect the Channel 2 probe tip to signal ground (see Fig. 5-8).
- j. Connect the Channel 1 probe tip to the base of Q553 (see Fig. 5-8).
- k. Position the pulse baseline 1 cm below the center horizontal line on the CRT screen with the test oscilloscope Vertical Position control (see Fig. 5-10A).
- l. Set the Type 115 PULSE POLARITY switch to —.
- m. CHECK FOR—Test oscilloscope display with the signal envelope of the negative-going pulse at the same level as that of the positive-going pulse (see Fig. 5-10B).
- n. ADJUST—R511 NEG DC LEVEL adjustment, (see Fig. 5-8) if the display is not correct.
- o. Disconnect the two probe tips from the Type 115 and disconnect the probes from the vertical input connectors of the test oscilloscope.
- p. Reconnect the Type 115 output pulse to the Channel 1 vertical input connector of the test oscilloscope.

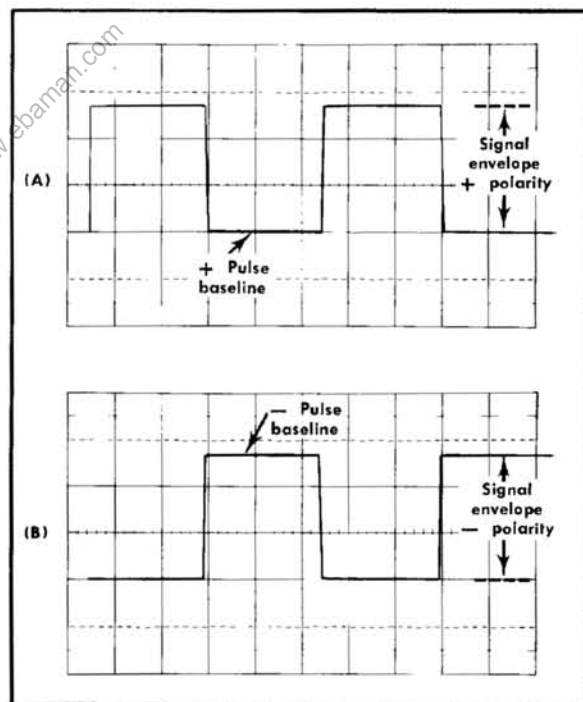


Fig. 5-10. Test oscilloscope display for checking adjustment of — polarity DC level.

Performance Check/Calibration—Type 115

q. Reset the following test oscilloscope controls:

Vertical Mode	Channel 1
Input Selector	Gnd

r. If R523 and/or R511 have been adjusted, reset the test oscilloscope Input Selector switch to DC and recheck the adjustments in parts b through n.

s. Free run the trace and position it to the center horizontal line of the CRT graticule.

t. Set the test oscilloscope Input Selector switch to DC.

u. CHECK FOR—Test oscilloscope display with the baseline of the negative-going pulse at the center horizontal line of the CRT graticule. (Be sure the Type 115 DC OFFSET VARIABLE control is set to 0).

v. ADJUST—R651, — OFFSET ZERO adjustment (see Fig. 5-8) if the zero offset is not correct.

13. Check Offset Accuracy

a. (If steps 9, 10 and 12 have just been completed, go to part n of this step). Test equipment is shown in Fig. 5-7.

b. Set the Type 115 DC OFFSET VARIABLE control to 0.

c. Set the test oscilloscope Input Selector switch to Gnd.

d. Free-run the trace and position it to the center horizontal line of the CRT graticule.

e. Set the test oscilloscope Input Selector switch to DC.

f. CHECK FOR—Test oscilloscope display with the baseline of the positive-going pulse at the center horizontal line of the CRT graticule.

g. Set the Type 115 PULSE POLARITY switch to —.

h. CHECK FOR—Test oscilloscope display with the baseline of the negative-going pulse at the center horizontal line of the CRT graticule.

i. Set the Type 115 PULSE POLARITY switch to +.

j. Set the Type 115 DC OFFSET VARIABLE control to +5.

k. CHECK FOR—Test oscilloscope display of the pulse baseline 2.5 cm (5 volts) above the center horizontal line of the CRT graticule.

l. Set the Type 115 DC OFFSET VARIABLE control to -5.

m. CHECK FOR—Test oscilloscope display of the pulse baseline 2.5 cm (5 volts) below the center horizontal line of the CRT graticule.

n. Set the Type 115 DC OFFSET PRESET-VARIABLE switch to PRESET.

o. Set the Type 115 front-panel PRESET screwdriver adjustment on fully clockwise.

p. Position the pulse baseline 1.5 cm above the center horizontal line of the CRT graticule.

q. Set the Type 115 front-panel PRESET screwdriver adjustment fully counterclockwise.

r. CHECK FOR—Test oscilloscope display of the pulse baseline at least 1.5 cm below the center horizontal line.

s. If the pulse offset is incorrect in any of the preceding checks, readjust R605, R655, R651 and R511 in Steps 9, 10 and 12.

14. Check Amplitude Accuracy

a. Trigger the test oscilloscope display.

b. Position the pulse so that it is centered on the CRT (see Fig. 5-9).

c. CHECK FOR—Test oscilloscope display of the positive-going pulse with an amplitude of at least 5 cm (10 volts). (Note the actual pulse amplitude for use in parts i and k).

d. Set the Type 115 PULSE POLARITY switch to —.

e. Position the pulse so that it is centered on the CRT screen.

f. CHECK FOR—Test oscilloscope display of the negative-going pulse with an amplitude of at least 5 cm (10 volts).

g. Reset the following Type 115 controls:

DC OFFSET AND	.5
AMPLITUDE MULT	
PULSE POLARITY	+

h. Position the pulse baseline 1 cm below the center horizontal line of the CRT graticule.

i. CHECK FOR—Test oscilloscope display of the pulse with an amplitude of 0.5 times the measurement made in part c, $\pm 5\%$.

j. Set the Type 115 DC OFFSET AND AMPLITUDE MULT switch to .2.

k. CHECK FOR—Test oscilloscope display of the pulse with an amplitude of 0.2 times the measurement made in part c, $\pm 5\%$.

l. Set the Type 115 DC OFFSET AND AMPLITUDE MULT switch to 1.

m. Position the pulse so that it is centered on the CRT.

n. Turn the AMPLITUDE (VOLTS) control to the 0 position while observing the display on the CRT screen.

o. CHECK FOR—Test oscilloscope display of the pulse with a continuously decreasing amplitude of from at least 10 volts to less than 100 mV.

p. If the pulse amplitude does not appear as described in any of the preceding checks, readjust R431, R523 and R511 in steps 11 and 12.

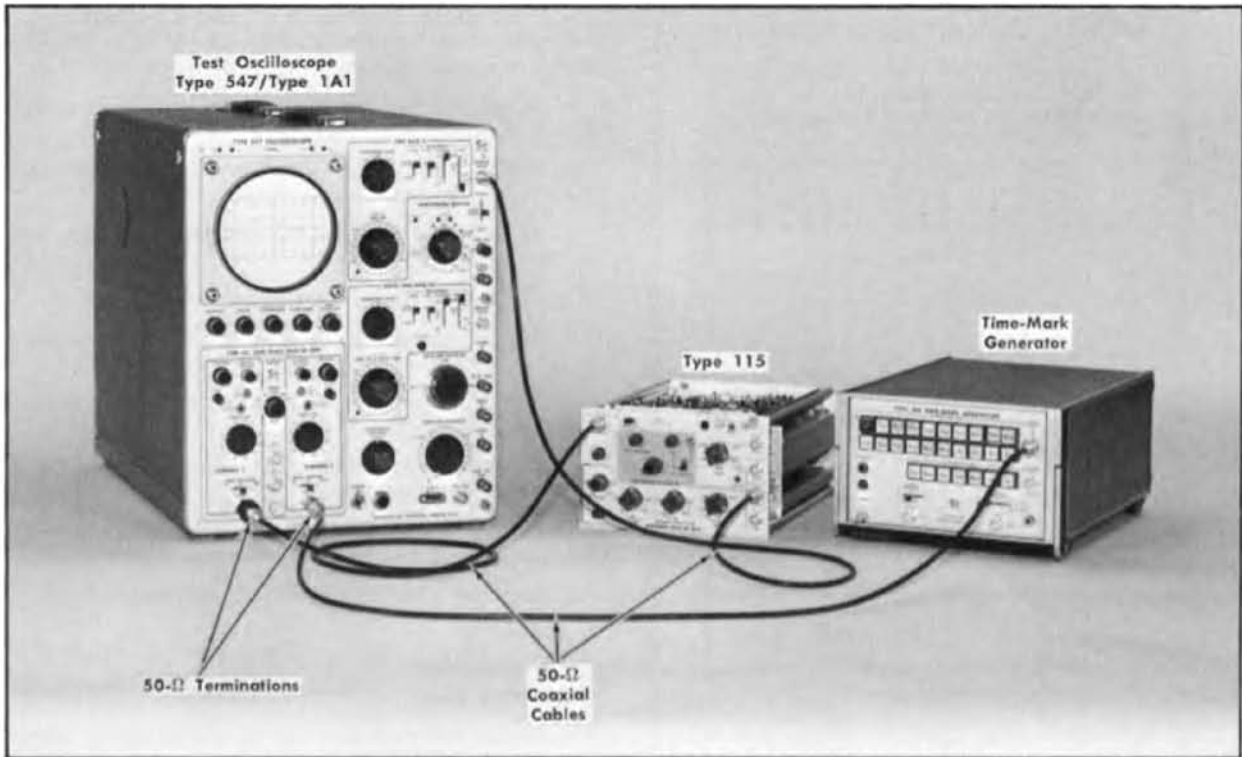


Fig. 5-11. Initial test equipment setup for steps 15 through 16.

Control Settings

	Type 115
MODE	UNDLY'D PULSE
TRIGGER	INT
PERIOD	1 mS
VARIABLE	CAL
DELAY OR BURST DURATION	50 μ S
VARIABLE	CAL
WIDTH	50 μ S
VARIABLE	Center of range
RISETIME AND FALLTIME	10 μS
RISETIME MULT	10
FALLTIME MULT	10

DC OFFSET AND AMPLITUDE MULT	1
AMPLITUDE (VOLTS)	10
DC OFFSET PRESET-VARIABLE switch	VARIABLE
DC OFFSET (VOLTS) VARIABLE	0
PULSE POLARITY	+

Test Oscilloscope	
Time/cm	20 μ S
Triggering	Int, Norm
Vertical Mode	Channel 2
Volts/Cm (Channel 1)	2
Volts/Cm (Channel 2)	1
Invert (Channel 2)	Normal
Input Selector	DC

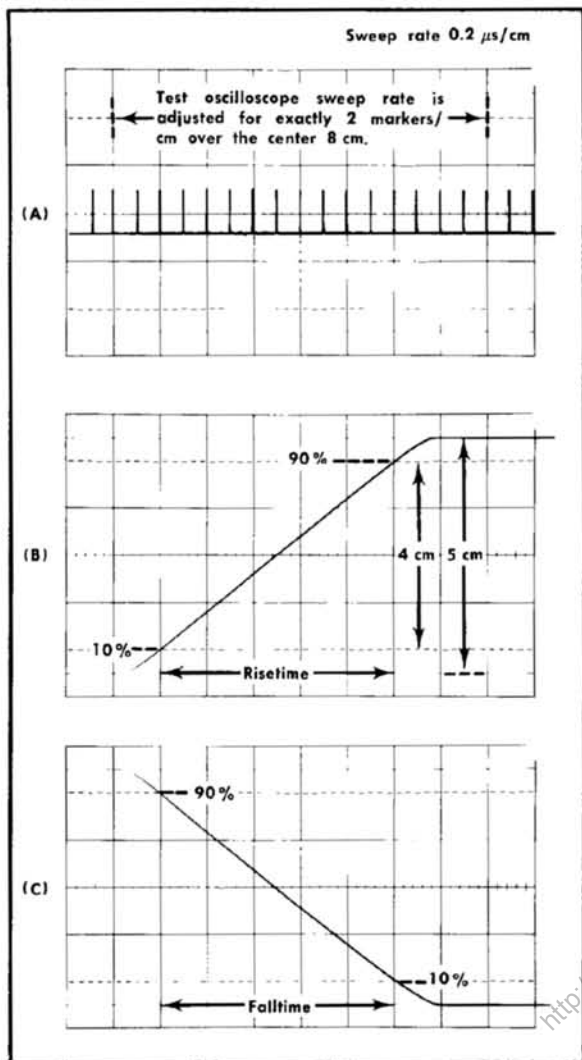


Fig. 5-12. Typical test oscilloscope displays for checking risetime and falltime of the output pulse.

RISETIME AND FALLTIME

15. Adjust Risetime and Falltime

- a. Test equipment setup is shown in Fig. 5-11.
- b. Connect the time-mark generator marker output through a coaxial cable and a 50- Ω termination (BNC connectors) to the test oscilloscope Channel 2 vertical input.
- c. Set the time-mark generator for a 10 μs marker output.
- d. If the test oscilloscope display does not contain exactly 2 markers/cm over the center 8 cm of the CRT graticule, adjust the variable sweep rate control to provide correct timing [see Fig. 5-12A].
- f. Set the test oscilloscope Vertical Mode switch to Channel 1.

g. If the display amplitude is not exactly 5 cm, adjust the test oscilloscope Variable Volts/Cm control to provide the correct amplitude for measuring risetime and falltime.

h. Trigger the test oscilloscope display to observe the rise of the Type 115 output pulse (see Fig. 5-12B).

i. CHECK FOR—Test oscilloscope display of the pulse rise with a risetime of 100 μs (5 cm).

j. ADJUST—R371, T_r TIMING adjustment, (see Fig. 5-8) if the display is not correct.

k. Set the test oscilloscope Trigger Slope switch to —.

l. Trigger the test oscilloscope on the negative-going slope of the waveform (see Fig. 5-12C).

m. CHECK FOR—Test oscilloscope display of the pulse fall with a falltime of 100 μs (5 cm).

n. ADJUST—R421, T_r TIMING adjustment, (see Fig. 5-8) if the falltime is not correct.

o. Set the Type 115 RISETIME MULT and FALLTIME MULT controls to the 1 position.

p. Reset the following test oscilloscope controls:

Time/Cm	2 μs
Trigger Slope	+
Vertical Mode	Channel 2

q. Set the time-mark generator for a 1- μs marker output.

r. Check the test oscilloscope display for exactly 2 markers/cm over the center 8 cm of the CRT graticule and adjust the variable sweep rate control if necessary.

s. Set the test oscilloscope Vertical Mode switch to Channel 1.

t. Trigger the test oscilloscope on the pulse rise.

u. CHECK FOR—Test oscilloscope display showing a risetime of 10 μs $\pm 5\%$ ± 1 ns (5 cm ± 2.5 mm).

v. ADJUST—R375, RISETIME CAL adjustment, (see Fig. 5-13) if the risetime is not correct.

w. Set the test oscilloscope Trigger Slope switch to —.

x. Trigger the test oscilloscope on the negative-going slope of the waveform.

y. CHECK FOR—Test oscilloscope display of the pulse fall with a falltime of 10 μs $\pm 5\%$ ± 1 ns (5 cm ± 2.5 mm).

z. ADJUST—R425, FALLTIME CAL adjustment, (see Fig. 5-13) if the falltime is not correct.

aa. If R375 and/or R425 are adjusted, set the test oscilloscope Vertical Mode switch to Channel 2, then recheck the adjustment of R371 and R421 in steps c through n.

bb. Reset the following Type 115 controls:

PERIOD	1 μs
WIDTH	500 ns
VARIABLE	CAL
RISETIME AND FALLTIME	100 ns

cc. Reset the following test oscilloscope controls:

Time/Cm	0.1 μ s
Sweep Magnifier	X5
Trigger Slope	+
Vertical Mode	Channel 2

dd. Set the time-mark generator for a 2-ns output marker.

ee. Trigger the test oscilloscope display.

ff. If the test oscilloscope display does not contain exactly 1 marker/cm over the center 8 cm of the CRT graticule adjust the variable sweep rate control to provide correct timing.

gg. Set the Vertical Mode switch to Channel 1.

hh. Trigger the test oscilloscope display to observe the rise of the Type 115 output pulse.

ii. CHECK FOR—Test oscilloscope display of the pulse rise with a risetime of $100 \text{ ns} \pm 5\% \pm 1 \text{ ns}$ (5 cm \pm 3 mm).

jj. ADJUST—C397 (see Fig. 5-8) if the risetime is not correct. Remove the adjustment tool while observing the risetime.

kk. Position the test oscilloscope to observe the fall of the pulse.

ll. CHECK FOR—Test oscilloscope display of the pulse fall with a falltime of $100 \text{ ns} \pm 5\% \pm 1 \text{ ns}$ (5 cm \pm 3 mm).

mm. If the falltime is not correct, readjust C397 for a compromise setting so that both the risetime and falltime are within tolerance.

16. Check Risetime and Falltime Accuracy

a. Test equipment setup is given in Fig. 5-11.

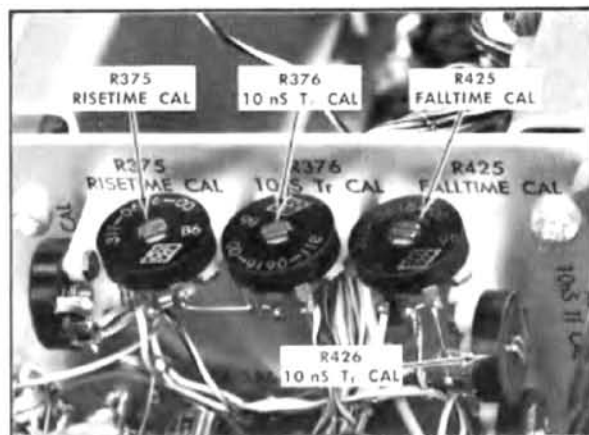


Fig. 5-13. Location of risetime and falltime adjustments on the right side of the Type 115 chassis subpanel.

b. Set the Type 115 controls, the time-mark generator and the test oscilloscope controls as given in Table 5-2. For each sweep rate, check the display timing by observing the time-mark signal (Channel 2) and adjusting the variable sweep rate control if necessary, then display the Type 115 output pulse.

c. CHECK FOR—Test oscilloscope displays of the pulse rise and the pulse fall with risetimes and falltimes as indicated in the table.

d. If the risetime and/or falltime are out of tolerance in any of the preceding checks, readjust R371, R421, R375, R425 or C397 as described in step 15.

TABLE 5-2

RISETIME AND FALLTIME ACCURACY CHECK

PERIOD	WIDTH	RISETIME MULT and FALLTIME MULT	RISETIME AND FALLTIME	Time Markers	Oscilloscope		Risetime and Falltime	
					Sweep Rate	Trig-gering	Time	Display
1 ms	50 μ s	1	10 μ s	1 μ s	2 μ s/cm	+	10 μ s \pm 5%	5 cm \pm 2.5 mm
						-	10 μ s \pm 5%	5 cm \pm 2.5 mm
100 μ s	5 μ s	1	1 μ s	0.1 μ s	0.2 μ s/cm	+	1 μ s \pm 5%	5 cm \pm 2.5 mm
						-	1 μ s \pm 5%	5 cm \pm 2.5 mm
100 μ s	5 μ s	10	100 ns	0.1 μ s	0.2 μ s/cm	+	1 μ s	5 cm
						-	1 μ s	5 cm
100 μ s	500 ns	1	100 ns	20 ns	20 ns/cm	+	100 ns \pm 5%	5 cm \pm 2.5 mm
						-	100 ns \pm 5%	5 cm \pm 2.5 mm

*0.1 μ s/cm Magnified X 5

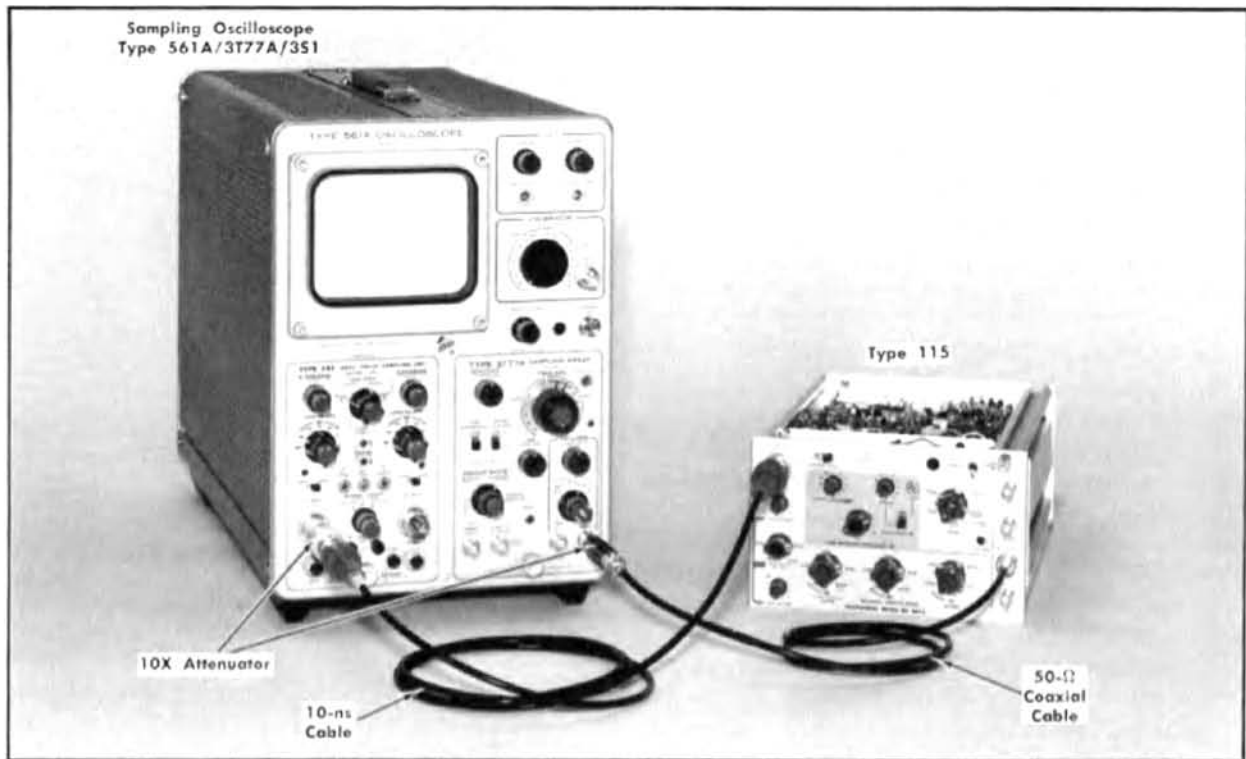


Fig. 5-14. Initial test equipment setup for steps 17 through 20.

Control Settings

	Type 115
MODE	UNDLY'D PULSE
TRIGGER	INT
PERIOD	1 μS
VARIABLE	CAL
DELAY OR BURST DURATION	50 μ S
VARIABLE	CAL
WIDTH	50 nS
VARIABLE	CAL
RISETIME AND FALLTIME	10 nS
RISETIME MULT	1
FALLTIME MULT	1
DC OFFSET AND AMPLITUDE MULT	1
AMPLITUDE (VOLTS)	10
DC OFFSET PRESET-VARIABLE switch	VARIABLE
DC OFFSET (VOLTS) VARIABLE	0
PULSE POLARITY	+

Sampling Oscilloscope

Type 561A

Calibrator	Off
CRT Cathode Selector (rear panel)	Chopped Blanking

Type 351

Mode	Channel A
Smooth-Normal	Normal
Position (A and B)	Centered
DC Offset (A and B)	Pulse centered
mVolts/Div (A and B)	200 (calibrated)
Invert-Norm (A and B)	Normal
Sampling Mode	Triggered
Internal Trigger	A

Type 3T77A

Sweep Rate Time/Div	20 ns (calibrated)
Triggering	+ Ext
Trigger Sensitivity	Stable Display
Recovery Time	Stable Display
Pull For Sync	Pulled Out
Sweep Mode	Normal
Horizontal Position	Trace centered
Dots per Div	100
Time Expander	X1
Time Position	Display centered

PULSE SHAPE, FAST RISETIME AND FALLTIME

NOTE

In order to determine if the instrument performance is within specified tolerance in the following 4 steps, use of the sampling equipment listed in the Equipment Required list is suggested. If the Type 115 is used in an application where the aberrations and the accuracy of the fast risetime and falltimes are not critical, these adjustments can be made with the specified real-time equipment.

17. Adjust Pulse for Minimum Aberrations **ⓐ**

- a. Test equipment setup is shown in Fig. 5-14.
- b. Disconnect the Type 115 output pulse and pretrigger from the test oscilloscope.
- c. Connect the Type 115 output pulse signal through a 10 ns coaxial cable and a 10X attenuator to the Channel A input of the Type 3S1 Dual-Trace Sampling Unit. (50- Ω termination is not required because the input to the Type 3S1 is 50- Ω).
- d. Connect the Type 115 pretrigger pulse through a 50- Ω coaxial cable terminated by a 50 Ω 10X attenuator to the External Input connector on the Type 3T77A Sampling Sweep Unit.
- e. Trigger the sampling oscilloscope display.
- f. Reset the Type 3T77A Time/Div switch to 5 ns.
- g. Position the pulse on the CRT screen with the Type 3T77A Time Position control.
- h. Reset the Type 3S1 mVolts/Div switch to 10.
- i. Vertically position the pulse baseline immediately following the pulse fall onto the CRT with the Type 3S1 Position and DC Offset controls (see Fig. 5-15A).
- j. CHECK FOR—Sampling oscilloscope display of the pulse fall and baseline with no more than 3 cm (3%) of overshoot, short-time rounding, tilt or droop and with total aberrations of no more than 3 cm (3%) peak-to-peak.
- k. ADJUST—C551, PULSE OVERSHOOT adjustment, (see Fig. 5-10) for the fastest falltime with minimum aberrations and adjust C563 (Pulse Tilt) for the flattest possible baseline.
- l. Vertically position the pulse top on to the CRT with the Type 3S1 position and DC Offset controls (see Fig. 5-15A).
- m. CHECK FOR—Sampling oscilloscope display of the pulse rise and pulse top with no more than 3 cm (3%) of overshoot, short-time rounding, tilt or droop and with total aberrations of no more than 3 cm (3%) peak-to-peak.
- n. ADJUST—C471 and R471 (see Fig. 5-16) for the fastest possible risetime with minimum aberrations.

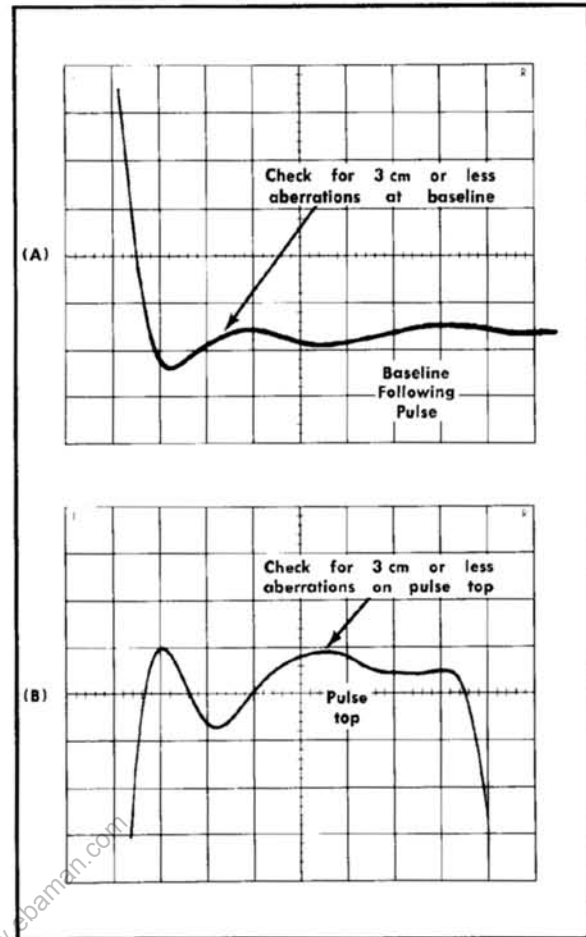


Fig. 5-15. Typical sampling oscilloscope displays for checking and adjusting pulse aberrations.

18. Check Pulse Aberrations

(If step 17 has just been completed, go to part m of this step).

- a. Test equipment setup is shown in Fig. 5-14.
- b. Disconnect the Type 115 output pulse and pretrigger from the test oscilloscope.
- c. Connect the Type 115 output pulse signal through a 10 ns coaxial cable and a 10X attenuator to the Channel A input of the Type 3S1 Dual-Trace Sampling Unit. (50- Ω termination is not required because the input to the Type 3S1 is 50- Ω).
- d. Connect the Type 115 pretrigger pulse through a 50- Ω coaxial cable terminated by a 50 Ω 10X attenuator to the External Input connector on the Type 3T77A Sampling Sweep Unit.
- e. Trigger the sampling oscilloscope display.

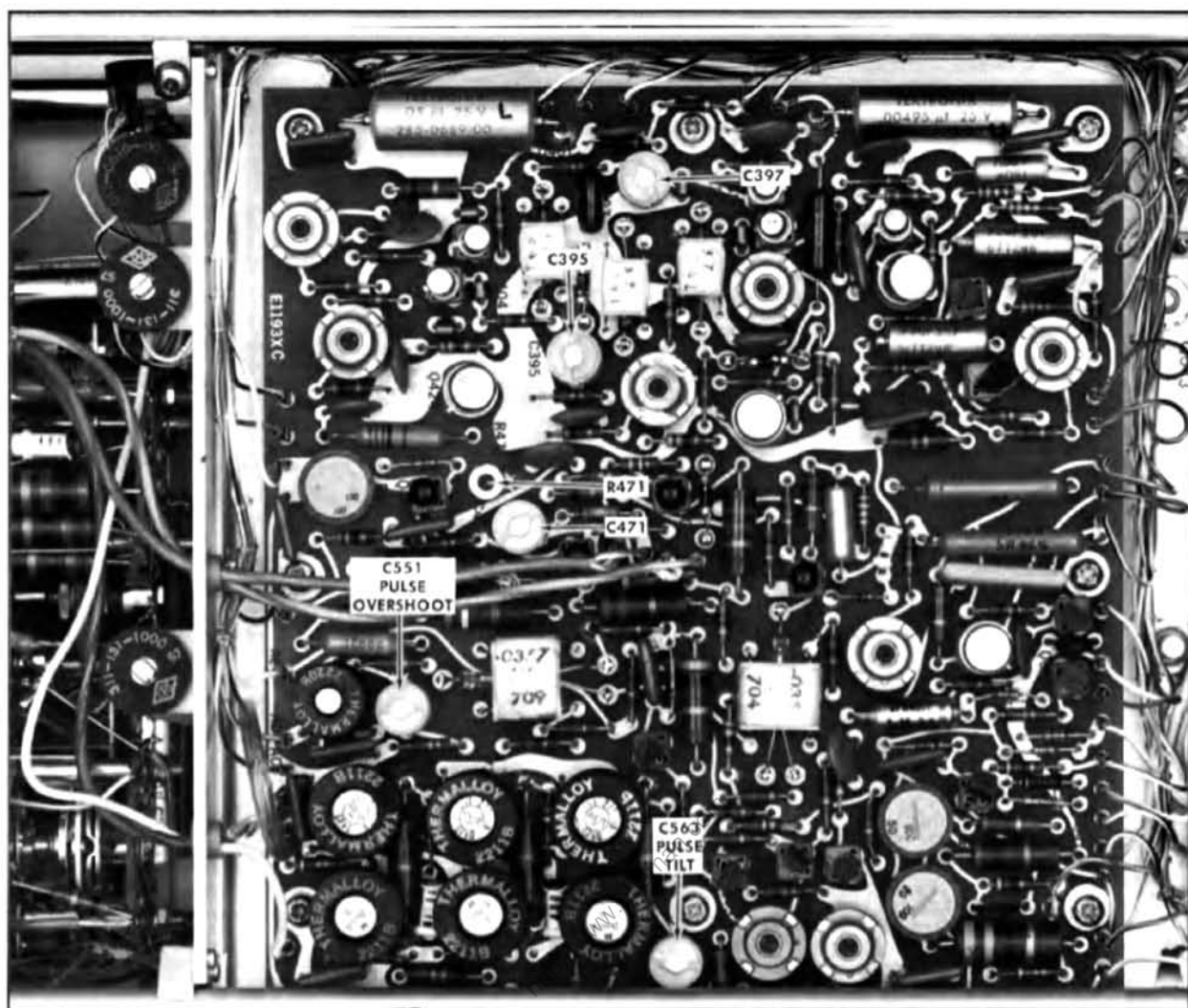


Fig. 5-16. Bottom circuit board: Location of adjustments in steps 17 through 20.

- f. Reset the Type 3T77A Time/Div switch to 5 ns.
- g. Position the pulse onto the CRT with the Type 3T77A Time Position control.
- h. Reset the Type 3S1 mVolts/Div switch to 10.
- i. Vertically position the pulse baseline immediately following the pulse fall on the CRT with the Type 3S1 Position and DC Offset controls [see Fig. 5-15A].
- j. CHECK FOR—Sampling oscilloscope display of the pulse fall and baseline with no more than 3 cm (3%) of overshoot, short-time rounding, tilt or droop and with total aberrations of no more than 3 cm (3%) peak-to-peak.
- k. Vertically position the pulse top onto the CRT with the

Type 3S1 Position and DC Offset controls [see Fig. 5-15B].

- l. CHECK FOR—Sampling oscilloscope display of the pulse rise and pulse top with no more than 3 cm (3%) of overshoot, short-time rounding, tilt or droop and with total aberrations of no more than 3 cm (3%) peak-to-peak.
- m. Set the Type 115 PULSE POLARITY switch to —.
- n. Repeat parts i through l for the negative-going pulse.
- o. If the pulse aberrations are out of tolerance in any of the preceding checks, adjust C551, C563, C471 and R471 as described in step 17 to bring the pulse aberrations within tolerance.
- p. Set the Type 115 PULSE POLARITY switch to +.

19. Adjust 10 ns and 100 ns Rise Time and Falltime

- a. Reset the following Type 115 controls:

PERIOD VARIABLE	Midrange
PULSE POLARITY	+
- b. Connect the time-mark generator marker output to the Channel B input of the Type 351 through a 50- Ω coaxial cable and a 5X attenuator.
- c. Disconnect the coaxial cable from the Type 115 + PRETRIG OUT connector and reconnect it to the time-mark generator Trigger Output.
- d. Set the time-mark generator for a 10-ns marker output and a 1- μ s trigger output.
- e. Reset the following sampling oscilloscope controls:

Vertical Mode	Channel B
Time/Div	2 ns
mVolts/Div (Channel 1)	200
- f. Trigger the sampling oscilloscope.
- g. Check the sampling oscilloscope display for exactly 1 cycle/5 cm and adjust the variable sweep rate control, if necessary, to obtain proper timing.
- h. Disconnect the coaxial cable from the time-mark generator Trigger Output connector and reconnect it to the Type 115 + PRETRIG OUT connector.
- i. Reset the sampling oscilloscope Vertical Mode switch to Channel A.
- j. Trigger the sampling oscilloscope display.
- k. Check that the display amplitude is exactly 5 cm and adjust the mVolts/Div Variable, if necessary, for correct deflection to measure risetime.
- l. Position the display with the Time Position control to observe the pulse rise.
- m. CHECK FOR—Sampling oscilloscope display of the pulse rise with a risetime of 10 ns $\pm 5\%$ ± 1 ns (5 cm ± 7.5 mm).
- n. ADJUST—R376, 10 ns T_r CAL adjustment, (see Fig. 5-13) and C395 (see Fig. 5-16) if the risetime is not correct. Remove the adjustment tool while observing the risetime.
- o. Time-position the display with the Time Position control to observe the falling edge of the pulse.
- p. CHECK for—Sampling oscilloscope display of the pulse fall with a falltime of 10 ns $\pm 5\%$ ± 1 ns (5 cm ± 7.5 mm).
- q. ADJUST—R426, 10 ns T_f CAL adjustment, (see Fig. 5-13) if the falltime is not correct.
- r. Reset the following Type 115 controls:

WIDTH	500 ns
RISETIME AND FALLTIME	100 ns
- s. Reset the following sampling oscilloscope controls:

Sweep Rate	20 ns/cm
Vertical Mode	Channel B

- t. Disconnect the coaxial cable from the Type 115 + PRETRIG OUT connector and reconnect it to the time-mark generator Trigger Output.
- u. Set the time-mark generator for a 20 ns marker output.
- v. Trigger the sampling oscilloscope display.
- w. Check for a display of 1 marker/cm and adjust the sampling oscilloscope variable sweep rate control, if necessary, for proper timing.
- x. Disconnect the coaxial cable from the time-mark generator Trigger Output and reconnect it to the Type 115 + PRETRIG OUT connector.
- y. Reset the sampling oscilloscope Vertical Mode switch to Channel A.
- z. Trigger the sampling oscilloscope display.
 - aa. Time position the display to observe the pulse rise.
 - bb. CHECK FOR—Sampling oscilloscope display of the pulse rise with a risetime of 100 ns $\pm 5\%$ ± 1 ns (5 cm ± 3 mm).
 - cc. ADJUST—C397 (see Fig. 5-16) if the risetime is not correct.
 - dd. Time-position the display to observe the pulse fall.
 - ee. CHECK FOR—Sampling oscilloscope display of the pulse fall with a falltime of 100 ns $\pm 5\%$ ± 1 ns (5 cm ± 3 mm).
 - ff. If the falltime is not correct, readjust C397 for a compromise setting so that both the risetime and falltime are within specifications.
 - gg. Disconnect the Type 115 output pulse and pretrigger and the time-mark generator output from the sampling oscilloscope.
 - hh. Reconnect the Type 115 output pulse through a 50- Ω coaxial cable terminated with a 50- Ω termination to the Channel 1 input of the test oscilloscope.
 - ii. Reconnect the time-mark generator marker output through a 50- Ω coaxial cable terminated in 50 Ω to the Channel 2 input of the test oscilloscope.
 - jj. Reconnect the Type 115 pretrigger to the test oscilloscope Trigger Input through a 50- Ω coaxial cable.

20. Check 10 ns Rise Time and Falltime Accuracy

(If step 19 has just been completed, go to step 21).

- a. Set the Type 115 PERIOD VARIABLE control to mid-range.
- b. Connect the time-mark generator marker output to the Channel B input of the Type 351 through a 50- Ω coaxial cable and a 5X attenuator.
- c. Disconnect the coaxial cable from the Type 115 + PRETRIG OUT connector and reconnect it to the time-mark generator triggering output.
- d. Set the time-mark generator for a 10-ns marker output and a 1- μ s trigger output.

Performance Check/Calibration—Type 115

e. Reset the following sampling oscilloscope controls:

Vertical Mode	Channel B
Time/Div	2 ns

f. Trigger the sampling oscilloscope.

g. Check the sampling oscilloscope display for exactly 1 cycle/5 cm and adjust the variable sweep rate control, if necessary, to obtain proper timing.

h. Disconnect the coaxial cable from the time-mark generator Trigger Output connector and reconnect it to the Type 115 + PRETRIG OUT connector.

i. Reset the sampling oscilloscope Vertical Mode switch to Channel A.

j. Trigger the sampling oscilloscope display.

k. Check that the display amplitude is exactly 5 cm and adjust the mVolts/Div Variable, if necessary, for correct deflection to measure risetime.

l. Position the display with the Time Position control to observe the pulse rise.

m. CHECK FOR—Sampling oscilloscope display of the pulse

rise with a risetime of $10 \text{ ns} \pm 5\% \pm 1 \text{ ns}$ ($5 \text{ cm} \pm 7.5 \text{ mm}$).

n. Position the display with the Time Position control to observe the falling edge of the pulse.

o. CHECK FOR—Sampling oscilloscope display of the pulse fall with a falltime of $10 \text{ ns} \pm 5\% \pm 1 \text{ ns}$ ($5 \text{ cm} \pm 7.5 \text{ mm}$).

p. If the 10-ns risetime and/or falltime is out of tolerance in the preceding check, adjust R376, R426 and C395 as described in Step 19.

q. Disconnect the Type 115 output pulse and pretrigger and the time-mark generator marker output from the sampling oscilloscope.

r. Reconnect the Type 115 output pulse through a $50\text{-}\Omega$ coaxial cable terminated with $50\text{-}\Omega$ to the Channel 1 input of the test oscilloscope.

s. Reconnect the time-mark generator marker output through a $50\text{-}\Omega$ coaxial cable terminated by $50\text{-}\Omega$ to the Channel 2 input of the test oscilloscope.

t. Reconnect the Type 115 pretrigger to the test oscilloscope Trigger Input through a $50\text{-}\Omega$ coaxial cable.

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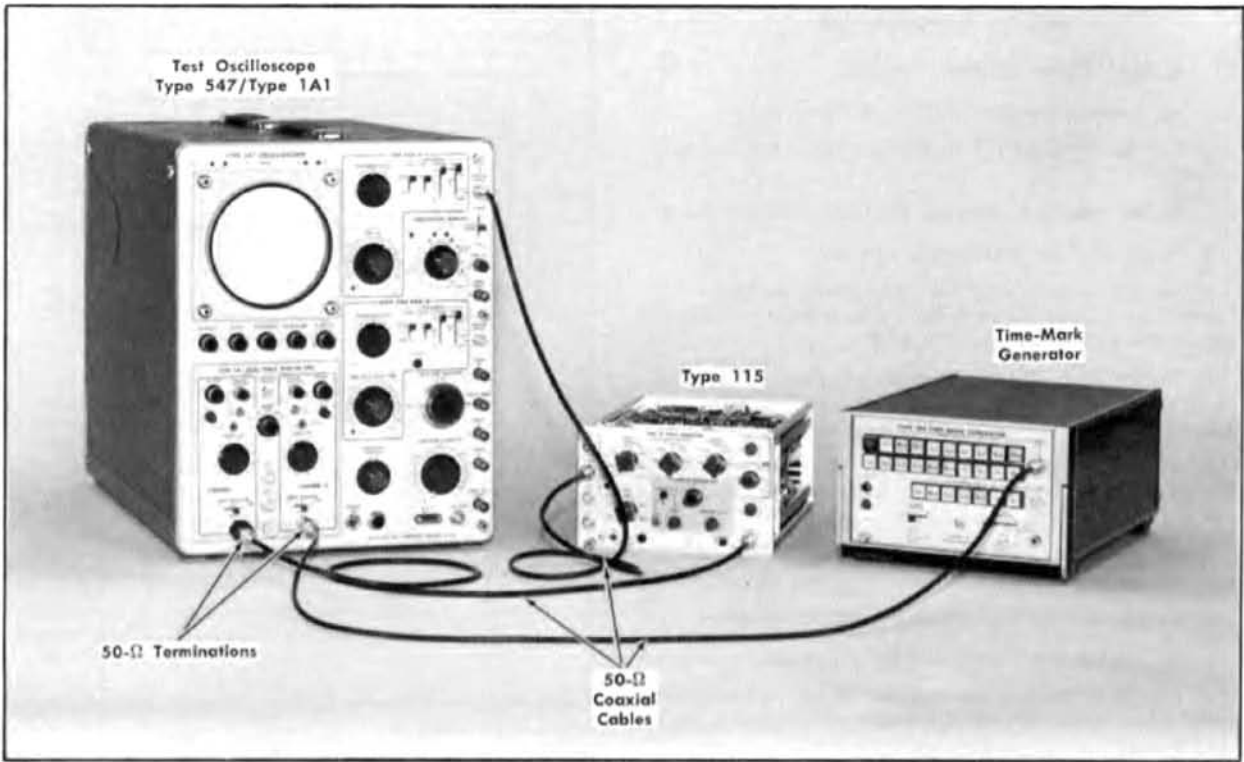


Fig. 5-17. Initial test equipment setup for steps 21 through 26.

Control Settings

	Type 115
MODE	UNDLY'D PULSE
TRIGGER	INT
PERIOD	1 mS
VARIABLE	CAL
DELAY OR BURST DURATION	50 μ S
VARIABLE	Fully clockwise
WIDTH	50 μ S
VARIABLE	Fully clockwise
RISETIME AND FALLTIME	10 nS
RISETIME MULT	1
FALLTIME MULT	1
DC OFFSET AND AMPLITUDE MULT	1

AMPLITUDE (VOLTS)	10
DC OFFSET PRESET-VARIABLE switch	VARIABLE
DC OFFSET (VOLTS) VARIABLE	0
PULSE POLARITY	+

Test Oscilloscope	
Time/Cm	0.1 ms
Sweep Magnifier	Off
Triggering	+ Int, Norm
Vertical Mode	Alternate
Volts/Cm (Channel 1)	2 V
Volts/Cm (Channel 2)	1 V
Input Selector	DC

WIDTH GENERATOR

21. Adjust Pulse Width Timing

- a. Test equipment setup is shown in Fig. 5-17.
- b. Position the Type 115 so that the top circuit board is visible.
- c. Set the time-mark generator for a 50- μ s marker output.
- d. Trigger the test oscilloscope display.
- e. Center the two displayed waveforms vertically and position the Type 115 output pulse rise to the 1 cm vertical line on the CRT screen (see Fig. 5-18).
- f. CHECK FOR—Test oscilloscope displays of a pulse width of at least 500 μ s, measured at the 50% level with respect to the time-mark waveform (5 cm).
- g. ADJUST—R331, WIDTH TIMING adjustment, (see Fig. 5-19) for a pulse width of 550 μ s (5.5 cm) if the display is not correct.
- h. Set the Type 115 WIDTH VARIABLE control to the CAL position.
- i. Set the test oscilloscope sweep rate to 10 μ s/cm.
- j. Set the time-mark generator for a 5- μ s marker output.
- k. CHECK FOR—Test oscilloscope display of a 50- μ s pulse width, within 3% of the time-mark waveform (5 cm \pm 1.5 mm).
- l. ADJUST—R335, VAR WIDTH CAL adjustment, (see Fig. 5-19) if the display is not correct.
- m. If R335 is adjusted, reset the Type 115 WIDTH VARIABLE fully clockwise, reset the test oscilloscope sweep rate to 0.1 ms/cm and recheck the width timing as in steps c and l.
- n. Reset the following Type 115 controls:

PERIOD	1 μ S
WIDTH	50 ns
VARIABLE	CAL

o. Reset the following test oscilloscope controls:

Time/Cm	10 ns (0.1 μ s magnified X10)
Volts/Cm (Channel 2)	.2

- p. Set the time-mark generator for a 10-ns marker output.
- q. Trigger the test oscilloscope display.
- r. CHECK FOR—Test oscilloscope display of 50-ns pulse width, within 5% of the time-mark waveform (5 cm \pm 2.5 mm). See Fig. 5-18B.
- s. ADJUST—C338 (see Fig. 5-19) if the display is not correct.
- t. If adjustment of C338 does not bring the 50-ns width within tolerance, readjustment of R331 and R335 at the beginning of this step may be necessary.
- u. If readjustment of R331, R335 and C338 does not bring the 50-ns width within tolerance, readjustment of R391 (T_r

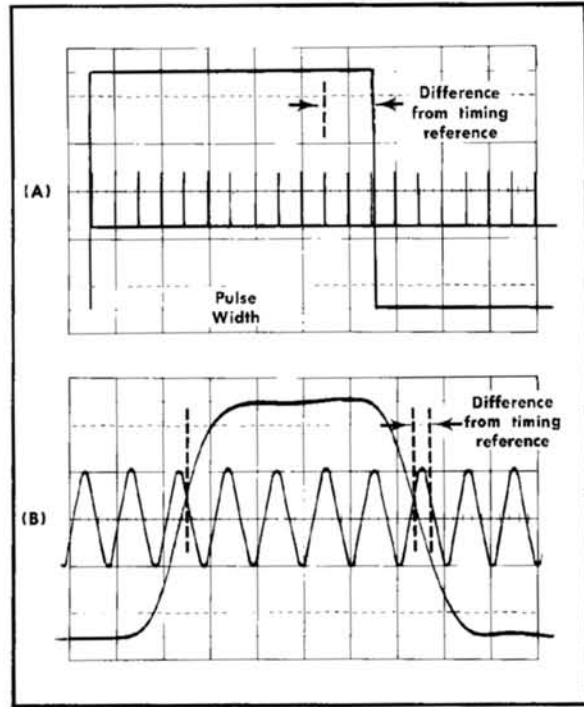


Fig. 5-18. Typical test oscilloscope displays for checking pulse width: (A) 500- μ s pulse width; (B) 50-ns pulse width.

CENTERING) in Step 4 and R411 (T_r CENTERING) in Step 5 may be necessary.

22. Check Pulse Width Accuracy

- a. Test equipment setup is shown in Fig. 5-17.
- b. Set the Type 115 controls, the test oscilloscope sweep and the time-mark generator as indicated in Table 5-3.
- c. CHECK FOR—Test oscilloscope displays of the pulse width, measured with respect to the time-mark waveform, as indicated in the last column of Table 5-3.
- d. If the pulse width timing is out of tolerance in any of the preceding checks, adjust R335, R331 and C338 as described in Step 21 to bring the width timing within tolerance on all ranges.

DELAY GENERATOR

23. Adjust Pulse Delay Timing

- a. Reset the following Type 115 controls:

MODE	PAIRED PULSES
PERIOD	1 mS
VARIABLE	Fully clockwise
WIDTH	50 μ S

- b. Set the test oscilloscope sweep rate to 0.1 ms/cm (unmagnified).

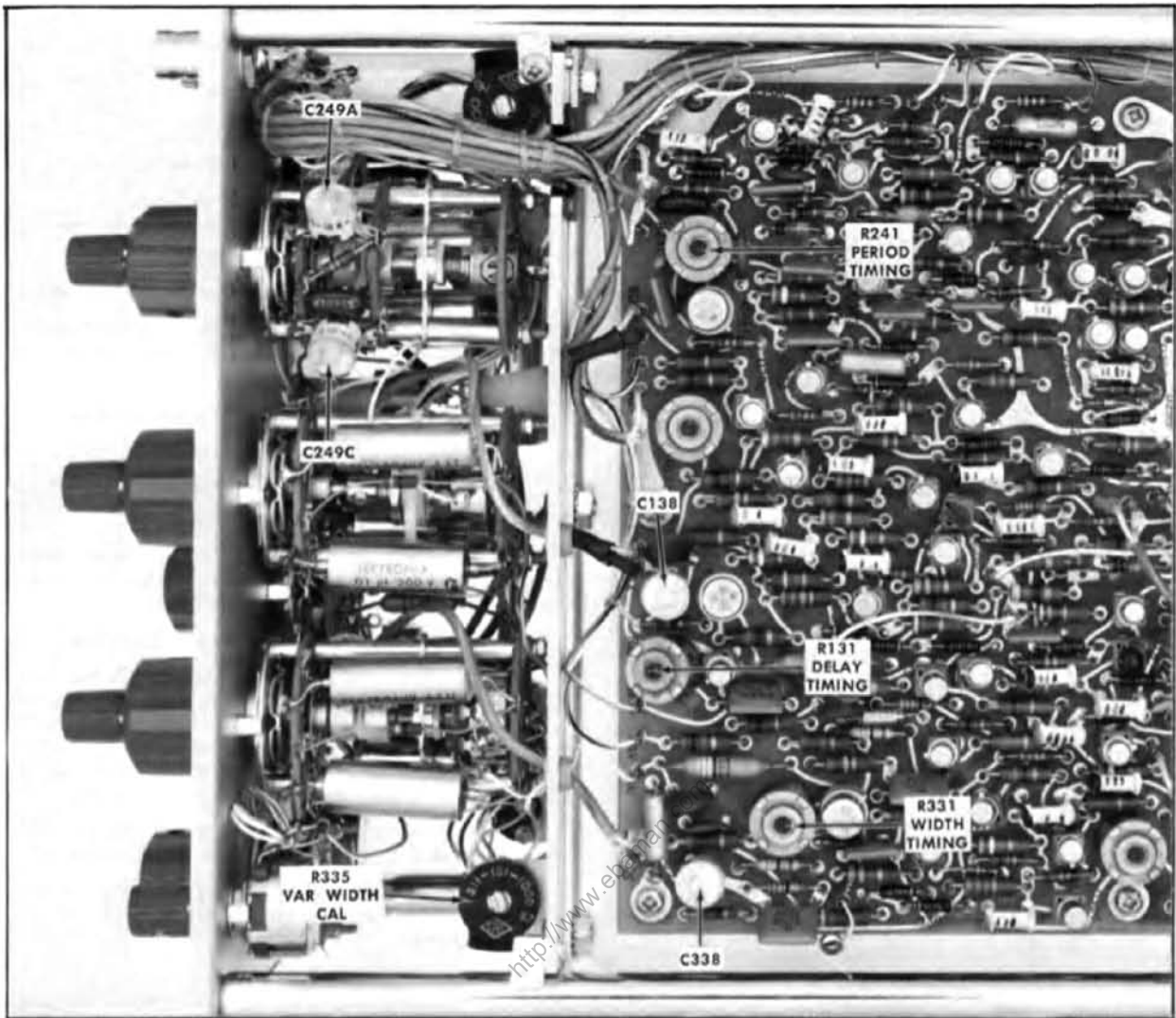


Fig. 5-19. Top circuit board: Location of adjustments used in steps 21 through 25.

TABLE 5-3
WIDTH TIMING ACCURACY CHECK

PERIOD	WIDTH	WIDTH VARIABLE	Time Markers	Oscilloscope Sweep Rate	Time	Difference from Reference Waveform
1 ms	50 μ s	CAL	5 μ s	10 μ s/cm	50 μ s \pm 3%	1.5 mm
100 μ s	5 μ s	CAL	0.5 μ s	1 μ s/cm	5 μ s \pm 3%	1.5 mm
10 μ s	500 ns	CAL	50 ns	0.1 μ s/cm	500 ns \pm 3%	1.5 mm
10 μ s	50 ns	Fully cw	50 ns	0.1 μ s/cm	> 500 ns	
1 μ s	50 ns	CAL	10 ns	10 ns/cm*	50 ns \pm 5%	2.5 mm

*0.1 μ s/cm Magnified X 10 and 0.2 v/cm.

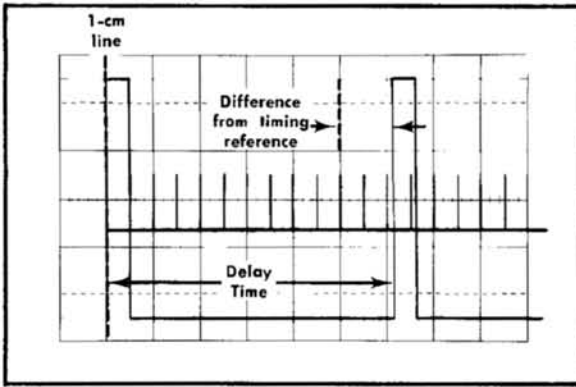


Fig. 5-20. Typical test oscilloscope display for checking delay timing adjustments; 500 μ s delay time.

- c. Set the time-mark generator for a 50- μ s marker output.
- d. Trigger the test oscilloscope display.
- e. CHECK FOR—Test oscilloscope display of the paired pulses with a delay period of at least 500 μ s between corresponding points on the two pulses (5 cm), measured with respect to the time-mark waveform (see Fig. 5-20).
- f. ADJUST—R131, DELAY TIMING adjustment, (see Fig. 5-19) for a delay interval of 550 μ s (5.5 cm) if the display is not correct.
- g. Reset the following Type 115 controls:

PERIOD VARIABLE	CAL
DELAY OR BURST DURATION VARIABLE	CAL
WIDTH	5 μ S
- h. Set the test oscilloscope sweep rate to 10 μ s/cm.
- i. Set the time-mark generator for a 5- μ s marker output.
- j. CHECK FOR—Test oscilloscope display of the paired pulses with a delay period of 50 μ s \pm 3% \pm 10 ns (5 cm \pm 1.5 mm).
- k. ADJUST—R135, VAR DELAY CAL adjustment, (see Fig. 5-21) if the delay interval is not correct.
- l. If R135 requires adjustment, recheck the delay timing adjustment as in parts a through k of this step.
- m. Reset the following Type 115 controls.

MODE	UNDLY'D PULSE
PERIOD	1 μ S

VARIABLE	CAL
DELAY OR BURST DURATION	50 ns
VARIABLE	CAL
WIDTH	50 ns

- n. Reset the following test oscilloscope controls.

Time/Cm	10 ns (0.1 μ s/cm magnified by 10)
Vertical Mode	Channel 2
- o. Set the time-mark generator for a 10-ns marker output.
- p. Trigger the test oscilloscope and adjust the Time/Cm Variable control for a CRT display of 1 cycle/cm over the center 8 cm of the graticule.

- q. Reset the following test oscilloscope controls:

Triggering	+ External
Vertical Mode	Channel 1
- r. Trigger the test oscilloscope display.
- s. With the test oscilloscope Horizontal Position control position the rise of the undelayed pulse on the 1-cm vertical line of the CRT graticule (see Fig. 5-22A).

- t. Set the Type 115 MODE switch to DLY'D PULSE.
- u. CHECK FOR—Test oscilloscope display with the rise of the delayed pulse at the 6-cm vertical line \pm 1.15 on the CRT graticule. This represents a delay time of 50 ns \pm 3% \pm 10 ns. The rise of the delayed pulse must cross the 6-cm line at the same pulse amplitude that the rise of the undelayed pulse crossed the 1-cm line (see Fig. 5-22B).
- v. ADJUST—R134, 50 ns CAL adjustment, (see Fig. 5-21) and C138 (see Fig. 5-19) if the display is not correct.
- w. If adjusting R134 and C138 does not bring the 50-ns delay time within tolerance, readjustment of R135 and R131 may be necessary.

24. Check Pulse Delay Timing

- a. Set the Type 115 MODE switch to PAIRED PULSES.
- b. Reset the following test oscilloscope controls:

Vertical Mode	Alternate
Trigger Source	+ Internal
- c. Set the Type 115 controls, the test oscilloscope sweep rate and the time-mark generator output as given in Table 5-4.

TABLE 5-4
DELAY OR BURST DURATION ACCURACY

PERIOD	DELAY OR BURST DURATION	DELAY OR BURST DURATION VARIABLE	WIDTH	Time Markers	Oscilloscope Sweep Rate	Delay Interval	
						Time	Difference from Reference Waveform
100 μ S	50 μ S	CAL	5 μ S	5 μ S	10 μ S/cm	50 μ s \pm 3% \pm 10 ns	1.5 mm
10 μ S	5 μ S	CAL	500 ns	0.5 μ S	1 μ S/cm	5 μ s \pm 3% \pm 10 ns	1.6 mm
1 μ S	500 ns	CAL	50 ns	50 ns	0.1 μ S/cm	500 ns \pm 3% \pm 10 ns	2.5 mm

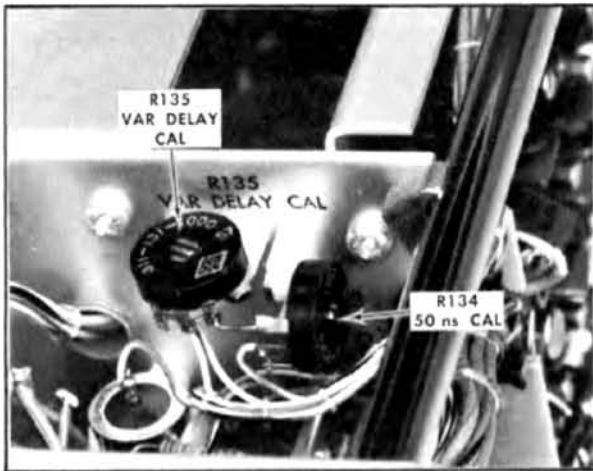


Fig. 5-21. Location of delay timing adjustments on the left side of the Type 115 chassis subpanel.

d. CHECK FOR—Test oscilloscope displays with a delay period between corresponding points on the two pulses (measured with respect to the time-mark waveform) as indicated in the last column of Table 5-4.

e. If the delay is out of tolerance in any of the preceding checks, adjust R135, R131, R134 and C138 as described in Step 23 to bring the delay time within tolerance on all ranges.

f. Reset the following Type 115 controls:

MODE	UNDLY'D PULSE
PERIOD	1 μ S
VARIABLE	CAL
DELAY OR BURST	50 nS
DURATION	
WIDTH	50 nS

g. Reset the following test oscilloscope controls:

Time/Cm	10 ns (0.1 μ s/cm magnified by 10)
Vertical Mode	Channel 2

h. Set the time-mark generator for a 10-ns marker output.

i. Trigger the test oscilloscope.

j. Adjust the Time/Cm Variable for a CRT display of 1 cycle/cm over the center 8 cm range.

k. Reset the following test oscilloscope controls:

Triggering	+ External
Vertical Mode	Channel 1

l. Trigger the test oscilloscope display.

m. Position the rise of the undelayed pulse on the 1-cm vertical line of the CRT graticule with the test oscilloscope horizontal position control [see Fig. 5-22A).

n. Set the Type 115 MODE switch to DLY'D PULSE.

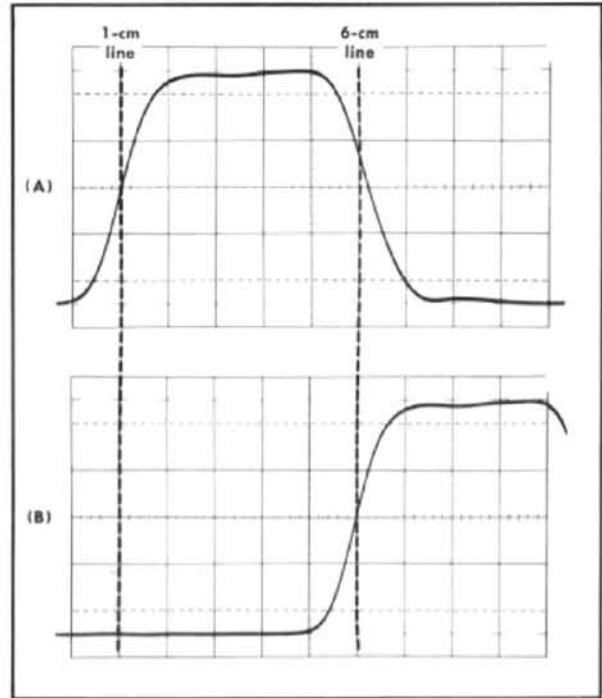


Fig. 5-22. Test oscilloscope displays for checking the 50-ns delay time adjustment.

o. CHECK FOR—Test oscilloscope display with the rise of the delayed pulse at the 6-cm vertical line on the CRT screen ± 1.15 cm. This represents a delay time of 50 ns $\pm 3\% \pm 10$ ns. The rise of the delayed pulse must cross the 6-cm vertical line at the same pulse amplitude as the rise of the undelayed pulse crossed the 1-cm line (see Fig. 5-22B).

p. Set the Type 115 MODE switch to UNDLY'D PULSE.

q. Set the test oscilloscope Sweep Magnifier to X1.

r. With the test oscilloscope Horizontal Position control, Position the undelayed pulse rise on the 1-cm vertical line of the CRT graticule.

s. Reset the following Type 115 controls:

MODE	DLY'D PULSE
DELAY OR BURST	Fully clockwise
DURATION VARIABLE	

t. CHECK FOR—Test oscilloscope display with the rise of the delayed pulse on at least the 6-cm vertical line of the CRT graticule (at least 500 ns).

u. If the delay timing is out of tolerance in parts o or t of this step, adjust R135, R131, R134 and C138 in Step 23.

PERIOD GENERATOR

25. Adjust Pulse Period Timing

a. Reset the following Type 115 controls:

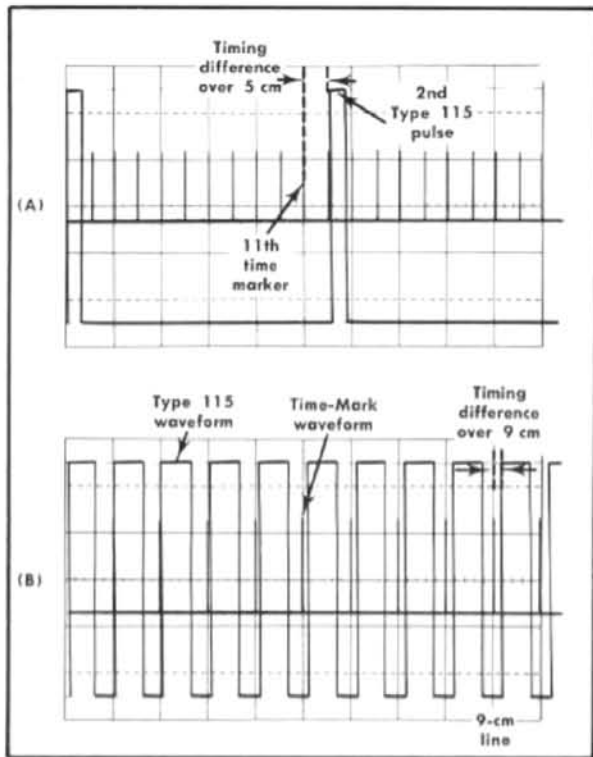


Fig. 5-23. Typical test oscilloscope displays for checking period timing: (A) PERIOD VARIABLE fully clockwise; (B) PERIOD VARIABLE in CAL position.

MODE	UNDLY'D PULSE
PERIOD	1 ms
VARIABLE	Fully clockwise
WIDTH	50 μ S
VARIABLE	Fully clockwise

b. Reset the following test oscilloscope controls:

Triggering	+ Internal
Time/Cm	2 ms (μ magnified)
Vertical Mode	Alternate

c. Set the time-mark generator for a 1-ms marker input.

d. Trigger the test oscilloscope display.

e. CHECK FOR—Test oscilloscope display with a time interval of at least 10 ms (5 cm) between the two pulses, measured with respect to the time-mark waveform (see Fig. 5-23A).

f. ADJUST—R241, PERIOD TIMING adjustment, (see Fig. 5-19) for a period of 11 ms (5.5 cm) if the display is not correct.

g. Set the Type 115 PERIOD VARIABLE to the CAL position.

h. Set the test oscilloscope sweep rate to 1 ms/cm.

i. CHECK FOR—Test oscilloscope display with equal time intervals between the Type 115 output pulses and the time-markers, ± 2.7 mm over the first 9 cm of the test oscilloscope CRT graticule, (1 ms $\pm 3\%$) (see Fig. 5-23B).

j. ADJUST—R245, VAR PERIOD CAL adjustment, (see Fig. 5-24) if the display is not correct. R245 is located on the bottom side of the instrument.

k. If R245 is adjusted, readjustment of R241 in parts a through f of this step may be necessary.

l. Reset the following Type 115 controls:

PERIOD	1 μ S
VARIABLE	CAL
WIDTH	500 nS
VARIABLE	CAL

m. Set the test oscilloscope sweep rate to 1 μ s/cm.

n. Set the time-mark generator for a 1- μ s marker output.

o. CHECK FOR—Check for test oscilloscope display with equal intervals between the Type 115 output pulses and the time markers, ± 2.7 mm over the first 9 cm (1 μ s $\pm 3\%$).

p. ADJUST—C249C (see Fig. 5-19) if the display is not correct.

q. Reset the following Type 115 controls:

PERIOD	100 nS
WIDTH	50 nS

r. Set the test oscilloscope sweep rate to 0.1 μ s/cm.

s. Set the time-mark generator for a 0.1- μ s marker output.

t. CHECK FOR—Test oscilloscope display with equal intervals between the Type 115 output pulses and the time markers, ± 4.5 mm over the first 9 cm (100 ns $\pm 5\%$).

u. ADJUST—C249A (see Fig. 5-19) if the display is not correct.

If adjustment of C249A and C249C does not bring the 100 ns and 1 μ s pulse period timing within tolerance, readjustment of R241 and R245 may be necessary.

26. Check Pulse Period Accuracy

a. Reset the following Type 115 controls:

MODE	UNDLY'D PULSE
PERIOD VARIABLE	CAL



Fig. 5-24. Location of period timing adjustment on bottom side of Type 115 chassis subpanel.

b. Set the Type 115 controls, the test oscilloscope sweep rate and the time-mark generator marker output as listed in Table 5-5.

c. CHECK FOR—Test oscilloscope displays with equal time intervals between the Type 115 output pulses and the time markers. For each setup in Table 5-5 turn the Type

115 PERIOD VARIABLE control fully clockwise and check for an interval of at least 5 cm between the two pulses, measured with respect to the time-mark waveform (see Fig. 5-23).

d. If the period timing is out of tolerance in any of the preceding checks, adjust R241, R245, C249A and C249C as described in Step 25.

TABLE 5-5
PERIOD ACCURACY CHECK

PERIOD	WIDTH	Time Markers	Oscilloscope Sweep Rate	Period	
				Time	Difference from Reference Waveform
1 ms	5 μ s	1 ms	2 ms/cm	1 ms \pm 3%	2.7 mm over 9 cm
100 μ s	500 ns	0.1 ms	0.2 ms/cm	100 μ s \pm 3%	2.7 mm over 9 cm
10 μ s	50 ns	10 μ s	20 μ s/cm	10 μ s \pm 3%	2.7 mm over 9 cm
1 μ s	50 ns	1 μ s	2 μ s/cm	1 μ s \pm 3%	2.7 mm over 9 cm
100 ns	50 ns	0.1 μ s	0.2 μ s/cm	100 ns \pm 5%	4.5 mm over 9 cm

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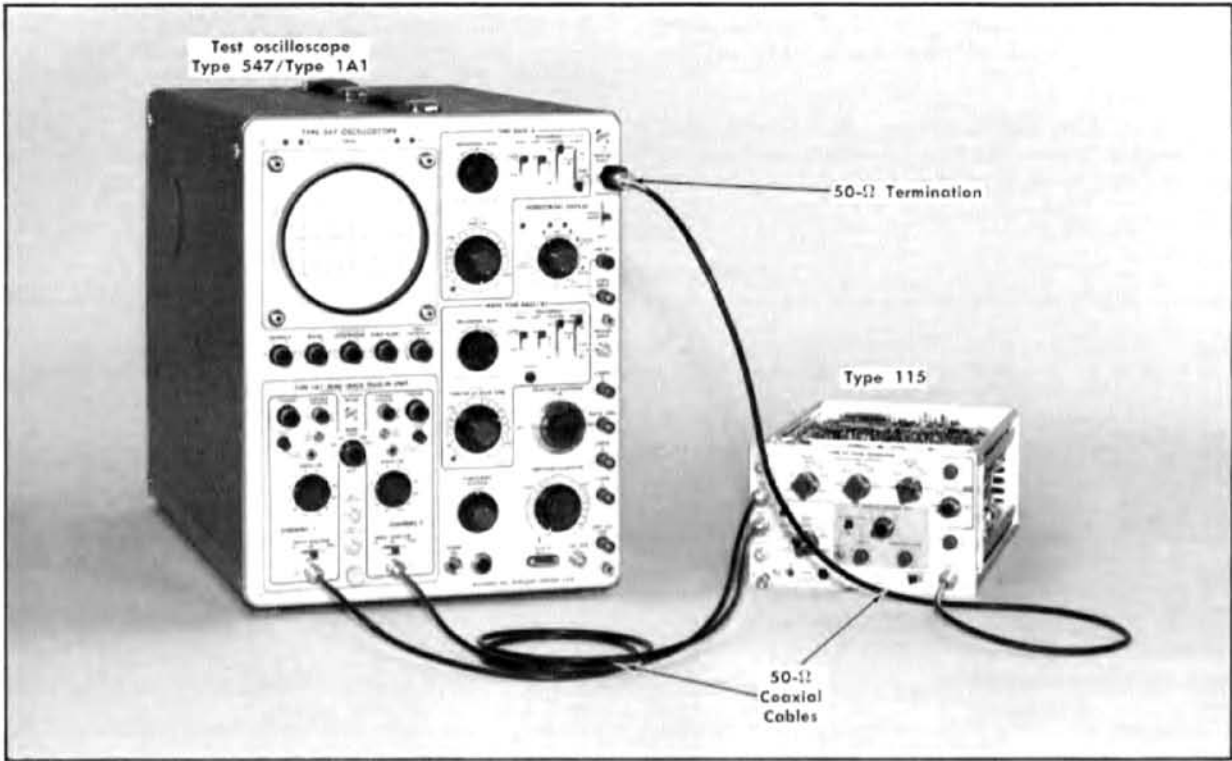


Fig. 5-25. Initial test equipment setup for steps 27 through 31.

Control Settings

	Type 115
MODE	UNDLY'D PULSE
TRIGGER	INT
PERIOD	10 μS
VARIABLE	CAL
DELAY OR BURST DURATION	50 nS
VARIABLE	CAL
WIDTH	5 μS
VARIABLE	CAL
RISETIME AND FALLTIME	10 nS
RISETIME MULT	1
FALLTIME MULT	1
DC OFFSET AND AMPLITUDE MULT	1

AMPLITUDE [VOLTS]	10
DC OFFSET PRESET-VARIABLE switch	VARIABLE
DC OFFSET [VOLTS] VARIABLE	0
PULSE POLARITY	+

Test Oscilloscope

Time/Cm	0.1 μs
Triggering	External
Vertical Mode	Alternate
Volts/Cm (Channel 1)	2 V
Volts/cm (Channel 2)	2 V
Input Selector	DC
Amplitude Calibrator	Off

MODES OF OPERATION, TRIGGERS AND TRIGGERING

27. Check Pretrigger and Delayed Trigger

- Test equipment setup is shown in Fig. 5-25.
- Disconnect the terminated coaxial cable from the Channel 1 input of the test oscilloscope and connect it to the Trigger Input connector.
- Connect a 50- Ω coaxial cable between the Type 115 + PRETRIG OUT connector and the test oscilloscope Channel 1 input.
- Connect a 50- Ω coaxial cable between the Type 115 + DLY'D TRIG OUT connector and the test oscilloscope Channel 2 input.
- Trigger the test oscilloscope.
- Position the pulses on the CRT so that they do not overlap (see Fig. 5-26).

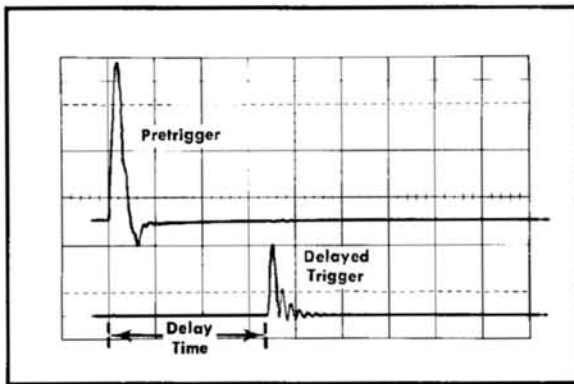


Fig. 5-26. Test oscilloscope display for checking pretrigger and delayed trigger output pulses.

- CHECK FOR—Test oscilloscope display of the two pulses each with an amplitude of at least 2 volts.
- Turn the DELAY OR BURST DURATION VARIABLE slowly to the fully clockwise position.
- CHECK FOR—Test oscilloscope display with the delayed trigger moving at least 5 cm (500 ns) to the right of the pre-trigger.

28. Check Undelayed Pulse, Delayed Pulse and Paired Pulses

- Disconnect all the 50- Ω coaxial cables from the test oscilloscope vertical inputs.
- Reconnect the 50- Ω coaxial cable, terminated in 50 Ω , between the Type 115 OUTPUT connector and the Channel 1 input.
- Reconnect the 50- Ω coaxial cable between the Type 115 + PRETRIG OUT connector and the Trigger Input connector on the test oscilloscope.

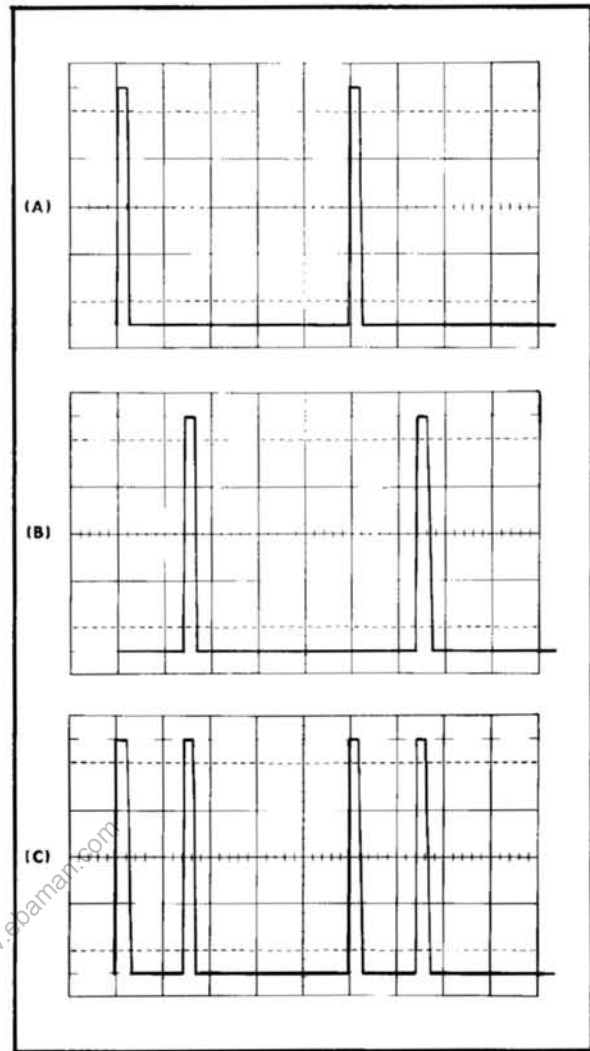


Fig. 5-27. Test oscilloscope displays for checking first three modes of operation: (A) Undelayed pulse; (B) Delayed pulse; (C) Paired Pulses.

- Reset the following Type 115 controls:

PERIOD	1 mS
DELAY OR BURST DURATION VARIABLE	50 μ S
WIDTH	CAL
RISETIME AND FALLTIME	50 μ S
	10 μ S

- Reset the following test oscilloscope controls:

Time/Cm	0.2 ms
Vertical Mode	Channel 1

- Trigger the test oscilloscope display.
- CHECK FOR—Test oscilloscope display of an undelayed output pulse with an approximate period of 1 ms (see Fig. 5-27A).
- Set the Type 115 MODE switch to DLY'D PULSE.

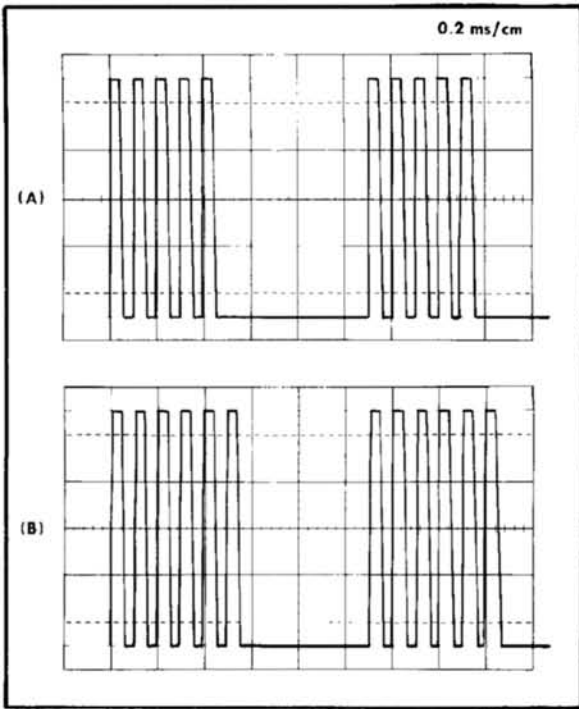


Fig. 5-28. Test oscilloscope display for checking burst: (A) Externally triggered burst; (B) Gated burst.

i. Turn the DELAY OR BURST DURATION VARIABLE control slowly clockwise while observing the test oscilloscope display.

j. CHECK FOR—Test oscilloscope display of the delayed pulse with the delay time controlled by the DELAY OR BURST DURATION VARIABLE controls.

k. Set the DELAY OR BURST DURATION VARIABLE control so that the rise of the delayed pulse is about 1.5 cm from the beginning of the sweep (see Fig. 5-27B).

l. Set the Type 115 MODE switch to PAIRED PULSES.

m. CHECK FOR—Test oscilloscope display of pairs of pulses with the second pulse of each pair delayed with respect to the first by an amount controlled by the DELAY OR BURST DURATION controls (see Fig. 5-27C).

29. Check External and Manual Triggering

a. Connect the BNC-T connector to the test oscilloscope Amplitude Calibrator Output connector.

b. Disconnect the 50-Ω coaxial cable from the Type 115 + PRETRIG OUT connector and reconnect it to one arm of the T-connector.

c. Connect another 50-Ω coaxial cable between the other arm of the T-connector and the Type 115 + TRIG IN connector.

d. Set the Type 115 TRIGGER switch to MAN OR EXTERNAL.

e. Set the test oscilloscope Amplitude Calibrator for 20 volts.

f. CHECK FOR Test oscilloscope display of the externally triggered Type 115 waveform.

g. Set the test oscilloscope Amplitude Calibrator for 2 volts.

h. CHECK FOR—Test oscilloscope display of the externally triggered Type 115 waveform as observed in part f.

i. Disconnect the 50-Ω coaxial cable connected between the Amplitude Calibrator Output connector and External Trigger Input of the test oscilloscope from the Amplitude Calibrator Output and reconnect it to the + PRETRIG OUT connector on the Type 115.

j. Reset the following Type 115 controls:

MODE	UNDLY'D PULSE
TRIGGER	INT
WIDTH VARIABLE	Fully clockwise

k. Reset the following test oscilloscope controls:

Amplitude Calibrator	Off
Triggering Mode	Triggered

l. Trigger the test oscilloscope.

m. Set the Type 115 TRIGGER switch to MAN or EXTERNAL.

n. Press the Type 115 MAN TRIG button.

o. CHECK FOR—Test oscilloscope display of manually triggered output pulse.

30. Check Burst Mode

a. Disconnect the 50-Ω coaxial cable from the Type 115 + PRETRIG OUT connector and reconnect it to the vacant arm of the T-connector on the test oscilloscope Amplitude Calibrator Output.

b. Reset the following Type 115 controls:

MODE	BURST
PERIOD	100 μS
DELAY OR BURST DURATION VARIABLE	Fully clockwise
WIDTH VARIABLE	CAL

c. Set the test oscilloscope Amplitude calibrator to 20 volts.

d. Trigger the test oscilloscope display.

e. CHECK FOR—Test oscilloscope display of burst of output pulses, with the burst duration set by the DELAY OR BURST DURATION controls and the burst period set by the test oscilloscope Amplitude Calibrator signal. The characteristics of each individual pulse within a burst are determined by the other Type 115 front-panel controls (see Fig. 5-28A).

f. Turn the DELAY OR BURST DURATION VARIABLE throughout its range while observing the change in burst duration.

g. Set the test oscilloscope Amplitude Calibrator to 2 volts.

h. CHECK FOR—Test oscilloscope display of the burst output, as observed in part e of this step.

31. Check Gated Output Mode

a. Disconnect the 50- Ω coaxial cable from the Type 115 + TRIG IN connector and reconnect it to the + GATE IN connector.

b. Set the Type 115 MODE switch to GATED.

c. Set the test oscilloscope Amplitude Calibrator to 20 volts.

d. CHECK FOR—Test oscilloscope display of the gated burst of output pulses, with the burst duration and the burst period set by the test oscilloscope Amplitude Calibrator signal. The characteristics of each pulse within a burst are determined by the other Type 115 controls (see Fig. 5-28B).

e. Decrease the test oscilloscope Amplitude Calibrator output to 2 volts.

f. CHECK FOR—Test oscilloscope display of the gated burst outputs, as observed in part d of this step.

This completes the calibration and performance check procedure of the Type 115. Test equipment may be disconnected and turned off.

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PARTS LIST ABBREVIATIONS

BHB	binding head brass	int	internal
BHS	binding head steel	lg	length or long
cap.	capacitor	met.	metal
cer	ceramic	mtg hdw	mounting hardware
comp	composition	OD	outside diameter
conn	connector	OHB	oval head brass
CRT	cathode-ray tube	OHS	oval head steel
csk	countersunk	PHB	pan head brass
DE	double end	PHS	pan head steel
dia	diameter	plstc	plastic
div	division	PMC	paper, metal cased
elect.	electrolytic	poly	polystyrene
EMC	electrolytic, metal cased	prec	precision
EMT	electrolytic, metal tubular	PT	paper, tubular
ext	external	PTM	paper or plastic, tubular, molded
F & I	focus and intensity	RHB	round head brass
FHB	flat head brass	RHS	round head steel
FHS	flat head steel	SE	single end
Fil HB	fillister head brass	SN or S/N	serial number
Fil HS	fillister head steel	SW	switch
h	height or high	TC	temperature compensated
hex.	hexagonal	THB	truss head brass
HHB	hex head brass	thk	thick
HHS	hex head steel	THS	truss head steel
HSB	hex socket brass	tub.	tubular
HSS	hex socket steel	var	variable
ID	inside diameter	w	wide or width
incd	incandescent	WW	wire-wound

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PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial or model number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

SPECIAL NOTES AND SYMBOLS

- ×000 Part first added at this serial number
- 00× Part removed after this serial number
- *000-0000-00 Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, Inc., or reworked or checked components.
- Use 000-0000-00 Part number indicated is direct replacement.
-  Screwdriver adjustment.
-  Control, adjustment or connector.

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SECTION 6

ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff Disc	Description		
Bulb					
B710	150-0045-00		Incandescent #685		
Capacitors					
Tolerance $\pm 20\%$ unless otherwise indicated.					
C10	281-0552-00		25 pF	Cer	500 V
C14	281-0518-00		47 pF	Cer	500 V
C17	283-0004-00		0.02 μ F	Cer	150 V
C20	283-0059-00		1 μ F		25 V
C31	283-0004-00		0.02 μ F	Cer	150 V
C33	283-0059-00		1 μ F	Cer	25 V
C38	281-0638-00		240 pF	Cer	500 V
C102	281-0549-00		68 pF	Cer	500 V
C119	281-0592-00		4.7 pF	Cer	± 0.5 pF
C127	281-0558-00		18 pF	Cer	500 V
C130	283-0059-00		1 μ F	Cer	25 V
C133	283-0004-00		0.02 μ F	Cer	150 V
C137	283-0095-00		5.5-18 pF, Var	Cer	
C138	281-0093-00		56 pF	Cer	200 V
C139C } C139D } C139E }	*295-0119-00		0.0085 μ F 0.1 μ F Timing Capacitor Assembly 863 pF		
C141	290-0183-00		1 μ F	Cer	35 V
C154	290-0162-00		22 μ F	Elect.	35 V
C155	281-0540-00		51 pF	Cer	500 V
C157	290-0135-00		15 μ F	Elect.	20 V
C164	281-0511-00		22 pF	Cer	500 V
C175	281-0523-00		100 pF	Cer	350 V
C180	283-0059-00		1 μ F	Cer	25 V
C184	281-0549-00		68 pF	Cer	500 V
C192	290-0135-00		15 μ F	Elect.	20 V
C194	290-0135-00		15 μ F	Elect.	20 V
C196	290-0162-00		22 μ F	Elect.	35 V
C198	290-0261-00		6.8 μ F	Elect.	35 V
C204	281-0516-00		39 pF	Cer	500 V
C214	281-0509-00		15 pF	Cer	500 V
C221	281-0523-00		100 pF	Cer	350 V

Capacitors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
C230	290-0261-00		6.8 μ F	Elect.	35 V	
C241	283-0059-00		1 μ F	Cer	25 V	+80%—20%
C243	283-0004-00		0.02 μ F	Cer	150 V	
C249A	281-0061-00		5.5-18 pF, Var	Cer		
C249B	281-0504-00		10 pF	Cer	500 V	10%
C249C	281-0063-00		9-35 pF, Var	Cer		
C249D	283-0651-00		430 pF	Mica	500 V	1%
C249E } C249F } C249G }	*295-0120-00		0.00488 μ F 0.00495 μ F Timing Capacitor Assembly 0.5 μ F			
C250	283-0059-00		1 μ F	Cer	25 V	+80%—20%
C252	283-0059-00		1 μ F	Cer	25 V	+80%—20%
C256	283-0059-00		1 μ F	Cer	25 V	+80%—20%
C263	281-0525-00		470 pF		500 V	
C266	281-0623-00		650 pF	Cer	500 V	5%
C270	281-0511-00		22 pF	Cer	500 V	10%
C273	283-0000-00		0.001 μ F	Cer	500 V	
C276	281-0543-00		270 pF	Cer	500 V	10%
C277	290-0162-00		22 μ F	Elect.	35 V	
C290	290-0162-00		22 μ F	Elect.	35 V	
C292	290-0135-00		15 μ F	Elect.	20 V	
C294	290-0135-00		15 μ F	Elect.	20 V	
C298	290-0261-00		6.8 μ F	Elect.	35 V	
C302	281-0504-00		10 pF	Cer	500 V	10%
C319	281-0592-00		4.7 pF	Cer		± 0.5 pF
C327	281-0509-00		15 pF	Cer	500 V	10%
C330	283-0059-00		1 μ F	Cer	25 V	+80%—20%
C333	283-0004-00		0.02 μ F	Cer	150 V	
C337	283-0534-00		65 pF	Mica	100 V	1%
C338	281-0093-00		5.5-18 pF, Var	Cer		
C339C } C339D } C339E }	*295-0118-00		0.0085 μ F 0.1 μ F Timing Capacitor Assembly 908 pF			
C341	283-0059-00		1 μ F	Cer	25 V	+80%—20%
C346	283-0059-00		1 μ F	Cer	25 V	+80%—20%
C360	290-0162-00		22 μ F	Elect.	35 V	
C362	290-0135-00		15 μ F	Elect.	20 V	
C366	290-0162-00		22 μ F	Elect.	35 V	
C367	290-0261-00		6.8 μ F	Elect.	35 V	
C368	290-0261-00		6.8 μ F	Elect.	35 V	
C370	283-0003-00		0.01 μ F	Cer	150 V	
C374	283-0003-00		0.01 μ F	Cer	150 V	
C381	283-0003-00		0.01 μ F	Cer	150 V	
C390	283-0003-00		0.01 μ F	Cer	150 V	
C395	281-0092-00		9-35 pF, Var	Cer		

Capacitors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No.		Description		
		Eff	Disc			
C396	283-0628-00		410 pF	Mica	500 V	1%
C397	281-0092-00		9-35 pF, Var	Cer		
C398 } C399 }	*295-0093-00		0.05 μ F 0.005 μ F	Checked Assembly		
C400	283-0059-00		1 μ F	Cer	25 V	+80%—20%
C401	283-0003-00		0.01 μ F	Cer	150 V	
C410	283-0003-00		0.01 μ F	Cer	150 V	
C420	283-0003-00		0.01 μ F	Cer	150 V	
C424	283-0003-00		0.01 μ F	Cer	150 V	
C434	283-0000-00		0.001 μ F	Cer	500 V	
C445	290-0162-00		22 μ F	Elect.	35 V	
C446	283-0059-00		1 μ F	Cer	25 V	+80%—20%
C453	283-0059-00		1 μ F	Cer	25 V	+80%—20%
C463	283-0059-00		1 μ F	Cer	25 V	+80%—20%
C467	283-0080-00		0.022 μ F	Cer	25 V	+80%—20%
C471	281-0093-00		5.5-18 pF, Var	Cer		
C473	283-0059-00		1 μ F	Cer	25 V	+80%—20%
C479	283-0059-00		1 μ F	Cer	25 V	+80%—20%
C481	283-0059-00		1 μ F	Cer	25 V	+80%—20%
C490	281-0616-00		6.8 pF	Cer	200 V	
C492	290-0261-00		6.8 μ F	Elect.	35 V	
C496	283-0059-00		1 μ F	Cer	25 V	+80%—20%
C497	290-0162-00		22 μ F	Elect.	35 V	
C498	290-0135-00		15 μ F	Elect.	20 V	
C499	283-0059-00		1 μ F	Cer	25 V	+80%—20%
C515	283-0080-00		0.022 μ F	Cer	25 V	+80%—20%
C543	283-0059-00		1 μ F	Cer	25 V	+80%—20%
C548	283-0059-00		1 μ F	Cer	25 V	+80%—20%
C549	290-0183-00		1 μ F	Elect.	35 V	10%
C551	281-0093-00		5.5-18 pF, Var	Cer		
C563	281-0092-00		9-35 pF, Var	Cer		
C571	290-0134-00		22 μ F	Elect.	15 V	
C572	283-0080-00		0.022 μ F	Cer	25 V	+80%—20%
C574	281-0511-00		22 pF	Cer	500 V	10%
C584	281-0638-00		240 pF	Cer	500 V	5%
C589	283-0059-00		1 μ F	Cer	25 V	+80%—20%
C592F	281-0512-00		27 pF	Cer (nominal value)	Selected	
C593	290-0312-00		47 μ F	Elect.	35 V	10%
C595	283-0059-00		1 μ F	Cer	25 V	+80%—20%
C599	283-0059-00		1 μ F	Cer	25 V	+80%—20%
C606	283-0003-00		0.01 μ F	Cer	150 V	
C614	283-0000-00		0.001 μ F	Cer	500 V	
C623	290-0121-00		2 μ F	Elect.	25 V	
C633	283-0059-00		1 μ F	Cer	25 V	+80%—20%
C634	283-0000-00		0.001 μ F	Cer	500 V	

Capacitors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No.		Description		
		Eff	Disc			
C712	290-0122-00		1000 μ F	Elect.	50 V	
C716	290-0122-00		1000 μ F	Elect.	50 V	
C717	290-0183-00		1 μ F	Elect.	35 V	10%
C722	283-0003-00		0.01 μ F	Cer	150 V	
C725	290-0183-00		1 μ F	Elect.	35 V	10%
C736	290-0312-00		47 μ F	Elect.	35 V	10%
C740	290-0183-00		1 μ F	Elect.	35 V	10%
C744	290-0297-00		39 μ F	Elect.	10 V	10%
C751	290-0297-00		39 μ F	Elect.	10 V	10%
C773	283-0004-00		0.02 μ F	Cer	150 V	
C776	290-0312-00		47 μ F	Elect.	35 V	10%
C780	290-0183-00		1 μ F	Elect.	35 V	10%
C786	290-0312-00		47 μ F	Elect.	35 V	10%

Semiconductor Device, Diodes

D11	*152-0185-00	Silicon	Replaceable by 1N4152
D17	152-0071-00	Germanium	ED2007
D18	*152-0185-00	Silicon	Replaceable by 1N4152
D25	152-0373-00	Tunnel	I _p -4.7 mA C _v -50 pF
D26	*152-0075-00	Germanium	Tek Spec
D32	*152-0185-00	Silicon	Replaceable by 1N4152
D38	*152-0075-00	Germanium	Tek Spec
D39	*152-0185-00	Silicon	Replaceable by 1N4152
D107	152-0212-00	Zener	1N936 0.5 W, 9 V, 5%, TC
D108	152-0055-00	Zener	1N962B 0.4 W, 11 V, 5%
D144	152-0071-00	Germanium	ED2007
D145	*152-0185-00	Silicon	Replaceable by 1N4152
D175	*152-0185-00	Silicon	Replaceable by 1N4152
D176	*152-0185-00	Silicon	Replaceable by 1N4152
D180	*152-0185-00	Silicon	Replaceable by 1N4152
D204	*152-0185-00	Silicon	Replaceable by 1N4152
D220	*152-0185-00	Silicon	Replaceable by 1N4152
D222	*152-0185-00	Silicon	Replaceable by 1N4152
D228	152-0280-00	Zener	1N753A 0.4 W, 6.2 V, 5%
D234	*152-0185-00	Silicon	Replaceable by 1N4152
D235	152-0373-00	Tunnel	I _p -4.7 mA C _v -50 pF
D240	*152-0185-00	Silicon	Replaceable by 1N4152
D241	*152-0185-00	Silicon	Replaceable by 1N4152
D254	*152-0185-00	Silicon	Replaceable by 1N4152
D279	*152-0185-00	Silicon	Replaceable by 1N4152
D280	*152-0075-00	Germanium	Tek Spec
D282	*152-0075-00	Germanium	Tek Spec
D283	*152-0185-00	Silicon	Replaceable by 1N4152
D307	152-0212-00	Zener	1N936 0.5 W, 9 V, 5%, TC
D308	152-0055-00	Zener	1N962B 0.4 W, 11 V, 5%

Semiconductor Device, Diodes (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
D345	152-0141-02		Silicon	1N4152
D381	152-0127-00		Zener	1N755A 0.4 W, 7.5 V, 5%
D401	152-0149-00		Zener	1N961B 0.4 W, 10 V, 5%
D414	*152-0322-00		Silicon	Tek Spec
D443	*152-0185-00		Silicon	Replaceable by 1N4152
D445	*152-0322-00		Silicon	Tek Spec
D453	*152-0322-00		Silicon	Tek Spec
D483	152-0141-02		Silicon	1N4152
D484	152-0141-02		Silicon	1N4152
D543	152-0123-00		Zener	1N935A 0.5 W, 9.1 V, 5%
D553	*152-0185-00		Silicon	Replaceable by 1N4152
D589	*152-0185-00		Silicon	Replaceable by 1N4152
D623	*152-0185-00		Silicon	Replaceable by 1N4152
D633	152-0166-00		Zener	1N753A 0.4 W, 6.2 V, 5%
D640	152-0236-00		Zener	0.4 W, 12.5 V, 4%
D641	152-0304-00		Zener	1N968B 0.4 W, 20 V, 5%
D643	*152-0185-00		Silicon	Replaceable by 1N4152
D644	*152-0185-00		Silicon	Replaceable by 1N4152
D712	152-0200-00		Rectifier Bridge	MDA 962-5 (Motorola)
D716	152-0200-00		Rectifier Bridge	MDA 962-5 (Motorola)
D717	*152-0212-00		Zener	1N936 0.5 W, 9 V, 5%, TC
D722	*152-0185-00		Silicon	Replaceable by 1N4152
D734	*152-0185-00		Silicon	Replaceable by 1N4152
D736	152-0056-00		Silicon	1N3194
D737	152-0089-00		Zener	12.6 V, 10 W, 5%
D740	152-0127-00		Zener	1N755A 0.4 W, 7.5 V, 5%
D744	152-0066-00		Silicon	1N3194
D751	*152-0107-00		Silicon	Replaceable by 1N647
D767	*152-0185-00		Silicon	Replaceable by 1N4152
D774	*152-0185-00		Silicon	Replaceable by 1N4152
D776	152-0066-00		Silicon	1N3194
D780	*152-0185-00		Silicon	Replaceable by 1N4152
D786	152-0066-00		Silicon	1N3194
D794	*152-0185-00		Silicon	Replaceable by 1N4152

Fuses

F702	159-0041-00	1.25 A 3AG Slo-Blo
F703	159-0018-00	0.8 A 3AG Slo-Blo

Connectors

J10	131-0106-00	BNC, 1 contact, female
J179	131-0105-00	BNC, 1 contact, female
J201	131-0106-00	BNC, 1 contact, female
J279	131-0106-00	BNC, 1 contact, female
J593	131-0106-00	BNC, 1 contact, female

Relays

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
K397	*108-0499-00			Coil, Reed
K397A	260-1002-00			Reed
K398	*108-0499-00			Coil, Reed
K398A	260-1002-00			Reed
K399	*108-0499-00			Coil, Reed
K399A	260-1002-00			Reed
K500	*108-0357-00			Coil, Reed
K500A	260-0721-00			Reed
K505	*108-0357-00			Coil, Reed
K505A	260-0721-00			Reed

Inductors

L25	*108-0148-00			2.4 μ H
L114	*108-0170-01			0.5 μ H (Wound on a 22 M Ω resistor)
L146	276-0528-00			Core, Ferramic Suppressor
L184	276-0528-00			Core, Ferramic Suppressor
L314	*108-0170-01			0.5 μ H (Wound on a 22 M Ω resistor)
L374	276-0507-00			Core, Ferramic Suppressor
L384	276-0507-00			Core, Ferramic Suppressor
L394	276-0507-00			Core, Ferramic Suppressor
L404	276-0507-00			Core, Ferramic Suppressor
L414	276-0507-00			Core, Ferramic Suppressor
L424	276-0507-00			Core, Ferramic Suppressor
L471	*108-0278-00			0.3 μ H (Wound on a 3.3 Ω resistor)
L591	276-0528-00	XB020000		Core, Ferramic Suppressor
L592	*108-0352-00	XB020000		0.1 μ H
L664A	108-0344-00			8.6 mH
L664B	*108-0354-00			5 mH
L664C	*108-0353-00			1.3 mH
L668	*108-0417-01			110 μ H
LR144	*108-0212-00			0.5 μ H (Wound on a 330 Ω resistor)
LR524	*108-0209-00			0.75 μ H (Wound on a 470 Ω resistor)

Transistors

Q14	*151-0108-00		Silicon	Replaceable by 2N2501
Q18	*151-0133-00		Silicon	Selected from 2N3251
Q32	*151-0127-00		Silicon	Selected from 2N2369
Q36	*151-0108-00		Silicon	Replaceable by 2N2501
Q38	*151-0133-00		Silicon	Selected from 2N3251
Q102	*151-0108-00		Silicon	Replaceable by 2N2501
Q106	*151-0127-00		Silicon	Selected from 2N2369
Q114	*151-0127-00		Silicon	Selected from 2N2369
Q124	*151-0127-00		Silicon	Selected from 2N2369
Q138	*151-0103-00		Silicon	Replaceable by 2N2219

Transistors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
Q144	*151-0127-00		Silicon	Selected from 2N2369
Q153	151-0190-00		Silicon	2N3904
Q164	*151-0133-00		Silicon	Selected from 2N3251
Q173	*151-0127-00		Silicon	Selected from 2N2369
Q184	151-0223-00		Silicon	2N4275
Q204	*151-0108-00		Silicon	Replaceable by 2N2501
Q214	*151-0133-00		Silicon	Selected from 2N3251
Q224	151-0225-00		Silicon	2N3563
Q226	*151-0127-00		Silicon	Selected from 2N2369
Q233	151-0223-00		Silicon	2N4275
Q244	*151-0103-00		Silicon	Replaceable by 2N2219
Q253	*151-0127-00		Silicon	Selected from 2N2369
Q264	*151-0133-00		Silicon	Selected from 2N3251
Q266	*151-0127-00		Silicon	Selected from 2N2369
Q274	*151-0133-00		Silicon	Selected from 2N3251
Q276	*151-0108-00		Silicon	Replaceable by 2N2501
Q302	*151-0108-00		Silicon	Replaceable by 2N2501
Q306	*151-0127-00		Silicon	Selected from 2N2369
Q314	*151-0127-00		Silicon	Selected from 2N2369
Q324	*151-0127-00		Silicon	Selected from 2N2369
Q338	*151-0103-00		Silicon	Replaceable by 2N2219
Q343	*151-0127-00		Silicon	Selected from 2N2369
Q353	*151-0108-00		Silicon	Replaceable by 2N2501
Q374	*151-0134-00		Silicon	Replaceable by 2N2905
Q384	*151-0133-00		Silicon	Selected from 2N3251
Q394	*151-0133-00		Silicon	Selected from 2N3251
Q404	*151-0127-00		Silicon	Selected from 2N2369
Q414	*151-0127-00		Silicon	Selected from 2N2369
Q424	*151-0103-00		Silicon	Replaceable by 2N2219
Q434	151-0164-00		Silicon	2N3702
Q443	151-0164-00		Silicon	2N3702
Q444	*151-0136-00		Silicon	Replaceable by 2N3053
Q453	*151-0133-00		Silicon	Selected from 2N3251
Q463	151-0221-00		Silicon	2N4258
Q473	151-0223-00		Silicon	2N4275
Q483	151-0221-00		Silicon	2N4258
Q493	151-0221-00		Silicon	2N4258
Q513	151-0188-00		Silicon	2N3906
Q523	*151-0198-00		Silicon	Replaceable by MPS-918
Q534	151-0223-00		Silicon	2N4275
Q543	151-0223-00		Silicon	2N4275
Q553	*151-0167-00		Silicon	Selected from 2N3546
Q563	*151-0211-00		Silicon	Selected from 2N3866
Q564	151-0235-00		Silicon	2N4890
Q573	*151-0211-00		Silicon	Selected from 2N3866

Electrical Parts List—Type 115

Transistors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No.		Description
		Eff	Disc	
Q574	151-0235-00		Silicon	2N4890
Q583	*151-0211-00		Silicon	Selected from 2N3866
Q584	151-0235-00		Silicon	2N4890
Q614	151-0164-00		Silicon	2N3702
Q623	151-0164-00		Silicon	2N3702
Q624	*151-0136-00		Silicon	Replaceable by 2N3053
Q634	151-0190-00		Silicon	2N3904
Q643	151-0227-00		Silicon	2N3741
Q654	151-0226-00		Silicon	2N3767
Q722	151-0188-00		Silicon	2N3906
Q724	151-0188-00		Silicon	2N3906
Q732	151-0188-00		Silicon	2N3906
Q734	151-0208-00		Silicon	2N4036
Q738	151-0258-00		Silicon	2N4905
Q744	*151-0136-00		Silicon	Replaceable by 2N3053
Q746	151-0188-00		Silicon	2N3906
Q752	151-0188-00		Silicon	2N3906
Q756	151-0208-00		Silicon	2N4036
Q758	151-0227-00		Silicon	2N3741
Q762	151-0190-00		Silicon	2N3904
Q764	151-0190-00		Silicon	2N3904
Q772	151-0190-00		Silicon	2N3904
Q774	*151-0136-00		Silicon	Replaceable by 2N3053
Q778	*151-0140-00		Silicon	Selected from 2N3055
Q782	151-0188-00		Silicon	2N3906
Q784	151-0188-00		Silicon	2N3906
Q794	151-0208-00		Silicon	2N4036
Q797	151-0226-00		Silicon	2N3767
Q798	151-0227-00		Silicon	2N3741

Resistors

Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.

R9	315-0101-00	100 Ω	1/4 W	5%
R10	315-0102-00	1 k Ω	1/4 W	5%
R13	315-0122-00	1.2 k Ω	1/4 W	5%
R14	315-0391-00	390 Ω	1/4 W	5%
R17	307-0104-00	3.3 Ω	1/4 W	5%
R18	315-0272-00	2.7 k Ω	1/4 W	5%
R20	315-0301-00	300 Ω	1/4 W	5%
R21	315-0152-00	1.5 k Ω	1/4 W	5%
R24	301-0332-00	3.3 k Ω	1/2 W	5%
R25	301-0330-00	33 Ω	1/2 W	5%

Resistors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
R26	301-0152-00		1.5 k Ω	1/2 W		5%
R27	301-0360-00		36 Ω	1/2 W		5%
R30	315-0100-00		10 Ω	1/4 W		5%
R31	315-0100-00		10 Ω	1/4 W		5%
R32	301-0152-00		1.5 k Ω	1/2 W		5%
R35	301-0751-00		750 Ω	1/2 W		5%
R36	315-0242-00		2.4 k Ω	1/4 W		5%
R101	301-0101-00		100 Ω	1/2 W		5%
R102	301-0391-00		390 Ω	1/2 W		5%
R104	301-0391-00		390 Ω	1/2 W		5%
R107	301-0472-00		4.7 k Ω	1/2 W		5%
R110	315-0101-00		100 Ω	1/4 W		5%
R114	301-0331-00		330 Ω	1/2 W		5%
R115	307-0060-00		6.8 Ω	1/2 W		5%
R119	301-0362-00		3.6 k Ω	1/2 W		5%
R120	301-0222-00		2.2 k Ω	1/2 W		5%
R121	311-0496-00		2.5 k Ω , Var			5%
R124	301-0241-00		240 Ω	1/2 W		5%
R125	301-0510-00		51 Ω	1/2 W		5%
R127	301-0681-00		680 Ω	1/2 W		5%
R130	301-0242-00		2.4 k Ω	1/2 W		5%
R131	311-0462-00		1 k Ω , Var			
R132	301-0202-00		2 k Ω	1/2 W		5%
R133	323-0151-00		365 Ω	1/2 W	Prec	1%
R134	311-0056-00		500 Ω , Var			
R135	311-0777-00		1 k Ω , Var			
R136	311-0860-00		10 k Ω , Var			
R137	301-0510-00		51 Ω	1/2 W		5%
R138	315-0560-00		56 Ω	1/4 W		5%
R139C	315-0220-00		22 Ω	1/4 W		5%
R140	321-0163-00		487 Ω	1/8 W	Prec	1%
R141	321-0165-00		511 Ω	1/8 W	Prec	1%
R146	301-0821-00		820 Ω	1/2 W		5%
R150	301-0101-00		100 Ω	1/2 W		5%
R154	307-0104-00		3.3 Ω	1/4 W		5%
R155	321-0161-00		464 Ω	1/8 W	Prec	1%
R156	321-0209-00		1.47 k Ω	1/8 W	Prec	1%
R157	307-0104-00		3.3 Ω	1/4 W		5%
R160	301-0820-00		82 Ω	1/2 W		5%
R164	301-0471-00		470 Ω	1/2 W		5%
R170	301-0470-00		47 Ω	1/2 W		5%
R175	301-0102-00		1 k Ω	1/2 W		5%
R179	315-0101-00		100 Ω	1/4 W		5%
R180	301-0123-00		12 k Ω	1/2 W		5%
R184	301-0511-00		510 Ω	1/2 W		5%

Electrical Parts List—Type 115

Resistors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
R185	301-0432-00		4.3 k Ω	1/2 W	5%
R192	307-0104-00		3.3 Ω	1/4 W	5%
R194	307-0104-00		3.3 Ω	1/4 W	5%
R196	307-0104-00		3.3 Ω	1/4 W	5%
R201	301-0102-00		1 k Ω	1/2 W	5%
R202	301-0512-00		5.1 k Ω	1/2 W	5%
R204	301-0153-00		15 k Ω	1/2 W	5%
R205	301-0471-00		470 Ω	1/2 W	5%
R210	301-0102-00		1 k Ω	1/2 W	5%
R214	301-0752-00		7.5 k Ω	1/2 W	5%
R215	301-0223-00		22 k Ω	1/2 W	5%
R220	301-0752-00		7.5 k Ω	1/2 W	5%
R221	301-0101-00		100 Ω	1/2 W	5%
R222	301-0202-00		2 k Ω	1/2 W	5%
R224	301-0561-00		560 Ω	1/2 W	5%
R225	315-0512-00		5.1 k Ω	1/4 W	5%
R226	315-0103-00		10 k Ω	(nominal value) Selected	5%
R228	315-0683-00		68 k Ω	1/4 W	5%
R230	315-0820-00		82 Ω	1/4 W	5%
R233	315-0101-00		100 Ω	1/4 W	5%
R234	301-0681-00		680 Ω	1/2 W	5%
R235	317-0101-00		100 Ω	1/8 W	5%
R236	307-0108-00		6.8 Ω	1/4 W	5%
R240	315-0302-00		3 k Ω	1/4 W	5%
R241	311-0496-00		2.5 k Ω , Var		
R243	321-0204-00		1.3 k Ω	1/8 W	Prec 1%
R245	311-0131-00		1 k Ω , Var		
R246	311-0642-00		20 k Ω , Var		
R247	307-0108-00		6.8 Ω	1/4 W	5%
R249A	307-0113-00		5.1 Ω	1/4 W	5%
R249D	315-0100-00		10 Ω	1/4 W	5%
R250	301-0471-00		470 Ω	1/2 W	5%
R251	301-0391-00		390 Ω	1/2 W	5%
R252	301-0162-00		1.6 k Ω	1/2 W	5%
R254	317-0101-00		100 Ω	1/8 W	5%
R256	301-0682-00		6.8 k Ω	1/2 W	5%
R263	315-0101-00		100 Ω	1/4 W	5%
R264	315-0121-00		120 Ω	1/4 W	5%
R265	315-0751-00		750 Ω	1/4 W	5%
R266	315-0620-00		62 Ω	1/4 W	5%
R270	301-0102-00		1 k Ω	1/2 W	5%
R271	301-0102-00		1 k Ω	1/2 W	5%
R273	315-0471-00		470 Ω	1/4 W	5%
R274	301-0202-00		2 k Ω	1/2 W	5%
R276	301-0331-00		330 Ω	1/2 W	5%

Resistors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No.		Description		
		Eff	Disc			
R277	307-0104-00		3.3 Ω	1/4 W		5%
R279	315-0102-00		1 k Ω	1/4 W		5%
R280	301-0101-00		100 Ω	1/2 W		5%
R282	301-0101-00		100 Ω	1/2 W		5%
R290	307-0104-00		3.3 Ω	1/4 W		5%
R292	307-0104-00		3.3 Ω	1/4 W		5%
R294	307-0104-00		3.3 Ω	1/4 W		5%
R302	301-0391-00		390 Ω	1/2 W		5%
R304	301-0391-00		390 Ω	1/2 W		5%
R307	301-0472-00		4.7 k Ω	1/2 W		5%
R310	315-0101-00		100 Ω	1/4 W		5%
R314	301-0331-00		330 Ω	1/2 W		5%
R315	307-0108-00		6.8 Ω	1/4 W		5%
R319	301-0362-00		3.6 k Ω	1/2 W		5%
R320	301-0222-00		2.2 k Ω	1/2 W		5%
R321	311-0496-00		2.5 k Ω , Var			
R324	301-0560-00		56 Ω	1/2 W		5%
R325	307-0113-00		5.1 Ω	1/4 W		5%
R327	301-0681-00		680 Ω	1/2 W		5%
R330	301-0123-00		12 k Ω	1/2 W		5%
R331	311-0463-00		5 k Ω , Var			
R332	301-0822-00		8.2 k Ω	1/2 W		5%
R333	323-0164-00		499 Ω	1/2 W	Prec	1%
R335	311-0777-00		1 k Ω , Var			
R336	311-0860-00		10 k Ω , Var			
R337	301-0510-00		51 Ω	1/2 W		5%
R338	315-0510-00		51 Ω	1/4 W		5%
R339C	315-0220-00		22 Ω	1/4 W		5%
R340	321-0163-00		487 Ω	1/8 W	Prec	1%
R341	321-0165-00		511 Ω	1/8 W	Prec	1%
R346	301-0182-00		1.8 k Ω	1/2 W		5%
R350	301-0271-00		270 Ω	1/2 W		5%
R354	315-0511-00		510 Ω	1/4 W		5%
R356	301-0751-00		750 Ω	1/2 W		5%
R360	307-0104-00		3.3 Ω	1/4 W		5%
R362	307-0104-00		3.3 Ω	1/4 W		5%
R366	307-0104-00		3.3 Ω	1/4 W		5%
R370	315-0242-00		2.4 k Ω	1/4 W		5%
R371	311-0462-00		1 k Ω , Var			
R372	315-0102-00		1 k Ω	1/4 W		5%
R373	315-0330-00		33 Ω	1/4 W		5%
R374	323-0133-00		237 Ω	1/2 W	Prec	1%
R375	311-0616-00		250 Ω , Var			
R376	311-0616-00		250 Ω , Var			
R378	311-0861-00		4 k Ω , Var			

Electrical Parts List—Type 115

Resistors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
R380	315-0220-00		22 Ω	$\frac{1}{4}$ W	5%
R381	315-0152-00		1.5 k Ω	$\frac{1}{4}$ W	5%
R383	315-0101-00		100 Ω	$\frac{1}{4}$ W	5%
R390	315-0222-00		2.2 k Ω	$\frac{1}{4}$ W	5%
R391	311-0462-00		1 k Ω , Var		
R392	315-0332-00		3.3 k Ω	$\frac{1}{4}$ W	5%
R393	315-0101-00		100 Ω	$\frac{1}{4}$ W	5%
R394	315-0180-00		18 Ω	$\frac{1}{4}$ W	5%
R395	307-0113-00		5.1 Ω	$\frac{1}{4}$ W	5%
R397	307-0113-00		5.1 Ω	$\frac{1}{4}$ W	5%
R401	301-0202-00		2 k Ω	$\frac{1}{2}$ W	5%
R403	315-0101-00		100 Ω	$\frac{1}{4}$ W	5%
R410	315-0221-00		220 Ω	$\frac{1}{4}$ W	5%
R411	311-0462-00		1 k Ω , Var		
R412	315-0222-00		2.2 k Ω	$\frac{1}{4}$ W	5%
R413	315-0101-00		100 Ω	$\frac{1}{4}$ W	5%
R414	315-0180-00		18 Ω	$\frac{1}{4}$ W	5%
R420	315-0242-00		2.4 k Ω	$\frac{1}{4}$ W	5%
R421	311-0462-00		1 k Ω , Var		
R422	315-0102-00		1 k Ω	$\frac{1}{4}$ W	5%
R423	315-0330-00		33 Ω	$\frac{1}{4}$ W	5%
R424	323-0136-00		255 Ω	$\frac{1}{2}$ W	1%
R425	311-0616-00		250 Ω , Var		
R426	311-0616-00		250 Ω , Var		
R428	311-0861-00		4 k Ω , Var		
R430	315-0102-00		1 k Ω	$\frac{1}{4}$ W	5%
R431	311-0462-00		1 k Ω , Var		
R432	315-0302-00		3 k Ω	$\frac{1}{4}$ W	5%
R433	315-0153-00		15 k Ω	$\frac{1}{4}$ W	5%
R434	301-0113-00		11 k Ω	$\frac{1}{2}$ W	5%
R443	315-0103-00		10 k Ω	$\frac{1}{4}$ W	5%
R444	315-0223-00		22 k Ω	$\frac{1}{4}$ W	5%
R453	315-0472-00		4.7 k Ω	$\frac{1}{4}$ W	5%
R460	315-0271-00		270 Ω	$\frac{1}{4}$ W	5%
R461	315-0244-00		240 k Ω	$\frac{1}{4}$ W	5%
R463	315-0100-00		10 Ω	$\frac{1}{4}$ W	5%
R464	303-0511-00		510 Ω	1 W	5%
R466	307-0113-00		5.1 Ω	$\frac{1}{4}$ W	5%
R467	315-0101-00		100 Ω	$\frac{1}{4}$ W	5%
R470	315-0101-00		100 Ω	$\frac{1}{4}$ W	5%
R471	311-0622-00		100 Ω , Var		
R473	315-0330-00		33 Ω	$\frac{1}{4}$ W	5%
R474	307-0113-00		5.1 Ω	$\frac{1}{4}$ W	5%
R476	303-0182-00		1.8 k Ω	1 W	5%
R479	311-0169-00		100 Ω , Var		

Resistors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No.		Description	
		Eff	Disc		
R480	303-0392-00		3.9 k Ω	1 W	5%
R481	311-0514-00		100 Ω , Var		
R482	315-0820-00		82 Ω	1/4 W	5%
R483	306-0122-00		1.2 k Ω	2 W	
R490	317-0101-00		100 Ω	1/8 W	5%
R491	315-0151-00		150 Ω	1/4 W	5%
R492	307-0104-00		3.3 Ω	1/4 W	5%
R493	301-0202-00		2 k Ω	1/2 W	5%
R494	315-0101-00		100 Ω	1/4 W	5%
R497	307-0104-00		3.3 Ω	1/4 W	5%
R498	307-0104-00		3.3 Ω	1/4 W	5%
R499	307-0104-00		3.3 Ω	1/4 W	5%
R500	315-0151-00		150 Ω	1/4 W	5%
R501	315-0270-00		27 Ω	1/4 W	5%
R503	315-0271-00		270 Ω	1/4 W	5%
R505	315-0151-00		150 Ω	1/4 W	5%
R506	315-0270-00		27 Ω	1/4 W	5%
R510	315-0221-00		220 Ω	1/4 W	5%
R511	311-0480-00		500 Ω , Var		
R512	303-0182-00		1.8 k Ω	1 W	5%
R514	301-0152-00		1.5 k Ω	1/2 W	5%
R515	315-0220-00		22 Ω	1/4 W	5%
R520	315-0220-00		22 Ω	1/4 W	5%
R522	315-0221-00		220 Ω	1/4 W	5%
R523	311-0480-00		500 Ω , Var		
R524	301-0561-00		560 Ω	1/2 W	5%
R531	315-0101-00		100 Ω	1/4 W	5%
R532	315-0274-00		270 k Ω	1/4 W	5%
R533	315-0153-00		1.5 k Ω	1/4 W	5%
R534	301-0752-00		7.5 k Ω	1/2 W	5%
R535	301-0821-00		820 Ω	1/2 W	5%
R541	315-0100-00		10 Ω	1/4 W	5%
R542	315-0330-00		33 Ω	1/4 W	5%
R543	303-0302-00		3 k Ω	1 W	5%
R544	315-0151-00		150 Ω	1/4 W	5%
R548	307-0106-00		4.7 Ω	1/4 W	5%
R549	307-0106-00		4.7 Ω	1/4 W	5%
R551	315-0181-00		180 Ω	1/4 W	5%
R553	308-0077-00		1 k Ω	3 W	5%
R554	307-0113-00		5.1 Ω	1/4 W	5%
R560	315-0330-00		33 Ω	1/4 W	5%
R563	315-0511-00		510 Ω	1/4 W	5%
R565	303-0750-00		75 Ω	1 W	5%
R567	315-0330-00		33 Ω	1/4 W	5%
R570	315-0330-00		33 Ω	1/4 W	5%

Electrical Parts List—Type 115

Resistors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
R571	307-0051-00		2.7 Ω	1/2 W	5%
R574	315-0391-00		390 Ω	1/4 W	5%
R575	303-0750-00		75 Ω	1 W	5%
R577	315-0330-00		33 Ω	1/4 W	5%
R580	315-0330-00		33 Ω	1/4 W	5%
R584	315-0222-00		2.2 kΩ	1/4 W	5%
R585	303-0750-00		75 Ω	1 W	5%
R587	315-0330-00		33 Ω	1/4 W	5%
R589	307-0106-00		4.7 Ω	1/4 W	5%
R591A	305-0510-00		51 Ω	2 W	5%
R591B	305-0510-00		51 Ω	2 W	5%
R591C	305-0101-00		100 Ω	2 W	5%
R591D	305-0101-00		100 Ω	2 W	5%
R592A	305-0101-00		100 Ω	2 W	5%
R592B	305-0101-00		100 Ω	2 W	5%
R592C	305-0101-00		100 Ω	2 W	5%
R592D	323-0606-00		60 Ω	1/2 W	Prec 1%
R592E	323-0606-00		60 Ω	1/2 W	Prec 1%
R592F	323-0606-00		60 Ω	1/2 W	Prec 1%
R592G	323-0047-00		30.1 Ω	1/2 W	Prec 1%
R595	307-0106-00		4.7 Ω	1/4 W	5%
R604	315-0202-00		2 kΩ	1/4 W	5%
R605	311-0462-00		1 kΩ, Var		
R606	315-0272-00		2.7 kΩ	1/4 W	5%
R613	315-0103-00		10 kΩ	1/4 W	5%
R614	323-0164-00		499 Ω		(nominal value) Selected
R615	311-0546-00		10 kΩ, Var		
R617	311-0131-00		1 kΩ, Var		
R618	311-0546-00		10 kΩ, Var		
R623	301-0182-00		1.8 kΩ	1/2 W	5%
R624	315-0273-00		27 kΩ	1/4 W	5%
R634	303-0102-00		1 kΩ	1 W	5%
R641	301-0622-00		6.2 kΩ	1/2 W	5%
R644	315-0470-00		47 Ω	1/4 W	5%
R645	308-0248-00		150 Ω	5 W	WW 1%
R646	308-0250-00		195 Ω	5 W	WW 1%
R647	310-0526-00		102.9 Ω	2 W	Prec
R650	315-0470-00		47 Ω	1/4 W	5%
R651	311-0866-00		12.5 Ω, Var		
R652	308-0297-00		24.7 Ω	3 W	WW 1%
R655	311-0867-00		30 Ω, Var		
R656	306-0330-00		33 Ω	2 W	
R664A	301-0222-00		2.2 kΩ	1/2 W	5%
R664B	301-0822-00		8.2 kΩ	1/2 W	5%
R664C	301-0512-00		5.1 kΩ	1/2 W	5%

Resistors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
R664D	301-0512-00		5.1 k Ω	1/2 W		5%
R664E	301-0512-00		5.1 k Ω	1/2 W		5%
R664F	301-0153-00		15 k Ω	1/2 W		5%
R710	315-0220-00		22 Ω	1/4 W		5%
R711	308-0165-00		0.5 Ω	5 W	WW	5%
R715	308-0165-00		0.5 Ω	5 W	WW	5%
R717	323-0225-00		2.15 k Ω	1/2 W	Prec	1%
R720	315-0221-00		220 Ω	1/4 W		5%
R722	315-0103-00		10 k Ω	1/4 W		5%
R723	301-0302-00		3 k Ω	1/2 W		5%
R724	315-0102-00		1 k Ω	1/4 W		5%
R725	315-0221-00		220 Ω	1/4 W		5%
R726	323-0239-00		3.01 k Ω	1/2 W	Prec	1%
R727	311-0658-00		500 Ω , Var			
R728	323-0213-00		1.62 k Ω	1/2 W	Prec	1%
R729	317-0510-00		51 Ω	1/8 W		5%
R730	315-0563-00		56 k Ω	1/4 W		5%
R733	321-0301-00		13.3 k Ω	1/8 W	Prec	1%
R734	321-0165-00		511 Ω	1/8 W	Prec	1%
R735	315-0470-00		47 Ω	1/4 W		5%
R738	308-0245-00		0.6 Ω	2 W	WW	5%
R740	301-0182-00		1.8 k Ω	1/2 W		5%
R742	308-0248-00		150 Ω	5 W	WW	1%
R743	315-0103-00		10 k Ω	1/4 W		5%
R746	315-0272-00		2.7 k Ω	1/4 W		5%
R748	315-0103-00		10 k Ω	1/4 W		5%
R750	322-0298-00		12.4 k Ω	1/4 W	Prec	1%
R751	321-0239-00		3.01 k Ω	1/8 W		1%
R752	315-0153-00		15 k Ω	1/4 W		5%
R756	315-0332-00		3.3 k Ω	1/4 W		5%
R757	315-0471-00		470 Ω	1/4 W		5%
R758	308-0179-00		5 Ω	5 W	WW	5%
R760	315-0272-00		2.7 k Ω	1/4 W		5%
R762	315-0163-00		16 k Ω	1/4 W		5%
R763	315-0682-00		6.8 k Ω	1/4 W		5%
R764	315-0221-00		220 Ω	1/4 W		5%
R766	323-0259-00		4.87 k Ω	1/2 W	Prec	1%
R767	322-0216-00		1.74 k Ω	1/4 W	Prec	1%
R768	323-0246-00		3.57 k Ω	1/2 W	Prec	1%
R770	307-0113-00		5.1 Ω	1/4 W		5%
R773	321-0304-00		14.3 k Ω	1/8 W		1%
R774	321-0165-00		511 Ω	1/8 W	Prec	1%
R775	304-0271-00		270 Ω	1 W		
R778	308-0245-00		0.6 Ω	2 W	WW	5%
R780	315-0102-00		1 k Ω	1/4 W		5%

Electrical Parts List—Type 115

Resistors (cont)

Ckt. No.	Part No. Tektronix	Serial/Model No. Eff	No. Disc	Description		
R781	315-0101-00		100 Ω	1/4 W		5%
R782	315-0331-00		330 Ω	1/4 W		5%
R783	303-0432-00		4.3 kΩ	1 W		5%
R784	301-0562-00		5.6 kΩ	1/2 W		5%
R786	315-0471-00		470 Ω	1/4 W		5%
R790	317-0101-00		100 Ω	1/8 W		5%
R794	306-0332-00		3.3 kΩ	2 W		
R795	307-0106-00		4.7 Ω	1/4 W		5%
R796	317-0510-00		51 Ω	1/8 W		5%
R797	317-0510-00		51 Ω	1/8 W		5%
R798	308-0179-00		5 Ω	5 W	WW	5%

Switches

	Wired or Unwired	Part No.	Eff	No.	Description
SW20		260-0247-00		Push	MAN TRIG
SW139	Wired	*262-0851-00		Rotary	DELAY OR BURST DURATION
SW139		260-0946-00		Rotary	DELAY OR BURST DURATION
SW249	Wired	*262-0852-00		Rotary	PERIOD
SW249		260-0951-00		Rotary	PERIOD
SW280	Wired	*262-0853-00		Rotary	MODE
SW280		260-0953-00		Rotary	MODE
SW339	Wired	*262-0850-00		Rotary	WIDTH
SW339		260-0946-00		Rotary	WIDTH
SW399		260-0945-00		Rotary	RISETIME AND FALLTIME
SW501		260-0969-00		Slide	PULSE POLARITY
SW591	Wired	*262-0854-00		Rotary	DC OFFSET AND AMPLITUDE MULT
SW591		260-0759-00		Rotary	DC OFFSET AND AMPLITUDE MULT
SW616		260-0968-00		Slide	DC OFFSET
SW701		260-0834-00		Toggle	POWER
SW702 ¹					
SW703 ¹					

Thermal Cut-out

TK701	260-0413-00	Opens at 175° F ±5° F
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Transformer

T701	*120-0560-00	POWER
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¹See Mechanical Parts List. Line Voltage Selector Body (*204-0279-00)

FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations which appear either on the back of the diagrams or on pullout pages immediately following the diagrams of the instruction manual.

INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the Description column.

Assembly and/or Component
Detail Part of Assembly and/or Component
mounting hardware for Detail Part
Parts of Detail Part
mounting hardware for Parts of Detail Part
mounting hardware for Assembly and/or Component

Mounting hardware always appears in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation.

Mounting hardware must be purchased separately, unless otherwise specified.

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial or model number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

ABBREVIATIONS AND SYMBOLS

For an explanation of the abbreviations and symbols used in this section, please refer to the page immediately preceding the Electrical Parts List in this instruction manual.

INDEX OF MECHANICAL PARTS LIST ILLUSTRATIONS

(Located behind diagrams)

FIG. 1 EXPLODED VIEW

FIG. 2 CABINET

FIG. 3 STANDARD ACCESSORIES

<http://www.ebaman.com>

SECTION 7

MECHANICAL PARTS LIST

FIG. 1 EXPLODED VIEW

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q † y	Description
		Eff	Disc		
1-1	366-0493-00			1	KNOB, red—CAL VARIABLE
	- - - - -			-	knob includes:
	213-0153-00			1	SCREW, set, 5-40 x 1/8 inch, HSS
-2	366-1062-00			1	KNOB, gray—PERIOD
	- - - - -			-	knob includes:
	213-0153-00			1	SCREW, set, 5-40 x 0.125 inch, HSS
-3	262-0852-00			1	SWITCH, wired—PERIOD
	- - - - -			-	switch includes:
	260-0951-00			1	SWITCH, unwired
-4	384-0102-00	B010100	B019999	1	ROD, extension shaft
	384-0103-00	B020000		1	ROD, extension shaft
-5	376-0051-00			1	ASSEMBLY, flexible coupling
	- - - - -			-	assembly includes:
	213-0022-00			4	SCREW, set
	354-0251-00			2	RING, coupling
	376-0049-00			2	COUPLING, plastic
-6	- - - - -			1	RESISTOR, variable
	- - - - -			-	mounting hardware: (not included w/switch)
-7	210-0590-00			1	NUT, hex., 3/8-32 x 7/16 inch
-8	366-0493-00			1	KNOB, red—CAL VARIABLE
	- - - - -			-	knob includes:
	213-0153-00			1	SCREW, set, 5-40 x 1/8 inch, HSS
-9	366-1062-00			1	KNOB, gray—DELAY or BURST DURATION
	- - - - -			-	knob includes:
	213-0153-00			1	SCREW, set, 5-40 x 1/8 inch, HSS
-10	262-0851-00			1	SWITCH, wired—DELAY or BURST DURATION
	- - - - -			-	switch includes:
	260-0946-00			1	SWITCH, unwired
-11	131-0371-00			2	CONNECTOR, single contact
-12	384-0440-00			1	ROD, extension shaft
	213-0048-00			1	SCREW, set, 4-40 x 1/8 inch, HSS (not shown)
-13	- - - - -			1	RESISTOR, variable
	- - - - -			-	mounting hardware: (not included w/resistor)
	210-0012-00			1	LOCKWASHER, internal, 3/8 ID x 7/16 inch OD (not shown)
	210-0590-00			1	NUT, hex., 3/8-32 x 1/2 inch
	- - - - -			-	mounting hardware: (not included w/switch)
-14	210-0590-00			1	NUT, hex., 3/8-32 x 7/16 inch
-15	366-0493-00			1	KNOB, red—CAL VARIABLE
	- - - - -			-	knob includes:
	213-0153-00			1	SCREW, set, 5-40 x 1/8 inch, HSS
-16	366-1062-00			1	KNOB, gray—WIDTH
	- - - - -			-	knob includes:
	213-0153-00			1	SCREW, set, 5-40 x 1/8 inch, HSS

FIG. 1 EXPLODED VIEW (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q					Description	
				†	y	1	2	3		4
1-17	262-0850-00			1						SWITCH, wired—WIDTH
	- - - - -			-						switch includes:
	260-0946-00			1						SWITCH, unwired
-18	131-0371-00			2						CONNECTOR, single contact
-19	384-0440-00			1						ROD, extension shaft
	213-0048-00			1						SCREW, set, 4-40 x 1/8 inch, HSS
-20	- - - - -			1						RESISTOR, variable
	- - - - -			-						mounting hardware: (not included w/resistor)
	210-0012-00			1						LOCKWASHER, internal, 3/8 ID x 1/2 inch OD (not shown)
	210-0590-00			1						NUT, hex., 3/8-32 x 7/16 inch (not shown)
	- - - - -			-						mounting hardware: (not included w/switch)
	210-0840-00			1						WASHER, flat, 3/8 ID x 7/16 inch OD
-21	210-0590-00			1						NUT, hex., 3/8-32 x 7/16 inch
-22	366-0373-00			1						KNOB, red—TRIGGER
	- - - - -			-						knob includes:
	213-0076-00			1						SCREW, set, 2-56 x 1/8 inch, HSS
-23	366-1062-00			1						KNOB, gray—MODE
	- - - - -			-						knob includes:
	213-0153-00			1						SCREW, set, 5-40 x 1/8 inch, HSS
-24	262-0853-00			1						SWITCH, wired—MODE
	- - - - -			-						switch includes:
	260-0958-00			1						SWITCH, unwired
	- - - - -			-						mounting hardware: (not included w/switch)
-25	210-0590-00			1						NUT, hex., 3/8-32 x 7/16 inch
-26	366-1028-00			1						KNOB, gray—DC OFFSET AND AMPLITUDE MULT
	- - - - -			-						knob includes:
	213-0153-00			2						SCREW, set, 5-40 x 1/8 inch, HSS
-27	262-0854-00			1						SWITCH, wired—DC OFFSET AND AMPLITUDE MULT
	- - - - -			-						switch includes:
	260-0959-00			1						SWITCH, unwired
-28	131-0371-00			2						CONNECTOR, single contact
	- - - - -			-						mounting hardware: (not included w/switch)
	210-0940-00			1						WASHER, flat, 3/8 ID x 1/2 inch OD
-29	210-0590-00			1						NUT, hex., 3/8-32 x 7/16 inch
-30	366-1054-00			1						KNOB, gray—RISETIME AND FALLTIME
	- - - - -			-						knob includes:
	213-0153-00			1						SCREW, set, 5-40 x 1/8 inch, HSS
-31	260-0945-00			1						SWITCH, unwired—RISETIME AND FALLTIME
	- - - - -			-						mounting hardware: (not included w/switch)
	210-0803-00			1						WASHER, flat, 0.150 ID x 3/8 inch OD
-32	210-0583-00			1						NUT, hex., 1/4-32 x 5/16 inch

FIG. 1 EXPLODED VIEW (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q					Description	
				t	y	1	2	3		4
1-33	366-0494-00			1						KNOB, gray—RISETIME MULT
	- - - - -			-						knob includes:
	213-0153-00			1						SCREW, set, 5-40 x 1/8 inch, HSS
-34	- - - - -			1						RESISTOR, variable
	- - - - -			-						mounting hardware: (not included w/resistor)
-35	210-0583-00			2						NUT, hex., 1/4-32 x 5/16 inch
-36	210-0046-00			1						LOCKWASHER, internal, 0.261 ID x 0.400 inch OD
	210-0803-00			1						WASHER, flat, 0.150 ID x 3/8 inch OD
-37	366-0494-00			1						KNOB, gray—FALLTIME MULT
	- - - - -			-						knob includes:
	213-0153-00			1						SCREW, set, 5-40 x 1/8 inch, HSS
-38	- - - - -			1						RESISTOR, variable
	- - - - -			-						mounting hardware: (not included w/resistor)
-39	210-0583-00			2						NUT, hex., 1/4-32 x 5/16 inch
-40	210-0046-00			1						LOCKWASHER, internal, 0.261 ID x 0.400 inch OD
	210-0803-00			1						WASHER, flat, 0.150 ID x 3/8 inch OD
-41	366-0494-00			1						KNOB, gray—AMPLITUDE (VOLTS)
	- - - - -			-						knob includes:
	213-0153-00			1						SCREW, set, 5-40 x 1/8 inch, HSS
-42	- - - - -			1						RESISTOR, variable
	- - - - -			-						mounting hardware: (not included w/resistor)
-43	361-0143-00			1						SPACER, ring, 0.281 ID x 0.562 inch OD
	210-0803-00			1						WASHER, flat, 0.150 ID x 3/8 inch OD
-44	210-0583-00			1						NUT, hex., 1/4-32 x 5/16 inch
-45	366-0494-00			1						KNOB, gray—VARIABLE
	- - - - -			-						knob includes:
	213-0153-00			1						SCREW, set, 5-40 x 1/8 inch, HSS
-46	- - - - -			1						RESISTOR, variable
	- - - - -			-						mounting hardware: (not included w/resistor)
-47	361-0143-00			1						SPACER, ring, 0.281 ID x 0.562 inch OD
	210-0803-00			1						WASHER, flat, 0.150 ID x 3/8 inch OD
-48	210-0583-00			1						NUT, hex., 1/4-32 x 5/16 inch
-49	260-0834-00			1						SWITCH, toggle—ON
	- - - - -			-						mounting hardware: (not included w/switch)
	210-0940-00			1						WASHER, flat, 1/4 ID x 3/8 inch OD
-50	210-0562-00			1						NUT, hex., 1/4-40 x 5/16 inch
-51	260-0247-00			1						SWITCH, push button, w/hardware—MAN TRIG
	- - - - -			-						mounting hardware: (not included w/switch)
-52	210-0940-00			1						WASHER, flat, 1/4 ID x 3/8 inch OD

FIG. 1 EXPLODED VIEW (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q					Description
				y	1	2	3	4	
1-53	260-0969-00			1					SWITCH, slide—PULSE POLARITY
-54	210-0406-00			-					mounting hardware: (not included w/switch)
				2					NUT, hex., 4-40 x 3/16 inch
-55	260-0968-00			1					SWITCH, slide—DC OFFSET (VOLTS)
	210-0406-00			-					mounting hardware: (not included w/switch)
				2					NUT, hex., 4-40 x 3/16 inch
-56	210-0471-00			1					RESISTOR, variable
				-					mounting hardware: (not included w/resistor)
-57	210-0046-00			1					NUT, hex., 1/4-32 x 5/16 x 1 1/32 inch long
-58	358-0054-00			1					LOCKWASHER, internal, 0.261 ID x 0.400 inch OD
				1					BUSHING, resistor mounting
-59	136-0279-00			1					LIGHT, indicator, w/hardware
-60	210-0046-00			-					mounting hardware: (not included w/light)
				1					LOCKWASHER, internal, 0.261 ID x 0.400 inch OD
-61	131-0106-00			2					CONNECTOR, coaxial, 1 contact, BNC w/hardware
-62	131-0106-00			3					CONNECTOR, coaxial, 1 contact, BNC w/hardware
-63	210-0255-00			-					mounting hardware for each: (not included w/connector)
				1					LUG, solder, 3/8 inch ID
-64	214-0553-00			1					SCREW, latch
-65	358-0255-00			1					BUSHING, latch, plastic
-66	333-1056-01			1					PANEL, front
-67	386-1379-00			1					PLATE, sub-panel
-68	200-0799-00								COVER, plastic
-69	386-1380-00			1					PLATE, chassis support
-70	211-0094-00			-					plate includes:
-71	406-0635-00			4					SCREW, 4-40 x 1/2 inch, THS
-72	213-0088-00			9					BRACKET, resistor mounting
				-					mounting hardware for each: (not included w/bracket)
				2					SCREW, thread forming, 4-40 x 1/4 inch, PHS
-73	210-0438-00			9					RESISTOR, variable
				-					mounting hardware for each: (not included w/resistor)
				2					NUT, hex., 1-72 x 5/32 inch
-74	352-0068-00			2					HOLDER, plastic
-75	348-0055-00			4					GROMMET, plastic, 1/4 inch diameter
-76	348-0056-00			1					GROMMET, plastic, 3/8 inch diameter
-77	348-0064-00			1					GROMMET, plastic, 5/8 inch diameter

FIG. 1 EXPLODED VIEW (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q					Description	
				t	y	1	2	3		4
1-78	348-0063-00			4						GROMMET, plastic, 1/2 inch diameter
-79	348-0031-00			1						GROMMET, plastic, 5/32 inch diameter
-80	358-0215-00			1						BUSHING, plastic, "U" shaped
-81	441-0781-00			1						CHASSIS, center
-82	211-0507-00			8						SCREW, 6-32 x 5/16 inch, PHS
-83	- - - - -			2						CAPACITOR
-84	211-0516-00			2						SCREW, 6-32 x 7/8 inch, PHS
-85	432-0048-00			1						BASE, mounting, plastic
-86	210-0457-00			2						NUT, keps, 6-32 x 5/16 inch
-87	- - - - -			3						COIL
-88	211-0553-00			1						SCREW, 6-32 x 1 1/2 inches, RHS
-89	200-0659-00			1						COVER, plastic
-90	211-0507-00			1						SCREW, 6-32 x 5/16 inch, PHS
-91	441-0782-00			1						CHASSIS, lower
-92	211-0507-00			6						SCREW, 6-32 x 5/16 inch, PHS
-93	211-0538-00			2						SCREW, 6-32 x 5/16 inch, 100° csk, FHS
-94	210-0457-00			6						NUT, keps, 6-32 x 5/16 inch
-95	213-0044-00			1						SWITCH, THERMAL CUTOUT
-96	124-0146-00			2						STRIP, ceramic, 7/16 inch h, w/16 notches
-97	361-0008-00			2						SPACER, plastic, 1/4 inch long
-98	- - - - -			2						TRANSISTOR
-99	210-0457-00			2						NUT, keps, 6-32 x 5/16 inch
-100	211-0510-00			2						SCREW, 6-32 x 3/8 inch, PHS

FIG. 1 EXPLODED VIEW (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q					Description
				y	1	2	3	4	
1-101	- - - - -			1					TRANSISTOR
	- - - - -			-					mounting hardware: (not included w/transistor)
-102	211-0510-00			2					SCREW, 6-32 x 3/8 inch, PHS
	386-0143-00			1					PLATE, insulator, small
	210-0803-00			2					WASHER, flat, 0.150 ID x 3/8 inch OD
	210-0935-00			2					WASHER, fiber, shouldered, 0.140 ID x 0.375 inch OD
	210-0202-00			1					LUG, solder, SE #6
-103	210-0457-00			2					NUT, keps, 6-32 x 5/16 inch
-104	- - - - -			1					DIODE
	- - - - -			-					diode includes:
	- - - - -			1					PLATE, insulator
	- - - - -			-					mounting hardware: (not included w/diode)
	210-0813-00			1					WASHER, fiber, shouldered, #10
	210-0805-00			1					WASHER, flat, 3/16 ID x 7/16 inch OD
	210-0410-00			1					LUG, solder, SE #10 long
-105	220-0410-00			1					NUT, keps, 10-32 x 3/8 inch
-106	670-0264-00			1					ASSEMBLY, circuit board—SHAPER/OUTPUT
	- - - - -			-					assembly includes:
	388-0984-00			1					BOARD, circuit
-107	131-0505-00	B010100	B020369	6					TERMINAL, stud, 0.345 inch long
	214-0579-00	B020370		1					PIN, test point
-108	131-0525-00			6					TERMINAL, stud, 0.449 inch long
-109	214-0506-00			40					PIN, connector
-110	344-0119-00			8					CLIP, diode
-111	136-0183-00			10					SOCKET, transistor, 3 pin
-112	136-0220-00			19					SOCKET, transistor, 3 pin
-113	214-0667-00			1					HEAT SINK
-114	214-0668-00			6					HEAT SINK
	- - - - -			-					mounting hardware: (not included w/assembly)
-115	211-0116-00			8					SCREW, sems 4-40 x 5/16 inch, PHB
-116	210-0202-00			1					LUG, solder, SE #6
	- - - - -			-					mounting hardware: (not included w/lug)
	213-0044-00			1					SCREW, thread forming, 5-32 x 5/16 inch, PHS
-117	381-0288-00			1					BAR, support
	- - - - -			-					mounting hardware: (not included w/bar)
-118	211-0507-00			2					SCREW, 6-32 x 5/16 inch, PHS
	210-0202-00			1					LUG, solder, SE #6
-119	214-0210-00			1					ASSEMBLY, solder spool
	- - - - -			-					assembly includes:
	214-0209-00			1					SPOOL, w/o solder
	- - - - -			-					mounting hardware: (not included w/ assembly)
	361-0007-00			1					SPACER, plastic, 0.188 inch long

FIG. 1 EXPLODED VIEW (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q					Description
				f	y	1	2	3	
1-120	- - - - -			1					TRANSFORMER
	- - - - -			-					transformer includes:
-121	212-0516-00			4					SCREW, 10-32 x 2 inches, HHS
	210-0812-00			4					WASHER, fiber, #10
	- - - - -			-					mounting hardware: (not included w/transformer)
-122	210-0206-00			1					LUG, solder, SE #10 long
-123	220-0410-00			4					NUT, keps, 10-32 x 3/8 inch
-124	407-0461-00			1					BRACKET, transistor mounting
	- - - - -			-					mounting hardware: (not included w/bracket)
-125	211-0008-00	B010100	B010129	3					SCREW, 4-40 x 1/4 inch, PHS
	211-0130-00	B010130		3					SCREW, 4-40 x 1/4 inch, HHS
-126	- - - - -			1					TRANSISTOR
	- - - - -			-					mounting hardware: (not included w/transistor)
-127	211-0510-00			2					SCREW, 6-32 x 3/8 inch, PHS
	210-0202-00			1					LUG, solder, SE #6
-128	386-0978-00			1					PLATE, insulator, large
	210-0935-00			2					WASHER, fiber, shouldered, 0.140 ID x 0.375 inch OD
	210-0803-00			2					WASHER, flat, 0.150 ID x 3/8 inch OD
-129	210-0457-00			2					NUT, keps, 6-32 x 5/16 inch
	- - - - -			1					TRANSISTOR (not shown)
	- - - - -			-					mounting hardware: (not included w/transistor)
	211-0578-00			2					SCREW, 6-32 x 7/16 inch, PHS
	210-0202-00			1					LUG, solder, SE #6
	386-0978-00			1					PLATE, insulator, large
	210-0935-00			2					WASHER, fiber, shouldered, 0.140 ID x 0.375 inch OD
	210-0803-00			2					WASHER, flat, 0.150 ID x 3/8 inch OD
	210-0457-00			2					NUT, keps, 6-32 x 5/16 inch
-130	- - - - -			2					TRANSISTOR
	- - - - -			-					mounting hardware for each: (not included w/transistor)
-131	211-0510-00			2					SCREW, 6-32 x 3/8 inch, PHS
	210-0202-00			1					LUG, solder, SE #6
-132	386-0143-00			1					PLATE, insulator, small
	210-0935-00			2					WASHER, fiber, shouldered, 0.140 ID x 0.375 inch OD
	210-0803-00			2					WASHER, flat, 0.150 ID x 3/8 inch OD
-133	210-0457-00			2					NUT, keps, 6-32 x 5/16 inch
-134	441-0783-00			1					CHASSIS, upper
	- - - - -			-					mounting hardware: (not included w/chassis)
-135	211-0507-00			5					SCREW, 6-32 x 5/16 inch, PHS
-136	211-0538-00			1					SCREW, 6-32 x 3/16 inch, 100° csk, FHS
-137	210-0457-00			6					NUT, keps, 6-32 x 5/16 inch
-138	670-0263-00			1					ASSEMBLY, circuit board—TIMING/POWER SUPPLY
	- - - - -			-					assembly includes:
	388-0933-00			1					BOARD, circuit
-139	136-0183-00			8					SOCKET, transistor, 3 pin
-140	136-0220-00			40					SOCKET, transistor, 3 pin
-141	214-0506-00			67					PIN, connector
-142	214-0578-00			5					PIN, test point
	- - - - -			-					mounting hardware: (not included w/assembly)
-143	211-0116-00			8					SCREW, sems 4-40 x 5/16 inch, PHB

FIG. 1 EXPLODED VIEW (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q					Description
				y	1	2	3	4	
1-144	147-0008-00			1					MOTOR, fan
	- - - - -			-					mounting hardware: (not included w/motor)
-145	212-0575-00			2					SCREW, 10-32 x 5/16 inch, HHS
-146	369-0024-00			1					FAN, impeller
-147	384-0615-00			3					ROD, spacer
	- - - - -			-					mounting hardware for each: (not included w/rod)
-148	212-0023-00			1					SCREW, 8-32 x 3/8 inch, PHS
-149	351-0096-00			1					RAIL, guide
	- - - - -			-					mounting hardware: (not included w/rail)
	211-0559-00			2					SCREW, 6-32 x 3/8 inch, 100° csk, FHS (not shown)
	212-0023-00			1					SCREW, 8-32 x 3/8 inch, PHS
-150	214-0680-00			1					PIN, guide
-151	214-0680-00			1					PIN, guide
	- - - - -			-					mounting hardware: (not included w/guide)
-152	210-0457-00			1					NUT, keps, 6-32 x 5/16 inch
-153	386-1381-00			1					PLATE, rear
-154	378-0035-01			1					FILTER, air
-155	380-0105-00			1					HOUSING, filter
	- - - - -			-					mounting hardware: (not included w/housing)
-156	211-0034-00			2					SCREW, 2-56 x 1/2 inch, RHS
	210-0001-00			2					LOCKWASHER, internal, #2
-157	210-0405-00			2					NUT, hex., 2-56 x 3/16 inch
-158	204-0279-00			1					BODY, line voltage selector
	- - - - -			-					mounting hardware: (not included w/body)
	210-0006-00			2					LOCKWASHER, internal, #6 (not shown)
-159	210-0407-00			2					NUT, hex., 6-32 x 1/4 inch
-160	200-0762-00			1					COVER, line voltage selector
	- - - - -			-					cover includes:
-161	352-0102-00			2					HOLDER, fuse, plastic
	- - - - -			-					mounting hardware for each: (not included w/holder)
-162	213-0035-00			2					SCREW, thread forming, 4-40 x 1/4 inch, PHS
-163	161-0033-00			1					CORD, power
-164	358-0161-00			1					BUSHING, strain relief
-165	103-0071-01			1					ADAPTER, strain relief
	- - - - -			-					mounting hardware: (not included w/adapter)
-166	211-0507-00			2					SCREW, 6-32 x 5/16 inch, PHS
-167	210-0457-00			2					NUT, keps, 6-32 x 3/16 inch
	210-0202-00		XB020000	1					LUG, solder, SE #6

FIG. 1 EXPLODED VIEW (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q					Description	
				t	y	1	2	3		4
1-168	124-0207-00			1						TERMINAL STRIP, ceramic
	- - - - -			-						mounting hardware: (not included w/terminal strip)
	358-0324-00			2						BUSHING, sleeve, plastic
-169	213-0166-00			2						SCREW, thread forming, 6-32 x 3/4 inch
-170	210-0202-00			1						LUG, solder, SE #6
	- - - - -			-						mounting hardware: (not included w/lug)
	213-0146-00			1						SCREW, thread forming, 6-32 x 5/16 inch, PHS (not shown)
-171	179-1293-00			1						CABLE HARNESS, lower board
	- - - - -			-						cable harness includes:
	131-0371-00			34						CONNECTOR, single contact
-172	179-1294-00			1						CABLE HARNESS, upper board
	- - - - -			-						cable harness includes:
	131-0371-00			59						CONNECTOR, single contact
-173	179-1295-00			1						CABLE HARNESS, 110 Volt

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FIG. 2 CABINET

Fig. & Index No.	Part No. Tektronix	Serial/Model No. Eff	No. Disc	Q					Description	
				f	y	1	2	3		4
2-	437-0096-00			1						ASSEMBLY, cabinet
	- - - - -			-						assembly includes:
-1	377-0122-00			1						INSERT, handle pivot, right
-2	377-0120-00			1						INSERT, frame, right
-3	377-0123-00			1						INSERT, handle pivot, left
-4	377-0121-00			1						INSERT, frame, left
-5	367-0052-00			1						HANDLE
	- - - - -			-						mounting hardware: (not included w/handle)
-6	212-0040-00			2						SCREW, 8-32 x 3/8 inch, 100° csk, FHS
-7	367-0050-00			1						PIVOT, handle, right
	- - - - -			-						mounting hardware: (not included w/pivot)
-8	214-0554-00			1						BOLT, hinge, 10-32 x 0.468 inch, HHS
-9	214-0558-00			1						WASHER, thrust, 5/16 ID x 1/2 inch OD
-10	367-0051-00			1						PIVOT, handle, left
	- - - - -			-						mounting hardware: (not included w/pivot)
-11	214-0554-00			1						BOLT, hinge, 10-32 x 0.468 inch, HSS
-12	214-0558-00			1						WASHER, thrust, 5/16 ID x 1/2 inch OD
-13	426-0252-00			1						FRAME, front, right
-14	426-0253-00			1						FRAME, front, left
-15	426-0255-00			1						FRAME, front, top
	- - - - -			-						mounting hardware: (not included w/frame)
-16	212-0002-00			4						SCREW, 8-32 x 1/4 inch, 100° csk, FHS
-17	426-0254-00			1						FRAME, front, bottom
	- - - - -			-						mounting hardware: (not included w/frame)
-18	212-0004-00			2						SCREW, 8-32 x 5/16 inch, PHS
-19	212-0002-00			2						SCREW, 8-32 x 1/4 inch, 100° csk, FHS
-20	351-0093-00			1						GUIDE, left
	- - - - -			-						mounting hardware: (not included w/guide)
-21	212-0023-00			1						SCREW, 8-32 x 0.375 inch, PHS
	210-0007-00			1						LOCKWASHER, external, #8
-22	211-0510-00			1						SCREW, 6-32 x 3/8 inch, PHS
	210-0005-00			1						LOCKWASHER, external, #6
-23	358-0293-01			1						BUSHING, plug-in securing, left
	- - - - -			-						mounting hardware: (not included w/bushing)
-24	212-0001-00			1						SCREW, 8-32 x 1/4 inch, PHS
	210-0007-00			1						LOCKWASHER, external, #8
-25	358-0294-01			1						BUSHING, plug-in securing, right
	- - - - -			-						mounting hardware: (not included w/bushing)
-26	212-0001-00			1						SCREW, 8-32 x 1/4 inch, PHS
	210-0007-00			1						LOCKWASHER, external, #8
-27	211-0510-00			1						SCREW, 6-32 x 1/2 inch, PHS
	210-0005-00			1						LOCKWASHER, external, #6
-28	210-0457-00			1						NUT, keps, 6-32 x 5/16 inch

FIG. 2 CABINET (cont)

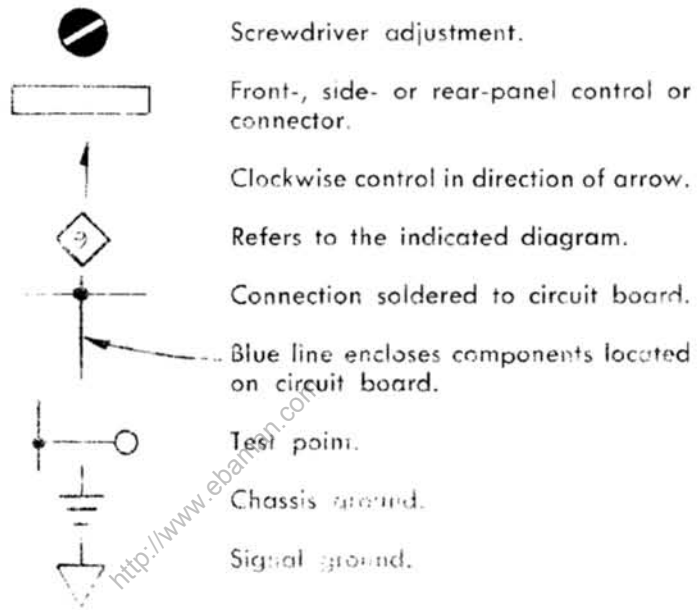
Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q † y	Description
		Eff	Disc		
2-29	351-0092-00			1	GUIDE, right
-30	348-0072-00			1	FOOT, flip stand
-31	348-0073-00			1	FOOT, bail limiting, left front
-	- - - - -			-	mounting hardware: (not included w/foot)
-32	211-0532-00			2	SCREW, 6-32 x 3/4 inch, Fil HS
-33	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
-34	348-0074-00			1	FOOT, bail limiting, right front
-	- - - - -			-	mounting hardware: (not included w/foot)
-35	211-0532-00			2	SCREW, 6-32 x 3/4 inch, Fil HS
-36	348-0073-00			1	FOOT, bail limiting, right rear
-	- - - - -			-	mounting hardware: (not included w/foot)
-37	211-0532-00			2	SCREW, 6-32 x 3/4 inch, Fil HS
-	348-0074-00			1	FOOT, bail limiting, left rear (not shown)
-	- - - - -			-	mounting hardware: (not included w/foot)
-	211-0532-00			2	SCREW, 6-32 x 3/4 inch, Fil HS
-38	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
-39	377-0119-00			4	INSERT, foot
-40	390-0043-00			1	CABINET, bottom
-41	386-1020-00			1	CABINET SIDE, right
-	- - - - -			-	mounting hardware: (not included w/cabinet side)
-42	212-0002-00			2	SCREW, 8-32 x 1/4 inch, 100° csk, FHS
-43	390-0045-00			1	CABINET SIDE, left
-	- - - - -			-	mounting hardware: (not included w/cabinet side)
-44	212-0002-00			2	SCREW, 8-32 x 1/4 inch, 100° csk, FHS
-45	386-0139-00			1	PLATE, rear
-46	386-0138-00			1	PLATE, top
-47	348-0075-00			2	FOOT, rear guard
-	- - - - -			-	mounting hardware for each: (not included w/foot)
-48	212-0039-00			2	SCREW, 8-32 x 3/8 inch, THS

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SECTION 8

DIAGRAMS

The following special symbols are used on the diagrams:



VOLTAGE AND WAVEFORM TEST CONDITIONS

Typical voltage measurements and waveform photographs were obtained under the following conditions unless noted otherwise on the individual diagrams:

Test Oscilloscope (with 10X Probe)

Frequency Response	DC to 50 MHz
Deflection factor (with probe)	100 millivolts to 5 volts/ division
Input impedance	10 Megohms, 7.5 picofarads
Probe ground	Type 115 chassis ground
Trigger Source	Type 115 + PRETRIG OUT
Recommended type (as used for waveforms on diagrams)	Tektronix Type 547 with Type 1A1 plug-in unit

Voltmeter

Type	Non-loading DC voltmeter
Sensitivity	20,000 ohms/volt
Range	0 to ± 30 volts
Reference voltage	Type 115 signal ground
Recommended type (as used for voltages on diagrams)	Triplet Model 630-NA

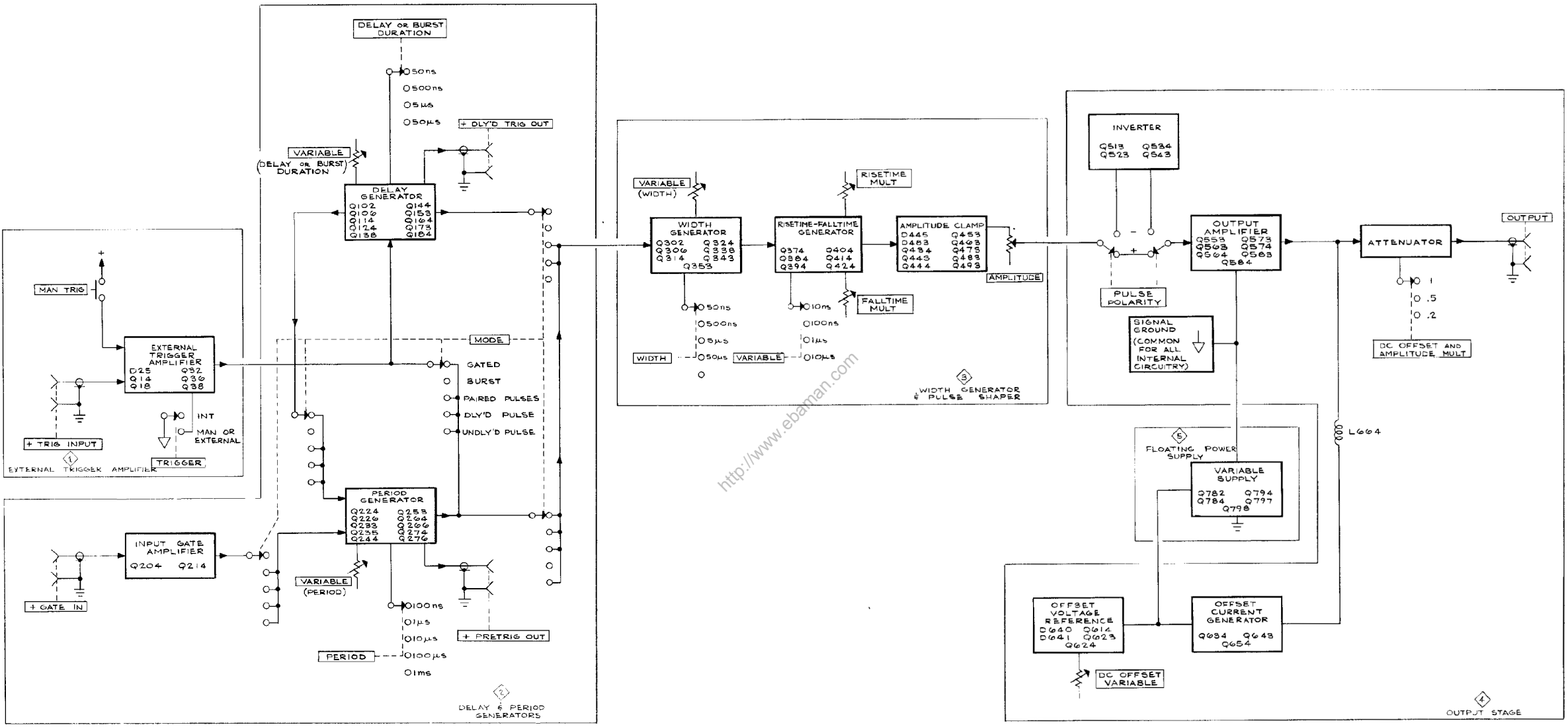
Type 115

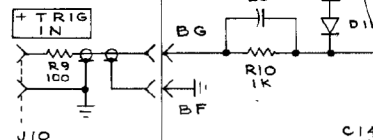
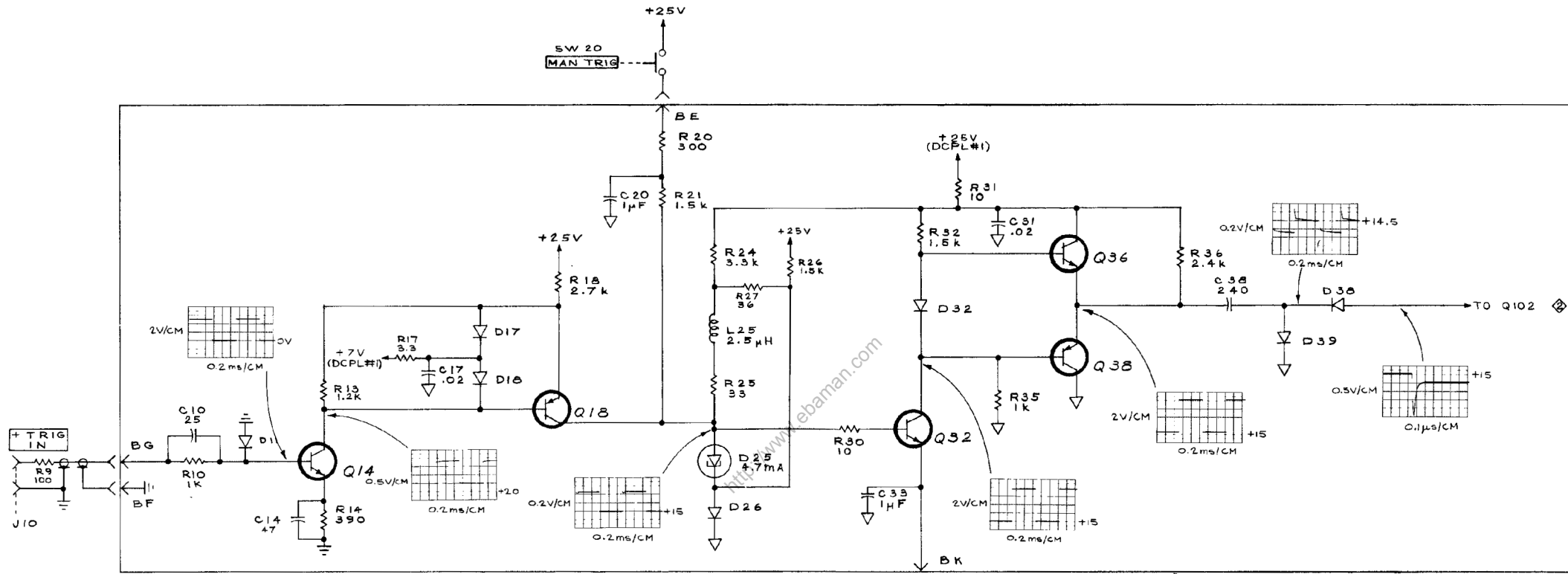
MODE	UNDFY'D PULSE
TRIGGERING	INT
PULSE POLARITY	+
PERIOD	1 ms
VARIABLE	CAL
DELAY OR BURST DURATION	50 μ s
VARIABLE	CAL
WIDTH	50 μ s
VARIABLE	CAL
RISETIME AND FALLTIME	10 μ s
RISETIME MULT	1
FALLTIME MULT	1
DC OFFSET AND AMPLITUDE MULT	1.0
AMPLITUDE (VOLTS)	10
DC OFFSET (VOLTS)	0
VARIABLE-PRESET switch	VARIABLE

All DC voltages indicated on waveform pictures are given with respect to chassis ground. To determine these voltages with respect to Type 115 signal ground subtract +13.5 volts from the given DC voltage.

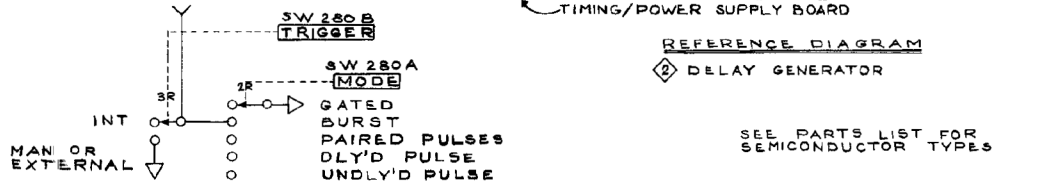
All DC voltages given but not related to a waveform picture are given with respect to signal ground and are in volts. Waveforms shown are actual waveform photographs taken with a Tektronix Oscilloscope Camera System and Projected Graticule.

Voltages and waveforms on the diagrams (shown in blue) are not absolute and may vary between instruments because of differing component tolerances, internal calibration or front-panel control settings.

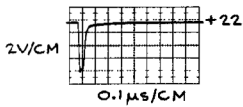




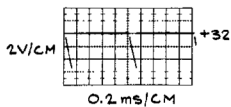
VOLTAGES and WAVEFORMS obtained under conditions given on left side of this diagram, except as follows:
 TRIGGER switch..... MAN OR EXTERNAL
 +TRIG IN connector..... +10V gate signal, 1kHz applied from Type 547 Amplitude Calibrator.



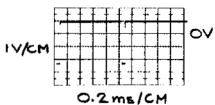
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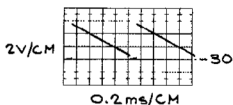
[13]



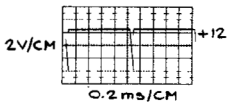
** [2]



[14]



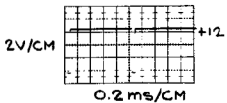
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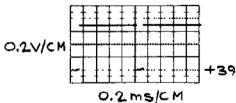
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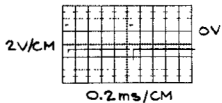
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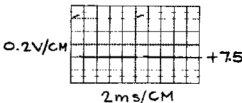
[16]



[5]

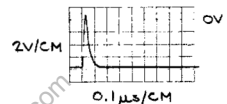
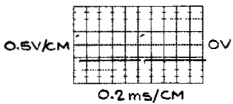


[17]

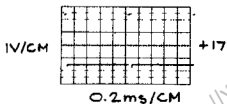


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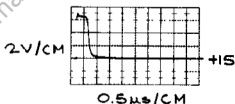
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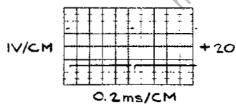
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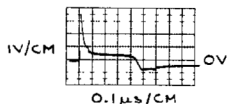
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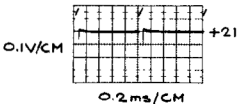
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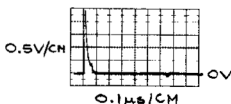
[20]



[9]

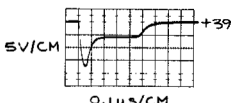
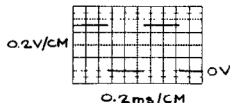


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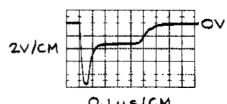
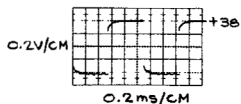
* [10]

[22]



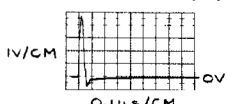
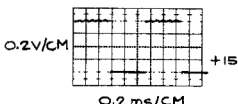
* [11]

[23]



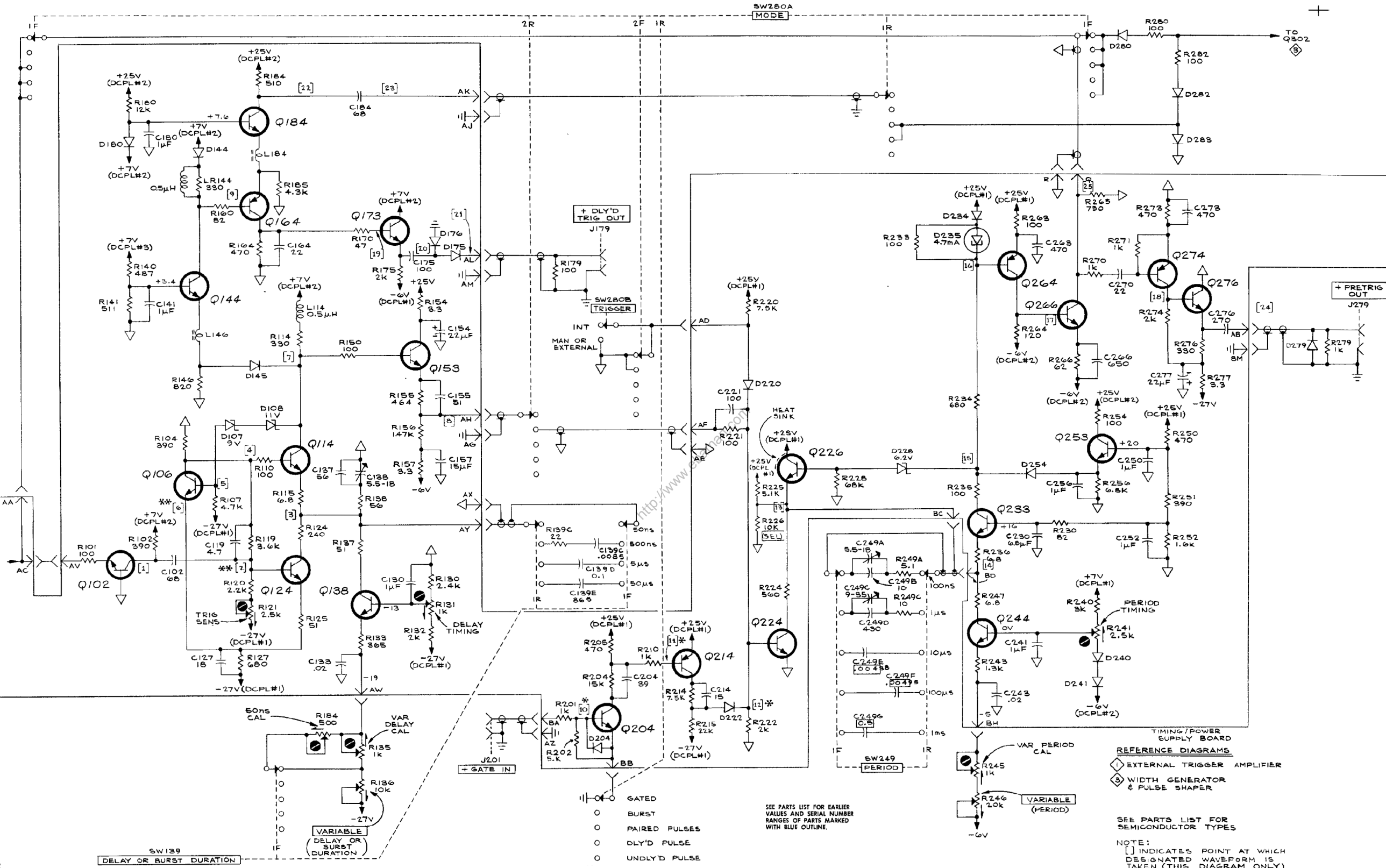
* [12]

[24]



[25]





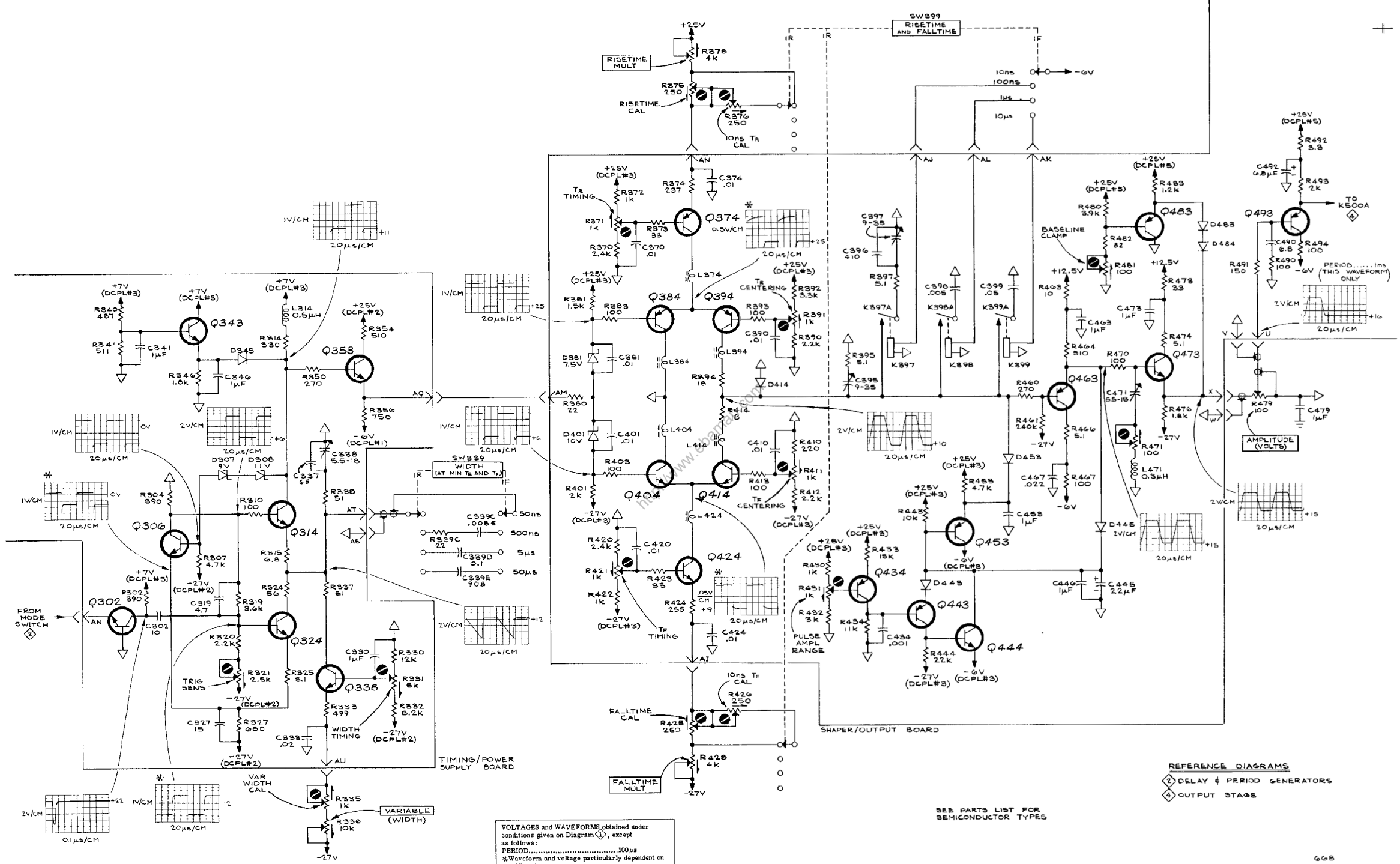
NOTE:
 [] INDICATES POINT AT WHICH DESIGNATED WAVEFORM IS TAKEN (THIS DIAGRAM ONLY)

SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

- GATED
- BURST
- PAIRED PULSES
- DLY'D PULSE
- UNDLY'D PULSE

REFERENCE DIAGRAMS
 ◇ EXTERNAL TRIGGER AMPLIFIER
 ◇ WIDTH GENERATOR & PULSE SHAPER

SEE PARTS LIST FOR SEMICONDUCTOR TYPES



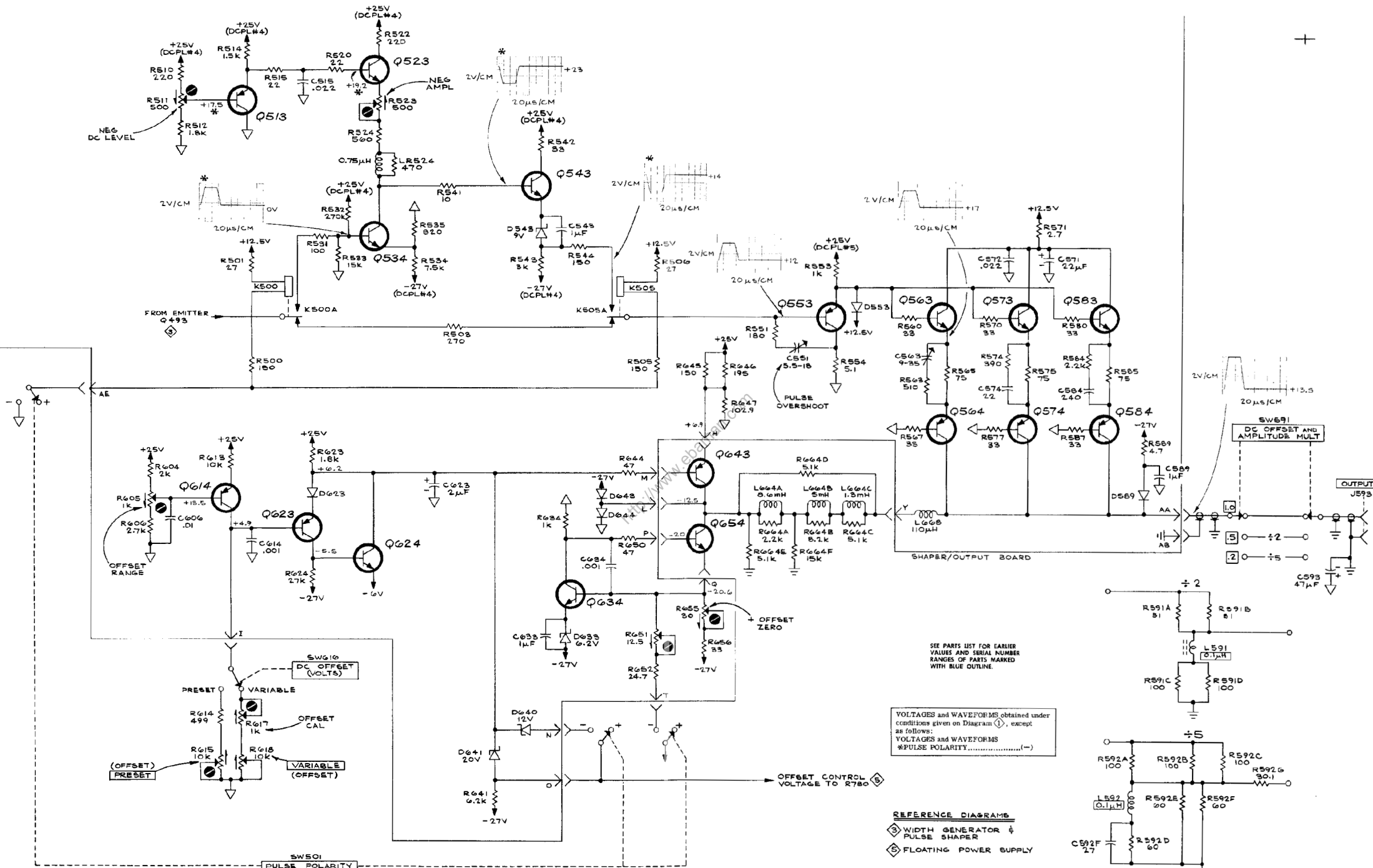
TYPE 115

VOLTAGES and WAVEFORMS obtained under conditions given on Diagram (V), except as follows:
 *Waveform and voltage particularly dependent on calibration.

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

REFERENCE DIAGRAMS
 (V) DELAY & PERIOD GENERATORS
 (W) OUTPUT STAGE

WIDTH GENERATOR & PULSE SHAPER (W)



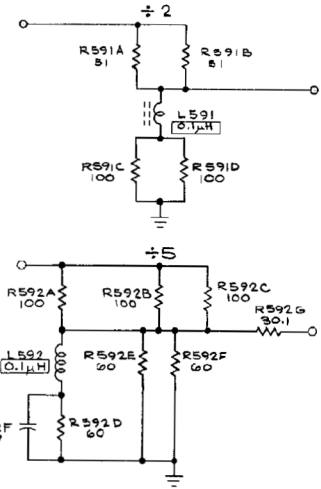
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

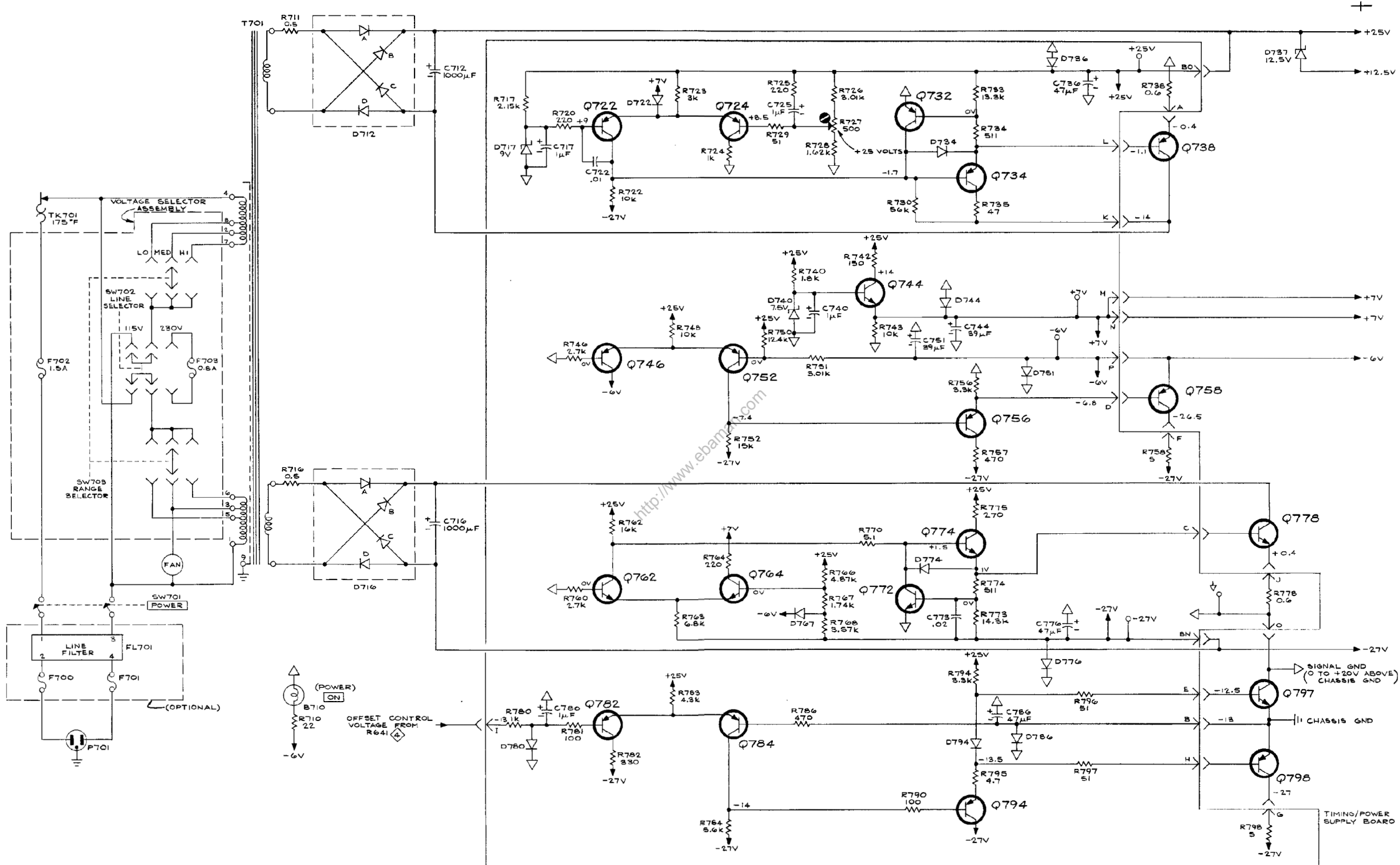
VOLTAGES and WAVEFORMS obtained under conditions given on Diagram ①, except as follows:
 VOLTAGES and WAVEFORMS #PULSE POLARITY.....(-)

REFERENCE DIAGRAMS

- ① WIDTH GENERATOR & PULSE SHAPER
- ② FLOATING POWER SUPPLY

SEE PARTS LIST FOR SEMICONDUCTOR TYPES





TYPE 115

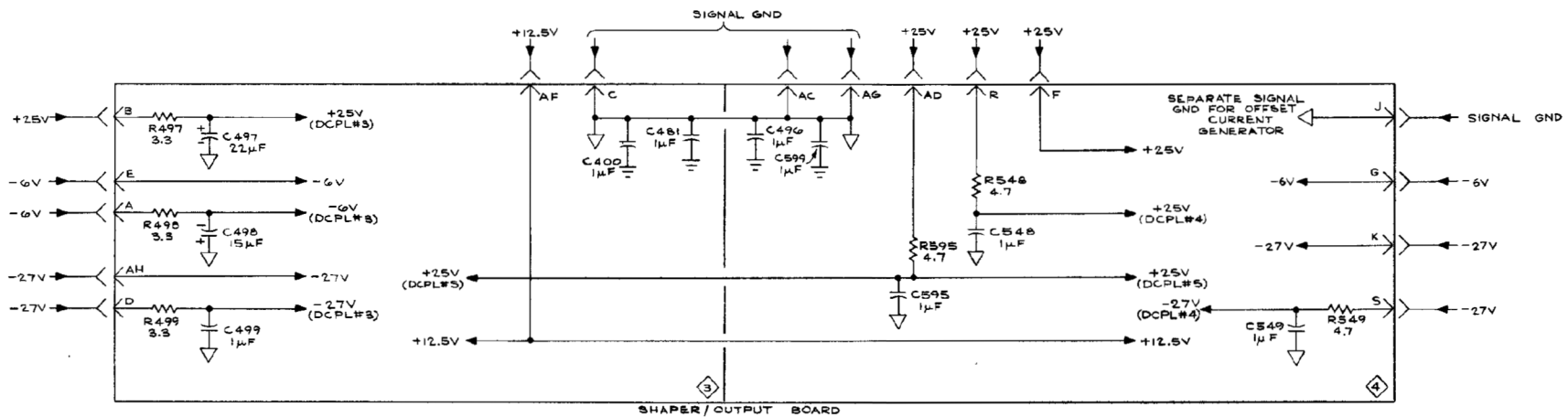
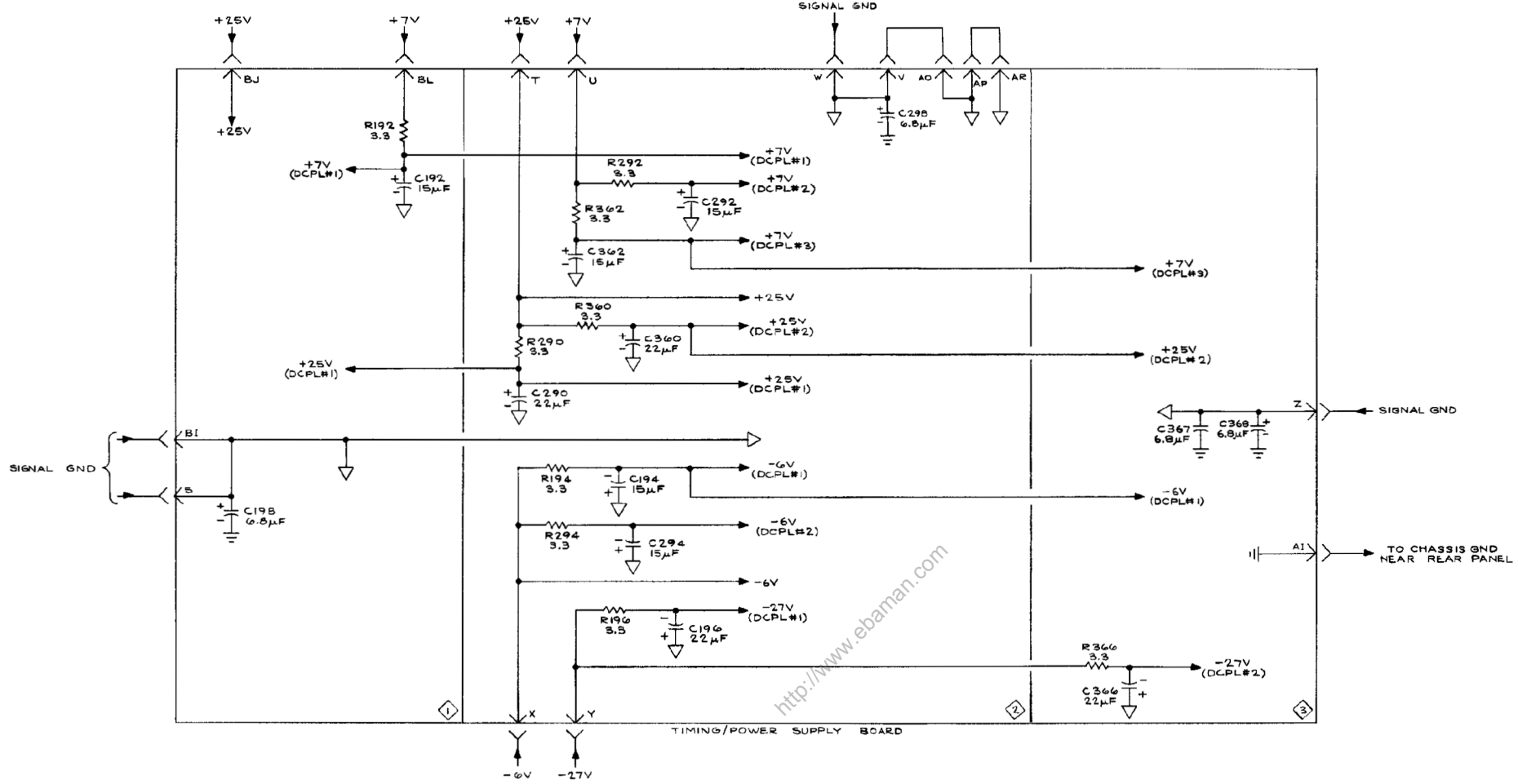
A

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

VOLTAGES obtained under conditions given

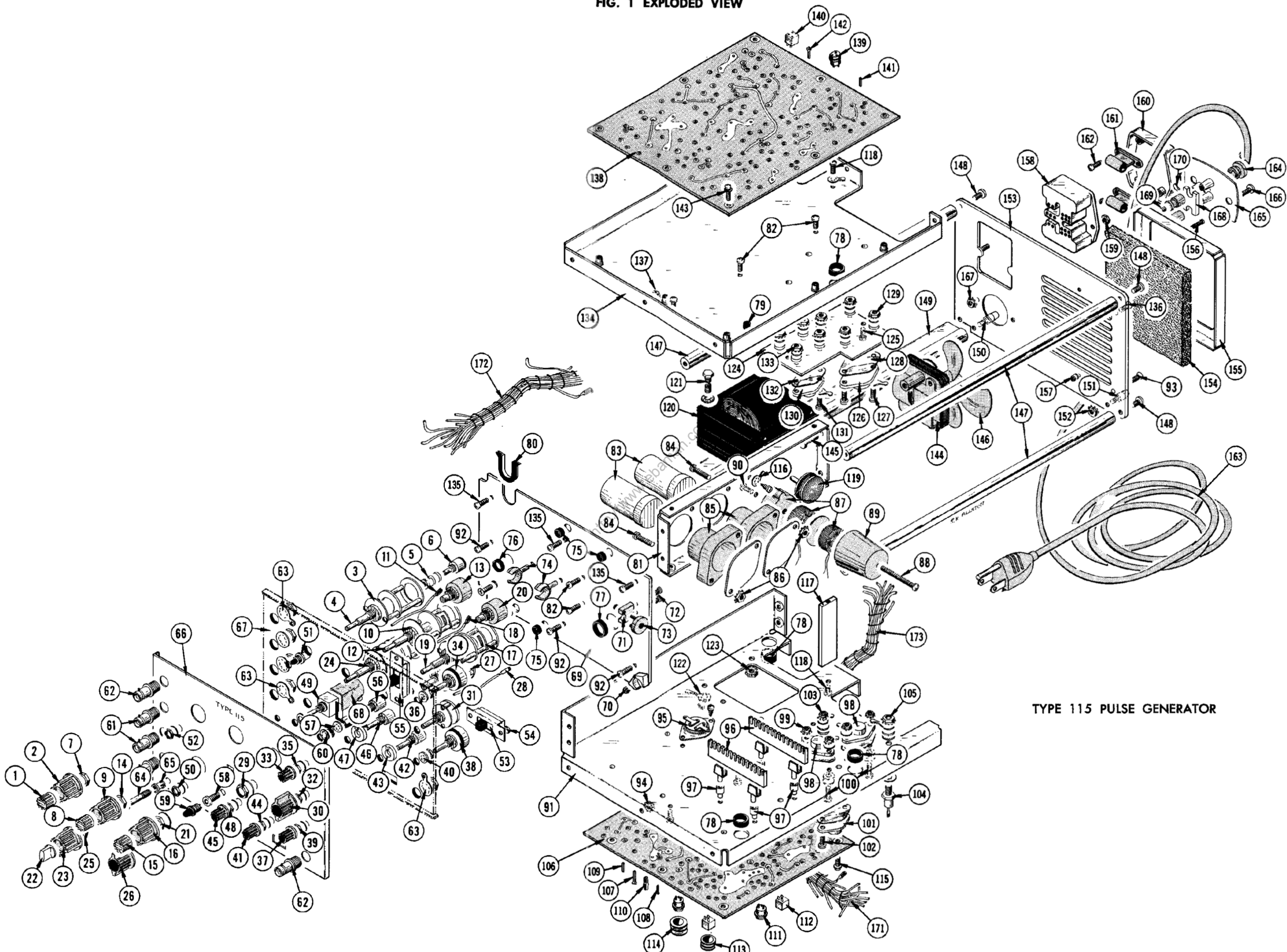
FLOATING POWER SUPPLY

668



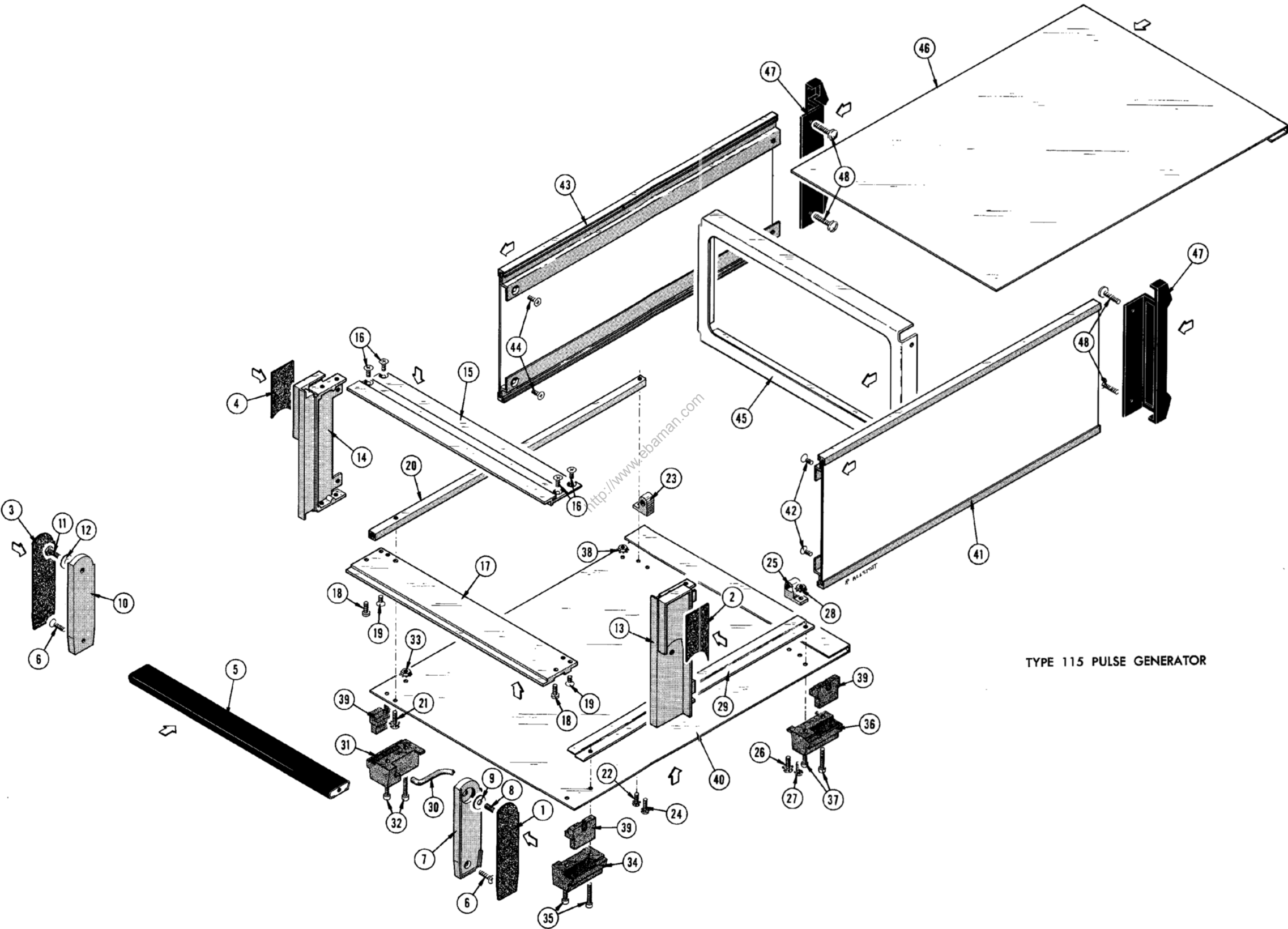
- REFERENCE DIAGRAMS
- ◇1 EXTERNAL TRIGGER AMPLIFIER
 - ◇2 DELAY & PERIOD GENERATORS
 - ◇3 WIDTH GENERATOR & PULSE SHAPER
 - ◇4 OUTPUT STAGE

FIG. 1 EXPLODED VIEW



TYPE 115 PULSE GENERATOR

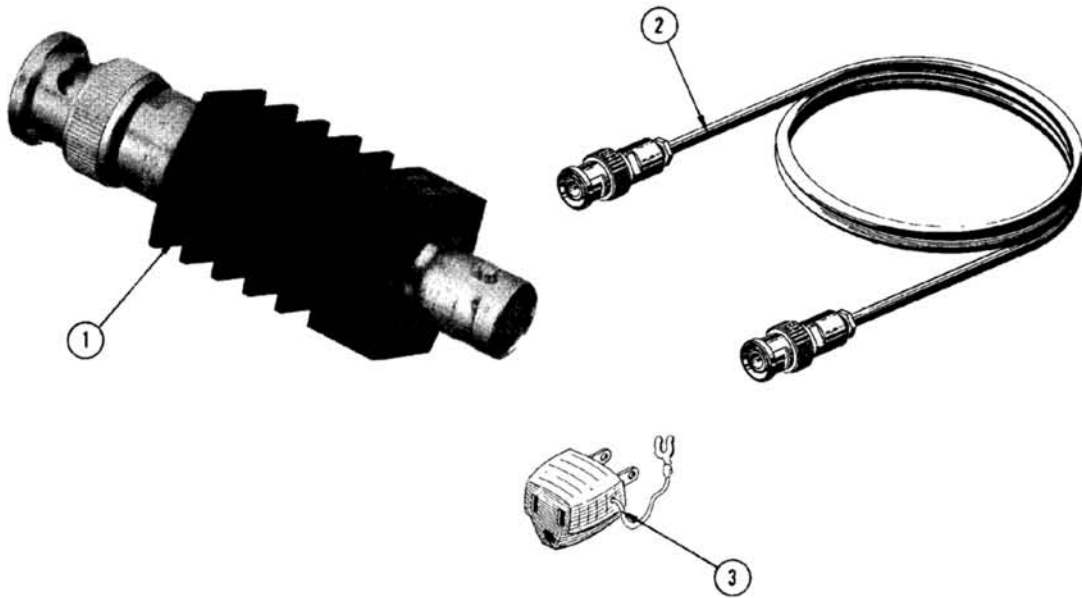
FIG. 2 CABINET



TYPE 115 PULSE GENERATOR

FIG. 3 STANDARD ACCESSORIES

+



+^A

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff Disc	Q					Description
			1	2	3	4	5	
3-1	011-0099-00		1					1 TERMINATION, NETWORK, 50 Ω, 5 W
-2	012-0057-01		1					1 CABLE ASSEMBLY, coaxial, 50 Ω
-3	103-0013-00		1					1 ADAPTER, 3 to 2 wire
	070-0786-00		2					2 MANUAL, instruction (not shown)

SECTION 9

MOD 146B AND RACK MOUNTING

Change information, if any, affecting this section will be found at the rear of the manual.

General

The Type 115 Mod 146B consists of a Type 115 without the standard cabinet and with a coiled power cord (Tektronix Part No. 161-0031-00). It is shipped in this manner so that it may be mounted in a rack adapter [such as the Tektronix Part No. 016-0086-00 or 016-0086-01].

Mounting the Rack Adapter

The rack adapter is designed for permanent mounting in a standard 19-inch wide rack with at least $5\frac{1}{4}$ inches of vertical space. Rear mounting brackets can be adjusted for rear mounting depths from $8\frac{1}{2}$ inches to 26 inches.

To mount the rack adapter into a rack proceed as follows:

1. Attach a rear mounting bracket to each side of the rack adapter.
2. Fasten the rear mounting extension brackets to the rear rails of the rack at the height which the rack adapter is to be mounted. Use bar-nuts if the holes on the rails are not tapped.
3. Hold the rack adapter in a position such that the rear mounting brackets slide inside the bracket extensions and

fasten the rack adapter securely to the front rails of the rack. Use bar-nuts if the holes on the rails are not tapped.

4. Connect the rear mounting brackets to the bracket extensions with hexagonal head screws and a bar-nuts. (see Fig. 9-1). Each screw-nut assembly should be arranged so that a screw head and a washer are on the instrument side of the rear mounting bracket.

Installation of the Type 115 into the Rack Adapter

To install the Type 115 Mod 146B into the rack adapter proceed as follows:

1. Set the rack adapter Line Voltage Selector switch to coincide with the line voltage source.
2. Plug the Type 115 power cord into one of the plugs mounted on the outlet strip inside the rack adapter.
3. Slide the Type 115 into one side of the rack adapter and tighten the slotted-thumb screw located beneath the + GATE IN connector.

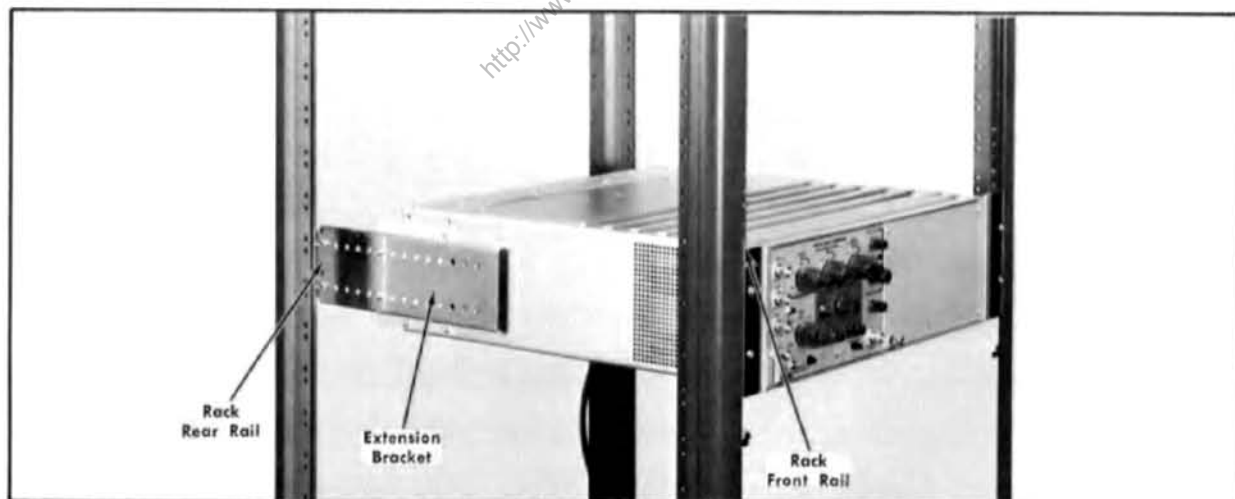


Fig. 9-1. Rack Adapter mounted in rack.

MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages.

A single change may affect several sections. Sections of the manual are often printed at different times, so some of the information on the change pages may already be in your manual. Since the change information sheets are carried in the manual until ALL changes are permanently entered, some duplication may occur. If no such change pages appear in this section, your manual is correct as printed.

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TEXT CORRECTIONS

Section 4 Maintenance

Page 4-10 Fig. 4-7A, Timing and Power Supply Board

Resistor R26 has been added between pin BJ and the cathode of D25. Resistor R140 has been removed and reconnected between the collector of Q173 and the positive terminal of C141. Resistor R225 has been added between the emitter of the collector of Q226. Resistor R226 has been added between the anode and the cathode of D235. Resistor R265 has been added between pin Q and the positive terminal of C198. Diode D202 has been added in parallel with R202.

Page 4-14 Fig. 4-8A, Pulse Shaper and Output Board

Diode D480 has been removed and R482 has been added in its place. Diode D484 has been added with its anode connected to the cathode of D483 and its cathode connected to the emitter of Q473.

<http://www.ebaman.com>

C4/469
(Revised)

ELECTRICAL PARTS LIST AND SCHEMATIC CORRECTION

CHANGE TO:

C139C	}	295-0119-00	863 pF
C139D			0.0985 μ F
C139E			0.1 μ F
C249F		295-0120-00	0.0495 μ F
C339C	}	295-0118-00	908 pF
C339D			0.00985 μ F
C339E			0.1 μ F

<http://www.ebaman.com>

TYPE 115

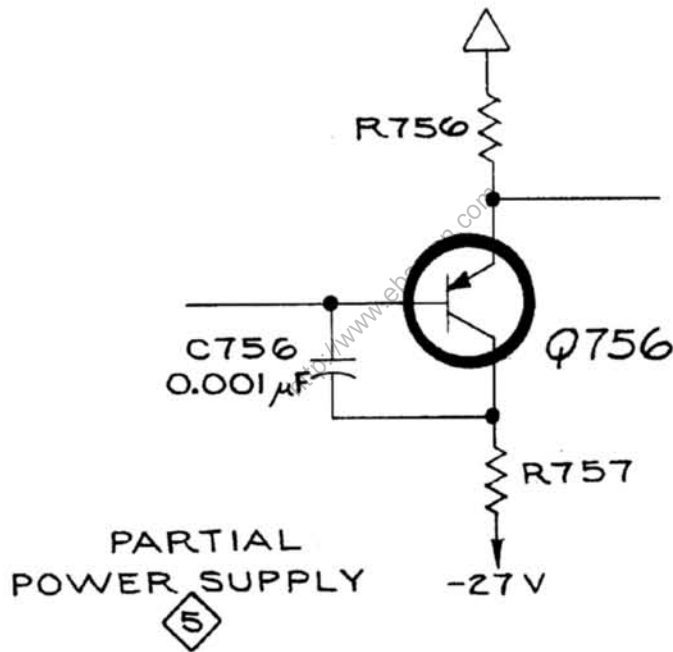
ELECTRICAL PARTS LIST AND SCHEMATIC CORRECTIONS

CHANGE TO:

C337	283-0639-00	56 pF	100 V	Mica	±1%
------	-------------	-------	-------	------	-----

ADD:

C756	283-0078-00	0.001 μ F	500 V	Cer	20%
------	-------------	---------------	-------	-----	-----



M16,357/370