

INSTRUCTION MANUAL

Serial Number _____



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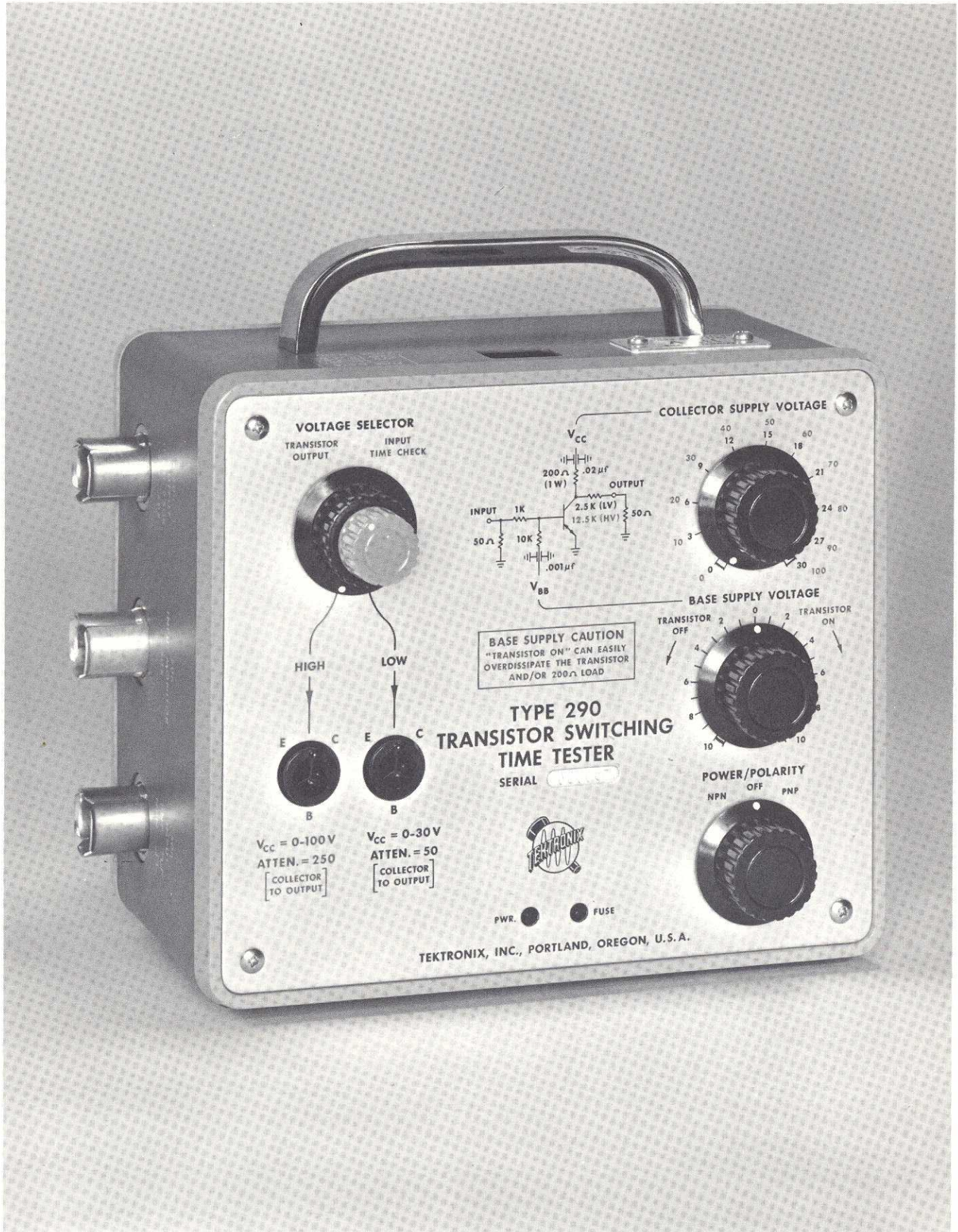
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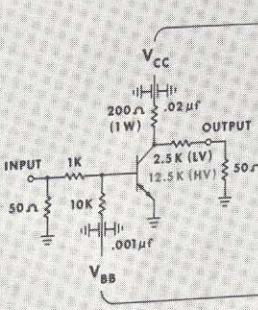
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VOLTAGE SELECTOR
TRANSISTOR OUTPUT INPUT TIME CHECK



COLLECTOR SUPPLY VOLTAGE

BASE SUPPLY VOLTAGE

BASE SUPPLY CAUTION
"TRANSISTOR ON" CAN EASILY
OVERDISSIPATE THE TRANSISTOR
AND/OR 200Ω LOAD

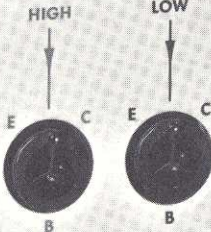
TYPE 290
TRANSISTOR SWITCHING
TIME TESTER

SERIAL



PWR. FUSE

TEKTRONIX, INC., PORTLAND, OREGON, U.S.A.



$V_{CC} = 0-100V$
ATTEN. = 250
[COLLECTOR TO OUTPUT]

$V_{CC} = 0-30V$
ATTEN. = 50
[COLLECTOR TO OUTPUT]

Type 290

SECTION 1

CHARACTERISTICS

Introduction

The Tektronix Type 290 Transistor Time Tester provides collector and base voltages, and a test circuit for testing fast-switching transistors. This tester is designed for use in test systems that can display transistor switching characteristics. The test systems described in this manual provide proper operating conditions for many types of fast-switching transistors.

Input Pulse Requirement

1 milliamp of base current requires an input pulse of about 1 volt.*

Input and Output Impedance

50 ohms.

Risetime

Better than 1 nanosecond (10% to 90%).

Collector Supply Output

Two ranges: 0 to 30 volts and 0 to 100 volts. Output

* For testers with modification 788A, a 1-volt input pulse provides about 0.2 milliamp of base current.

within 10% of COLLECTOR SUPPLY VOLTAGE control setting.

Base Supply Output

0 to 10 volts + or -. Output within 10% of BASE SUPPLY VOLTAGE control setting.

Power Supply Regulation

With line voltage varied from 105 to 125 volts, there should not be more than 1.5 volts change for the 100-volt collector supply, 0.5 volt for the 30-volt collector supply, and 0.5 volt for the 10-volt base supply.

Power Requirements

105 to 125 or 210 to 250 volts, 50 to 800 cps, 15 watts.

Mechanical

Construction—Die cast aluminum alloy top and bottom covers, with steel wrap-around housing. Aluminum alloy power chassis. Etched circuitboard test circuit chassis.

Dimensions—6" high, 7" wide, 4" deep.

Weight—5 pounds.

Finish—Photo-etched anodized aluminum front panel. Blue vinyl paint on steel wrap-around housing.

SECTION 2

THEORY OF OPERATION

Introduction

The switching characteristics of a fast-switching transistor are measured by connecting the transistor into a grounded-emitter circuit. Then the transistor is switched on and off by a fast-rise switching pulse applied to its base. Comparing the applied switching pulse with the resultant collector output signal provides a method for measuring the switching characteristics of the transistor.

The fast-rise switching pulse is obtained from an external generator and the comparison of the switching pulse and collector signals is made on an oscilloscope. Both the pulse generator and the oscilloscope are dc-coupled to the Type 290. This permits transistor collector voltage levels to be observed on the oscilloscope.

Grounded-Emitter Test Circuit

Components in the grounded-emitter test circuit, and applied voltages determine the potentials applied to the

transistor. Fig. 2-1 is a simplified schematic of the grounded-emitter test circuit used in the Type 290.

When the fast-rise input pulse saturates the transistor, the base is near ground potential. Transistor dc-bias current is determined by the base supply voltage (V_{BB}) and the 10 kilohm bias resistor. This current flows to the nearly grounded base of the transistor during saturation. The input signal current is determined by the input voltage drop across the 1 kilohm base resistor*. Depending on voltage polarities, the input current either overcomes or adds to the bias current.

The voltage at the collector is determined by the collector current through the 200 ohm collector-load resistor and the amount of collector supply voltage (V_{CC}). When the LOW transistor socket is used, the output voltage at the collector is attenuated by the 2.5 kilohm attenuation resistance (LV) and the 50 ohm output termination resistance. When the HIGH socket is used, the collector output voltage is attenuated by the 12.5 kilohm attenuation resistance (HV) and 50 ohm output termination resistance. The input signal sees a 50 ohm termination resistance at the input.

*For testers with modification 788A, the base resistor is 5 kilohms.

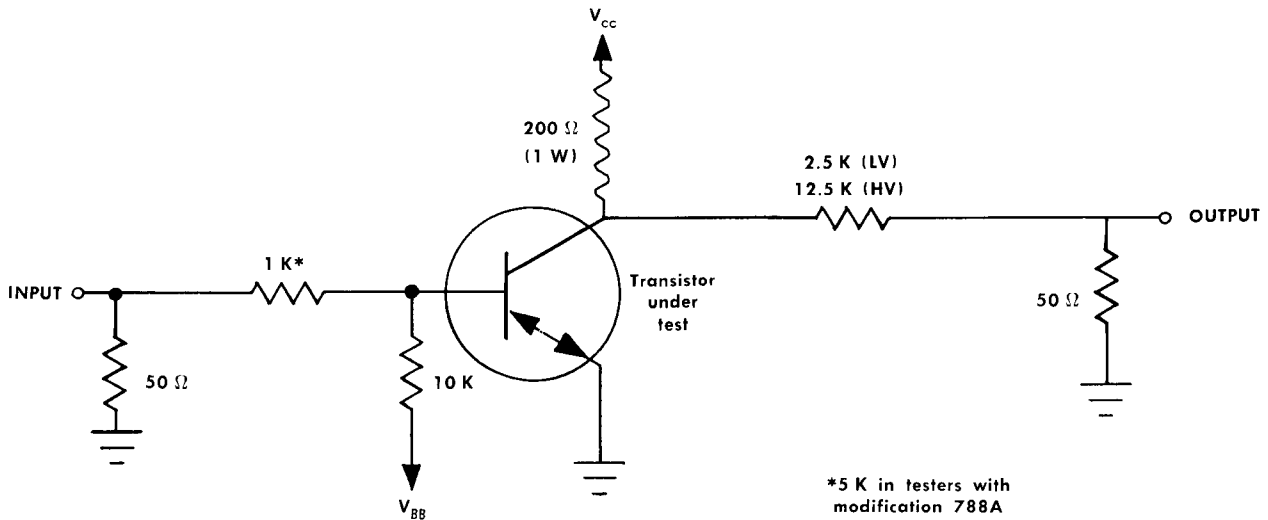


Fig. 2-1. Simplified schematic of Type 290 Grounded-Emitter Test Circuit.

SECTION 3

OPERATING INFORMATION

General

This section contains information necessary for operating the Type 290 and associated equipment. The operator should perform the applicable preliminary instructions prior to operating the test system.

The operating procedures for the test system are divided into three general areas: (1) operation of the Type 290; (2) methods of connecting the Type 290 into test systems; and (3) techniques for measuring the switching characteristics of a transistor.

PRELIMINARY INSTRUCTIONS

Power Requirements

There are two primary windings in the power transformer. One winding has its terminals marked 1 and 3; the other marked 2 and 4. For 117-volt operation, the two windings are connected in parallel by wiring terminal 1 to 2 and terminal 3 to 4. For 234-volt operation, the two primary windings are connected in series by wiring terminal 2 to 3. For both 117- and 234-volt operation, one ac power input lead is connected to terminal 1 and the other to terminal 4.

A label on top of the tester indicates the voltage for which it was wired at the factory.

Fuse Requirements

Use a 2/10-amp slow-blowing type fuse if the Type 290 is wired for 117-volt operation, or a 1/10-amp slow-blowing type fuse for 234-volt operation.

Test System Risetime

Risetime of the test system limits the minimum transistor risetime that can be accurately measured.

Calculate the test system risetime by taking the square root of the sums of the squared risetimes of each piece of test equipment in the system. That is, square the risetime of the pulse generator, Type 290 (1 nanosecond), oscilloscope, and delay line (if used); then add these squared risetimes and take the square root of the sum.

Pulse Generator Requirements

The switching pulse from the fast-rise pulse generator must have enough amplitude and width to drive the transistor under test into saturation for a short time. The pulse polarity must be positive for NPN transistors and negative for PNP.

Transistor Voltage Requirements

The collector and base voltage ratings of the transistor under test should never be exceeded. Also, make sure the tester POWER/POLARITY switch is in the right position for the type of transistor under test.

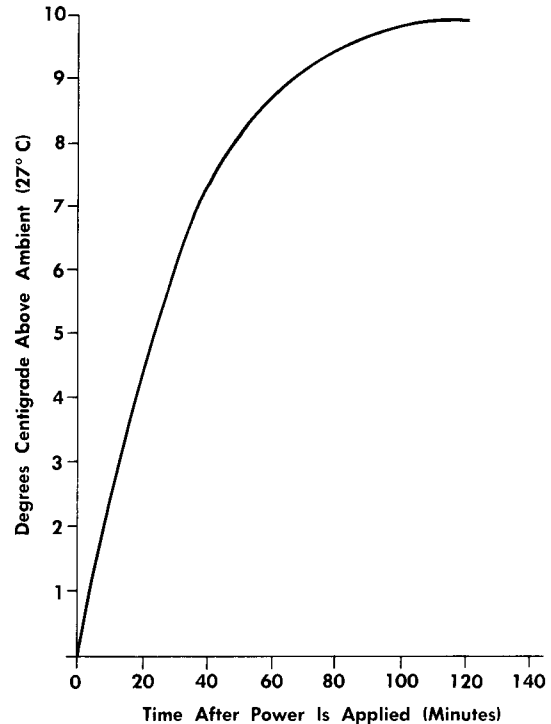


Fig. 3-1. Rise in tester temperature after power is applied.

Transistor Heating

The transistor under test is heated by the potentials applied directly to it and the heat dissipated through the case of the Type 290. Fig. 3-1 shows the temperature rise of the tester case after the tester is turned on. Fig. 3-2 shows the temperature rise of the transistor case after a transistor is inserted into the heated tester.

Transistor Switching Terms (See Fig. 3-3)

Delay Time: The time interval between the 10% levels on the leading edge of the input and output pulses.

Risetime: The time interval between the 10% level and 90% levels on the leading edge of the output pulse.

Turn-On Time: The time interval between the 10% level on the leading edge of the input pulse and the 90% level on the leading edge of the output pulse. Turn-on time is the sum of the delay time and risetime.

Storage Time: The time between 90% levels on the trailing edge of the input and output pulses.

Falltime: The time interval between the 90% and 10% levels on the trailing edge of the output pulse.

Operating Instructions — Type 290

Turn-Off Time: The time interval between the 90% level on the trailing edge of the input pulse and the 10% level on the trailing edge of the output pulse. The turn-off time is the sum of the storage time and fall time.

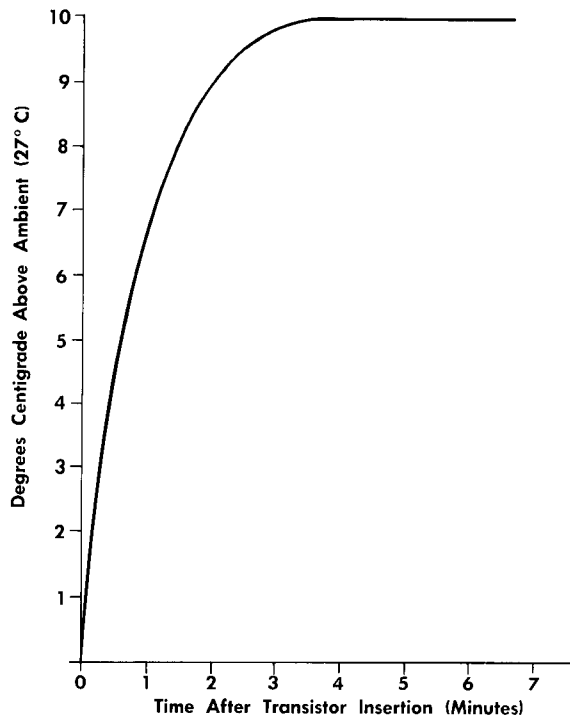


Fig. 3-2. Rise in transistor temperature caused by tester heating (tester temperature 37° C).

Saturation Voltage: The voltage difference between transistor collector voltage at saturation and zero collector voltage.

Calculating Forced-Circuit Beta

The grounded-emitter circuit in the Type 290 is sometimes referred to as a forced-circuit; that is when testing a high-beta transistor, the indicated beta of the transistor is limited to the forced-circuit beta of the tester. A transistor having a beta lower than the forced-circuit beta of the tester cannot be tested under forced-circuit conditions and thus will not reach saturation and may have a slow risetime.

Maximum beta of the circuit is determined by the ratio of the base resistances to collector resistances and the amplitude of input pulses and the values of V_{BB} (base supply voltage) and V_{CC} (collector supply voltage) applied. In the Type 290, the resistances are fixed so only the input, base, and collector voltages can vary the forced-circuit beta. Forced-circuit beta of the tester is determined by comparing the collector current to the base current produced by the input pulse. The forced-circuit beta formula for the Type 290 is derived by starting with:

$$B_{fc} = I_c \div I_b$$

where B_{fc} is the forced-circuit beta, I_c is collector current, and I_b is base current.

The collector current is determined by the formula:

$$I_c = \frac{V_{CC}}{0.2k}$$

where V_{CC} is the collector supply voltage and 0.2k is the collector resistance.

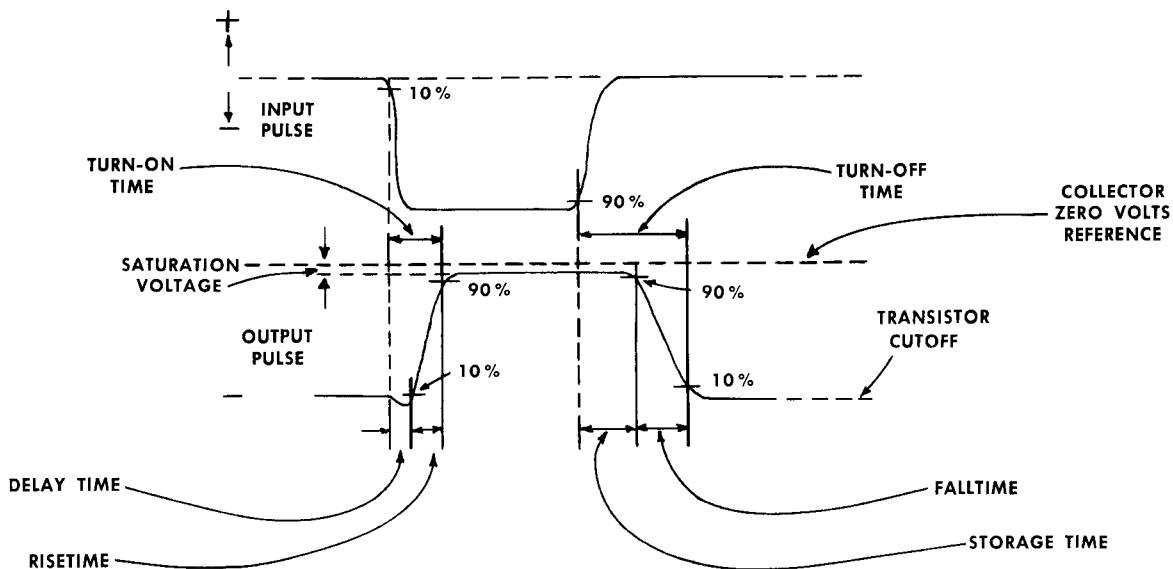


Fig. 3-3. Transistor switching characteristics.

The base current is determined by the formula:*

$$I_b = \frac{E_{gen} - V_{EB}}{1k} - \frac{V_{BB}}{10k} = \frac{10(E_{gen} - V_{EB}) - V_{BB}}{10k}$$

where E_{gen} is the input pulse amplitude, V_{EB} is the voltage drop across the transistor emitter-to-base junction with forward bias, and $1k$ is the base resistor. V_{BB} is base supply voltage and $10k$ is the bias resistor.

Now we have:**

$$\beta_{fc} = I_c \div I_b = \frac{V_{CC}}{0.2k} \div \frac{10(E_{gen} - V_{EB}) - V_{BB}}{10k} = \frac{V_{CC}}{0.2k} \times \frac{10k}{10(E_{gen} - V_{EB}) - V_{BB}} = \frac{50V_{CC}}{10(E_{gen} - V_{EB}) - V_{BB}}$$

which is the forced-circuit beta of the tester with a given collector supply voltage (V_{CC}), a certain input pulse amplitude (E_{gen}), a certain forward bias voltage at the emitter-to-base junction of the transistor (V_{EB}), and a given base supply voltage (V_{BB}). If V_{EB} is not known, 0.5 volts is a close approximation.

Values for V_{CC} and V_{BB} are obtained from the Type 290 control settings. E_{gen} can be measured at a point just before the pulse enters the Type 290 INPUT connector. Or, values for V_{CC} , V_{BB} , and E_{gen} can be calculated using the information under "Determining V_{CC} , E_{gen} , and V_{BB} ".

Calculating I_{B1} and I_{B2}

I_{B1} is determined by the formula:**

$$I_{B1} = \frac{E_{gen} - V_{EB}}{1k} - I_{B2}$$

where E_{gen} is the amplitude of the input pulse and V_{EB} is the transistor's emitter-to-base voltage drop when forward biased. (Often V_{EB} is neglected when calculating I_{B1} and I_{B2} .) I_{B2} is closely approximated by the formula:

$$I_{B2} = \frac{V_{BB} + V_{EB}}{10k}$$

where V_{BB} is the base supply voltage and $10k$ is the bias resistor.

*For testers with modification 788A, the base resistor is changed from 1k to 5k which changes the I_b and β_{fc} calculations as follows:

$$I_b = \frac{E_{gen} - V_{EB}}{5k} - \frac{V_{BB}}{10k} = \frac{2(E_{gen} - V_{EB}) - V_{BB}}{10k}$$

$$\beta_{fc} = I_c \div I_b = \frac{V_{CC}}{0.2k} \div \frac{2(E_{gen} - V_{EB}) - V_{BB}}{10k} = \frac{V_{CC}}{0.2k} \times \frac{10k}{2(E_{gen} - V_{EB}) - V_{BB}} = \frac{50V_{CC}}{2(E_{gen} - V_{EB}) - V_{BB}}$$

**For testers with modification 788A, the base resistor is changed from 1k, to 5k which changes the formula for I_{B1} to:

$$I_{B1} = \frac{E_{gen} - V_{EB}}{5k} - I_{B2}$$

[A] $I_C = 1.0\text{ ma}$ $I_{B1} = 1.0\text{ ma}$ $I_{B2} = 1.0\text{ ma}$

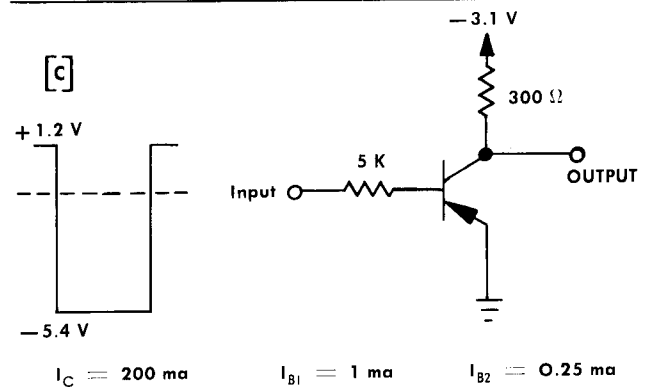
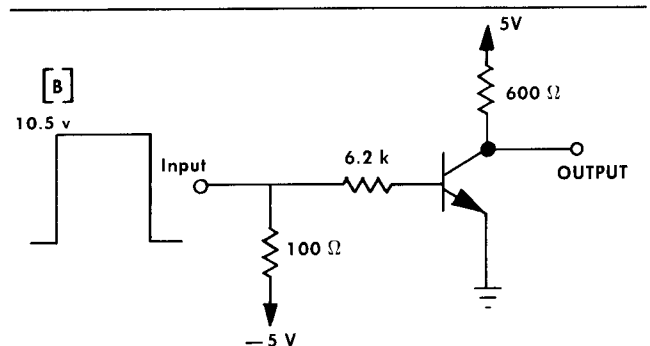


Fig. 3-4. Three examples of typical switching-transistor test specifications.

Determining V_{CC} , E_{gen} , and V_{BB}

The values of V_{CC} , E_{gen} , and V_{BB} used in the Type 290 test system can be calculated from the transistor test specifications. Usually, test specifications appear in one of the three forms shown as example (A), (B), and (C) in Fig. 3-4. Example (A) has three test currents listed, (B) show the test circuit used, and (C) has both the current and test circuit given.

Using the test specifications, V_{CC} , E_{gen} , and V_{BB} can be obtained by the following calculations. These calculations are not valid if the manufacturers' test circuit contains speed-up capacitors and may not be valid if the collector load resistance is very many times greater than 200 ohms. V_{CC} calculations. V_{CC} is determined by the formula:

$$V_{CC} = I_C (200 \Omega)$$

where I_C is saturated transistor collector current and 200 Ω is the Type 290 collector load resistance.

CAUTION

V_{CC} should not exceed transistor collector voltage rating. Otherwise, the transistor may be damaged.

V_{CC} (example (A) in Fig. 3-4):

$$V_{CC} = 10\text{ ma} (200 \Omega) = 2\text{ v.}$$

Operating Instructions — Type 290

V_{CC} (example (B)) is calculated after I_C as follows:

$$I_C = \frac{5 \text{ V}}{600 \Omega} = 8 \text{ ma and,}$$

$$V_{CC} = 8 \text{ ma} (200 \Omega) = 1.6 \text{ v.}$$

V_{CC} (example (C)):

$$V_{CC} = 200 \text{ ma} (200 \Omega) = 40 \text{ v.}$$

E_{gen} calculations. E_{gen} is determined by the formula:

$$E_{gen} = (I_{B1} + I_{B2}) 1 \text{ k}^* + V_{EB}$$

where 1 k^* is the Type 290 base resistor and V_{EB} is emitter-to-base forward bias voltage drop. If V_{EB} is not known, 0.5 volts is a close approximation.

E_{gen} (example (A) in Fig. 3-4):

$$E_{gen} = (1 \text{ ma} + 1 \text{ ma}) 1 \text{ k}^* + 0.5 \text{ v} = 2.5 \text{ v.}$$

E_{gen} (example (B)) is calculated after I_{B1} and I_{B2} as follows:

$$I_{B2} = \frac{5 \text{ v} + 0.5 \text{ v}}{6.3 \text{ k}} = 0.8 \text{ ma and,}$$

$$I_{B1} = \frac{10.5 \text{ v} - 0.5 \text{ v}}{6.2 \text{ k}} - 0.8 \text{ ma} = 0.8 \text{ ma,}$$

then,

$$E_{gen} = (0.8 \text{ ma} + 0.8 \text{ ma}) 1 \text{ k}^* + 0.5 \text{ v} = 2.1 \text{ v.}$$

E_{gen} (example (C)):

$$E_{gen} = (1 \text{ ma} + 0.25 \text{ ma}) 1 \text{ k}^* + 0.5 \text{ v} = 1.75 \text{ v.}$$

V_{BB} calculations. V_{BB} is determined by the formula:

$$V_{BB} = I_{B2} (10 \text{ k})$$

where 10 k is the Type 290 bias resistor.

V_{BB} (example (A) in Fig. 3-4):

$$V_{BB} = 1 \text{ ma} (10 \text{ k}) = 10 \text{ v.}$$

V_{BB} (example (B)) is calculated after I_{B2} as follows:

$$I_{B2} = \frac{5 \text{ v} + 0.5 \text{ v}}{6.3 \text{ k}} = 0.8 \text{ ma, then,}$$

$$V_{BB} = 0.8 \text{ ma} (10 \text{ k}) = 8 \text{ v.}$$

V_{BB} (example (C)):

$$V_{BB} = 0.25 \text{ ma} (10 \text{ k}) = 2.5 \text{ v.}$$

Whenever I_{B2} exceeds 1 ma, the Type 290 can no longer be used to establish V_{BB} . However, V_{BB} can be established by a switching pulse if the pulse can start at one voltage polarity and step to the other polarity. Such a switching pulse is shown in example (C) of Fig. 3-4. In example (C), the pulse starts at +1.2 volts to establish V_{BB} and steps to -5.4 volts for switching.

If the switching pulse is used to establish V_{BB} for a transistor in the Type 290, set the BASE SUPPLY VOLTAGE control to 0 and start the switching pulse at the level (V_{BB}) determined by:

$$V_{BB} = I_{B2} (1 \text{ k}^*).$$

The voltage the pulse steps to is the same as that calculated for E_{gen} .

* For testers with modification 788A, this resistance is 5 k.

The pulse level needed to establish V_{BB} for testing the transistor in example (C) of Fig. 3-4 would be:

$$V_{BB} = 0.8 \text{ ma} (1 \text{ k}^*) = 0.8 \text{ v.}$$

and E_{gen} is +2.1 v. Thus, this transistor could be tested in the Type 290 (BASE SUPPLY VOLTAGE set to 0) by a switching pulse that starts at -0.8 v and steps to +2.1 v.

OPERATING PROCEDURES

Function of Controls and Connectors

Transistor Test Sockets

LOW — The collector signal from this socket is attenuated 50 times at the 50Ω OUTPUT connector. The collector voltage range is from 0 to 30 volts.

HIGH — The collector signal from this socket is attenuated 250 times at the 50Ω OUTPUT connector. The collector voltage range is from 0 to 100 volts.

Power Supply Controls

VOLTAGE SELECTOR — Selects the collector supply voltage range (0 to 30 volts or 0 to 100 volts) and the proper transistor socket (HIGH or LOW).

COLLECTOR SUPPLY VOLTAGE — Varies the collector supply voltage (V_{CC}) over the range selected by the VOLTAGE SELECTOR switch. The collector supply voltage is positive when the POWER/POLARITY switch is at NPN and negative when the POWER/POLARITY switch is at PNP.

BASE SUPPLY VOLTAGE — Controls the magnitude and polarity of the base supply voltage (V_{BB}). When turned fully clockwise from the extreme counterclockwise position, the base supply voltage starts at 10 volts at one polarity, reduces to zero, then increases to 10 volts at the opposite polarity. The switch is labeled TRANSISTOR OFF to the left of zero and TRANSISTOR ON to the right. The polarity of the base voltage on either side of zero is determined by the POWER/POLARITY switch. With the control set to the left of zero, the base supply voltage is positive when the POWER/POLARITY switch is set to PNP, and negative when set to NPN.

CAUTION

Be careful when testing transistors with this control set to TRANSISTOR ON. Excessive current could result and cause damage to either the transistor or the Type 290.

POWER/POLARITY — Turns instrument power on and off, and selects the proper voltage polarity for the collector and base supplies when testing NPN and PNP transistors.

Test Circuit Connectors And Switch

50Ω INPUT — Input connector for fast-rise switching pulse. A negative pulse is required to test PNP transistors, and a positive pulse is required for NPN transistors.

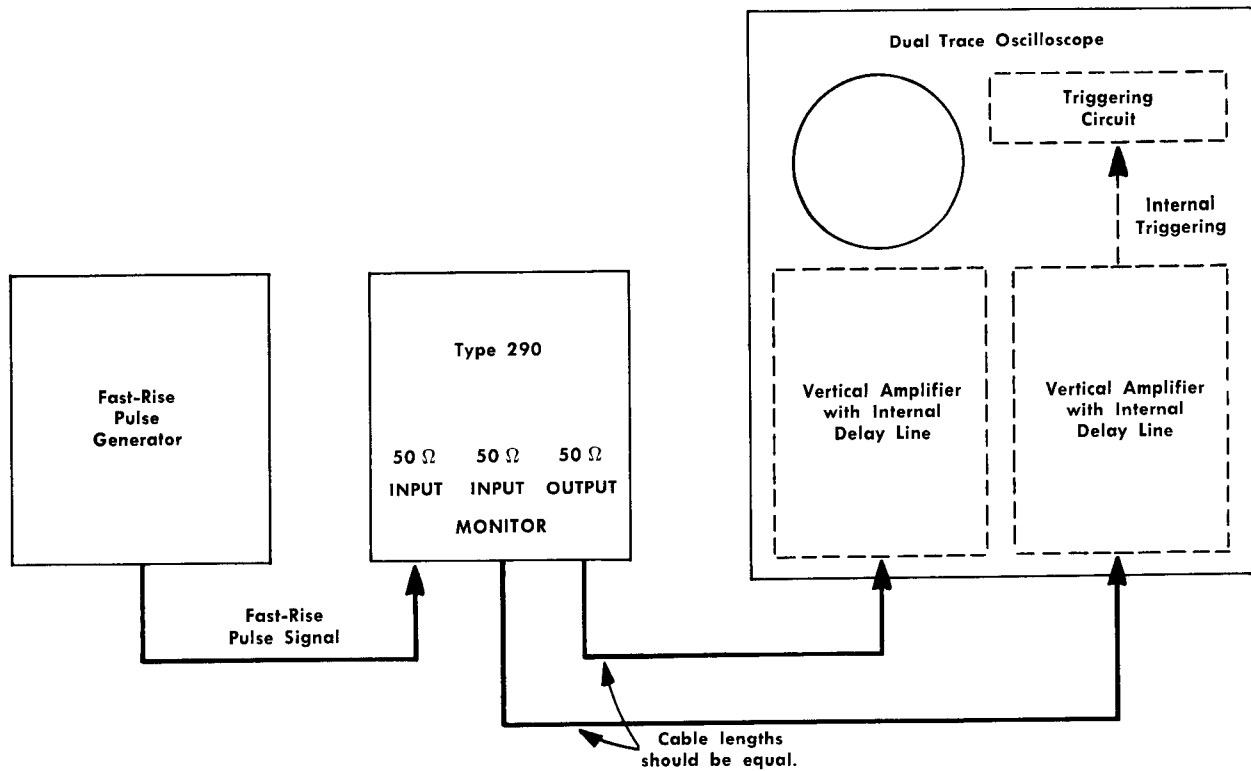


Fig. 3-5. Block representation of Test System One.

50 Ω INPUT MONITOR — Output connector to monitor the input switching pulses. The input pulse is attenuated 50 times, and delayed about 2.6 nanoseconds through the monitor path. When a dual-trace oscilloscope is used, the monitor pulse can be used as the time reference.

50 Ω OUTPUT — Connector for observing either the input switching pulse, or the collector signal of the transistor under test, depending on the setting of the TRANSISTOR OUTPUT/INPUT TIME CHECK switch.

TRANSISTOR OUTPUT/INPUT TIME CHECK — Selects from two signal paths between the 50 Ω INPUT connector and the 50 Ω OUTPUT connector.

In the INPUT TIME CHECK position, the output signal is essentially identical to the signal that appears at the 50 Ω INPUT MONITOR connector.

In the TRANSISTOR OUTPUT position, the input pulse is applied to the base of the transistor under test, and the collector signal appears at the 50 Ω OUTPUT connector.

If a single-trace oscilloscope is used, the INPUT TIME CHECK signal is used as the time reference and the TRANSISTOR OUTPUT signal is the test signal. The operator must manually switch between the two positions for pulse comparison. For dual-trace operation, the 50 Ω INPUT MONITOR signal is applied to one channel, and the TRANSISTOR OUTPUT signal at the 50 Ω OUTPUT connector is applied to the other channel, thus, both signals can be observed simultaneously.

BASIC TEST SYSTEMS

There are several test systems that can be assembled using the Type 290 with various combinations of fast-rise pulse generators and oscilloscopes. However, only four basic systems are described in the following discussions. If your test equipment does not fit one of the basic test systems described, see if using parts of more than one system will make a useable combination.

Regardless of the generator and oscilloscope used, each instrument should be operated according to its individual instruction manual.

The entire test system should be dc-coupled. Attenuators may have to be used to maintain dc-coupling by reducing signals to useable levels. Also, the risetime of the test system limits the fastest transistor risetime that can be accurately measured.

Test System One

Test system one uses a dual-trace oscilloscope with internal vertical-signal delay and any fast-rise pulse generator. Fig. 3-5 shows the test setup. This system simultaneously displays the transistor base input signal on one trace and the collector output signal on the other trace. Transistor switching characteristics are determined by comparing the two signals.

The signal path from the generator to the display is different for each trace. Thus, transit time for one signal may be longer than for the other. Differences in transit time must be considered when measuring transistor switching

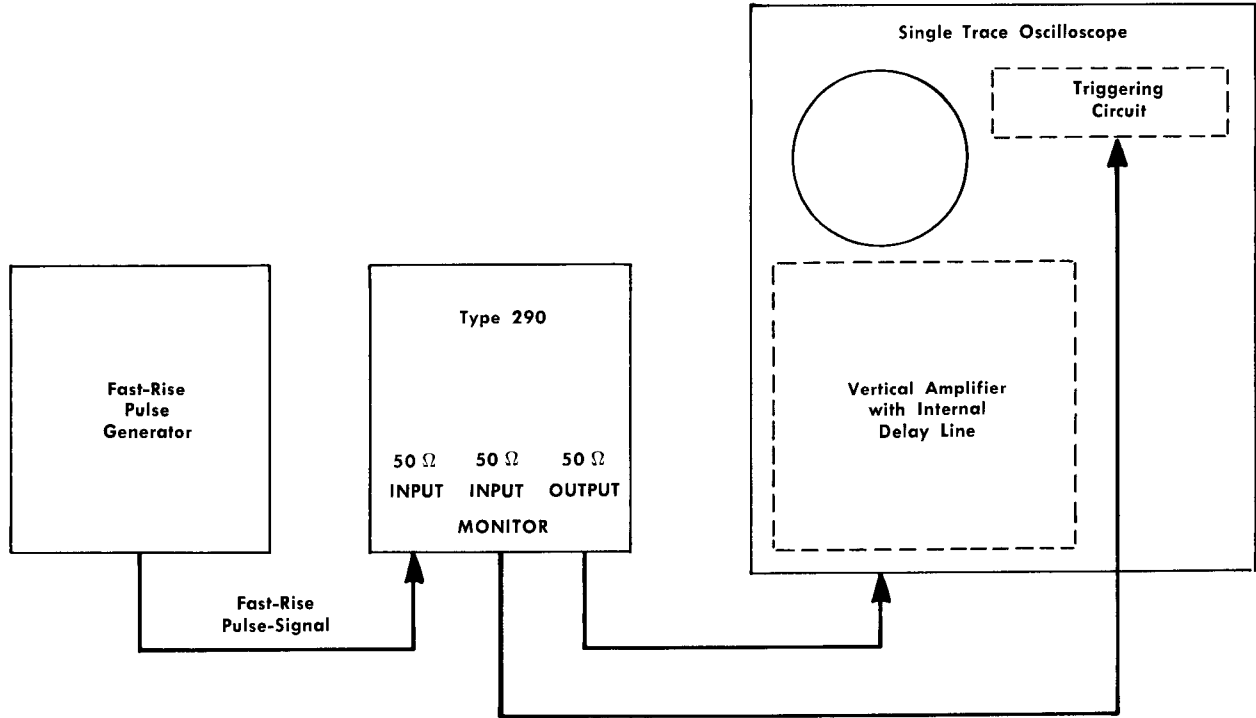


Fig. 3-6. Block representation of Test System Two.

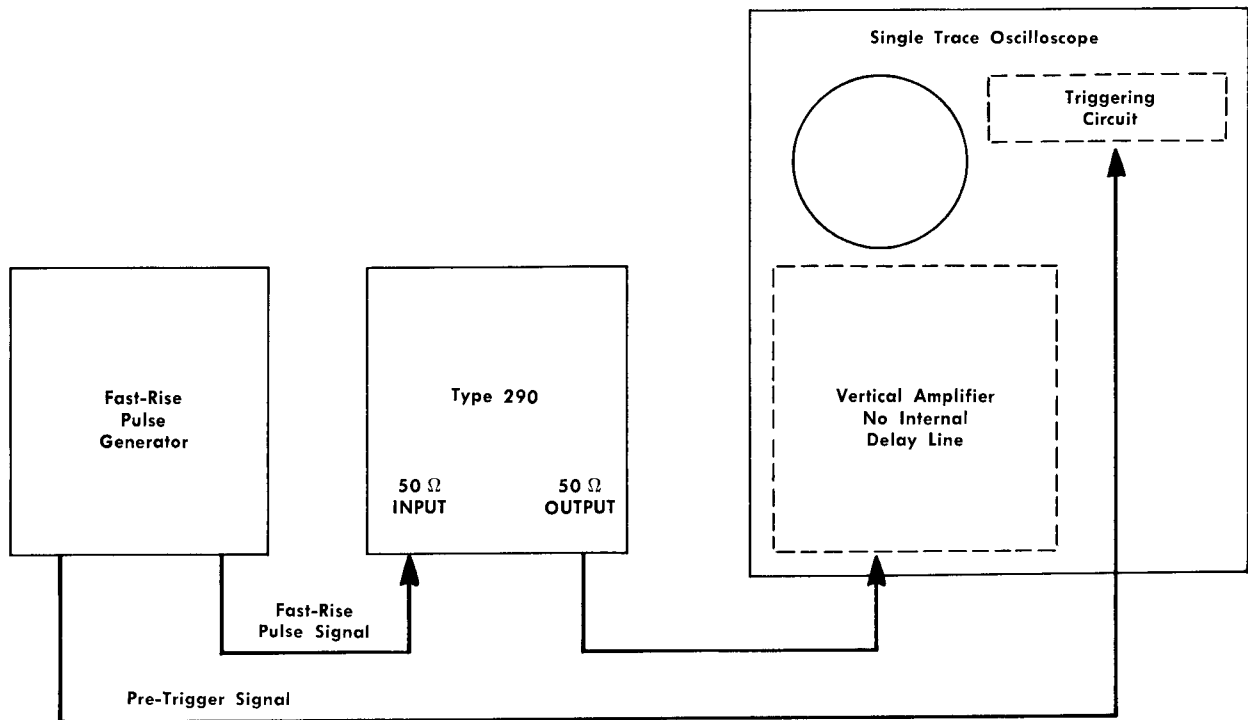


Fig. 3-7. Block representation of Test System Three.

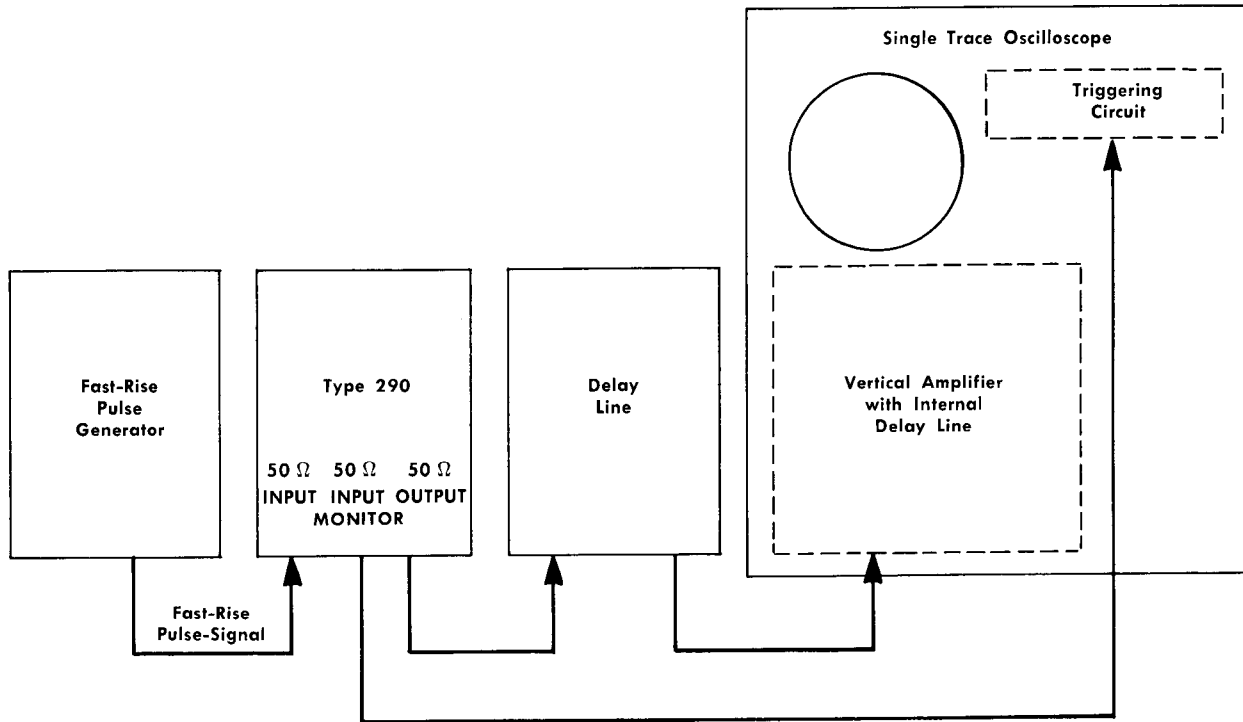


Fig. 3-8. Block representation of Test System Four.

characteristics. To determine the time difference, compare the two fast-rise generator pulses displayed when the Type 290 TRANSISTOR OUTPUT/INPUT TIME CHECK switch is set to INPUT TIME CHECK. Reduce signal transit times by using cables of equal length. Interchanging the cables also may reduce differences in signal transit time.

Test System Two

Test system two uses a single-trace oscilloscope with internal vertical-signal delay and any fast-rise pulse generator. Fig. 3-6 shows the test setup. This system displays the transistor base input signal with the Type 290 TRANSISTOR OUTPUT/INPUT TIME CHECK switch set to INPUT TIME CHECK and displays the transistor collector output signal with the switch set to TRANSISTOR OUTPUT. Transistor switching characteristics are determined by comparing the two signals.

Test System Three

Test system three uses a single-trace oscilloscope without internal vertical-signal delay and a pulse generator with a pretrigger output. Fig. 3-7 shows the test setup. This system operates the same as test system two.

Test System Four

Test system four uses a single-trace oscilloscope without internal vertical-delay, a fast-rise pulse generator without a pretrigger output, and an external delay line. Fig. 3-8

shows the test setup. This system operates the same as test system two.

MEASURING TECHNIQUES

The following information provides techniques for measuring switching characteristics of fast-switching transistors. The switching characteristics are displayed when the transistor is switched into saturation from cutoff. Thus, saturation voltage, turn-on characteristics, and turn-off characteristics can be seen and measured.

The information previously discussed in this section under "Determining V_{CC} , E_{gen} , and V_{BB} " may be used to determine the proper generator output voltage (E_{gen}), the Type 290 base supply voltage (V_{BB}) and collector supply voltage (V_{CC}). V_{CC} determines the setting of the VOLTAGE SELECTOR control and thus the proper transistor socket to use (HIGH or LOW). A negative pulse from the fast-rise pulse generator is required for switching PNP transistors and a positive pulse for switching NPN transistors.

The steps in the following procedures are for single-trace test systems. Most steps are identical for dual-trace test systems and those that are not identical have additional information at the end of the step.

CAUTION

Turn the pulse generator and Type 290 off when inserting or removing a transistor from a test socket; otherwise, the transistor may burn out.

Saturation Voltage

To obtain an oscilloscope display for measuring transistor saturation voltage, use the following procedure:

1. Set pulse generator output voltage and Type 290 COLLECTOR SUPPLY VOLTAGE, BASE SUPPLY VOLTAGE, and VOLTAGE SELECTOR controls to their proper values. Set TRANSISTOR OUTPUT/INPUT TIME CHECK switch to TRANSISTOR OUTPUT and POWER/POLARITY switch to OFF.
2. Obtain a free-running sweep on the oscilloscope, and vertically position the trace to a convenient graticule line. This establishes the zero collector-volts reference line; therefore, do not adjust vertical position control during the remainder of this procedure. (For dual-trace test systems, display only the one signal from the Type 290 50 Ω OUTPUT connector for the entire procedure.)
3. Insert transistor into proper test socket.

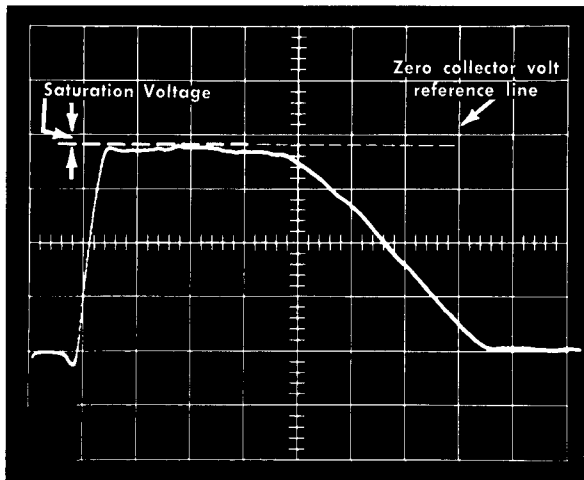


Fig. 3-9. An oscilloscope display used to measure saturation voltage.

4. Turn pulse generator on. Set Type 290 POWER/POLARITY switch to NPN or PNP (depending on type of transistor under test) and set oscilloscope triggering controls for a display similar to that shown in Fig. 3-9. Use this display to measure saturation voltage of the transistor.

NOTE

Any number of transistors with the same specifications can be measured by repeating steps 3 and 4. Turn pulse generator and Type 290 off before inserting transistors into or removing transistors from test sockets.

Turn-on Characteristics

To obtain an oscilloscope display for measuring transistor turn-on characteristics (delay time, risetime, and turn-on time), use the following procedure:

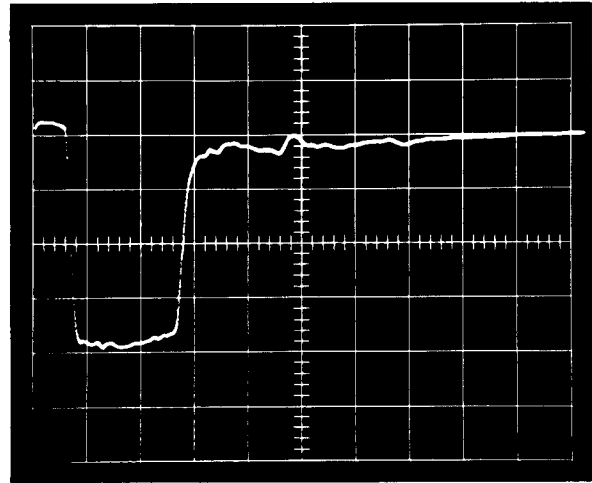


Fig. 3-10. The switching pulse applied to the transistor base.

1. Set pulse generator output voltage and Type 290 COLLECTOR SUPPLY VOLTAGE, BASE SUPPLY VOLTAGE, and VOLTAGE SELECTOR controls to their proper values. Set TRANSISTOR OUTPUT/INPUT TIME CHECK switch to INPUT TIME CHECK and POWER/POLARITY switch to OFF.
2. Turn pulse generator on and set oscilloscope controls for a display similar to that shown in Fig. 3-10.
3. Readjust oscilloscope sweep rate to display the switching-pulse leading edge as shown in Fig. 3-11. Horizontally position the display so the 10% level coincides with a convenient vertical graticule line. This establishes the turn-on reference line; therefore, do not adjust horizontal position control during remainder of this procedure. (For dual-trace test systems, use the signal from the Type 290 50 Ω INPUT MONITOR connector to obtain the display.)
4. Turn pulse generator off, and set Type 290 TRANSISTOR OUTPUT/INPUT TIME CHECK switch to TRANSISTOR OUTPUT.
5. Insert transistor into proper test socket.

6. Turn pulse generator on. Set Type 290 POWER/POLARITY switch to NPN or PNP (depending on type of transistor under test) and set oscilloscope controls for a display of the collector output signal leading edge similar to that shown in Fig. 3-12. Use this display to measure transistor turn-on characteristics. (For dual-trace test systems, use the signal from the Type 290 50 Ω OUTPUT connector to obtain the display.)

NOTE

Any number of transistors with the same specifications can be measured by repeating steps 5 and 6. Turn pulse generator and Type 290 off before inserting transistors into or removing transistors from test sockets.

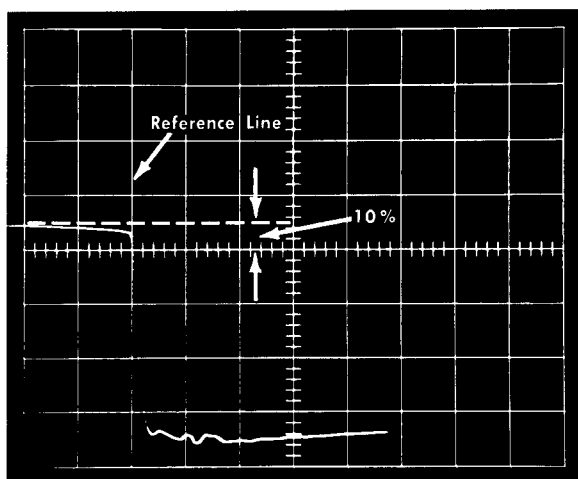


Fig. 3-11. Establishing the turn-on reference line from the 10% level of the switching-pulse leading edge.

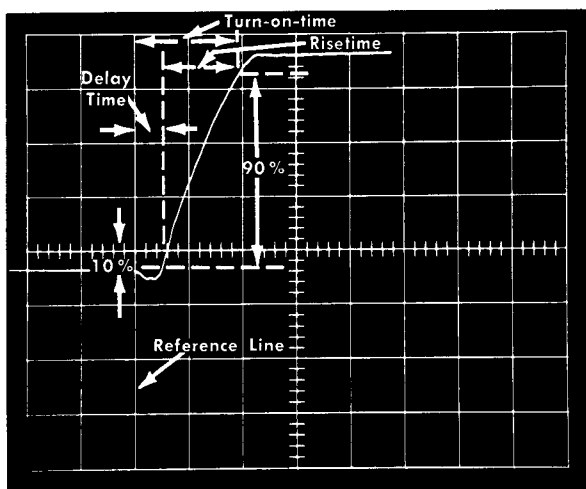


Fig. 3-12. Measuring transistor turn-on characteristics from the leading edge of the collector output signal.

Turn-off Characteristics

To obtain an oscilloscope display for measuring transistor turn-off characteristics (storage time, falltime, and turn-off time), use the following procedure:

1. Set pulse generator output voltage and Type 290 COLLECTOR SUPPLY VOLTAGE, BASE SUPPLY VOLTAGE con-

trols and VOLTAGE SELECTOR switch to their proper values. Set TRANSISTOR OUTPUT/INPUT TIME CHECK switch to INPUT TIME CHECK and POWER/POLARITY switch to OFF.

2. Turn pulse generator on and set oscilloscope controls for a display similar to that shown in Fig. 3-10.

3. Readjust oscilloscope sweep rate to display the switching-pulse trailing edge as shown in Fig. 3-13. Horizontally position the display so the 90% level coincides with a convenient vertical graticule line. This establishes the turn-off reference line; therefore do not change the horizontal position of the display during the rest of this procedure. (For dual-trace test systems, use the signal connected to the Type 290 50 Ω INPUT MONITOR connector to obtain the display.)

4. Turn pulse generator off and set Type 290 TRANSISTOR OUT/INPUT TIME CHECK switch to TRANSISTOR OUTPUT.

5. Insert transistor into proper socket.

6. Turn pulse generator on, Type 290 POWER/POLARITY switch to NPN or PNP (depending on type of transistor under test and set oscilloscope controls for collector output signal trailing-edge display similar to that shown in Fig. 3-14. Use this display to measure the transistor turn-off characteristics. (For dual-trace test systems, use the signal from the Type 290 50 Ω OUTPUT connector to obtain the display.)

NOTE

Any number of transistors with the same specifications can be measured by repeating steps 5 and 6. Turn pulse generator and Type 290 off before inserting transistors into or removing transistors from test socket.

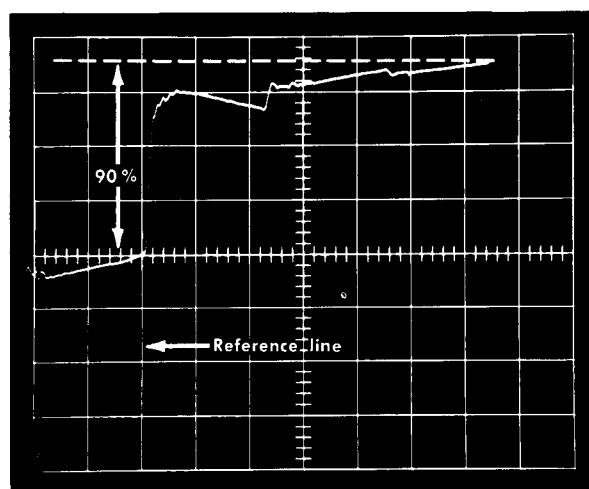


Fig. 3-13. Establishing the turn-off reference line from the 90% level of the switching-pulse trailing edge.

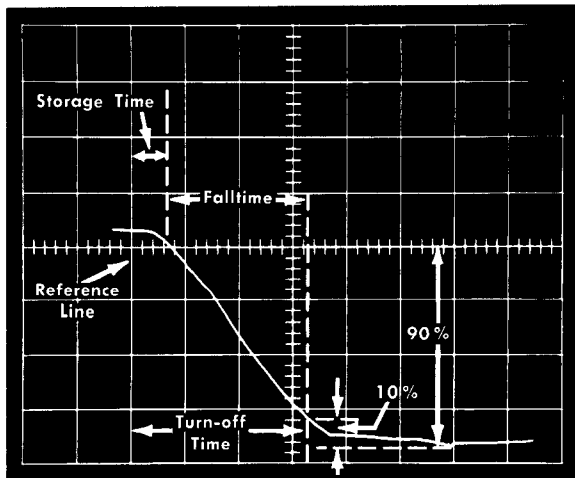


Fig. 3-14. Measuring transistor turn-off characteristics from the trailing edge of the collector output signal.

Class A Operation

The Type 290 can be used to measure the risetime of transistors used as Class A amplifiers.

To test a class A amplifier transistor, it should be biased in a "transistor on" condition (not cutoff), and the fast-rise input pulse should be small to keep from driving the transistor into saturation.

With the transistor on, the front panel voltage markings for the collector supply voltage control are inaccurate because of loading. The collector voltage is determined from the dc-coupled oscilloscope display.

Care must be taken on how much "transistor on" bias is used because it is possible to have excessive emitter to collector current that would damage either the transistor or Type 290. To determine the maximum "transistor on" base bias voltage that may be applied before the transistor is damaged use the following equation.

$$\text{Max. } V_{BB} = \frac{10 P}{\beta V_{CC}}$$

P is the maximum power the transistor can dissipate in milliwatts, β is beta of the transistor, and V_{CC} is the collector supply voltage. To determine the maximum "transistor on" base voltage that may be applied before the Type 290 is damaged, use the following equation.

$$\text{Max. } V_{BB} = \frac{700}{\beta}$$

SECTION 4

CIRCUIT DESCRIPTION

General

The Type 290 Transistor Switching Time Tester is composed of a test circuit and a power supply. These two circuits are described separately in this section.

Test Circuit

The Type 290 test circuit contains a grounded-emitter circuit with three signal channels: Input Monitor channel, Input Time Check channel, and Transistor Output channel. Signal transit time through any one of these channels is about 2.6 nanoseconds with the transit times of all three channels matched to within 0.2 nanoseconds.

Gimmick capacitors provide transit compensation for each channel. These capacitors let high frequencies bypass channel series resistance. The Type 290 gimmick capacitors are heavy pieces of wire, parallel to a resistor, with one end soldered to one resistor lead (see Fig. 4-1). Capacitance is changed by bending the wire closer to or farther from the resistor.

Each channel has a common input path from the 50 Ω INPUT connector through a 50 Ω cable to the input termination network which includes R411 and R421 (see schematic). Input signals enter the individual channels from this input termination network.

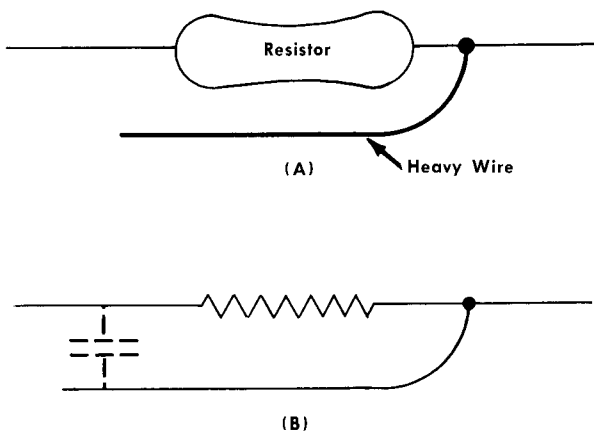


Fig. 4-1. (A). Gimmick capacitor and resistor.
(B). Schematic symbol.

Input Monitor Channel

The Input Monitor channel attenuates the input signal 50 times and delays it about 2.6 nanoseconds. The signal applied to the 50 Ω INPUT connector always appears, attenuated and delayed, at the 50 Ω INPUT MONITOR connector.

R412, R416, and R417 provide the 50 times attenuation while most of the 2.6 (approximate) nanosecond delay occurs in the 50 Ω cable.

Input Time Check Channel

The Input Time Check channel also attenuates the input signal 50 times and delays it about 2.6 nanoseconds. However, the input signal applied to the 50 Ω INPUT connector passes through this channel only when the TRANSISTOR OUTPUT/INPUT TIME CHECK switch SW466 is in the INPUT TIME CHECK position.

The Input Time Check channel consists of input termination network R411-R421, R422, and termination resistors R426 and R427 which attenuate the signal 50 times. After attenuation, the signal passes through three pieces of 50 Ω cable and two contacts of SW466 to the 50 Ω OUTPUT connector.

If the TRANSISTOR OUTPUT/INPUT TIME CHECK switch is set in the TRANSISTOR OUTPUT position, the channel is terminated through SW466 by 50 Ω termination resistors R466 and R467.

Transistor Output Channel

When the transistor under test is inserted into a socket with voltage applied, and the TRANSISTOR OUTPUT/INPUT TIME CHECK switch SW466 is in the TRANSISTOR OUTPUT position, the signal will pass through the transistor output channel to the 50 Ω OUTPUT connector.

The input signal passes from input termination network R411-R421 through resistors R431 or R432 to the base of the transistor under test. Transistor base bias voltage for each transistor socket comes from the base supply through R436 or R437. Each volt of input signal will produce about 1 milliamp* of base current. This base current switches the transistor to produce a signal at the collector. If the LOW socket is used, the collector signal passes through attenuating resistor R446, through three sections of 50 Ω cable and two contacts of SW466, to the 50 Ω OUTPUT connector. If the HIGH socket is used, the collector signal goes through attenuating resistors R456 and R457, through the cable and switch contacts, to the 50 Ω OUTPUT connector. The collector signal from the HIGH transistor socket is attenuated 250 times before it reaches the 50 Ω OUTPUT connector. The collector signal from the LOW socket is attenuated 50 times before it reaches the 50 Ω OUTPUT connector.

Only the transistor socket being used for testing has collector voltage applied. The LOW socket receives voltage

* Testers with modification 788A have about 0.2 milliamp of base current for each volt of input signal.

Circuit Description — Type 290

from the LV supply through R441 and R442 while the HIGH socket receives voltage from the HV supply through R452 and R451.

With the TRANSISTOR OUTPUT/INPUT TIME CHECK switch in the INPUT TIME CHECK position, the Transistor Output channel is terminated by R466 and R467.

Power Supply

The Power Supply is a floating shunt-regulated supply which provides collector and base voltages to the transistor under test. The floating supply enables voltages of either polarity to be selected with respect to ground.

Power to the tester is applied through a three-wire conductor to T601 (See schematic). The primary of T601 has two equal windings which are connected in parallel for 117-volt operation or in series for 234-volt operation. Neon bulb B601 lights when power is applied to T601 via POWER/POLARITY switch SW620. Neon bulb B602 is a fuse indicator which lights if the fuse should open. Normally it remains extinguished.

The induced voltage in the secondary of T601 is applied through R608 to four silicon diodes, D610A, B, C, and D. R608 serves as surge-current limiting resistor to protect the diodes when the power supply is first turned on. The rectified voltage is applied to a capacitor-input filter network consisting of C610A, R610, and C610B. An additional

filtering network composed of R612, R613, C612, and C613 filter out power line transient signals and keep them from entering the transistor test circuitry.

Three dc voltage ranges are available from the supply: plus or minus 100 volts, plus or minus 30 volts, and plus or minus 10 volts. The plus or minus 100-volt and plus or minus 30-volt ranges are selected by VOLTAGE SELECTOR switch SW630. When the switch is placed to the HIGH position, 100 volts from the supply is applied across COLLECTOR SUPPLY VOLTAGE control (R630B section) through R629. The 100 volts is shunt-regulated by zener diodes D620 and D626A or D626B. To make the 100-volt front-panel markings accurate to within 10%, series resistor R629 is selected to provide the correct voltage drop across R630B.

When the switch is placed at the LOW position, R616 drops the SUPPLY VOLTAGE so that 30 volts is applied across the COLLECTOR SUPPLY VOLTAGE control (R630A section). This 30 volts is shunt-regulated by D621 and D626A or D626B.

The plus or minus 10-volt range is obtained by the drop across D626A and D626B. POWER/POLARITY switch SW620 connects these diodes across BASE SUPPLY VOLTAGE control R626.

POWER/POLARITY switch SW620 sets the polarity of all three ranges by switching the polarity of the power supply with respect to ground. Simplified diagrams in Fig. 4-2 show the shunt-regulator connections of the plus or minus 30- and plus or minus 10-volt supplies for each polarity.

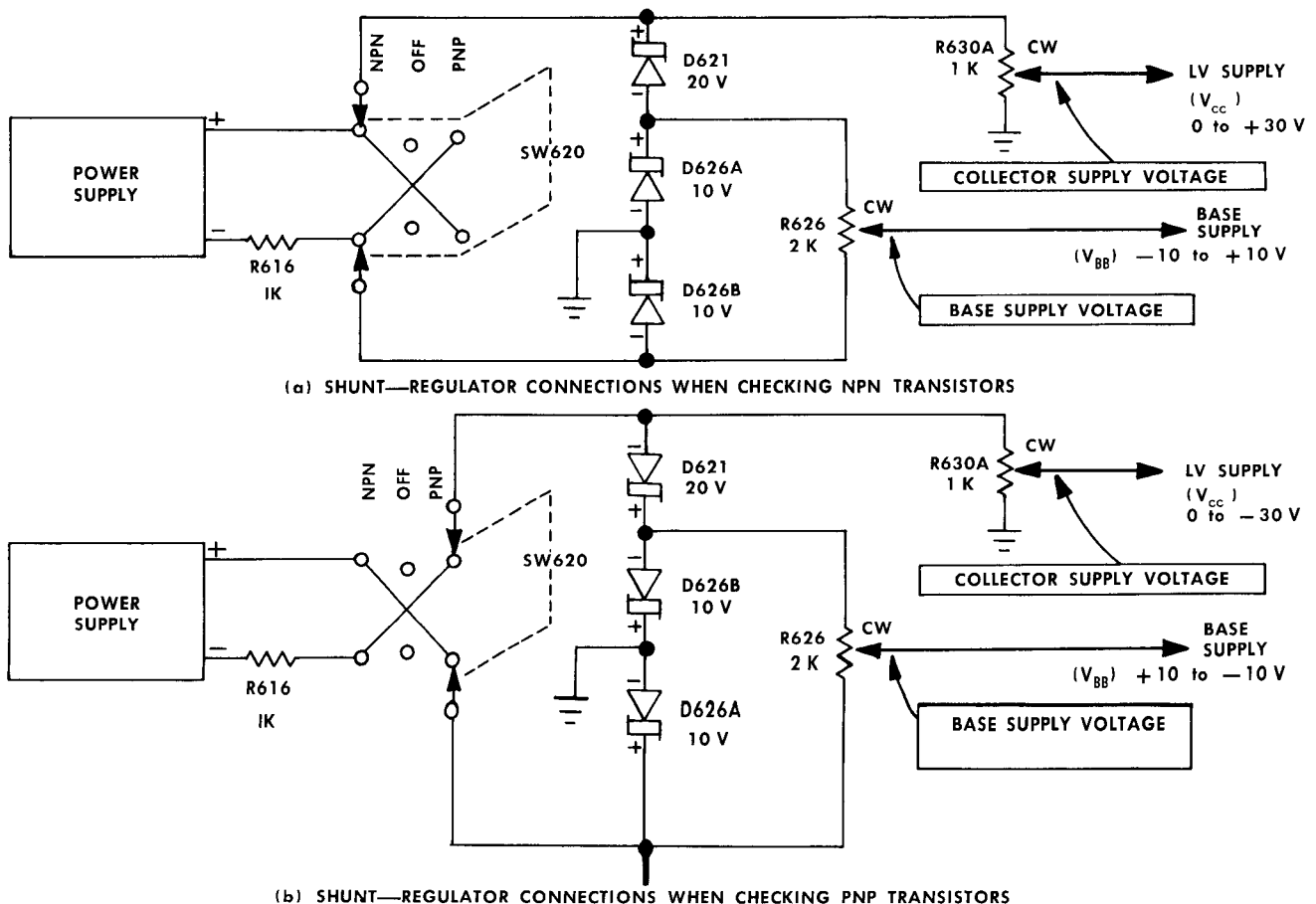


Fig. 4-2. Simplified diagrams of the shunt-regulated low-voltage supply.

SECTION 5

MAINTENANCE

General

If trouble occurs in the Type 290, make sure the associated equipment is operating properly and the controls are set correctly. Improper control settings such as the POWER/POLARITY switch in the wrong position for the transistor being used, may cause trouble symptoms. Also, if the COLLECTOR SUPPLY VOLTAGE control is set too high, the transistors may burn out. Remember, the BASE SUPPLY VOLTAGE is seldom used in the TRANSISTOR ON range. Also, the VOLTAGE SELECTOR switch must be set to the socket (HIGH or LOW) being used. If the fast-rise input pulse is the wrong polarity, the transistor will not be tested properly.

If you are certain the trouble is in the Type 290, a visual check will often reveal the cause. Defects such as loose or broken connections, frayed or broken cables, damaged connectors, burned components, and broken terminal strips can generally be detected by a visual inspection. Except for heat-damaged components, the remedy for these defects is obvious. Since heat damage is usually the result of other, less apparent, trouble in the circuits, be sure to locate the source before replacing components.

If the cause cannot be seen, it can usually be located by performing the following circuit checks. Follow instruc-

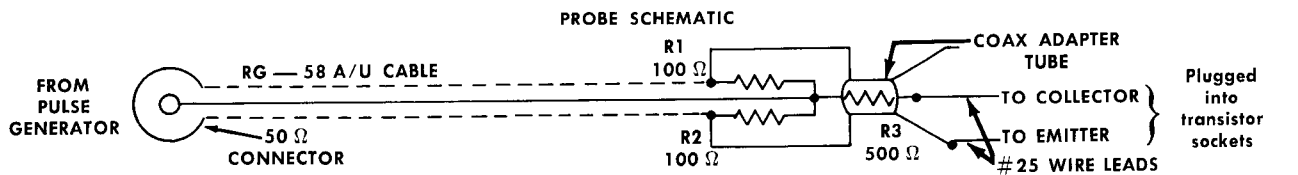
tions under Removing and Replacing Parts near the end of this section before removing or replacing defective components. Troubleshooting and periodic maintenance are based on the following circuit checks. There is one procedure for the test circuit and another for the power supply.

Test Circuit Check

Each channel in the test circuit is checked by inserting a fast-rise pulse into the circuit (tester deenergized) and observing the resulting output signal. The fast-rise pulse is used to compare the transit time of the three channels, and to check the channel transit compensation.

Input Monitor and Input Time Check Channels

Check the Input Monitor and Input Time Check channels by connecting a fast-rise pulse to the INPUT connector. Observe the Input Monitor channel output with an oscilloscope at the 50 Ω INPUT MONITOR connector. Observe the Input Time Check channel output at the 50 Ω OUTPUT connector with the TRANSISTOR OUTPUT/INPUT TIME CHECK position.



PARTS REQUIRED

Description	Tektronix Part No.
RG-58A/U cable, 8" long, with GR-50 Ω connector	017-503
R1, R2—100 Ω, 1/8 watt, 1% resistors	318-040
R3—500 Ω, 1/8 watt, 1% resistor	318-037
Coaxial adaptor tube	166-239
Spaghetti insulation	
Two wires—0.017" dia. or #25 AWG Band S gauge, 3/4" long (Same diameter as transistor leads.)	

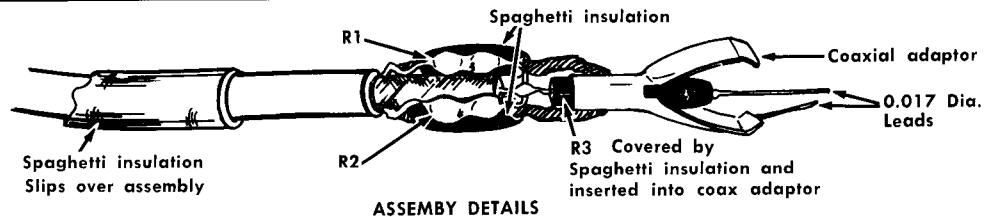


Fig. 5-1. Signal-injection probe construction.

Maintenance — Type 290

A signal passing through either the Input Monitor or the Input Time Check channel is attenuated 50 times. In either channel, signal risetime should not exceed 1 nanosecond, and the leading corner of the output waveform should have minimum rounding or peaking.

Gimmick capacitors (see explanation in Theory or Operation section) across R412 and R422 provide transit compensation for the Input Monitor and Input Time Check channels. If necessary, compensate the channels for the least amount of roll-off and peaking of the output waveform by moving the gimmick wire closer to (increasing capacitance) or farther from (decreasing capacitance) the resistors.

Transistor Output Channel

Both resistance and signal checks are used to test the Transistor Output channel.

The resistance from the 50 Ω INPUT connector to the base hole of the LOW and HIGH socket should be about 920 ohms.* The resistance from either the LOW or HIGH socket base hole to the arm of R626 (BASE SUPPLY VOLTAGE control) should be about 5.5 kilohms. The resistance from the junction of R446 and R457 to ground with the TRANSISTOR OUTPUT/INPUT TIME CHECK switch in the INPUT TIME CHECK position should be about 50 ohms.

To signal check the Transistor Output channel, first assemble a signal-injection probe as shown in Fig. 5-1. Then place the TRANSISTOR OUTPUT/INPUT TIME CHECK switch in the TRANSISTOR OUTPUT position and apply a fast-rise pulse to the LOW socket, then to the HIGH socket, by inserting the signal-injection probe into the socket collector and emitter holes. The pulse applied to the LOW socket should appear, attenuated 50 times, at the 50 Ω OUTPUT connector while the HIGH socket pulse should appear, attenuated 250 times, at the 50 Ω OUTPUT connector.

Risetime of the output pulse from both sockets should be less than 1 nanosecond and the leading corner should have minimum rounding or peaking. The LOW socket pulse is compensated by a gimmick capacitor across R446. Two gimmick capacitors are used to compensate the HIGH socket pulse: one across R456 and one across R457. The gimmick capacitor across R456 has the most effect on rounding and peaking, while the capacitor across R457 has the least effect.

If necessary, compensate the channel for the least amount of rounding and peaking by moving the gimmick wire closer to (increasing capacitance) or further from (decreasing capacitance) the resistors.

Transit-Time Comparison

A transit-time comparison is made by measuring the time it takes a signal to go through the Input Monitor channel and comparing this to the time it takes a signal to go through each of the other two channels individually. The difference between the signal transit time through the Input Time Check and Transistor Output channel when compared to the transit time through the Input Monitor channel should not exceed 0.1 nanosecond (this allows a maximum of 0.2 nanosecond difference between the Transistor Output and Input Time Check channels only).

*3.49 kilohms for testers with modification 788A.

Compare the signal transit time through the Input Time Check channel to that of the Input Monitor channel by feeding a fast-rise pulse into the 50 Ω INPUT connector. Observe the time difference between the output waveforms at the 50 Ω INPUT MONITOR and the 50 Ω OUTPUT connector with the TRANSISTOR OUTPUT/INPUT TIME CHECK switch in the INPUT TIME CHECK position. Similarly, compare the signal transit time through the Transistor Output channel to that of the Input Monitor channel with the TRANSISTOR OUTPUT/INPUT TIME CHECK switch in the TRANSISTOR OUTPUT position lead) inserted between the diameter wire (e.g. transistor lead) inserted between the base and collector holes in the HIGH transistor socket.

Power Supply Check

Check the power supply by measuring its output voltages and ripple.

100-Volt Collector Supply

Set the VOLTAGE SELECTOR switch to HIGH. Turn the COLLECTOR SUPPLY VOLTAGE control and check the output voltage from the wiper of R630B to see that it is within $\pm 10\%$ of the front panel markings. The voltage should be positive with the POWER/POLARITY switch set to PNP, and negative when set to NPN. Nominal ripple is 30 millivolts.

30-Volt Collector Supply

Set the VOLTAGE SELECTOR switch to LOW. Turn the COLLECTOR SUPPLY VOLTAGE control and check the output voltage from the wiper of R630A to see that it is within $\pm 10\%$ of the front panel markings. The voltage should be positive with the POWER/POLARITY switch set to PNP and negative when set to NPN. Nominal ripple is 10 millivolts.

Base Supply Voltage

Turn the BASE SUPPLY VOLTAGE control and check the output voltage from the wiper of R626 to see that it is within $\pm 10\%$ of the front panel markings. The voltage should be positive on one side of the zero position, and negative on the other. With the VOLTAGE SELECTOR switch set to HIGH, the nominal ripple is 10 millivolts.

Removing and Replacing Parts

Most parts in the Type 290 can be replaced without detailed instructions. Some, however, are best removed and replaced by using definite procedures contained in the following paragraphs. Parts ordering information is included in the Parts List section of this manual.

Whenever a part has been replaced, check and adjust the instrument calibration as necessary.

Access To The Interior

To gain access to the interior of the Type 290, remove the four screws on the front of the tester and remove the back panel. Then lift off the wrap-around housing.

CAUTION

When operating the Type 290 without the wrap-around housing, be sure to connect the power cord properly. If care is not used, the cord can be connected 120-degrees from the correct position.

Soldering Precautions and Procedures

In Tektronix instruments, parts connected to ceramic terminal strips are mechanically and electrically bonded using solder containing 3% silver. These bonds may be broken by repeated use of ordinary 60-40 tin-lead solder or by excessive heat. The ceramic strip may break with excessive pressure. Therefore, when resoldering parts to a ceramic strip use 3% silver solder and do not press too hard or overheat the work. Occasional use of ordinary solder, however, will not break the bond.

Usually 3% silver solder is available locally; if not, one-pound rolls may be purchased through your Tektronix Field Office by ordering Tektronix Part Number 251-514.

The following recommended soldering procedure may be used to remove and replace parts on a ceramic terminal strip.

1. Use 50- to 70-watt soldering iron with a wedge-shaped tip. (This type of tip applies heat directly to the ceramic strip solder slot without overheating.)
2. Tin soldering-iron with silver-bearing solder.
3. Heat parts soldered to ceramic strip just enough to make solder flow freely by touching one corner of the soldering-iron tip to the notch. (Be careful, excessive pressure may break the ceramic strip.)
4. If a part is being removed, pull it out of the notch while the solder is hot.
5. If a part is replaced, apply only enough solder to cover the wires and form a small fillet on the wire.
6. Clip excess leads, and remove clippings from instrument.

Replacing Ceramic Terminal Strips

Damaged ceramic-terminal strips can be removed and replaced by the following procedure. See Fig. 5-2.

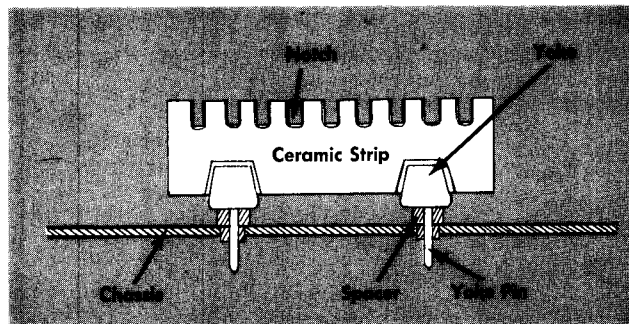


Fig. 5-2. Ceramic terminal strip assembly.

1. Unsolder all connections to damaged ceramic strip.
2. Cut off one side of each plastic yoke holding the ceramic strip.
3. Remove the ceramic strip.
4. Remove remainder of yokes from spacers.
5. Replace spacers with new ones (undamaged spacers can be reused).
6. Set new ceramic strip yoke pins into spacers.
7. Drive new yoke pins completely into spacers by pressing or lightly tapping the ceramic strip directly above the yokes.
8. Cut off portion of new yoke pins protruding through spacers on side of chassis opposite the ceramic strip.
9. Resolder connections to new ceramic strip using the information in this manual under Soldering Precautions and Procedure.

Replacing Switches

Normally, if one wafer is defective in a switch, the entire switch should be replaced. Switches can be ordered from Tektronix, either wired or unwired.

ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description	S/N Range
BULBS			
B601	150-002	Neon, NE-2	PWR.
B602	150-002	Neon, NE-2	FUSE

CAPACITORS

Tolerance $\pm 20\%$ unless otherwise indicated.

Tolerance of all electrolytic capacitors are as follows (with exceptions):

3 V — 50 V = -10% , $+250\%$

51 V — 350 V = -10% , $+100\%$

351 V — 450 V = -10% , $+50\%$

C412	283-590	7.5 pf	Mica	500 v	5%
C422	283-590	7.5 pf	Mica	500 v	5%
C435	283-563	.001 μ f	Mica	500 v	10%
C440	283-563	.001 μ f	Mica	500 v	10%
C441	283-004	.02 μ f	Disc Type	150 v	
C450	283-563	.001 μ f	Mica	500 v	10%
C451	283-004	.02 μ f	Disc Type	150 v	
C460	283-590	7.5 pf	Mica	500 v	5%
C610A,B	*290-040	2 x 40 μ f	EMC	250 v	
C612	283-002	.01 μ f	Disc Type	500 v	
C613	283-002	.01 μ f	Disc Type	500 v	

DIODES

D610A,B,C,D	152-047	Silicon	1N2862 (or equivalent)		
D620	152-052	Zener	91 v 10 w 5%		
D621	152-053	Zener	20 v 10 w 5%		
D626A } D626B }	152-054	Zener	10 v 1.5 w 5%	Matched within 2% of each other	

FUSES

F601	159-044	.2 Amp 3AG Slo-Blo		
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Parts List — Type 290

RESISTORS

Ckt. No.	Tektronix Part No.	Description		S/N Range
Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.				
R411	318-091	120 Ω	$\frac{1}{8}$ w	Prec. 1%
R412	319-060	1.24 k	$\frac{1}{4}$ w	Prec. 1%
R416	318-040	100 Ω	$\frac{1}{8}$ w	Prec. 1%
R417	318-040	100 Ω	$\frac{1}{8}$ w	Prec. 1%
R421	318-091	120 Ω	$\frac{1}{8}$ w	Prec. 1%
R422	319-060	1.24 k	$\frac{1}{4}$ w	Prec. 1%
R426	318-040	100 Ω	$\frac{1}{8}$ w	Prec. 1%
R427	318-040	100 Ω	$\frac{1}{8}$ w	Prec. 1%
R431	319-042	1 k	$\frac{1}{4}$ w	Prec. 1%
R432	319-042	1 k	$\frac{1}{4}$ w	Prec. 1%
R436	318-084	10 k	$\frac{1}{8}$ w	Prec. 1%
R437	318-084	10 k	$\frac{1}{8}$ w	Prec. 1%
R441	309-173	109 Ω	$\frac{1}{2}$ w	Prec. 1%
R442	309-173	109 Ω	$\frac{1}{2}$ w	Prec. 1%
R446	309-411	2.43 k	$\frac{1}{2}$ w	Prec. 1%
R451	309-287	101 Ω	$\frac{1}{2}$ w	Prec. 1%
R452	309-287	101 Ω	$\frac{1}{2}$ w	Prec. 1%
R456	309-410	8.25 k	$\frac{1}{2}$ w	Prec. 1%
R457	319-059	4.22 k	$\frac{1}{4}$ w	Prec. 1%
R466	318-040	100 Ω	$\frac{1}{8}$ w	Prec. 1%
R467	318-040	100 Ω	$\frac{1}{8}$ w	Prec. 1%
R601	302-334	330 k	$\frac{1}{2}$ w	
R602	302-334	330 k	$\frac{1}{2}$ w	
R608	302-100	10 Ω	$\frac{1}{2}$ w	
R610	308-089	1 k	10 w	WW 5%
R612	302-470	47 Ω	$\frac{1}{2}$ w	
R613	302-470	47 Ω	$\frac{1}{2}$ w	
R616	308-089	1 k	10 w	WW 5%
R626	311-141	2 k		Var. WW
R629	Selected			
R630A,B	311-251	1 k x 5 k	3 w	Var. WW

5%
BASE SUPPLY VOLTAGE
COLLECTOR SUPPLY
VOLTAGE

SWITCHES

	Unwired	Wired		
SW466†	260-389		Rotary	TRANSISTOR OUTPUT
SW620	260-380		Rotary	INPUT TIME CHECK
SW630†	260-389		Rotary	POWER/POLARITY
				VOLTAGE SELECTOR

TRANSFORMERS

T601	*120-223	Power
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†SW630 and SW466 are concentric. Furnished as a unit.

SECTION 6

PARTS LIST AND SCHEMATICS

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix Field Office.



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 including any suffix, instrument type, serial number, and modification number if applicable.

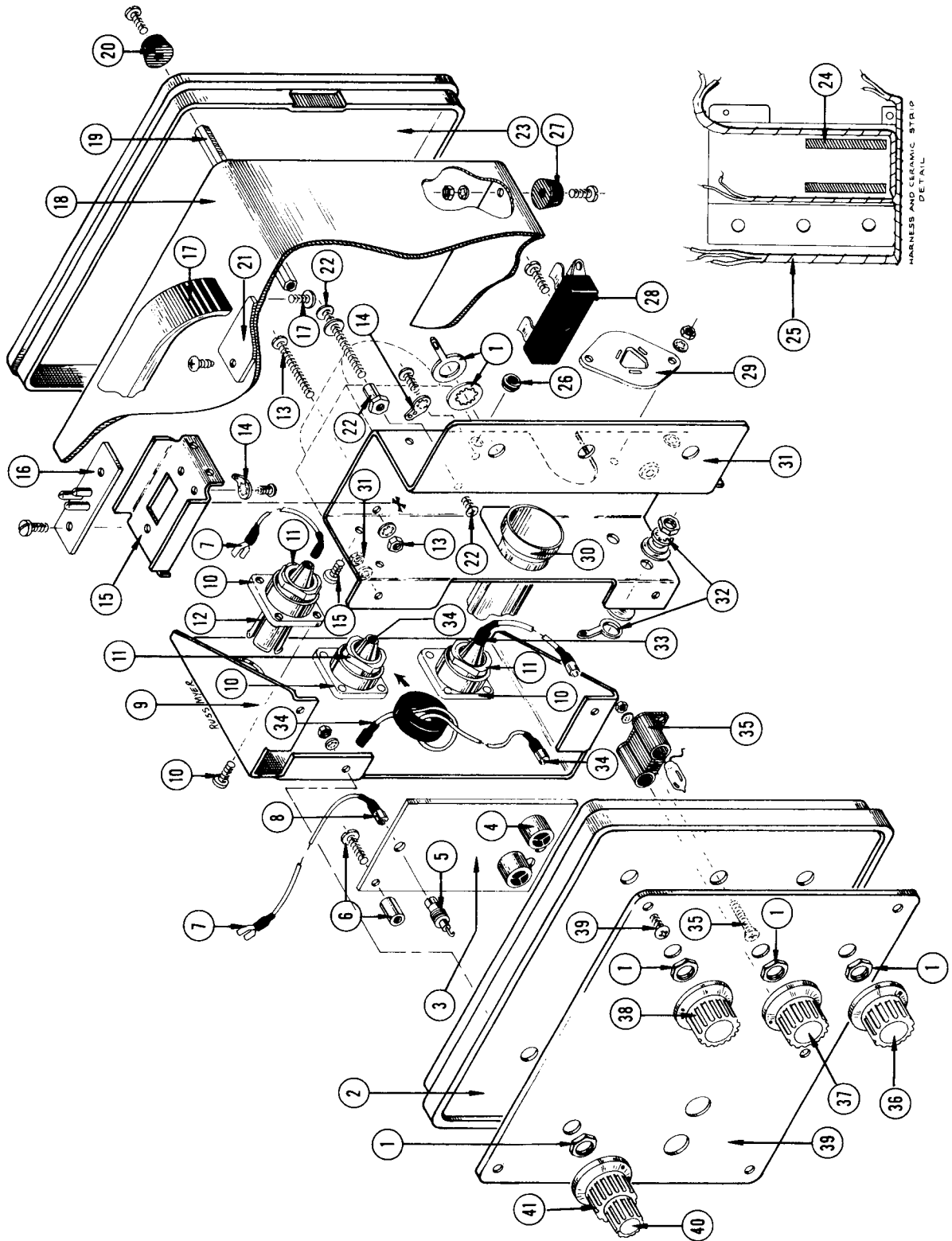
If a part you have ordered has been replaced with a new or improved part, your local Tektronix Field Office will contact you concerning any change in part number.

ABBREVIATIONS AND SYMBOLS

a or amp	amperes	mm	millimeter
BHS	binding head steel	meg or M	megohms or mega (10 ⁶)
C	carbon	met.	metal
cer	ceramic	μ	micro, or 10 ⁻⁶
cm	centimeter	n	nano, or 10 ⁻⁹
comp	composition	Ω	ohm
cps	cycles per second	OD	outside diameter
crt	cathode-ray tube	OHS	oval head steel
CSK	counter sunk	p	pico, or 10 ⁻¹²
dia	diameter	PHS	pan head steel
div	division	piv	peak inverse voltage
EMC	electrolytic, metal cased	plstc	plastic
EMT	electrolytic, metal tubular	PMC	paper, metal cased
ext	external	poly	polystyrene
f	farad	Prec	precision
F & I	focus and intensity	PT	paper tubular
FHS	flat head steel	PTM	paper or plastic, tubular, molded
Fil HS	fillister head steel	RHS	round head steel
g or G	giga, or 10 ⁹	rms	root mean square
Ge	germanium	sec	second
GMV	guaranteed minimum value	Si	silicon
h	henry	S/N	serial number
hex	hexagonal	t or T	tera, or 10 ¹²
HHS	hex head steel	TD	toroid
HSS	hex socket steel	THS	truss head steel
HV	high voltage	tub.	tubular
ID	inside diameter	v or V	volt
incd	incandescent	Var	variable
int	internal	w	watt
k or K	kilohms or kilo (10 ³)	w/	with
kc	kilocycle	w/o	without
m	milli, or 10 ⁻³	WW	wire-wound
mc	megacycle		

SPECIAL NOTES AND SYMBOLS

X000	Part first added at this serial number.
000X	Part removed after this serial number.
*000-000	Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, or reworked or checked components.
Use 000-000	Part number indicated is direct replacement.
	Internal screwdriver adjustment.
	Front-panel adjustment or connector.

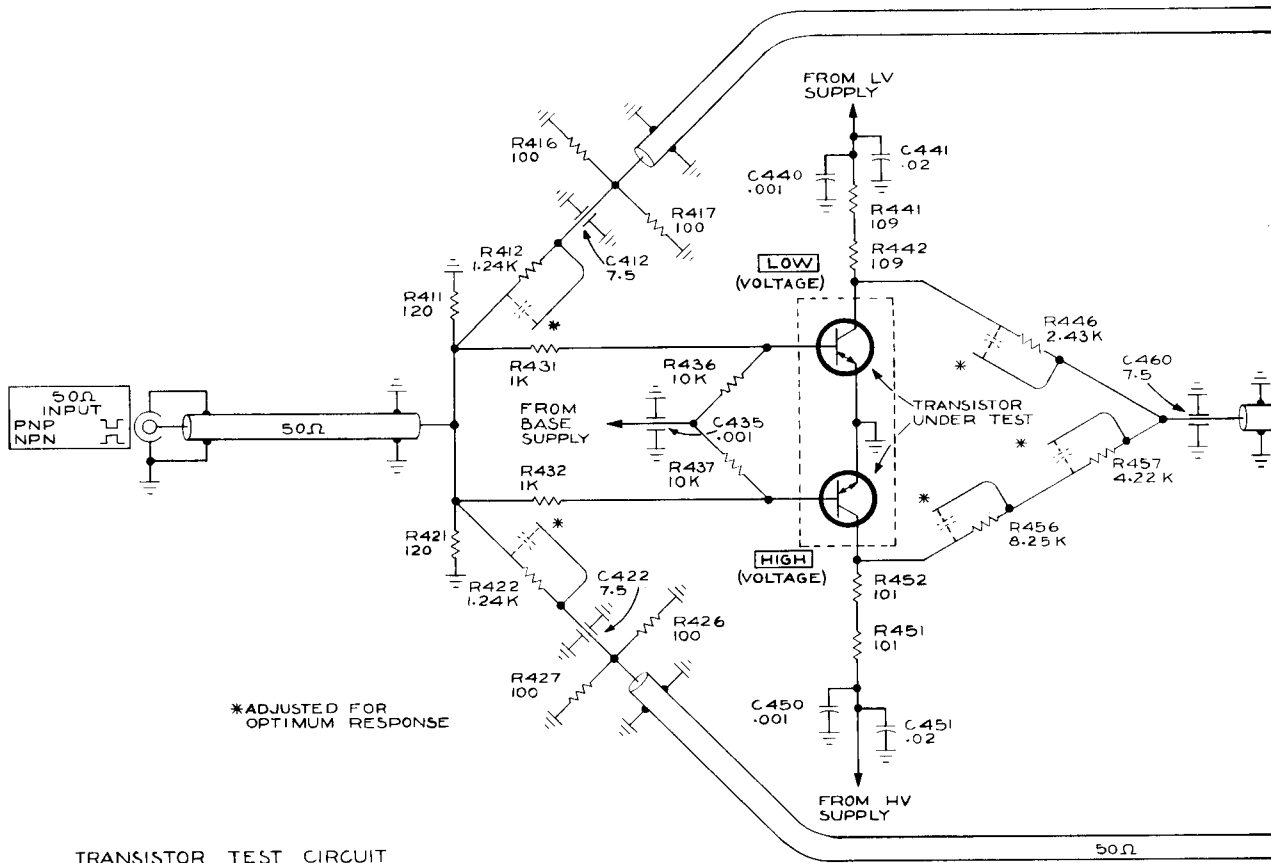


EXPLODED VIEW

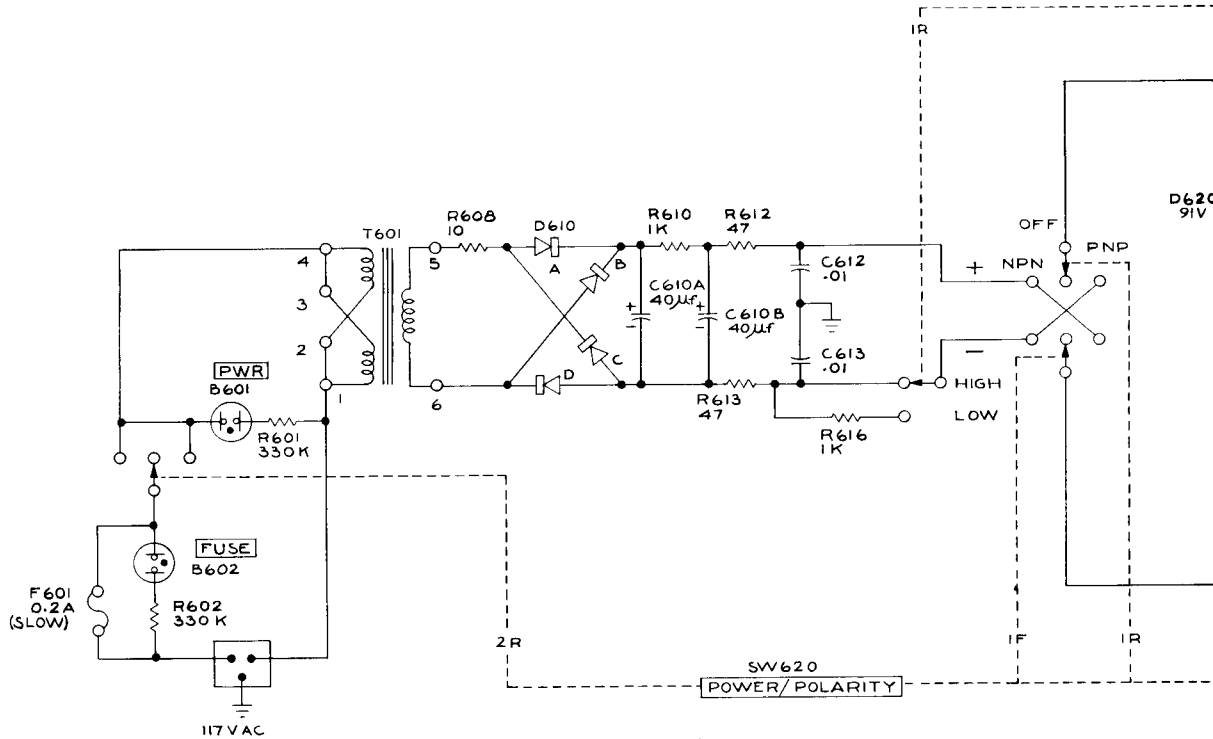
REF. NO.	PART NO.	SERIAL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
1	210-413			4	NUT, hex, $\frac{3}{8}$ -32 x $\frac{1}{2}$
	210-012			4	LOCKWASHER, int, $\frac{3}{8}$ x $\frac{1}{2}$
	210-207			1	LUG, solder, pot, plain, $\frac{3}{8}$
2	200-300			1	COVER, box, top
3	388-532			1	BOARD, wired, assembly Includes:
4	136-132			2	SOCKET, 3 pin transistor
5	131-156			4	CONNECTOR, coaxial, mini., chassis mt. Mounting Hardware For Board: (not included)
6	211-008			4	SCREW, 4-40 x $\frac{1}{4}$ BHS
	361-041			4	SPACER, hex
7	166-287			3	SLEEVE, coaxial adapter
	166-221			3	TUBE, ferrule
8	131-155			2	CONNECTOR, coaxial, miniature, cable
9	406-704			1	BRACKET, connector Mounting Hardware: (not included)
	210-407			3	NUT, hex, 6-32 x $\frac{1}{4}$
	210-006			3	LOCKWASHER, int. #6
10	132-040			3	ADAPTER Mounting Hardware For Each: (not included)
	211-065			4	SCREW, 4-40 x $\frac{3}{16}$ PHS phillips slot
11	132-016			3	NUT, retaining
12	132-001			1	COUPLING, nut
	132-002			1	SLEEVE, conductor, outer
	132-007			1	RING, snap
	132-026			1	TRANSITION, outer
	132-027			1	TRANSITION, inner
	132-028			1	INSULATOR
	132-029			1	CONDUCTOR, inner
	166-221			1	TUBE, ferrule
13	211-021			2	SCREW, 4-40 x $1\frac{1}{4}$ FHS (transformer mtg.)
	210-004			2	LOCKWASHER, int. #4
	210-406			2	NUT, hex, 4-40 x $\frac{3}{16}$
14	210-201			2	LUG, solder, SE 4
	213-044			2	SCREW, thread cutting, 5-32 x $\frac{3}{16}$ PHS phillips slot
15	406-703			1	BRACKET, power plug Mounting Hardware: (not included)
	211-504			4	SCREW, 6-32 x $\frac{1}{4}$ BHS
16	392-136			1	BOARD, power receptacle Mounting Hardware: (not included)
	211-507			2	SCREW, 6-32 x $\frac{5}{16}$ BHS
17	367-007			1	HANDLE Mounting Hardware: (not included)
	212-004			2	SCREW, 8-32 x $\frac{5}{16}$ BHS
18	380-025			1	HOUSING, wrap-around
19	381-188			4	BAR, spacer
20	348-037			4	FOOT, rubber Mounting Hardware For Each: (not included)
	211-014			1	SCREW, 4-40 x $\frac{1}{2}$ BHS
21	334-650			1	TAG, voltage rating Mounting Hardware: (not included)
	213-088			2	SCREW, thread forming, 4-40 x $\frac{1}{4}$ PHS phillips slot
22	211-553			2	SCREW, 6-32 x $1\frac{1}{2}$ RHS phillips slot
	210-601			2	EYELET
	210-478			2	NUT, hex, 5-10 W resistor mounting
	211-507			2	SCREW, 6-32 x $\frac{5}{16}$ BHS
23	200-299			1	COVER, box, bottom
24	124-090			2	STRIP, ceramic, $\frac{3}{4}$ x 9 notches
	361-009			1	SPACER, nylon, molded
25	179-540			1	CABLE harness, chassis
26	348-002			2	GROMMET, rubber, $\frac{1}{4}$

EXPLODED VIEW

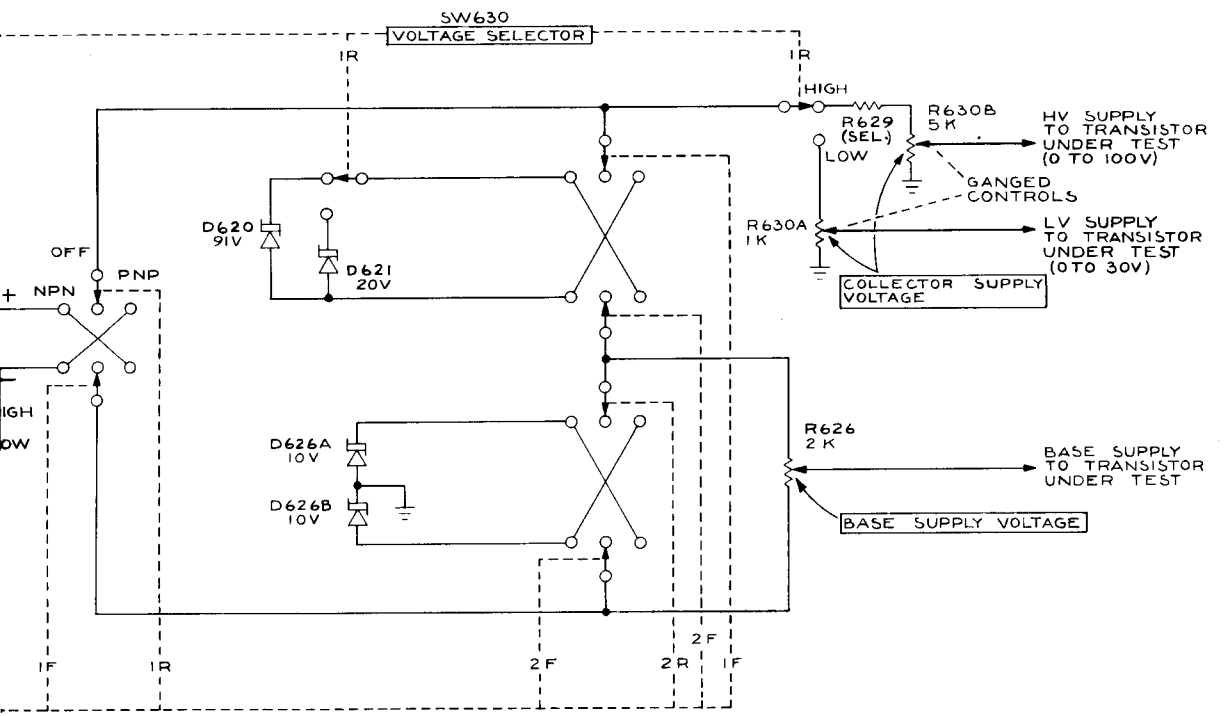
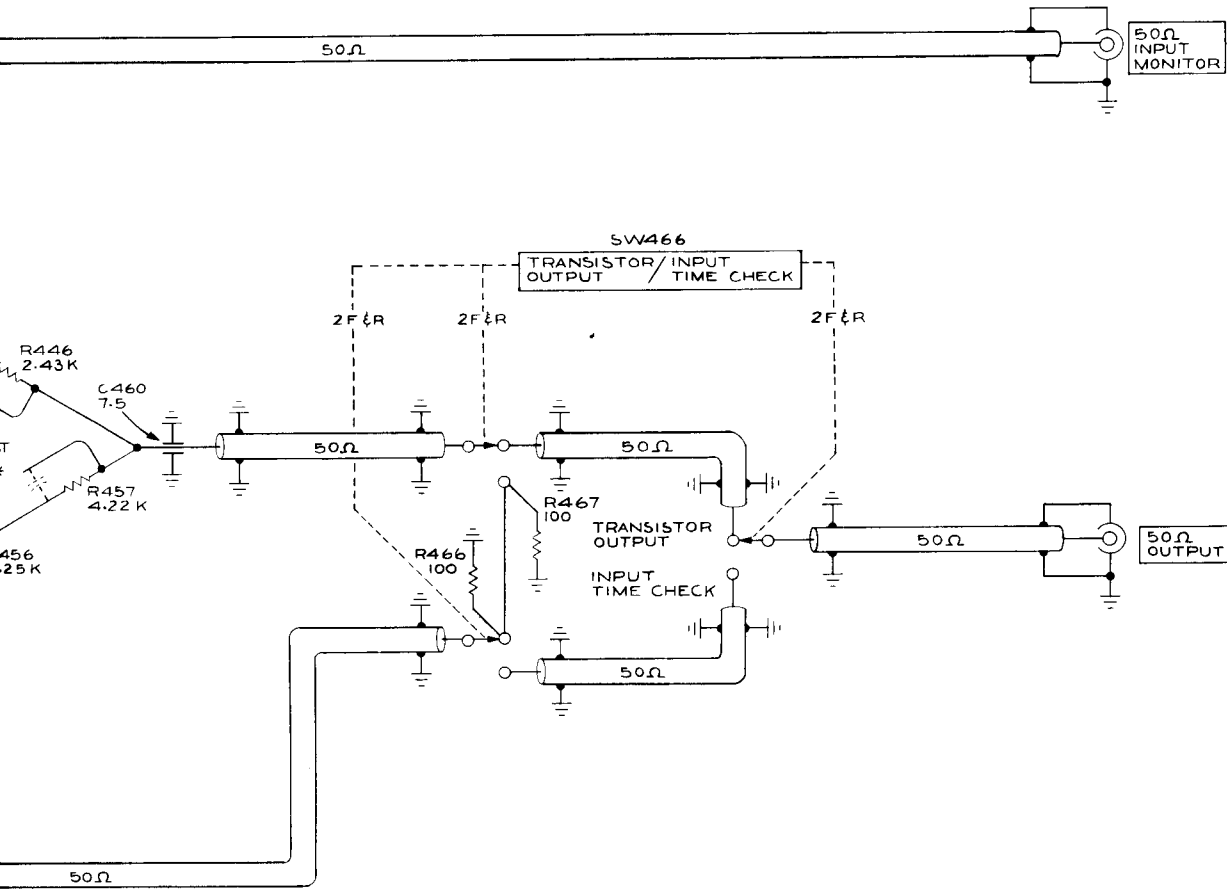
REF. NO.	PART NO.	SERIAL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
27	348-037			4	FOOT, rubber Mounting Hardware For Each: (not included)
	211-008			1	SCREW, 4-40 x 1/4 BHS
	210-004			1	LOCKWASHER, int. #4
	210-406			1	NUT, hex, 4-40 x 3/16
28	352-031			1	HOLDER, fuse, single Mounting Hardware: (not included)
	211-507			1	SCREW, 6-32 x 5/16 BHS
29	386-252			1	PLATE, fiber, capacitor mounting Mounting Hardware: (not included)
	210-407			2	NUT, hex, 6-32 x 1/4
	210-006			2	LOCKWASHER, int. #6
30	200-256			1	COVER, capacitor
31	441-381			1	CHASSIS, power supply Mounting Hardware: (not included)
	210-407			2	NUT, hex, 6-32 x 1/4
	210-006			2	LOCKWASHER, int. #6
32					Mounting Hardware For Each Diode:
	210-410			1	NUT, hex, 10-32 x 5/16
	210-010			1	LOCKWASHER, int. #10
	210-805			1	WASHER, 10S
	210-909			2	WASHER, mica, .625 OD x .196 ID
	210-910			1	WASHER, insulator, 5/16 OD x 3/16 ID
	210-224			1	LUG, solder, #10
33	175-201			1	CABLE, assembly, 50 Ω input Includes:
	131-155			1	CONNECTOR, coaxial, miniature, cable
	132-001			1	COUPLING, nut
	132-002			1	SLEEVE, conductor, outer
	132-007			1	RING, snap
	132-026			1	TRANSITION, outer
	132-027			1	TRANSITION, inner
	132-028			1	INSULATOR
	132-029			1	CONDUCTOR, inner
	166-221			1	TUBE, ferrule
	175-068			1	CABLE, coaxial, 50 Ω (4 inches)
34	175-202			1	CABLE, assembly, 50 Ω input/monitor Includes:
	131-155			1	CONNECTOR, coaxial, miniature, cable
	132-001			1	COUPLING, nut
	132-002			1	SLEEVE, conductor, outer
	132-007			1	RING, snap
	132-026			1	TRANSITION, outer
	132-027			1	TRANSITION, inner
	132-028			1	INSULATOR
	132-029			1	CONDUCTOR, inner
	166-221			1	TUBE, ferrule
	175-068			1	CABLE, coaxial, 50 Ω (15 inches)
35	325-006			1	HOLDER, neon, bulb Mounting Hardware: (not included)
	211-031			1	SCREW, 4-40 x 1" FHS
	210-406			2	NUT, hex, 4-40 x 3/16
36	366-028			1	KNOB, large black, POWER POLARITY
37	366-028			1	KNOB, large black, BASE SUPPLY VOLTAGE
38	366-028			1	KNOB, large black, COLLECTOR SUPPLY VOLTAGE
39	333-712			1	PANEL, front Mounting Hardware: (not included)
	211-071			4	SCREW, 4-40 x 3/8 PHS phillips slot
	004-135			1	COVER, panel, plastic
40	366-031			1	KNOB, small red
41	366-029			1	KNOB, large black, VOLTAGE SELECTOR



TRANSISTOR TEST CIRCUIT



POWER SUPPLY



PLM
4-23-62

TRANSISTOR SWITCHING TIME TESTER

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. If it does not, your manual is correct as printed.