HUNTRON INSTRUMENTS, INC.
TRACKER 1000 SERIES
INSTRUCTION MANUAL

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ABOUT THIS MANUAL

This instruction manual is divided into two major parts. Sections one through six cover the general operation and maintenance of your instrument. Sections seven through sixteen cover applications and specific uses for your Tracker test instrument.

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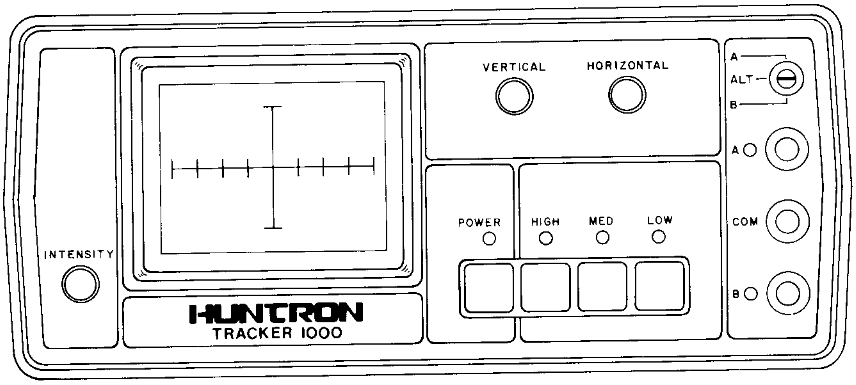
INTRODUCTION AND SPECIFICATIONS



Huntron Tracker 1000 Series

1-1. INTRODUCTION

The Tracker 1000 Series is a useful and efficient troubleshooting tool enhanced by the following features:

- ★ 80 Hz test frequency.
- ★ Three impedance ranges (low, medium, high).
- ★ LED indicators for all functions.
- ★ Dual channel capability for easy comparison.
- ★ Large CRT display with easy to operate controls.

1-2. SPECIFICATIONS

The specifications for the Tracker 1000 Series are listed in Table 1-1.

Table 1-1. Tracker 1000 Series Specifications

ELECTRICAL

Unless otherwise specified, all measurements are within ± 5%

Impedance Ranges

Terminal Characteristics:

Range	Open Circuit Voltage (V_p)	Max Short Circuit Current (mA_{rms})
HIGH	60	0.6
MED	20	0.6
LOW	10	135

Test Signal

Waveform	sine wave
Frequency	80Hz

Channels

Number	2
Alternation Rate	0.8Hz
Overload Protection	1/4A type AGC internal fuse (operator replaceable)

Display

Type	Monochrome CRT
Size	2.8" (7cm) diagonal
Acceleration Potential	1320VDC ± 20VDC (regulated)

POWER REQUIREMENTS

AC Line Voltage	115VAC or 230VAC (selectable via internal switch)
Frequency	47-63Hz
Power	15 Watts max
Line Fuse	1/4A type AGC (internal —operator replaceable)

GENERAL

Size	9"W x 4"H x 11"L (23cmW x 10cmH x 28cmL)
Weight	5 lbs.
Shock and Vibration	will withstand shock and vibration encountered in commercial shipping and handling.

ENVIRONMENTAL

Operating Temperature	0 to 50° C
Storage Temperature	−50 to +60° C
Relative Humidity	0 to 70% R.H.

SECTION 2
OPERATING INSTRUCTIONS

2-1. INTRODUCTION

This section describes the basic operation of your 1000 (for the rest of the manual, The Tracker 1000 Series will be referred to simply as a "1000"). It is suggested that you take time to read this section carefully so that you can take full advantage of all of the troubleshooting capabilities of the 1000.

2-2. UNPACKING YOUR INSTRUMENT

Your instrument was shipped with two Huntron Microprobes (one red and one black), a common test lead (black), an accessory cable (for use with the Huntron Switchers HSR210 and HSR410), a power cord, and this manual. Check the shipment carefully and contact the place of purchase if anything is missing or damaged in shipment. If reshipment is necessary, please use the original shipping carton and packing foam. If these are not available, be sure that adequate protection is provided to prevent damage during shipment.

2-3. GENERAL OPERATION

Components are tested by the 1000 using a two terminal system where two test leads are placed on the leads of the component under test. The 1000 tests componenets in-circuit, even when there are several components in parallel.

Devices that are normally tested by the 1000 include the following: semiconductor diodes, bipolar and field effect transistors; bipolar and MOS integrated circuits (both analog and digital); resistors, capacitors, and inductors.

The 1000 is only intended for use in boards and systems with all voltage sources in a power-off condition. A 0.25 ampere signal fuse (F1) is connected in series with the channel A and B test terminals. Accidental contact of the test leads to active voltage sources (e.g. line voltage, powered-up boards or systems, charged high voltage capacitors, etc.), may cause this fuse to open, making replacement necessary. When the signal fuse blows, open circuit signatures will be displayed even with the test leads shorted together.

CAUTION: THE DEVICE TO BE TESTED MUST HAVE ALL POWER TURNED OFF AND HAVE ALL HIGH VOLTAGE CAPACITORS DISCHARGED BEFORE CONNECTING THE 1000 TO THE DEVICE.

The line fuse (F2) should only open when there is an internal failure inside the instrument. Therefore the problem should always be located and corrected before replacing F2.

2-4. FUSE REPLACEMENT

To replace either fuse, disconnect the 1000 from the power line. Remove the four case screws located on the underside of the case and lift off the top case half. The signal fuse (F1) is located in back of the front panel on the main printed circuit board assembly (refer to Figure 6-1). The line fuse (F2) is located at the back of the main printed circuit board assembly next to the power transformer (refer to Figure 6-1). Replace F1 or F2 with a 0.25A, 250V, type AGC fuse.

2-5. PHYSICAL FEATURES

Before you begin to use your 1000, please take a few minutes to familiarize yourself with the instrument. All of the externally accessible features are discussed in sections 2-6, 2-7, and 2-8.

2-6. FRONT PANEL

The front panel of the 1000 is designed to make function selection easy. Interlocking pushbutton switches are used for range selection. A toggle switch is provided for channel selection and integral LED indicators show which functions are active. Refer to Figure 2-1 and Table 2-1 for a detailed description of each item on the front panel.

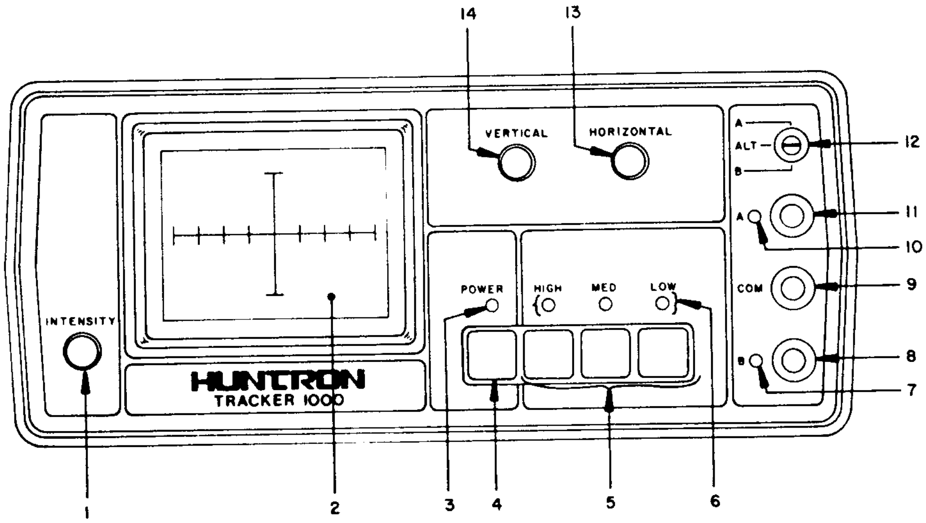


Figure 2-1. Front Panel

Table 2-1. Front Panel Controls & Connectors

ITEM NO.	NAME	FUNCTION
1	INTENSITY Control	Controls the intensity of the CRT Display.
2	CRT Display	Displays the component signatures produced by the 1000.
3	Power Indicator	LED that indicates power-on
4	Power On/Off Switch	Push-On, Push-Off.
5	Range Selectors	Push buttons that select one of three impedance ranges: low, medium high

Table 2-1. Front Panel Controls & Connectors (cont.)

ITEM NO.	NAME	FUNCTION
6	Range Indicators	LEDs that indicate which range is in use.
7	Channel B	LED that indicates channel B is in Indicator use.
8	Channel B Test Terminal	Fused test lead connector that is active when channel B is selected. All test lead connectors accept standard banana plugs.
9	COM Test Terminal	Test lead connector that is instrument common and the common reference point for both channel A and channel B.
10	Channel A Indicator	LED that indicates channel A is in use.
11	Channel A Test Terminal	Fused test lead connector that is active when channel A is selected.
12	Channel A or B or ALT Switch	Toggle switch that can be used to select either channel A or channel B or cause the 1000 to alternate between channel A and channel B at a fixed rate.
13	HORIZONTAL Control	Controls the horizontal position of the CRT display.
14	VERTICAL Control	Controls the vertical position of the CRT display.

2-7. BACK PANEL

Secondary controls and connectors are on the back panel. Refer to Figure 2-2 and Table 2-2 for a detailed description of each item on the back panel.

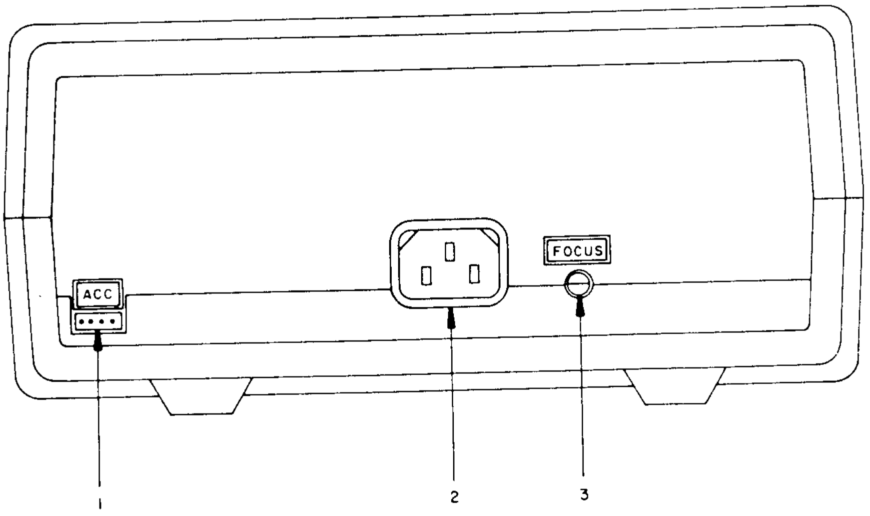


Figure 2-2. Back Panel

Table 2-2. Back Panel Controls & Connectors

ITEM NO.	NAME	FUNCTION
1	Acessory Output Connector	Connector which provides power to the Huntron Switchers, Models HSR210 and HSR410.
2	Power Cord Connector	IEC standard connector that mates with any CEE-22 power cord.
3	FOCUS Control	Controls the focus of the CRT display.

2-8. CRT DISPLAY

The CRT displays the signatures of the components being tested. The display has a graticule consisting of a horizontal axis which represents voltage, and a vertical axis which represents current. See figure 2-3.

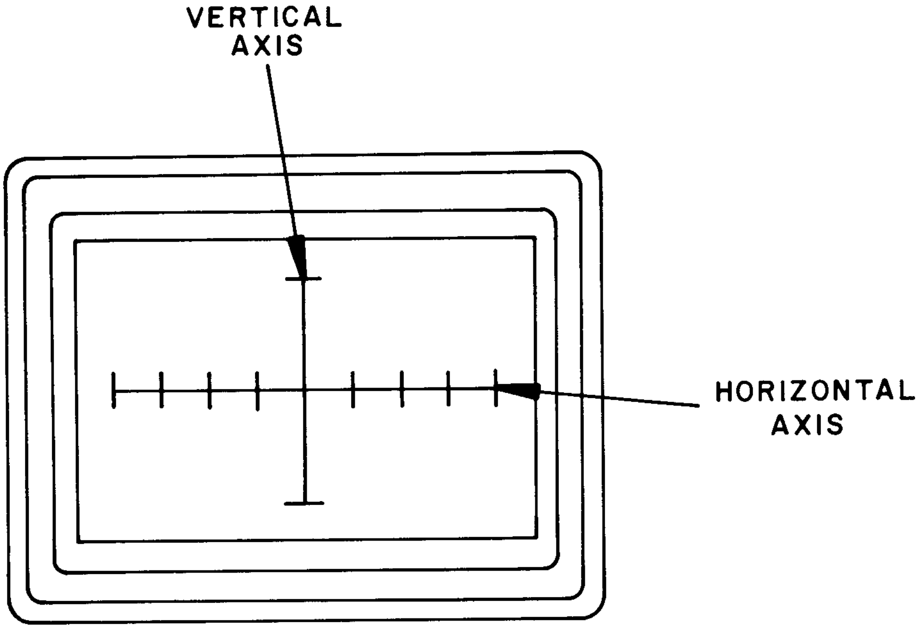


Figure 2-3. CRT Display

The horizontal axis is divided into eight divisions, which allow the operator to estimate the voltage at which changes in the signature occur. This is mainly useful in determining semiconductor junction voltages under either forward or reverse bias. Table 2-3 lists the approximate horizontal sensitivities for each range.

Table 2-3. Horizontal Sensitivities

RANGE	VOLTS/DIV
High	~15
Medium	~5
Low	~2.5

2-9. OPERATION

The following sections explain how to use the front and back panel features. Use sections 2-6 and 2-7 for the description and location of each control. Signatures of components will be covered in Sections 7 through 16.

2-10. INITIAL SETUP

Push in the power on/off switch. The 1000 should come on with the power LED illuminated.

Focusing of the 1000 display is important in analyzing the signatures displayed on the CRT. This is done by turning the intensity control to a comfortable level and adjusting the focus control (back panel) for the narrowest possible trace. Aligning the trace is important in determining the voltges at which changes in the signature occur. With a short circuit on channel A, adjust the horizontal control until the vertical trace is even with the vertical axis. Open channel A, and adjust the vertical control until the horizontal trace is even with the horizontal axis.

Once set, these adjustments should not have to be readjusted during normal operation. The power is turned off by pushing the power switch in, and when power is turned on again the same intensity setting will be present.

2-11. RANGE SELECTION

The 1000 is designed with three impedance ranges (low, medium, and high). These ranges are selected by pressing the appropriate button on the front panel. It is best to start with the medium range. If the signature on the CRT display is close to an open (horizontal trace), go to the next higher range for a more descriptive signature. If the signature is close to a short (vertical trace), go to the next lower range.

2-12. CHANNEL SELECTION

There are two channels on the 1000 (channel A and channel B) which are selected by moving the toggle switch to the desired position. When using a single channel, the red probe should be plugged into the corresponding channel test terminal and the black probe should be plugged into the common test terminal. When testing, the red proble should be connected to the positive terminal of a device (i.e. anode, +V, etc.), and the black probe should be connected to the negative terminal of a device (i.e. cathode, ground, etc.). Following this procedure should assure that the signature appears in the correct position on the CRT display.

The Alternate mode of the 1000 is provided to automatically switch back and forth between channel A and channel B. This allows easy comparison between two devices or the same points on two circuit boards. The Alternate mode is selectd by moving the toggle switch to the ALT position. One of the most useful features of the 1000 is using the Alternate mode to compare a known good device with the same type of device that is of unknown quality. Figure 2-4 shows how the instrument is connected to a known good board and a board under test. This mode uses the supplied common test lead to connect two equivalent points on the boards to the common test terminal.

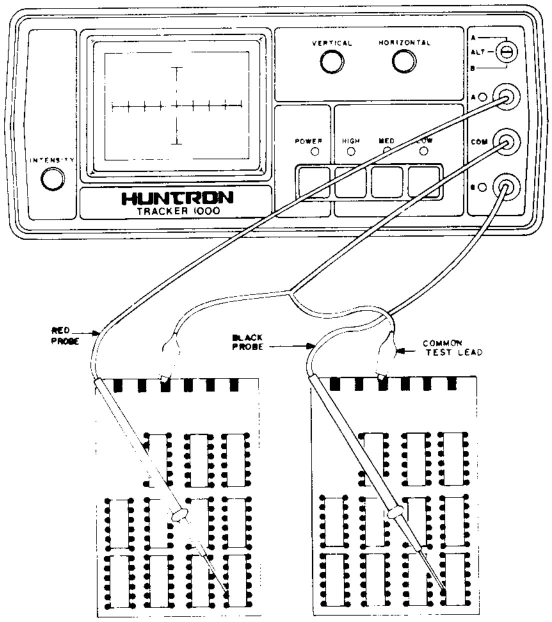


Figure 2-4. Alternate Mode Setup

2-13. HUNTRON SWITCHER CONNECTIONS

Refer to Figure 2-5 for the interconnection diagram to use a Huntron Switcher (either the HSR210 or HSR410) with the 1000. The two terminals marked TRACKER on the Switcher are connected to either channel of the 1000 using the double banana plug cable supplied with the Switcher and the corresponding channel is selected. The Accessory cable, which comes with the 1000, is connected between the accessory output connector (1000 back panel) and the jack on the Switcher marked INPUT 8VDC-12VDC. Both of the connectors on the cable are different so that the cable can only be hooked up the correct way.

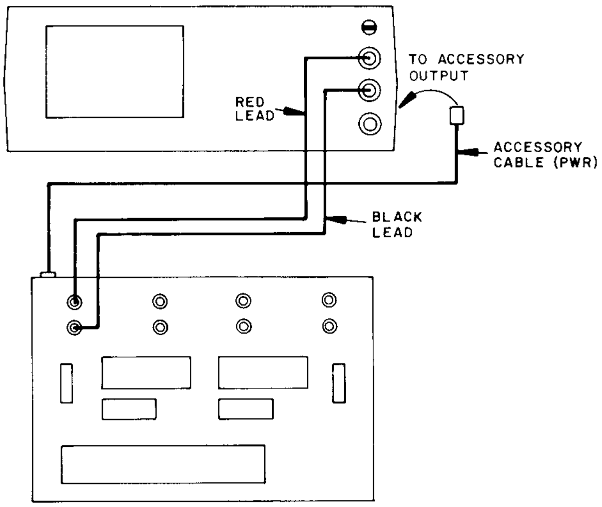


Figure 2-5. 1000/Switcher Interconnection.

The setup procedure above supplies the Switcher with power. To use the Switcher, set the TRACKER/OFF/EXTERNAL switch to TRACKER which illuminates the TRACKER LED. The REF/ALT/TEST switch when set to either REF or TEST is used in the normal manner, i.e. the selected device is continuously connected through the Switcher to the 1000 and signatures can be viewed by selecting a common pin and pressing the button for a particular IC pin number. When the REF/ALT/TEST switch is set to ALT, the Switcher will alternate between the reference device and the test device at a frequency determined by the rate control on the Switcher.

SECTION 3
THEORY OF OPERATION

3-1. INTRODUCTION

This section describes how the 1000 works. An overview of the operation is provided first, followed by descriptions of the major sections of the circuit and their function. Detailed schematics of the 1000 appear in Section 6.

3-2. FUNCTIONAL DESCRIPTION

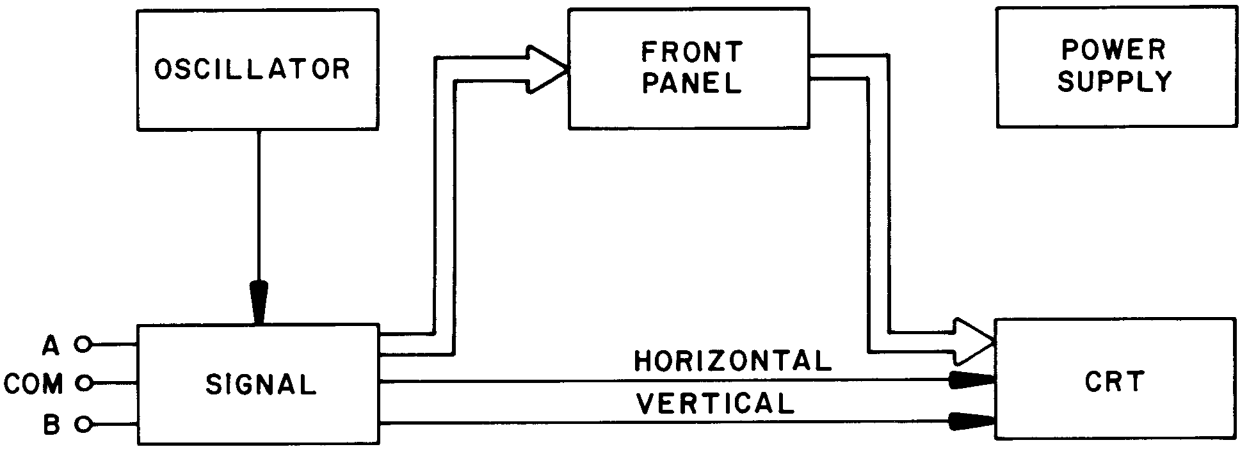


Figure 3-1. 1000 Block Diagram

The major circuits of the 1000 are arranged in a block diagram in Figure 3-1. The oscillator provides the test signal used by the signal section. In the signal section, the test terminals are driven by the test signal while signal conditioners monitor the terminals and produce the horizontal and vertical signals used to produce a component signature on the CRT display. The power supply produces voltages for the CRT acceleration, deflection, and filament as well as the low voltage general purpose supply used by all the other sections of the circuit. These circuits will be described in more detail in the following paragraphs.

3-3. OSCILLATOR

The oscillator is located on the main PCB. This circuit produces a constant amplitude, low distortion sine wave test signal. The frequency of the test signal is factory adjusted to 80 Hz.

3-4. SIGNAL SECTION

The signal section is located on the main PCB. In the signal section, the test signal from the oscillator is applied across two terminals of a device being tested via the front panel test terminals. The test signal causes current to flow through the device and a voltage drop across its terminals. The current flow causes a vertical deflection of the signature on the CRT display while the voltage across the device causes a horizontal deflection of the signature on the CRT display. The combined effect produces the current-voltage signature of the device on the CRT display.

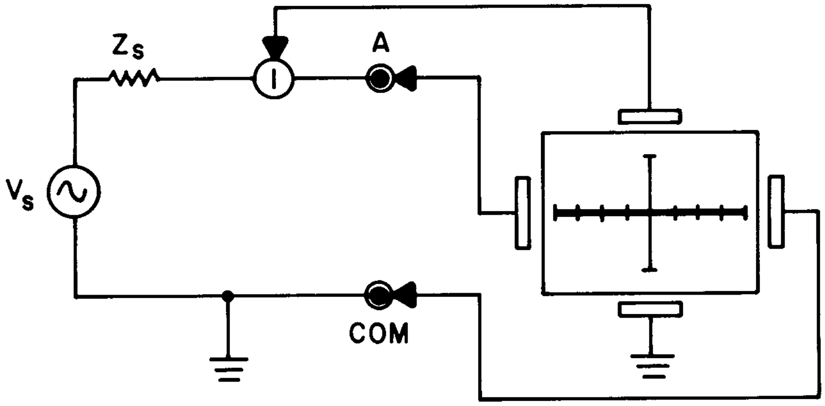


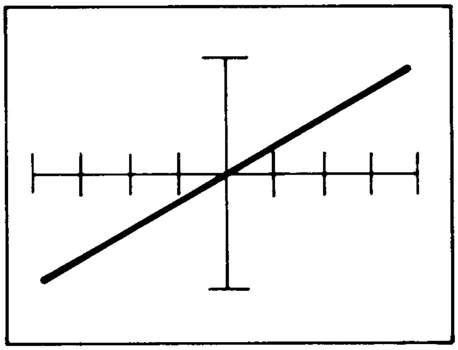
Figure 3-2. Signal Section Equivalent Circuit

Electronically, the test signal appears at the front panel test terminals as though it is being originated by a voltage source (V_S) with a series output impedance (Z_S). An equivalent circuit of the signal section is shown in Figure 3-2. The figure also shows how the terminal voltage affects the horizontal deflection plates of the CRT, and how the current through the terminals affects the vertical deflection plates through current sensing point I. The open circuit voltage and output impedance for each range is shown in Table 3-1.

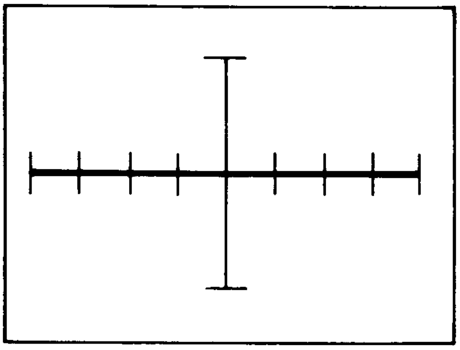
Table 3-1. Terminal Characteristics

Range	V_S (V_p)	Z_S (ohms)
High	60	83K
Medium	20	27K
Low	10	55

An open circuit has zero current flowing through the terminals and has maximum voltage across the terminals. In the LOW range, an open circuit is represented by a diagonal signature from the upper right to the lower left of the CRT (see Figure 3-3a). In the HIGH and MEDIUM ranges this is represented by a horizontal trace from the left to the right of the CRT graticule (see Figure 3-4b). When the terminals are shorted, the maximum current flows through the terminals and the voltage at the terminals is zero. This is indicated by a vertical trace from the top to the bottom of the CRT graticule in all ranges (see Figure 3-3c). Signatures of components will be covered in the second half of this manual (sections 7 through 16).



Low Range Open Circuit
Figure 3-3a.



Medium and High Open Circuit
Figure 3-3b.

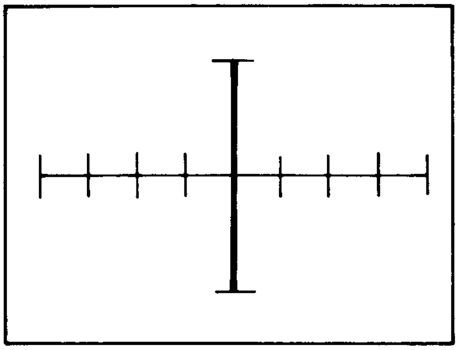


Figure 3-3c. All ranges Short Circuit

3-5. CRT DISPLAY

The CRT deflection drivers boost the low level outputs from the signal section to the higher voltage levels needed by the deflection plates in the CRT. The HORIZONTAL and VERTICAL controls on the front panel adjust the position of the trace on the CRT display.

Three other CRT controls are used to adjust the brightness and clarity of the trace: INTENSITY, FOCUS, and ASTIGMATISM. The front panel intensity control is the primary means of adjusting the visual characteristics of the trace. The focus control is located on the back panel and is operator adjustable. The astigmatism trim pot (R73), is located inside the 1000 on the main printed circuit board (see figure 6-1), and is factory adjusted to the correct setting.

3-6. POWER SUPPLY

This is an AC line operated power supply that is turned on by pushing in the POWER switch (push-off). The POWER LED will come on indicating that power is on before the CRT warms up.

The low voltage power supply provides outputs of ±12VDC (nominal) and ±5VDC (regulated) for the oscillator and signal section.

The other outputs of the power supply are related to the CRT display. The filament voltage is $6.3V_{rms}$. There is a +180VDC output which is primarily used by the deflection driver circuits. Finally, there is a regulated −1320VDC output for the CRT acceleration voltage.

SECTION 4
MAINTENANCE

WARNING: THESE SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY.

4-1. INTRODUCTION

This section contains information regarding the maintenance of your instrument. It includes information about service, performance tests, internal adjustments, and troubleshooting. The combined performance tests are recommended as an acceptance test when the instrument is first received, and can be used later as a preventive maintenance tool.

4-2. SERVICE INFORMATION

The conditions of the 1000 warranty are given at the front of this manual. Malfunctions that occur within the limits of the warranty will be corrected at no cost to the purchaser exclusive of one-way shipping costs to Huntron Instruments, Inc. Huntron service is also available for calibration and/or repair of instruments that are beyond the warranty period. In either case, please describe clearly the problems encountered with the instrument.

For in-warranty or out of warranty factory service in the United States, call (toll-free) 800-426-9265 and receive an RMA number and shipping instructions prior to shipment. This number must be clearly displayed on the exterior of the shipping carton. Only parcels displaying an RMA number will be accepted. In Alaska or Washington, call 206-743-3171.

4-3. PERFORMANCE TESTS

The following procedures allow you to compare the performance of your instrument with the specifications listed in Section 1. They are recommended for incoming inspection, periodic adjustments, and to verify specifications. If the instrument fails any test, internal adjustment and/or repair is needed. You do not have to disassemble the instrument to perform the tests.

SIGNAL SECTION:

1. Select channel A on the front panel. Adjust the CRT controls (Intensity and Focus), for a sharp trace on the CRT display.
2. Measure the sine wave voltage between the channel A and common test terminals using an oscilloscope or a digital multimeter. Verify the presence of the following voltages on the test terminals in each range. For this test, make sure that the input impedance of your scope or DMM is at least 10 Megohm.

Range	V_p	V_{rms}
High	60	42.43
Medium	20	14.14
Low	10	7.07

3. Measure the short circuit current in each range. Connect your DMM to the channel A and common test terminals and set to AC mA. Verify the following maximum current readings:

Range	mA_{rms}
High	0.6
Medium	0.6
Low	135

4. Use a scope or frequency counter to measure the test signal frequency. The test signal frequency should be 80Hz regardless of the frequency of the power line being used.

4-4. INTERNAL ADJUSTMENTS

If your 1000 has been repaired or if it has failed any of the performance tests, it is necessary to perform these internal adjustments. To gain access to the internal adjustments, first turn the instrument over and remove the four screws holding the case together, then lift off the case top.

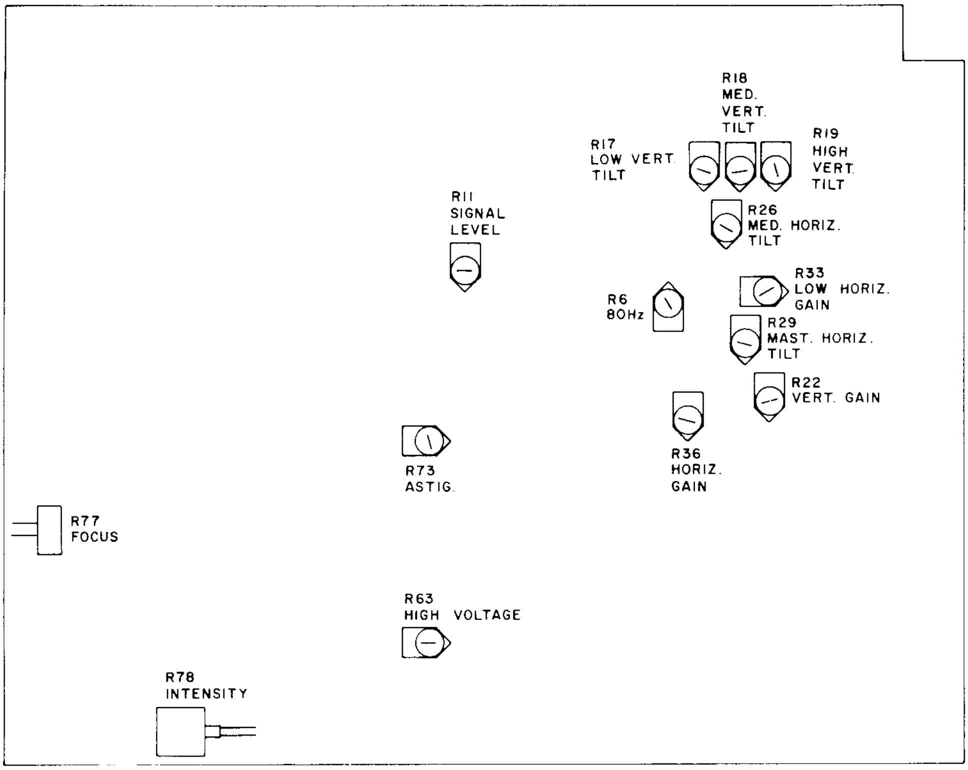


Figure 4-1. Main PCB Adjustment Locations

A. POWER SUPPLY SECTION:

The high voltage is factory adjusted to -1320VDC, and the user is advised not to readjust trimpot R63 unless it is absolutely necessary. This adjustment requires a digital multimeter (DMM) and a High Voltage probe. Refer to Figure 4-1 for adjustment location and Figure 6-2 for schematic.

WARNING: HAZARDOUS HIGH VOLTAGE.

PROCEDURE:

1. Connect the common lead of the High Voltage Probe to the common test point on the Main PCB.
2. Connect the voltage input of the High Voltage Probe to P3 pin 6 on the Main PCB.
3. Turn the power on.
4. Adjust R63 (Main PCB) until the DMM reads -1320VDC.

B. OSCILLATOR SECTION:

All adjustments in this section are located on the Main PCB Assembly. Refer to the Figure 4-1 for adjustment locations and to Figure 6-2 for the schematic.

PROCEDURE:

1. Turn power on
2. Connect frequency counter to Test Point #1 (TP1).
3. Adjust R6 (80 Hz) until frequency counter reads 80Hz.

C. SIGNAL SECTION:

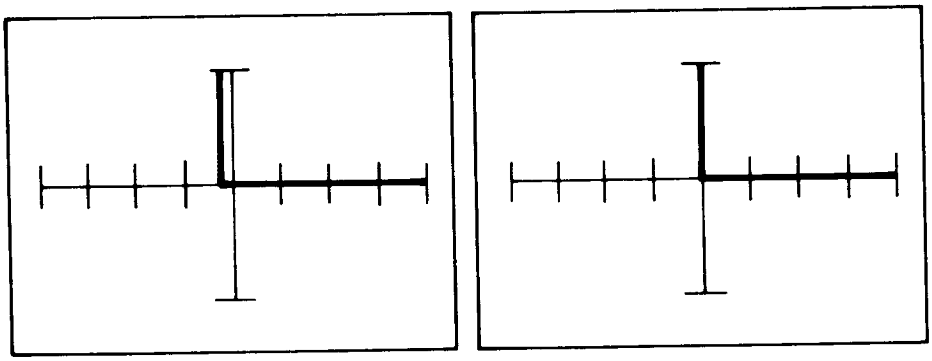
All adjustments in this section are located on the Main PCB Assembly. Refer to Figure 4-1 for adjustment locations and to Figure 6-2 for the schematic.

PROCEDURE:

1. Turn trim pots (R17,R18,R19,R22,R26,R29,R33,R36) to their fully counterclockwise position.
2. Turn Horizontal and Vertical position controls to the center of their range.
3. Turn the Intensity control fully counterclockwise.
4. Turn power on.
5. Measure the sine wave voltage between the channel A and common test terminals in low range using an oscilloscope or a digital multimeter. Adjust R11 (Signal Level) to give $10V_p$ (scope) or 7.07_{rms} (DMM).
6. Verify the presence of the following voltages on the test terminals in each range. For this test, make sure that the input impedance of your scope or DMM is at least 10 Megohm.

Range	V_p	V_{rms}
High	60	42.43
Medium	20	14.14

7. Set the Range selectors to the HIGH range position.
8. Adjust the Intensity until a spot appears on the CRT.
9. Adjust R22 (Master Vertical Gain) for vertical deflection of approximately ½ inch.
10. Adjust R77 (Focus), and R73 (Astigmatism) for the sharpest trace. Check intensity for correct brightness.
11. Adjust R29 (Master Horizontal Tilt) to the center of its range.
12. Adjust R36 (Master Horizontal Gain) until trace fills out the graticule.
13. Short between the Channel A and Common Test Terminals.
14. Adjust R22 (Master Vertical Gain) until the vertical trace is 1-3/8 inch long.
15. Adjust R19 (High Vertical Tilt) until there is no vertical tilt.
16. Readjust R22 (Master Vertical Gain) if necessary.
17. Remove short from the Test Terminals.
18. Adjust R29 (Master Horizontal Tilt) until the horizontal trace has no tilt.
19. Switch to the MEDIUM range position.
20. Short between the Channel A and Common Test Terminals.
21. Adjust R18 (Medium Vertical Tilt) until the trace has no vertical tilt.
22. Remove the short from the Channel A and Common Test Terminals.
23. Adjust R26 (Medium Horizontal Tilt) until the trace has no tilt.
24. Switch back and forth between HIGH and MED range, and observe the trace. It should have no horizontal tilt on either range, and the ends of the trace should be very close to the graticule, but not out of view. Both traces should be within 5% of each other in length.
25. Short between the Channel A and Common Test Terminals, and switch back and forth between HIGH and MED ranges. Both vertical traces should be within 5% of each other in length.
26. Install a diode across the Channel A and Common Test Terminals. You should see a signature as displayed in Figure 4-2.



MED HIGH

Figure 4-2. Signatures of a diode in the MED and HIGH ranges

27. Final adjustments can be made on Horizontal and Vertical Gain, and Horizontal and Vertical Tilt for correct trace. The trace length difference should be less than 5%. The vertical and horizontal traces should have no tilt. The edge of the traces should not go off the screen.

28. Switch to the LOW range.

29. Short between the channel A and Common Test Terminals and adjust R17 (Low vertical Tilt).

30. Remove the short from the Test Terminals, and adjust R33 (Low Horizontal Gain) so that the trace looks like Figure 4-3.

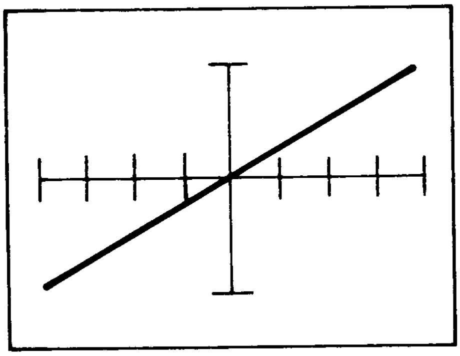


Figure 4-3. Open circuit (Low range)

31. Insert a diode between the Channel A and Common Test Terminals. The signature should look like Figure 4-4.

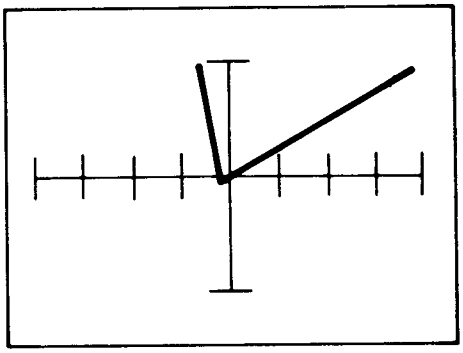


Figure 4-4. Signature of a diode in Low range

32. Final Focus and Astigmatism adjustments can be made with the diode still across the Test Terminals, and the range switch in HIGH or MEDIUM position.

4-5. TROUBLESHOOTING

If necessary, refer to Section 2 for operating instructions or Section 3 for the theory of operation. This troubleshooting information is supported by the schematics in Section 6.

This section assumes that the user has done the performance tests in Section 4-3 and noted any discrepancies in performance. Further, it is also assumed that the user has completed or attempted to complete the internal adjustments in Section 4-4 and noted any problems found.

SECTION 5
LIST OF REPLACEABLE PARTS

5-1. INTRODUCTION

This section contains the parts list for the 1000. Components are listed alphanumerically by assembly. Both electrical and mechanical components are listed by reference designation, and can be referenced to assembly drawings and schematics.

Parts lists include the following information:

1. Reference Designation
2. Description of each part
3. HUNTRON Part Number

Numbers in parenthesis following the reference designation refer to the total quantity of the part for that assembly. The part description generally includes either generic part numbers or component specifications. Unless otherwise specified, all fixed resistors are ¼ Watt, 5%, carbon film and all resistor values are in ohms.

5-2. HOW TO OBTAIN PARTS

Components may be ordered directly from a manufacturer by using the part description, or from Huntron Instruments, Inc. or its authorized distributors by using the HUNTRON PART NUMBER. In the event the part you order has been replaced by a new part, the replacement will be accompanied by an explanatory note and installation instructions if necessary.

To ensure prompt and efficient handling of your order, please include the following information:

1. Quantity
2. HUNTRON Part Number
3. Part Description
4. Reference Designation
5. Printed Circuit Board Part Number and Revision Letter
6. Instrument Model and Serial Number

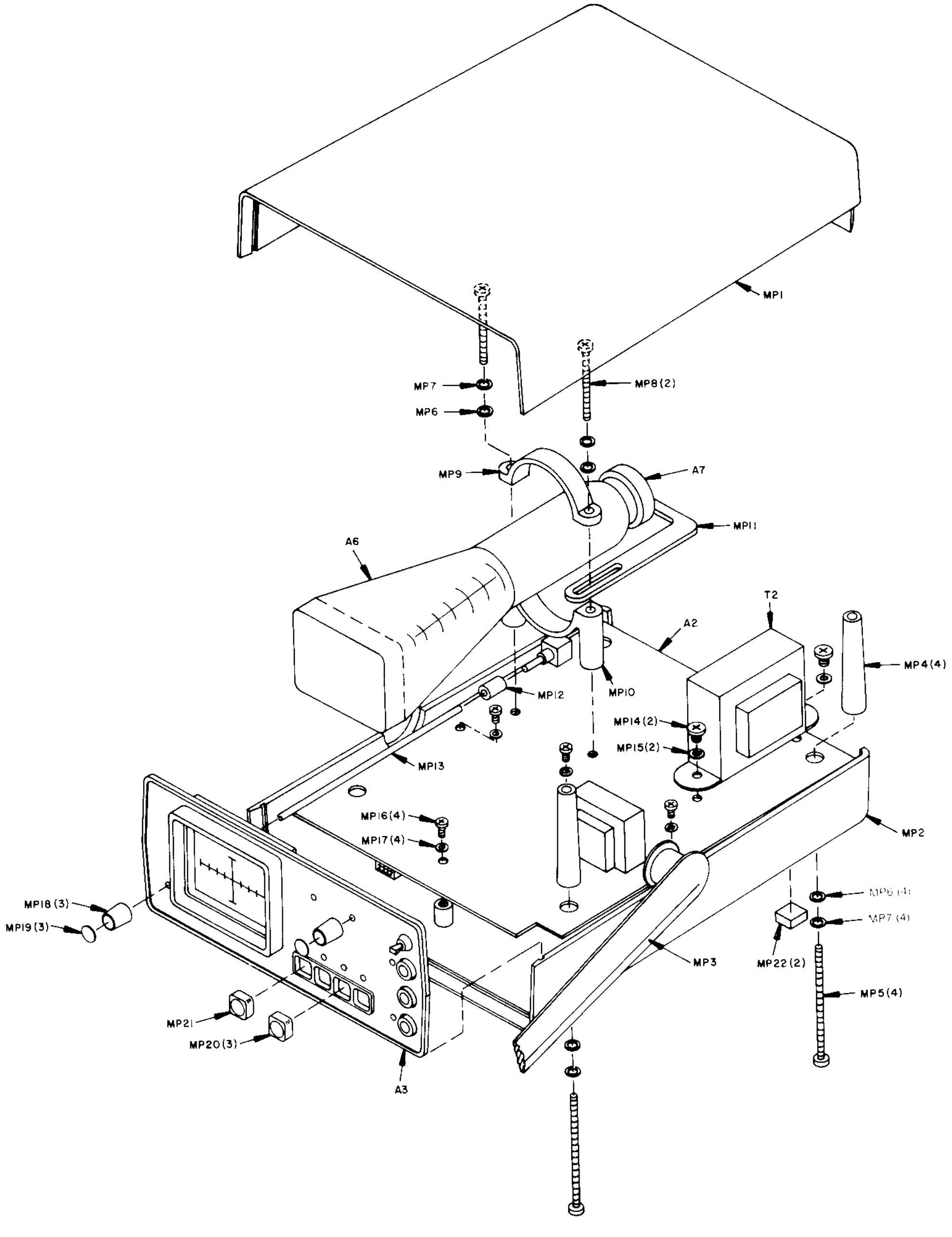


Figure 5-1. Series 1000 Final Assembly

WARNING!

MP6 and MP7 MUST BEINSTALLED. FAILURE TO DO SO MAY RESULT IN DAMAGE TO THE CASE.

DO NOT USE AIR TOOLS TO TIGHTEN CASE SCREWS (MP5).

FINAL ASSEMBLY:
(Refer to Figure 5-1)

REF. DES.	DESCRIPTION	HUNTRON PART NO.
A1	Tracker, Final Assembly 1000	01-2082
A2	Main PCB Assembly	07-1038
A3	Front Control Assembly	01-2143
A6	CRT Assembly NEC	07-1072
	Toshiba	07-1073
MP1	Top, Case	01-1155
MP2	Bottom, Case	01-1156
MP3	Handle, Case	01-1157
MP4 (4)	Spacer, Case	01-1158
MP5 (4)	Screw, #6-32 2 ⅞" P.H. Phil.	01-1019
MP6 (4)	Washer, #6 Flat Steel	07-7123
MP7 (4)	Washer, #6 Lock Split	07-7384
MP8 (2)	Screw, #6-32 2" P.H. Phil.	07-7383
MP9	Cap, CRT Yoke	01-1165
MP10	Base, CRT Yoke	01-1166
MP11	Stop, CRT	01-1167
MP12	Coupler, ⅛" to ⅛"	07-7147
MP13	Shaft, Intensity, ⅛"D x 7¾"L	07-7397
MP14 (2)	Screw, #8-32 ⅜" P.H. Phil.	07-7385
MP15 (2)	Washer, #8 Lock Star	07-7176
MP16 (4)	Screw, #4-40 ¼" P.H. Phil	07-7085
MP17 (4)	Washer, #4 Lock Star	07-7089
MP18 (3)	Knob, Black	01-1081
MP19 (3)	Knob Cap, Blue	01-1106
MP20 (3)	Button, Swtich,Gray	07-7398
MP21	Button, Switch, Black	07-7233
MP22 (2)	Feet, Rubber, ½" sq.	01-1115
MP23	Decal, Instruction	01-1160
MP24	Decal FOCUS	01-1161
MP25	Decal, ACC (Accessory)	01-1162
T2	Transformer, Power 115VAC/230VAC	06-6028

FACE PLATE ASSEMBLY:

REF. DES.	DESCRIPTION	HUNTRON PART NO.
A5	Face Plate Assembly	01-2142
J1	Socket, 6 pin Polarized	07-7225
MP1	Face Plate	01-1153

MP2	Overlay	01-1159
MP3	Jack Banana, Red W/Hex Nut	01-1030
MP4	Jack Banana, Black W/Hex Nut	01-1031
MP5	Jack Banana, Blue W/Hex Nut	01-1082
MP6	Lens, Glass	01-1006
MP7	Graticule, Film	01-2002
MP8	Lens Gasket, Vertical	01-1107
MP9	Lens Gasket, Horizontal	01-1108
S6	Toggle Switch	07-7071

FRONT CONTROL ASSEMBLY:

REF. DES.	DESCRIPTION	HUNTRON PART NO.
A3	Front Control Assembly	01-2143
A4	Control PCB Assembly	07-1039
A5	Face Plate Assembly	01-2142
MP1 (5)	Screw, #4-40 ¼" P.H. Phil.	07-7085
MP2 (5)	Washer, #4 Lock Star	07-7089

CRT ASSEMBLY:

REF. DES.	DESCRIPTION		HUNTRON PART NO.
A6	CRT Assembly	NEC	07-1072
		Toshiba	07-1073
CRT1	Cathode Ray Tube	NEC	07-7059
		Toshiba	07-7076

MAIN PCB ASSEMBLY:

(Refer to Figures 6-1 and 6-2)

REF. DES.	DESCRIPTION		HUNTRON PART NO.
A2	Main PCB Assembly		07-1038
C1	Not Used		
C2	Cap, Tantalum	10uF, 25V	03-3011
C3	Cap, Mono. Ceramic	100pF, 50V	03-3071
C4	Cap, Mono. Ceramic	.01uF, 50V	03-3051
C5	Cap, WIMA	.luF, 50V, 5%(WIMA)	03-3063
C6	Cap, WIMA	.luF, 50V, 5%(WIMA)	03-3063

C7		Cap, WIMA	.22uF, 50V, 5%(WIMA)	03-3054
C8		Cap, Mono. Ceramic	.1uF, 50V	03-3028
C9		Cap, Mono. Cermaic	.1uF, 50V	03-3028
C10		Cap, WIMA	.22uF, 50V, 5%(WIMA)	03-3054
C11		Cap, Electrolytic	1uF, 450V	03-3040
C12		Cap, Electrolytic	1uF 450V	03-3040
C13		Cap, Electrolytic	1uF, 450V	03-3040
C14		Cap, Electrolytic	1uF, 450V	03-3040
C15		Cap, Ceramic	.01uF, 2kV	03-3042
C16		Cap, Ceramic	.1uF, 500V	03-3007
C17		Cap, Electrolytic	22uF, 250V	03-3055
C18		Cap, Electrolytic	2200uF, 250V	03-3056
C19		Cap, Electrolytic	2200uF, 25V	03-3056
C20		Cap, Tantalum	10uF, 25V	03-3011
C21		Cap, Tantalum	10uF, 25V	03-3011
C22		Cap, Mono. Ceramic	.1uF, 50V	03-3028
C23		Cap, Mono. Ceramic	.1uF, 50V	03-3028
C24		Cap, Electrolytic	1uF, 450V	03-3040
C25		Cap, Ceramic	.02uF, 1kV	03-3004
D1		Diode, Signal	1N914	04-4007
D2		Diode, 3kV	HV30	04-4016
D3		Diode, 3kV	HV30	04-4016
D4		Diode, 600V	1N4005	04-4012
D5		Diode, 600V	1N4005	04-4012
D6		Diode, 600V	1N4005	04-4012
D7		Diode, 600V	1N4005	04-4012
D8		Diode, 600V	1N4005	04-4012
D9		Diode, 600V	1N4005	04-4012
D10		Diode, 600V	1N4005	04-4012
D11		Diode, 600V	1N4005	04-4012
D12		Diode, Signal	1N914	04-4007
D13		Diode, Signal	1N914	04-4007
F1		Fuse, AGC	¼ A, 250V	02-2041
F2		Fuse, AGC	¼ A, 250V	02-2041
J2		Socket, Dual Row, 7 pin		07-7377
K1		Relay, 1 Form C 5V		07-7904
MP1		PCB, Main		07-7735
MP2	(4)	Clip, Fuse		02-2044
MP4	(5)	Screw, 4-40, ¼" P.H. Phil.		07-7085
MP5	(5)	Washer, #4 Lock Star		07-7089
MP7	(5)	Insulator, Capacitor		07-7226
P1		Header, 6 Pin, Polarized		07-7224
P3		Header, 12 Pin, Polarized		07-7158
P4		Header, 14 Pin, Polarized		07-7376
P5		Header, Power Receptacle		07-7379
P6		Header, 4 Pin Recessed, Polarized		07-7380

Q1	Transistor, PNP, Power	TIP30	05-5008
Q2	Transistor, NPN, Power	TIP29	05-5007
Q3	Transistor, NPN, 300V	MPSA42	05-5003
Q4	Transistor, NPN, 300V	MPSA42	05-5003
Q5	Transistor, NPN, 300V	MPSA42	05-5003
Q6	Transistor, NPN, 300V	MPSA42	05-5003
Q7	Transistor, NPN, 300V	MPSA42	05-5003
Q8	Transistor, NPN, 300V	MPSA42	05-5003
Q9	Transistor, NPN, 500V	TIP50	05-5016
R1	Resistor	10K	02-2137
R2	Resistor	4.7K	02-2145
R3	Resistor	10K	02-2137
R4	Resistor	2K	02-2184
R5	Resistor	62K	02-2172
R6	Pot, Trimmer	1K	02-2083
R7	Resistor	1.8K	02-2128
R8	Resistor	180K	02-2124
R9	Resistor	10K	02-2137
R10	Resistor	10K	02-2137
R11	Pot Trimmer	10K	02-2084
R12	Resistor	150	02-2138
R13	Resistor	150	02-2138
R14	Resistor	47	02-2141
R15	Resistor	10	02-2097
R16	Resistor	6.8, 1W	02-2086
R17	Pot, Trimmer	5K	02-2090
R18	Pot, Trimmer	5K	02-2090
R19	Pot, Trimmer	5K	02-2090
R20	Resistor	180	02-2101
R21	Resistor, Metal Film	43.2K, 1%	02-2195
R22	Pot, Trimmer	50K	02-2085
R23	Resistor, Metal Film	681K, 1%	02-2123
R24	Resistor, Metal Film	2M, 1%	02-2161
R25	Resistor	10, 1W	02-2000
R26	Pot, Trimmer	100K	02-2091
R27	Resistor, Metal Film	86.6K, 1%	02-2136
R28	Resistor	16K	02-2134
R29	Pot Trimmer	25K	02-2155
R30	Resistor	20K NEC	02-2082
		47K Toshiba	02-2143
R31	Resistor	10K	02-2137
R32	Resistor	220, ½W	02-2003
R33	Pot Trimmer	500K	02-2058
R34	Resistor, Metal Film	196K, 1%	02-2153
R35	Resistor, Metal Film	590K, 1%	02-2154
R36	Pot, Trimmer	10K	02-2084
R37	Resistor	180K	02-2124
R38	Resistor	180K	02-2124
R39	Resistor	1K	02-2125
R40	Resistor	1K	02-2125
R41	Resistor	1.6K	02.2135
R42	Resistor	3K	02-2126

R43	Resistor	16K	02-2134
R44	Resistor	180K	02-2124
R45	Resistor	180K	02-2124
R46	Resistor	1K	02-2125
R47	Resistor	1K	02-2125
R48	Resistor	1.6K	02-2135
R49	Resistor	180	02-2101
R50	Resistor	180	02-2101
R51	Resistor	2K	02-2184
R52	Resistor	2M	02-2129
R53	Resistor	15K	02-2151
R54	Resistor	180	02-2101
R55	Resistor	1M	02-2130
R56	Resistor	10M, ½W	02-2102
R57	Resistor	10M, ½W	02-2102
R58	Resistor	10M, ½W	02-2102
R59	Resistor	10M, ½W	02-2102
R61	Resistor, High Voltage	5M, ½W	02-2088
R63	Pot Trimmer	10K	02-2084
R64	Resistor	12K	02-2238
R65	Resistor	2M	02-2129
R66	Resistor	1K	02-2125
R67	Resistor	2M	02-2129
R68	Resistor	2.2K	02-2079
R69	Resistor	180K	02-2124
R70	Resistor	1.8K	02-2128
R71	Resistor	1.8K	02-2128
R72	Resistor	4.7M	02-2127
R73	Pot, Trimmer	1M	02-2070
R75	Resistor, High Voltage	5M, ½W	02-2088
R77	Pot, Trimmer, W/Shaft	1M	02-2207
R78	Pot, Control, W/Shaft	500K	02-2095
R79	Resistor	510K NEC	02-2142
		220K Toshiba	02-2204
R80	Resistor	68K	02-2144
S1-S4	Switch Assembly		07-7067
S5	Switch, DPDT		07-7381
T1	Transformer, Signal		06-6034
U1	IC, Dual Op-Amp	LM1458N	05-5012
U2	IC, Voltage Ref, 1.2V	ICL8069	05-5014
U3	IC, Voltage Ref, 1.2V	ICL8069	05-5014
U4	IC, Op-Amp	LF 351	05-5034
U5	IC, Dual Op-Amp	LM1458	05-5012
U6	IC, Timer	NE555	05-5006
U7	IC, Op-Amp	741	05-5009
U8	IC, Regulator, +5V	7805	05-5017
U9	IC, Regulator, −5V	7905	05-5037
Z1	ZNR 130V		02-2038

CONTROL PCB ASSEMBLY
(Refer to Figures 6-3 and 6-4)

REF. DES.	DESCRIPTION		HUNTRON PART NO.
A4	Front Panel PCB Assembly		07-1039
D1	LED, (Red)	T-1 ¾	04-4013
D2	LED, (Yellow)	T-1 ¾	04-4017
D3	LED, (Red)	T-1 ¾	04-4013
D4	LED, (Green)	T-1 ¾	04-4014
D5	LED, (Green)	T-1 ¾	04-4014
D6	LED, (Green)	T-1 ¾	04-4014
MP1	PCB, Front Panel		07-7736
P2	Header, Dual Row, 7 Pin		07-7378
R1	Pot, Control W/¼" Shaft 1K		02-2186
R2	Pot, Control W/¼" Shaft 1K		02-2186

SECTION 6
SCHEMATIC DIAGRAMS

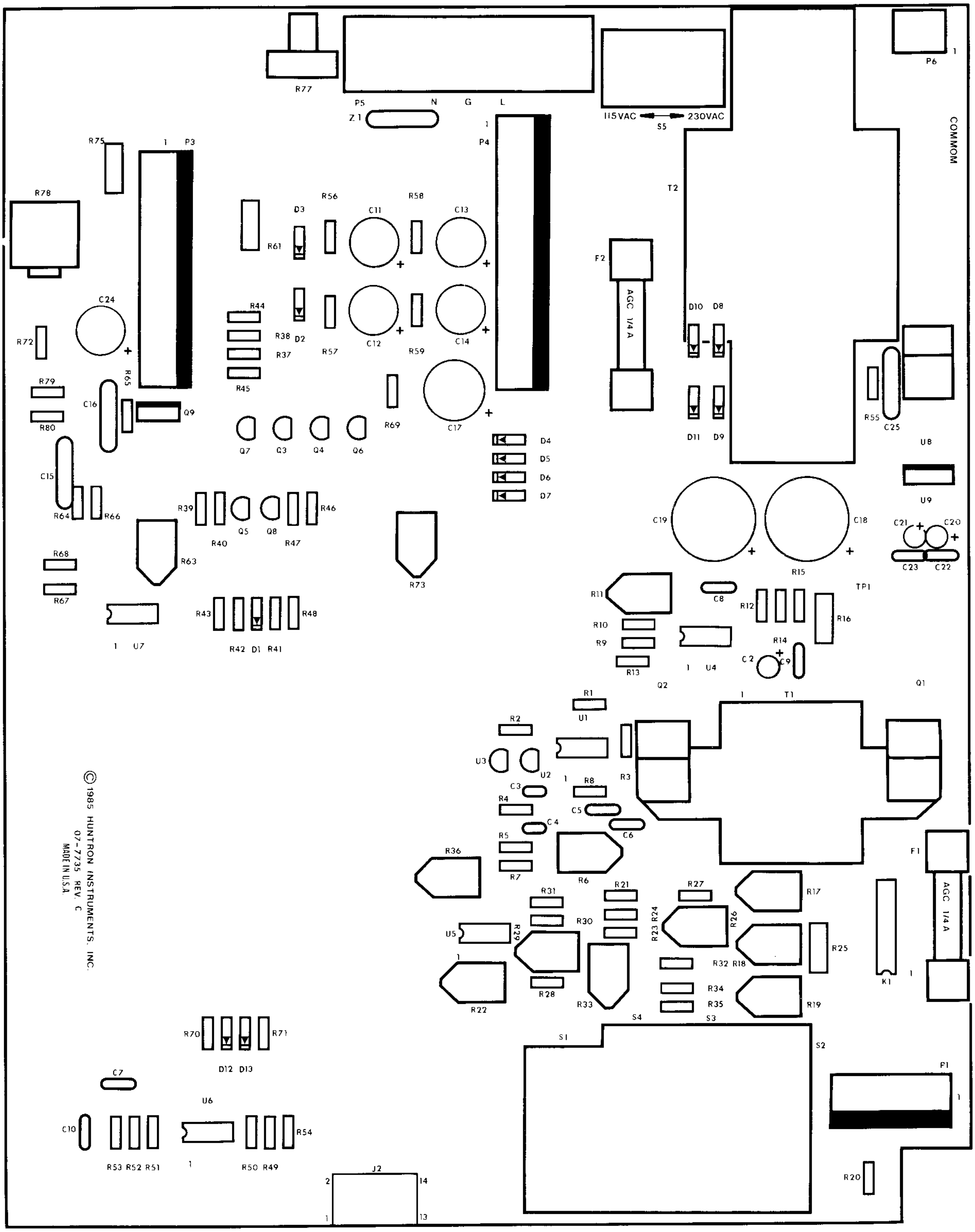
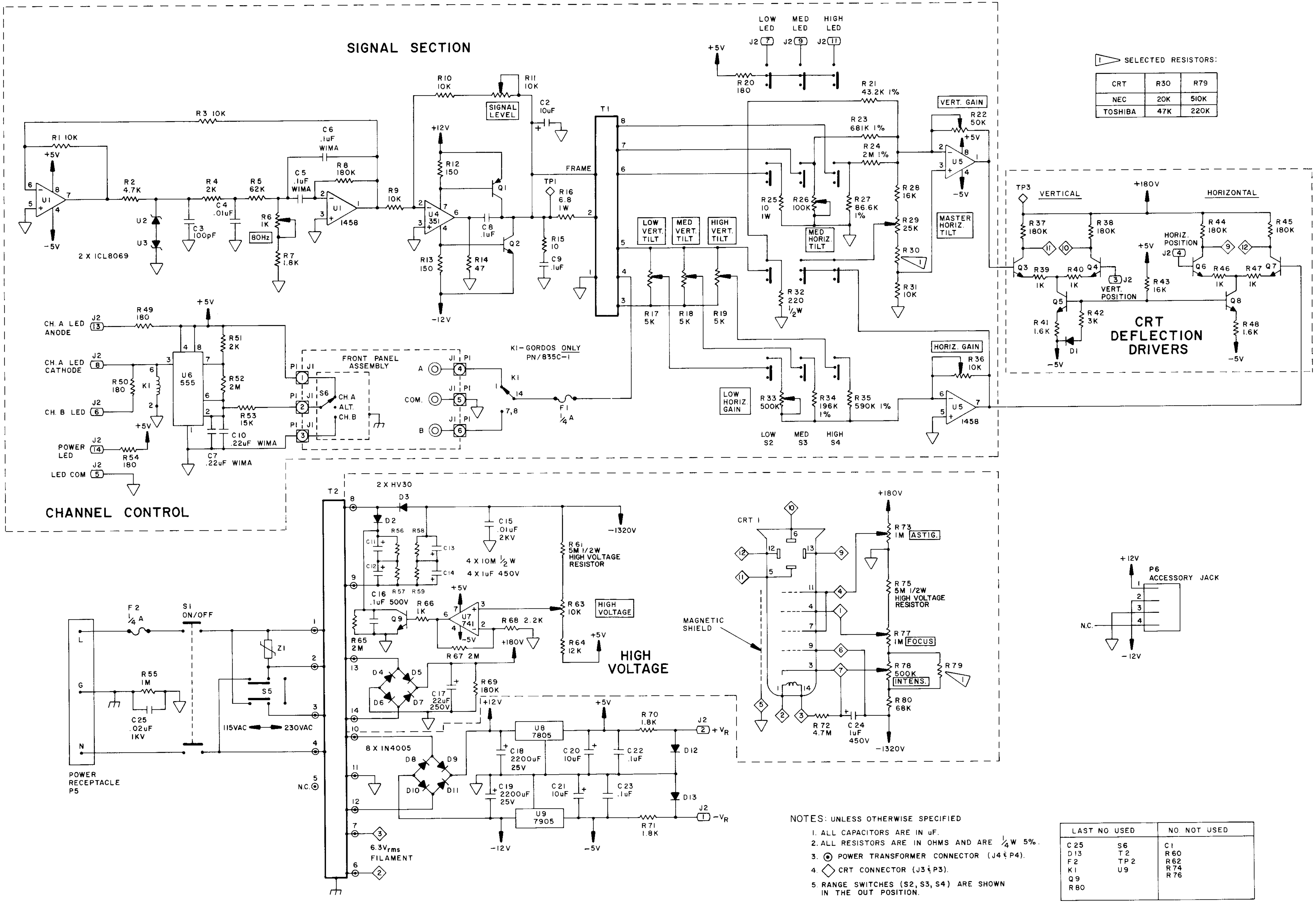


Figure 6-1. Main PCB Component Locations.



CRT	R30	R79
NEC	20K	510K
TOSHIBA	47K	220K

NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL CAPACITORS ARE IN uF.
2. ALL RESISTORS ARE IN OHMS AND ARE 1/4W 5%.
3. ⊙ POWER TRANSFORMER CONNECTOR (J4 & P4).
4. ◇ CRT CONNECTOR (J3 & P3).
5. RANGE SWITCHES (S2, S3, S4) ARE SHOWN IN THE OUT POSITION.

LAST NO USED		NO NOT USED
C25	S6	C1
D13	T2	R60
F2	TP2	R62
K1	U9	R74
Q9		R76
R80		

Figure 6-2. Main PCB Schematic.

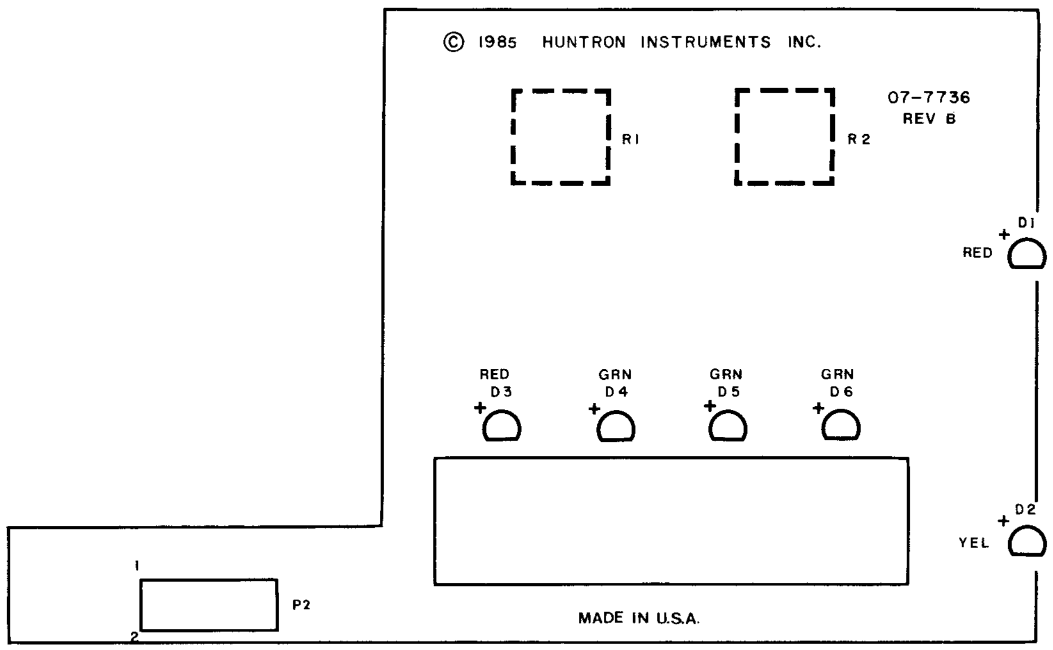
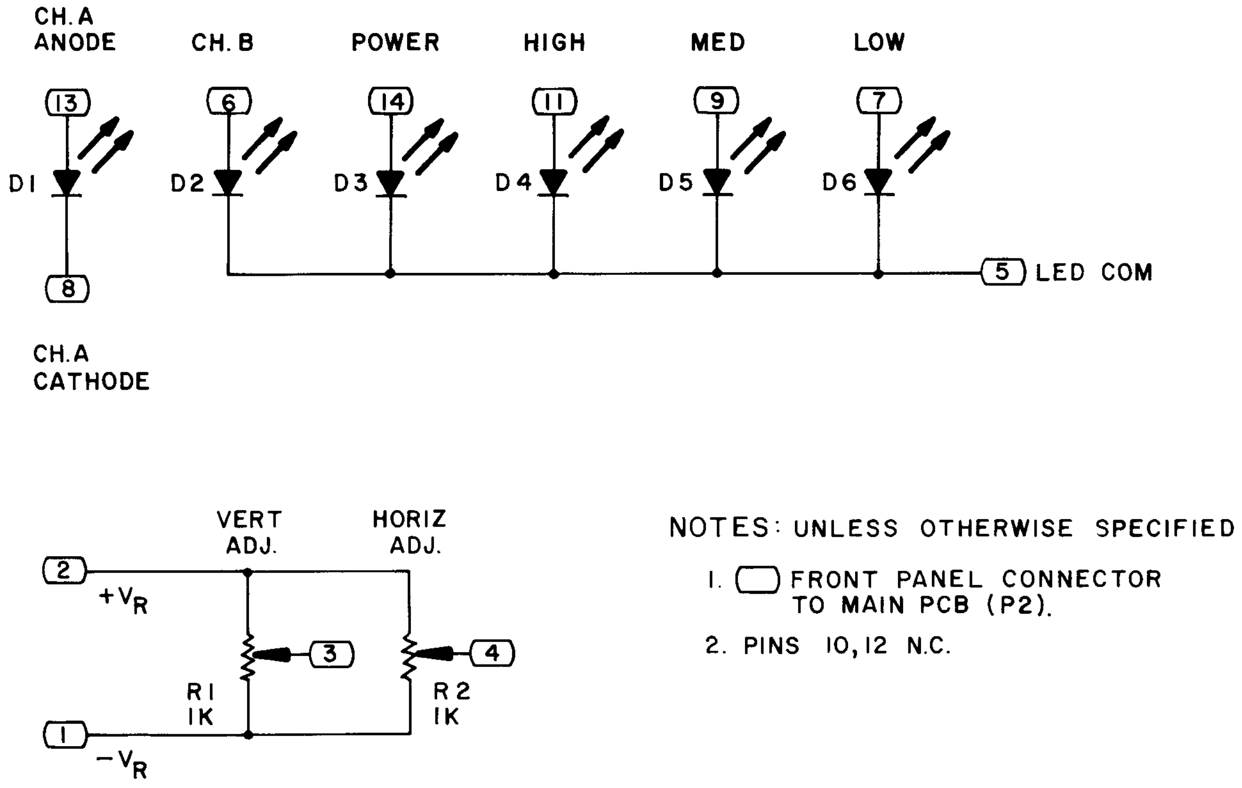


Figure 6-3. Control PCB Component Locations.



NOTES: UNLESS OTHERWISE SPECIFIED

1. ▭ FRONT PANEL CONNECTOR TO MAIN PCB (P2).
2. PINS 10, 12 N.C.

Figure 6-4. Control PCB Schematic.

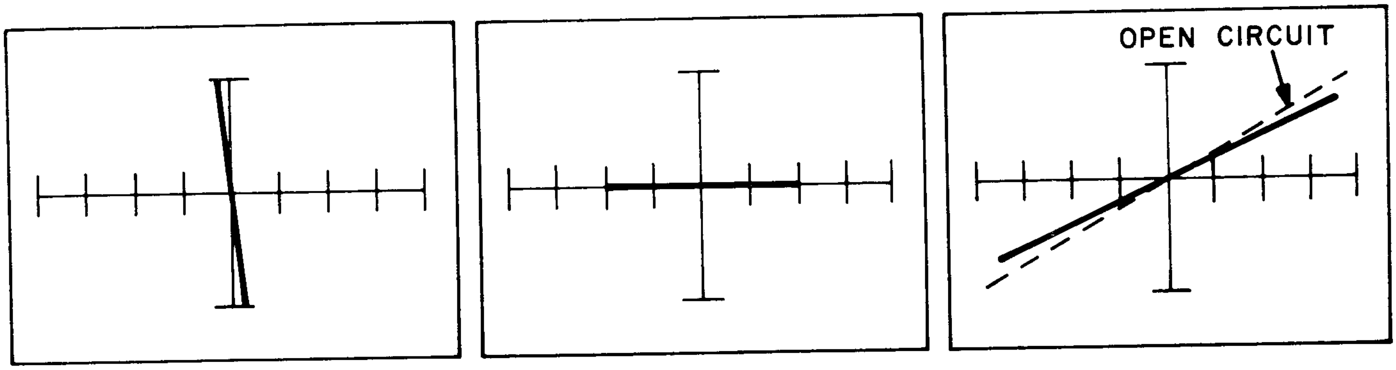
SECTION 7
RESISTORS, CAPACITORS AND INDUCTORS

7-1. Testing Resistors

A pure resistance across the test probes will cause the trace on the 1000 display to rotate in a clockwise direction around its center axis from an open circuit position. The degree of rotation is a function of the resistance value.

7-2. Low Range

The low range is designed to detect resistance between 1 ohm and 1K ohms. Figure 7-1 shows the effect of resistance on the angle of rotation in low range. A 1 ohm resistor causes a great deal of rotation and almost produces a short circuit (i.e. vertical signature). A 50 ohm resistor produces a 45 degree angle of rotation while a 400 ohm resistor causes a small angle of rotation. Resistance lower than 1 ohm appears as a short circuit while resistance above 400 ohms appears as an open circuit (i.e. diagonal signature).



1 ohm Resistor

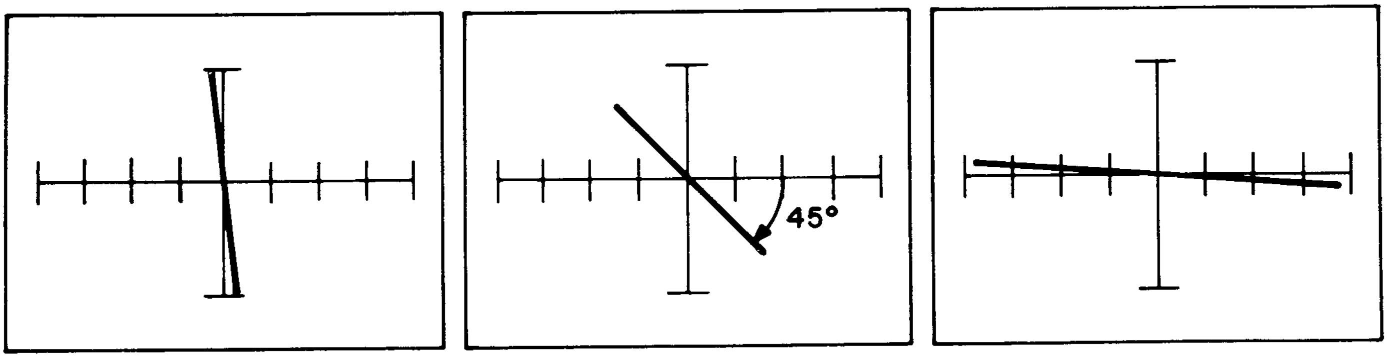
50 ohm Resistor

400 Ohm Resistor

Figure 7-1. Effects of Resistance on the Rotation Angle - Low Range

7-3. Medium Range

The medium range is designed to detect resistance between 1K ohms and 200K ohms. Figure 7-2 shows the signatures for a 1K resistor, a 15K resistor, and a 200K resistor using the medium range. Resistors that are smaller than 1K ohms appear almost as a short circuit. A 15K resistor causes an angle of rotation of 45 degrees, while the display for a 200K resistor shows only a slight rotation. Resistance values higher than 200K produce such a small rotation angle that it appears almost as an open circuit (i.e. horizontal signature).

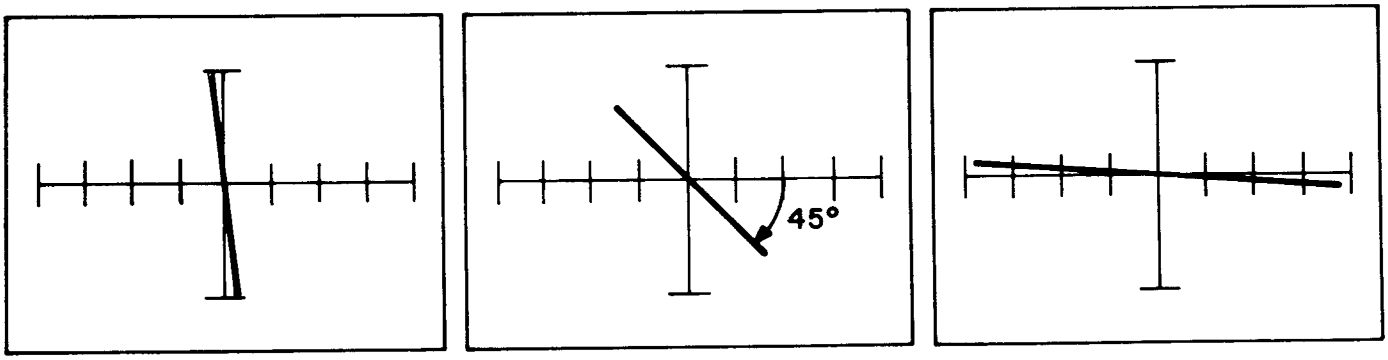


1K Resistor 15K Resistor 200K Resistor

Figure 7-2. Effects of resistance on Rotation Angle - Medium Range

7-4. High Range

The high range is designed to detect resistance between 3K and one Megohm. Figure 7-3 shows the signatures for a 3K resistor, a 50K resistor, and a one Megohm resistor using the high range. Resistors that are smaller than 3K appear almost as a short circuit. A 50K resistor causes an angle of rotation of 45 degrees, while the display for a one Megaohm resistor shows only slight rotation. Resistance values higher than one Megohm produce such a small rotation angle that it appears almost as an open circuit (i.e. horizontal signature).



3K Resistor 50k Resistor 1M Resistor

Figure 7-3. Effects of Resistance on Rotation Angle - High Range

7-5. TESTING CAPACITORS

With a capacitor connected to the 1000 the voltage, V(t), across the capacitor is given as:

$$V(t) = a \text{ Sin } (wt) \ldots\ldots (1)$$

The current in the loop, I(t), is 90 degrees out of phase with respect to the voltage and is given as:

$$I(t) = b \text{ Cos } (wt) \ldots\ldots (2)$$

where a and b are constants, and w is the test signal frequency.

From equation (1):

$$V(t)/a = \text{Sin}\ (wt)$$

or

$$V^2(t)/a^2 = \text{Sin}^2\ (wt) \qquad \text{(3)}$$

From equation (2):

$$I(t)/b = \text{Cos}\ (wt)$$

or

$$I^2(t)/b^2 = \text{Cos}^2\ (wt) \qquad \text{(4)}$$

Adding equations (3) and (4):

$$V^2(t)/a^2 + I^2(t)/b^2 = \text{Sin}^2\ (wt) + \text{Cos}^2\ (wt) = 1 \qquad \text{(5)}$$

This is the equation of an ellipse. It becomes a circle if a = b. The size and shape of the ellipse depends on capacitor value and the selected impedance range.

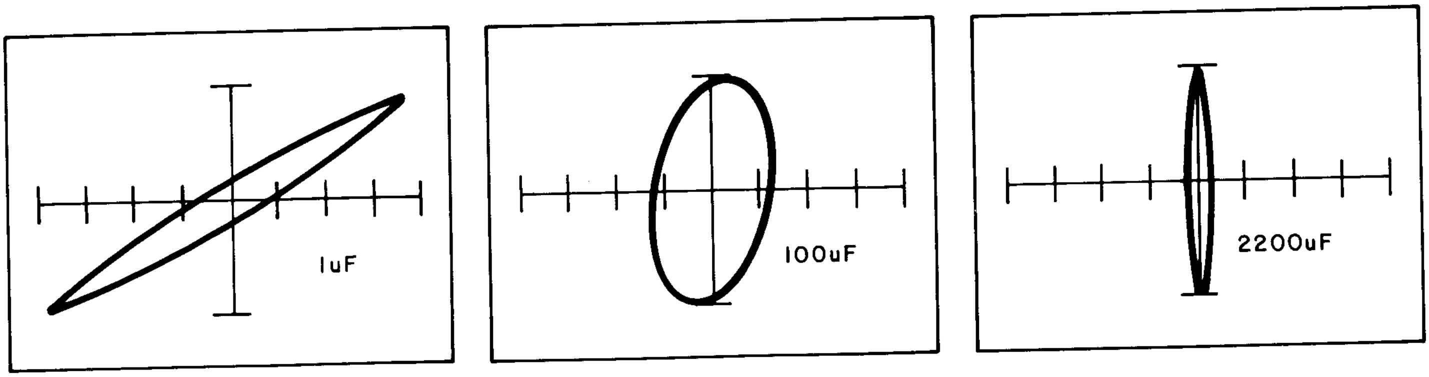


Figure 7-4. Signatures of Capacitors in Low Range

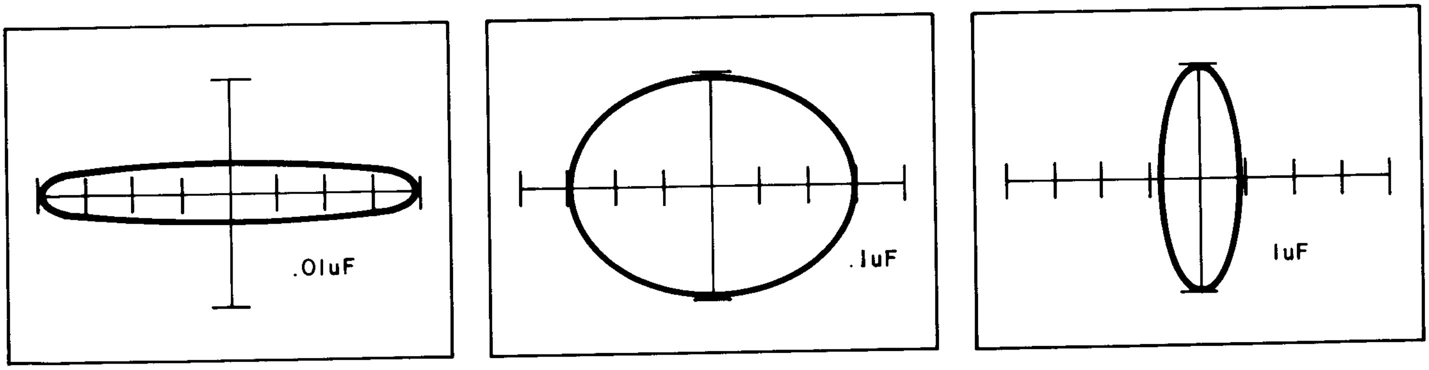


Figure 7-5. Signatures of Capacitors in Medium Range

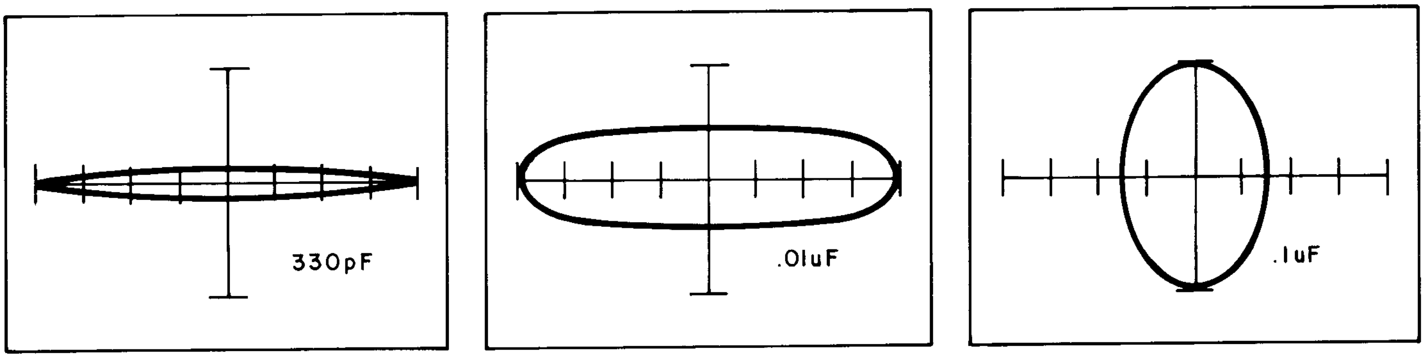
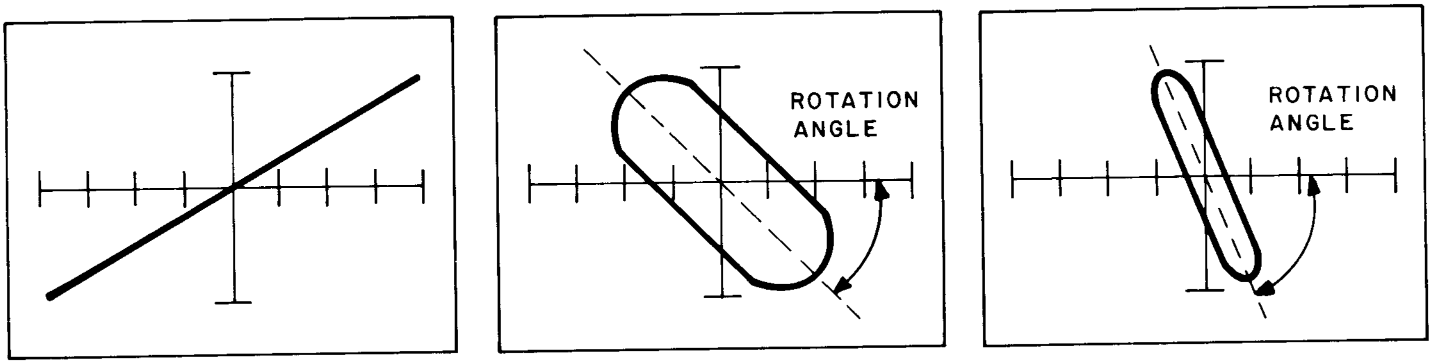


Figure 7-6. Signatures of Capacitors in High Range

For Capacitor testing, low range covers luF to 2200 uF; medium range covers 0.01uF to 1.0uF, and high range covers 330pF to 0.luF. Capacitive values less than 1.0uF appear as an open circuit in the low range, while capacitors with values higher than luF appear as short circuit in the medium and high ranges.

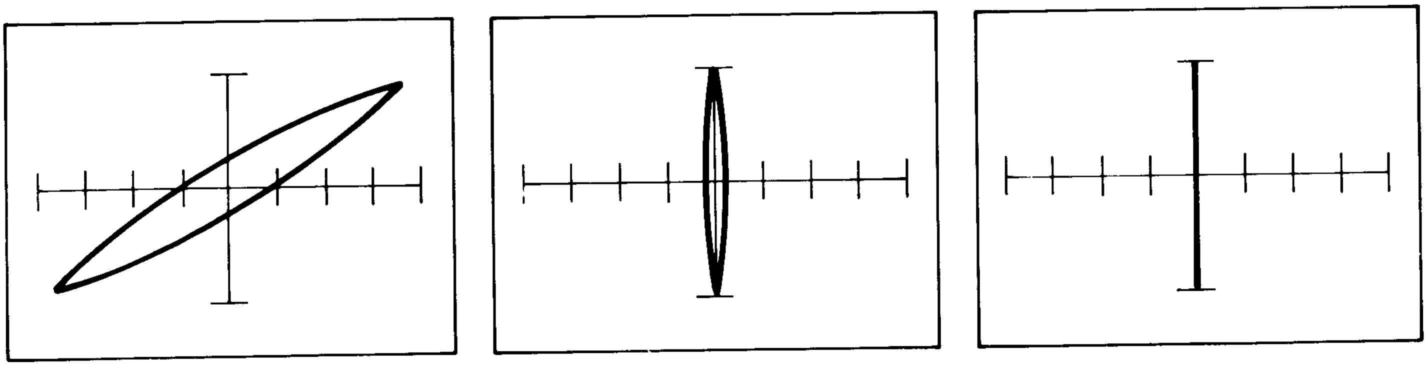
7-6. TESTING INDUCTORS

Inductors, like capacitors, produce elliptical signatures on the 1000 display. Figure 7-7 shows the signatures for a 6H inductor and Figure 7-8 shows the signatures produced in each of the three ranges by a 250mH inductor.



Low Medium High

Figure 7-7. Signatures of a 6H Inductor

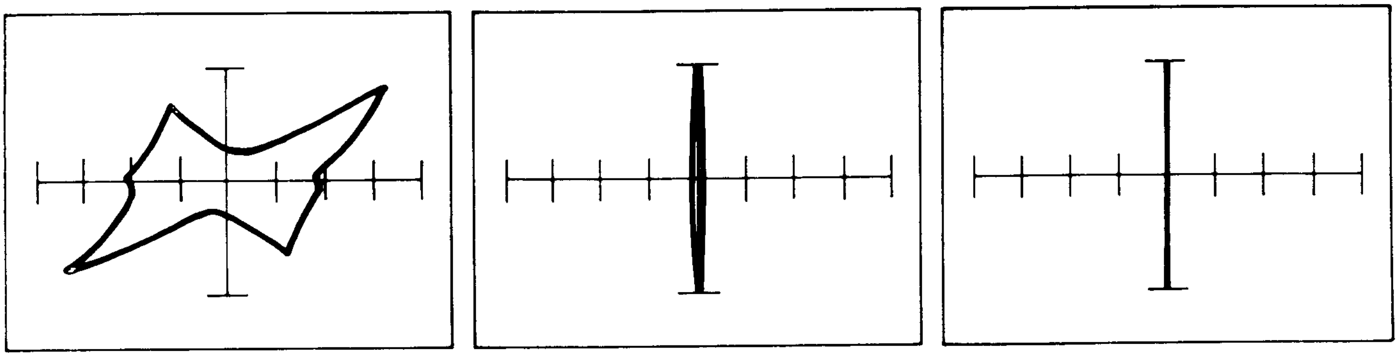


Low Medium High

Figures 7-8. Signatures of a 250mH Inductor

7-7. TESTING FERRITE INDUCTORS

Ferrite inductors can be checked with the 1000, but produce a signature that differs from the previously described inductor. Ferrite inductors operate well at high frequencies, but saturate at low frequencies. Figure 7-9 shows the signatures of a 490mH ferrite inductor. In low range the signature shows distortion. However, in medium and high range, the impedance of the inductor is low compared with the internal impedance of the 1000 so the signatures are a "split" vertical trace.



Low Medium High

Figure 7-9. Signatures of a 490mH Ferrite Inductor

SECTION 8
TESTING DIODES

8-1. THE SEMICONDUCTOR DIODE AND ITS CHARACTERISTICS

8-2. Diode Symbol and Definition

A semiconductor diode is formed by the creation of a junction between P-material and N-material within a crystal during the manufacturing process. The standard semiconductor diode has in its symbol, an arrow to indicate the direction of forward current flow, as shown in Figure 8-1. With positive voltage applied to the P-material and negative voltage applied to the N-material, the diode is said to be forward biased, as shown in Figure 8-2. The current (I_f) increases rapidly with small increases in applied voltage (V).

When the applied voltage is reversed, the P-material is negative with respect to the N-material, and very small levels of current flow through the diode. Figure 8-3 shows the P-N junction in the reverse bias mode. The small current (I_0) is the diode "reverse saturation current," and its magnitude increases with temperature. In practice, I_0 can be ignored.

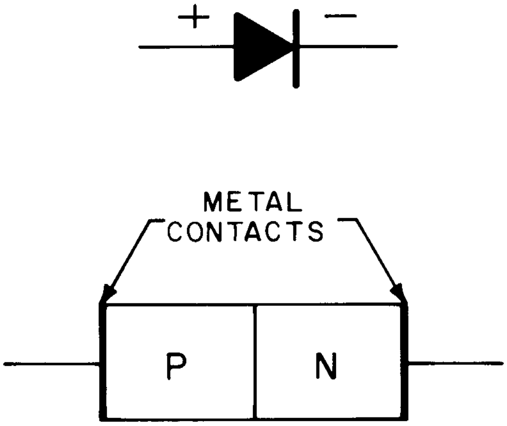


Figure 8-1. Diode Symbol

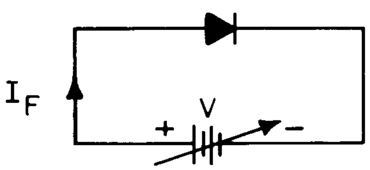


Figure 8-2. P-N Junction
Biased in the Forward direction

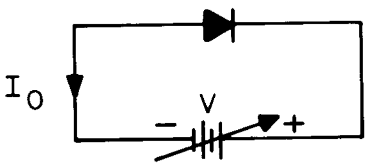


Figure 8-3. P-N Junction
Biased in the Reverse
Direction

8-3. The Volt-Ampere Characteristic

For a P-N junction, the current (I) is related to the voltage (V) by the following equation:

$$I = I_0(\exp kV\text{-}1)$$

Where K is a constant depending on the temperature and material. The volt-ampere characteristic described by the equation above is shown in Figure 8-4. For the sake of clarity, the current (I_0) has been greatly exaggerated in magnitude. The dashed portion of the curve in Figure 8-4 indicates that, at a certain point reverse voltage (V_{br}), the diode characteristic exhibits an abrupt and marked departure from the equaltion above. At this critical voltage, a large reverse current flows and the diode is said to be in the breakdown region.

8-4. SILICON RECTIFIER DIODES

8-5. Signatures of a Good Diode

A good diode has very large reverse biased resistance and small forward biased resistance. The forward junction voltage drop (V_f) is between 0.5 Volts and 2.8 Volts depending on the semiconductor material. For example, V_f is 0.6 Volts for a silicon diode, and V_f is 1.5 Volts for a typical light emitting diode. The 1000 can visually display all these parameters.

Figure 8-5 shows typical signatures (low, medium, and high range) and waveforms, plus the circuit equivalent for a good silicon diode. The forward junction voltage drop of a diode can be determined (approximately) from the low range signature.

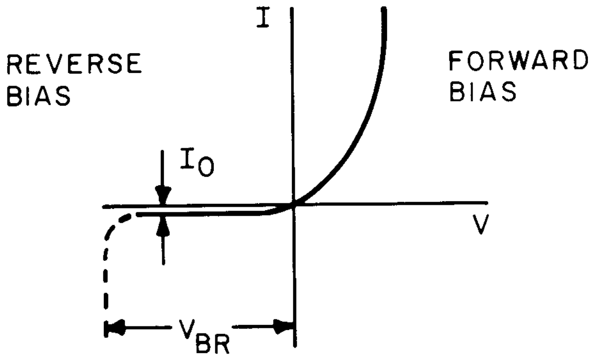
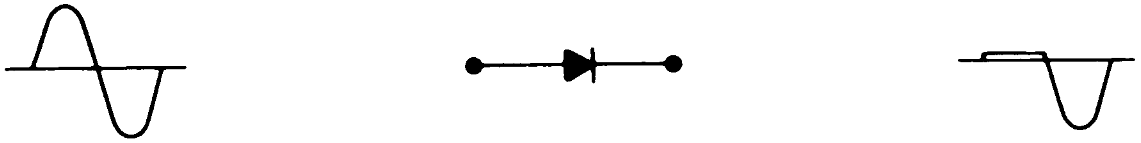
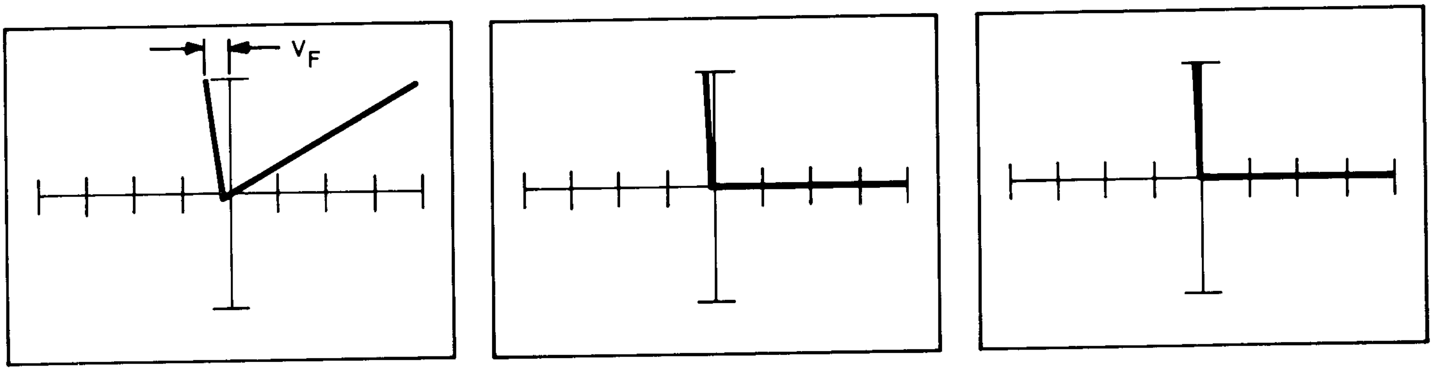


Figure 8-4. The Volt-Amphere Characteristic of a Semiconductor



INPUT WAVEFORM CIRCUIT EQUIVALENT OUTPUT WAVEFORM



Low Medium High

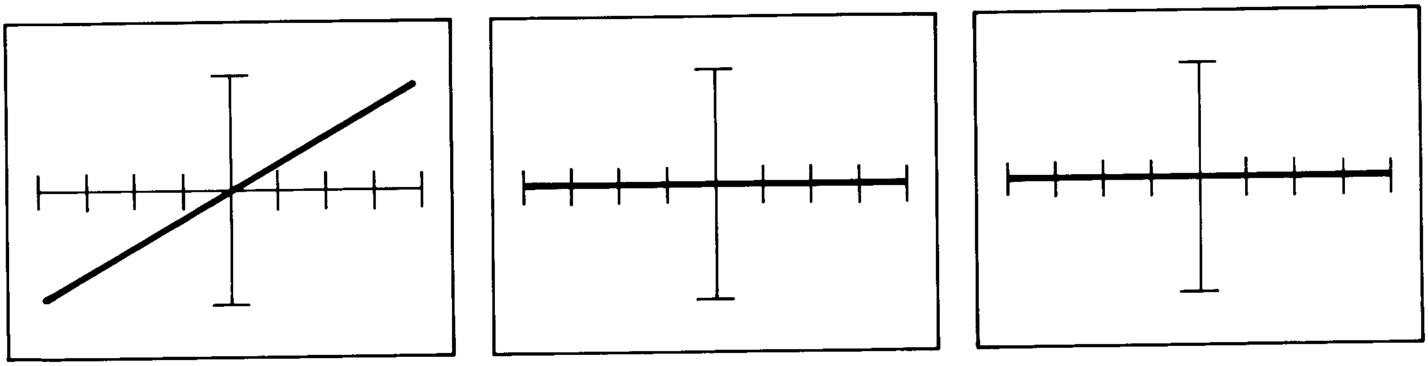
Figure 8-5. Signatures of a Silicon Diode

8-6. Signatures of Defective Diodes

A rectifier diode is defective if it is shorted (low impedance), or if it is open (high internal impedance), or contains leakage. Figure 8-6 shows the signatures of an "open" diode in all ranges.

The 1000 is capable, in the low range, of detecting resistance higher than one ohm, and this resistance causes the vertical line to rotate in a counterclockwise direction. The angle of rotation is a function of the resistance. Figure 8-7 shows the effect of circuit resistances on the trace rotation while in the low range. This small short circuit resistance does not cause rotation in the medium, and high ranges of the 1000.

Figure 8-8 shows the waveforms, circuit equivalent and signatures of a diode that exhibits a nonlinear resistance (high internal impedance) in series with the diode junction. This resistance effects the ability of the diode to turn on at the proper voltage, and causes excessive heat dissipation.



Low Medium High

Figure 8-6. Signature of an Open Diode

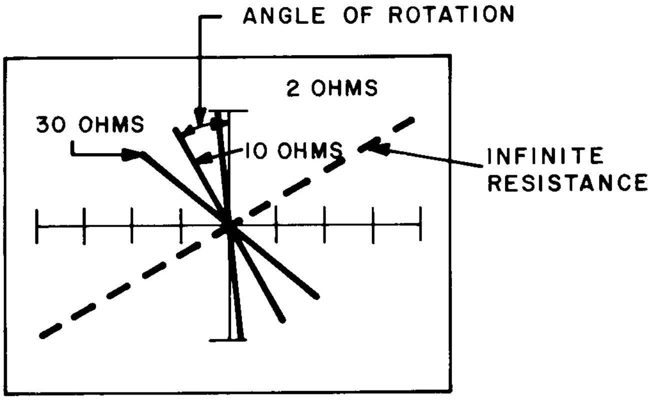
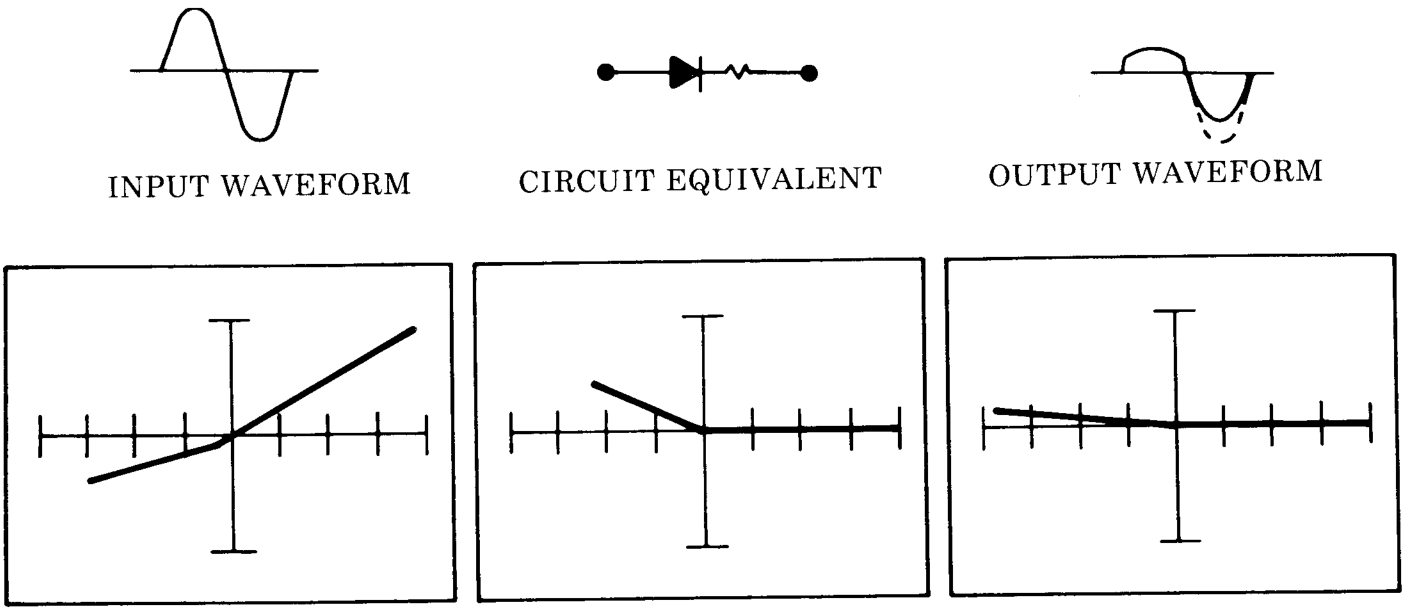


Figure 8-7. Effect of Resistance on the 1000 Signature in Low Range.



Good 1N4001 Diode

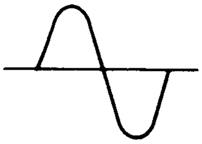
1N4001 with 10 ohm series resistance

1N4001 with 100 ohm series resistance

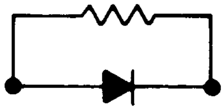
Figure 8-8. Signatures of a Diode with High Internal Impedance

Another Diode failure mode is leakage resistance which can be modeled as a resistance in parallel with a perfect diode as shown in Figure 8-9.

Figure 8-9 shows the waveforms, circuit equivalent and signatures of a diode that exhibits a nonlinear resistance in parallel with the diode junction (leaky) when reverse biased. This resistance effects the ability of the diode to provide maxiumum output for a given input.

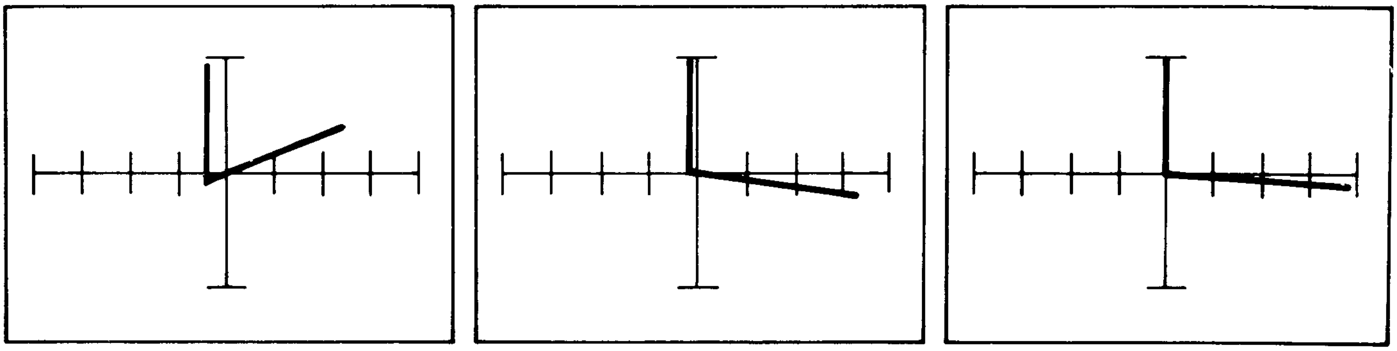


INPUT WAVEFORM



CIRCUIT EQUIVALENT

OUTPUT WAVEFORM



No Leakage

R = 1K

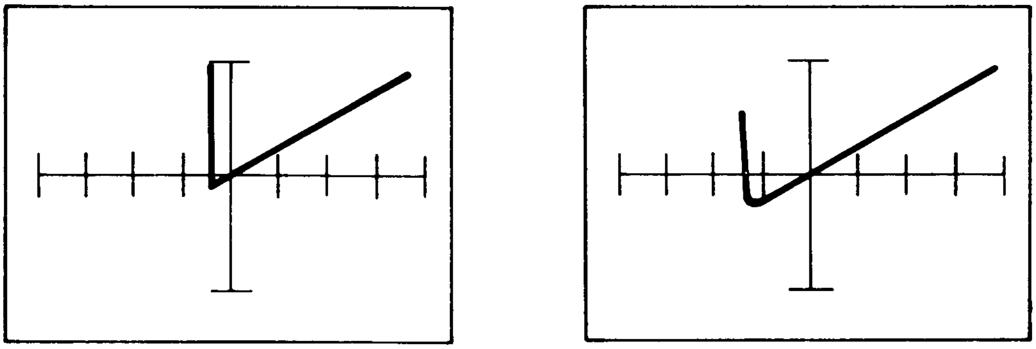
R = 10K

Figure 8-9. Signatures of a Diode with Leakage Resistance

The 1000 is capable of detecting leakage resistance with values between 1 ohm and 2 Megohms.

HIGH VOLTAGE SILICON DIODES

High voltage diodes are tested in the same manner as that described for rectifier diodes in section 8-4. High voltage diodes, such as the HV30F, display higher forward voltage drop (V_f) than low voltage diodes because the doping is different and the diode junction is required to withstand the rated high voltage. Figure 8-10 shows the signatures of a 1N4001 and a high voltage diode HV30 (3KV breakdown).



1N4001

HV30

Figure 8-10. Signatures of a 1N4001 and an HV30 in Low Range

8-8. RECTIFIER BRIDGES

A rectifier bridge assembly is made up of four diodes configured as shown in Figure 8-11. Points A and B are the ac power input terminals, and points C and D are the positive and negative output terminals, respectively. To test the bridge, the 1000 is connected to terminals A and B as shown in Figure 8-11.

A good bridge appears as an open circuit to the 1000 because the diodes are reverse biased. Figure 8-12 shows the signatures produced by a good bridge with the 1000 connected across points A and B. Figure 8-13 shows the signatures produced by a bridge with either diode D2 or D4 shorted, while Figure 8-14 shows the signatures produced with either diode D1 or D3 shorted.

Figure 8-15 shows the test connections of the 1000 to the positive and negative terminals of the rectifier bridge. Channel A is connected to the positive terminal, and common is connected to the negative terminal. Figure 8-16 shows the signatures of a good bridge when connected as shown in Figure 8-15.

Figure 8-17 shows a reversal of the test connections shown in Figure 8-15. Figure 8-18 shows the signatures resulting from the reversal of the test connections to the bridge.

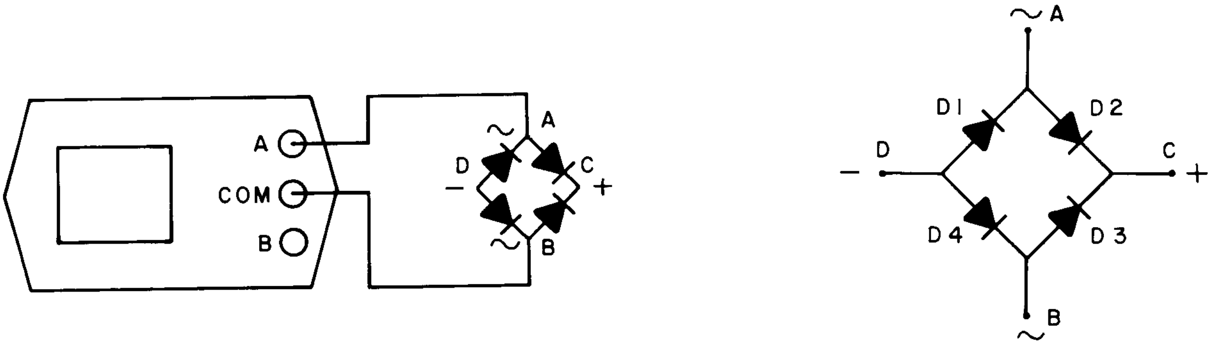


Figure 8-11. Rectifier Bridge Test Connections - AC Input

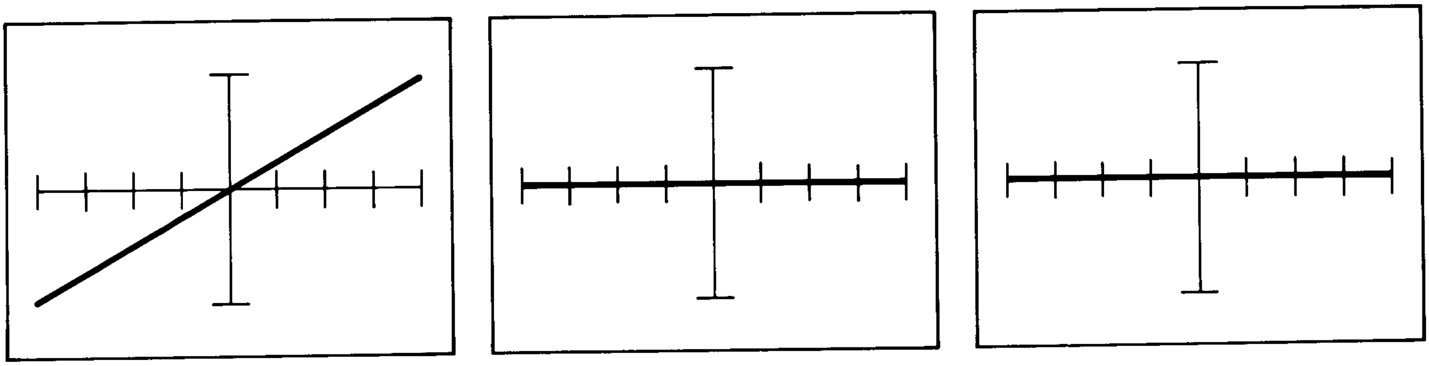


Figure 8-12. Signatures of a Good Rectifier Bridge in all Ranges

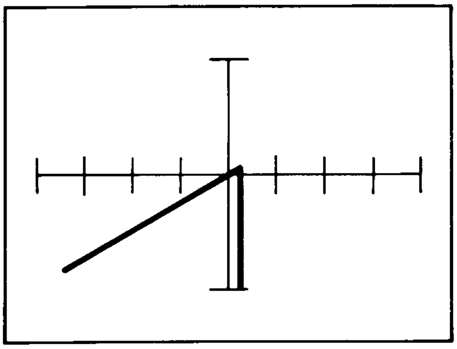


Figure 8-13. Signature with D2 or D4 Shorted in Low Range

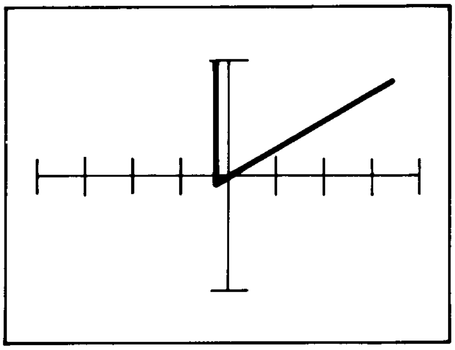


Figure 8-14. Signature with D1 or D3 Shorted in Low Range

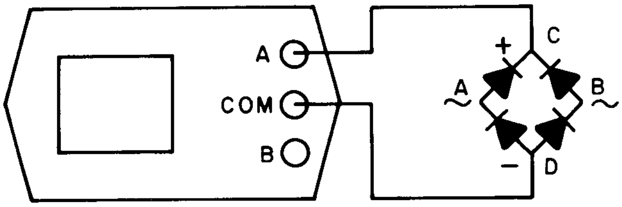


Figure 8-15. Rectifier Bridge Connections - DC Output

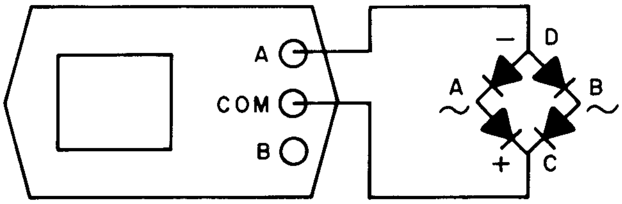


Figure 8-16. Rectifier Bridge, Reversed Test Connections

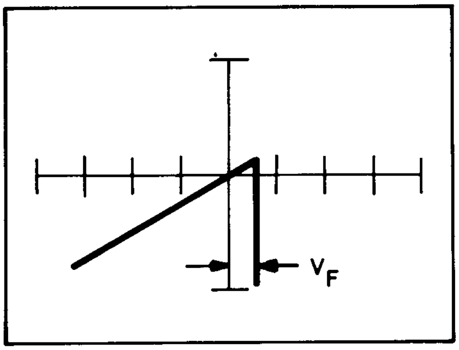


Figure 8-17. Signature of the DC Output in Low Range

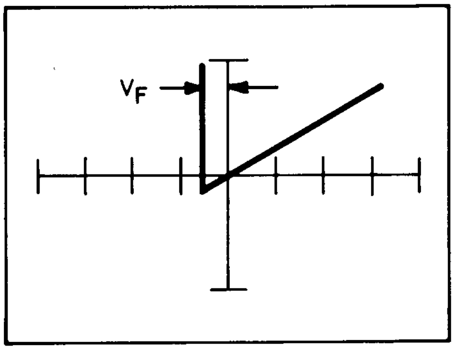
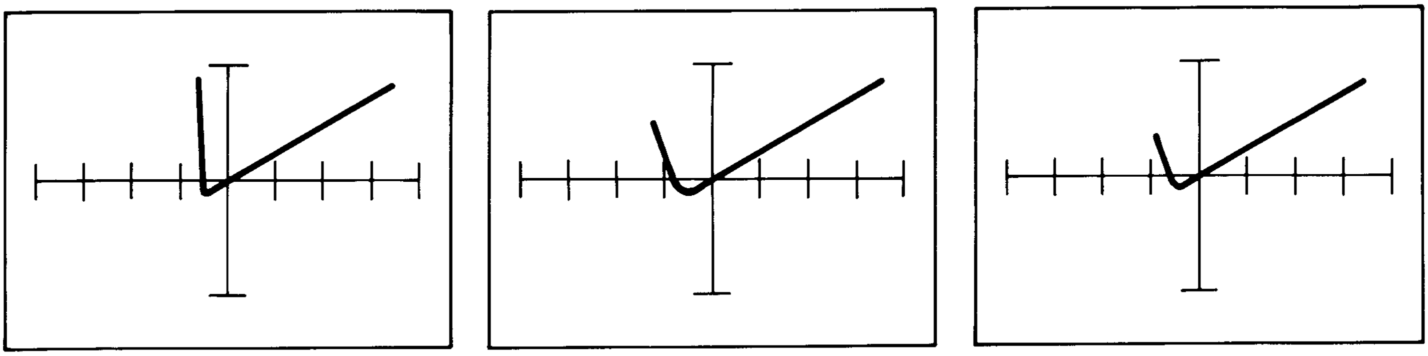


Figure 8-18. Signature with the DC Output Reversed in Low Range

8-9. LIGHT-EMITTING DIODES

Light-emitting diodes (LEDs) may be tested with the 1000 by using the low range and connecting the probes across the LED. A good LED provides an adequate amount of light as a result of the 1000 connections. Figure 8-19 shows the signatures for different colored LEDs, each of which exhibit different forward voltages (V_f).



COLOR: RED
RANGE: LOW

COLOR: AMBER
RANGE: LOW

COLOR: GREEN
RANGE: LOW

Figure 8-19. LED Signatures

8-10. ZENER DIODES

The zener diode is unique among the semiconductor family of devices in that its electrical properties are derived from a rectifying junction which operates in the reverse bias region. Figure 8-20 shows the volt-ampere characteristics of a typical 30 Volt zener diode.

Figure 8-20 shows that the zener diode conducts current in both directions, with the forward current being a function of the forward voltage. Note that the forward current is small until the forward voltage is approximately 0.65V, then the forward current increases rapidly. When the forward voltage is greater than 0.65V, the forward current is limited primarily by the circuit resistance external to the diode.

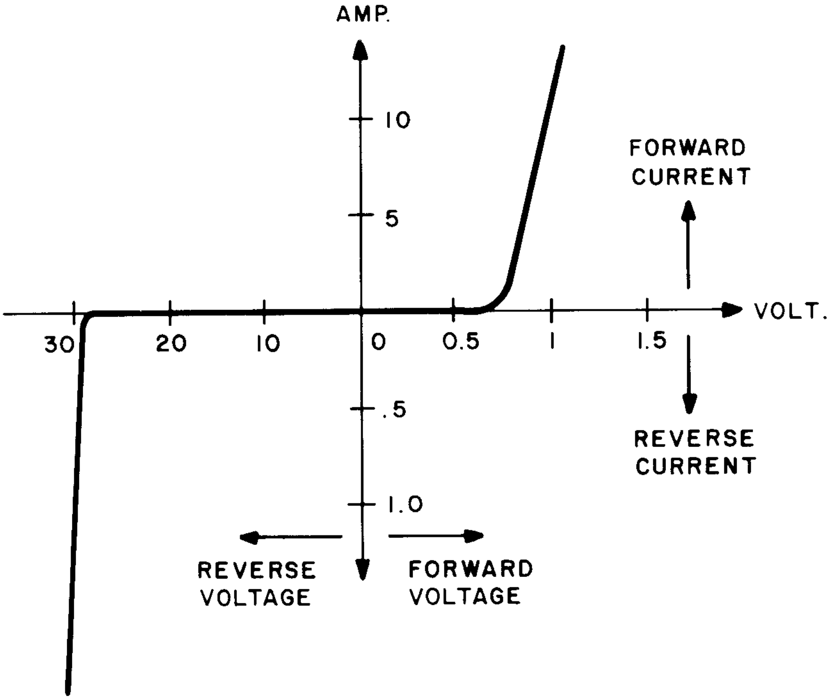
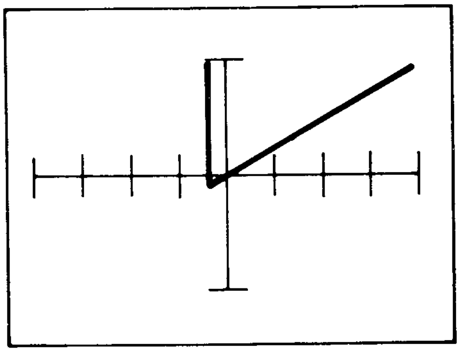


Figure 8-20. Characteristics of a Typical 30V Zener Diode

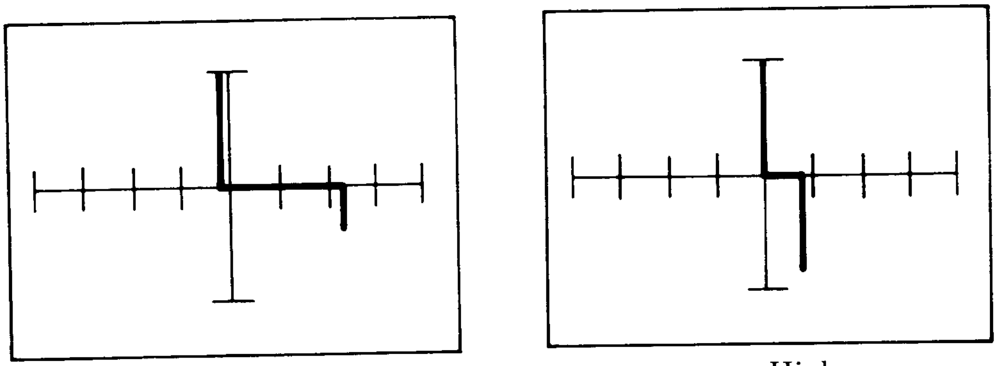
The reverse current is a function of the reverse voltage and, for most practical purposes, is zero until such time as the reverse voltage equals the P-N junction breakdown voltage. At this point the reverse current increases rapidly. The P-N junction breakdown voltage (V_Z) is usually called the zener voltage. Commercial zener diodes are available with zener voltages from about 2.4V to 200V. The 1000 displays the zener diode breakdown voltage (V_Z) on the display.

Figure 8-21 shows the signatures produced by the zener diode.



Low

Test Signal is not high
enough to cause Zener Breakdown



Medium

High

Figure 8-21. Signatures of a 1N5242 Zener Diode

In the low range, the 1000 test signal at the probes is 10 Volts peak, and is insufficient to cause zener breakdown for the 1N5242. As a result, the signature looks identical to that of a general purpose diode such as a 1N4001.

A good zener diode gives a sharp, well-defined signature of zener breakdown voltage, while an inferior zener device gives a signature with a rounded corner (refer to Figures 8-22 and 8-23).

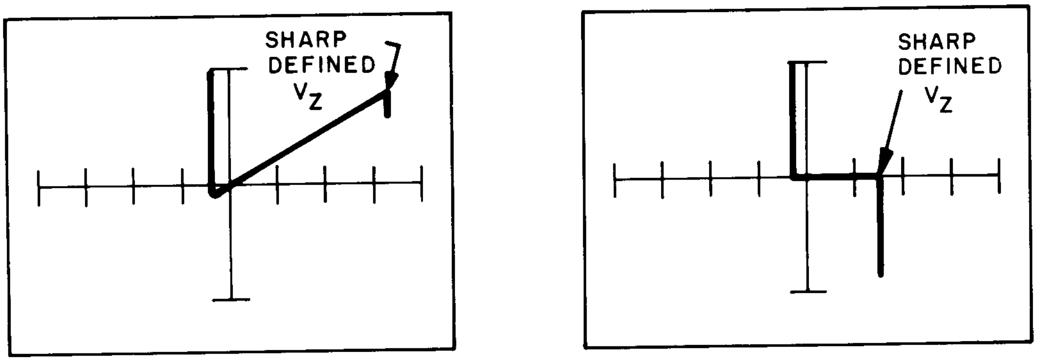


Figure 8-22. Signature of a Good Zener Diode

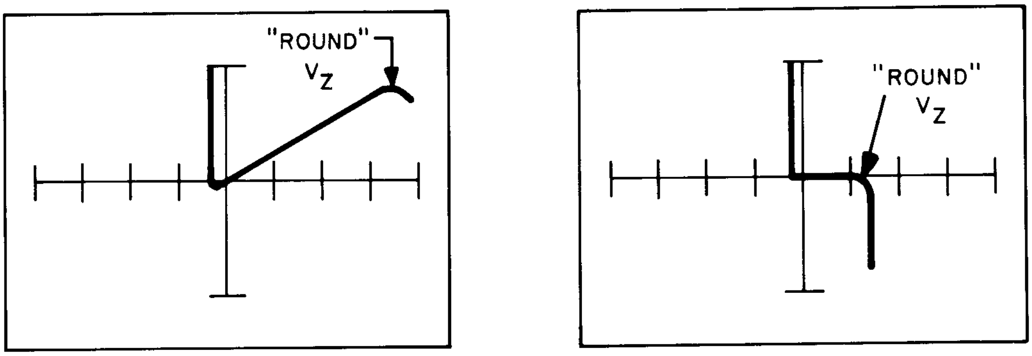
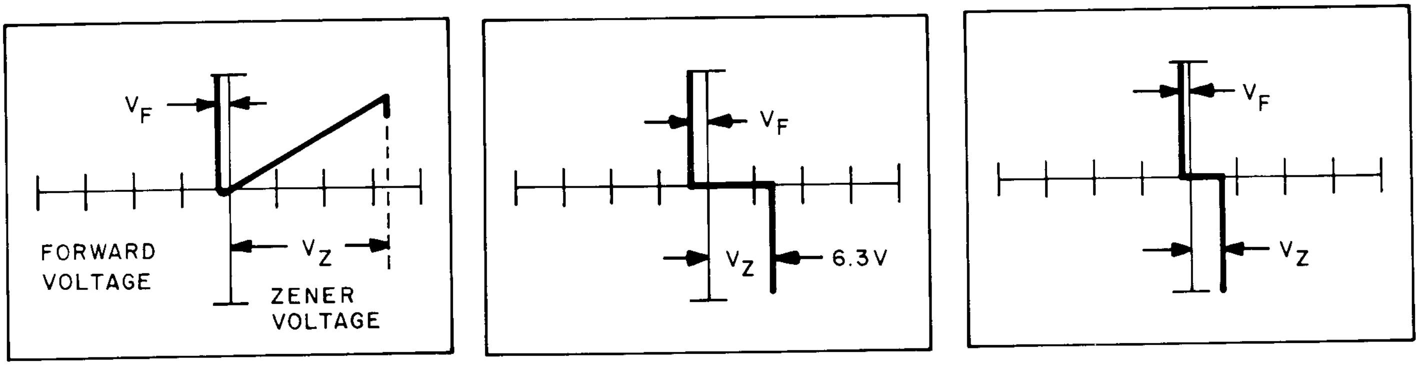


Figure 8-23. Signature of an Inferior Zener Diode

Figure 8-24 shows that the base-emitter junction of a silicon bipolar transistor (a PN2222) exhibits the property of a zener diode. The zener voltage (V_z) can be determined from the signature. In this example, V_z is approximately 6.3 Volts.



Low

Medium

High

Figure 8-24. Signature of a PN2222 B-E Junction

SECTION 9
TESTING TRANSISTORS

9-1. BIPOLAR JUNCTION TRANSISTORS

A bipolar junction transistor consists of a silicon crystal in which a layer of N-type silicon is sandwiched between two layers of P-type silicon. This type of transistor is referred to as a PNP type. Figure 9-1 shows a PNP and its circuit symbol.

A transistor may also consist of a layer of P-type silicon sandwiched between two layers of N-type silicon. This is referred to as an NPN transistor. Figure 9-2 shows an NPN transistor and its circuit symbol.

The three portions of a transistor are known as the emitter, base, and collector. The arrow on the emitter lead specifies the direction of current flow when the base-emitter is biased in the forward direction.

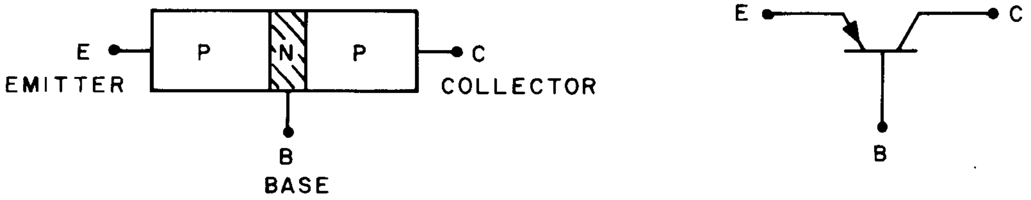


Figure 9-1. PNP Transistor and Circuit Symbol

Figure 9-2. NPN Transistor and Circuit Symbol

The test signals at the 1000 probes are sinusoidal and can be used to forward bias, as well as reverse bias, a semiconductor junction. To test a transistor, the base-emitter (B-E), collector-base (C-B), and collector-emitter (C-E) junctions all need to be examined.

9-2. An Important Note about Testing Transistors

Use of this instrument may alter the current gain (h_{FE} or β) of a bipolar transistor whenever the emitter is tested. Either the base-emitter or collector-emitter test circuits satisfy this criterion. While heating of the device due to the current produced by the instrument may cause a temporary change in the h_{FE} (most noticable in the low range), a permanent shift in h_{FE} may occur whenever the base-emitter junction is forced into reverse breakdown (approx. 6-10 Volts). The magnitude of the shift depends on the duration of the test and the range selected with the low current ranges, medium and high, producing the smallest changes.

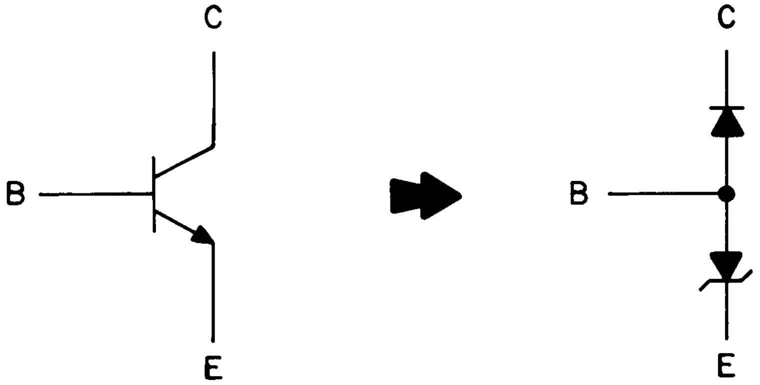
Most bipolar transistor circuit designers take into account a wide variation in h_{FE} as a normal occurance and design the related circuitry to function properly over the expected range of h_{FE}. The effects mentioned above are for the most part much smaller than the normal device variation so that the use of this instrument will have no effect on the functionality of good devices and can fullfill its intended purpose as a means to locate faulty components. However, some circuits may depend on the h_{FE} of the particular part in use e.g. instrumentation that is calibrated to a certain h_{FE} value, or precision differential amplifiers with matched transistors. In such instances, this instrument should not be used as its use may cause the h_{FE} to shift outside the limited range where calibration can correct any change.

Suggestions to minimize effects on bipolar transitors:

1. Keep the duration of the test as short as possible.
2. Use the Medium or High ranges as much as possible.

9-3. NPN BIPOLAR TRANSISTORS

A bipolar transistor consists of two PN junctions which the 1000 can examine in a manner similar to that used for testing diodes. Figure 9-3 shows an equivalent circuit for an NPN bipolar transistor.



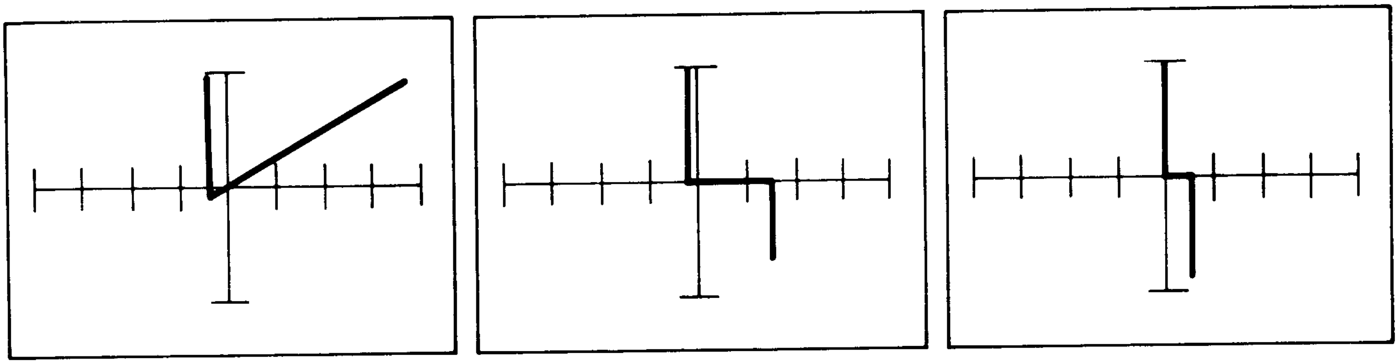
Symbol

Equivalent Circuit

Figure 9-3 NPN Transistor

9-4. B-E Junction

The B-E junction exhibits a zener diode characteristic, i.e. normal diode voltage drop under forward bias, and zener breakdown under reverse bias with Vz usually in the range of 6 to 10 Volts. Figure 9-4 shows the signatures produced by the B-E junction of a 2N3904 NPN transistor in each range.

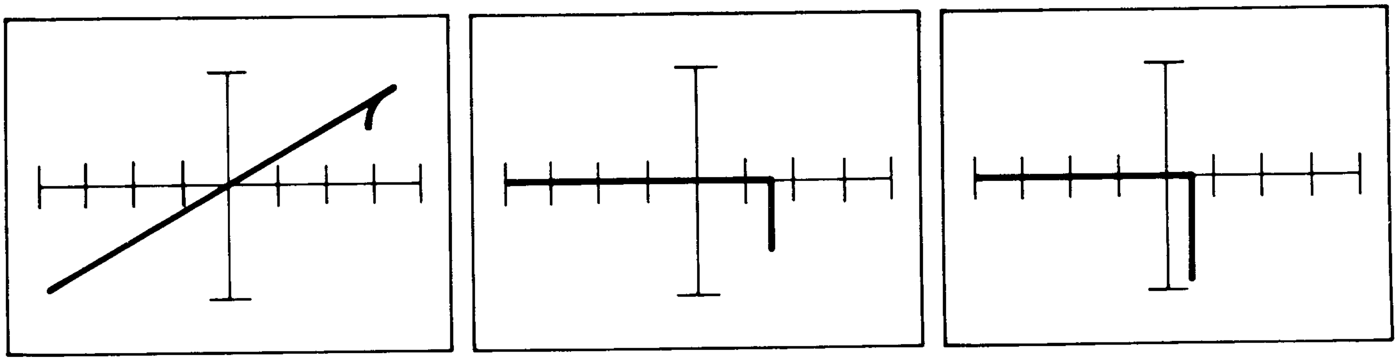


Low Medium High

Figure 9-4. B-E Signatures of an NPN Transistors (2N3904)

9-5. C-E Junction

Referring to Figure 9-3, this test examines a series connection of the two junctions, i.e. a simple diode in series with a zener diode. The resulting signatures are shown in Figure 9-5. When the collector is positive with respect to the emitter (left side of display) the C-B diode is reverse biased and the combination appears as an open circuit. This is expected because the normal operation of an NPN transistor uses positive C-E voltage and there is no base drive in the test circuit. When the collector is negative with respect to the emitter, the C-B diode is forward biased and the B-E junction goes into zener breakdown. The low impedance section of the signature is displaced to the right of the vertical axis by the sum of the voltage drops across the two junctions.

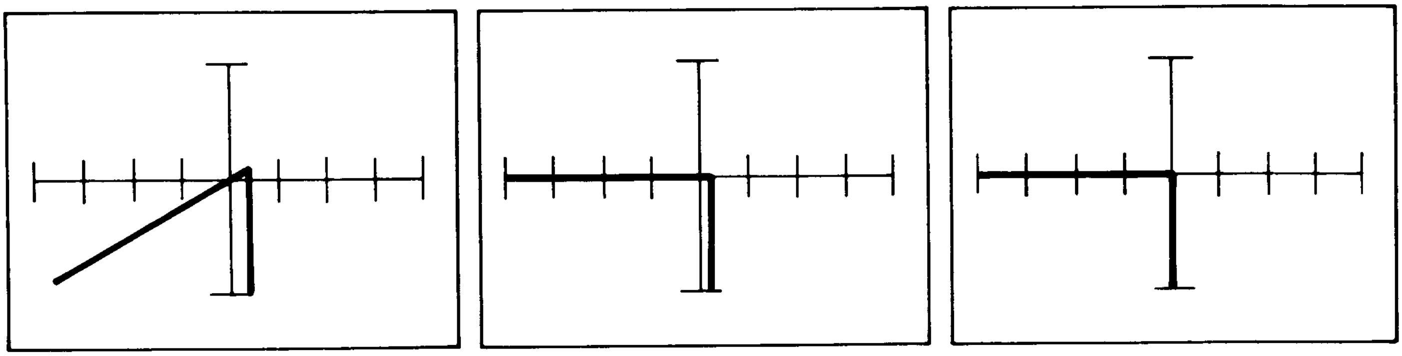


Low Medium High

Figure 9-5. C-E Signatures of an NPN Transistor (2N3904)

9-6. C-B Junction

From Figure 9-3, it is seen that this junction is a simple diode and it produces signatures like that of a diode in all ranges (Refer to Figure 9-6).

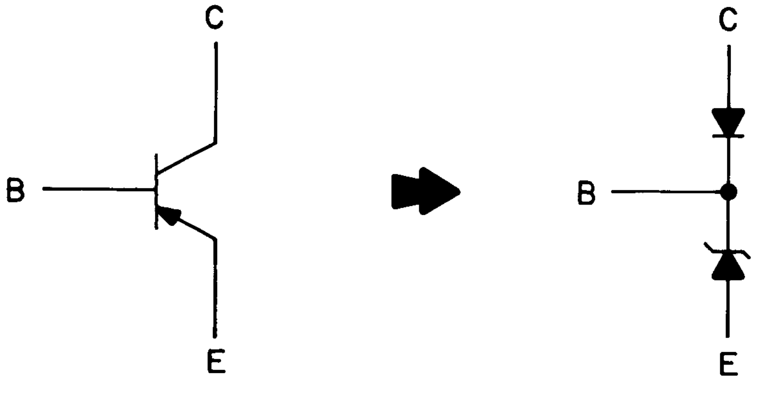


Low Medium High

Figure 9-6. C-B Signatures of an NPN Transistor (2N3904)

9-7. PNP BIPOLAR TRANSISTORS

The testing of PNP transistors is the same as that described for NPN transistors, except that the signatures are reversed from those of an NPN device. This is because in the equivalent circuit of a PNP transistor, the polarity of the two diodes is reversed (see Figure 9-7).

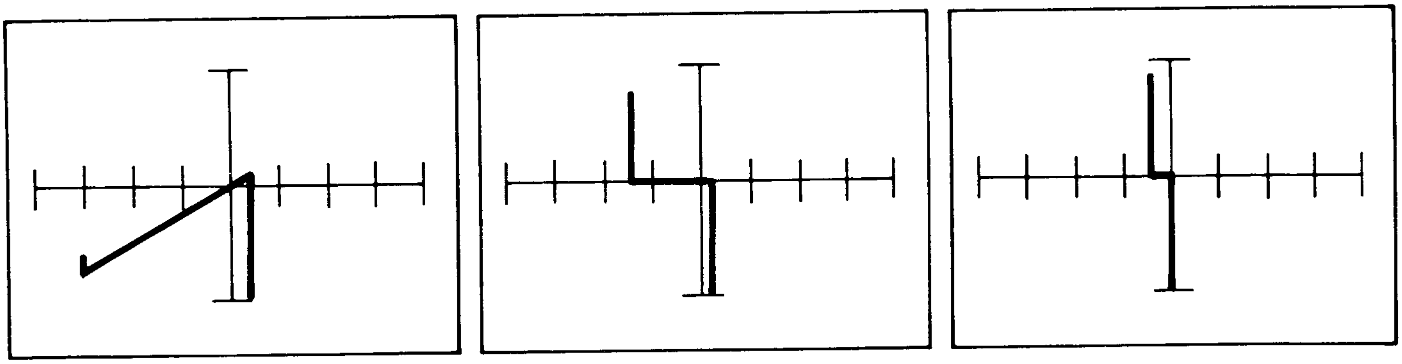


Symbol Equivalent

Figure 9-7. PNP Transistors

9-8. B-E Junction

The B-E junction signatures are shown in Figure 9-8.

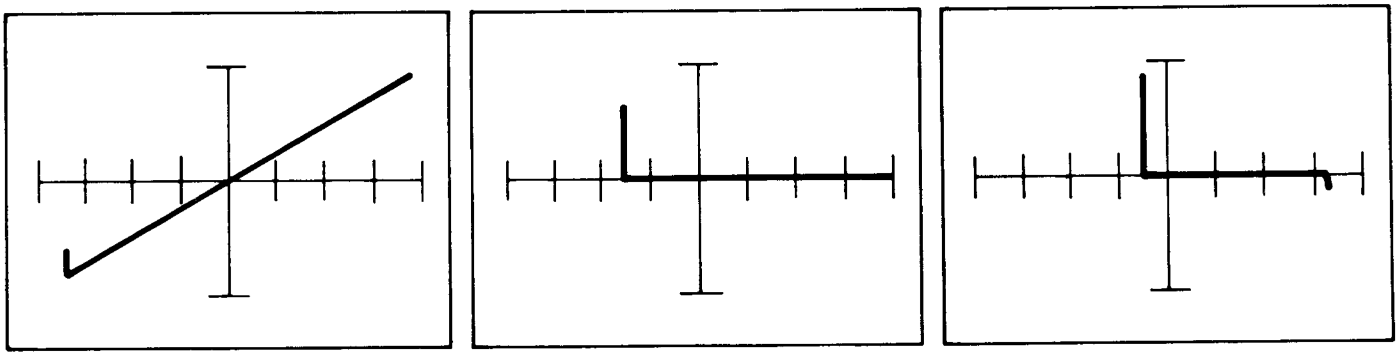


Low Medium High

Figure 9-8. B-E Signatures of a PNP Transistor (2N3906)

9-9. C-E Junction

Signatures of the C-E junction are shown in Figure 9-9.

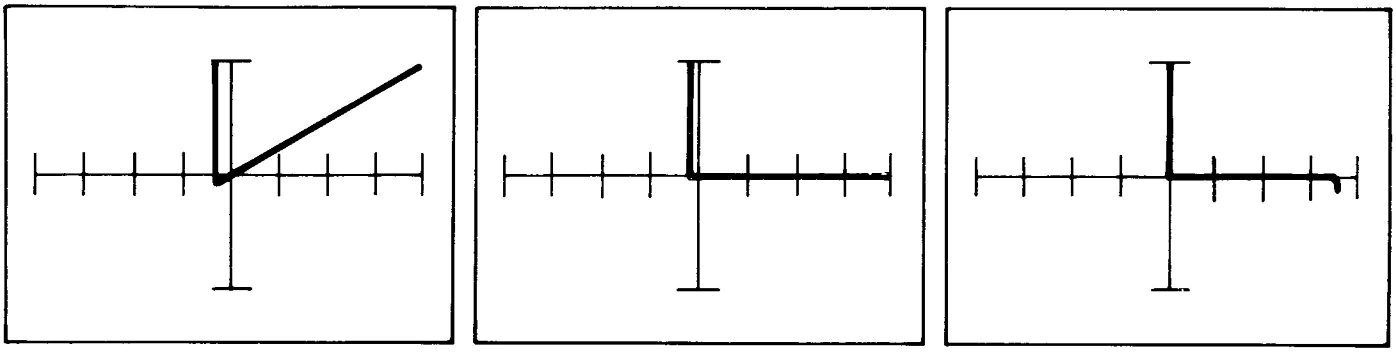


Low Medium High

Figure 9-9. C-E Signatures of a PNP Transistor (2N3906)

9-10. C-B Junction

The signatures of the C-B junction are shown in Figure 9-10.

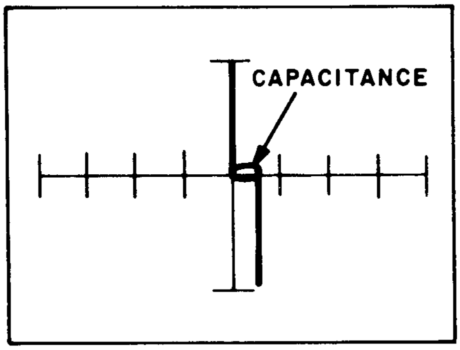


Low Medium High

Figure 9-10. C-B Signatures of a PNP Transistor (2N3906)

9-11. POWER TRANSISTORS—NPN AND PNP

Transistor testing procedures described in sections 9-3 and 9-7 are applicable to power transistors. However, most power transistors show capacitance in the signature when the high range is used. Figure 9-11 shows the loop in the signatures caused by capacitance.



High

Figure 9-11. B-E Signatures of a Power Transistor (TIP50)

9-12. DARLINGTON TRANSISTORS

The Darlington transistor is basically two transistors connected to form a composite pair as shown in Figure 9-12. The input resistance of Q2 constitutes the emitter load for Q1.

Darlington transistors are tested in the same manner as NPN and PNP bipolar transistors, except that their signatures differ. Figure 9-13 shows the equivalent circuit of a commonly used Darlington transistor, the TIP112, and its pin assignments.

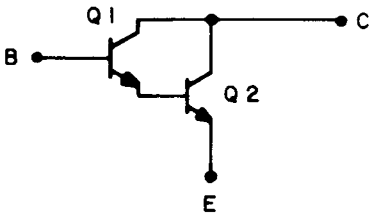


Figure 9-12. Darlington Transistor—Schematic Diagram

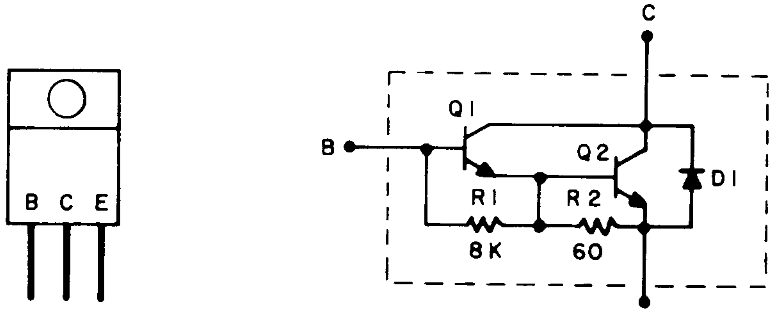
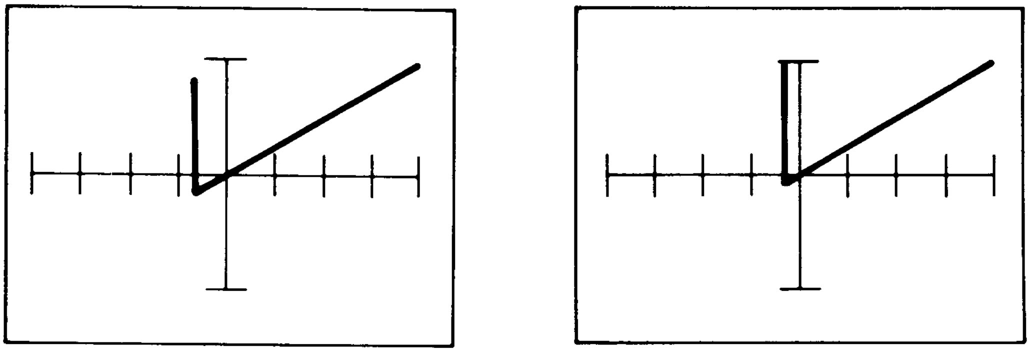


Figure 9-13. The TIP112 Darlington Transistor

9-13. Comparing B-E Junctions

It is useful to compare the B-E junction of a Darlington transistor with that of a regular transistor. Figure 9-14 shows the signatures.



Darlington Transistor

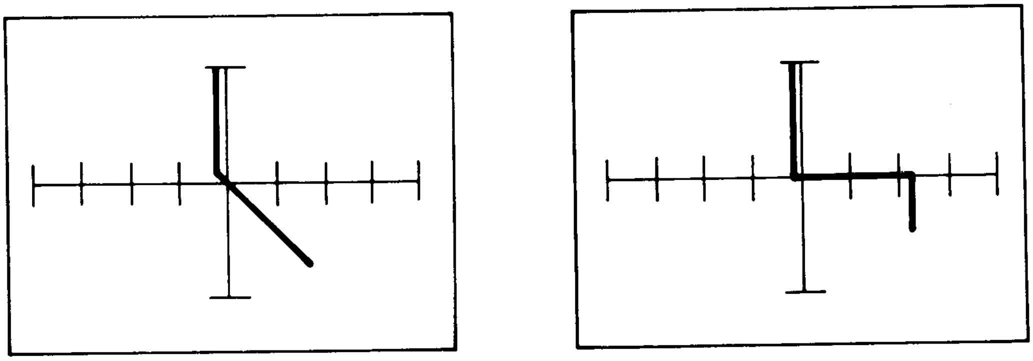
TIP112

Low

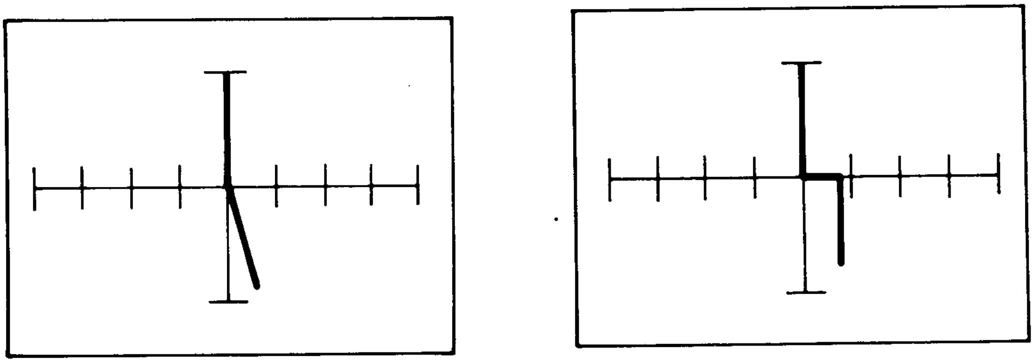
Regular Transistor

TIP29

Low



Medium Medium



High High

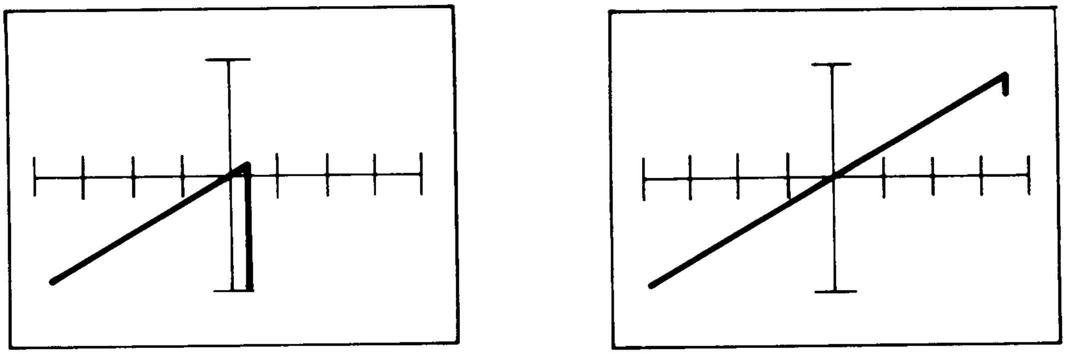
Figure 9-14. B-E Signature Comparison of a Darlington Transistor (TIP112) and a Regular Transistor (TIP29)

9-14. Comparing C-E Connections

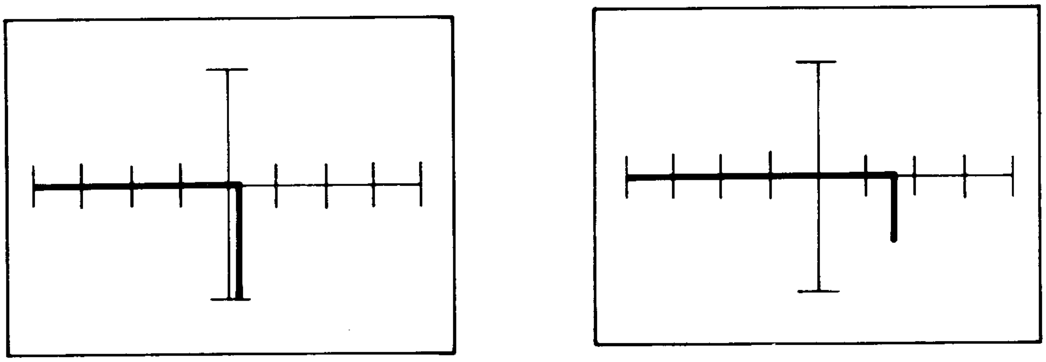
This section compares the C-E junctions of a Darlington transistor and a regular transistor. Figure 9-15 shows the signatures.

Darlington Transistor
TIP112

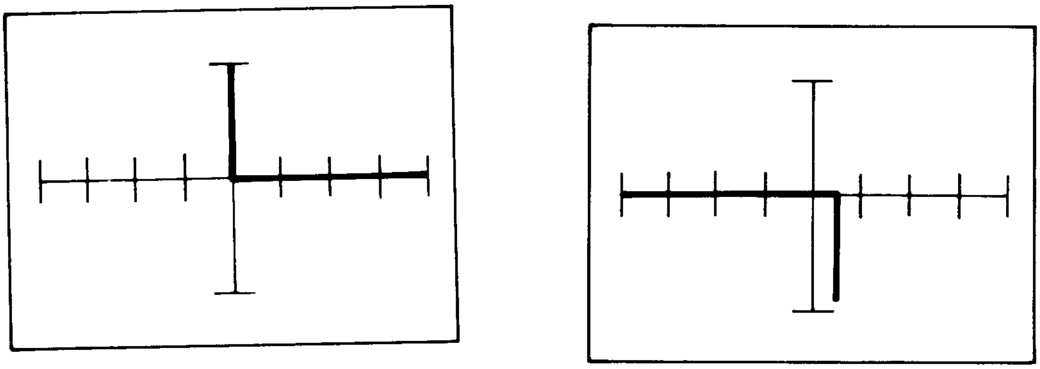
Regular Transistor
TIP29



Low Low



Medium Medium



High High

Figure 9-15. C-E Signature Comparison of a Darlington Transistor (TIP112) and a Regular Transistor (TIP29)

9-15. Comparing C-B Junctions

The C-B signatures of a Darlington Transistor are the same as the C-E signatures. They are also the same as the C-B signatures of a regular transistor.

9-16. JUNCTION FIELD EFFECT TRANSISTORS

The structure of an N-channel Junction Field Effect Transistor (JFET) is shown in Figure 9-16. Resistive contacts are made to the ends of a semiconductor bar of N-type material (if P-type material is used, the device is referred to as a P-channel JFET). The voltage supply connected to the ends causes current to flow along the length of the bar. This current is made up of majority carriers, which in this case are electrons. The circuit symbol is shown in Figure 9-17. The following FET notation is standard.

SOURCE: The source (S) is the terminal at which the majority carriers enter the bar. The current entering the bar at S is designated by I_s.

DRAIN: The drain (D) is the terminal at which the majority carriers leave the bar. The current entering the bar at D is designated by I_d. If D is more positive than S then the drain to source voltage (V_{ds}) is positive.

GATE: On both sides of the N-type bar shown in Figure 9-24, heavily doped (P+) sections of acceptor impurities have been created by aloying, by diffusion, or by some other means of creating P-N junctions. These sections of impurities are called the gate (G). The gate to source voltage (V_{gs}) is applied to reverse bias the P-N junction. The current entering the bar is designated I_g.

CHANNEL: The section of N-type material between the two gate sections is the channel through which the majority carriers travel from source to drain.

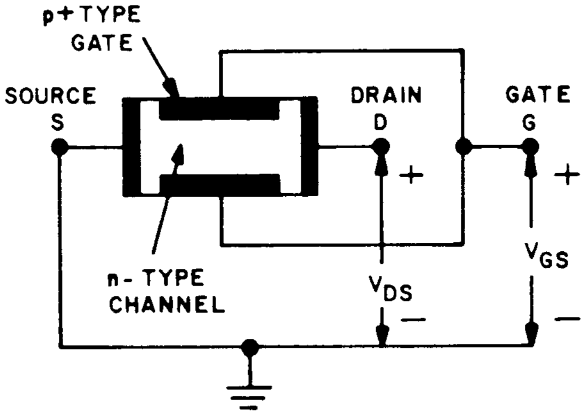


Figure 9-16. The Basic Structure of an N-Channel Junction Field Effect Transistor

NOTE: In a P-channel JFET the voltages would be reversed.

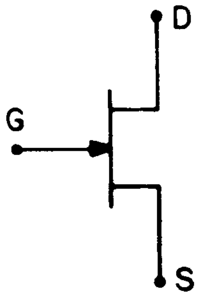
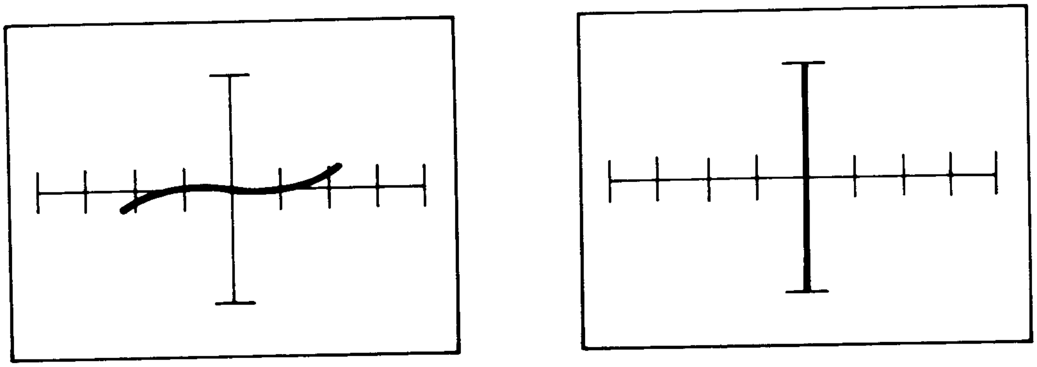


Figure 9-17. Circuit Symbol for an N-Channel JFET

9-17. Drain-Source Connection

Figure 9-18 shows the signatures in each range.

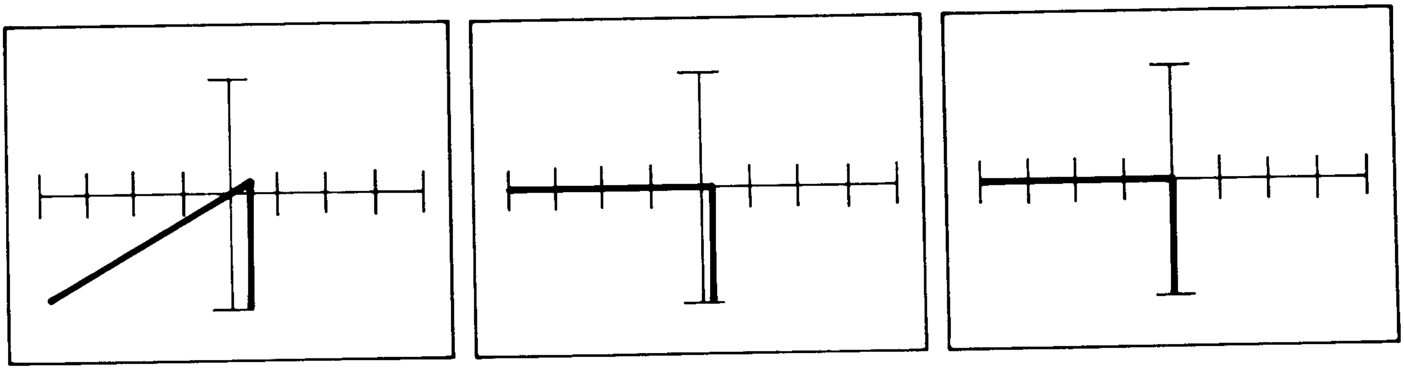

Low

Medium and High

Figure 9-18. D-S Signatures of an N-Channel JFET (2N5638)

9-18. Gate-Drain Connection

Figure 9-19 shows the signatures of the Gate-Drain connection.


Low

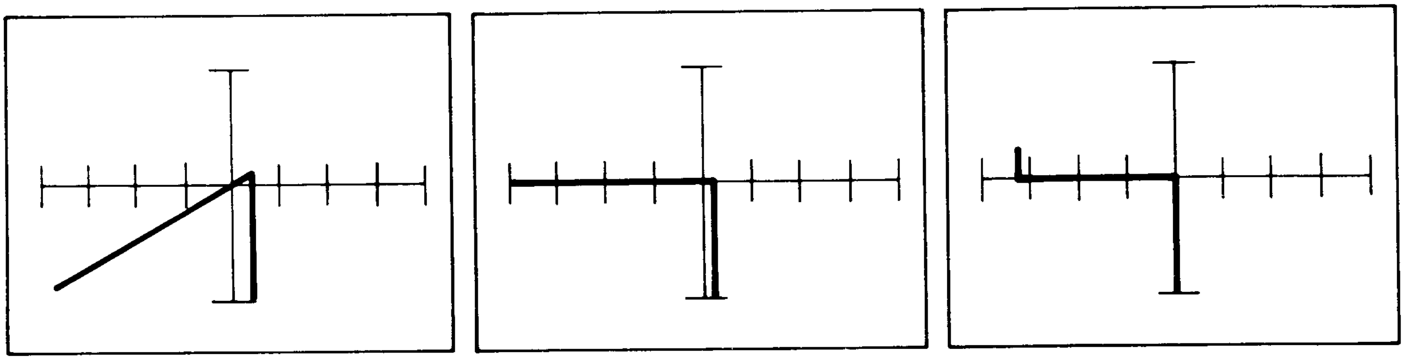
Medium

High

Figure 9-19. G-D Signatures of an N-Channel JFET (2N5638)

9-19. Source-Gate Connection

Figure 9-20 shows the signatures of the Source-Gate connection.



Low

Medium

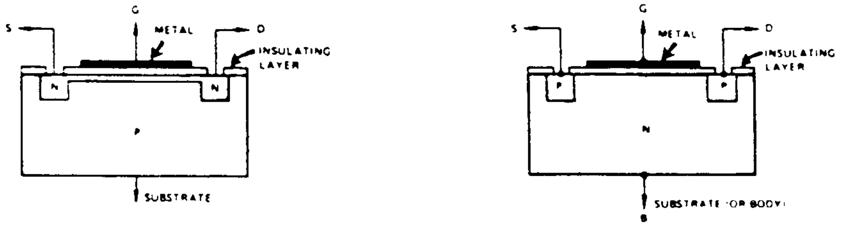
High

Figure 9-20. S-G Signatures of an N-Channel JFET (2N5638)

9-20. MOS FIELD EFFECT TRANSISTORS

MOS field effect transistors (MOSFETs) are constructed as either "depletion" or "enhancement" mode devices. Each type requires a distinct test procedure with the 1000. Figure 9-21 shows the construction and circuit symbol of N-channel and P-channel MOSFETs. The depletion mode MOSFET is a "normally on" device. When $V_{gs} = 0$, a conducting path exists between source and drain. An enhancement mode MOSFET is a "normally off" device, and increasing the voltage applied to the gate will enhance channel conduction, and depletion will never occur.

Because MOS devices require higher voltage levels for testing than JFETs, the medium range must be used. The amount of "in circuit" loading that can be tolerated is limited by the impedance of the signal generator inside the 1000.



Idealized cross-section through an N-channel depletion-type MOSFET

Idealized cross-section through a P-channel enhancement MOSFET

Circuit arrangement for N-channel depletion MOSFET

Circuit arrangement for P-channel enhancement MOSFET

Figure 9-21. N-channel and P-channel MOSFET Devices.

9-21. MOSFET WITH PROTECTION DIODE, VN10KM

Some MOSFET devices have an input protection diode, and the 1000 displays the effect of this diode. Figure 9-22 shows a Siliconix N-channel enhancement mode MOSFET (VN10KM). This device has a protection diode between the gate and source, and the substrate is internally connected to the source.

9-22. Source-Gate Connection

To test the gate and source of the VN10KM, connect the test probes to the gate (G) and source (S) terminals. Note that the drain (D) terminal is not connected.

Figure 9-23 shows the signatures of the protection zener diode in the low, medium and high ranges. The test signal in the low range is 10 Volts peak, and is not high enough to cause zener breakdown. The test signal in the medium range is 20 Volts peak, and is not high enough to cause zener breakdown. However, in the high range, the test signal is sufficient to cause zener breakdown.

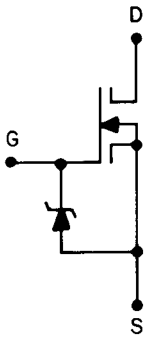
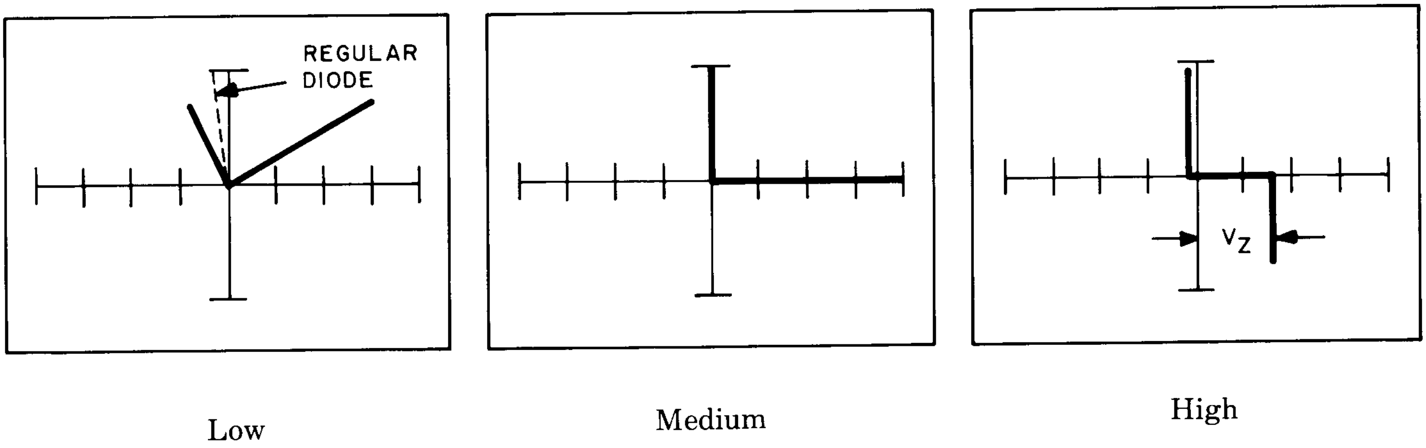


Figure 9-22. VN10KM MOSFET With a Source to Gate Protection Diode



Low

Medium

High

Figure 9-23. S-G Signatures of an N-channel Enhancement Mode MOSFET (VN10KM)

9-23. Drain-Source Connection

Figure 9-24 shows the signatures of the Drain-Source connection.

Gate Open Circuit

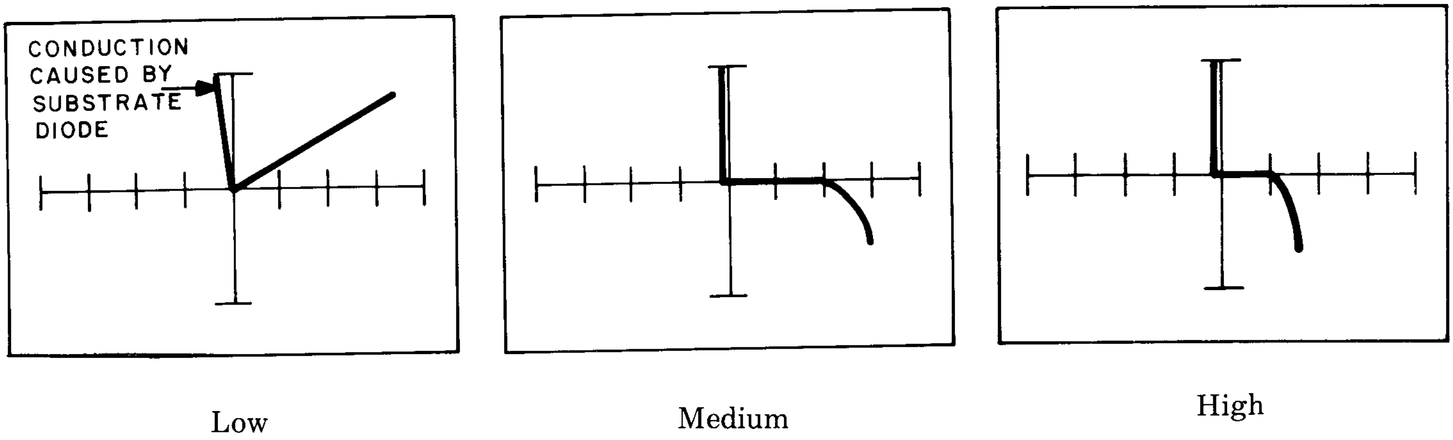


Figure 9-24 signatures of the Drain-Source connection.

9-24. Gate-Drain Connection

Figure 9-25 shows the signatures of the Gate-Drain connection.

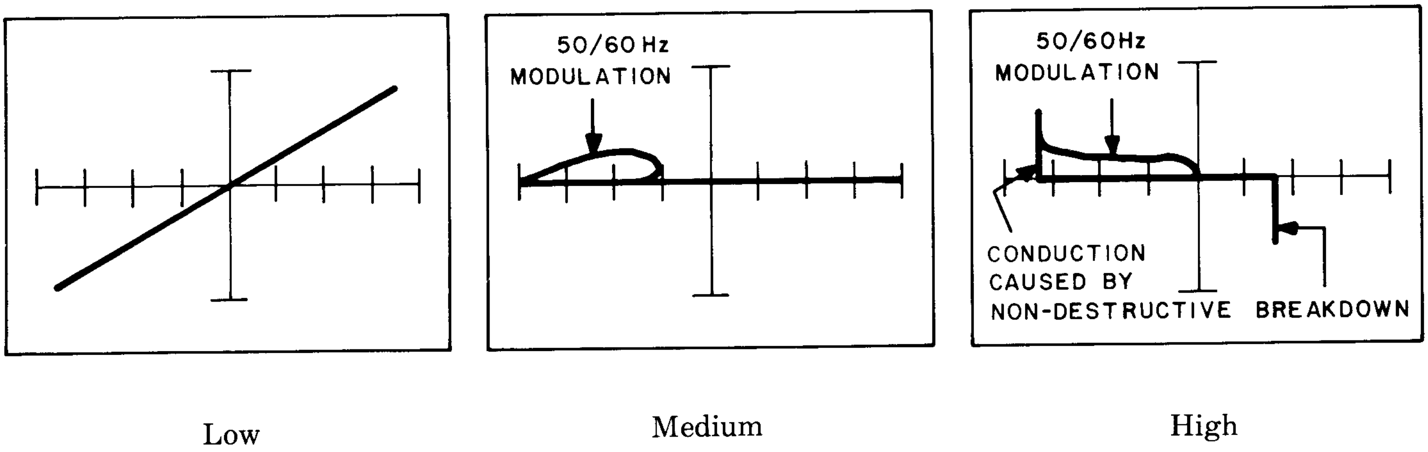


Figure 9-25. G-D signatures of an N-channel Enhancement Mode MOSFET (VN10KM)

9-25. MOSFET WITHOUT A PROTECTION DIODE, VN10LM

Figure 9-26 shows a Siliconix N-channel enhancement mode MOSFET (VN10LM). This device does not have a protection diode between the gate and source, and the substrate is internally connected to the source.

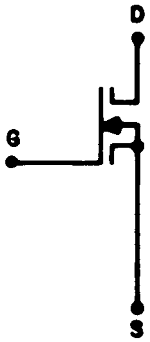


Figure 9-26. VN10LM MOSFET Without a Source to Gate Protection Diode.

The signatures of the Gate-Source connection and the signatures of the Drain-Gate connection are Open Circuit signatures. The Signatures of the Drain-Source connection are the same as the signatures of the Drain-Source connection of the VN10KM. The 2000 series Tracker with its pulse generator, is capable of dynamic testing of the VN10LM, thus giving a more accurate test.

9-26. UNIJUCTION TRANSISTORS (UJT)

The unijuction transistor, or double-base diode, has a small rod of P material extending into the block of N material which service as a P-N junction. Two metallic contacts, called bases, are welded to the N block without creating new juctions. Figure 9-27 shows the construction and symbol of the unijuction transistor.

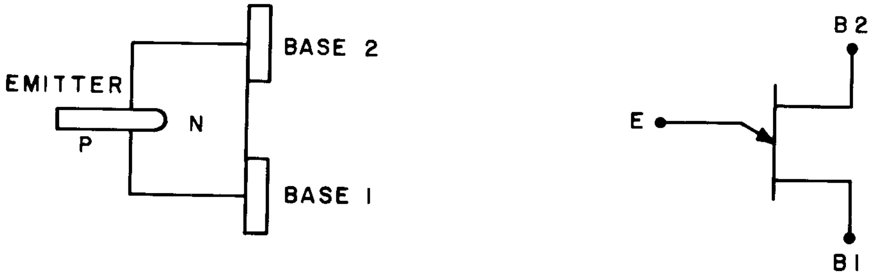


Figure 9-27. The Unijuction Transistor

9-27. Emitter-Base Connection

Figure 9-28 shows the test connections of the UJT and also the lead assignments for a 2N4871 device. Set the 1000 to the alternate mode and the low range, then verify a signature as shown in Figure 9-29 for diodes E-B1 and E-B2. (There is a slight difference in forward voltage drops between the diodes; the difference depends on the intrinsic standoff ration of the UJT).

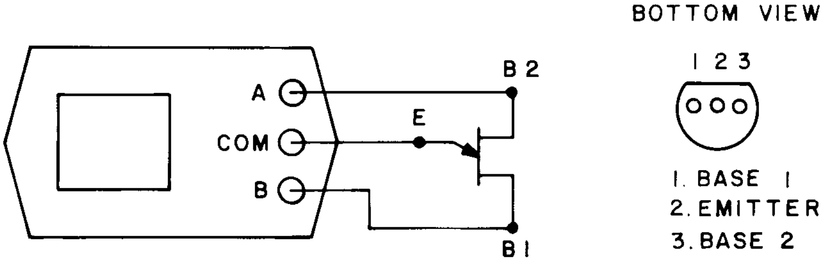


Figure 9-28. Test Circuit, Emitter-Base Junction—2N4871 Transistor

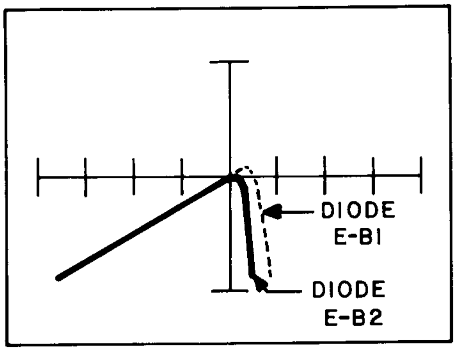
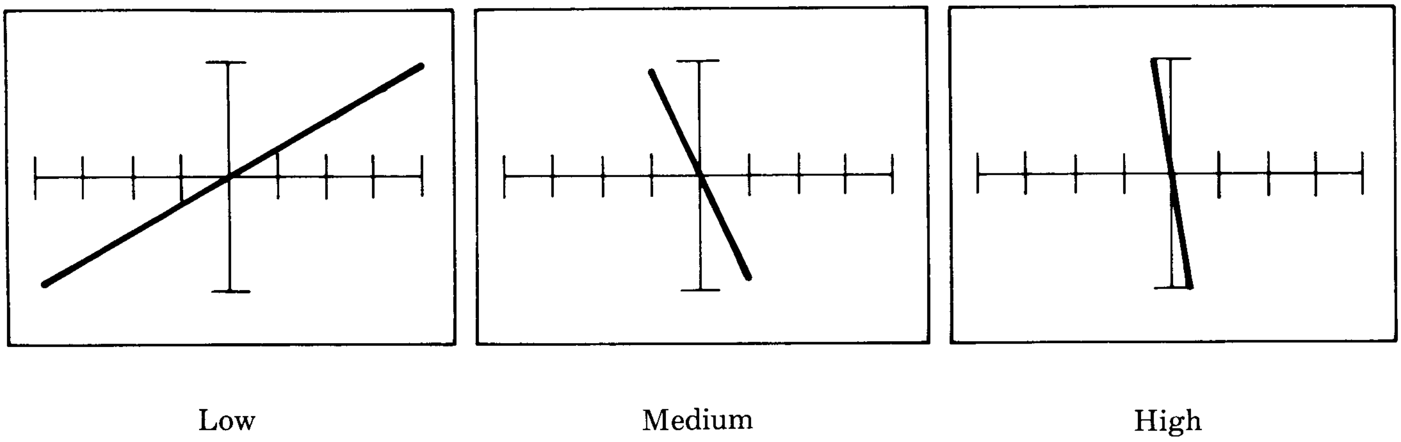


Figure 9-29. Low Range Signature for Diodes E-B1 and E-B2

9-28. B1 to B2 Connection

The signatures should be as shown in Figure 9-30 for B1 to B2 in all ranges.


Low

Medium

High

Figure 9-30. Signature for B1 to B2

SECTION 10

TESTING THYRISTORS AND OPTOCOUPLERS

10-1. SILICON CONTROLLED RECTIFIERS (SCRs)

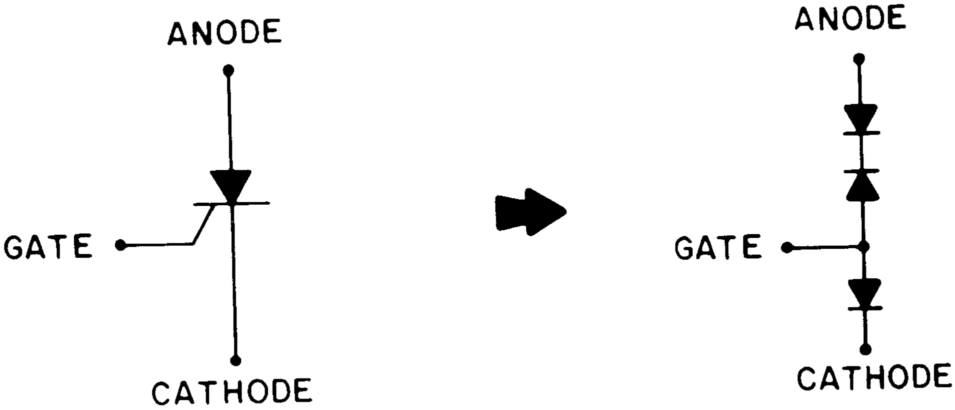
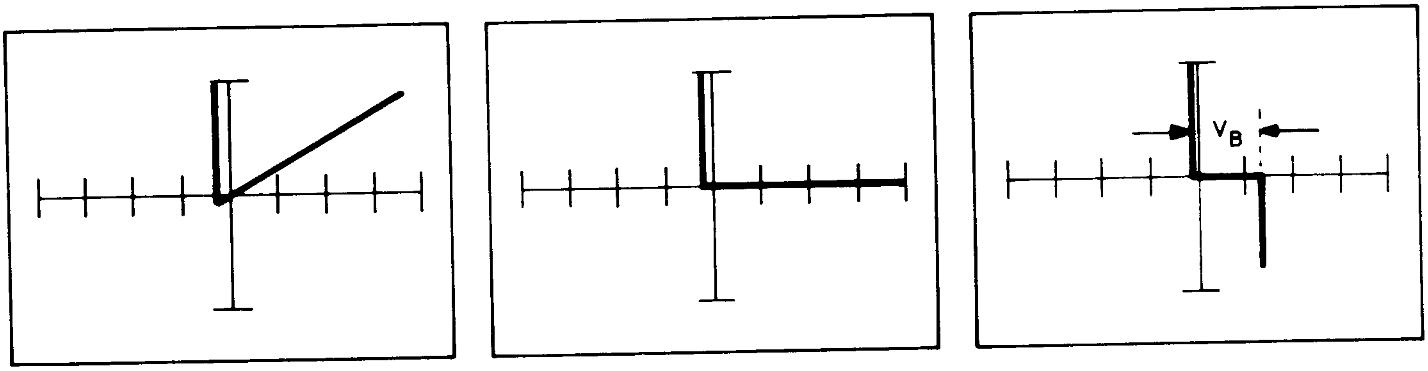


Figure 10-1. Silicon Controlled Rectifier

The symbol and equivalent circuit of a silicon controlled rectifier is shown in Figure 10-1. An SCR looks like a diode across its gate-cathode junction. If the 1000 is connected to the gate and cathode the diode signatures appear on the display as shown in Figure 10-2. Note that the gate-cathode breakdown voltage can be observed.



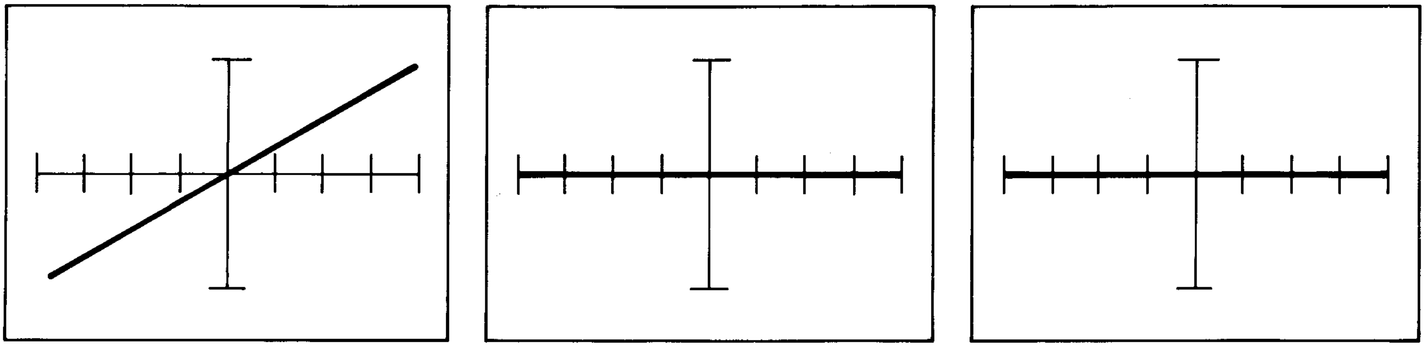
Low

Medium

High

Figure 10-2. Signatures Between Gate and Cathode of a C103 SCR

An SCR is like two diodes back to back across its gate-to-anode junction (See Figure 10-1). The 1000 displays these back to back diodes as an open circuit. The signatures for either Anode-Gate or Anode-Cathode junction are open circuit traces in all ranges as shown in Figure 10-3.



Low

Medium

High

Figure 10-3. Signatures Between Anode-Gate of Anode-Cathode of a C103 SCR

10-2. TRIAC DEVICES

The triac is a bidirectional thyristor that was developed to extend the positive or negative supply of an SCR and to allow firing on either polarity with either positive or negative gate current pulses. Figure 10-4 shows the construction and symbol of a triac.

Apply the probes to the TRIAC 2N6070 between the gate and the MT1. There are two diodes in parallel (See Figure 10-5). The resulting signatures are shown in Figure 10-6.

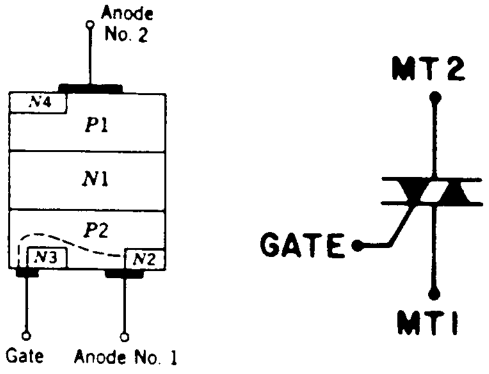


Figure 10-4. The Construction and Symbol of a Triac

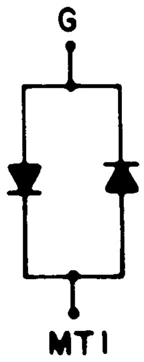
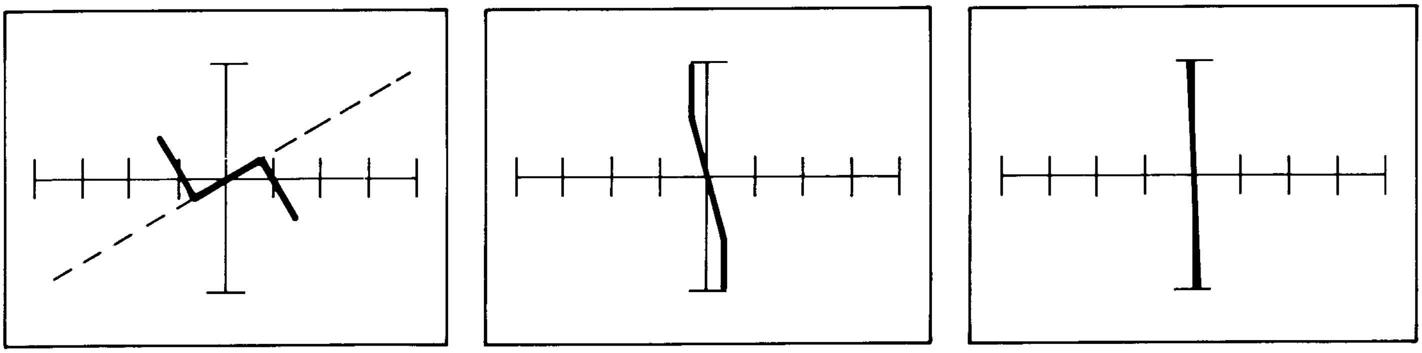


Figure 10-5. Gate-MT1 Equivalent Circuit

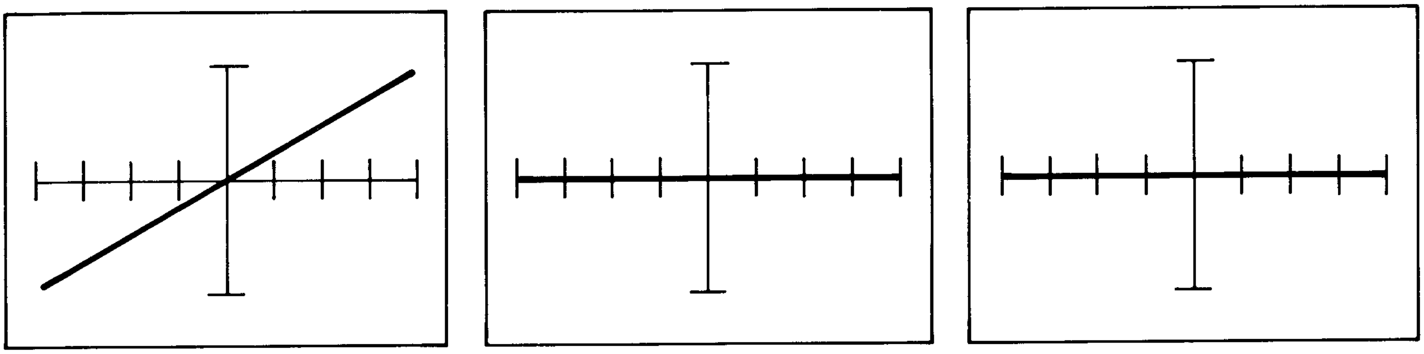

Low

Medium

High

Figure 10-6. Signatures Between Gate and MT1 of a 2N6070 Triac

Using either MT2 with Gate as Common or MT2 with MT1 as Common the 1000 should see an open circuit in all ranges as shown in Figure 10-7.


Low

Medium

High

Figure 10-7. Signatures Between MT2-Gate of MT1-MT2 of a 2N6070

10-3. OPTOCOUPLERS

The optocoupler (Optically Coupled Isolator, Photo-coupler) is a device designed for the tranformation of electrical signals by utilizing optical radiant energy so as to provide coupling with electrical isolation between the input and the output.

These devices consist of a gallium arsenide infrared light emitting diode and a silicon photodevice and provide high voltage isolation between separate pairs of input and output terminals. They include:

- Transistor optocoupler
- Darlington transistor optocoupler
- SCR optocoupler
- Triac optocoupler
- Photocell optocoupler

10-4. Transistor Optocoupler

The 4N25 transistor optocoupler consists of a gallium arsenide infrared light emitting diode coupled with a silicon phototransistor in a dual in line package.

Using the 1000 some data about optocouplers **can** be learned. The input LED of the optocoupler can be tested as a stand alone diode. Figure 10-8 shows the pin configuration of a 4N25. Figure 10-9 shows the signature of the LED part of a 4N25.

In a similar manner, the output NPN transistor can be tested by examining the signatures of base-emitter (Figure 10-10) and collector-emitter (Figure 10-11).

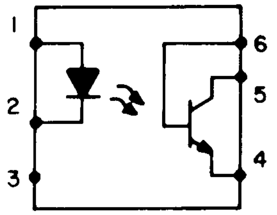
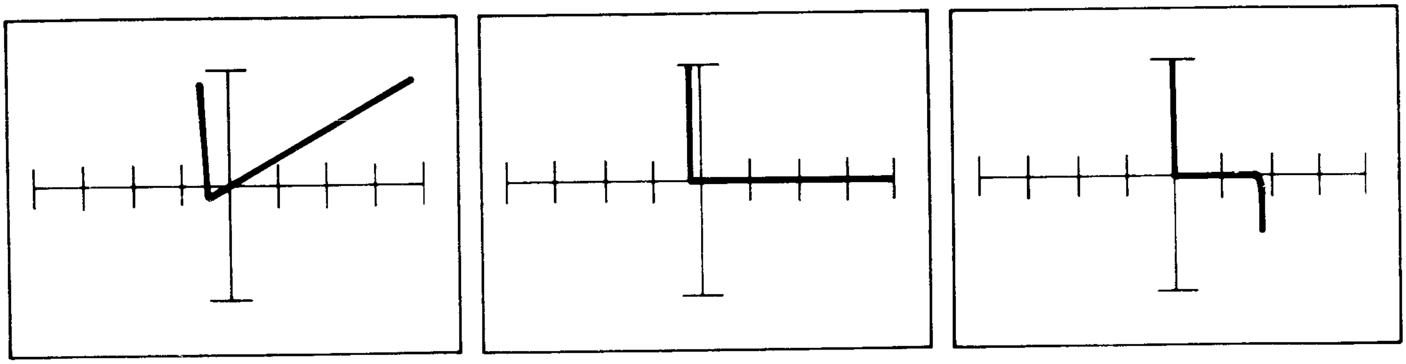
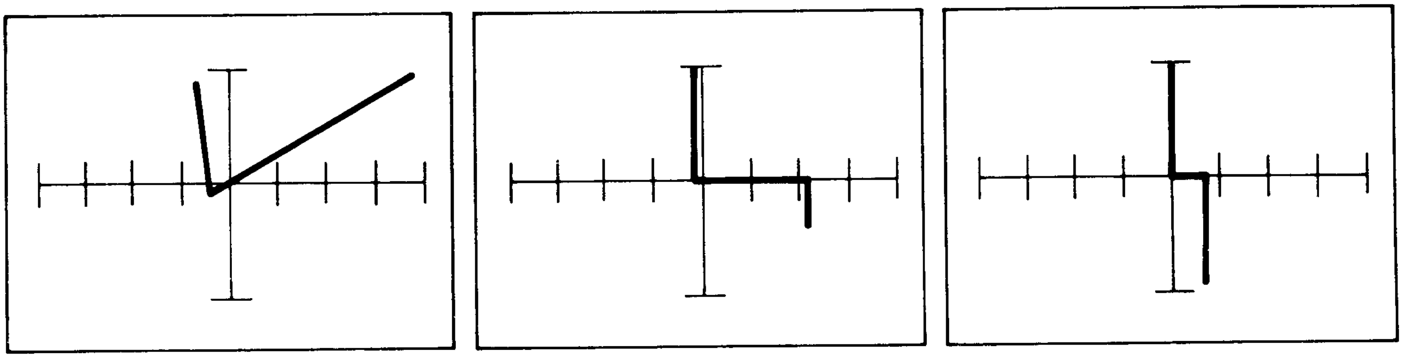


Figure 10-8. Pin configuration of a 4N25 Transistor Optocouler



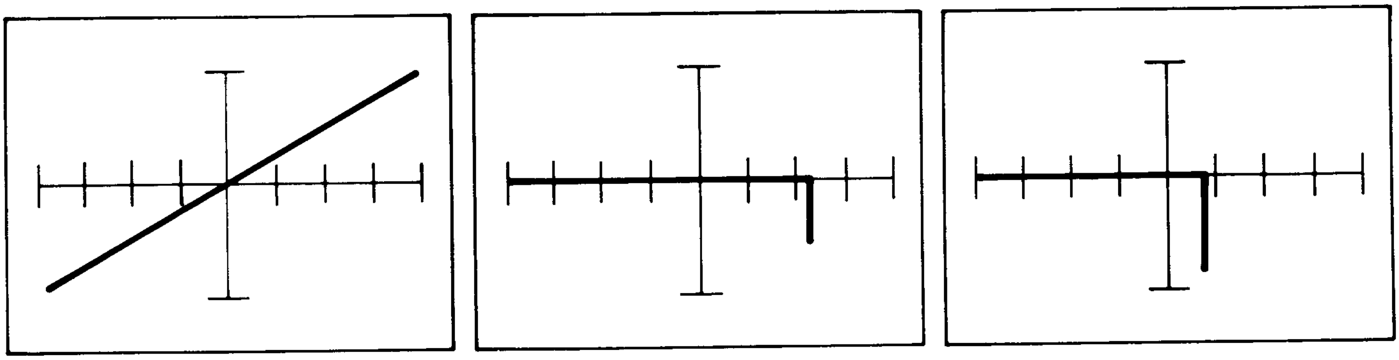
Low Medium High

Figure 10-9. Signatures of the LED of a 4N25



Low Medium High

Figure 10-10. Signatures of the Base-Emitter of a 4N25



Low Medium High

Figure 10-11. Signatures of the Collector-Emitter of a 4N25

10-5. Darlington Transistor Optocoupler

The darlington transistor optocoupler consists of a gallium arsenide infrared light emitting diode coupled with a silicon photodarlington transistor in a dual-in-line package. Figure 10-12 shows the pin configuration of a 4N31 darlington transistor optocoupler. The darlington adds the effects of an additional stage of transistor gain to the transistor optocoupler. The test mode of a 4N31 is similar to that of 4N25 discussed in the last section, and its signatures are shown in Figure 10-13 through 10-15.

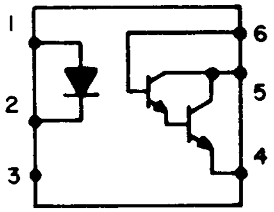
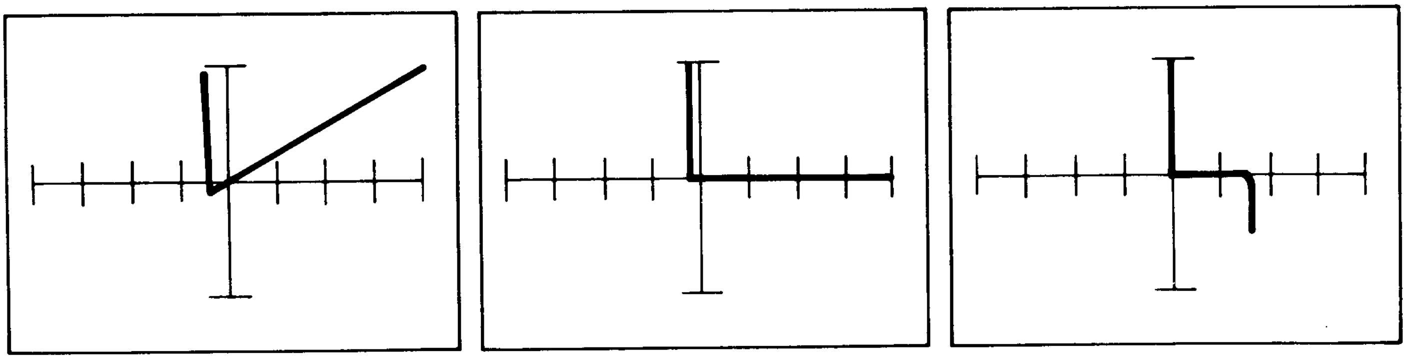


Figure 10-12. Pin configuration of a 4N31 Darlington Transistor Optocoupler

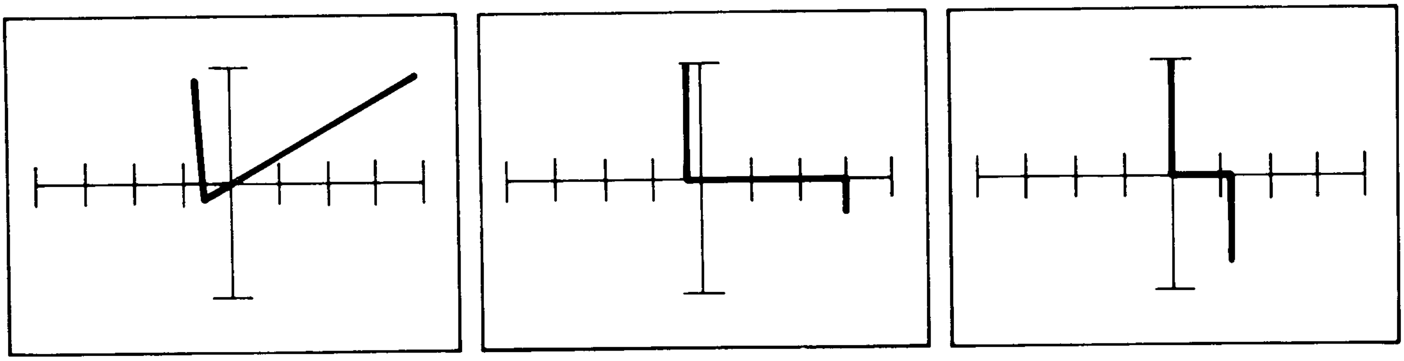


Low

Medium

High

Figure 10-13. Signatures of the LED Part of a 4N31

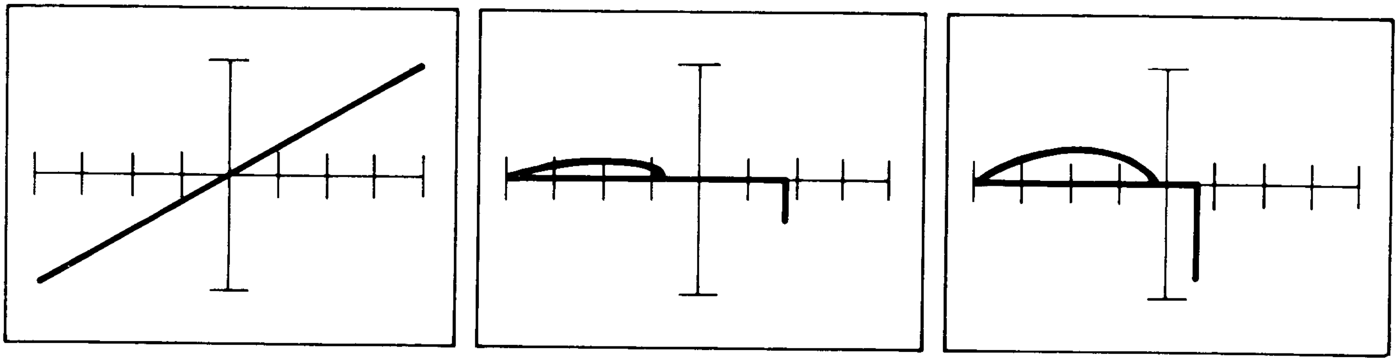


Low

Medium

High

Figure 10-14. Signatures of the Base-Emitter of a 4N31



Low

Medium

High

Figure 10-15. Signatures of the Collector-Emitter of a 4N31

The loops that appear in the medium and high range signatures in Figure 10-15 are caused by a 80Hz signal picked up by the base of the Darlington transistor.

10-6. SCR Optocouler

The GE H11C3 (for pin configuration see Figure 10-16) consists of a gallium arsenide infrared light emitting diode coupled with a light activated Silicon Controlled Rectifier in a dip package.

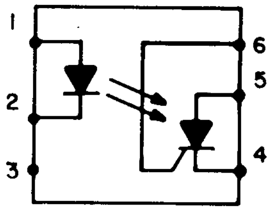
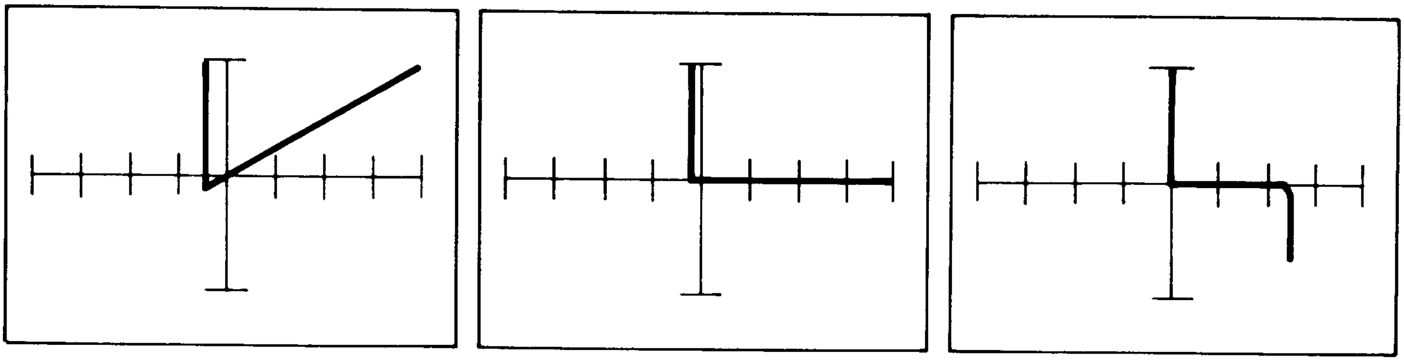


Figure 10-16. Pin Configuration of a H11C3 SCR Optocoupler

Figures 10-17 through 10-19 show the signatures of a H11C3.

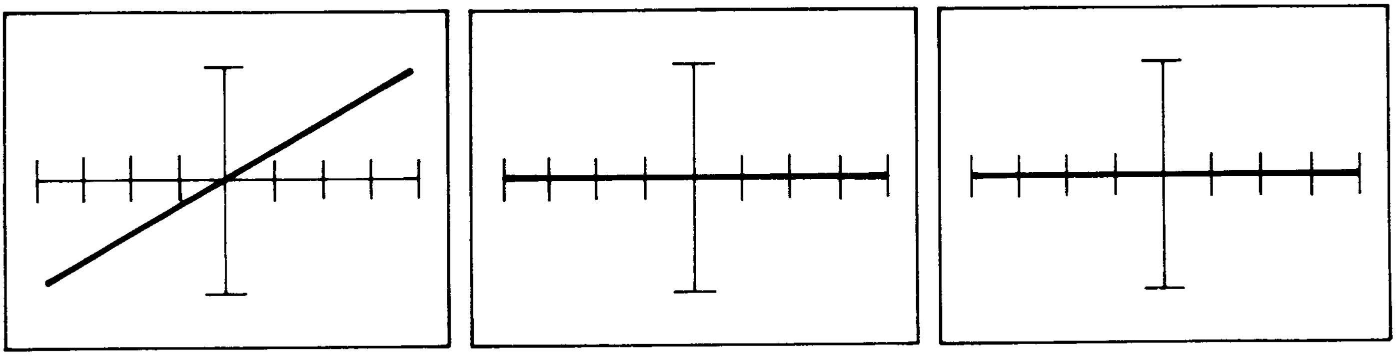


Low

Medium

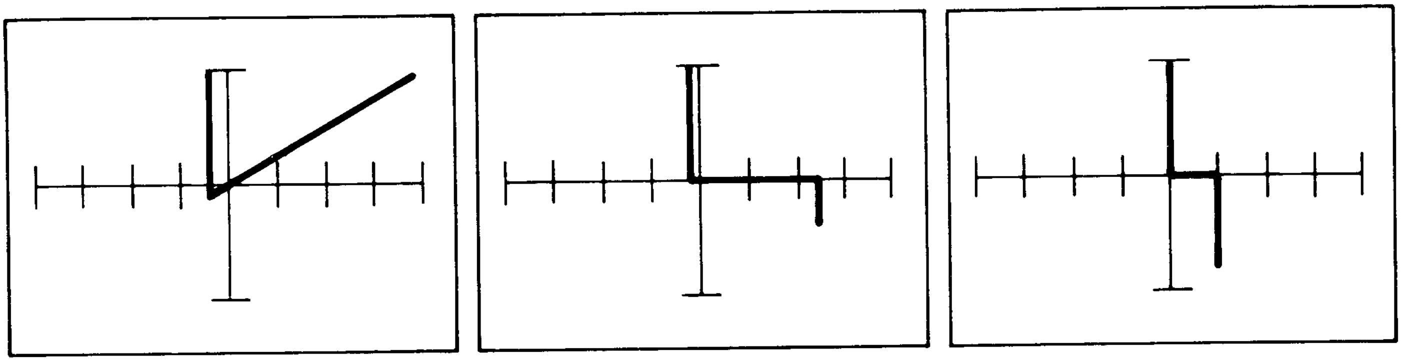
High

Figure 10-17. Signatures of the LED Part of a H11C3



Low Medium High

Figure 10-18. Signatures Between Cathode and Anode (Pin 4 and Pin 5) of a H11C3



Low Medium High

Figure 10-19. Signatures Between Gate and Cathode (Pin 6 and Pin 4) of a H11C3

10-7. Triac Optocoupler

The Motorola MOC3010 (for pin configuration see Figure 10-20) consists of a gallium arsenide infrared light emitting diode coupled with a light activated triac in a dip package.

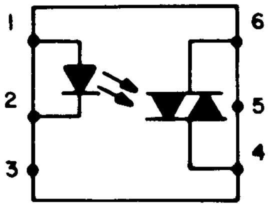
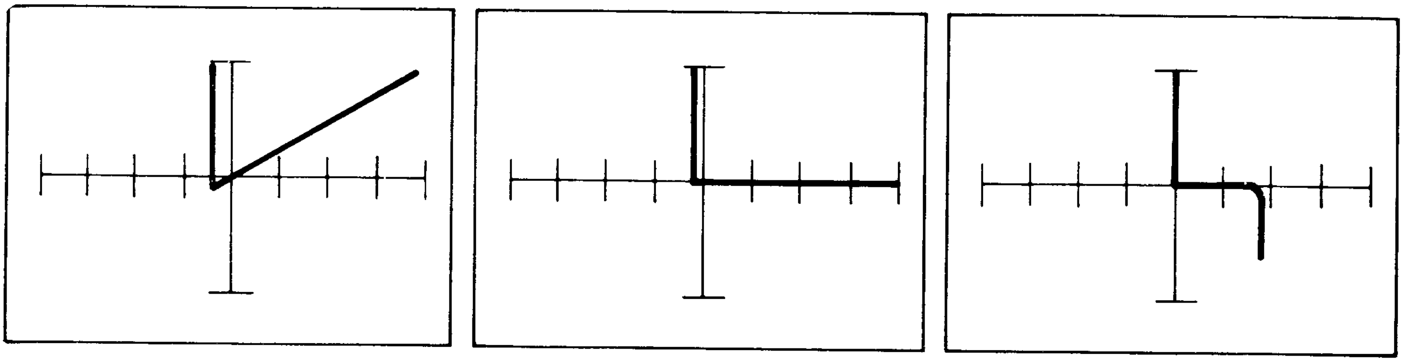


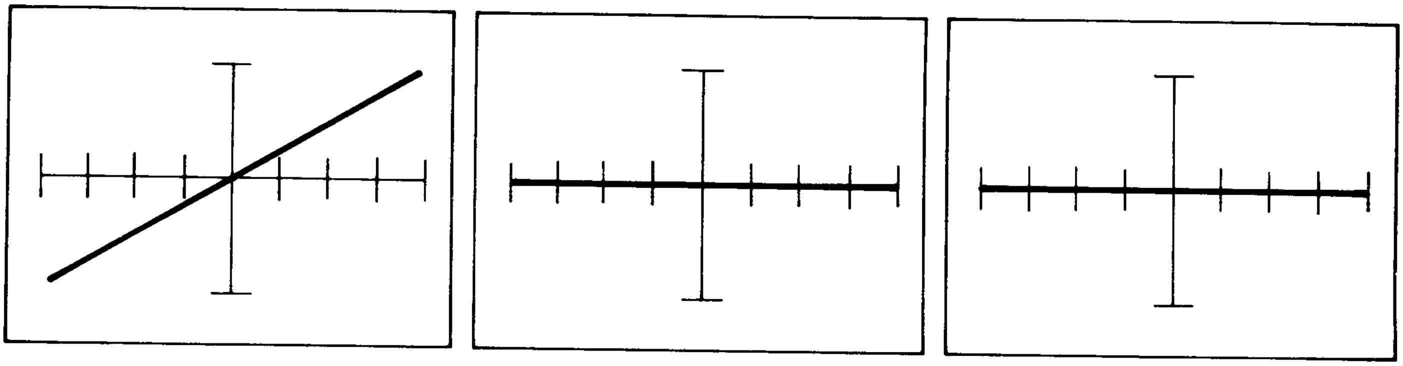
Figure 10-20. Pin Configuration of a MOC3010 Triac Optocoupler

The signatures of a MOC3010 are shown in Figure 10-21 through 10-22.



Low Medium High

Figure 10-21. Signatures of the LED Part (Pin 1 and Pin 2) of a MOC3010



Low Medium High

Figure 10-22. Signatures of the Triac Part (Pin 6 and Pin 4) of a MOC3010

10-8. Photocell Optocoupler

The Clairex CLM51 photocell optocoupler consists of a gallium arsenide infrared light emitting diode coupled to a symmetrical bilateral photoconductive cell. The cell is electrically isolated from the input. Figure 10-23 shows the pin configuration of a CLM51. The off resistance of the cell is in excess of 1 megohm, thus it appears as open circuit to the 1000.

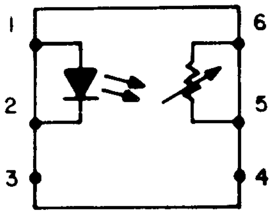
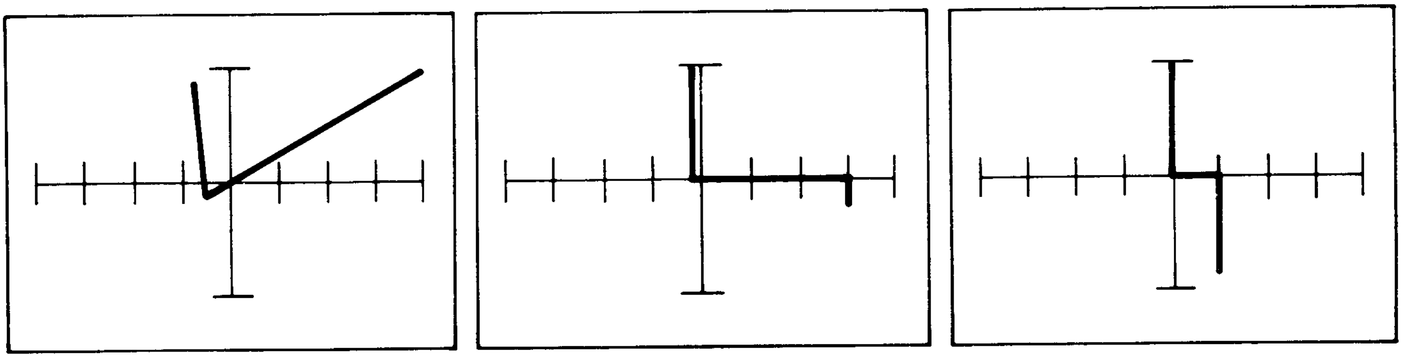


Figure 10-23. Pin Configuration of a CLM51 Photocell Optocoupler

The signatures of a CLM51 are shown in Figure 10-24 and Figure 10-25.

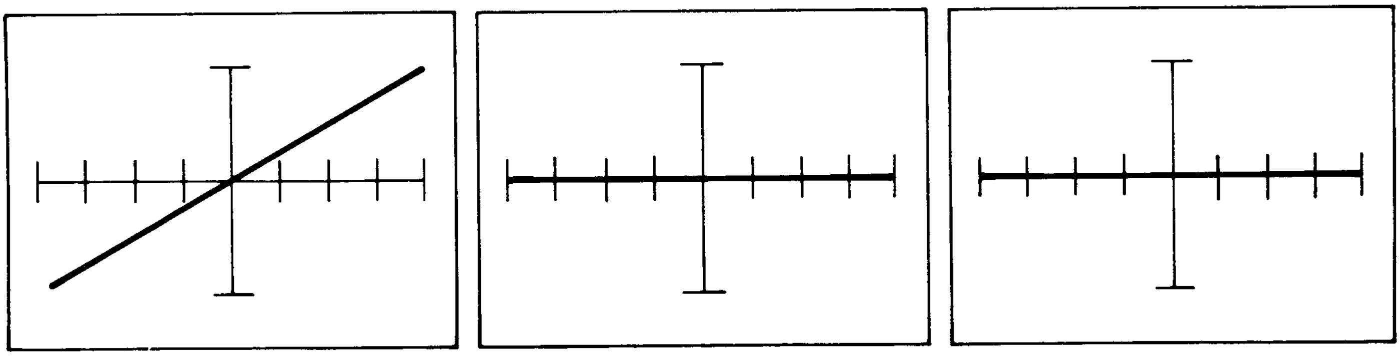


Low

Medium

High

Figure 10-24. Signatures of the LED Part (Pin 1 and Pin 2) of a CLM51



Low

Medium

High

Figure 10-25. Signatures of the Cell (Pin 6 and Pin 5) of a CLM51

SECTION 11
TESTING MULTIPLE COMPONENT CIRCUITS

11-1. 1000 DIAGNOSTIC PRINCIPLES

The preceeding sections discussed in detail the signatures for diodes, transistors, resistors, capacitors, and inductors. Section 11 examines circuits formed by multiple components, such as diodes in series or in parallel with a resistor etc. It is very important for users to understand composite circuit signatures prior to printed circuit board level troubleshooting. Based on the information contained in the previous sectons, the following diagnostics are presented in table 11-1.

Table 11-1. Diagnostic table

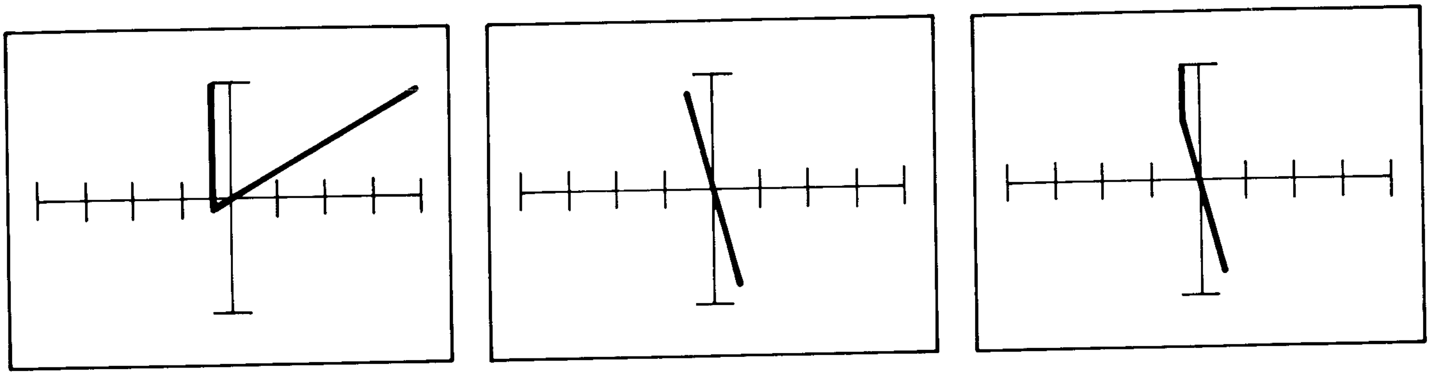
COMPONENTS	RANGE	SIGNATURE DESCRIPTION
Open circuit	Low	Diagonal line
	Medium, High	Horizontal line
Short circuit	All	Vertical line
Resistor	Low	Straight lines rotated clockwise from diagonal line
	Medium, High	Straight lines rotated clockwise from horizontal line
Diode	Low	Check mark
	Medium, High	"L" shape
Capacitor	All	Ellipse or circle
Inductor	All	Ellipse or circle

11-2. DIODE/RESISTOR CIRCUITS

When testing diode/resistor circuits, the test signature on the 1000 depends on whether the diode is in series or in parallel with a resistor, the value of the resistor, and the selected range.

11-3. Diode in Parallel With a Resistor

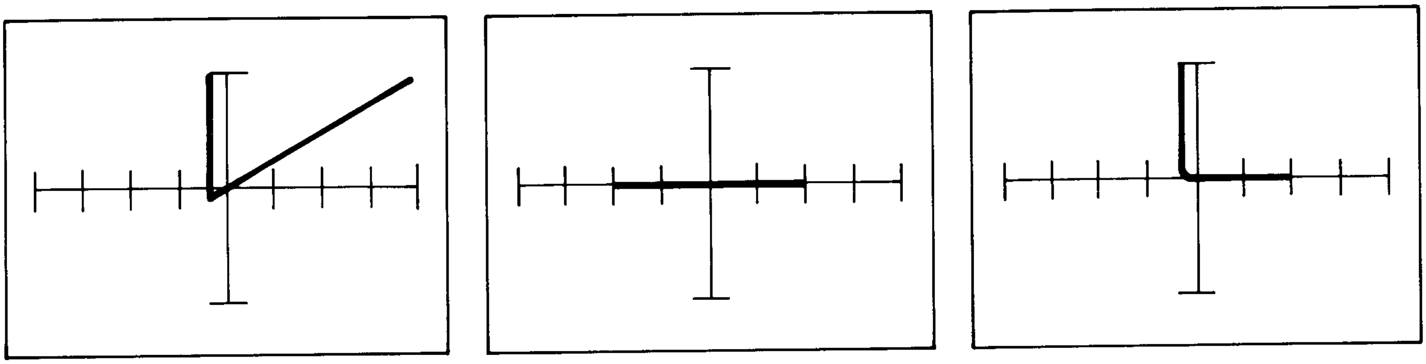
Figure 11-1 shows the effect of various resistance values on a diode (1N4001) signature with the low range selected on the 1000. When the value of the resistor is over 1K ohm, it contributes little to the signature, and the 1000 displays mainly the diode effect. On the other hand, resistances of less than 5 ohms dominate the signature.



Diode Only

10 ohm Resistor Only

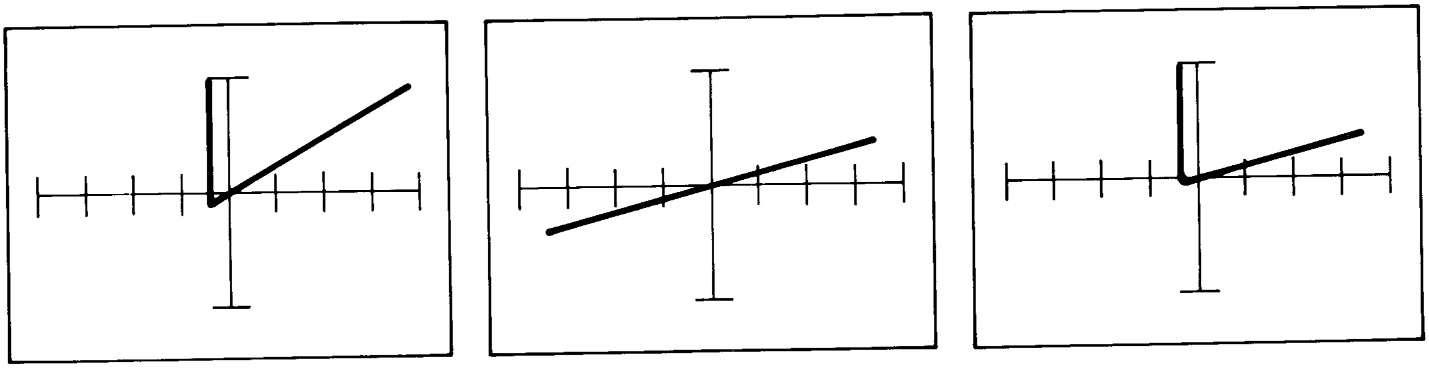
Diode and 10 ohm Resistor



Diode Only

50 ohm Resistor Only

Diode and 50 ohm Resistor



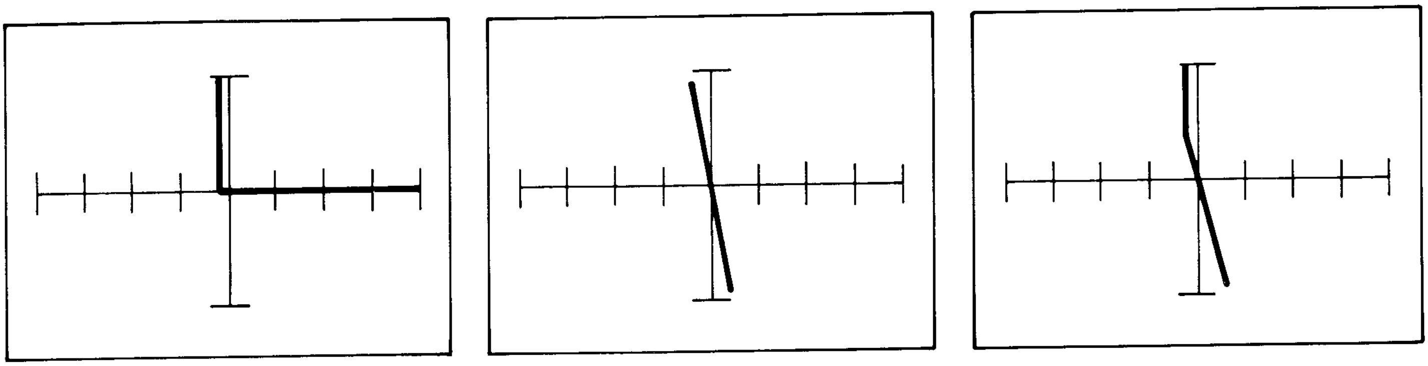
Diode Only

200 ohm Resistor Only

Diode and 200 ohm Resistor

Figure 11-1. Parallel Diode/Resistor Signatures—Low Range

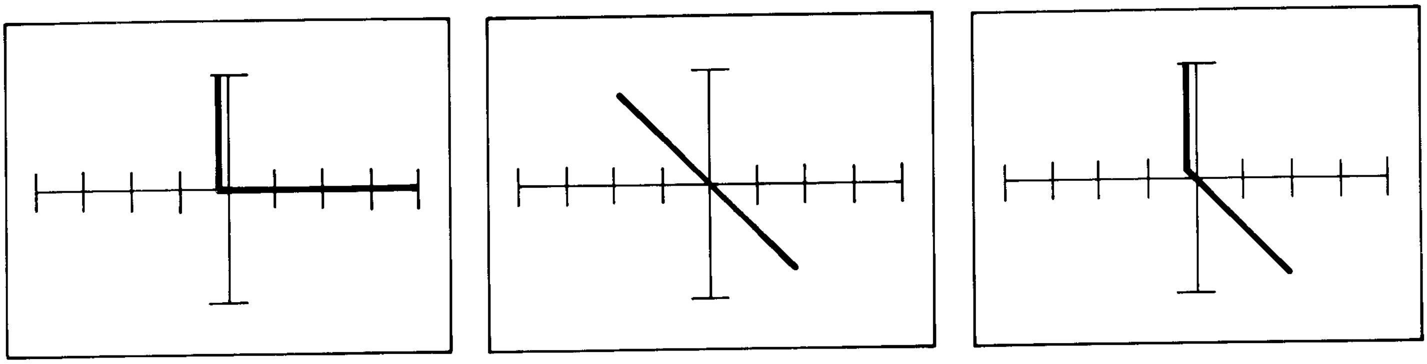
Figure 11-2 shows the signatures for various resistors in parallel with the diode and the medium range selected on the 1000. Resistors with values greater than 50K have insignificant influence on the diode signature. For resistors of less than 500 ohms, the signature is dominated by the resistor, while the diode contributes little. The high range of the 1000 provides signatures similar to that of the medium range, except that it covers higher resistance values.



Diode Only

2K ohm Resistor Only

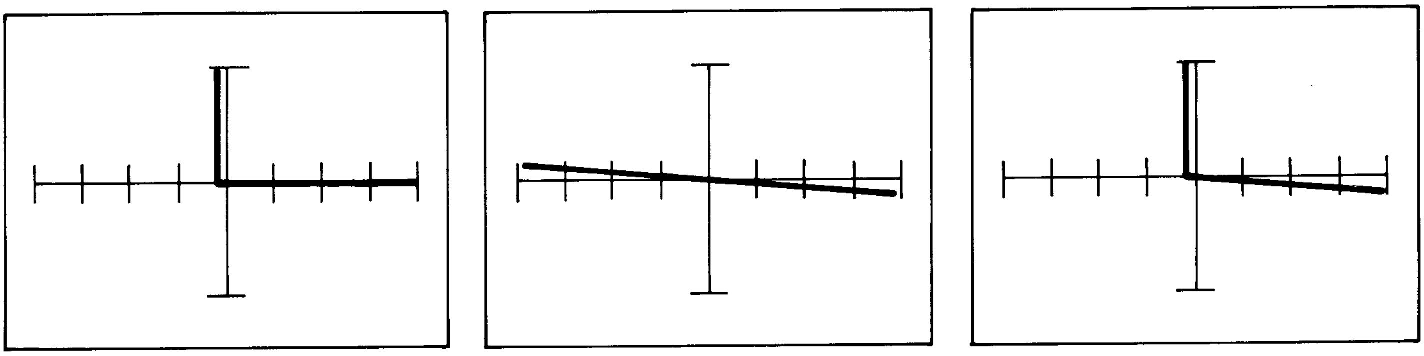
Diode and 2K ohm Resistor



Diode Only

15K ohm Resistor Only

Diode and 15K ohm Resistor



Diode Only

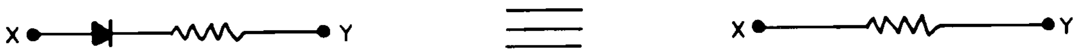
150K ohm Resistor Only

Diode and 150K ohm Resistor

Figure 11-2. Parallel Diode/Resistor Signatures—Medium Range

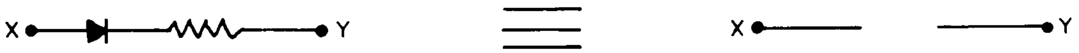
11-4. Diode in Series With a Resistor

When the diode is forward biased, it is in a low impedance state and the 1000 diplays only the resistor. However, if the diode is reverse biased, the series circuit appears as an open circuit to the 1000. Figure 11-3 shows the equivalent circuits for the diode resistor series combination when forward and reverse biased.



Actual Circuit

Equivalent Circuit when Diode
is Forward Biased

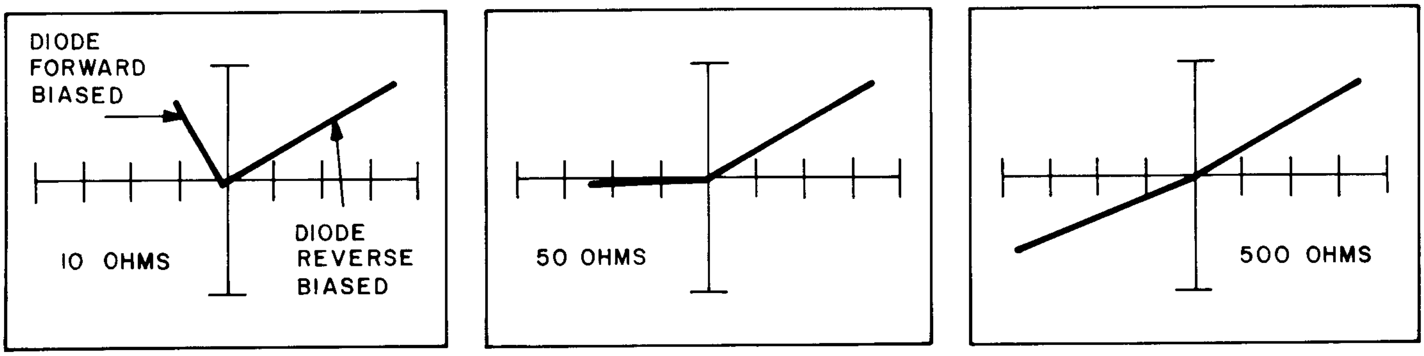


Actual Circuit

Equivalent Circuit when Diode
is Reversed Biased

Figure 11-3. Diode/Resistor Equivalent Circuits

Figures 11-4, 11-5 and 11-6 show the 1000 signatures for various values of resistors in series with a diode while operating in the low, medium and high ranges.

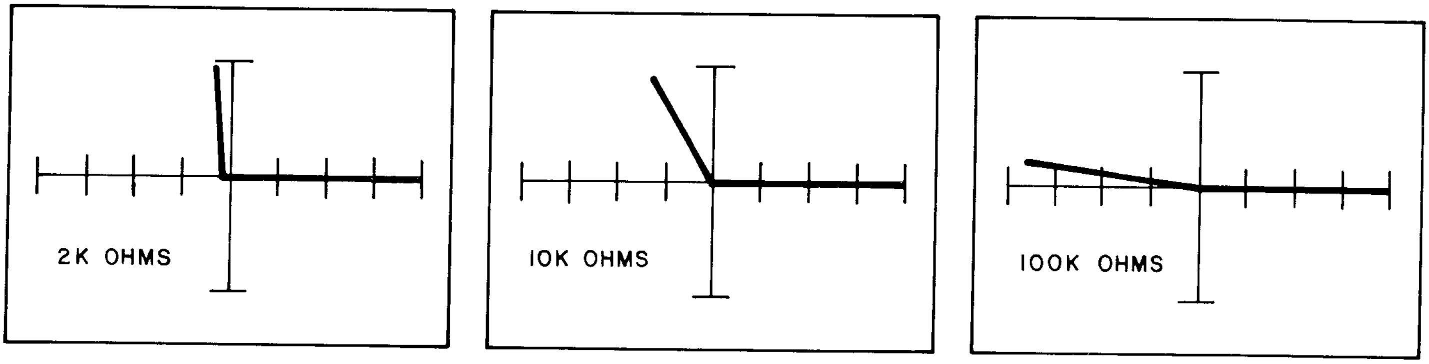


10 ohm Resistor

50 ohm Resistor

500 ohm Resistor

Figure 11-4. Low Range Signatures for Various Resistors and Series Diode

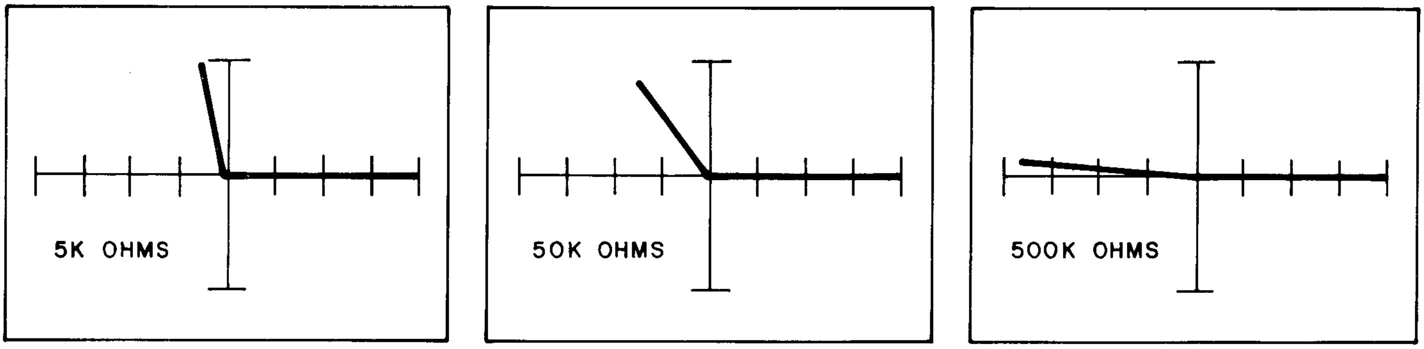


2K Resistor

10K Resistor

100K Resistor

Figure 11-5. Medium Range Signatures for Various Resistors and Series Diode



5K Resistor

50K Resistor

500K Resistor

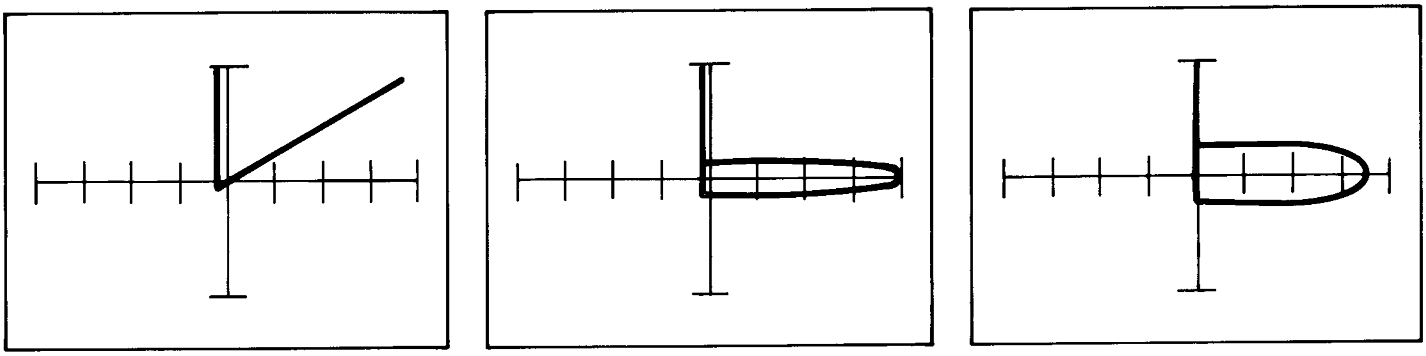
Figure 11-6. High Range Signatures for Various Resistors and Series Diode

11-5. DIODE AND CAPACITOR PARALLEL COMBINATION

Figures 11-7 through 11-9 show the 1000 displays for different values of capacitance with all three 1000 ranges. In Figure 11-10, the 100uF capacitor causes a vertical trace in the medium and high range regardless of the diode.

Capacitors having values higher than 1000uF dominate the signature and diode effect is negligible. In such a case, the medium and high ranges produce a vertical trace while the low range yields a small ellipse. Refer to figure 11-11, which shows the effect of a 2200uF capacitor in parallel with a diode.

NOTE: CAPACITOR HAS NO EFFECT ON LOW RANGE SIGNATURES

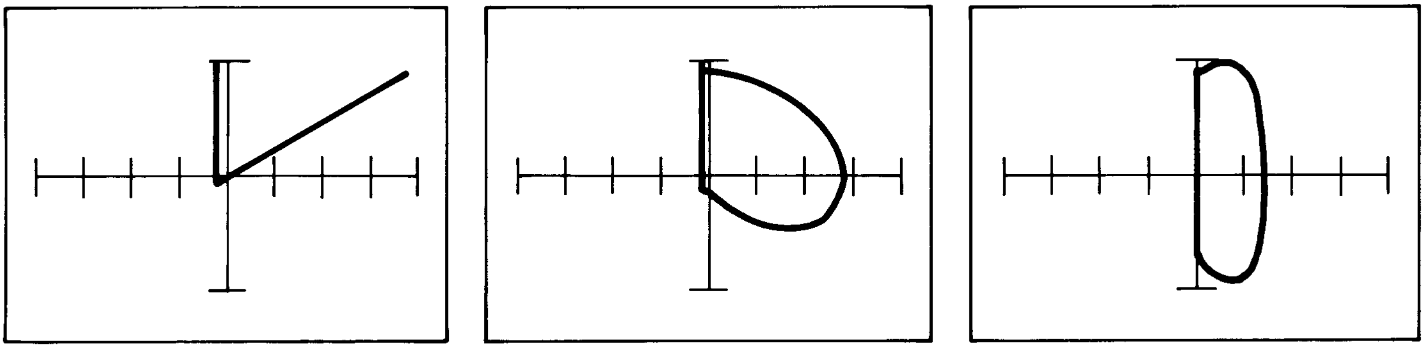


Low

Medium

Figure 11-7. Diode and a 0.01uF Capacitor

NOTE: CAPACITOR HAS NO EFFECT ON LOW RANGE SIGNATURES



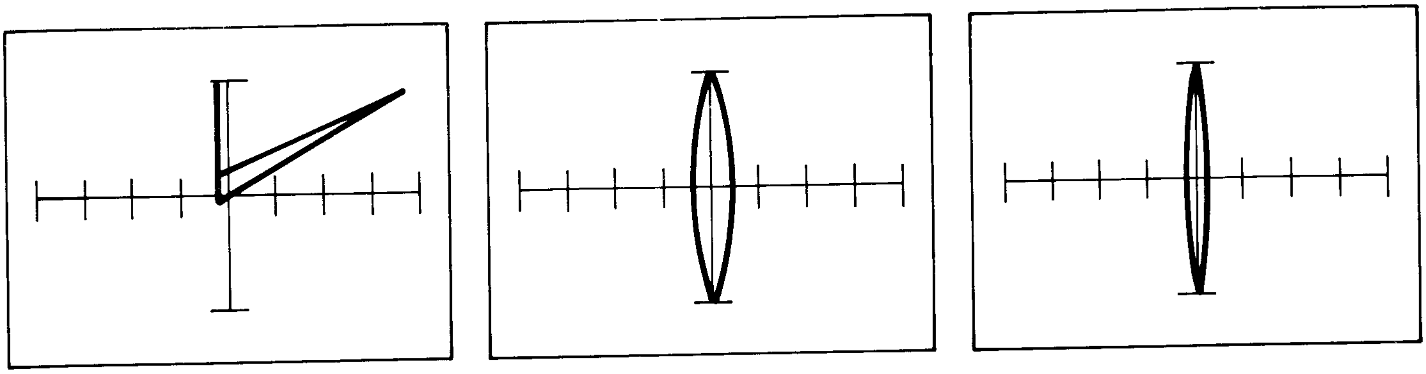
Low

Medium

High

Figure 11-8. Diode and a 0.1uF Capacitor

NOTE: DIODE HAS LITTLE EFFECT ON THE MEDIUM AND HIGH RANGE SIGNATURES

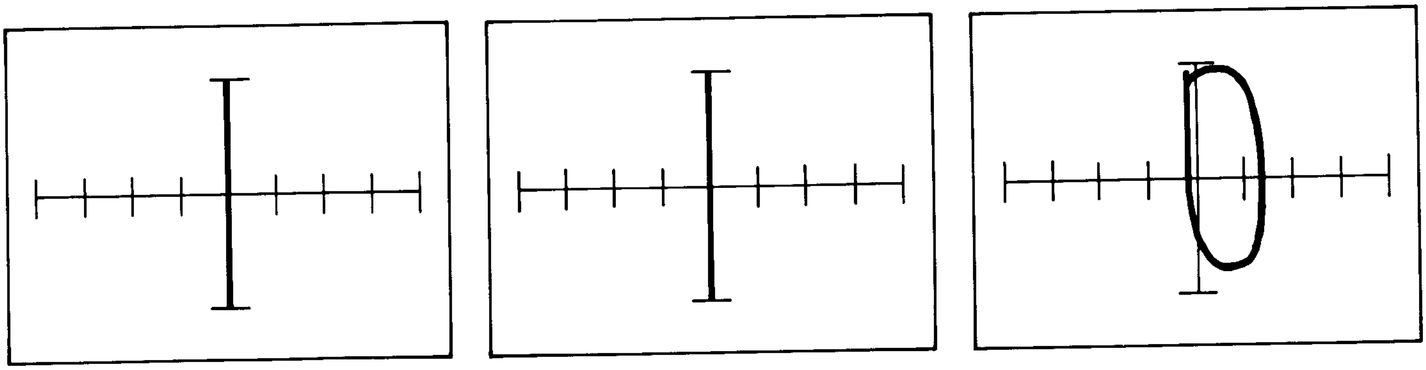


Low

Medium

High

Figure 11-9. Diode and a 1.0uF Capacitor

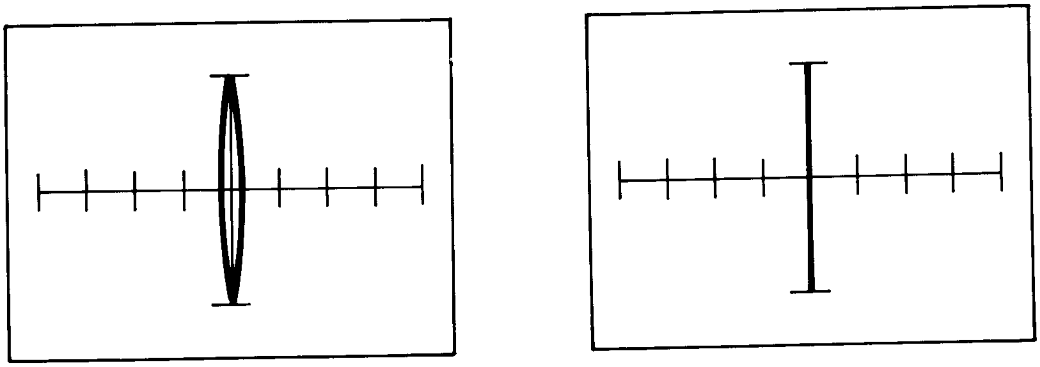


Low

Medium

High

Figure 11-10. Diode and a 100uF Capacitor



Medium/High

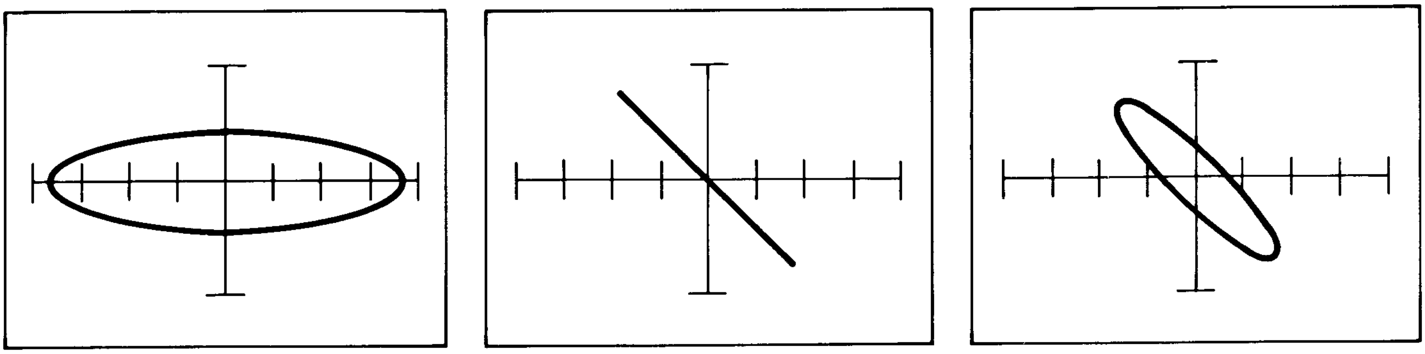
Low

Figure 11-11. Diode and a 2200uF Capacitor

11-6. RESISTOR AND CAPACITOR PARALLEL COMBINATION

As previously discussed, a capacitor produces an ellipse, and a resistor produces trace rotation and amplitude reduction. Consequently, a resistor reduces the size of an ellipse and causes its major axis to rotate. The magnitude of the angle is determined by the value of the resistor and the range selected on the 1000.

Figure 11-12 shows the effect of a 51K resistor on a .1uF capacitor (rotation and shrinkage of the ellipse).



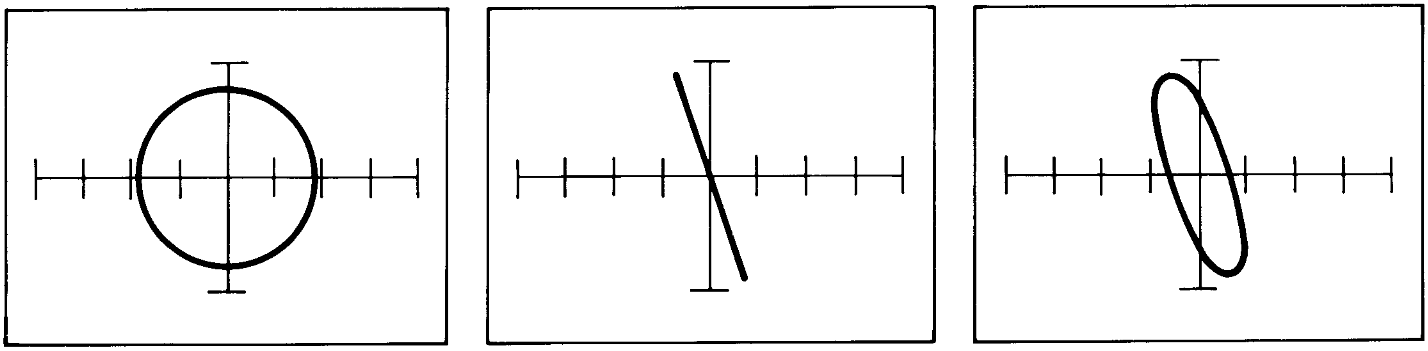
.1uF Capacitor only

51K Resistor only

Capacitor and Resistor
in Parallel

Figure 11-12. Effects of a 51K ohm Resistor on a 0.1uF Capacitor in the High Range

Figure 11-13 shows the effect of a 5K resistor on .1uF capacitor.



.1uF Capacitor only

5K Resistor only

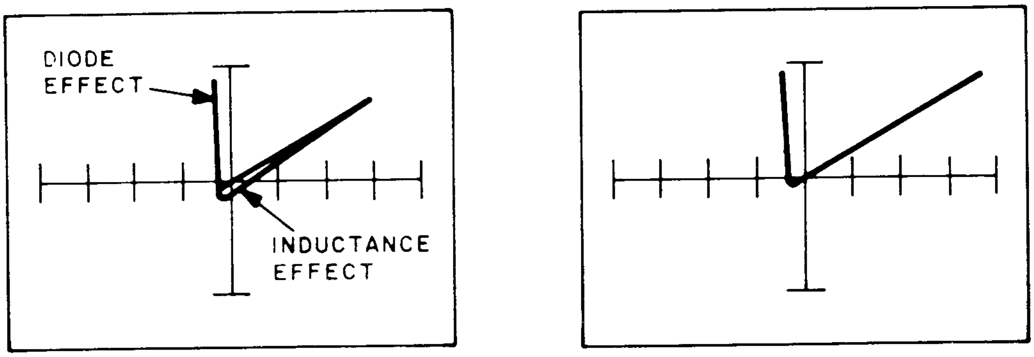
Capacitor and Resistor
in Parallel

Figure 11-13. Effect of a 5K Resistor on a .1uF capacitor in the Medium Range

11-7. INDUCTOR IN PARALLEL WITH A DIODE

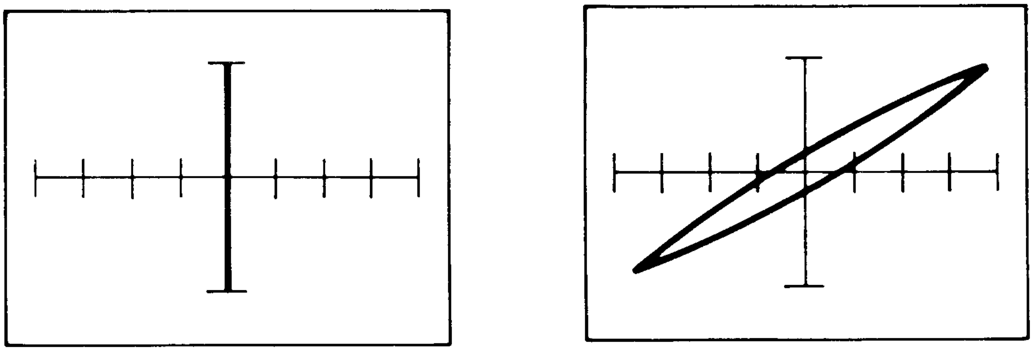
This type of circuit is found in relays and line printers. The diode supresses the high voltage "kick" produced when the inductor or coil is de-energized.

Figure 11-14 displays signatures of a 1N4001 diode in parallel with an Aromat Relay HB1E-DC12.



Good Circuit

Open Coil



Open Diode

Shorted Diode

Figure 11-14. Signatures of a 1N4001 diode in Parallel with an Aromat Relay HB1E-DC12 in Low Range.

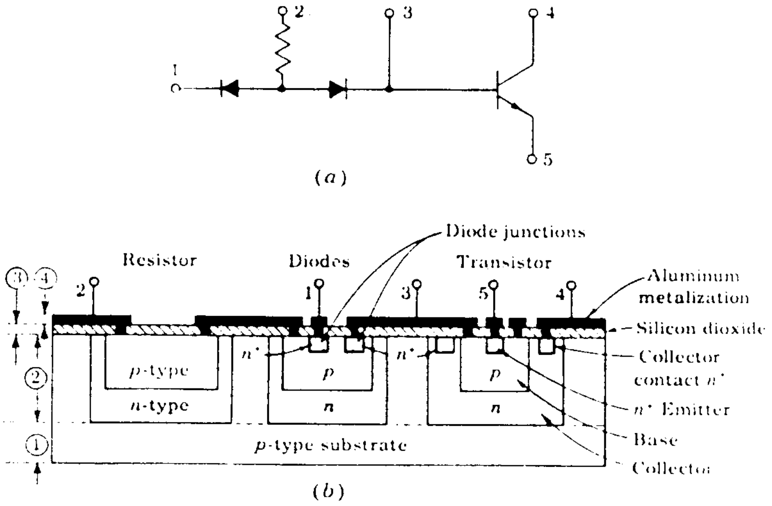
SECTION 12
TESTING INTEGRATED CIRCUITS

12-1. INTRODUCTION

12-2. Integrated Circuit Technology

An integrated circuit consists of a single crystal chip of silicon, typically 50 x 50 mils in cross-section, containing both active and passive elements, plus their interconnections. Such circuits are produced by the same processes used to fabricate individual transistors and diodes. These processes include epitaxial growth, masked impurity diffusion, oxide growth, and oxide etching, using photolithography for pattern definition.

The basic structure of an integrated circuit is shown in Figure 12-1, and consists of four distinct layers of material. The bottom layer (1) (6 mils thick) is P-type silicon and serves as a substrate upon which the integrated circuit is to be built. The second layer (2), typically 25 mils thick, is an N-type layer which is grown as a single-crystal extension of the substrate. All components are built within the N-type layer using a series of diffusion steps. The third layer of material (3) is silicon dioxide, and it also provides protection of the semiconductor surface against contamination. Finally, a fourth metallic (aluminum) layer (4) is added to supply the necessary interconnections between components.



(*a*) A circuit containing a resistor, two diodes, and a transistor. (*b*) Cross-sectional view of the circuit in (*a*) when transformed into a monolithic form (not drawn to scale). The four layers are ① substrate, ② *n*-type crystal containing the integrated circuit, ③ silicon dioxide, and ④ aluminum metalization.

Figure 12-1. Typical Integrated Circuit Construction

12-3. Integrated Circuit Testing Techniques

This manual has discussed the techniques of testing resistors, capacitors, inductors, diodes, and transistors. All these techniques can be applied to test integrated circuits. The signatures produced across any two pins of an integrated circuit is the resultant effect of resistors, diodes, transistors, and capacitors. Apply the 1000 probes between two pins on an integrated circuit to display the resultant signature of these composite components.

This section provides information related to testing the following devices:

- Linear operational amplifiers
- Linear voltage regulators
- 555 timers
- TTL digital ICs
- Low power Schottky digital ICs
- CMOS digital ICs
- MOS static RAMs
- EPROMs
- Bipolar PROMs
- Digital-to-Analog converters
- Microprocessors

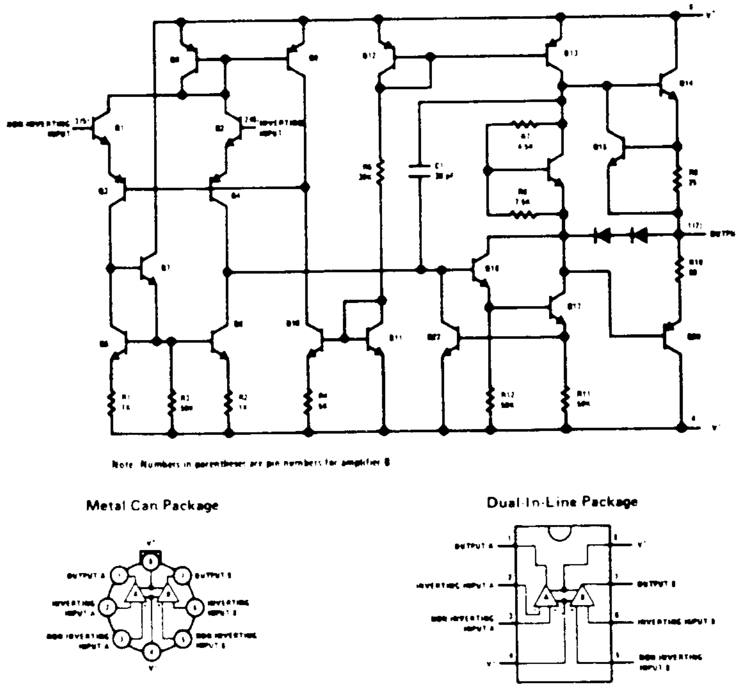
To test an integrated circuit, the 1000 probes are applied to two pins at a time. Since the typical integrated circuit has many pins, the number of possible testing combinations becomes very large; for example, a 16 pin device has 240 possible two pin combinations. It becomes impractical to test all possibilities, and our experience has shown that it is adequate to test the input and output pins with respect to V+ and V− in order to determine whether a device is good or bad.

12-4. LINEAR OPERATIONAL AMPLIFIERS

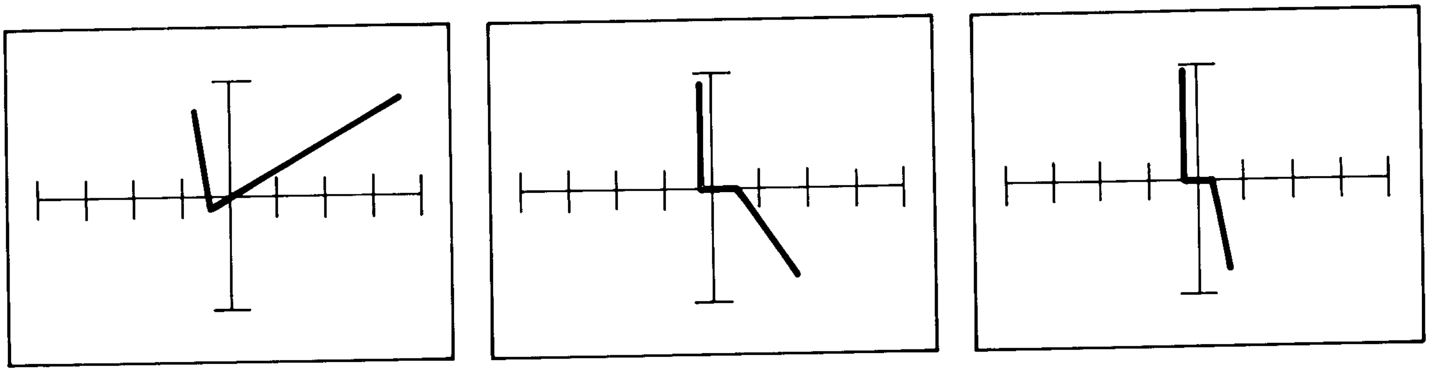
When checking an analog device or circuit, the low range is used most of the time. Analog circuits have many more single junctions to examine. Analog flaws are easier to detect in the low range. The 55 ohm internal impedance of the low range makes it less likely that other components, in parallel with the device under test, will load the 1000 sufficiently to modify the signatures produced if the device were tested out of circuit.

When checking an op amp in-circuit, it is almost mandatory to do a direct comparison with a known good circuit because the many different feedback loops associated with op amps may cause an almost infinite number of signatures. Figure 12-2 shows the schematic and connection diagram of a National Semiconductor 1458 Op Amp.

Figures 12-3 through 12-6 show the signatures between pin 8 (V+) and other pins of the LM1458, while Figures 12-7 through 12-9 show the signatures between pin 4 (V−) and the other pins.



Figures 12-2. The LM1458 Op Amp, Schematic and Connections

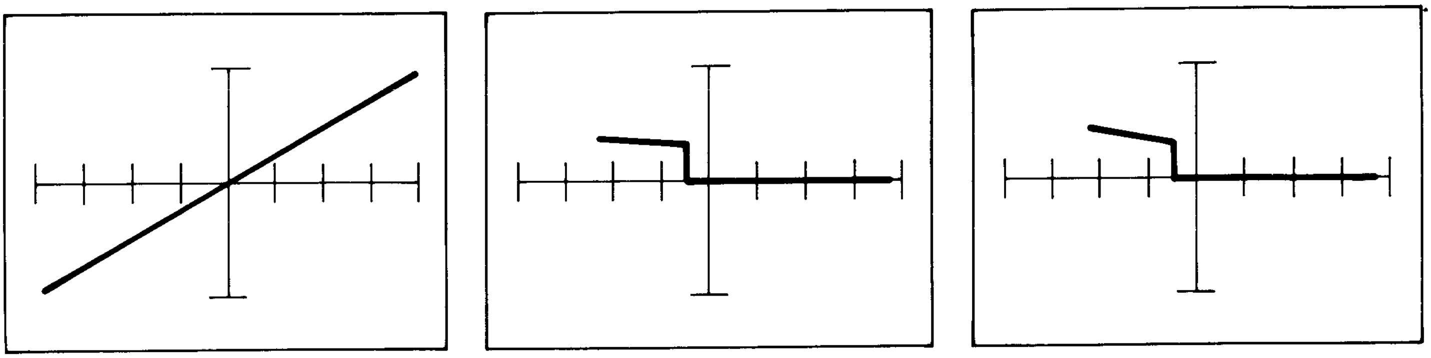


Low

Medium

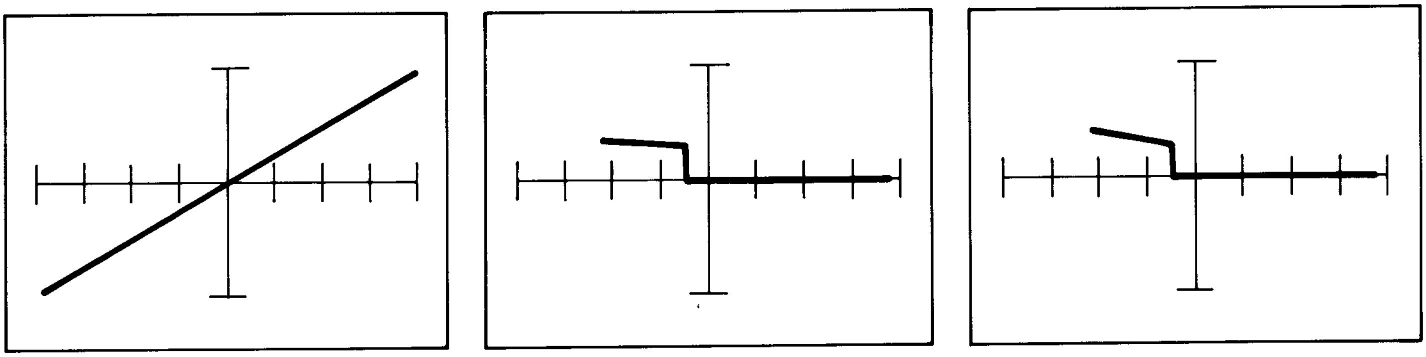
High

Figures 12-3. Signatures Between Pin 4 (V−) and Pin 8 (V+) of an LM1458.



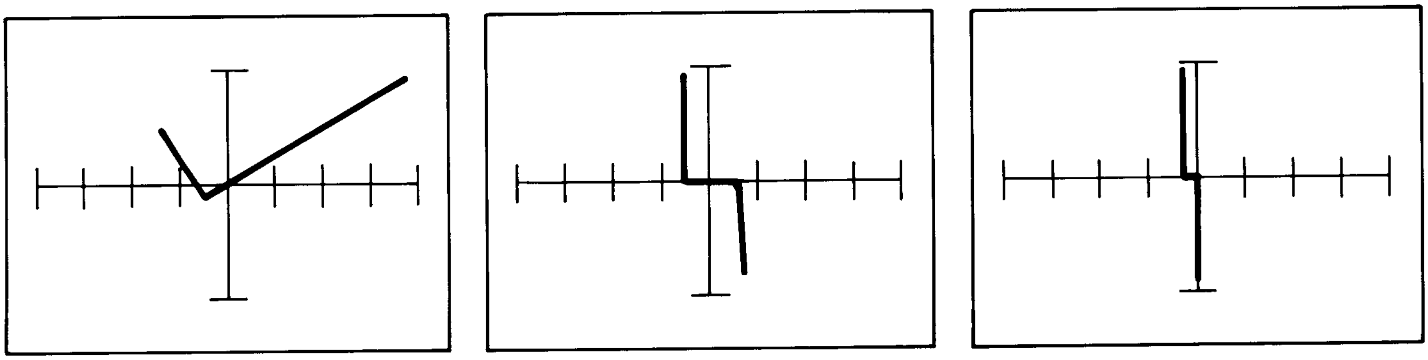
Low Medium High

Figure 12-4. Signatures Between Pin 2 (Inverting Input) and Pin 8 (V+) of an LM1458



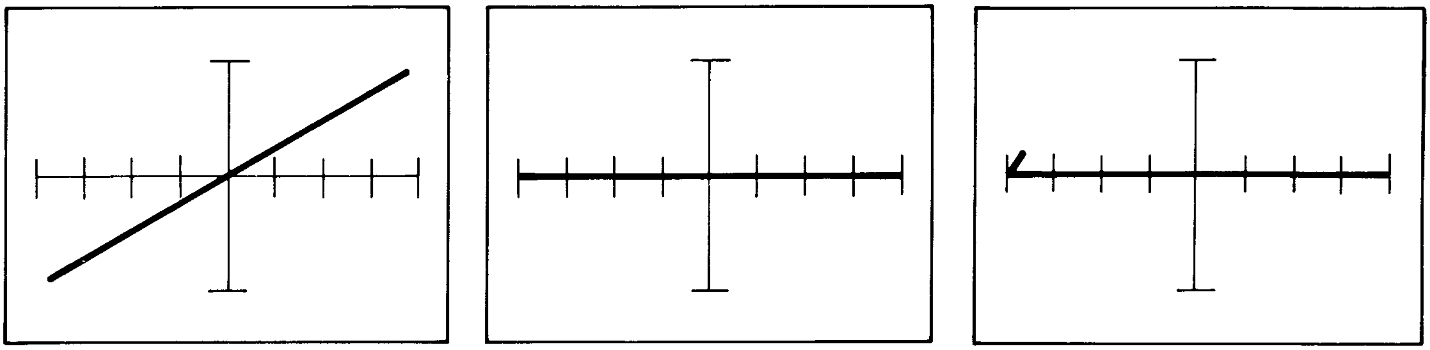
Low Medium High

Figure 12-5. Signatures Between Pin 3 (Non-Inverting Input) and Pin 8 (V+) of an LM1458



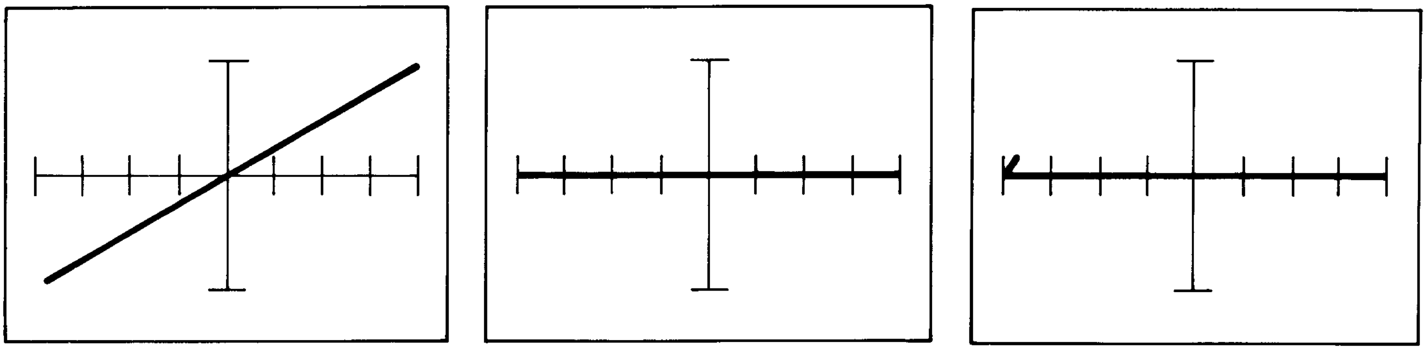
Low Medium High

Figure 12-6. Signatures Between Pin 1 (Output) and Pin 8 (V+) of an LM1458



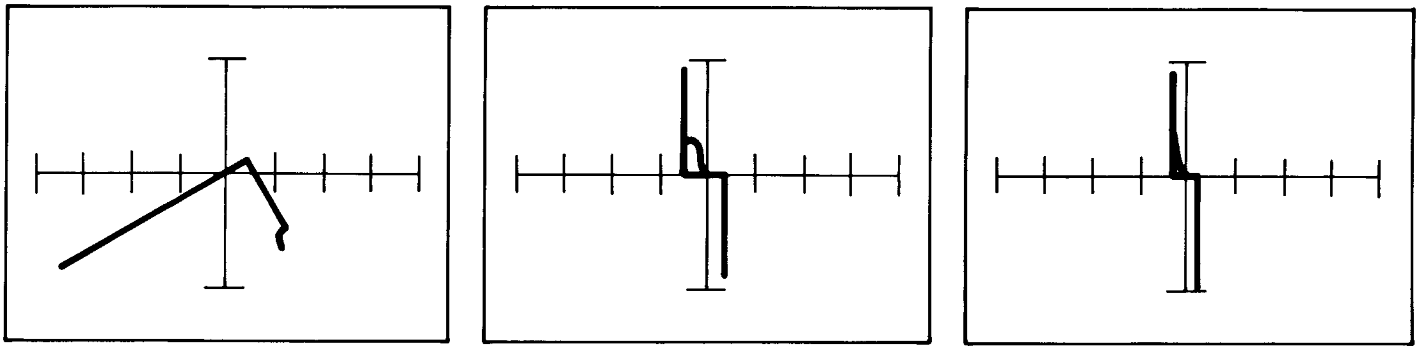
Low Medium High

Figure 12-7. Signatures Between Pin 2 (Inverting Input) and Pin 4 (V−) of an LM1458



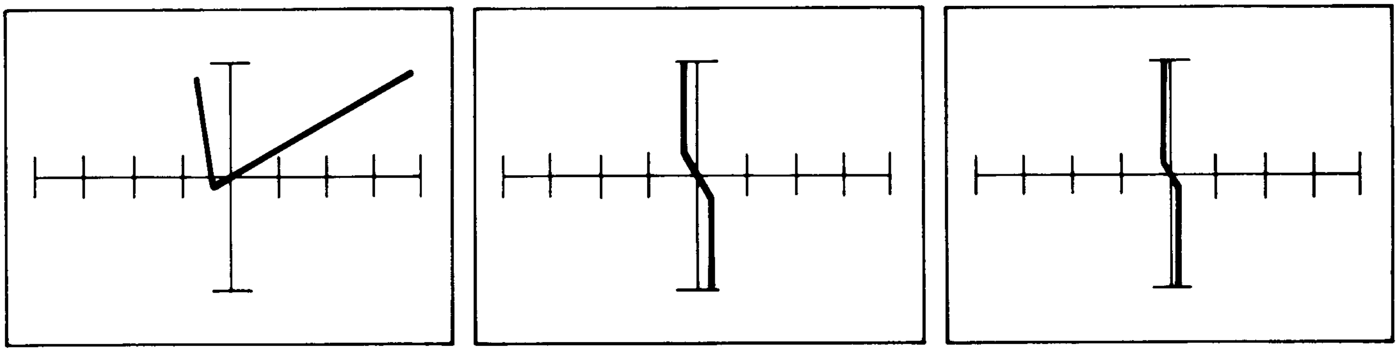
Low Medium High

Figure 12-8. Signatures Between Pin 3 (Non-inverting Input) and Pin 4 (V−) of an LM1458



Low Medium High

Figure 12-9. Signatures between Pin 1 (Output) and Pin (V-) of an LM1458



Low

Medium

High

Figure 12-10. Signatures Between Pin 4 (V−) and Pin 8 (V+) of a Defective LM1458

12-5. LINEAR VOLTAGE REGULATORS

Voltage regulators, especially the 7800 and 7900 series, are used in many pieces of electronic equipment.

12-6. The 7805 Regulator

Figure 12-11 shows the schematic and the connection of a 7805 +5V regulator. Figures 12-12 through 12-14 show the test signatures for a 7805. Different manufacturers implement their products with different topologies and it is expected that the signatures will vary for the same devices from different manufacturers. Figure 12-15 shows the signatures of a defective 7805. There is a substantial difference in the signature between a good and defective device in the low and medium ranges.

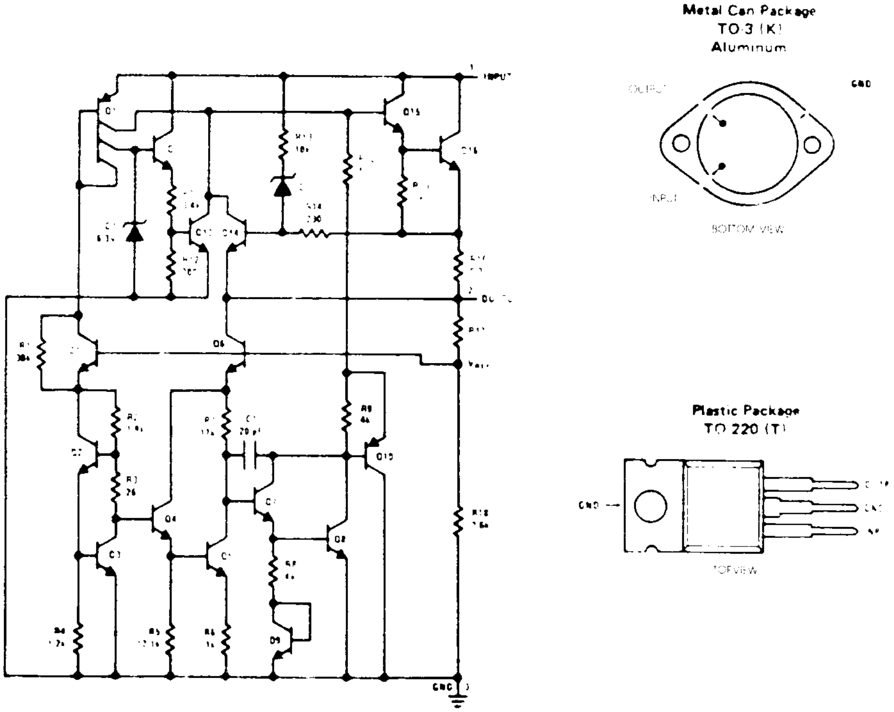
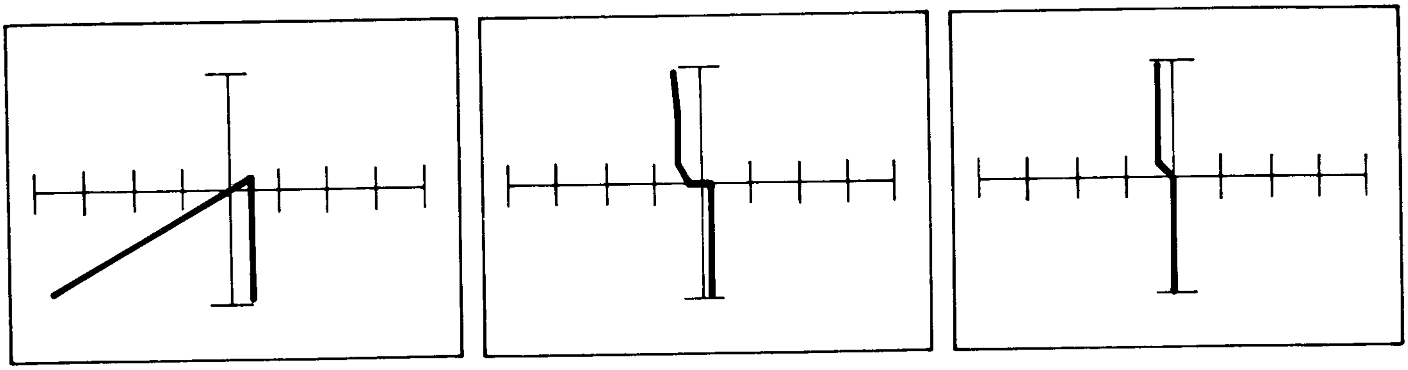
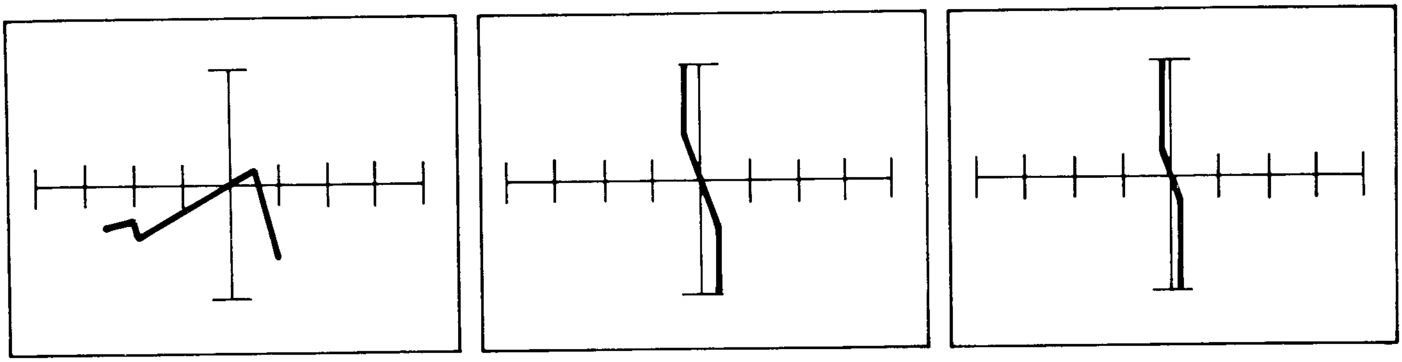


Figure 12-11. 7805 Schematic and Pin Layout



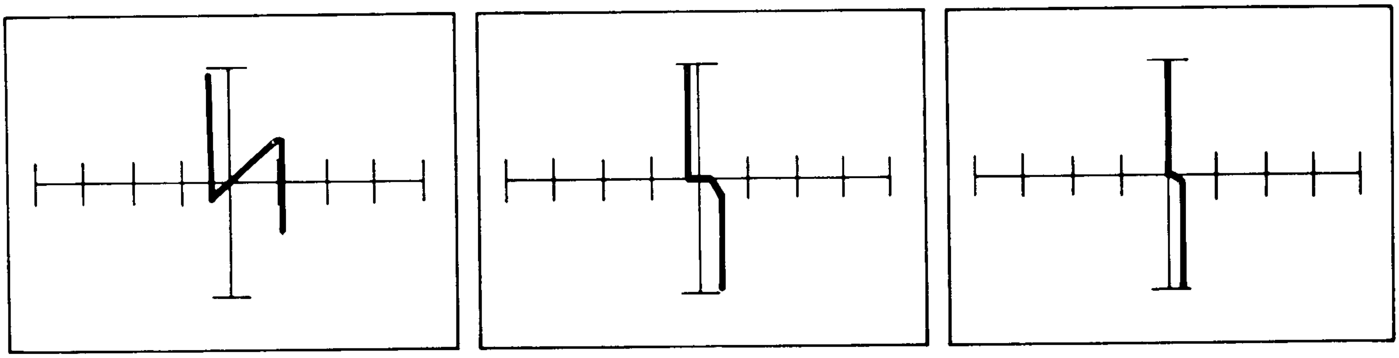
Low Medium High

Figure 12-12. Signatures Between The Input and Ground Pins - 7805



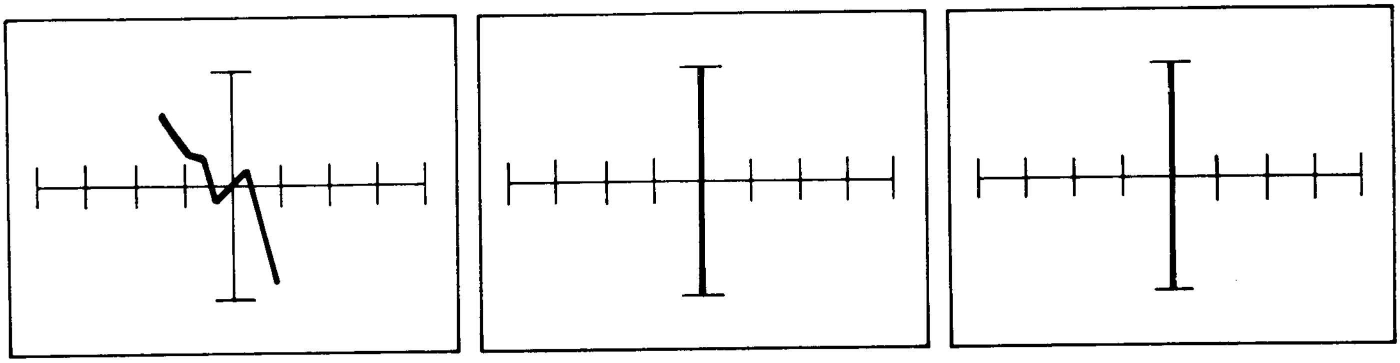
Low Medium High

Figure 12-13. Signatures Between The Output and Ground Pins - 7805



Low Medium High

Figure 12-14. Signatures Between The Input and Output Pins - 7805



Low

Medium

High

Figure 12-15. Signatures Between The Input and Output Pins of a Defective 7805

12-7. The 7905 Regulator

Figure 12-16 shows the schematic and connection diagrams for a 7905 −5V regulator. Figures 12-17 through 12-19 show the test signatures for a 7905 voltage regulator on all ranges. Again, these signatures are for reference only and change slightly from manufacturer to manufacturer.

Figure 12-20 shows the signatures of a defective 7905 voltage regulator. Comparing Figure 12-19 and Figure 12-20 in medium range, there is a significant difference in signatures.

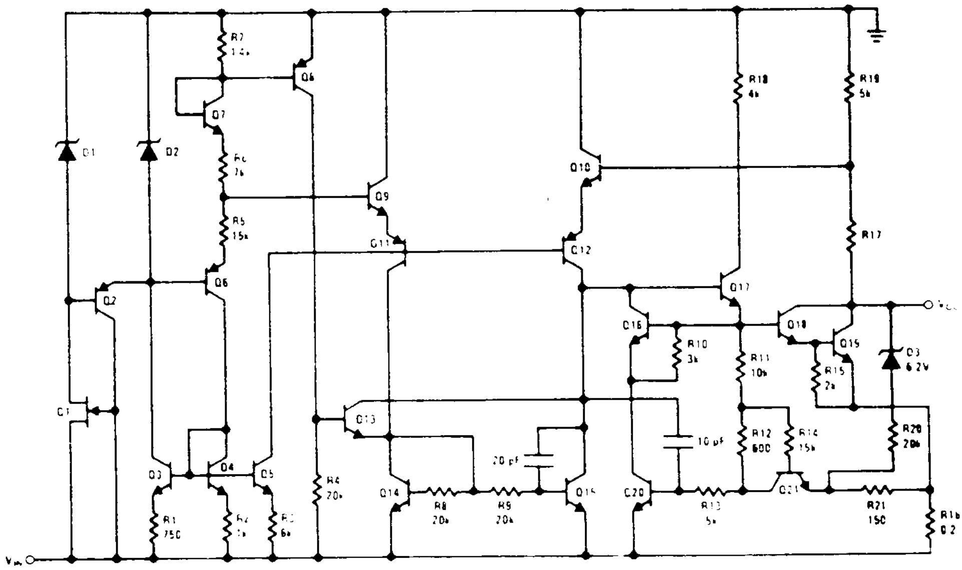
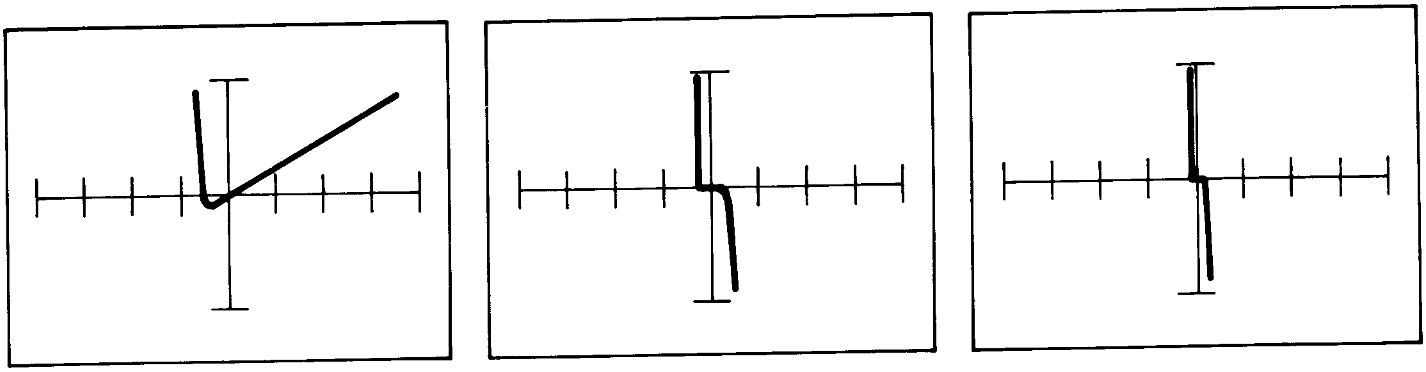
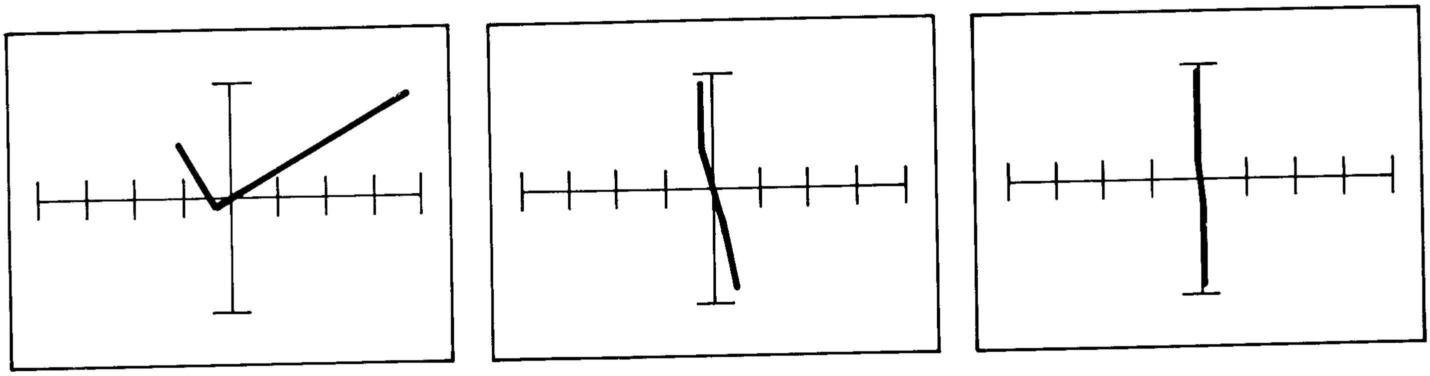


Figure 12-16. Schematic and Connections of the 7905 −5V Regulator



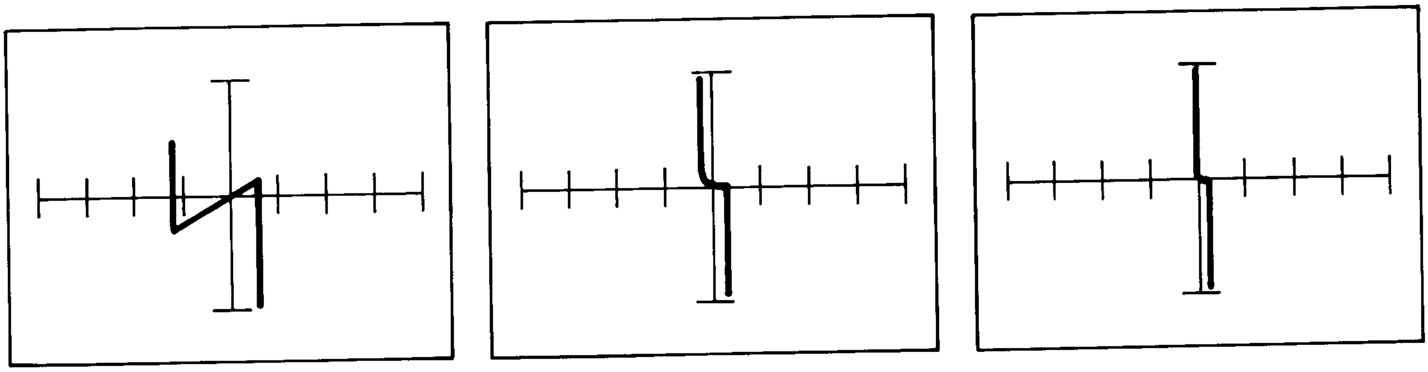
Low Medium High

Figure 12-17. Signatures Between the Input and Ground Pins - 7905



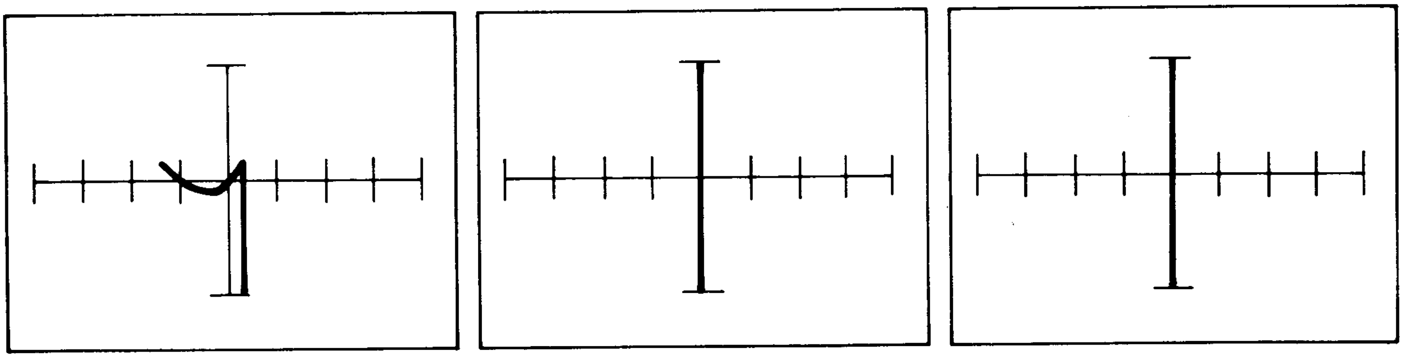
Low Medium High

Figure 12-18. Signatures Between the Output and Ground Pins - 7905



Low Medium High

Figure 12-19. Signatures Between the Input and Output Pins - 7905



Low Medium High

Figure 12-20. Signatures Between the Input and Output Pins of a Defective 7905

12-8. 555 TIMERS

The 555 timer is a popular linear integrated circuit, and is used in precision timing, pulse generation, and pulse width modulation applications. The 1000 is used to examine signatures between various pins with respect to ground. Figure 12-21 shows the schematic and connection diagram of the National Semiconductor LM555 timer.

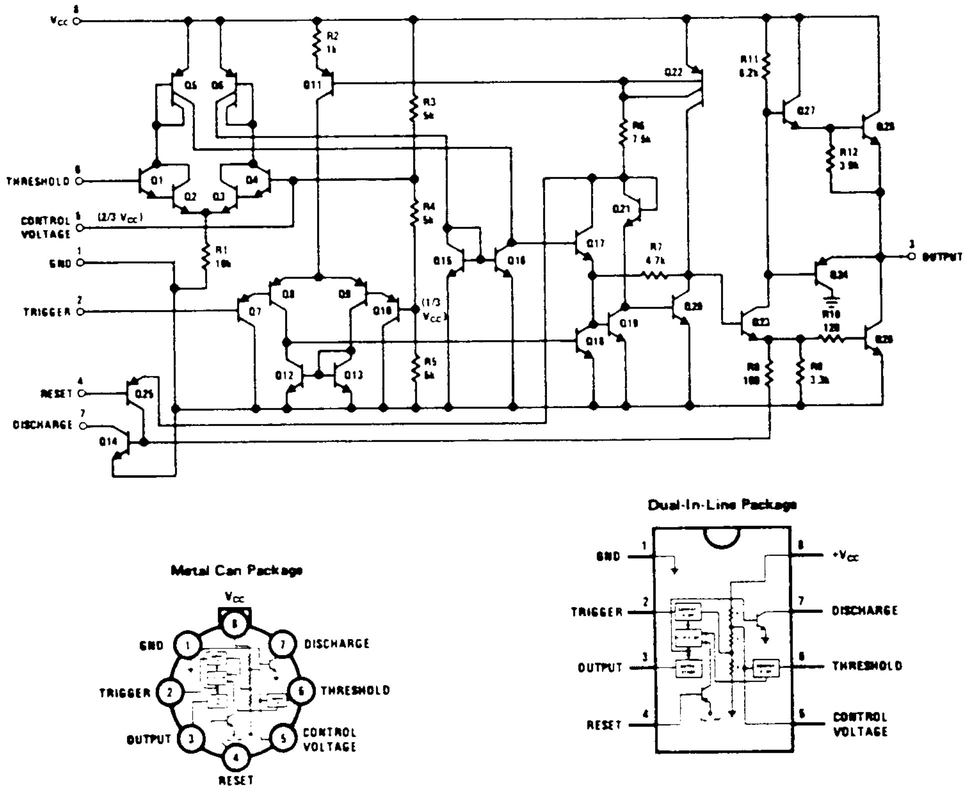


Figure 12-21. Schematic and Connection Diagram of an LM555 Timer

Figures 12-22 through 12-25, and 12-16 through 12-29, show the signatures between different pins of the LM555 using all ranges of the 1000. In Figure 12-22 the 1000 displays the base-collector junction of transistor Q7 (see schematic in Figure 12-21). Figure 12-24 shows the signatures between pin 4 (reset) and Pin 1 (gnd). In this case, the 1000 displays the series junctions transistors Q25 and Q14 (see Figure 12-21). Consequently, a transistor signature is expected.

Figure 12-25 shows the signatures between pin 5 (control voltage) and Pin 1. Pin 5 is connected to resistors R3, R4, R5, and the Darlington transistor formed by Q3 and Q4. The impedence between pin 5 and pin 1 is too high to cause any significant effect in low range. As a result, a diagonal signature is produced.

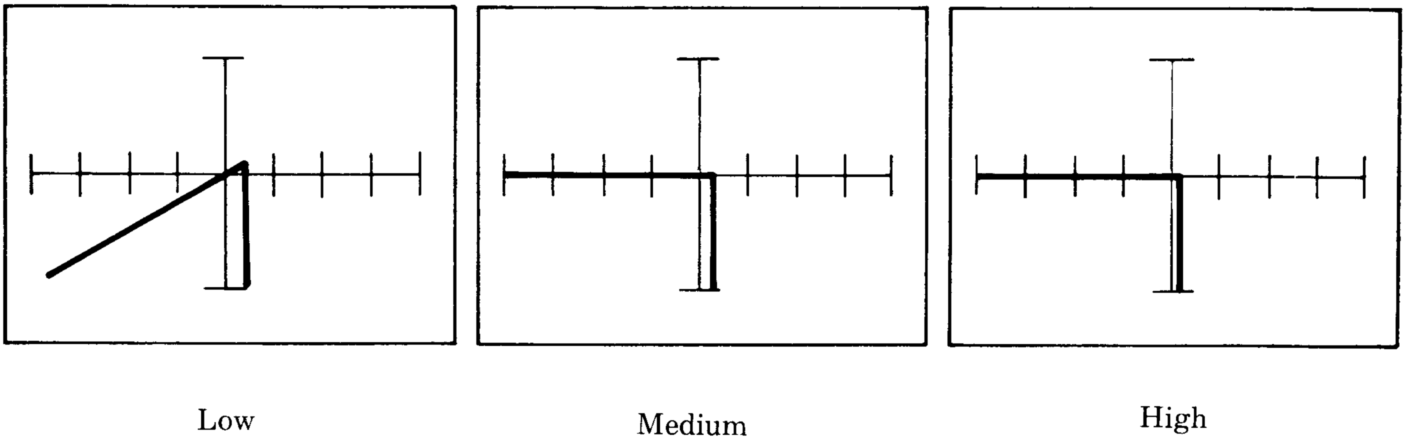

Low Medium High

Figure 12-22. Signatures Between Pin 2 and Pin 1 of an LM555 Timer

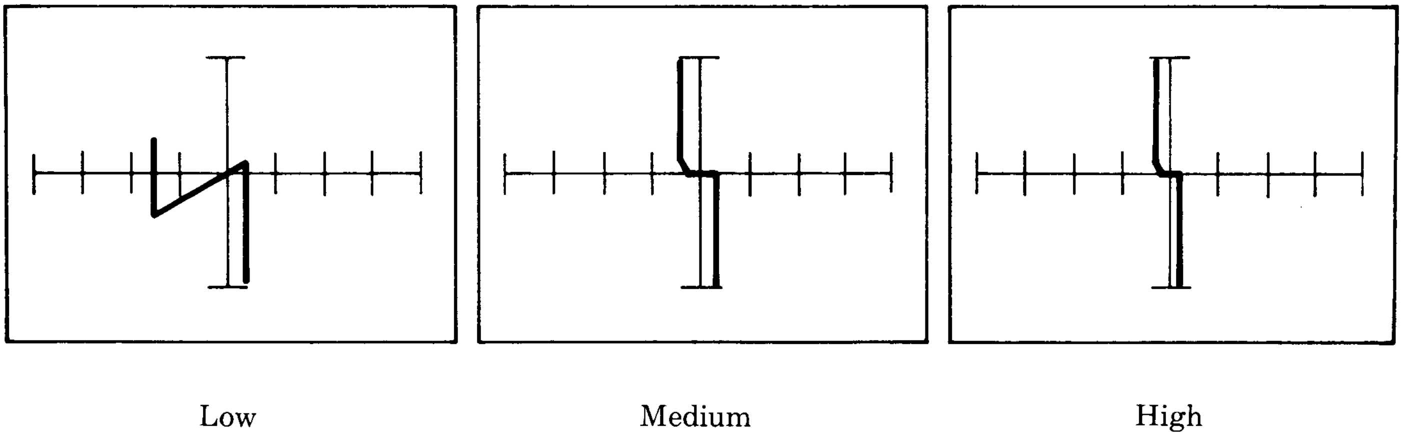
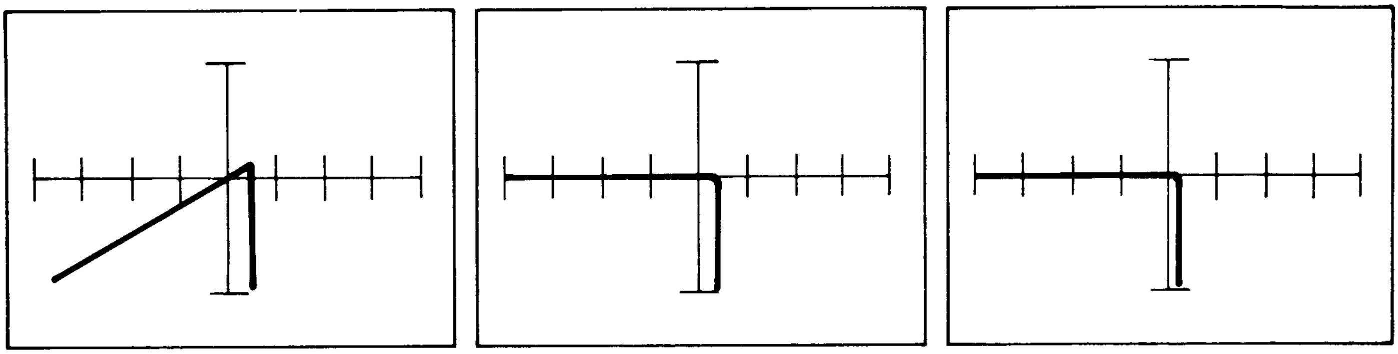
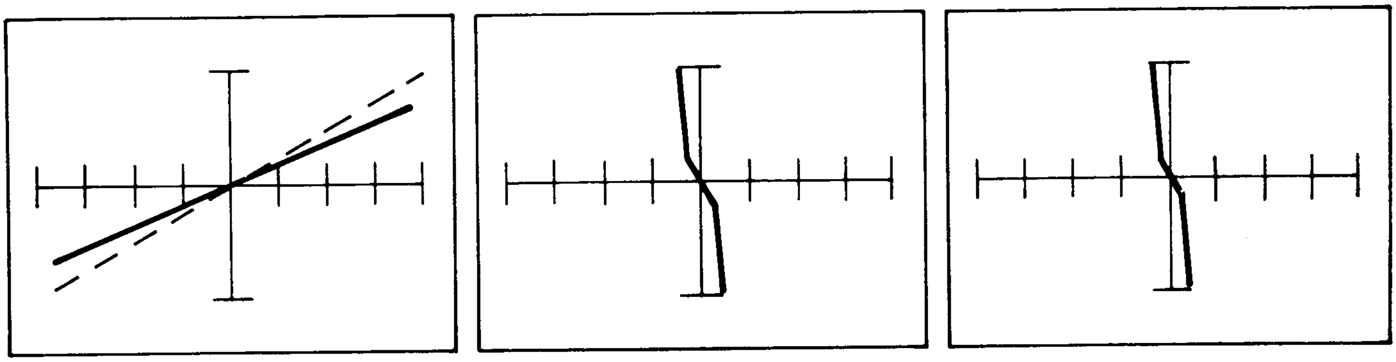

Low Medium High

Figure 12-23. Signatures between Pin 3 (Output) and Pin 1 of an LM555 Timer



Low Medium High

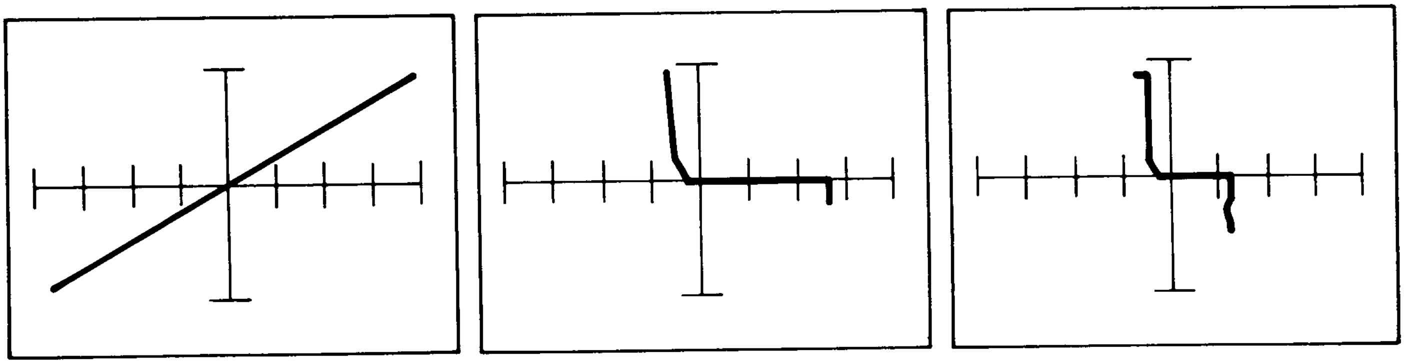
Figure 12-24. Signatures Between Pin 4 (Reset) and Pin 1 of an LM555 Timer



Low Medium High

Figure 12-25. Signatures Between Pin 5 (Control Voltage) and Pin 1 of an LM555 Timer

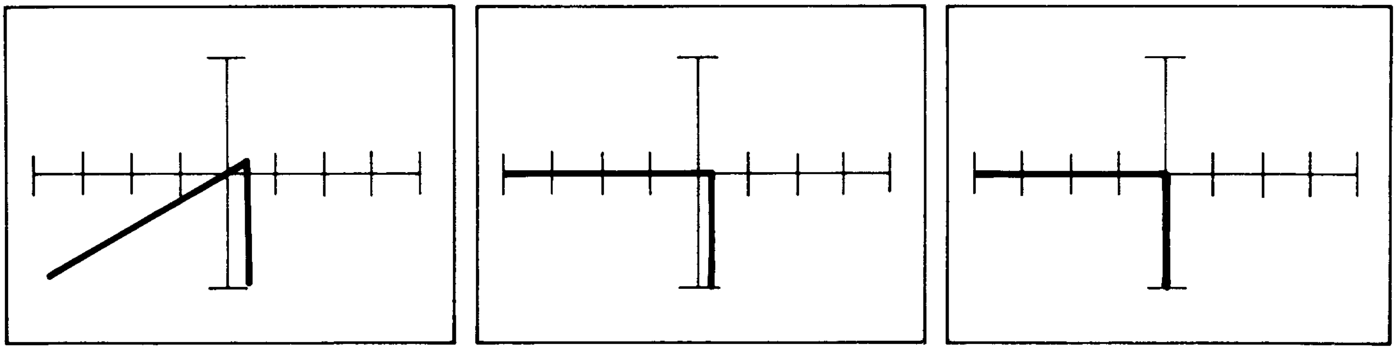
Figure 12-26 shows the signatures between pin 6 and pin 1. Pin 6 is connected to a Darlington transistor (formed by Q1 and Q2) which is in series with resistor R1 (10k resistor). The impedence is too high to show much change in the low range.



Low Medium High

Figure 12-26. Signatures Between Pin 6 (Threshold) and Pin 1 of an LM555 Timer

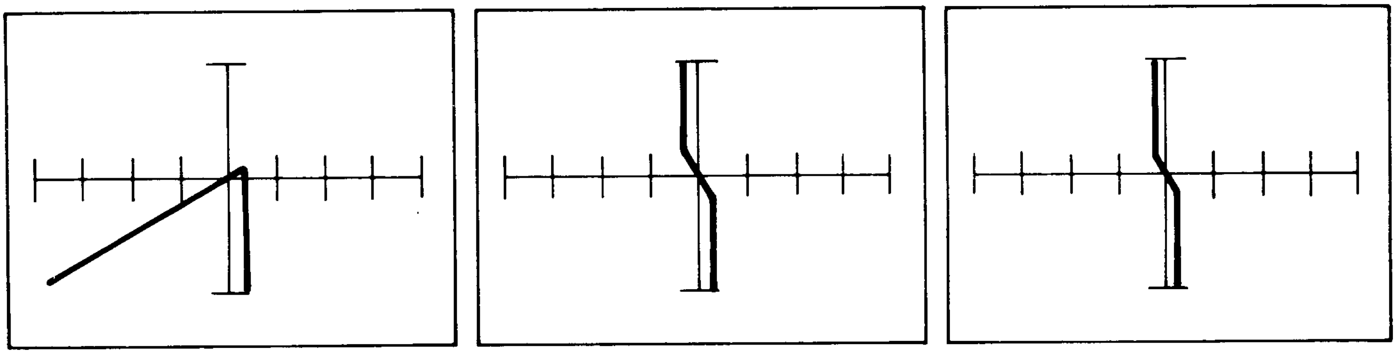
Figure 12-27 shows the signatures between pin 7 and pin 1. These pins are connected to the collector and emitter of Q14.



Low Medium High

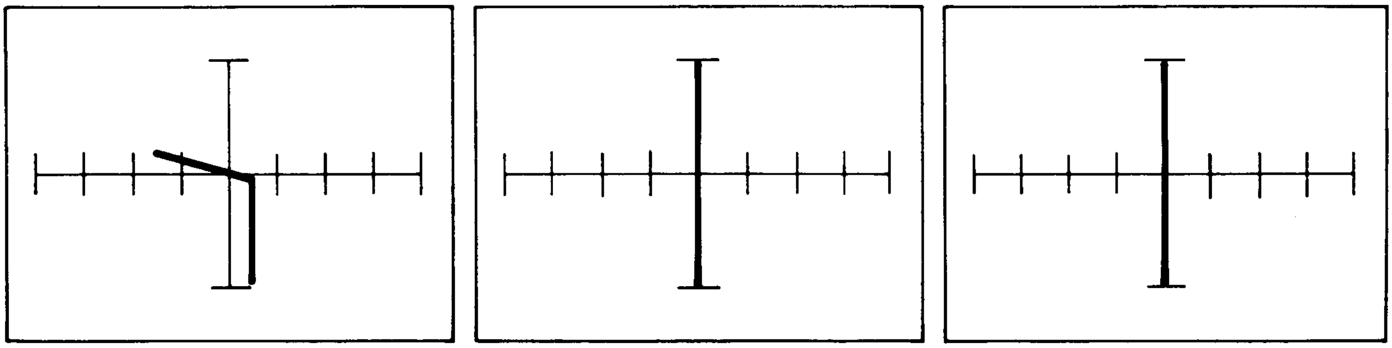
Figure 12-27. Signatures Between Pin 7 (Discharge) and Pin 1 of an LM555 Timer

Figure 12-28 shows the signatures between pin 8 (V_{cc}) and Pin 1. Figure 12-29 shows the signature between the same pins of an LM555 timer which was damaged by power supply polarity reversal.



Low Medium High

Figure 12-28. Signatures Between Pin 8 (V_{cc}) and Pin 1 of an LM555 Timer



Low Medium High

Figure 12-29. Signatures Betwen Pin 8 (V_{cc}) and Pin 1 of a Damaged LM555 Timer

12-9. TTL DIGITAL INTEGRATED CIRCUITS

12-10. General

The schematics of the basic gates of the various families are shown in Figures 12-30a, b, c, d, and e. All are similar, containing an input, gate, phase splitter (Q2) with emitter and collector load resistors, pull-up mechanism (Q3/Q4) and a pull-down transistor (Q5). In all TTL circuits, except LS TTL circuits, the AND function is formed by a multi-emitter transistor in which the emitter-base junctions serve to isolate the input signal sources from each other.

The inputs of these gates contain input protection diodes. To test a digital IC, we need to examine:

- Inputs with respect to ground to see if the input diode and transitor are damaged.
- Output pin with respect to ground to see if the C-E junction of Q5 is damaged.
- Output pin with respect to V_{cc} to see if Q4 is damaged.
- V_{cc} with respect to ground. Generally, the 1000 can display flaws caused by overloading.

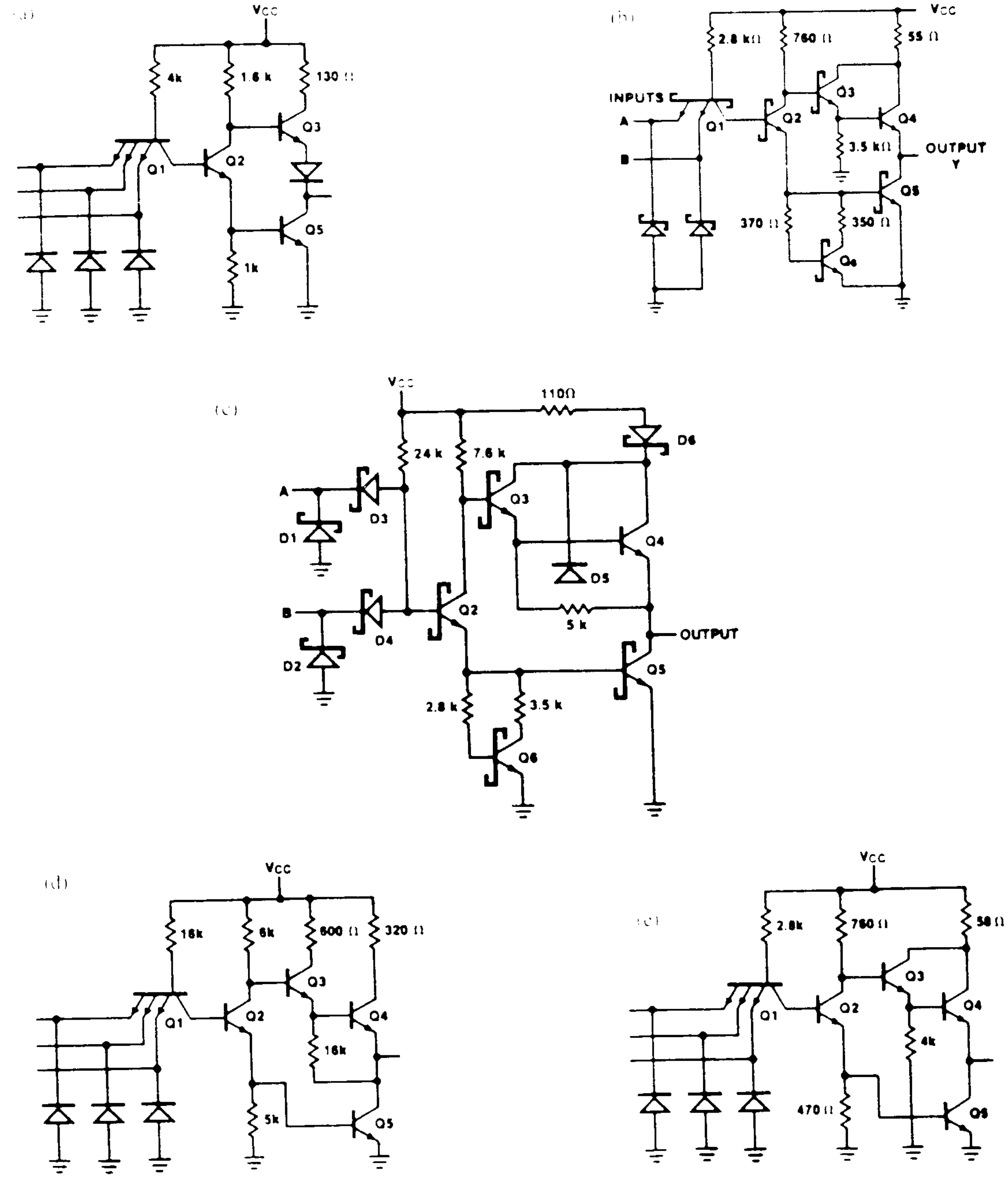
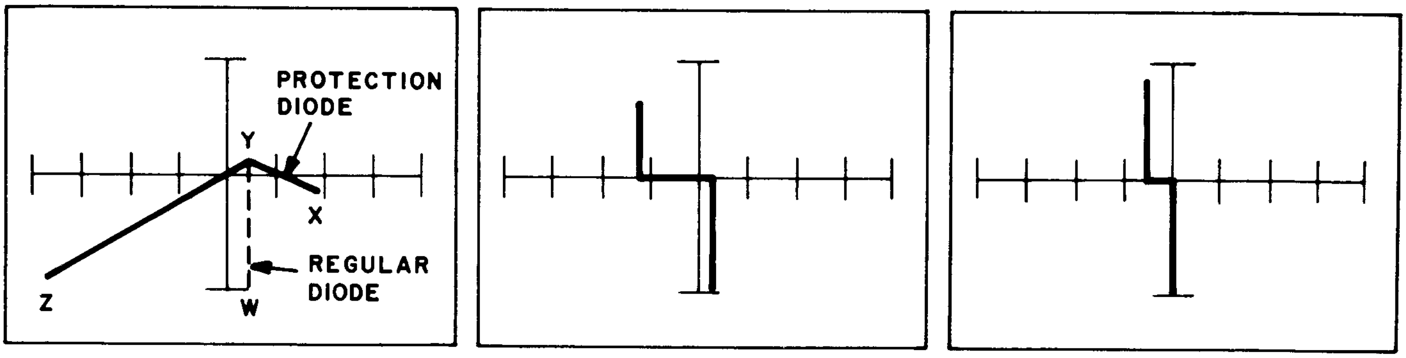


Figure 12-30. Various TTL implementation

12-11. TTL Devices With Totem Pole Output

Figures 12-31 through 12-33 show the signatures of input, output, and V_{cc} with respect to ground of the 7410 TTL device. As mentioned previously, the test signatures may vary from device to device, and from manufacturer to manufacturer, depending on the level of doping and logic implementation.

Figure 12-31 shows the signatures between an input pin and the ground pin. In the low range, the input protection diode signature is represented by XYZ instead of WYZ (as a regular diode would have been represented.) The difference between a regular diode and a protection diode is that protection diodes have a 50 ohm resistance in series with the diode junction.



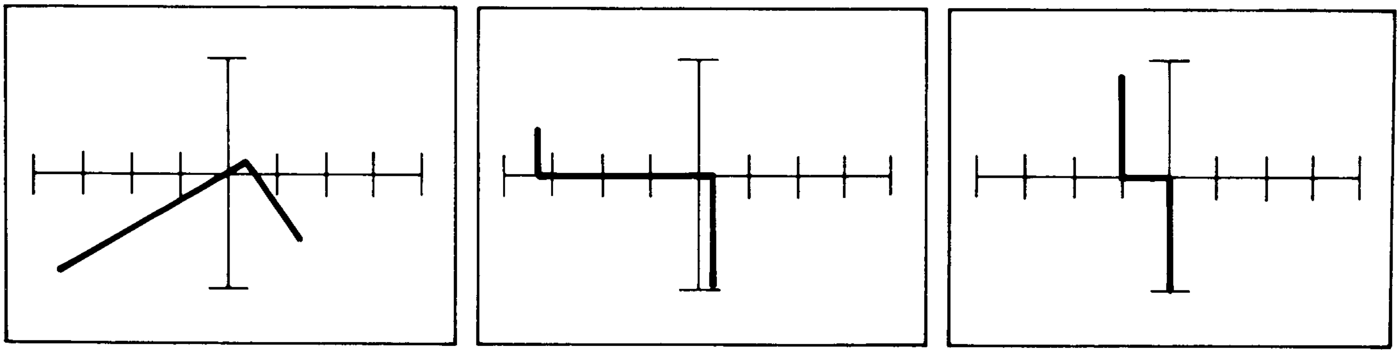
Low

Medium

High

Figure 12-31. Signatures Between an Input Pin and Ground Pin of a 7410

Figure 12-32 shows the signatures between an output pin and the ground pin. In low range, the test voltage is not high enough to cause non-destructive breakdown.



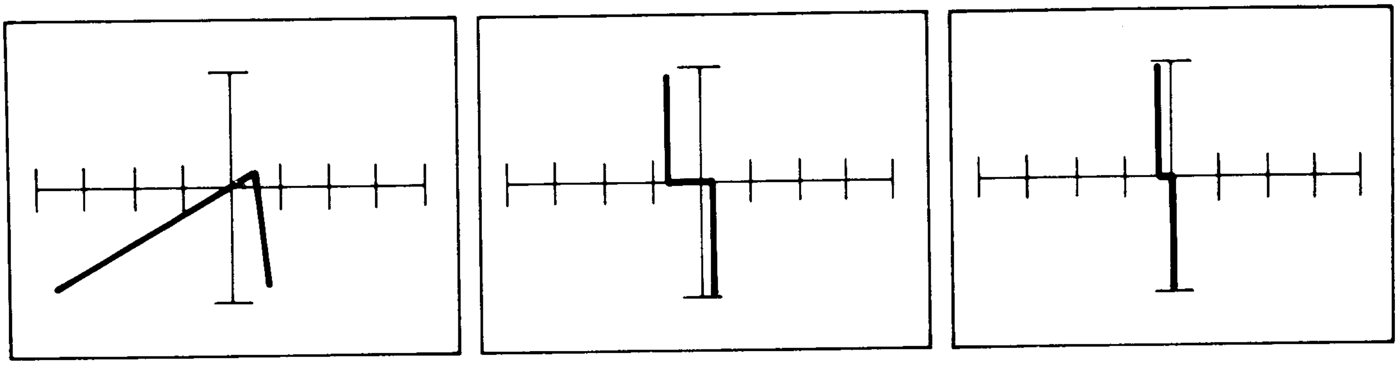
Low

Medium

High

Figure 12-32. Signatures Between an Output Pin and the Ground Pin of a 7410

Figure 12-33 shows signatures between the V_{cc} pin and the ground pin.

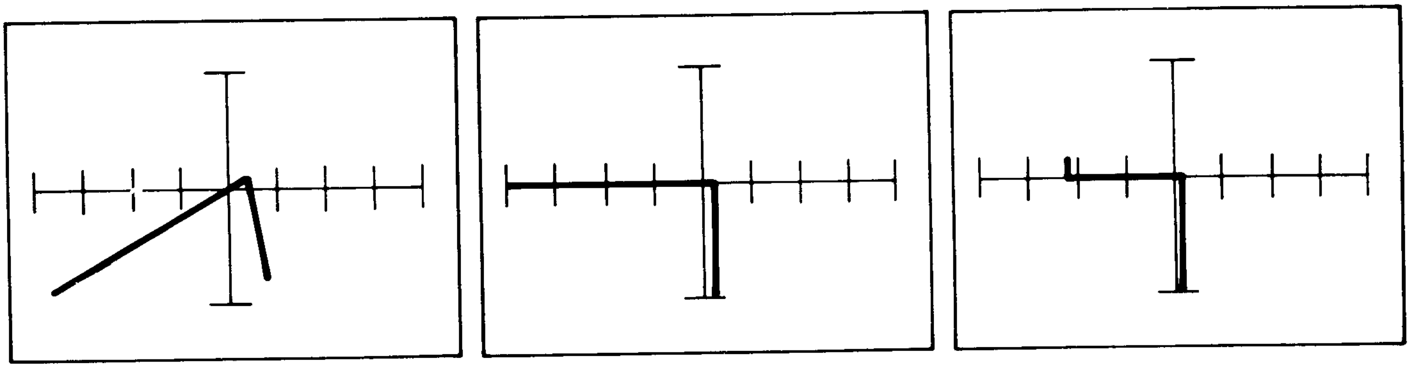


Low Medium High

Figure 12-33. Signatures Between the V_{cc} Pin and Ground Pin of a 7410

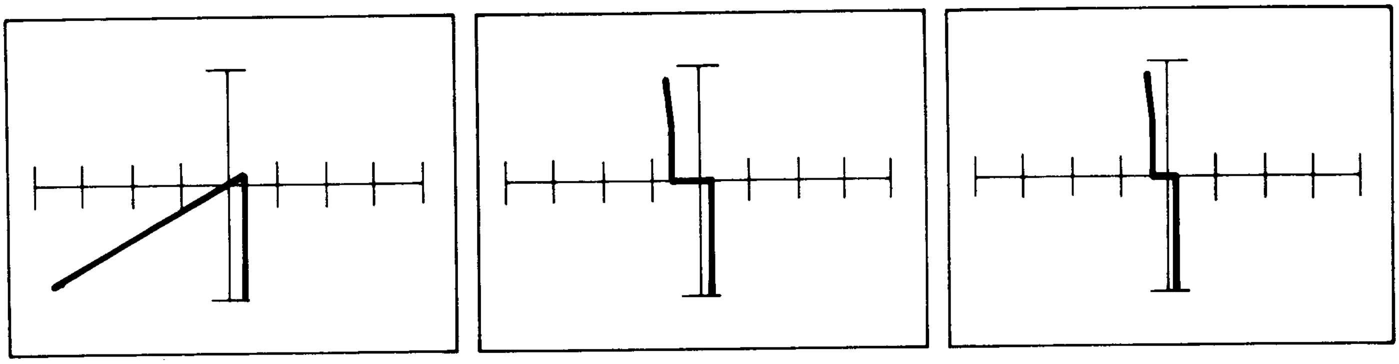
12-12. LS TTL Devices

Implementation of LS digital ICs is different from others. The LS series is not implemented with multiple-emitter transistor topology. Figures 12-34 through 12-36 show the signatures between different pins of a 74LS00.



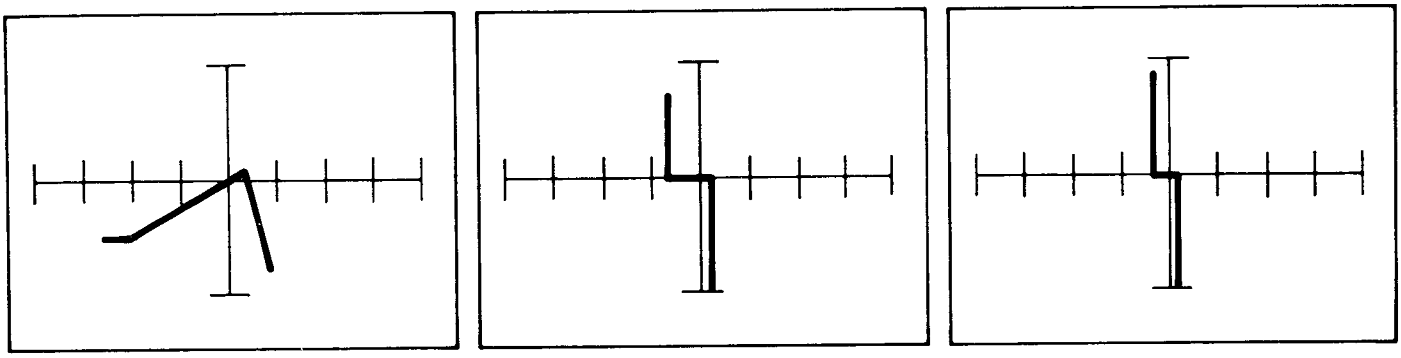
Low Medium High

Figure 12-34. Signatures Between an Input Pin and the Ground Pin of a 74LS00



Low Medium High

Figure 12-36. Signatures Between the V_{cc} Pin and Ground Pin of a 74LS00

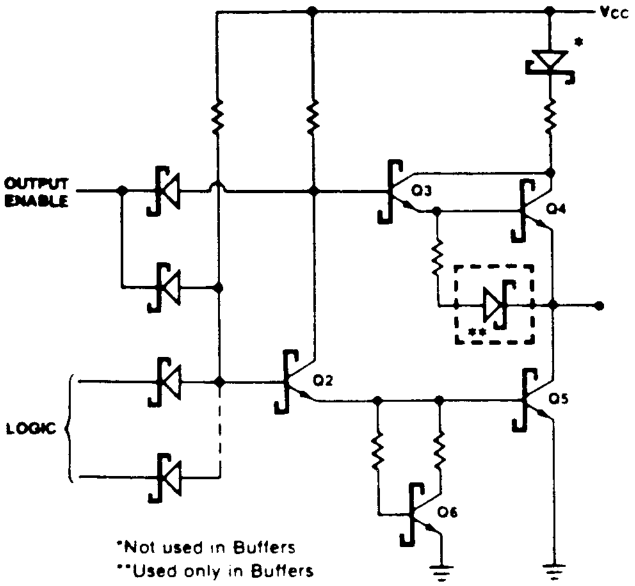


Low Medium High

Figure 12-35. Signatures Between an Input Pin and Ground Pin of a 74LS00

12-13. Tri-State LS TTL Devices

In the tri-state LS TTL family, there are many circuits that have an auxiliary control input that allows both the output pull-up and pull-down circuitry to be disabled. This condition is called the high impedance (high Z) state and allows the outputs of different circuits to be connected to a common line or data bus. Figure 12-37 shows a typical tri-state output device. The device to be tested has power off, so the enable pin is considered just another input pin, and tri-state devices are tested in the same manner as other TTL devices except their signatures are different. It is extremely easy to test a tri-state device when compared with a known good device. Figure 12-38 shows a connection diagram of a 74LS125.



*Not used in Buffers
**Used only in Buffers

Figure 12-37. Typical Tri-State Output Control

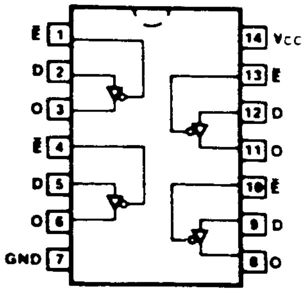
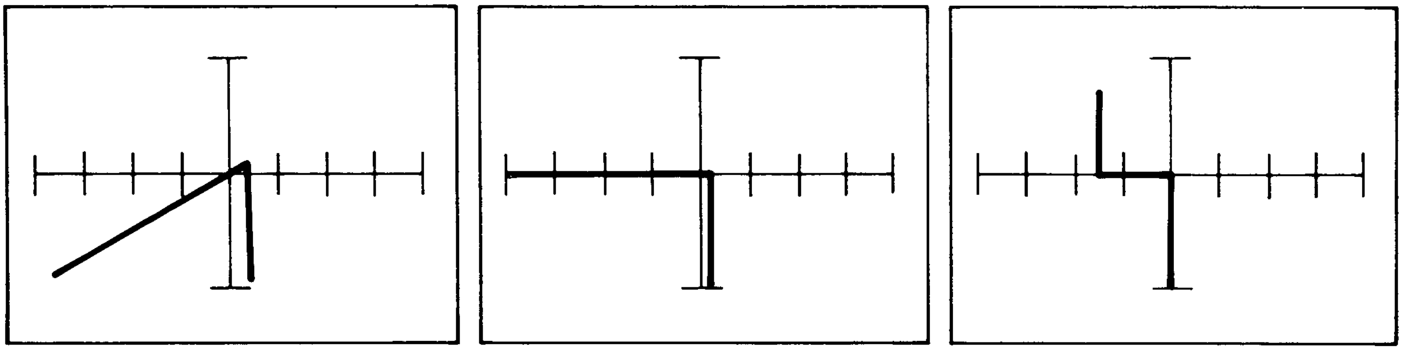


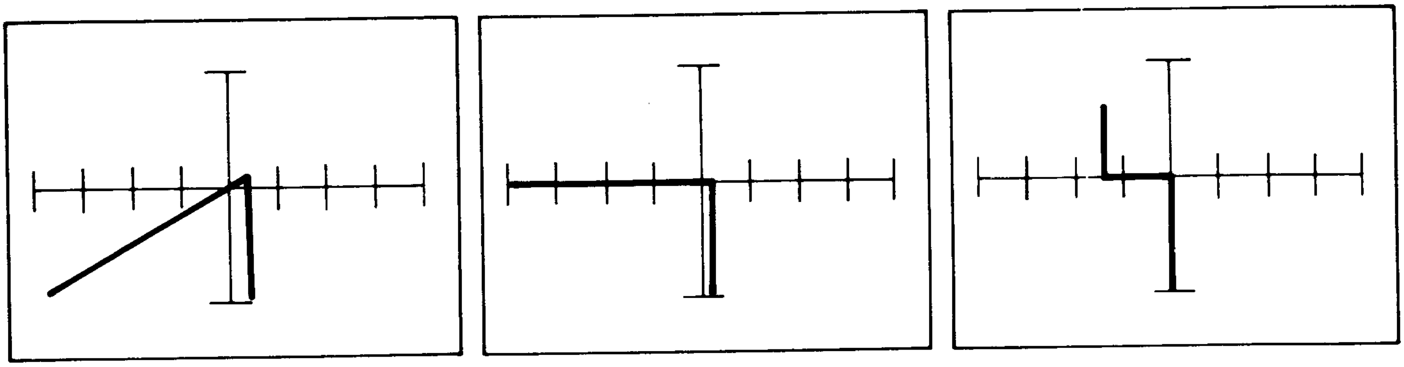
Figure 12-38. Connection Diagram of a 74LS125

Figure 12-39 shows the signatures between an input pin and ground pin, and Figure 12-40 shows the signatures between the enable pin and ground pin. These two figures exhibit similar signatures because both the input and enable pins have similar electrical paths to ground.



Low Medium High

Figure 12-39. Signatures Between an Input Pin and the Ground Pin of a 74LS125

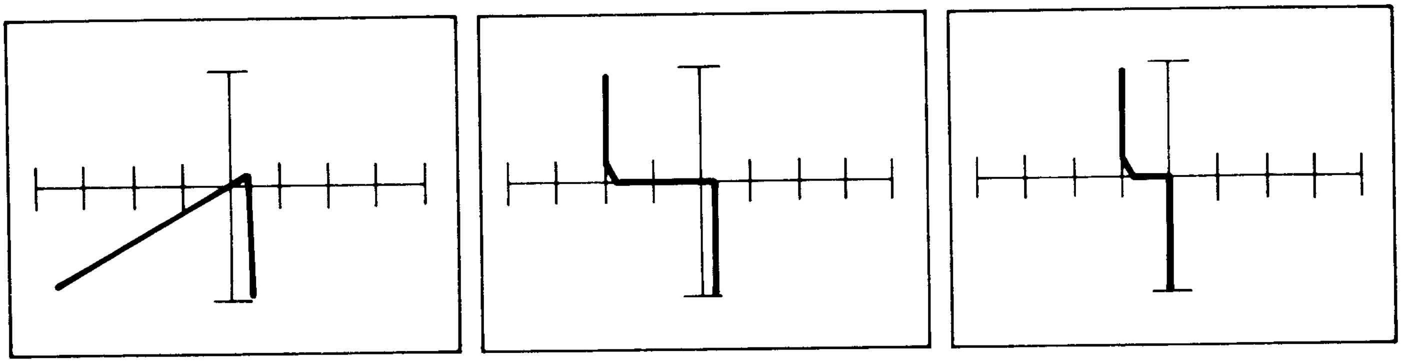


Low

Medium

High

Figure 12-40. Signatures Between the Enable Pin and Ground Pin of a 74LS125



Low

Medium

High

Figure 12-41. Signatures Between the Output Pin and Ground Pin of a 74LS125

12-14. CMOS INTEGRATED CIRCUITS

CAUTION

Ⓩ

WHEN TESTING CMOS COMPONENTS BE SURE TO FOLLOW ALL STATIC HANDLING PRECAUTIONS. THESE INCLUDE:

- Store and transport in conductive packaging.
- The person handling the device should be grounded with a one Megohm wrist strap.
- All surfaces should be conductive and connected to earth ground.
- All parts should be handled by their packages and not by the leads.

THESE ARE SOME OF THE MAJOR PRECAUTIONS - CHECK THE MANUFACTURER'S HANDLING TECHNIQUES FOR COMPLETE PROCEDURES.

NOTE: When testing CMOS devices, it is recommended that the V_{ss} and V_{dd} pins be shorted together to eliminate noise in the 1000 signatures.

NOTE: Tests were conducted in an independent laboratory to show that the 1000 test signals are safe to test CMOS, MOS and low power Schottky devices. Refer to the Appendixes at the back of this manual.

The CMOS IC has become very popular because of its low power consumption and high noise immunity. Figure 12-42 shows the schematic and connection diagram of a Motorola MC14011B CMOS NAND gate. All CMOS input pins have protection diodes which have fairly high DC resistance. Figures 12-43 through 12-45 show the 1000 signatures between different pins of the MC14011B.

Figure 12-43 shows the signatures between an input pin and the $V_{ss}-V_{dd}$ pins of the MC1401lB. In the low range, the signature does not look like that of a regular diode because of the high input resistance in series with the protection diodes.

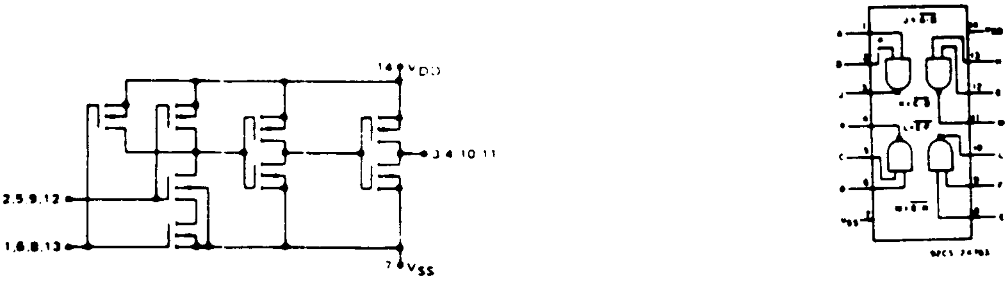
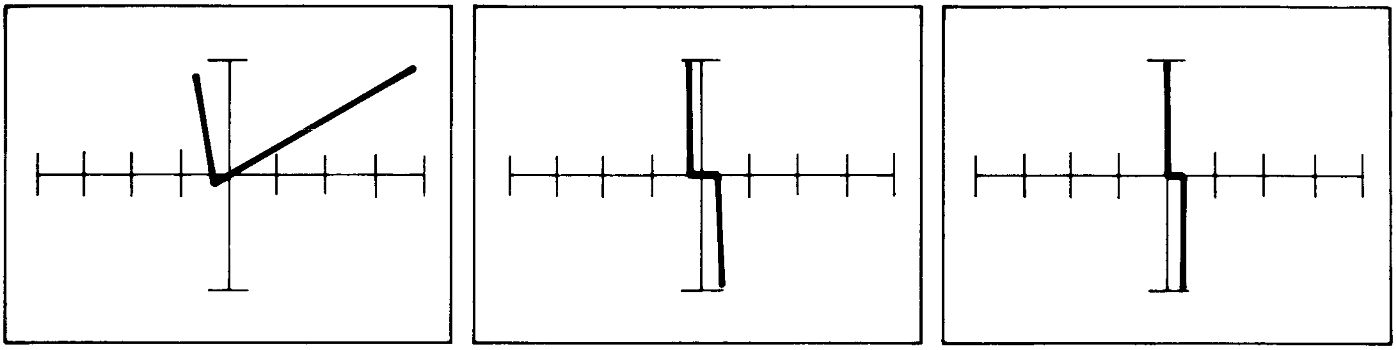
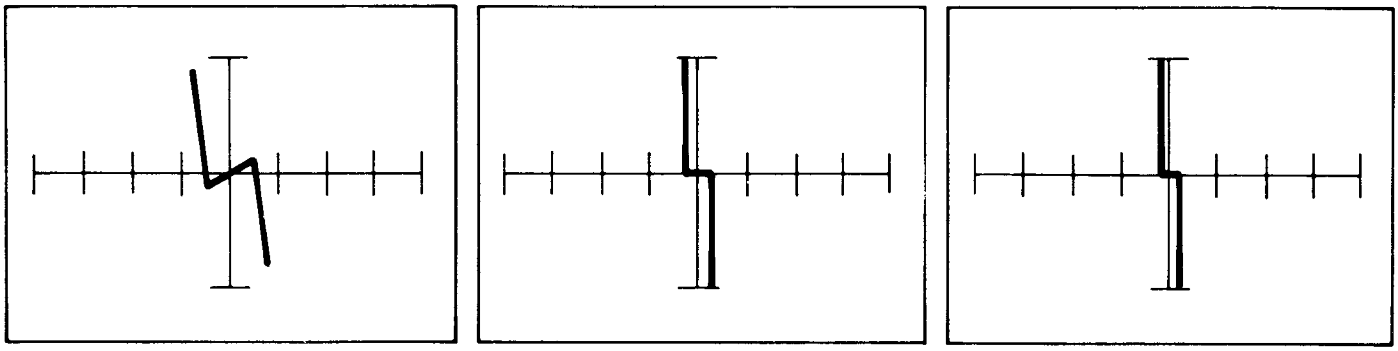


Figure 12-42. Schematic and Connection Diagram of a MC14011B



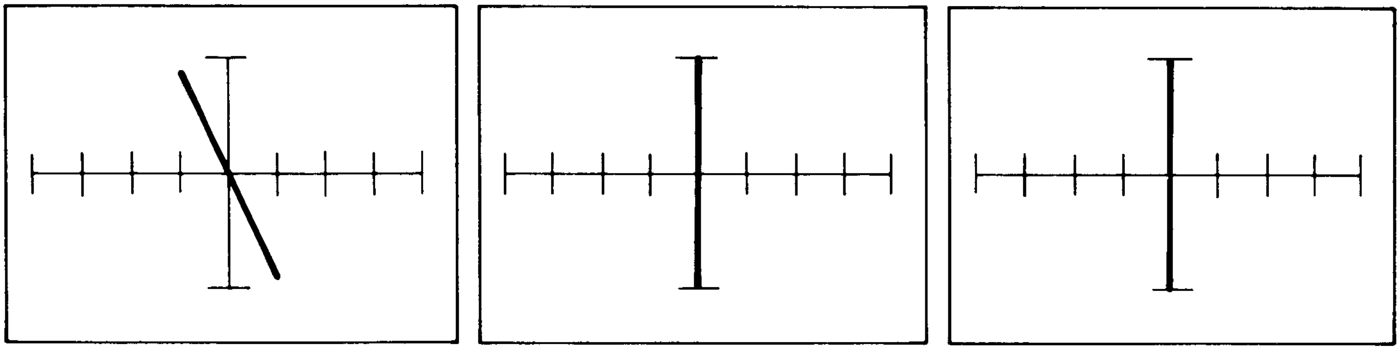
Low Medium High

Figure 12-43. Signatures Between an Input Pin and the $V_{ss}-V_{dd}$ Pins of a MC14011B



Low Medium High

Figure 12-44. Signatures Between an Output Pin and $V_{ss}-V_{dd}$ Pins of a MC14011B



Low Medium High

Figure 12-45. Signatures Between an Input Pin and $V_{ss}-V_{dd}$ Pins of a Defective MC14011B

12-15. CMOS ANALOG SWITCH

CAUTION

Ⓩ

WHEN TESTING CMOS COMPONENTS BE SURE TO FOLLOW ALL STATIC HANDLING PRECAUTIONS. THESE INCLUDE:

- Store and transport in conductive packaging.
- The person handling the device should be grounded with a one Megohm wrist strap.
- All surfaces should be conductive and connected to earth ground.
- All parts should be handled by their packages and not by the leads.

THESE ARE SOME OF THE MAJOR PRECAUTIONS - CHECK THE MANUFACTURER'S HANDLING TECHNIQUES FOR COMPLETE PROCEDURES.

NOTE: When testing CMOS devices, it is recommended that the V_{ss} and V_{dd} pins be shorted together to eliminate noise in the 1000 signatures.

NOTE: Tests were conducted in an independent laboratory to show that the 1000 test signals are safe to test CMOS, MOS and low power Schottky devices. Refer to the Appendixes at the back of this manual.

The MC14016B quad bilateral switch is constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. Each MC14016B consists of four independent switches capable of controlling either digital or analog signals.

The quad bilateral switch is used in signal gating, chopper, modulator, demodulator, and CMOS logic implementation.

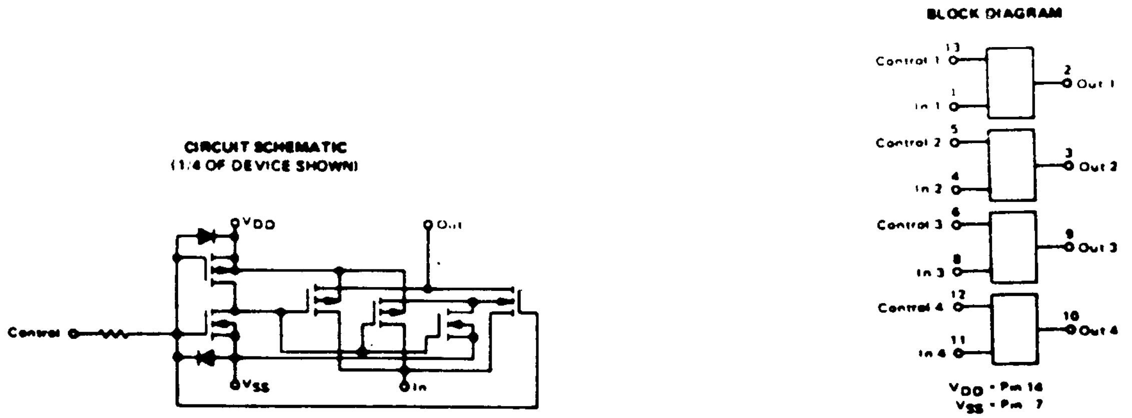
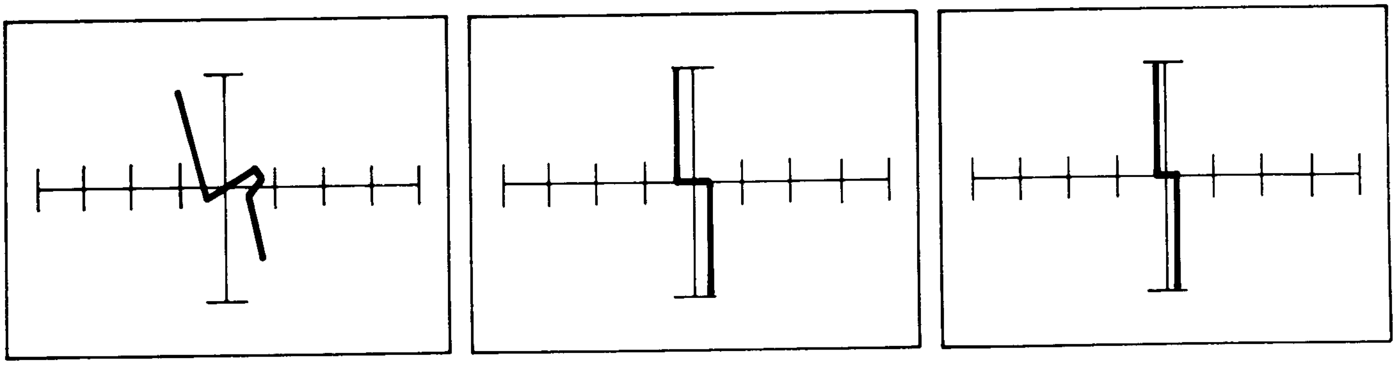


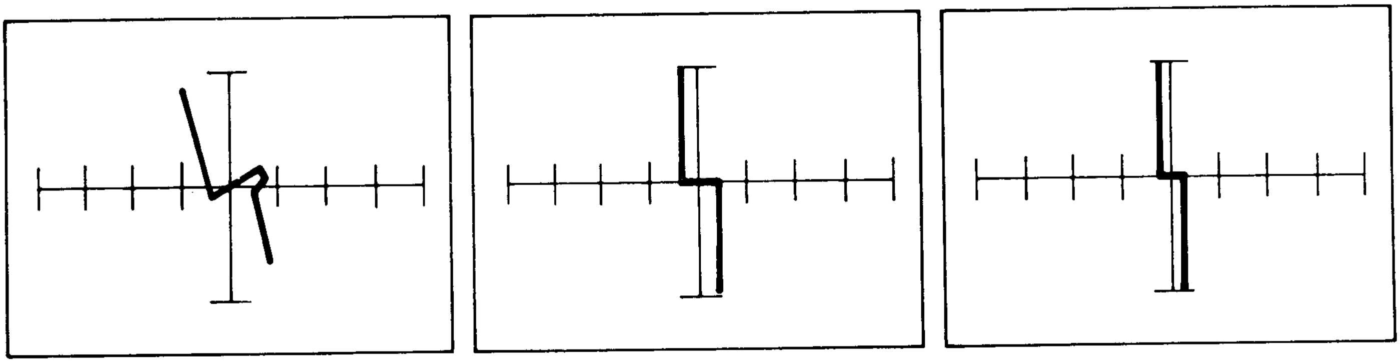
Figure 12-46. Pin Connections and Circuit Schematic of a MC14016B

To test a 4016B analog switch we need to examine the input, output and control pins with respect to $V_{ss}-V_{dd}$. Figures 12-47 through 12-49 show the signatures of a good 4016B analog switch. Figure 12-50 exhibits the signatures of a defective 4016B. Comparing Figure 12-47 to Figure 12-50, the signatures show a significant difference between a good and defective device.



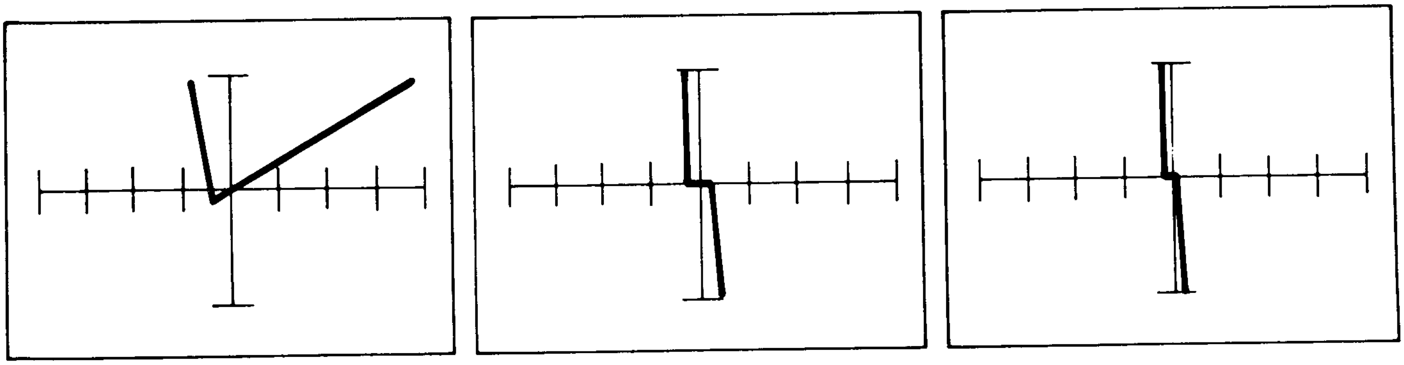
Low Medium High

Figure 12-47. Signatures Between an Input Pin and $V_{ss}-V_{dd}$ of an MC14016B Gate



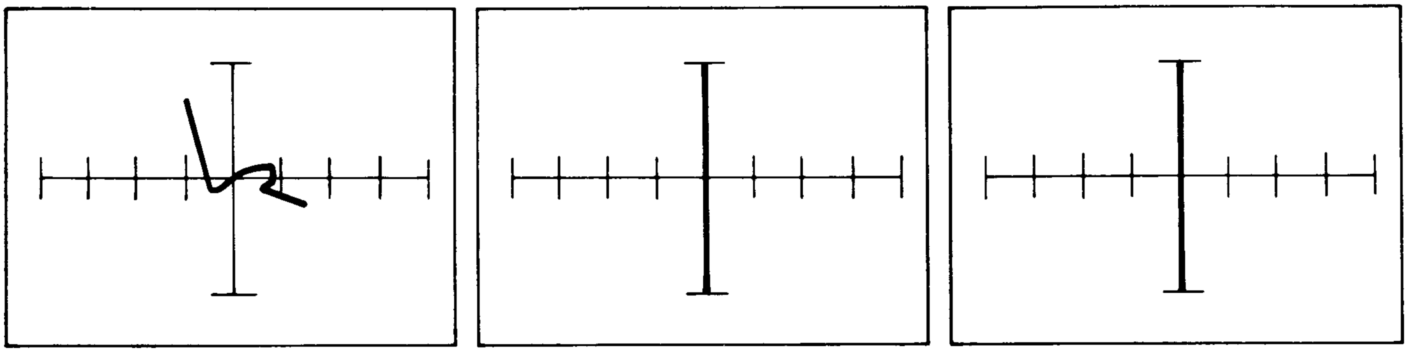
Low Medium High

Figure 12-48. Signatures Between an Output Pin and $V_{ss}-V_{dd}$ of an MC14016B Gate



Low Medium High

Figure 12-49. Signatures Between a Control Pin and $V_{ss}-V_{dd}$ of an MC14016B Gate



Low

Medium

High

Figure 12-50. Signatures Between an Input Pin and $V_{ss}-V_{dd}$ of a Defective 4016B

12-16. EPROM

The 2708JL is an ultraviolet light erasable, electrically programmable, read only memory. The 2708JL has 8,192 bits organized as 1024 words of 8-bit length. These devices are fabricated using N-channel silicon gate technology for high speed and simple interface with MOS and bipolar circuits. The data outputs for all three circuits are tri-state for connecting multiple devices on a common bus. The pin configuration of a 2708JL is shown in Figure 12-51. The signatures of various pins with respect to V_{ss} are shown in Figures 12-52 through 12-58. Signatures may vary from manufacturer to manufacturer, however, in general, the signatures are similar.

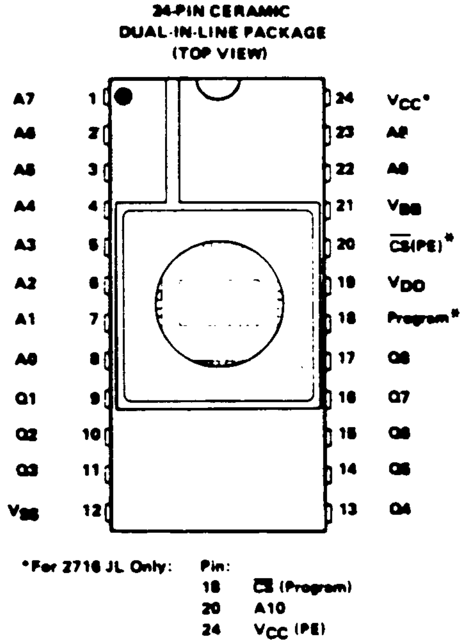
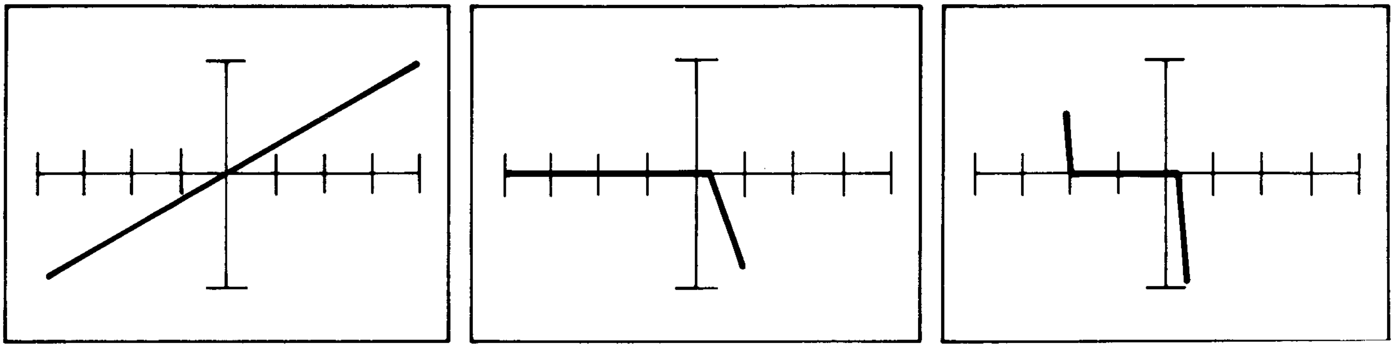
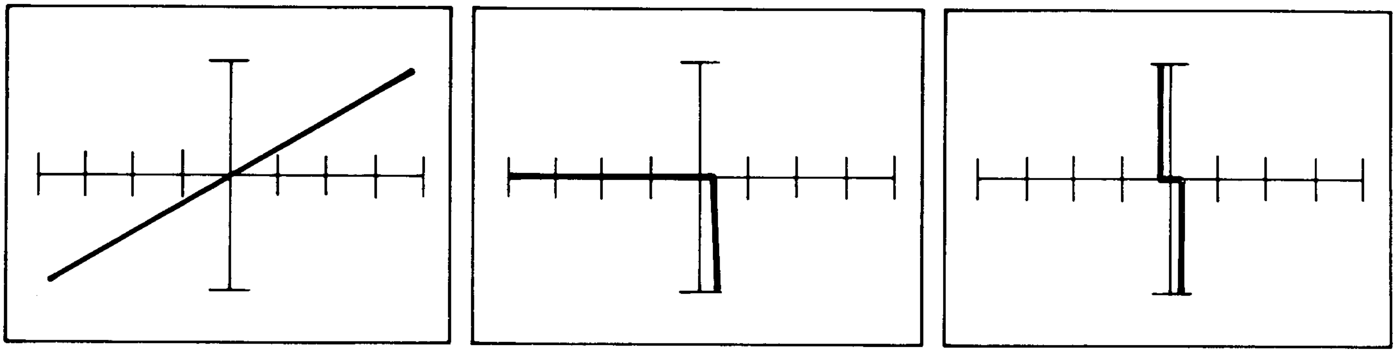


Figure 12-51. Pin Configuration of a 2708JL



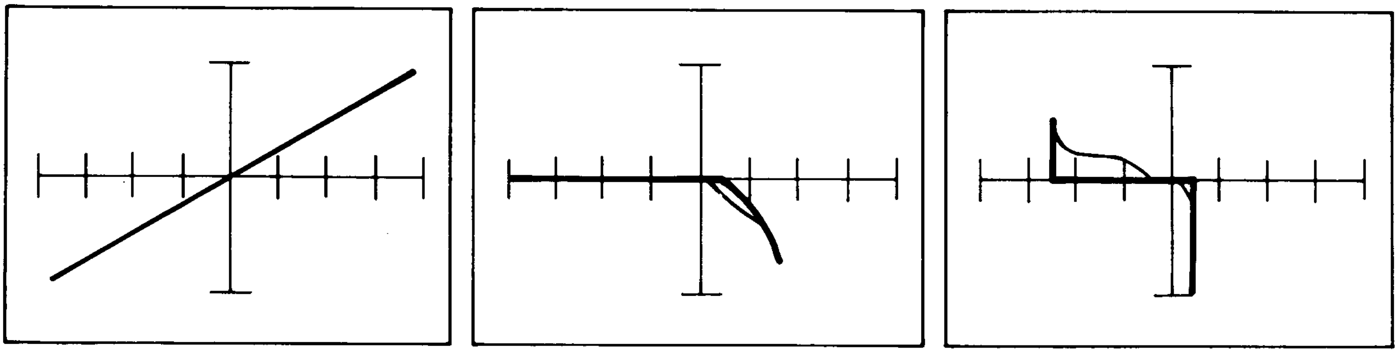
Low Medium High

Figure 12-52. Signatures Between an Address Pin and the V_{ss} Pin of a 2708JL



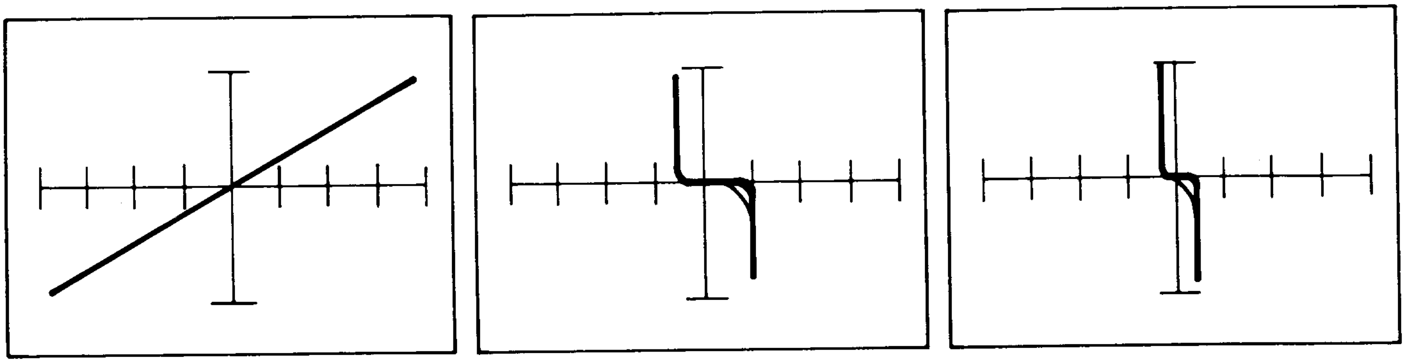
Low Medium High

Figure 12-53. Signatures Between an Output Pin and the V_{ss} Pin of a 2708JL



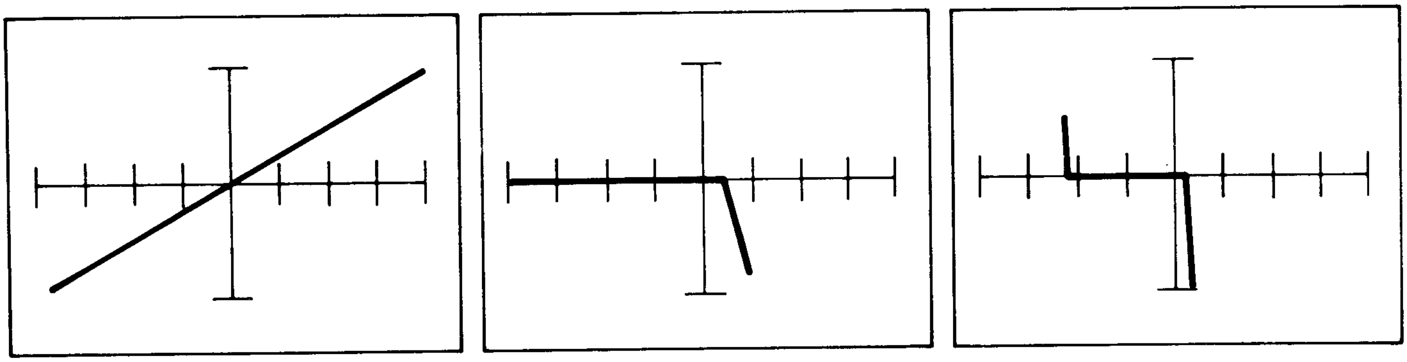
Low Medium High

Figure 12-54. Signatures Between the Program Pin (18) and V_{ss} Pin of a 2708JL



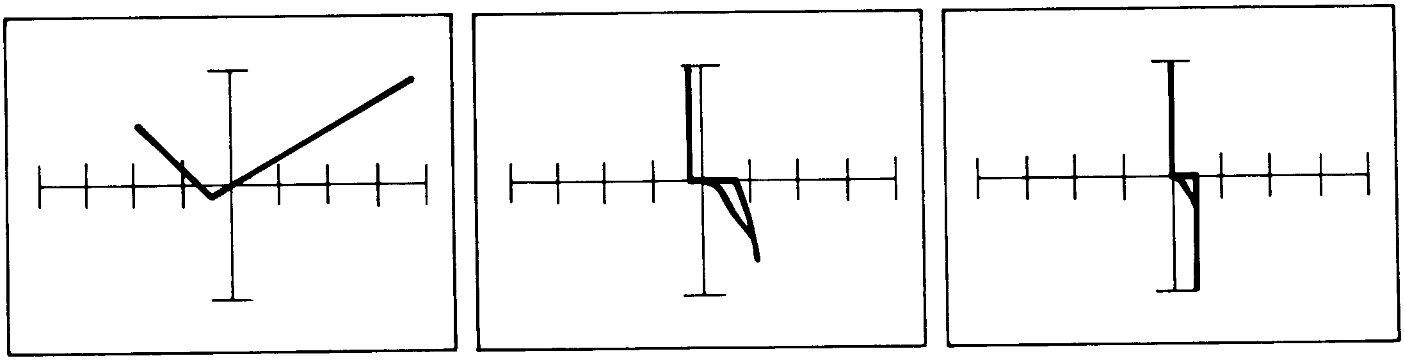
Low Medium High

Figure 12-55. Signatures Between the V_{dd} Pin (19) and the V_{ss} Pin of a 2708JL



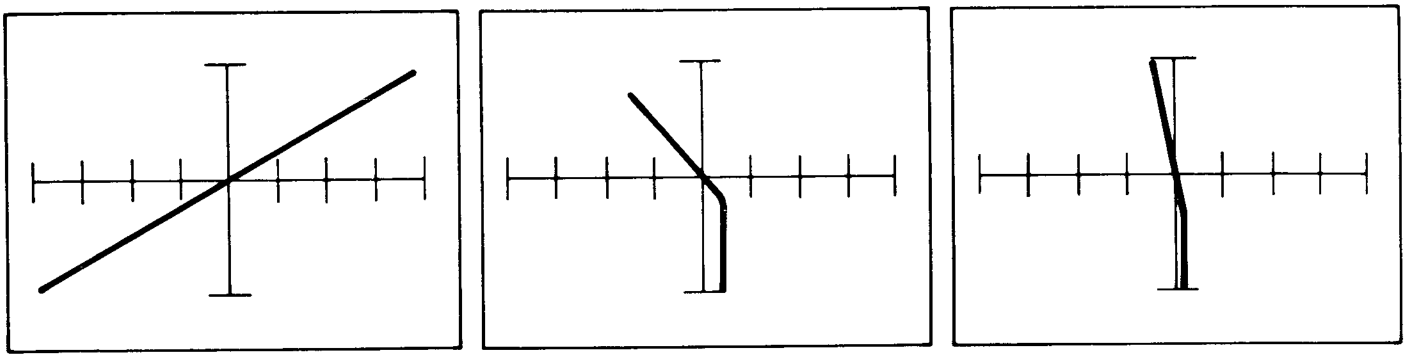
Low Medium High

Figure 12-56. Signatures Between the CS Pin (20) and the V_{ss} Pin of a 2708JL



Low Medium High

Figure 12-57. Signatures Between the V_{bb} Pin (21) and the V_{ss} Pin of a 2708JL



Low　Medium　High

Figure 12-58. Signatures Between the V_{cc} Pin (24) and the V_{SS} Pin of a 2708JL

12-17. BIPOLAR PROM

The Monolithic Memories 6301-1J is a 256x4 prom with tri-state outputs. It is implemented with standard Schottkey technology. The pin configuration of a 6301-1J is shown in Figure 12-59. The signatures of various pins with respect to ground are shown in Figures 12-60 through 12-63.

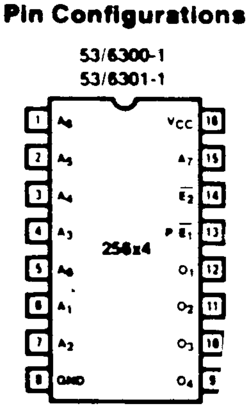
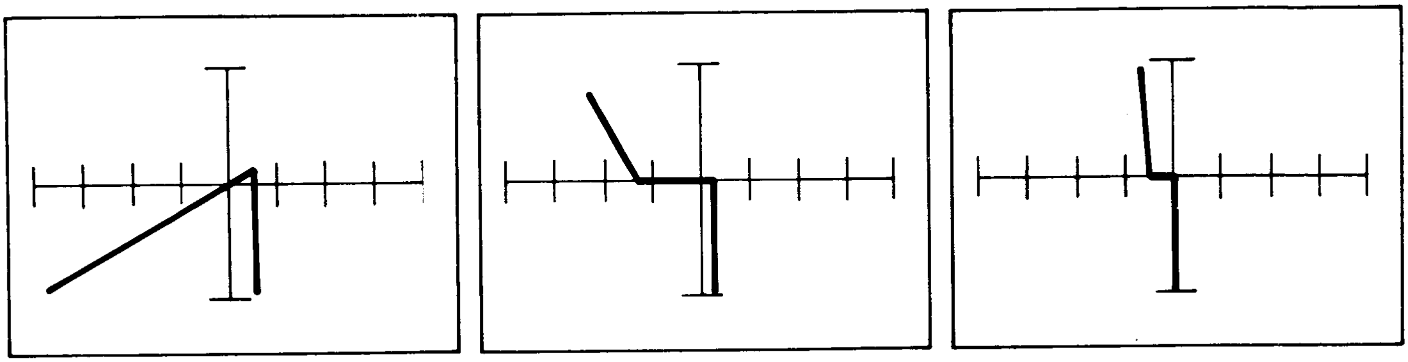
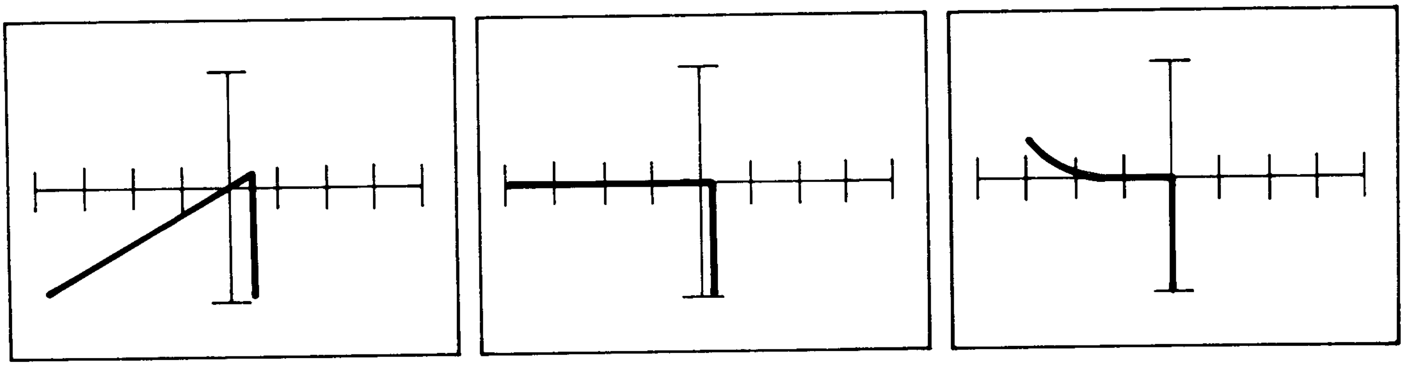


Figure 12-59. Pin Configuration of a 6301-1J



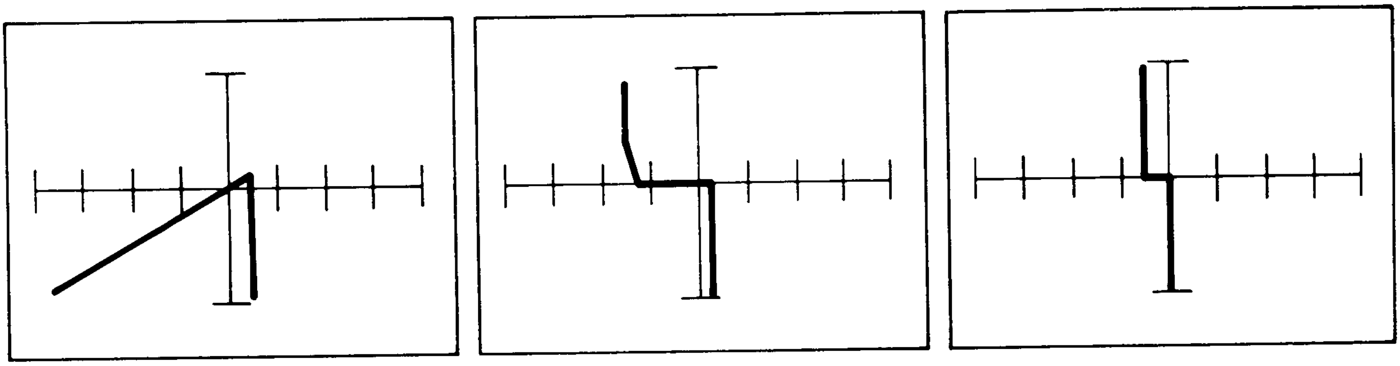
Low Medium High

Figure 12-60. Signatures Between an Address Pin and the Ground Pin of a 6301-1J



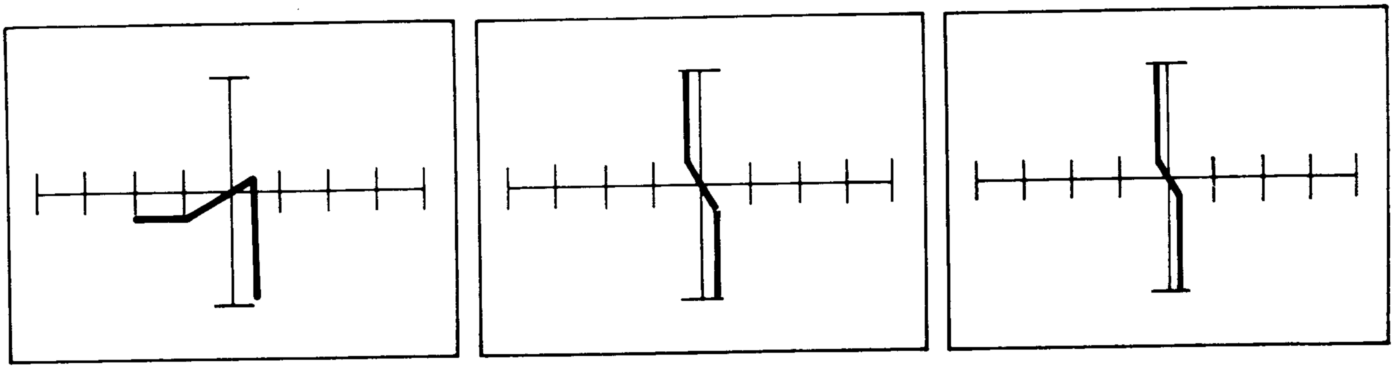
Low Medium High

Figure 12-61. Signatures Between an Output Pin and the Ground Pin of a 6301-1J



Low Medium High

Figure 12-62. Signatures Between the Enable Pin (E2) and the Ground Pin of a 6301-1J



Low

Medium

High

Figure 12-63. Signatures Between the V_{cc} Pin and the Ground Pin of a 6301-1J

12-18. DIGITAL TO ANALOG CONVERTER

The National DAC0800L is a monolithic, 8-bit, high speed, current output, digital to analog converter implemented with bipolar technology. Figure 12-64 shows the pin configuration and equivalent circuit of a DAC0800L. The signatures of various pins with respect to V− are shown in Figures 12-65 through 12-71.

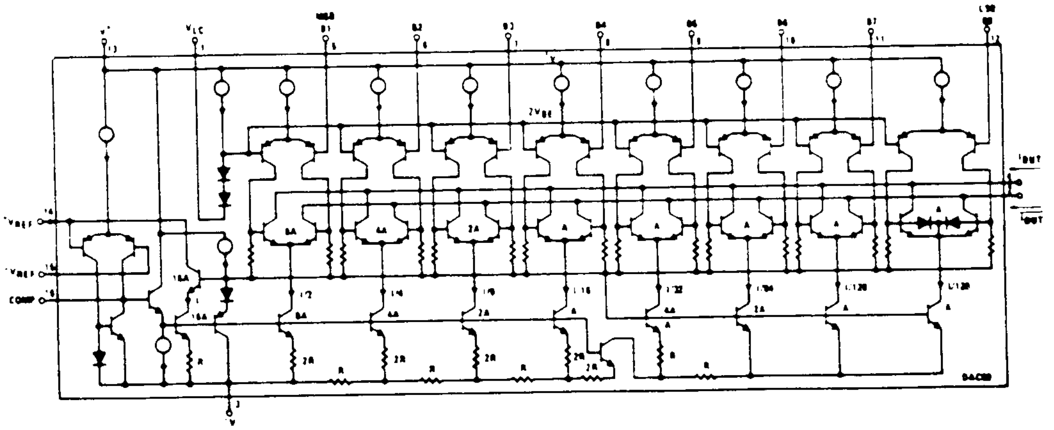
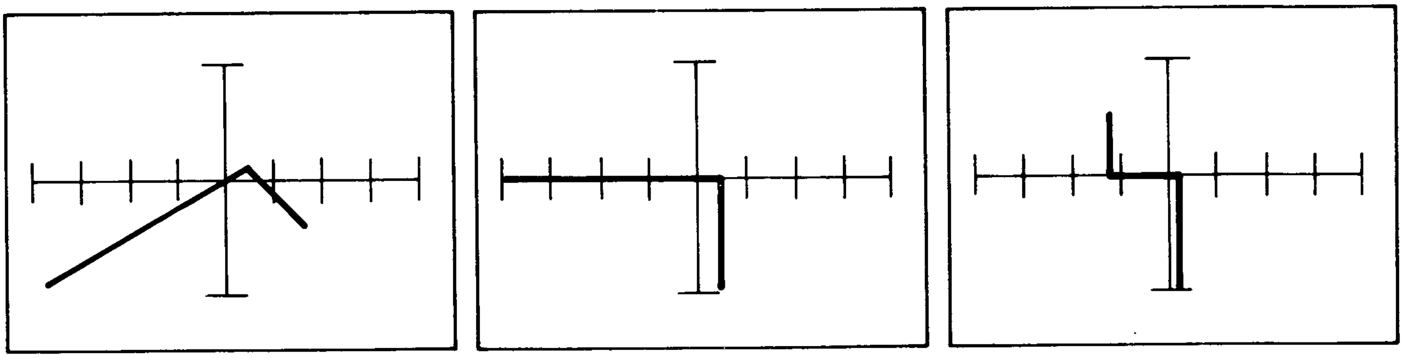
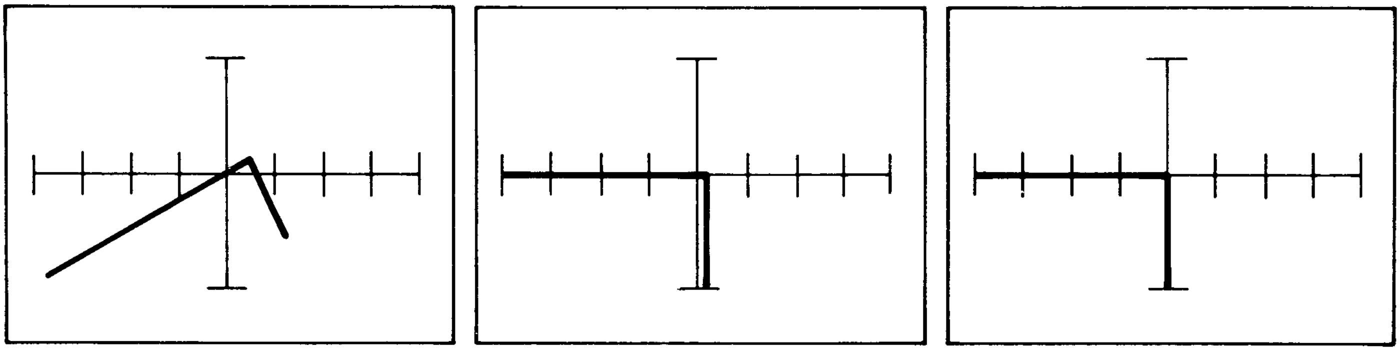


Figure 12-64. Pin Configuration and Equivalent Circuit of a DAC0800L



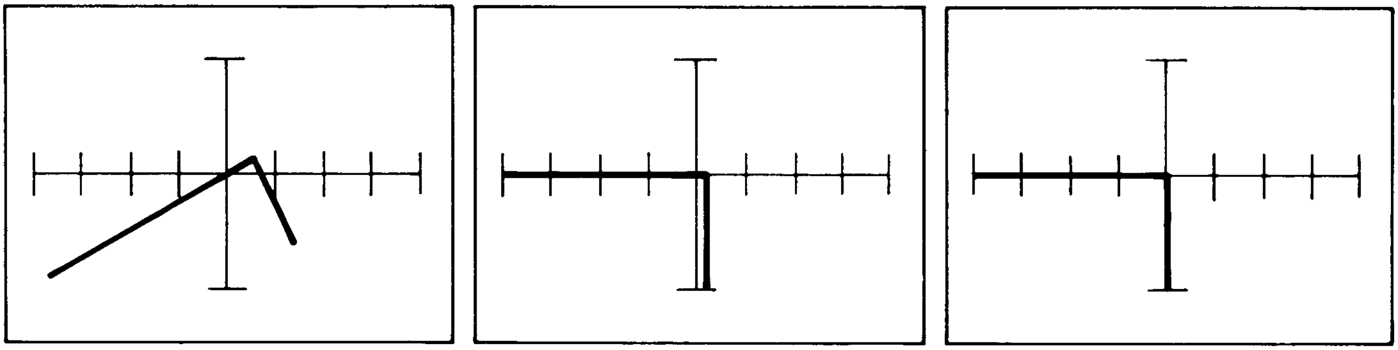
Low Medium High

Figure 12-65. Signatures Between the Threshold Pin (V_{1c}) and the V− Pin of a DAC0800L



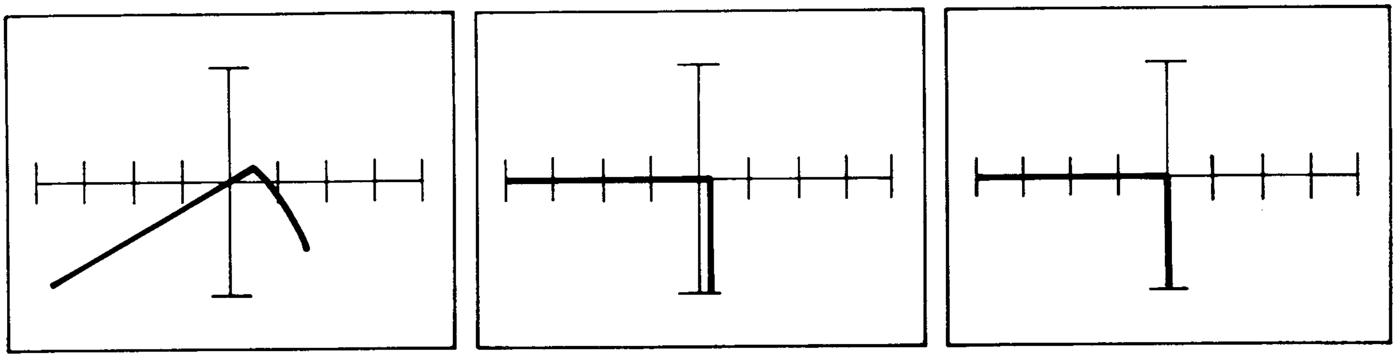
Low Medium High

Figure 12-66. Signatures Between the I_{out} Pin (4) and the V− Pin of a DAC0800L



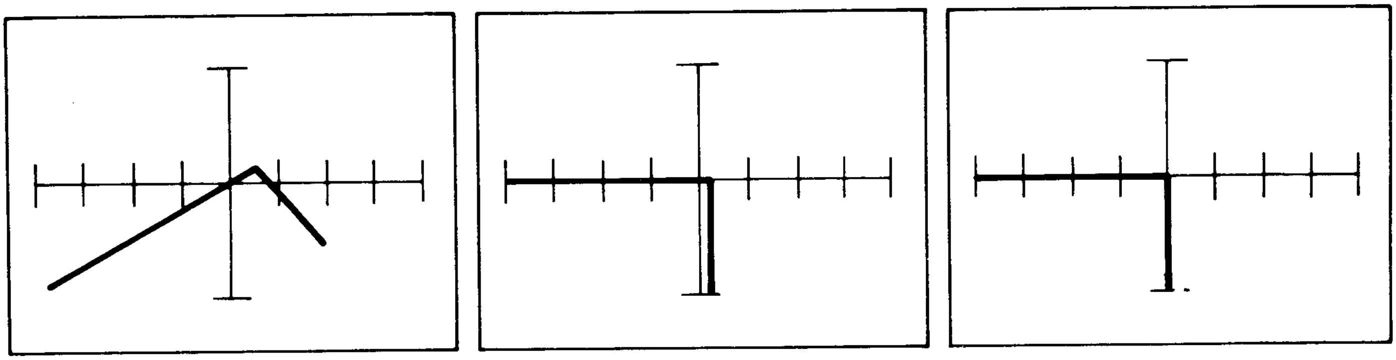
Low Medium High

Figure 12-67. Signatures Between a Digital Input Pin and the V− Pin of a DAC0800L



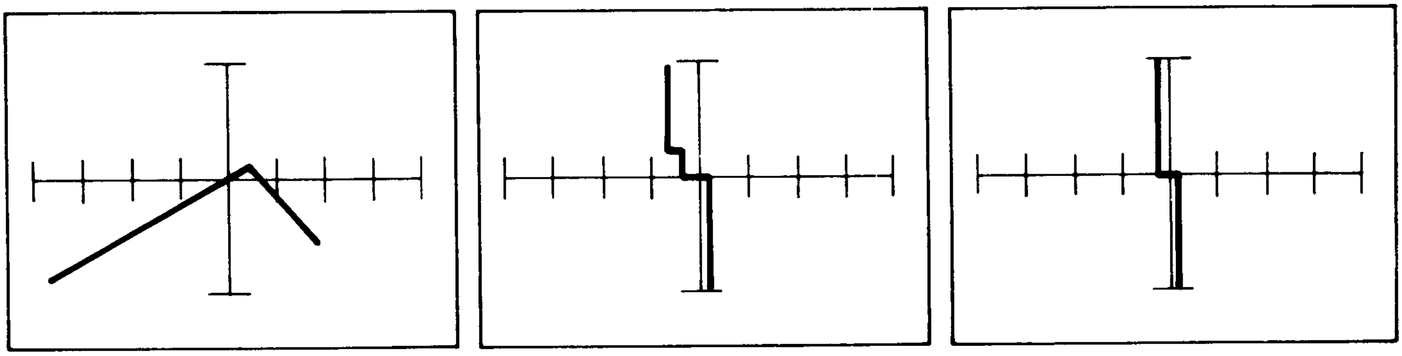
Low Medium High

Figure 12-68. Signatures Between the Reference Pin $V_{ref}(+)$ and the V− Pin of a DAC0800L



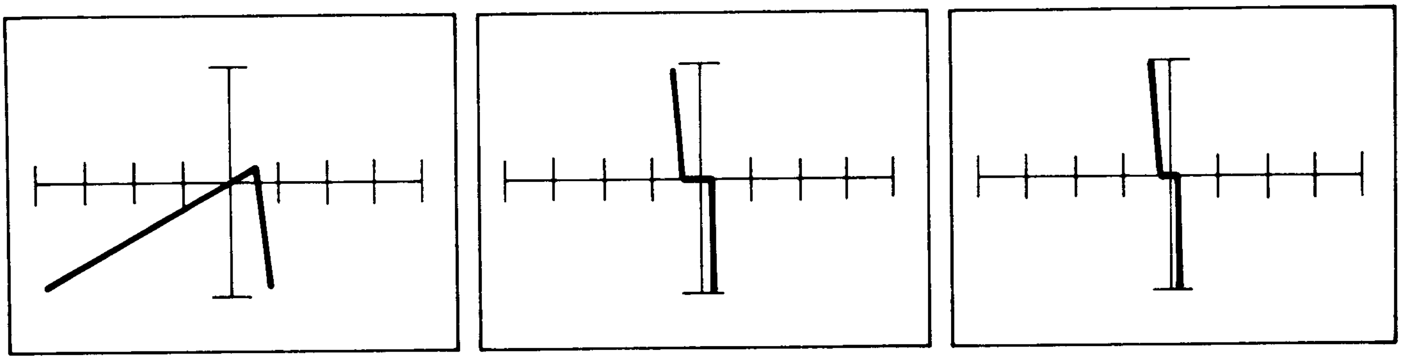
Low Medium High

Figure 12-69. Signatures Between the Reference V_{ref} (−) Pin and the V− Pin of a DAC0800L



Low Medium High

Figure 12-70. Signatures Between the Compensation Pin and the V− Pin of a DAC0800L



Low

Medium

High

Figure 12-71. Signatures Between the V+ and V− Pins of a DAC0800L

12-19. MICROPROCESSORS

The 8080A is a 8-bit parallel central processing unit (CPU). It is fabricated on a single LSI chip using an N-channel silicon gate MOS process. Figure 12-72 shows the pin configuration of an 8080A microprocessor

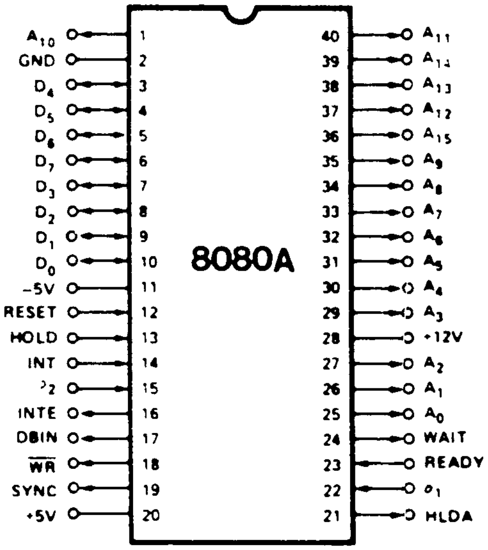
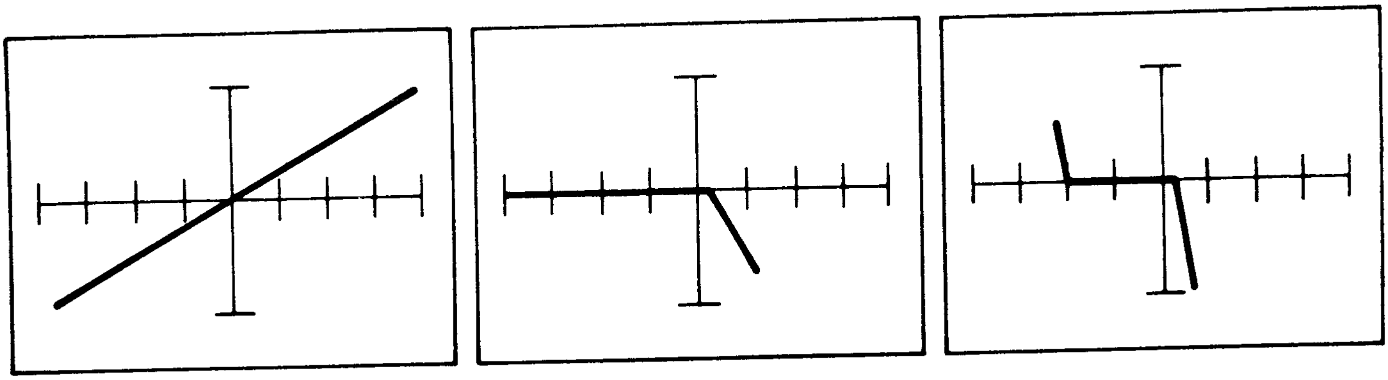


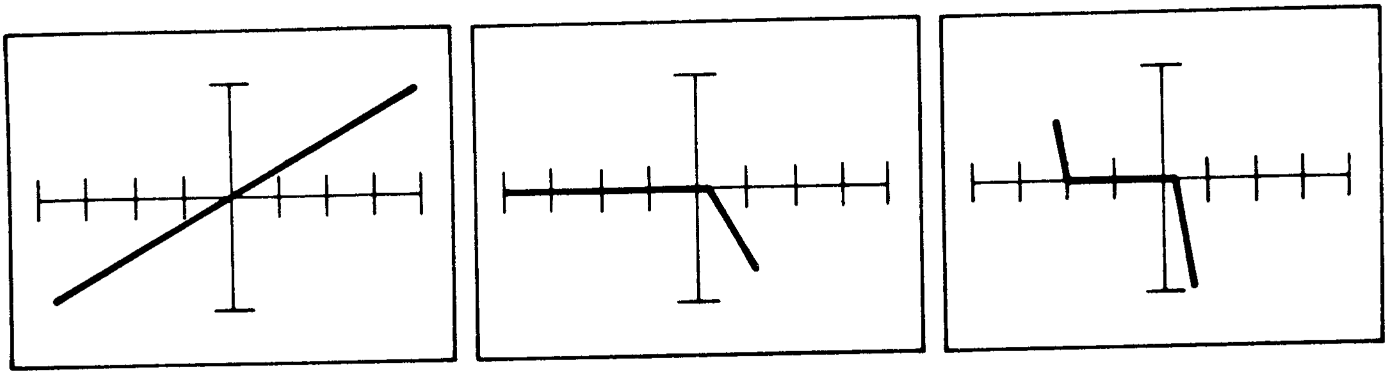
Figure 12-72. Pin Configuration of an 8080A

The signatures of various pins with respect to the −5V pin are shown in Figures 12-73 through 12-78



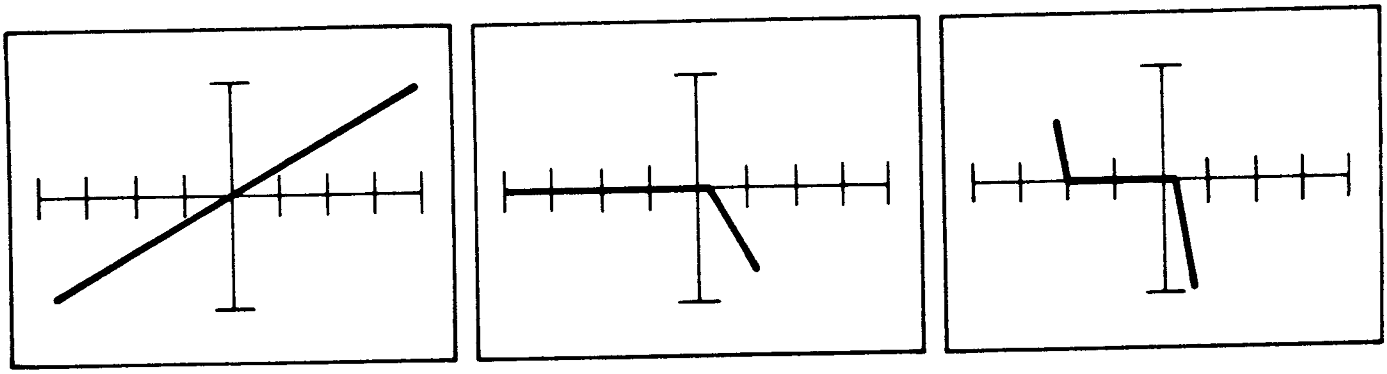
Low Medium High

Figure 12-73. Signatures Between an Address Pin and the −5V Pin of an 8080A



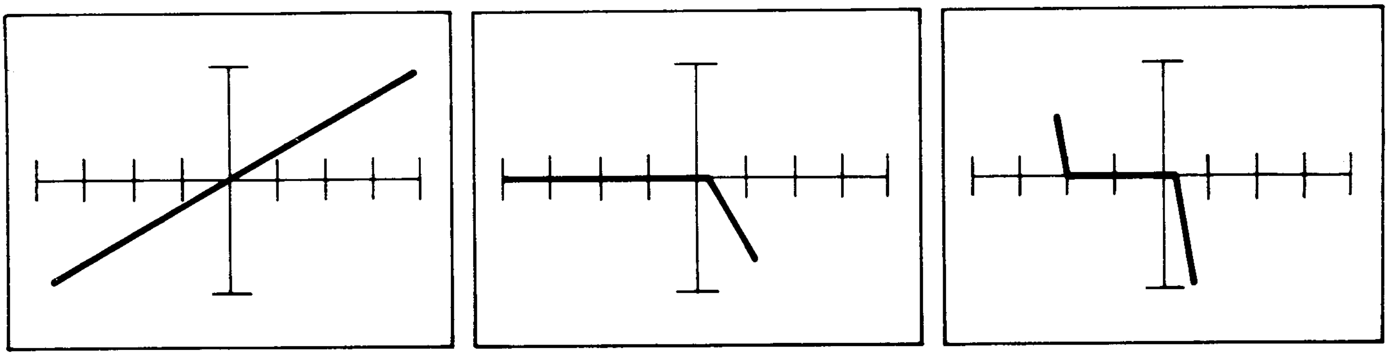
Low Medium High

Figure 12-74. Signatures Between a Data Pin and the −5V Pin of an 8080A



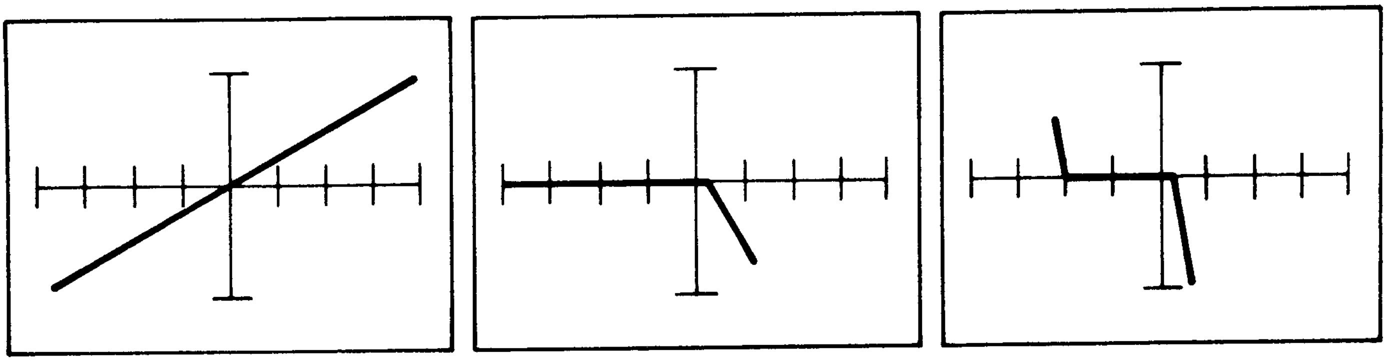
Low Medium High

Figure 12-75. Signatures Between the Reset Pin (12) and the −5V Pin of an 8080A



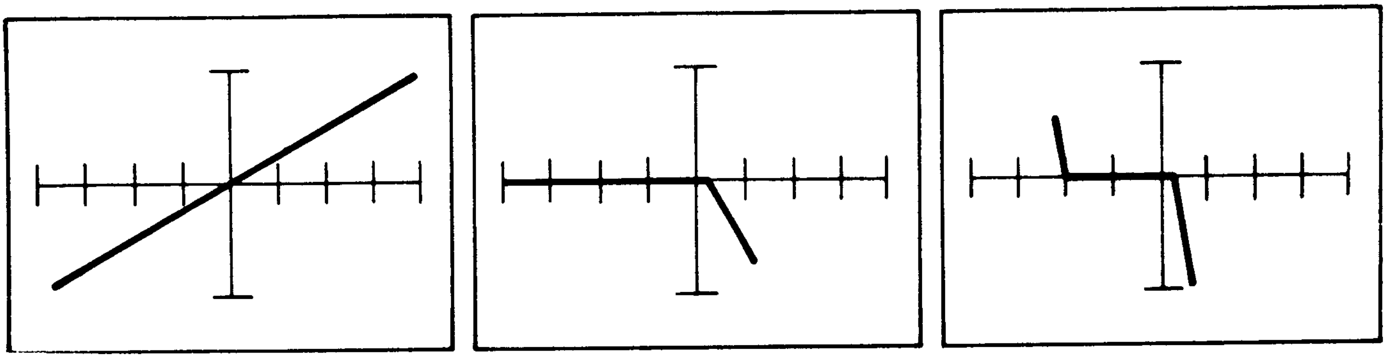
Low Medium High

Figure 12-76. Signatures Between the +5V Pin (20) and the −5V Pins of an 8080A



Low Medium High

Figure 12-77. Signatures Between the +12V Pin (28) and the −5V Pin of an 8080A



Low Medium High

Figure 12-78. Signatures Between the INTE Pin (16) and the −5V Pin of an 8080A

SECTION 13

TESTING COMPONENTS BY COMPARISON

13-1. INTRODUCTION

The previous sections of this manual have described the techniques of using the 1000 to examine good components. This section describes the examination of defective components using the 1000 in the alternate (comparison) mode.

As described in Section 2, when the alternate mode is selected, the 1000 operates in the alternate mode and will switch from displaying channel A to displaying channel B. In this mode, common on a known good circuit or device is connected to the same common on the circuit or device under test. A dissimilarity in the signatures then shows an impedance difference between the known good unit and the unit under test. Refer to Figure 13-1 for 1000 connections in the alternate mode.

13-2. SETUP PROCEDURES

Set up the 1000, the known good device, and the device under test as follows:

1. Connect the channel A test lead to a known good device.
2. Connect the channel B test lead to the same node of the device under test.
3. Connect the 1000 common to the same nodes of the known good device and the device under test.
4. Select the alternate mode. The 1000 circuit will alternately display the signature of the known good device and the device under test. By examining the signature differences, a defective component can be detected.

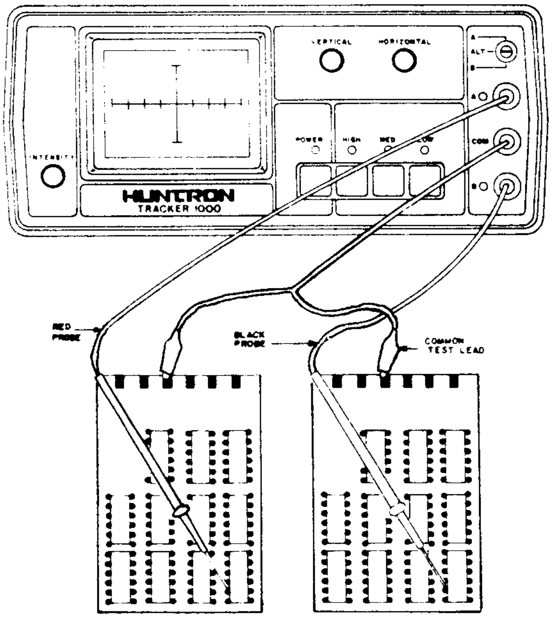


Figure 13-1. Alternate Mode Setup

13-3. POWER TRANSISTOR MJE240

13-4. MJE240 B-E Junction

Figure 13-2 shows the signatures of a known good MJE240 using the emitter as the common. This device has a sharp zener voltage (V_Z) across the B-E junction.

Figure 13-3 shows the signatures of a defective MJE240. This device has no zener voltages across the B-E junction in the medium and high ranges.

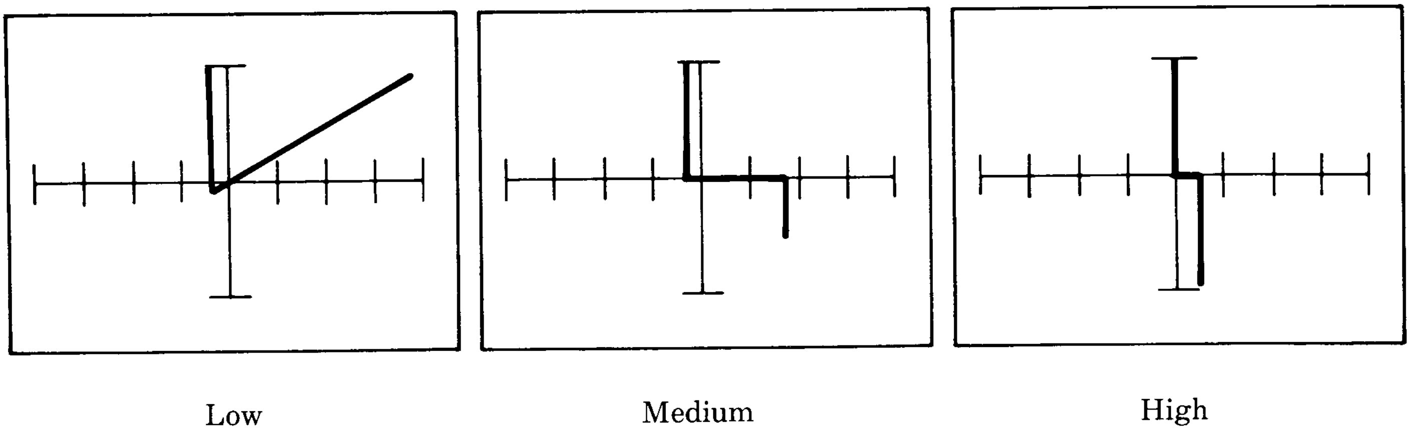


Figure 13-2. Signatures Between the Base-Emitter of a Good MJE240 Transistor

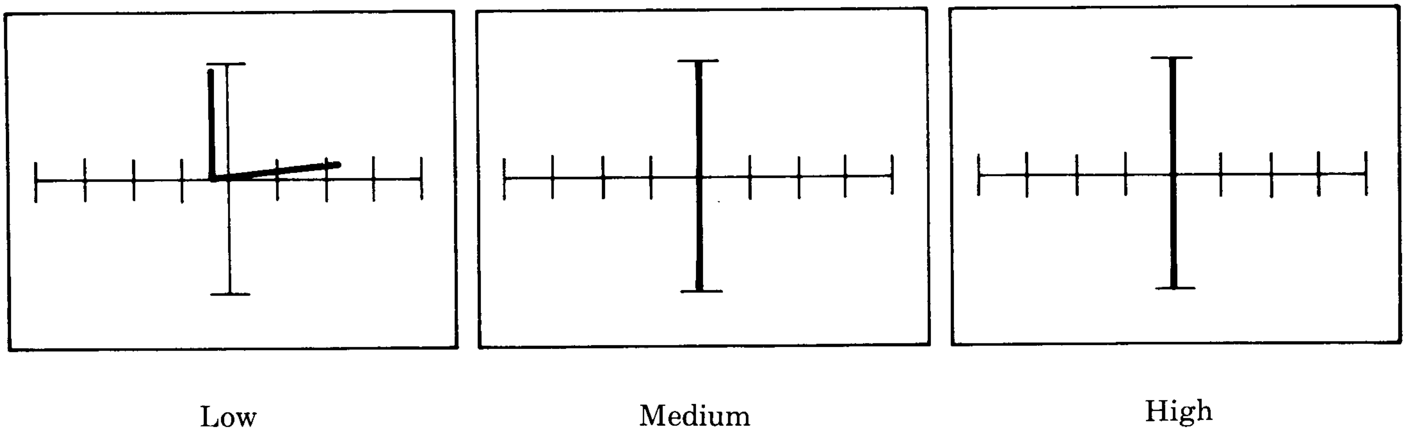
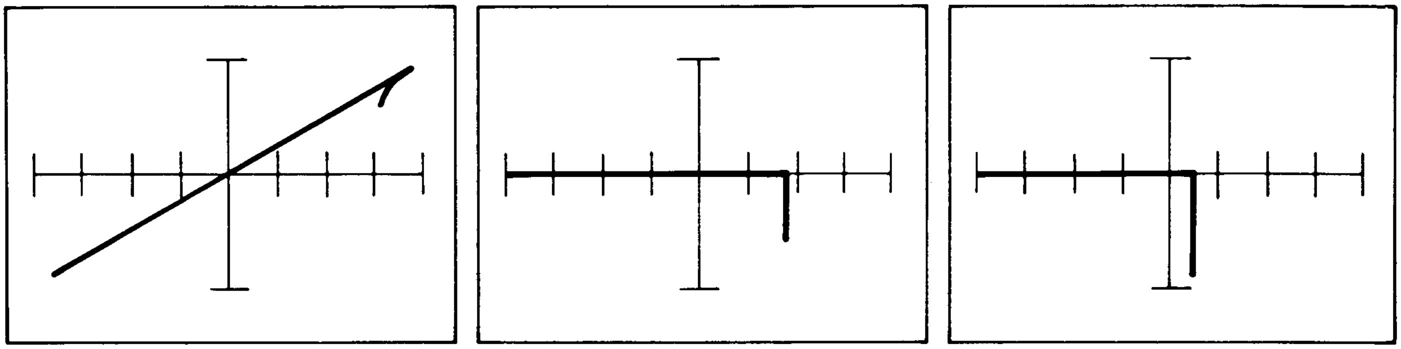


Figure 13-3. Signatures Between Base-Emitter of a Defective MJE240 Transistor

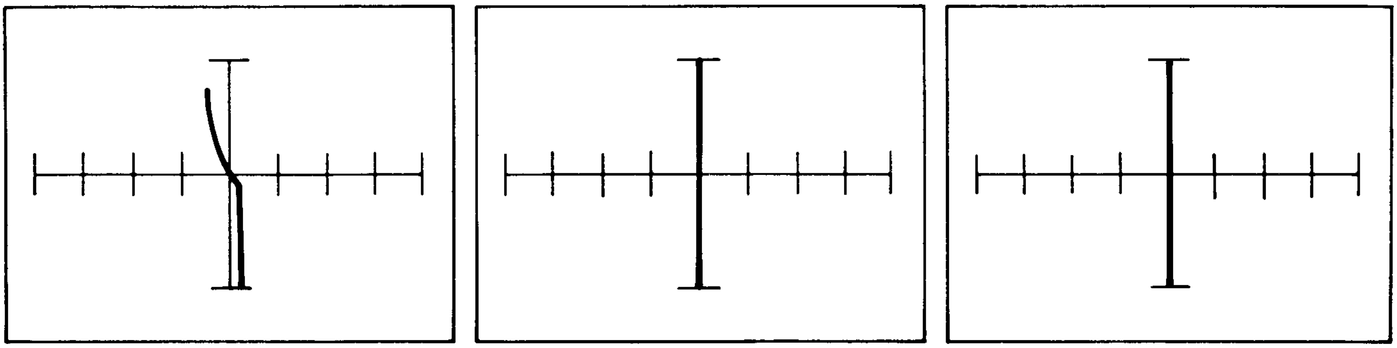
13-5. MJE240 C-E Connection

Figure 13-4 shows the signatures of a known good MJE240 using the emitter as common. The MJE240 has a 80 volt C-E breakdown voltage so the left side of the signature (positive half-cycle of the test signal) appears as an open circuit in all ranges. The current leg on the right side of the signature is due to a series connection of C-B junction (forward biased) and the B-E junction (zener breakdown). Since this is an NPN transistor, only the right side (positive C-E voltages) is normally used in most circuits, and the reverse breakdown does not affect anything. Figure 13-5 shows the signatures of a defective MJE240



Low Medium High

Figure 13-4. Signatures Between Collector-Emitter of a Good MJE240 Transistor

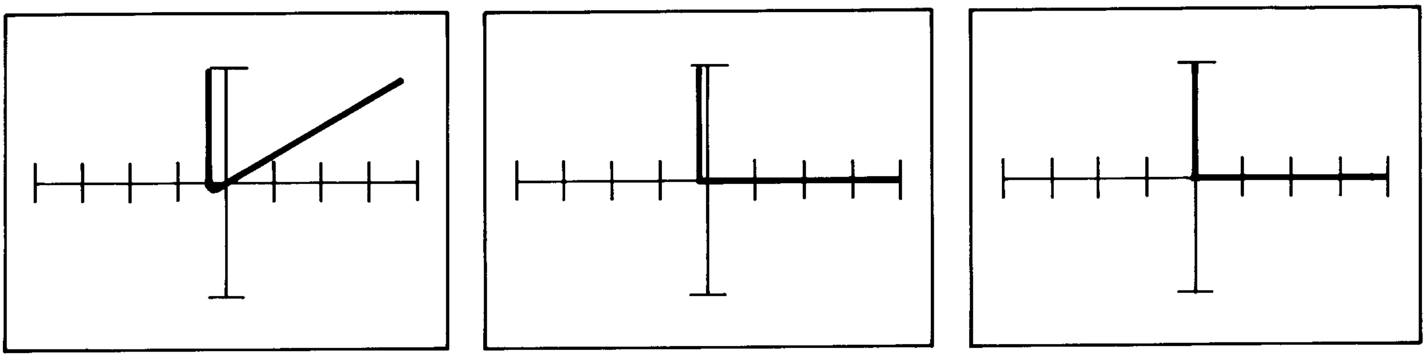


Low Medium High

Figure 13-5. Signatures Between Collector-Emitter of a Defective MJE240 Transistor

13-6. HIGH VOLTAGE DIODE HV15F

In this example, there is no signature difference when comparing a known good diode and defective diode in the low range. In the medium and high ranges, the difference is obvious (See Figure 13-6 and 13-7).

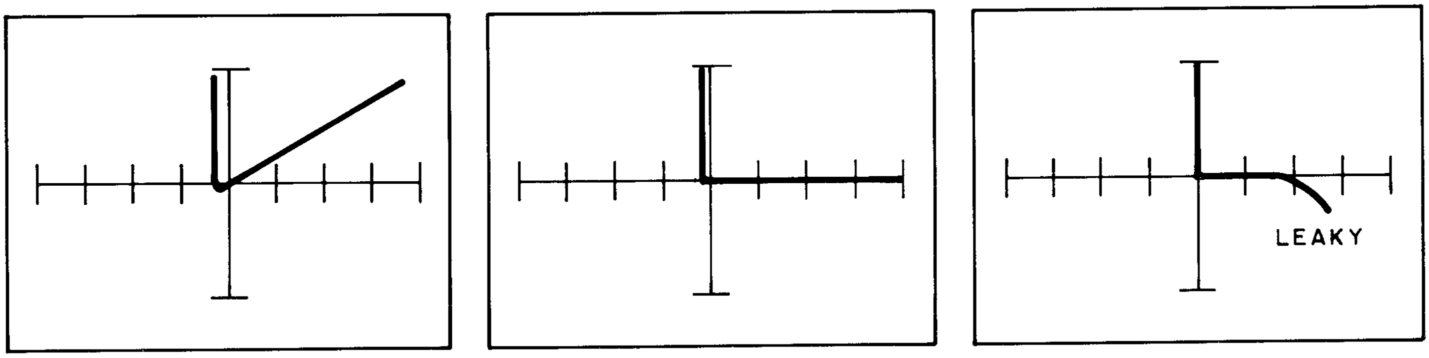


Low

Medium

High

Figure 13-6. Signatures of a Good HV15F Diode



Low

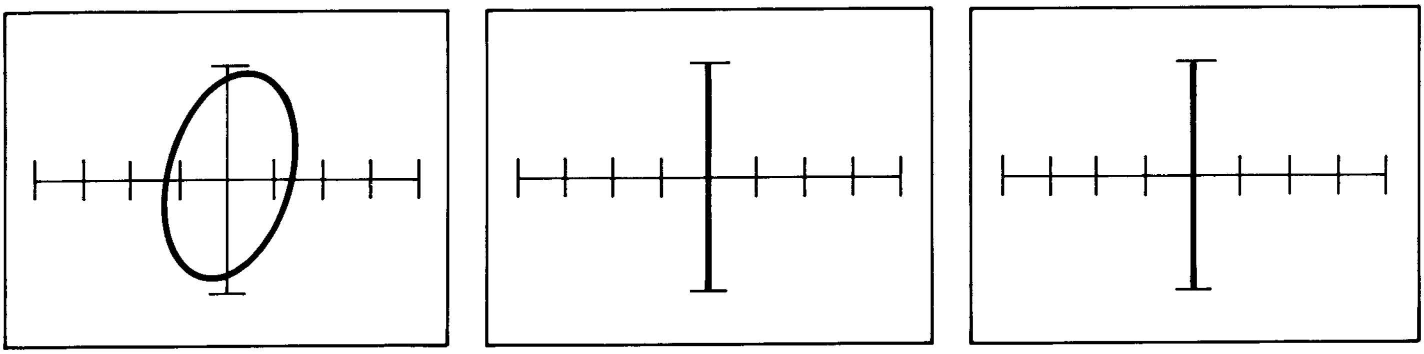
Medium

High

Figure 13-7. Signatures of a Defective HV15F Diode

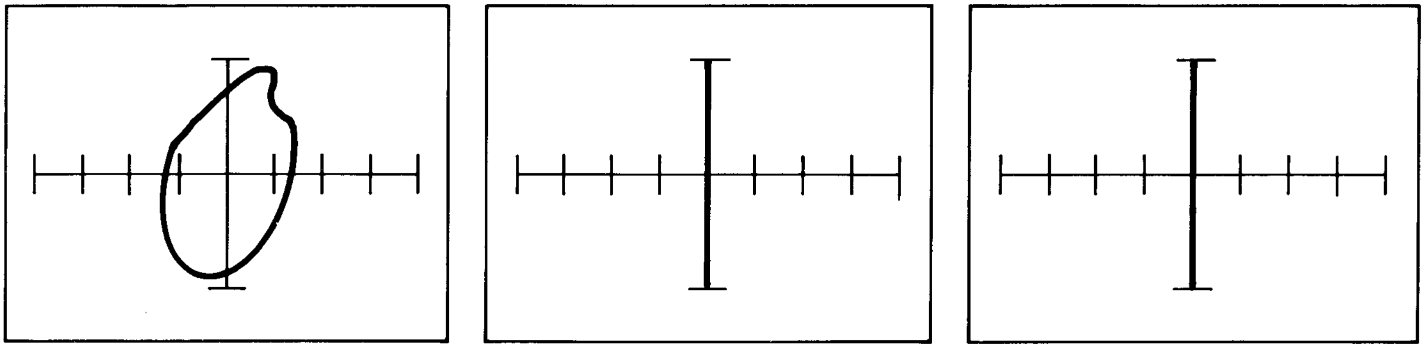
13-7. 100uF 25V ELECTROLYTIC CAPACITOR

For a good 100uF capacitor, a smooth ellipse is produced in the low range, while a defective capacitor displays an irregular shape. Figures 13-8 and 13-9 provide a comparison of good to defective capacitors.



Low Medium High

Figure 13-8. Signatures of a Good 100uF Capacitor



Low Medium High

Figure 13-9. Signatures of a Defective 100uF Capacitor

SECTION 14
TESTING POWER SUPPLIES

14-1. GENERAL

The power supply is the most common functional block in electronic equipment. Traditionally, it has been impossible to troubleshoot without being in a power-on condition. With power on, components, even good ones, can be damaged due to excessive current levels.

Basically, all linear power supplies consist of a transformer, a rectifier, electrolytic capacitors, and a load that represents the rest of the system. Figure 14-1 shows the typical power supply (equivalent circuit).

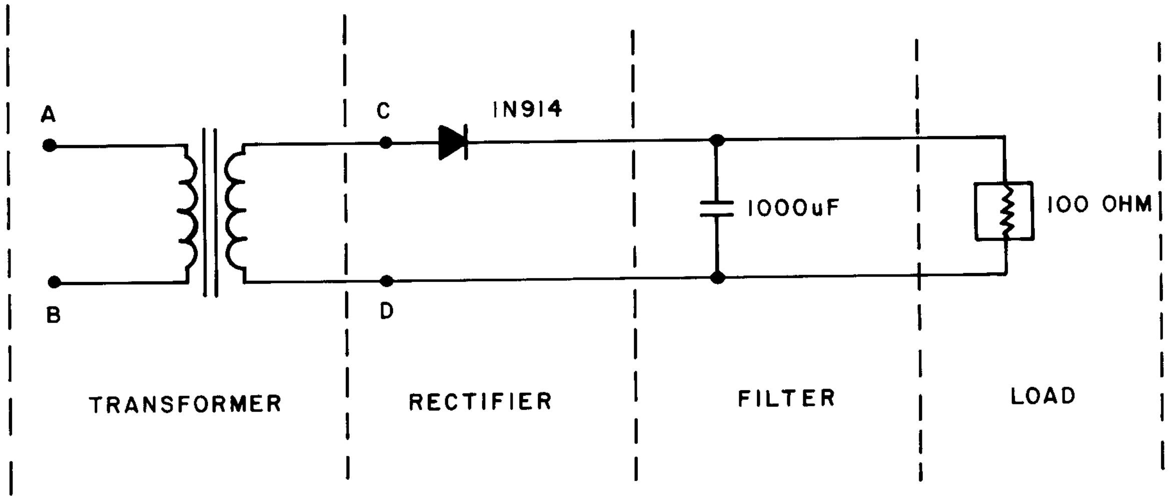


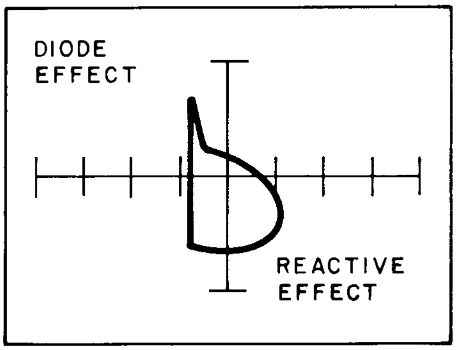
Figure 14-1. Typical Power Supply - Equivalent Circuit

When testing power supplies, make sure all power is removed from the supply and all capacitors are discharged. If the supply is a linear type, then proceed to test all the capacitors, rectifiers, zener diodes, series regulator transistors, control transistors, etc.

Switching regulator supplies are a little different to test because the ac input is first rectified and filtered and then fed to the switching devices.

14-2. TESTING PROCEDURES

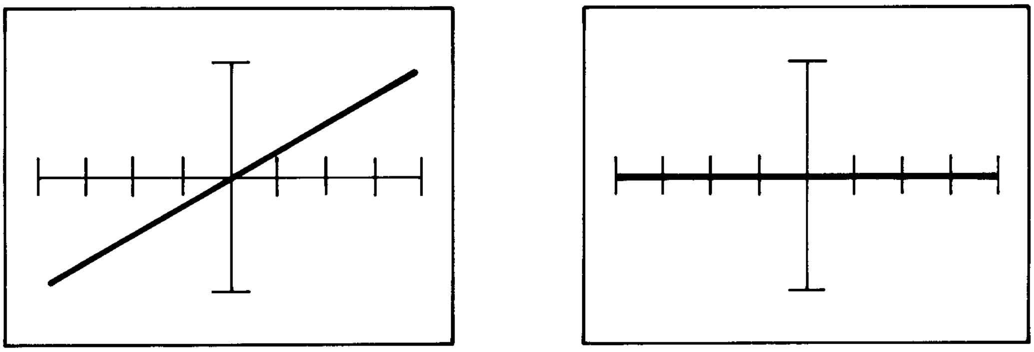
With the 1000 connected across points A and B in Figure 14-1, the display shown in Figure 14-2 should be obtained. Figure 14-2 shows a signature generated in the medium range. The diode effect and inductive effect are reflected to the primary through transformer action.



Medium

Figure 14-2. Signature Across Transformer Primary

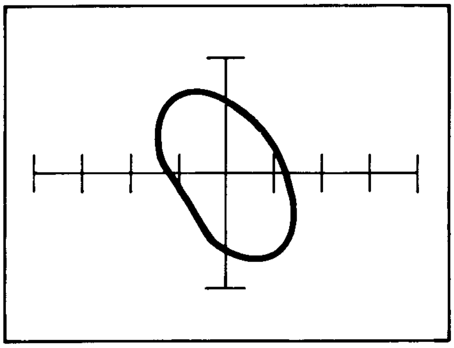
If the primary winding of the transformer is an open circuit, the display shows a horizontal signature in the medium and high ranges, and a diagonal signature in the low ranges. Refer to Figure 14-3.



Low Medium/High

Figure 14-3. Signatures Due to Open Transformer Primary

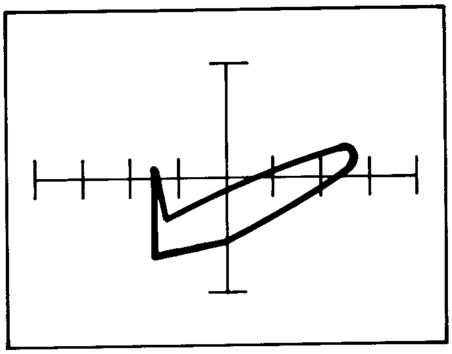
If the diode is open, the remainder of the circuit is disconnected from the transformer. The 1000 displays only the primary winding inductance, and shows a slightly distorted ellipse due to iron core saturation. Refer to Figure 14-4.



Medium

Figure 14-4. Signature Due to Open Diode

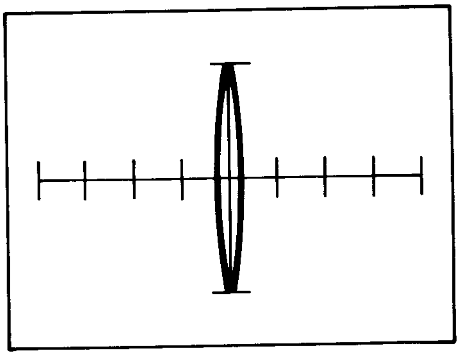
With the 1000 probes connected across points C and D of Figure 14-1, the signatures shown in Figures 14-5 through 14-10 will result from the indicated circuit conditions. Figure 14-5 shows the display of a good working circuit.



Low

Figure 14-5. Signature of a Good Circuit

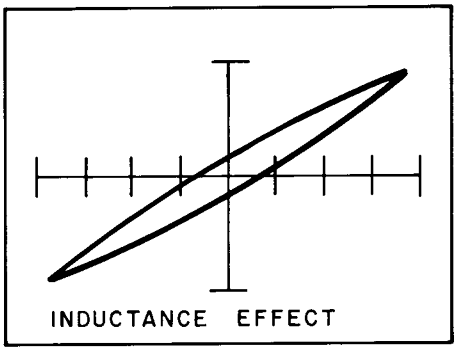
Figure 14-6 shows the signature produced by a shorted diode. With the shorted diode, the 1000 displays the secondary winding, the capacitor, and the 100-ohm resistor, all in parallel. However, at 80Hz, the 1000uF capacitor is dominant (no diode effect).



Low

Figure 14-6. Signature with Shorted Diode

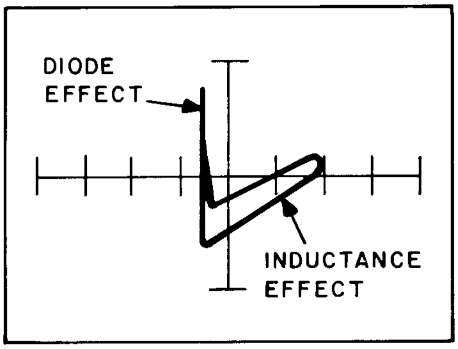
Figure 14-7 shows the signature produced by an open diode. With the open diode, the 1000 displays the secondary winding only.



Low

Figure 14-7. Signature with Open Diode

Figure 14-8 shows the signature produced by a shorted capacitor. With the shorted capacitor, the 1000 displays the diode effect and the inductive effect from the winding in parallel with the diode.



Low

Figure 14-8. Signature with Shorted Capacitor

With the open capacitor, the 1000 displays the circuit in Figure 14-9 and produces the trace shown in Figure 14-10.

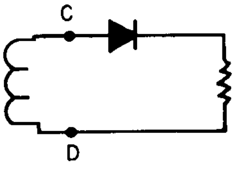


Figure 14-9. Open Capacitor Equivalent Circuit

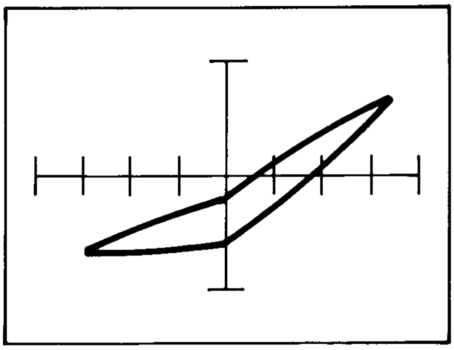


Figure 14-10. Signature with Open Capacitor

SECTION 15
SOLVING BUS PROBLEMS

15-1. INTRODUCTION

There are many different bus structures and it is not practical to analyze each one of them. The following paragraphs contain general troubleshooting information for several types of bus-related problems.

15-2. STUCK WIRED-OR BUS

Occasionally an integrated circuit will develop an internal short on a lead that is connected to a common bus. This causes a portion of the bus to remain fixed at some voltage level. If you check the stuck bus line to ground or the positive voltage supply with the 1000 in the low range, the signature will usually be a diagonal line indicating a short of four to ten ohms (although some IC shorts are as high as 50 ohms). A zero ohm short (vertical line) would indicate a mechanical short (non-IC).

The shorted device is almost certain to have other pins that show serious flaws when connected to the 1000. To locate the defective device, switch the 1000 to the medium range and check all the non-bussed pins of all devices connected to the bus. Be sure the common lead is connected to ground or the positive voltage supply. The defective device will show up as having flaws on more than one pin; usually on several pins.

15-3. UNSTUCK WIRE-OR BUS

In this type of bus problem, the signature presented on the 1000 does not indicate a short, but may show serious leakage current or some other flaw in the medium range. This type of problem is solved in a similar manner to the previously described stuck bus. Connect the common lead to ground or the positive voltage supply and examine all the pins of all integrated circuits connected to the defective bus. Usually, the defective device will have more than one pin showing an internal defect. If there are not any chips with multiple pin failures, try heating or cooling each IC individually (using a soldering iron or circuit cooler, respectively) while watching the signature of the bus line that shows leakage. Since leakage is highly temperature dependent, the defective IC should cause the signature to change, whereas the good IC's should cause no substantial change. If the defect cannot be traced to a single device by these methods, it is necessary to desolder pins connected to the bus in order to pinpoint the defective device.

15-4. MEMORIES

Memory boards can be very difficult to troubleshoot if the system does not have built-in diagnostics to identify the section of memory where information cannot be stored or retrieved. The problem may be easily displayed on the 1000 on a bus line, but since memory devices have most of their pins connected in parallel, it is difficult to isolate the bus problem down to one device.

If the memory devices are in sockets, it is a simple matter to locate the problem using the 1000. Merely locate the bus line that produces a defective signature, then remove the memory devices one at a time until the signature indicates a normal bus line.

If the memory devices are soldered in, fault isolation becomes more difficult. It should be noted that most memory failures are not due to failure of memory devices themselves, but are more often due to failures in the devices that access and control the memory section of the equipment. With this in mind, examine the memory control section of the equipment before spending much time on the actual memory devices.

If the failure is definitely in a memory device that is soldered to the PCB, find a pin that is not connected in common with the other memory devices like a chip select line (CS or CE on many memories). There must be at least one such pin per memory IC and the use of a schematic diagram is a definite help in making repairs of this type. Then check this non-bussed pin using the 1000 in the alternate mode, with the common lead of the 1000 tied to the defective bus line. Connect the channel A test lead to one non-bussed pin of one memory IC, and the channel B test lead to the same non-bussed pin of an adjacent memory IC. Compare the two signatures that result, looking for substantial changes in the shape of the signature between the two devices indicating that one of the two is probably the defective device. These changes in shape may or may not be accompanied by a DC shift (the signature shifts to the left or right as the 1000 alternates between channels). If there is only a DC shift and no change in the basic shape of the signature, that is probably due to manufacturing differences between the devices and should be ignored for the purpose of this comparison. If there are no substantial changes in the signatures of the first two devices, they are presumed to be functional and one should proceed to the next pair in the array of memory devices until the defective device is isolated. For example, if the PCB to be tested has sixteen memory IC's arranged in a two by eight array, start with the two IC's on one end and step through the array two by two for a total of eight times. If only one device is defective, one of those eight comparisons will show differences between the two devices. At that point, one should have a good idea of the "normal" signature that most of the devices have exhibited. The defective device is probably the one in the identified pair that is unlike this normal signature. This technique may not always work: sometimes a defective bus line may cause all the devices to show bad signatures and the defective IC cannot be isolated. If this occurs and there are multiple bus line failures, try using a different defective bus line as common and test all the devices again.

If none of the above troubleshooting methods provides a solution to the bus problem, unsolder one pin at a time from the defective bus line until its signature returns to normal.

SECTION 16
TROUBLESHOOTING TIPS

This section describes several tips that may be useful when using the 1000 to test various types of devices and circuits. This information is provided as a supplement to all testing information provided thus far in this manual. It is recommended reading whether or not it appears to apply to an immediate troubleshooting situation or not. There is no logical order to the presentation of the troubleshooting tips presented below.

Nearly all testing is performed with the medium or low range selected on the 1000. The high range should only be used if testing at a high impedance point, or if higher test voltages is required, such as when is desired to examine the zener region of a 40 Volt device. Sometimes component defects are more obvious in one range than another, so if a suspect device appears normal for one range, try the other ranges.

When testing a single bipolar junction, such as a diode, a base-emitter junction, or a base-collector junction, the low range usually offers the best signature. However, if checking the device for reverse bias leakage, then a higher range should be used.

Attempt to relate the failure mode of the circuit under test to the type of defect indicated by the 1000. For example, a catastrophic printed circuit board failure can be expected to be caused by a failed device with a dramatic signature difference from that of a normal device of the same type. A marginally operating or intermittent board may have a failed component that indicates only a small pattern difference from normal.

Devices made by different manufacturers, especially digital integrated circuits, are likely to produce slightly different signatures. This is normal and does not necessarily indicate a failed device.

When performing in-circuit testing, always do a direct comparison to a known good circuit of similar design, if at all possible, until a good skill level is acquired using the 1000.

If a failure system cannot be related to a specific area of the printed circuit board, begin by examining the signatures produced at the connector pins. This method of troubleshooting shows all the inputs and outputs and will often lead directly to the failing area of the board.

It should be kept in mind that leakage current doubles with every ten degree Celsius rise in temperature. Leakage current shows up on the 1000 as a rounded transition (where the signatures show the change from zero current flow to current flow) or by causing curvature at other points in the signatures. Leakage current causes curvatures due to its nonlinearity.

Never begin the testing of an integrated circuit using the low range. If the low range is initially used, confusion can result from the inability of this range to display the various junctions. Always begin testing using the medium range and, if the signature is a vertical line, switch to the low range to check for a short or low impedance (less than 500 ohms). Switch to the low range if the device is suspect and appears normal in the medium range. This will reveal a defective input protection diode not evident using the medium range.

It should be noted that the 1000 test leads are non insulated at the tips. Be sure that good contact is made to the device(s) under test.

Bipolar integrated circuits containing internal shorts produce a resistive signature (a straight line) beginning in the ten o'clock to eleven o'clock position and ending in the four o'clock to five o'clock position on the 1000 display when using the low range. This type of signature is always characteristic of a shorted integrated circuit, and results from a resistive value of four to ten ohms, typical of a shorted integrated circuit. A shorted diode, capacitor, transistor junction, etc. always produces a vertical (twelve o'clock) straight line on the 1000 display when using the low range.

When testing analog devices or circuits, the low range is used in most instances. Analog circuits contain many more single junctions, and any defects in these junctions show more easily when using the low range. Also, the 55 ohm internal impedance offered by the 1000 in the low range makes it less likely that other components in parallel with the device under test will load the 1000 sufficiently to alter the signature.

When testing an op amp in-circuit, it is highly recommended that it be compared directly with a known good circuit. This is because the many different feedback paths associated with op amps can cause an almost infinite number of signatures.

Often when checking a zener diode in-circuit, it will not be possible to examine the zener region due to circuit leakage. If it is necessary to observe the zener region under this condition, one side of the diode must be unsoldered to eliminate the loading effects of the circuit.

APPENDIX A

HUNTRON TRACKER CMOS TEST
MTL Microtesting Limited
Alton, Hampshire, England

REQUIREMENTS

It was required to ascertain whether normal usage of various types of Huntrol Tracker instruments on any, or all, of their ranges could cause damage or catastrophic failure of normal C-MOS devices.

Equipment used

Five Huntron Trackers were used to conduct five tests simultaneously. All had been checked as being to manufacturers standards prior to the test. Types were as follows:

Qty 1	Huntron Tracker Type HTR-1005-BE
Qty 3	Huntron Tracker Type HTR-1005-B1
Qty 1	Huntron Tracker Type HTR-1005-B1S

The Compar-a-trace model was used in the Tracker mode (mode switch in the "up" position) except during the actual Compar-a-trace test.

60 C-MOS devices were obtained from three manufacturers as shown below. All were brand new devices and were delivered in protective packing. Half of the devices were retained as reference devices and were kept in protective conductive foam except when removed for data-logging at the beginning and end of the test. Each device was numbered and retained the same number throughout the test.

Device No.	Manufacturer	Type No.	Type	Used for
1	Motorola	MC14071BC	Quadruple 2-input OR Gate	Test
2	Motorola	MC14071BC	Quadruple 2-input OR Gate	Test
3	Motorola	MC14071BC	Quadruple 2-input OR Gate	Test
4	Motorola	MC14071BC	Quadruple 2-input OR Gate	Test
5	Motorola	MC14071BC	Quadruple 2-input OR Gate	Test
6	Motorola	MC14071BC	Quadruple 2-input OR Gate	Reference
7	Motorola	MC14071BC	Quadruple 2-input OR Gate	Reference
8	Motorola	MC14071BC	Quadruple 2-input OR Gate	Reference
9	Motorola	MC14071BC	Quadruple 2-input OR Gate	Reference
10	Motorola	MC14071BC	Quadruple 2-input OR Gate	Reference
11	Motorola	MC14081BC	Quadruple 2-input AND Gate	Test
12	Motorola	MC14081BC	Quadruple 2-input AND Gate	Test
13	Motorola	MC14081BC	Quadruple 2-input AND Gate	Test
14	Motorola	MC14081BC	Quadruple 2-input AND Gate	Test
15	Motorola	MC14081BC	Quadruple 2-input AND Gate	Test
16	Motorola	MC14081BC	Quadruple 2-input AND Gate	Reference
17	Motorola	MC14081BC	Quadruple 2-input AND Gate	Reference
18	Motorola	MC14081BC	Quadruple 2-input AND Gate	Reference

19	Motorola	MC14081BC	Quadruple 2-input AND Gate	Reference
20	Motorola	MC14081BC	Quadruple 2-input AND Gate	Reference
21	N.S.C.	MC14071BCN	Quadruple 2-input OR Gate	Test
22	N.S.C.	MC14071BCN	Quadruple 2-input OR Gate	Test
23	N.S.C.	MC14071BCN	Quadruple 2-input OR Gate	Test
24	N.S.C.	MC14071BCN	Quadruple 2-input OR Gate	Test
25	N.S.C.	MC14071BCN	Quadruple 2-input OR Gate	Test
26	N.S.C.	MC14071BCN	Quadruple 2-input OR Gate	Reference
27	N.S.C.	MC14071BCN	Quadruple 2-input OR Gate	Reference
28	N.S.C.	MC14071BCN	Quadruple 2-input OR Gate	Reference
29	N.S.C.	MC14071BCN	Quadruple 2-input OR Gate	Reference
30	N.S.C.	MC14071BCN	Quadruple 2-input OR Gate	Reference
31	N.S.C.	MC14081BCN	Quadruple 2-input AND Gate	Test
32	N.S.C.	MC14081BCN	Quadruple 2-input AND Gate	Test
33	N.S.C.	MC14081BCN	Quadruple 2-input AND Gate	Test
34	N.S.C.	MC14081BCN	Quadruple 2-input AND Gate	Test
35	N.S.C.	MC14081BCN	Quadruple 2-input AND Gate	Test
36	N.S.C.	MC14081BCN	Quadruple 2-input AND Gate	Reference
38	N.S.C.	MC14081BCN	Quadruple 2-input AND Gate	Reference
38	N.S.C.	MC14081BCN	Quadruple 2-input AND Gate	Reference
39	N.S.C.	MC14081BCN	Quadruple 2-input AND Gate	Reference
41	R.C.A.	MC14071BE	Quadruple 2-input OR Gate	Test
42	R.C.A.	MC14071BE	Quadruple 2-input OR Gate	Test
43	R.C.A.	MC14071BE	Quadruple 2-input OR Gate	Test
44	R.C.A.	MC14071BE	Quadruple 2-input OR Gate	Test
45	R.C.A.	MC14071BE	Quadruple 2-input OR Gate	Test
46	R.C.A.	MC14071BE	Quadruple 2-input OR Gate	Reference
47	R.C.A.	MC14071BE	Quadruple 2-input OR Gate	Reference
48	R.C.A.	MC14071BE	Quadruple 2-input OR Gate	Reference
49	R.C.A.	MC14071BE	Quadruple 2-input OR Gate	Reference
50	R.C.A.	MC14071BE	Quadruple 2-input OR Gate	Reference
51	R.C.A.	MC14081BE	Quadruple 2-input AND Gate	Test
52	R.C.A.	MC14081BE	Quadruple 2-input AND Gate	Test
53	R.C.A.	MC14081BE	Quadruple 2-input AND Gate	Test
54	R.C.A.	MC14081BE	Quadruple 2-input AND Gate	Test
55	R.C.A.	MC14081BE	Quadruple 2-input AND Gate	Test
56	R.C.A.	MC14081BE	Quadruple 2-input AND Gate	Test
57	R.C.A.	MC14081BE	Quadruple 2-input AND Gate	Test
58	R.C.A.	MC14081BE	Quadruple 2-input AND Gate	Test
59	R.C.A.	MC14081BE	Quadruple 2-input AND Gate	Test
60	R.C.A.	MC14081BE	Quadruple 2-input AND Gate	Test

A test jig was constructed using Ver-Board and high quality gold flashed 14-pin DIL sockets. Each socket was isolated from all others by track cutting in order to avoid any effects of circulating earth currents due to variations in the output levels of the various Huntron Test units. As each device contained four identical gates only one gate per device (pins 1, 2 and 3) was checked on each device, although data logging checked all gates.

PROTECTION

All devices were kept in conductive foam except when actually being tested. Devices were only handled when a wrist earth strap (connected to the Test House Silent Earth) was being worn. The bench on which the tests were carried out was surfaced with a conductive mat also connected to the Silent Earth.

TEST SYSTEM

The five Huntron Trackers were connected to the five test sockets with the Huntron black socket connected to pin 7 which was made a common earthpoint for all untested gates, and an earth point for the unconnected inputs in the tested gate. The Huntrons were left connected for a period of one hour, and then switched off and the devices changed. The first check was carried out on the Huntron low range with connections to pin 1 and pin 7 with pin 2 earthed. Pin 3 was left open circuit. After all test devices had been checked in pin 1 the Huntrons were then reconnected to pin 2 and pin 7 with pin 1 earthed and pin 3 open circuit. The final check per device was with the Huntrons connected to pin 3 with pins 1 and 2 earthed.

All devices (both reference and test) were data-logged on Imperial Technology IT200 equipment prior to the start of the tests. The test devices were then data-logged again after pin 1 tests were completed and again after the pin 2 tests. The final data-logging was completed when all tests on pins 1, 2 and 3 were complete with the Huntrons switched to the low range.

All test devices were then tested in a similar way using the Huntrons on medium range, except that the test devices were not data-logged after pins 1 and 2 were completed. Data-logging did take place when tests on pin 3 were complete. Devices were then tested using the high range with data-logging again taking place on completion of tests on pin 3. In order to check the effect (if any) of the Huntron Compar-a-trace action on the CMOS devices a sample device of each manufacturer was subject to ten minutes Compar-a-trace action on the low range (2.53V) output at approx .9Hz cycle rate (Nos 12, 32, 52, 2 22 and 42). The six devices (3 x 4071 and 3 x 4081) were then data-logged.

In order to ascertain whether leads connecting the Huntrons to the devices under test could act as antennas in the region of weak fields of electo-magnetic radiation thus causing damage to the devices, the five Huntrons were left connected to five test devices (2 x Motorola-No 1, a 4071 and No 11, a 4081; 2 x NSC-No 21, a 4071 and No 31, a 4081; and 1 x RCA-No 41, a 4071).

The devices under test were then subjected to radiation from a battery driven, all solid-state frequency modulation type transmitter operating on 145MHz. The PA input power was approximately 2 watts and the antenna was a ¼ whip vertical located approximately 19'' (¼) from the center of the interconnecting wiring. Modulation was NOT applied but the carrier was switched at irregular intervals. Induction was evident by "jumping" of the Huntron traces, except on the type HTR-1005-BE. RF was radiated for approximately 15 minutes. The devices were then data-logged. All sixty off devices were then loaded onto static burn-in boards with input and output pins terminated to Vcc by 47K pull up resistors and then loaded into a Ceetel burn-in chamber at 125 degrees Celsius. After 48 hours at 125 degrees Celsuis the devices were removed from the oven and all devices data-logged. The devices were then re-loaded into the burn-in chamber for a futher 120 hours burn-in at 125 degrees Celsuis. The devices were then finally data-logged to determine the long-term effect (if any) of the Huntron Trackers.

ROTATIONAL TESTING

In order to ensure that any variations in output levels of the three types of Huntron Instruments used did not affect part of the test series devices only, devices under test were "rotated" around the test instruments as shown in the Table below. The figures shown represent the Test Number followed by the Section Number, i.e. 9/2 = Test No. 9, the 2nd Part.

DEVICE NOS	HUNTRON INSTRUMENTS				
	1	2	3	4	5
1	1/1	3/1	5/1	9/1	7/1
2	7/2	1/2	3/2	5/2	9/2
3	9/2	7/2	1/3	3/2	5/2
4	5/3	9/3	7/3	1/3	3/3
5	3/3	5/3	9/3	7/3	1/3
11	2/1	4/1	6/1	10/1	8/1
12	8/2	2/2	4/2	6/2	10/2
13	10/2	8/1	2/2	4/2	6/2
14	6/3	10/3	8/1	2/3	4/3
15	4/3	6/3	10/3	8/3	2/3
21	7/1	1/1	3/1	5/1	9/1
22	9/2	7/2	1/2	3/2	5/2
23	5/2	9/1	7/2	1/2	3/2
24	3/2	5/2	9/2	7/2	1/2
25	1/3	3/3	5/3	9/3	7/3
31	8/1	2/1	4/1	6/1	10/1
32	10/1	8/1	2/1	4/1	6/1
33	6/2	10/2	8/1	2/2	4/2
34	4/2	6/2	8/2	10/2	2/2
35	2/3	4/3	6/3	10/3	8/3
41	5/1	9/1	7/1	1/1	3/1
42	3/1	5/1	9/1	7/1	1/1
43	1/2	3/2	5/1	9/2	7/2
44	7/3	1/3	3/3	5/3	9/3
45	9/3	7/3	1/3	3/3	5/3
51	6/1	10/1	8/1	2/1	4/1
52	4/1	6/1	10/1	8/1	2/1
53	2/2	4/2	6/1	10/2	8/2
54	8/3	2/3	4/3	6/3	10/3
55	10/3	8/3	2/3	4/3	6/3

RESULTS SUMMARY

1. Motorola devices appeared to be more sensitive on the input pins when subject to the Tracker tests.

2. No change in functionality of dc parameters were exhibited on any device subjected to stimulae from the Huntron on all ranges prior to burn-in at 125 degrees Celsius.

3. Device No 1 (Motorola 14071) failed supply current after 48 hours burn-in. Device No 3 (Motorola 14071) failed supply current and functionality in gate No 4 (pins 11, 12 and 13) after 48 hours burn-in.

4. Device No 1 failed supply current and functionality in gate No 4 (pins 11, 12 and 13) after 168 hours burn-in. Device No 17 (Motorola 14081 Reference device) failed supply current after 168 hours burn-in.

CONCLUSIONS

Although three devices failed during static burn-in it is felt that the failures cannot be contributed to any harmful effects due to stimulae from the Huntron Trackers as the failure modes were totally independent of pins 1, 2 or 3 which were pins stimulated by the Trackers. Furthermore, one of the devices which failed during burn-in was a Reference device which was not connected to a Tracker in any form.

It should be noted that the burn-in condition which was applied to the device is very extreme (viz. 125 degrees) for plastic encapsulated devices and that the incident of failure is unlikely to be related to the test performed by the Huntron Tracker.

APPENDIX B

HUNTRON TRACKER TTL AND CMOS TESTS

Components Concepts
Everett, WA 98201

OBJECT: To determine the effect of the testing signals from a Huntron Tracker in-circuit component tester on performance of CMOS integrated circuits.

COMPONENT TESTED: Motorola MC 14011 and TI74LS11

(1) Burn-in (100%) 180 pieces at 125 degrees Celsuis = 48 hours

(2) Electrical (100%) to obtain 150 units to be labeled as follows:

  Label 25 units as HH1, HH2, HH3 .... HH25
  Label 25 units as HM1, HM2, HM3 .... HM25
  Label 25 units as HL1, HL2, HL3 .... HL25
  Label 25 units as VH1, VH2, VH3 .... VH25
  Label 25 units as VM1, VM2, VM3 .... VM25
  Label 25 units as VL1, VL2, VL3 .... VL25M

(3) Electrical (100%) in the following sequence:

  (a) HH1, HH2 .... HH25
  (b) HM1, HM2....... HM25
  (c) HL1, HL2 .... HL25
  (d) VH1, VH2 .... VH25
  (e) VM1, VM2 .... VM25
  (f) VL1, VL2 .... VL25

For DC Parametrics and function per the manufacturers specifications, TA=25 degrees Celsius. They are to be tested on HP5054 digital IC tester. All parameters data logged. Propagation delay tested per specification for pass/fail only.

(4) Connect Huntron Tracker to sequencer (sequencer is a piece of equipment supplied by Huntron Instruments, Inc. which applies testing signals from Tracker and tester to device under test) to each piece of equipment and turn on power.

(5) (a) Set Tracker range to HIGH.

  (b) Set Tester range to HIGH.

  (c) Insert HH1 in zero-insertion force socket marked "Huntron Tracker" located on top of sequencer.

  (d) Activate "start" button on sequencer. The red LED will come on when sequencing is completed. (It takes 90 seconds).

  (e) Remove devices under test.

  (f) Repeat steps (c), (d), (e), (f), for HH2, HH3 . . . HH25.

(6) Set Tracker and tester range to medium and repeat steps (c), (d), (e), (f) described in (5) for HM1, HM2 . . . HM25, and VM1, VM2 . . . VM25.

(7) Set Tracker and test range to low and repeat steps (c), (d), (e), (f) described in (5) for HL1, HL2 . . . HL25, and VL1, VL2 . . . VL25.

(8) Electrical test (100%) in the following sequences:

HH1, HH2 .... HH25
HM1, HM2 .... HM25
HL1, HL2 .... HL25
VH1, VH2 .... VH25
VM1, VM2 .... VM25
VL1, VL2 .... VL25

For DC parametrics and function T=25 degrees Celsius. Propagation delay tested per specification for pass/fail only. All parameters data logged on HP5054 digital tester.

TEST REPORT

Component Concepts, Inc., an independent test lab for active electronic components, performed testing on the effect of part exposure to the Huntron “Tracker.” The Huntron “Tracker” is an in-circuit stand-alone component tester. Two types of parts were tested in pertinent data recorded prior to test with the “Tracker.” The parts were then tested and data logged after the “Tracker” test. The two sets of data, pre- and post-, were then compared for any possible effects that the “Tracker” might have upon the parts. Seventy-five pieces of 74LS11's and seventy-five of 4011's were tested. All parts passed after testing with the Huntron. The data logged parameters were input and operation current, and output voltage. No discernable effects were observed upon analysis of the pre- and post- data logs.

The exact test flow is as follows:

1. All parts before testing were subjected to 48 hours burn-in at 125 degrees Celsius.
2. 74LS11 and 4011 tested for pass/fail operation at 125 Celsius.
3. 75 of each part tested for propagation delay, pass/fail.
4. Parts datalogged for specific parameters.
5. Parts subjected to test by the Huntron instrument.
6. Propagation delay tested.
7. Post-test datalog performed, same parameters recorded.
8. Datalogs analyzed to determine any effects of Huntron“Tracker” upon parts.

TEST DISCUSSION

The testing procedures used can only validate the externally measurable parameters of the part and its function. The internal functioning of the part can be assumed to follow with the externally measureable parameters.

The lot of parts received from Huntron were uniform in date code and manufacture. All parts were 100% functional after a static burn-in of 48 hours. The ITL and CMOS parts were tested on a Hewlett Packard 5045 IC Tester (Ser. # 1712A00222). The data was recorded on a companion HP9825 Calculator. Huntron provided a “Tracker” and “Sequencing Unit.” The Huntron “Tracker,” (Ser. # 21F01001), was connected to the sequence unit which, according to Huntron, automatically connected the leads of the part to the tester one lead at a time. The actual functioning of the sequencer and the two test units are not the responsibility of Component Concepts other than the following of instructions provided by Huntron for proper operation.

After burn-in the parts were tested pass/fail for propagation delay in a bench set-up using a pulse generator and a 100MHz HP oscilloscope. The parts were also data logged. They were then tested on the sequencer with the two testers attached. After being tested with the sequencer the parts were again tested for propagation delay and data logged. At all times attention was paid to static ESD precautions.

TEST RESULTS

At pre-test, after burn-in, all parts were functional for DC and ASC parameters, seventy-five parts were datalogged from each part type, 74LS11 and 4011 BC. A comparison of data after testing showed no significant change in either input current or output voltage under load. The data printed out by the HP9825 Calculator was reduced to a more readable format which clearly shows the value recorded before and after the differences between the two values. The majority of differences between values are within the accuracy limits of the HP 5045 Tester. Points where there are differences greater than that value are not significant in number to produce any possible negative conclusions on tester interaction with the tested parts. Based on the collected data, the Huntron "Tracker" has no discernable impact on the parts they test.

NOTES