HUNTRON®

TRACKER® 2000

OPERATING & MAINTENANCE MANUAL

FOR MODELS
2000
2000E
2000J

HUNTRON®

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HUNTRON® TRACKER®

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HUNTRON INSTRUMENTS, INC.
TRACKER® 2000
OPERATING & MAINTENANCE MANUAL

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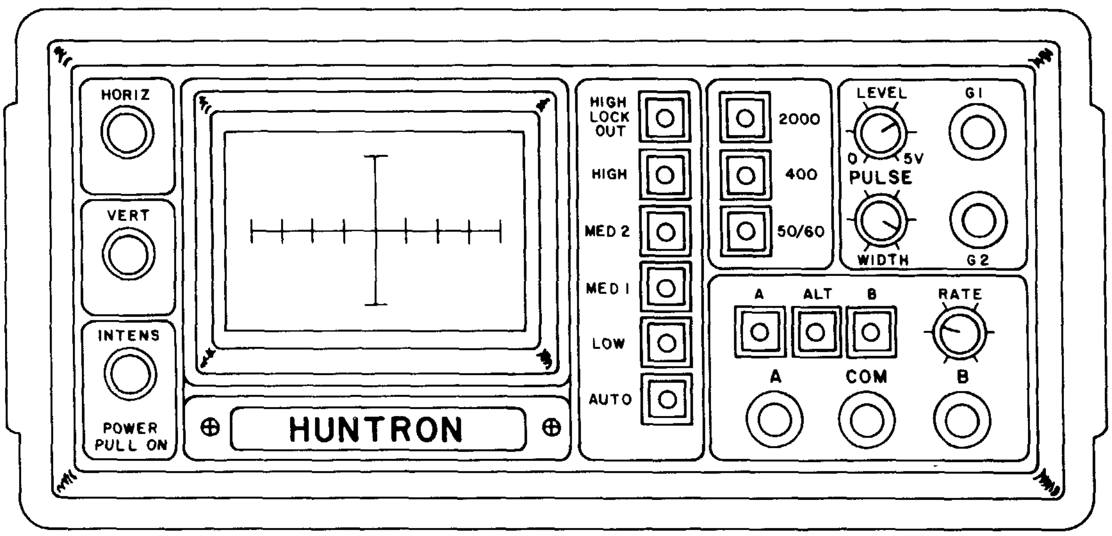


Huntron Tracker Model 2000

1-1. INTRODUCTION

The Tracker 2000 is a useful and efficient troubleshooting tool enhanced by the following new features:

★ Multiple test signal frequencies (50/60Hz, 400Hz, 2000Hz).

★ Four impedance ranges (low, medium 1, medium 2, high).

★ Automatic range scanning.

★ Range control: High Lockout.

★ Rate of channel alteration and/or range scanning is adjustable.

★ Built-in pulse generator for dynamic testing of three terminal devices.

★ LED indicators for all functions.

Other features include:

★ Dual channel capability for easy comparison.

★ Large CRT display with easy to operate controls.

1-2. SPECIFICATIONS

The specifications of the Tracker 2000 are listed in Table 1-1.

Table 1-1. Tracker 2000 Specifications

ELECTRICAL

Impedance Ranges

Terminal Characteristics:

Range	Open Circuit Voltage (V_{pp})	Short Circuit Current (mA_{rms})
HIGH	120	0.6
MED2	40	0.6
MED1	30	9.0
LOW	20	135

Autoranging Rate .... adjustable from 0.4Hz to 5.0Hz (ALT=off)
adjustable from 0.2Hz to 2.5Hz (ALT=on)

Test Signal

Waveform .... sine wave

Frequencies 50/60Hz, 400Hz, 2000Hz

Channels

Number 2

Alternation Rate .... adjustable from 0.4Hz to 5.0Hz (ALT=on)

Overload Protection .... 1/4 A internal fuse (operator replaceable)

Pulse Generator

Level............................ adjustable from zero to +5 Volts (with respect to instrument common)

Frequency .... 2 times the test signal frequency

Duty Cycle .... adjustable from ~0% to 100% (DC)

Output Impedance................ 100 ohms (each output)

Short Circuit Current .... 50mA max (each output)

Table 1-1. Tracker 2000 Specifications (cont.)

ELECTRICAL (cont.)	
Display	
Type	Monochrome CRT
Size	2.8" (7cm) diagonal
Acceleration Potential	1350VDC (regulated)
POWER REQUIREMENTS	
AC Line Voltage:	
2000	115VAC
2000E	220/240VAC
2000J	100VAC
Frequency	47-400Hz
Power	20 Watts max
Line Fuse	1/4 A type GMA (back panel accessible)
GENERAL	
Size	8.8" W x 4.5" H x 11" D (22.5cm W x 11.5cm H x 28.0cm D)
Weight	7 lbs. 8 oz. (3.4kg)
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 Tracker 2000. 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 Tracker 2000.

2-2. UNPACKING YOUR INSTRUMENT

Your instrument was shipped with two Huntron Microprobes (one red and one black), a common test lead (black), two micro clip leads (blue), a power/clock cable (for use with the Huntron Switcher 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 Tracker 2000 using a two terminal system (three terminal system when the built-in pulse generator is used), where two test leads are placed on the leads of the component under test. The Tracker 2000 tests components in-circuit, even when there are several components in parallel.

The Tracker 2000 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 a 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 capacitators, etc.), may cause this fuse to open, making replacement necessary. When the signal fuse blows, a dot will be displayed on the CRT display.

CAUTION: THE DEVICE TO BE TESTED MUST HAVE ALL POWER TURNED OFF, AND HAVE ALL HIGH VOLTAGE CAPACITATORS DISCHARGED BEFORE CONNECTING THE TRACKER 2000 TO THE DEVICE.

2-4. SIGNAL FUSE REPLACEMENT

To replace the signal fuse (F1), disconnect the Tracker 2000 from the power line. Remove the eight case bezel screws located on the sides of the Tracker 2000. Remove the front and back bezels and lift off the case top (refer to Figure 2-1). Locate F1 on the main printed circuit board assembly immediately behind the channel test terminals (refer to Figure 7-1). Replace F1 with a 0.25A, 250V, type AGX fuse.

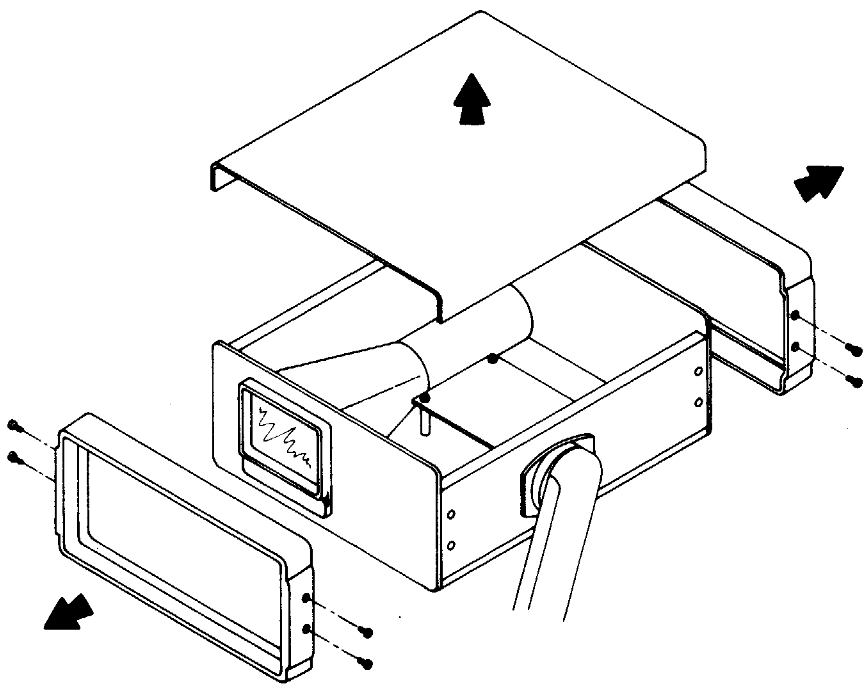


Figure 2-1. Signal Fuse Access Procedure

2-5. LINE FUSE REPLACEMENT

The line fuse (F2) should only open when there is an internal failure inside the Tracker 2000. Therefore the problem should always be located and corrected before replacing F2. F2 is accessible via a removeable compartment on the back panel of the Tracker 2000 (see section 2-8). Replace F2 with a 0.25A, 250V, type GMA (5mm x 20mm) fuse.

2-6. PHYSICAL FEATURES

Before you begin to use your Tracker 2000, please take a few minutes to familiarize yourself with the instrument. All of the externally accessible features are discussed in sections 2-7, 2-8, and 2-9.

2-7. FRONT PANEL

The front panel of the Tracker 2000 is designed to make function selection easy. All push buttons are momentary action and have integral LED indicators that show which functions are active. Refer to Figure 2-2 and Table 2-1 for a detailed description of each item on the front panel.

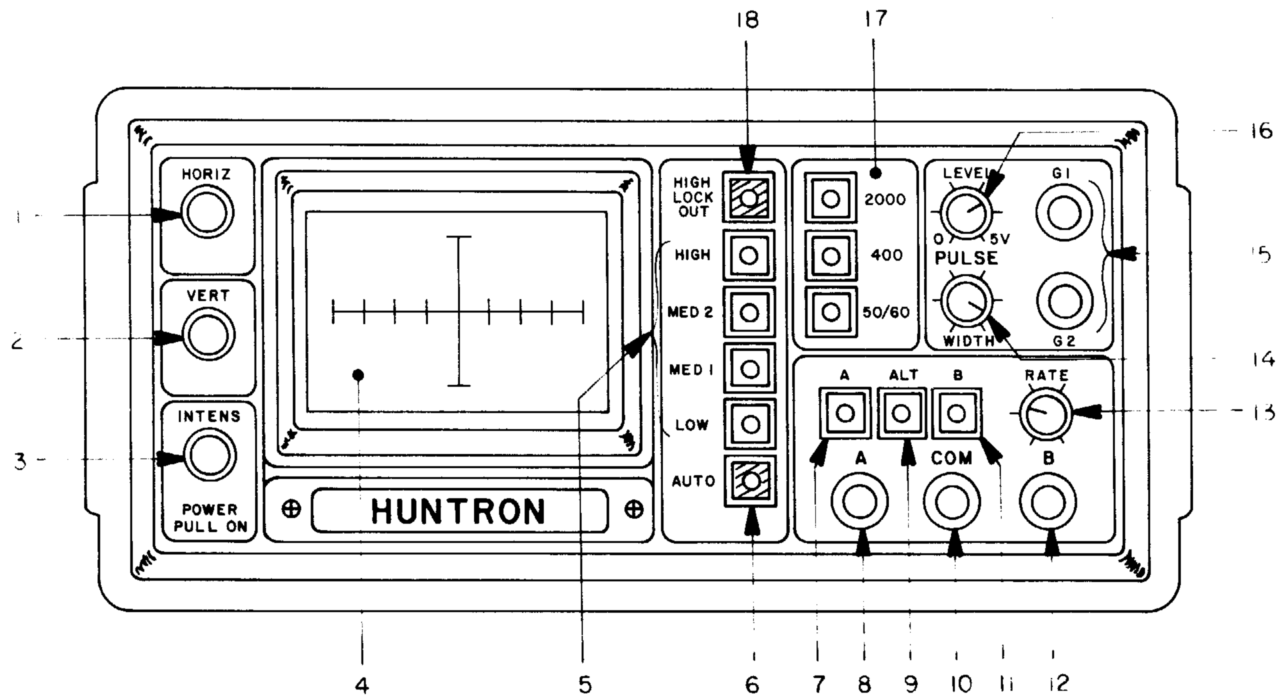


Figure 2-2. Front Panel

Table 2-1. Front Panel Controls & Connectors

ITEM NO.	NAME	FUNCTION
1	HORIZ control	Controls the horizontal position of the CRT display
2	VERT Control	Controls the vertical position of the CRT display.
3	INTENS Control Power On/Off Switch	Controls the intensity of the CRT display. Power Switch: Pull-On, Push-Off.
4	CRT Display	Displays the component signatures produced by the Tracker 2000.
5	Range Selectors	Push buttons that select one of four impedance ranges: low, medium 1, medium 2, high.

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

ITEM NO.	NAME	FUNCTION
6	AUTO Switch	Push button that initiates automatic scanning of the four ranges from low to high. The scanning speed is determined by the RATE control (see item #13).
7	Channel A Switch	Push button that causes channel A to be displayed.
8	Channel A Test Terminal	Fused test lead connector that is active when channel A is selected. All test lead connectors accept standard banana plugs.
9	ALT Switch	Push button that causes the Tracker 2000 to alternate between channel A and channel B at a speed determined by the RATE control (see item #13).
10	COM Test Terminal	Fused test lead connector that is instrument common and the common reference point for both channel A and channel B.
11	Channel B Switch	Push button that causes channel B to be displayed.
12	Channel B Test Terminal	Fused test lead connector that is active when channel B B is selected.
13	RATE Control	Controls the rate of channel alternation and/or range scanning.
14	WIDTH Control	Controls the duty cycle of the internal pulse generator.
15	G1 & G2 Terminals	Pulse generator output test lead connectors.
16	LEVEL Control	Controls the amplitude of the internal pulse generator.
17	Frequency Selectors	Push buttons that select one of three test signal frequencies: 50/60Hz, 400Hz, 2000Hz.
18	HIGH LOCKOUT Switch	Push button that activates a mode where it is not possible to enter the high range either by manual or automatic range selection.

2-8. BACK PANEL

Secondary controls and connectors are on the back panel. Refer to Figure 2-3 and Table 2-2 for a detailed description of each item on the back panel.

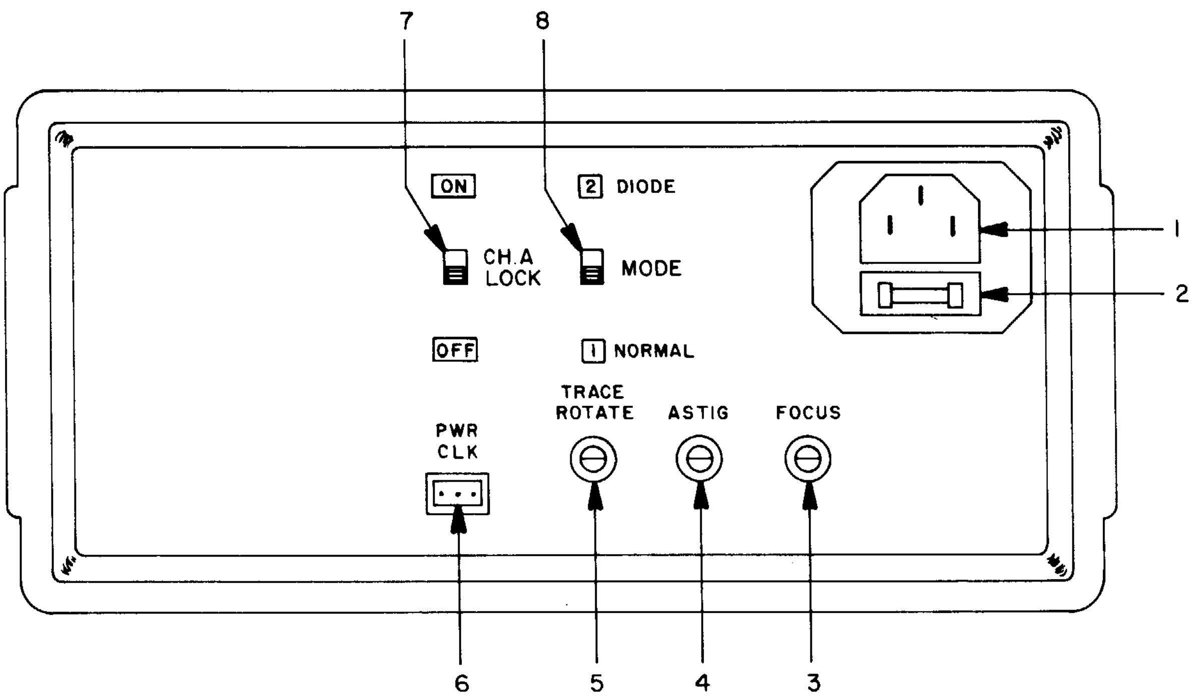


Figure 2-3. Back Panel

Table 2-2. BBack Panel Controls & Connectors

ITEM NO.	NAME	FUNCTION
1	Power Cord Connector	IEC standard connector that mates with any CEE-22 power cord.
2	Line Fuse Holder	Removable compartment holding a 5 x 20mm fuse (¼ A, type GMA) with space for a spare fuse.
3	FOCUS Control	Controls the focus of the CRT display.
4	ASTIG Control	Controls the astigmatism of the CRT display.
5	TRACE ROTATE Control	Controls the trace rotation of the CRT display.
6	PWR/CLK Output Connector	Connector which provides power and clock to the Huntron Switcher Model HSR410.

Table 2-2. Back Panel Controls & Connectors (cont.)

ITEM NO.	NAME	FUNCTION
7	CH. A LOCK Switch	Slide switch which is normally left in the OFF position. The Switch is set to ON only when using the Tracker 2000 and Huntron Switcher Model HSR410. The ON condition locks the Tracker 2000 into channel A and disables the front panel channel selectors.
8	MODE Switch	Slide switch usually left in the NORMAL position. See detailed operating instructions for explanation of MODE switch use.

2-9. CRT DISPLAY

The CRT displays the signature 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. The axes divide the display into four quadrants. Each quadrant displays different portions of the signatures. Quadrant 1 displays positive voltage (+ V) and positive current (+ I), quadrant 2 displays negative voltage (– V) and positive current (+ I), quadrant 3 displays negative voltage (– V) and negative current (– I), and quadrant 4 displays positive voltage (+ V) and negative current (– I). See figure 2-4.

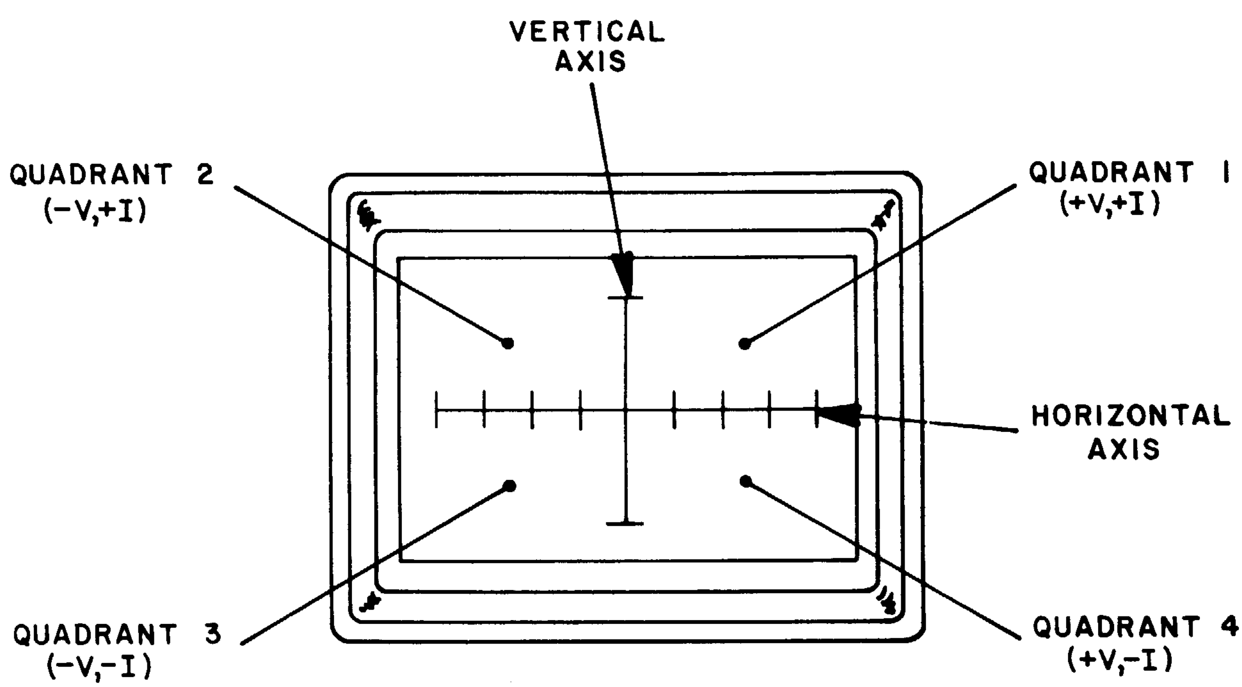


Figure 2-4. CRT Display

The horizontal axis is divided in 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 2	~5
Medium 1	~3.75
Low	~2.5

2-10. INITIAL SETUP

Pull the power on/off switch out. The Tracker 2000 should come on with the LEDs for channel A, 50/60Hz, and low range illuminated.

Focusing of the Tracker 2000 display is important in analyzing the test signatures. This is done by turning the intensity control to a comfortable level. Turn the focus control fully clockwise (viewed from the back). Adjust the astigmatism control until the ends of the trace are circular. Adjust the focus control for the narrowest possible trace.

Aligning the trace is important in determining which quadrants the portions of a signature are in. With a short circuit on channel A, adjust the rotation control (back panel) until the trace is parallel to the vertical axis. 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 intensity knob in, and when power is turned on again the same intensity setting will be present.

2-11. TRACKER 2000 OPERATION

The following sections explain how to use the rest of 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 Section 4 on Applications.

2-12. RANGE SELECTION

The Tracker 2000 is designed with four impedance ranges (low, medium 1, medium 2, and high). These ranges are selected by pressing the appropriate button on the front panel. It is best to start with one of the medium ranges (i.e. medium 1 or medium 2). 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.

The High Lockout feature, when activated, prevents the instrument from entering the high range in either the Manual or Auto mode.

The Auto feature scans through the four ranges (three with the High Lockout activated) at a speed set by the Rate control. This feature allows the user to see the signature of a component in different ranges while keeping hands free to hold the test leads.

2-13. CHANNEL SELECTION

There are two channels on the Tracker 2000 (channel A and channel B) which are selected by pressing the appropriate front panel button. 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 probe 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 quadrants of the display.

The Alternate mode of the Tracker 2000 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 selected by pressing the ALT button on the front panel, and the alternation frequency is varied by the Rate control. One of the most useful features of the Tracker 2000 is using the Alternate mode to compare a known good device with the same type of device that is of unknown quality. Figure 2-5 shows how the instrument is connected to a known good board and a board under test. This test mode uses the supplied common test lead to connect two equivalent points on the boards to the common test terminal.

When using the Alternate and Auto features simultaneously, each channel is displayed before the range changes. Figure 2-6 shows the sequence of these changes.

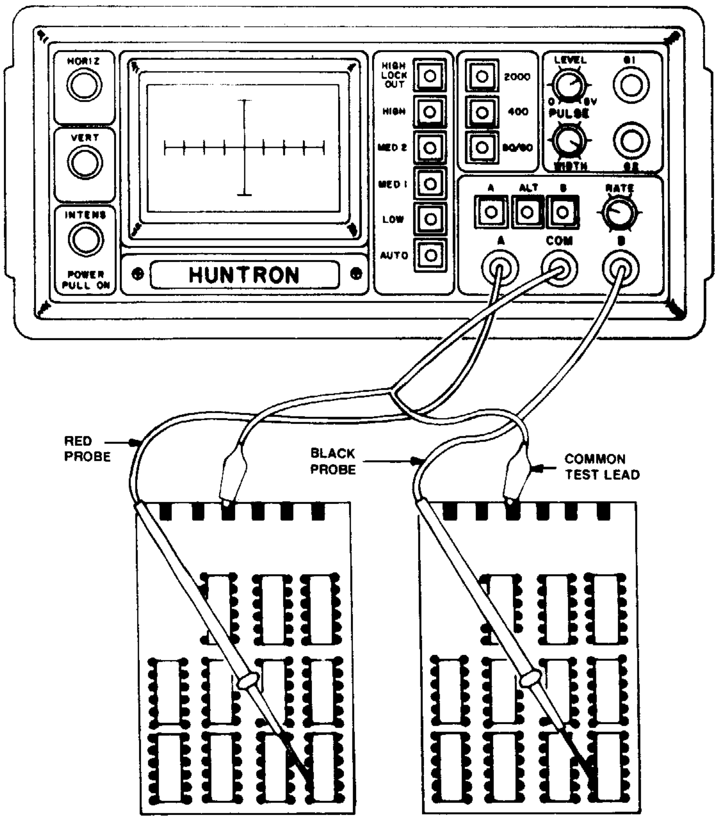


Figure 2-5. Alternate Mode Setup

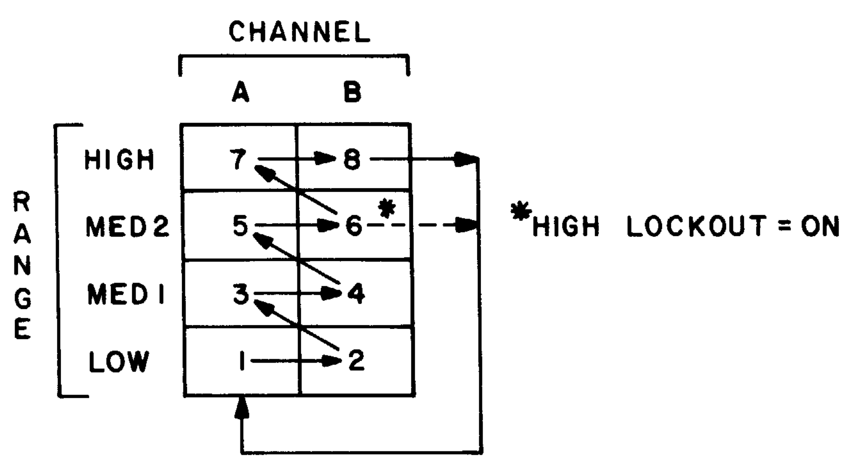


Figure 2-6. Auto/Alternate Sequence

2-14. FREQUENCY SELECTION

The Tracker 2000 has three test signal frequencies (50/60Hz, 400Hz and 2000Hz), which are selected by pressing the appropriate button on the front panel. In most cases the 50/60Hz test signal is the best to start with. The other two frequencies are generally used to view small amounts of capacitance or large amounts of inductance.

2-15. PULSE GENERATOR

The built-in pulse generator of the Tracker 2000 allows dynamic, in-circuit testing of certain devices in their active mode. In addition to using the red and black probes, the output of the pulse generator is connected to the control input of the device to be tested with one of the blue micro clips provided. The pulse generator has two outputs (G1 and G2) so that three terminal devices can also be tested in the Alternate mode. Figure 2-7 shows how to hook up the Tracker 2000 in Alternate mode using the pulse generator.

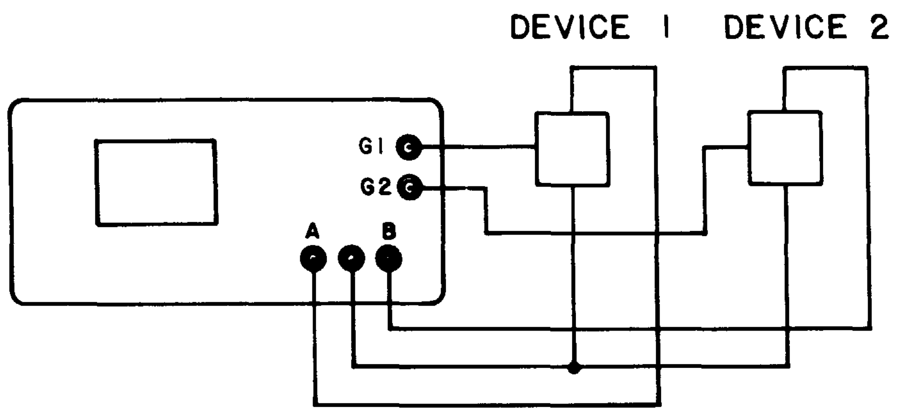


Figure 2-7. Pulse Generator Comparison Mode

The generator outputs are controlled by the Level and Width controls. The Level control varies the signal amplitude from zero to +5 Volts, and the Width control varies the pulse width from a low duty cycle to DC (100% duty cycle).

2-16. MODE SWITCH OPERATION

The mode switch is left in the NORMAL (1) position most of the time. When displaying diode signatures in the HIGH-400Hz, HIGH-2000Hz, or MED2-2000Hz combinations, the mode switch should be switched to DIODE (2). This will display the signature in the proper quadrants, rather than at the bottom of the CRT display.

2-17. HUNTRON SWITCHER HSR410 CONNECTIONS

Refer to Figure 2-8 for the interconnection diagram to use the Huntron Switcher HSR410 with the Tracker 2000. The two terminals marked TRACKER on the HSR410 are connected to the channel A and common test terminals on the Tracker 2000 using the double banana plug cable supplied with the HSR410. The power/clock cable, which comes with the Tracker 2000, is connected between the PWR/CLK output connector (Tracker 2000 back panel) and the two jacks on the HSR410 marked INPUT 8VDC–12VDC and EXT CLK. Each of the three connectors on the cable are different so that the cable can only be hooked up the correct way. Next, the Channel A Lock switch on the back panel of the Tracker 2000 should be put in the ON position which deactivates front panel control over channel selection and locks the Tracker 2000 into channel A. Finally, press the ALT button on the Tracker 2000 and verify that both the channel A LED and the ALT LED are continuously illuminated.

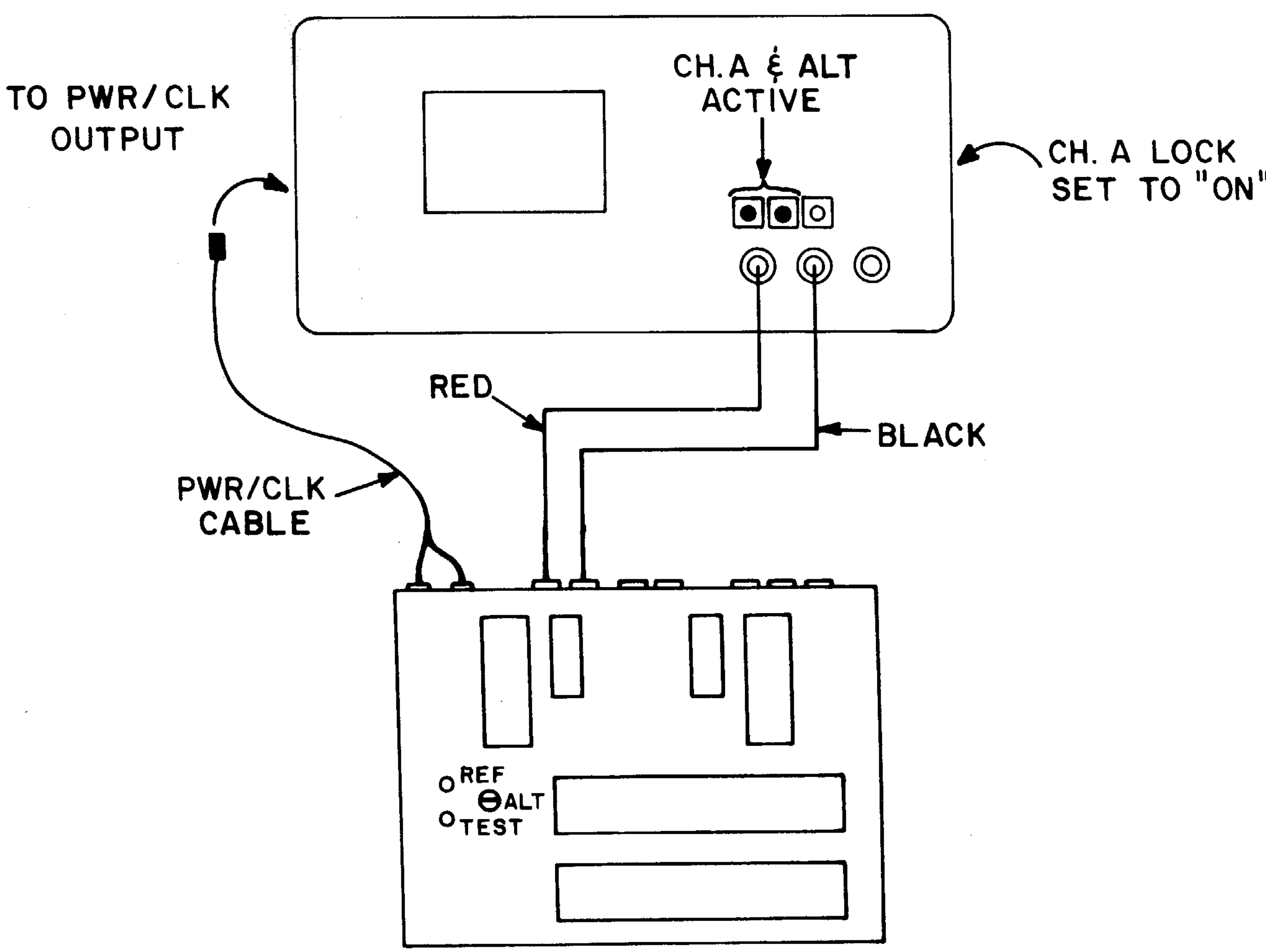


Figure 2-8. Tracker/Switcher Interconnection

The setup procedure above supplies the HSR410 with power and a clock signal controlled by the Rate control on the Tracker 2000. To use the HSR410, 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 HSR410 to the Tracker 2000 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 HSR410 will alternate between the reference device and the test device at a frequency determined by the Rate control of the Tracker 2000. The Rate control on the HSR410 is disabled in this mode. If the Auto scanning feature of the Tracker 2000 is activated, the alternation rate of the HSR410 will be synchronized with the range scanning rate of the Tracker 2000. This activates a similar scanning sequence to that shown in Figure 2-6, except that forty different points on two devices can be easily examined instead of one point on two devices with the Tracker 2000 alone.

For best results, the 50/60Hz test signal frequency should be selected when using the HSR410.

SECTION 3
THEORY OF OPERATION

3-1. INTRODUCTION

This section describes how the Tracker 2000 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 Tracker 2000 appear in Section 7.

3-2. FUNCTIONAL DESCRIPTION

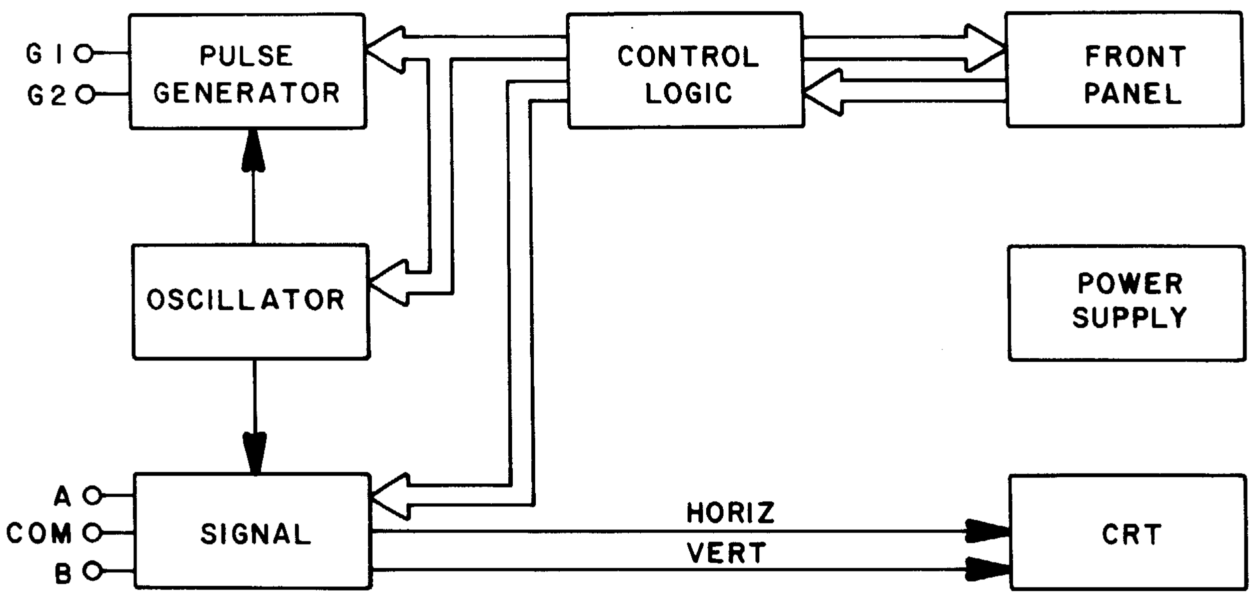


Figure 3-1. Tracker 2000 Block Diagram

The major circuits of the Tracker 2000 are arranged in a block diagram in Figure 3-1. The control logic selects the appropriate channel, frequency, and impedance range according to the front panel buttons pushed by the operator. The oscillator provides the test signal used by the signal section and the pulse generator. 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 pulse generator provides an added source of stimulus for testing three terminal devices. The power supply produces voltages for 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. CONTROL LOGIC

The control logic senses button pushes through input lines connected to the front panel pushbuttons. Since the pushbuttons are the momentary action type, the logic must remember which button was pushed, turn on the LED indicator in the button, and activate the appropriate configuration of the oscillator and signal section. After a button is pushed, the Tracker 2000 will remain in that configuration until another button is pushed or the power is turned off. The buttons operate in a "latched until cancelled by another button" mode, except for the High Lockout feature which turns on and off only with repetitive pushes of the HIGH LOCKOUT button.

The channel buttons, A, ALT, and B affect the channel relay. The relay is a single pole, double throw type and is de-energized for channel A and energized for channel B. If channel A is already active and the channel B button is pressed, channel A will be cancelled and channel B selected and vice versa. When the ALT button is pushed, another control line is set which enables an internal clock to toggle the channel relay on and off thereby alternating between channel A and B. The internal clock is controlled by the front panel Rate control. When ALT mode is active, the LEDs within the A and B buttons flash alternately and the ALT LED is continuously on. Pressing either channel button cancels the ALT mode and the relay is forced to the selected channel.

The frequency buttons, 50/60, 400, and 2000 (Hz) latch control lines F1, F2, and F3 respectively. These lines directly control the operation of the oscillator and the pulse generator.

The range buttons, LOW, MEDium 1, MEDium 2, and HIGH, latch control lines RS1, RS2, RS3, and RS4 respectively. These four lines control the four relays in the signal section that select the appropriate terminal characteristics for each impedance range.

The four ranges can be selected manually by pressing a particular range button, or they can be scanned automatically using the Auto function. When Auto is activated, the control logic will follow the sequence low, medium 1, medium 2, high, low, medium 1, etc. if High Lockout is off. The current active range is always indicated by which range LED is on. Once activated, the Tracker 2000 will remain in Auto until the operator manually selects a range which cancels the Auto function. While Auto is active, the AUTO LED is continuously on. The speed at which the ranges are scanned is controlled by the front panel Rate control so that the operator may adjust the time each range is displayed according to individual desires. If Auto and Alternate are active at the same time, the Rate control affects the speed of both functions with Alternate having priority. This is done so that the two channels can be compared to each other within one range before the next range is selected (see Figure 3-2).

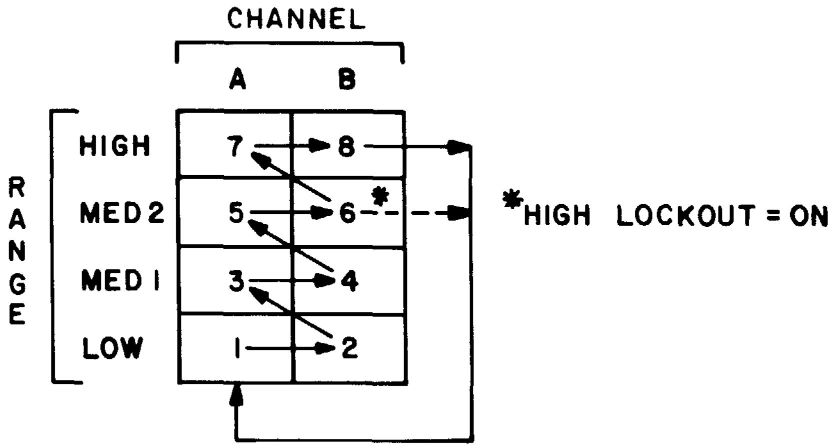


Figure 3-2. Range Scanning Sequence With AUTO And ALT Active

The High Lockout function disables the high range and limits the maximum test signal to $40V_{pp}$ rather than $120V_{pp}$. The HIGH LOCKOUT button toggles on/off, i.e. one press turns it on and another press turns it off. No other button on the front panel affects this one so that it cannot be unintentionally turned off. Detailed operation is as follows: in manual mode (Auto = Off), activating High Lockout prevents the high range from being selected and, if the high range is active when the HIGH LOCKOUT button is pressed, the high range is cancelled and the next lower range, medium 2, is selected. In Auto mode, the range sequence is changed to low, medium 1, medium 2, low, etc., bypassing the high range. Also pressing the HIGH button will not cancel the Auto function and return the Tracker 2000 to manual mode.

At power up, the initial conditions of the control logic are low range, 50/60Hz, and channel A, with Auto, Alternate, and High Lockout turned off.

3-4. OSCILLATOR

The oscillator is entirely contained on a small PCB mounted above the main PCB. This circuit produces a constant amplitude, low distortion sine wave test signal. The frequency of the test signal is programmable between one variable frequency (50/60Hz), and two fixed frequencies (400Hz and 2000Hz). The signals are first generated as triangle waves and then converted to sine waves using a wave shaping circuit. The variable frequency, 50/60Hz, depends on the frequency of the power line used with the Tracker 2000: a 50Hz line produces a 50Hz test signal and a 60Hz line produces a 60Hz test signal. If a 400Hz power line is used, an 80Hz test signal is provided. This is done so that the operator will always have low, medium, and high frequencies to work with.

3-5. SIGNAL SECTION

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 a current to flow through the device and a voltage drop across its terminals. The current flow causes a vertical deflection of the CRT trace, while the voltage across the device causes a horizontal deflection of the CRT trace. The combined effect produces the current-voltage signature of the device on the CRT display.

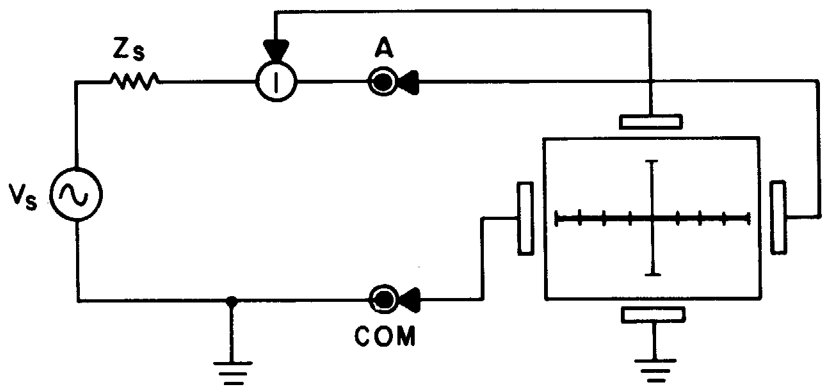
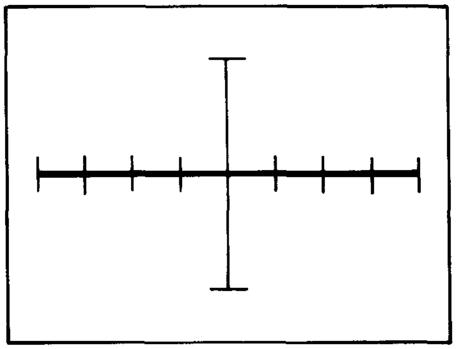


Figure 3-3. Signal Section Equivalent Circuit

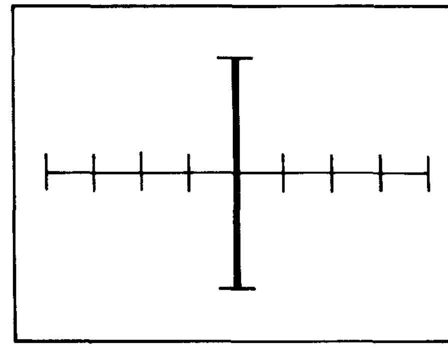
Electrically, the test signal appears at the front panel test terminals as though it is being originated by a voltage source (V_S) with a series output impedance (Z_S). An equivalent circuit of the signal section is shown in Figure 3-3. The figure also shows how the terminal voltage affects the horizontal 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 are shown in Table 3-1.

TABLE 3-1. Terminal Characteristics

Range	V_s (V_{pp})	Z_s (ohms)
High	120	83K
Medium 2	40	27K
Medium 1	30	1.3K
Low	20	55



Open Circuit Display
All Ranges
Figure 3-4a.



Short Circuit Display
All Ranges
Figure 3-4b.

An open circuit has zero current flowing through the terminals and has maximum voltage across the terminals. In all ranges this is represented by a horizontal trace from the left to the right of the CRT (see Figure 3-4a). When the terminals are shorted, 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 in all ranges (see Figure 3-4b). Signature of components will be covered in Section 4 on Applications.

3-6. PULSE GENERATOR

The pulse generator is used to drive the control input of a device under test which provides a dynamic test for certain types of devices. The normal two terminal mode of using the Tracker 2000 can be thought of as a static test since devices with three or more terminals are not tested in their active mode. However, with the pulse generator, an in-circuit active test of a device is possible. Figure 3-5 shows the equivalent circuit of the pulse generator and the signal section with the CRT connections eliminated for clarity.

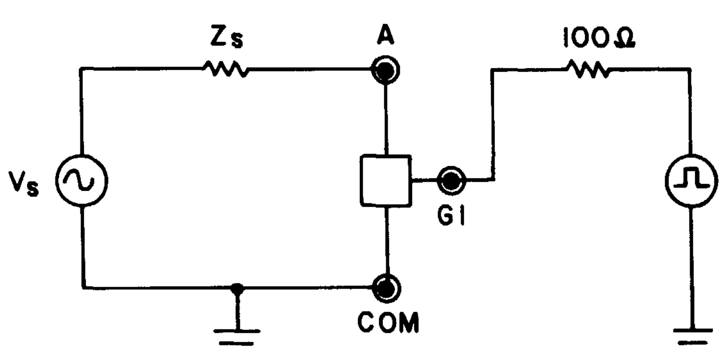


Figure 3-5. Pulse Generator/Signal Section Equivalent Circuit

The circuit uses the test signal from the oscillator as a reference and generates a pulse with a rising edge that is coincident with any zero-crossing of the test signal. Since each zero-crossing triggers a pulse, the pulse frequency is always twice the selected test signal frequency (see Figure 3-6). The pulse width is adjusted by the front panel WIDTH control. The duty cycle of the pulse waveform can be varied from a low value to 100% (i.e. DC voltage with no pulse) as shown in Figure 3-6. The front panel LEVEL control adjusts the peak amplitude of the pulse from zero to +5 Volts with respect to instrument common.

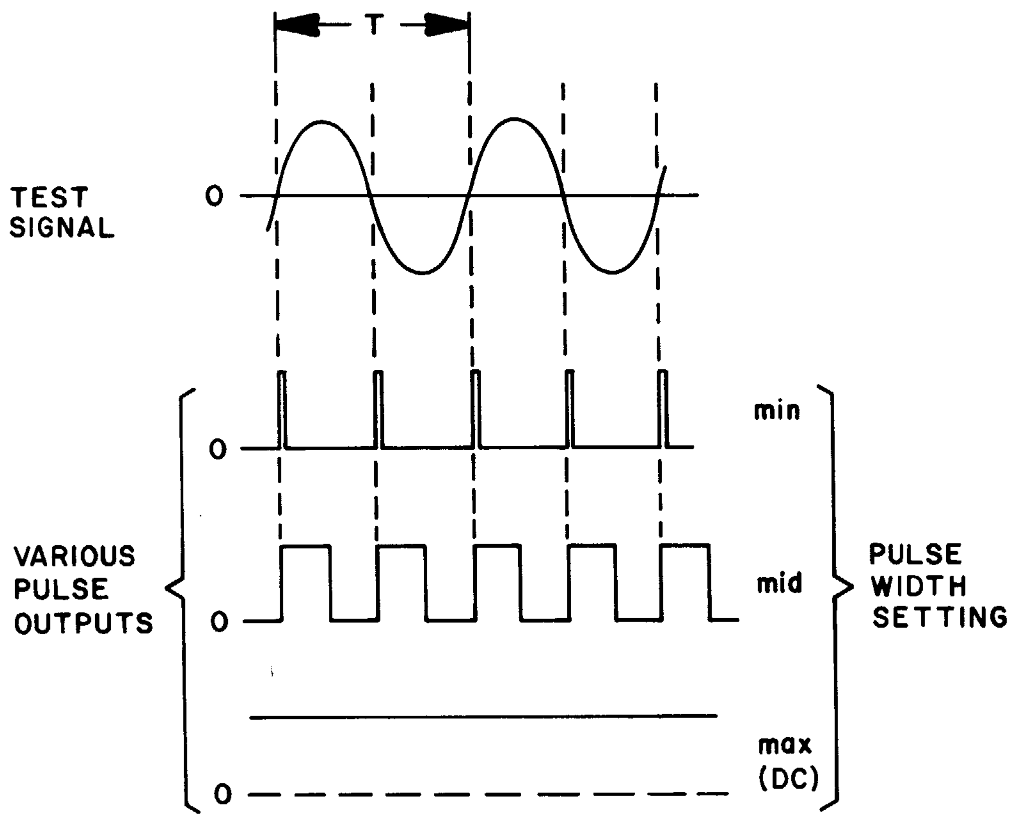


Figure 3-6. Pulse Generator Waveforms

3-7. 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 CRT trace. The TRACE ROTATE control on the back panel is used to adjust the short circuit vertical trace to be parallel with the vertical axis on the CRT graticle after changes caused by the magnetic field of the Earth.

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. Focus and astigmatism are located on the back panel and are operator trimming adjustments.

3-8. POWER SUPPLY

This is an AC line operated power supply that is turned on by pulling out the INTENSity knob on the front panel (push-off). At least three of the front panel LEDs are always on and they serve as an indication that the power is on before the CRT warms up.

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

The other outputs of the power supply are related to the CRT display. The filament voltage is 6.3Vrms. There is a +180VDC output which is primarily used by the deflection driver circuits. Finally, there is a regulated −1350VDC output for the CRT acceleration voltage.

SECTION 4
APPLICATIONS

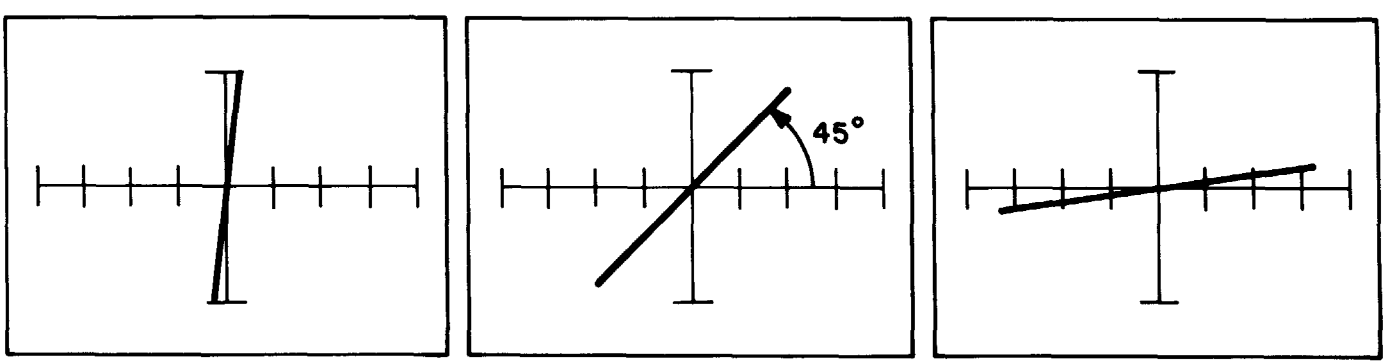
4-1. INTRODUCTION

This section covers the Tracker 2000 signatures of commonly encountered active and passive components. The purpose of doing this is to acquaint the user with the signatures produced by good components so that the user can start to recognize differences that may indicate bad parts. Most of this material covers the use of the Tracker 2000 in the two terminal mode. Also included is a section on the use of the Tracker 2000 in a three terminal mode using the built-in pulse generator.

4-2. TESTING RESISTORS

A pure resistance across the test terminals will cause the trace on the Tracker 2000 display to rotate counterclockwise on its center axis. The degree of rotation is a function of resistance value. In all ranges, the trace rotates in a counterclockwise direction from the horizontal (open circuit) position, and the length of the trace is reduced because of the voltage drop caused by the internal impedance of the signal source within the Tracker 2000.

The low range is designed to detect resistance between zero and 1K ohm. Figure 4-1 shows the effect of resistance on the angle of rotation in low range. A 2 ohm resistor causes almost 90 degrees of rotation, and a 50 ohm resistor produces a 45 degree rotation. A 400 ohm resistor causes a small rotation in angle. Resistors lower than 2 ohms appear as a short circuit (i.e. vertical trace) and resistance values above 400 ohms look like open circuits (i.e. horizontal trace).

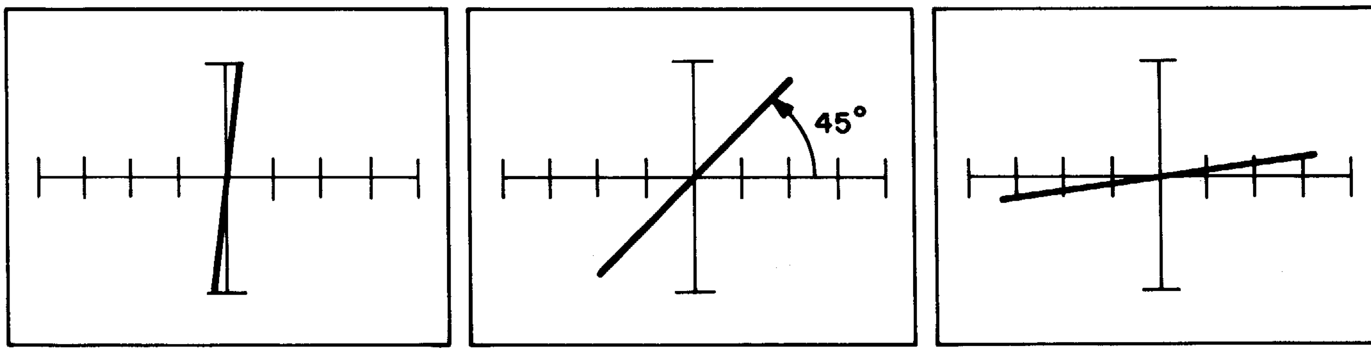


2 ohm Resistor | 50 ohm Resistor | 400 ohm Resistor

Effects of Resistance on Rotation Angle - Low Range

Figure 4-1.

The medium 1 range is designed to detect resistance between 50 and 10K ohm. Figure 4-2 shows the display for a 50 ohm resistor, a 1K resistor, and a 10K resistor using the medium 1 range. Resistors that are smaller than 50 ohm appear almost as a vertical line. A 1K resistor causes an angle of rotation of 45 degrees, while the display for a 10K resistor shows only slight rotation. Resistance values higher than 10K produce such a small rotation angle that it appears almost as a horizontal line.

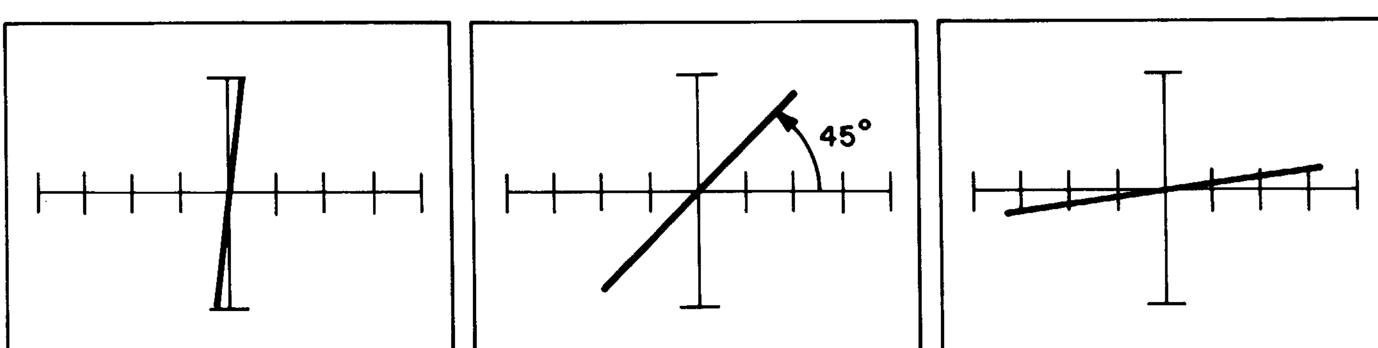


50 ohm Resistor | 1K Resistor | 10K Resistor

Effects of Resistance on Rotation Angle - Medium 1 Range

Figure 4-2.

The medium 2 range is designed to detect resistance between 1K and 200K ohm. Figure 4-3 shows the displays for a 1K resistor, a 15K resistor, and a 200K resistor using the medium 2 range. Resistance values smaller than 1K appear almost as a vertical line. A 15K resistor causes an angle of rotation of 45 degrees, while the display for a 200K resistor shows only slight rotation. Resistors higher than 200K produce such a small rotation angle that it appears almost as a horizontal line.

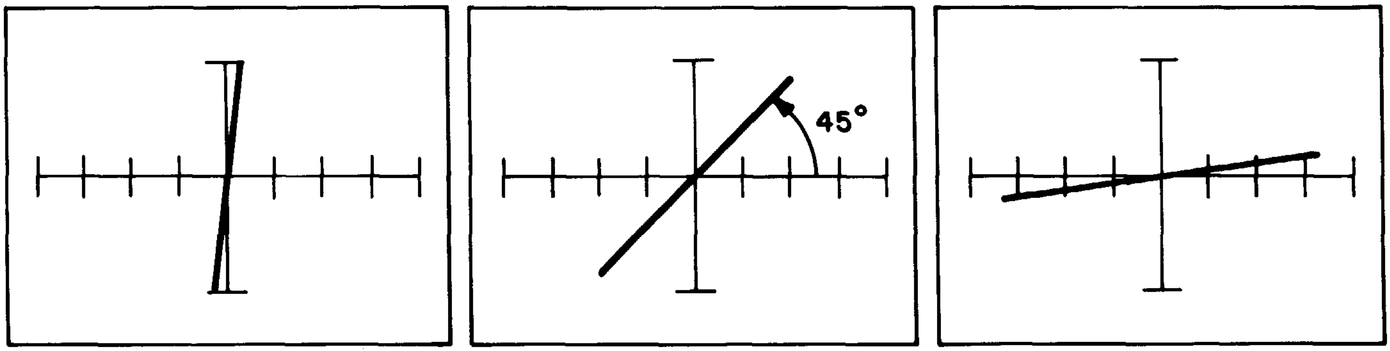


1K Resistor | 15K Resistor | 200K Resistor

Effects of Resistance on Rotation Angle - Medium 2 Range

Figure 4-3.

The high range is designed to detect resistance between 3K and one Megohm. Figure 4-4 shows the displays 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 vertical line. A 50K resistor causes an angle of rotation of 45 degrees, while the display for a one Megohm resistor shows only slight rotation. Resistance values higher than one Megohm produce such a small rotation angle that it appears almost as a horizontal line.



3K Resistor 50K Resistor 1Megohm Resistor

Effects of Resistance on Rotation Angle - High Range

Figure 4-4.

4-3. TESTING CAPACITORS

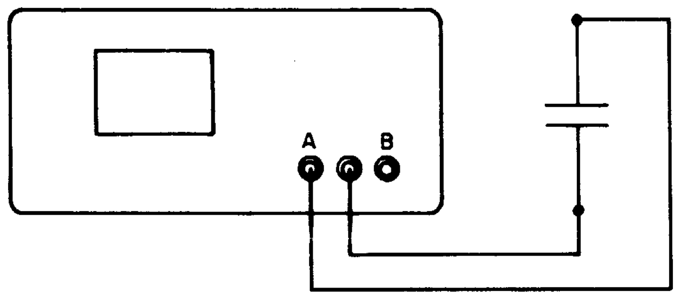


Figure 4-5. Capacitor Test Connections

With a capacitor connected to the Tracker 2000 as shown in Figure 4-5, the voltage, V(t), across the capacitor is given as:

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

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

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

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

From equation (1):

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

or

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

From equation (2):

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

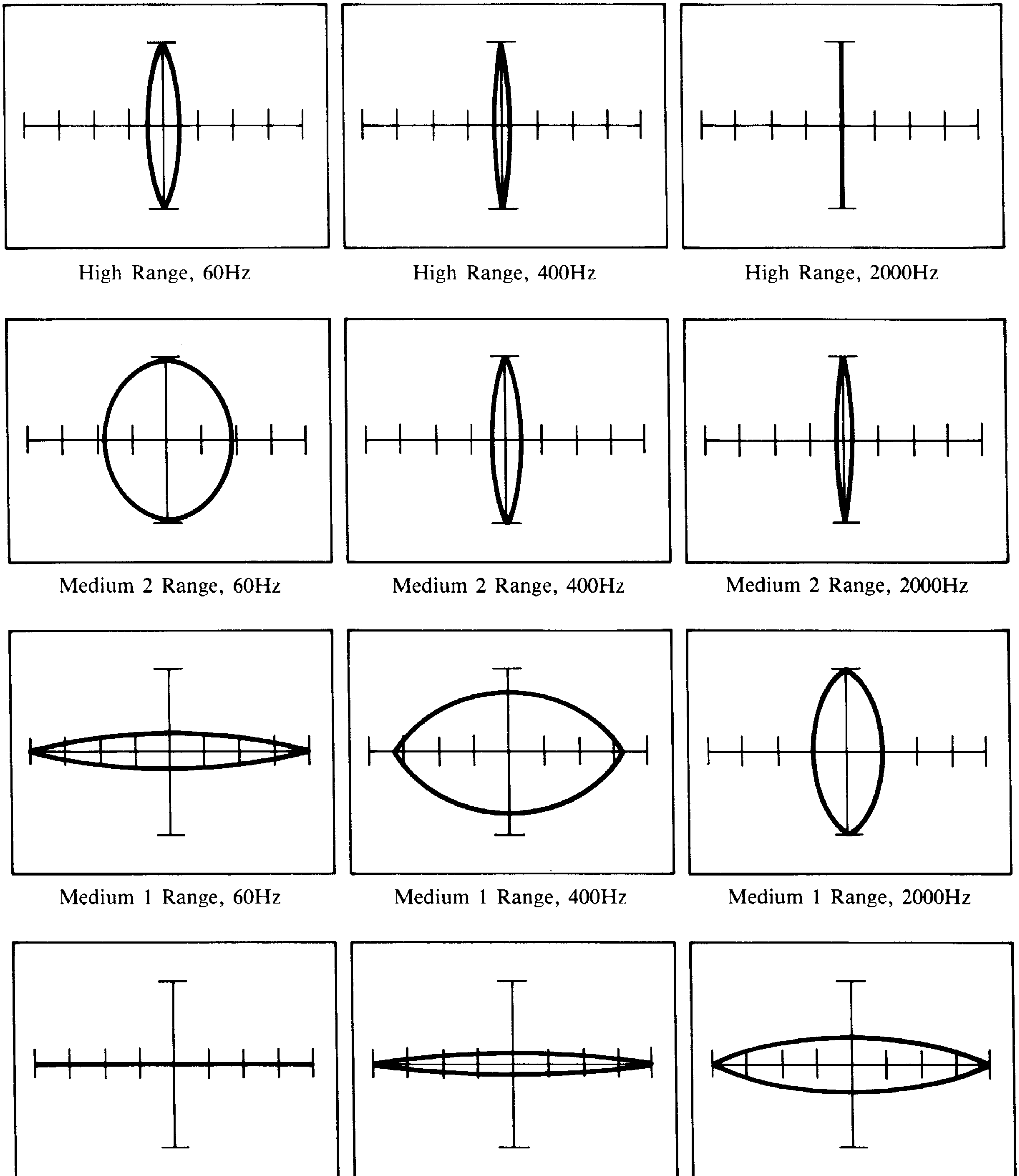
or

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

Adding equations (3) and (4):

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

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, test signal frequency, and the selected impedance range.



High Range, 60Hz | High Range, 400Hz | High Range, 2000Hz

Medium 2 Range, 60Hz | Medium 2 Range, 400Hz | Medium 2 Range, 2000Hz

Medium 1 Range, 60Hz | Medium 1 Range, 400Hz | Medium 1 Range, 2000Hz

Low Range, 60Hz | Low Range, 400Hz | Low Range, 2000Hz

Figure 4-6. Signatures of a 0.22μF Capacitor

Figure 4-6 shows the signatures of a 0.22μF capacitor in each of the twelve combinations of range and frequency. Note that this value of capacitance appears to be an open circuit in the low range at 60Hz, while in the high range at 2000Hz this value is equivalent to a short circuit. In between the extremes this capacitor produces a variety of ellipsoids which demonstrates that certain range and frequency combinations are better than others for examining this particular value. Table 4-1 lists the range of capacitance covered by each of the twelve range and frequency combinations. The lowest value of capacitance in each combination gives a narrow horizontal ellipsoid on the display and capacitors less than the lower bound look like an open circuit. The upper bound of capacitance will produce a narrow vertical ellipsoid with capacitors of greater value appearing as the vertical line signature of a short circuit.

Table 4-1

Range	**50 / 60Hz**	**400Hz**	**2000Hz**
High	.001μF - 1μF	500pF - .1μF	100pF - .02μF
Medium 2	.01μF - 2μF	.001μF - .5μF	200pF - .05μF
Medium 1	.2μF - 50μF	.02μF - 5μF	.005μF - 1μF
Low	5μF - 2000μF	.5μF - 100μF	.2μF - 25μF

4-4. TESTING INDUCTORS

Inductors, like capacitors, produce elliptical signatures on the Tracker 2000 display. Figure 4-7 shows the test circuit for a 250mH inductor and Figure 4-8 shows the signatures produced in each of the twelve range and frequency combinations by a 250mH inductor.

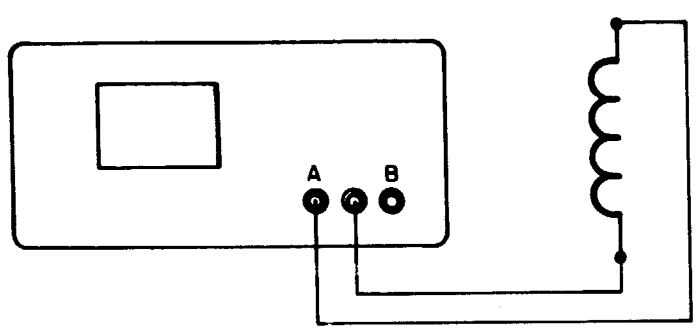
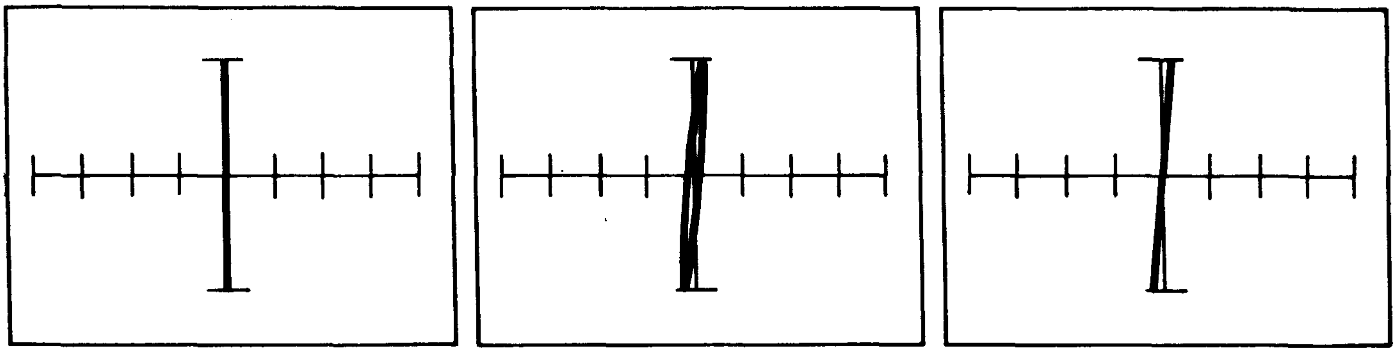
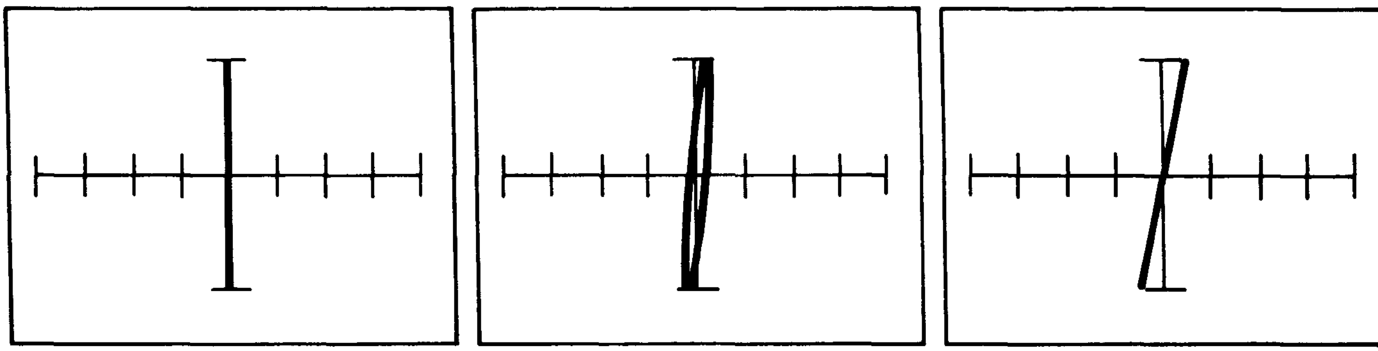


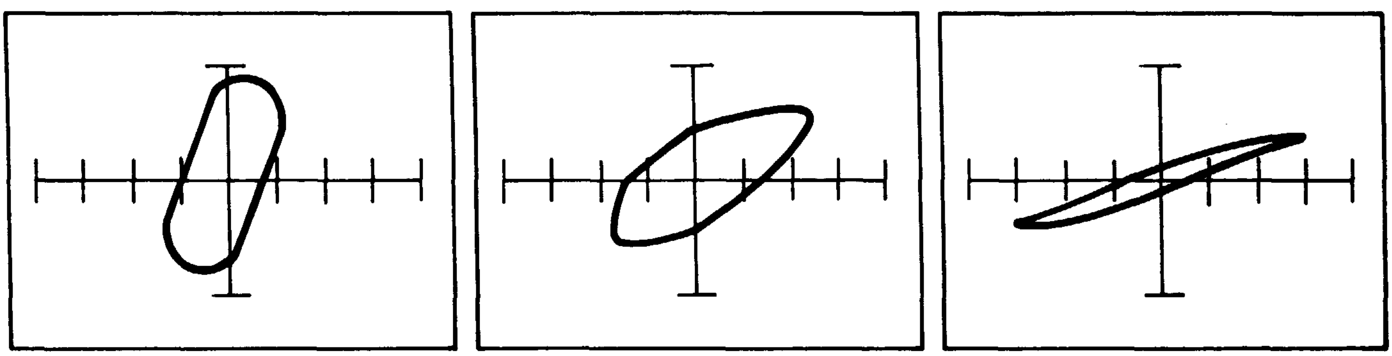
Figure 4-7. Inductor Test Connections



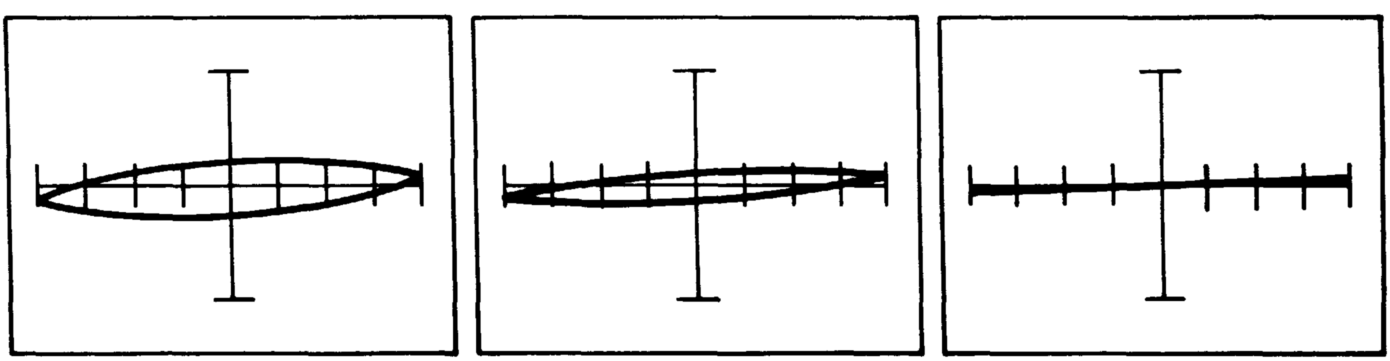
High Range, 60Hz | High range, 400Hz | High Range, 2000Hz



Medium 2 Range, 60Hz | Medium 2 Range, 400Hz | Medium 2 Range, 2000Hz



Medium 1 Range, 60Hz | Medium 1 Range, 400Hz | Medium 1 Range, 2000Hz



Low Range, 60Hz | Low Range, 400Hz | Low Range, 2000Hz

Figure 4-8. Signatures of a 250mH Inductor

4-5. TESTING DIODES

In the forward direction a diode looks like a very low resistance after the forward junction voltage drop, V_f, has been exceeded. In the reverse direction, only small leakage currents flow and the diode appears to be an open circuit.

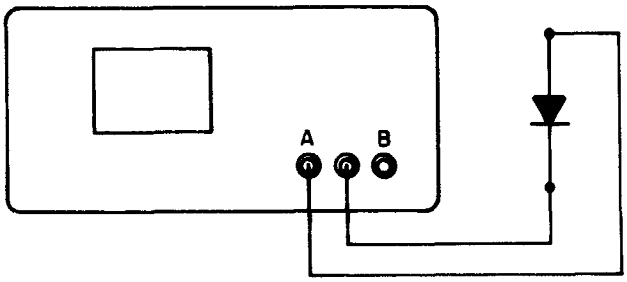
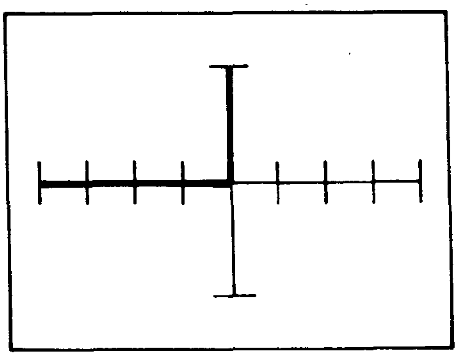
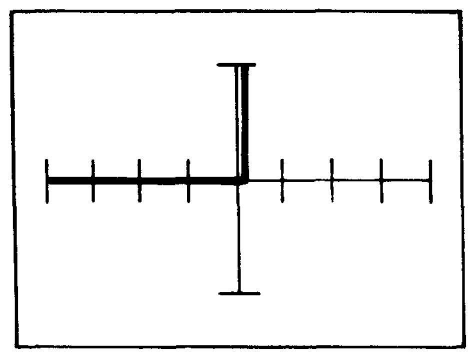


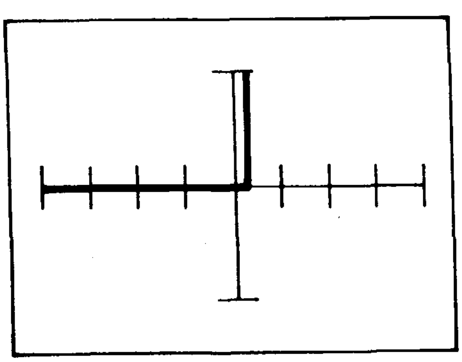
Figure 4-9. Diode Test Connections



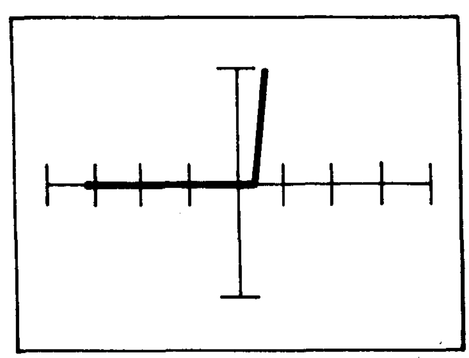
High Range, 60Hz



Medium 2 Range, 60Hz



Medium 1 Range, 60Hz



Low Range, 60Hz

Figure 4-10. Signatures of a Silicon Diode.

Figure 4-9 shows the circuit for testing diodes with the Tracker 2000, and Figure 4-10 shows the signatures produced in each range for a typical silicon diode like a IN4001 or a IN4148. The only difference observed between ranges is the distance between the vertical short circuit portion of the signatures and the vertical axis. This effect is caused by the forward voltage (V_f) and the changing horizontal sensitivity from one range to the next. The low range has the greatest horizontal sensitivity and therefore shows the greatest horizontal displacement from the vertical axis. V_f is between 0.5 Volts and 2.8 Volts depending on the semiconductor used to construct a diode, e.g. V_f = 0.6 Volts for a typical silicon diode and V_f = 1.5 Volts for a typical red light-emitting diode. The relative values of V_f for different diodes can be approximately determined from the low range signatures.

The typical failure modes for a diode are an open diode and a shorted diode. The open diode produces the characteristic horizontal line, while a shorted diode displays a vertical line or close to a vertical line if the diode has some resistance.

4-6. TESTING ZENER DIODES

The zener diode is unique among the semiconductor family of devices in that its electrical properties are derived from a junction which operates in the reverse-breakdown region. Figure 4-11 shows the volt-ampere characteristics of a typical 30-volt zener diode.

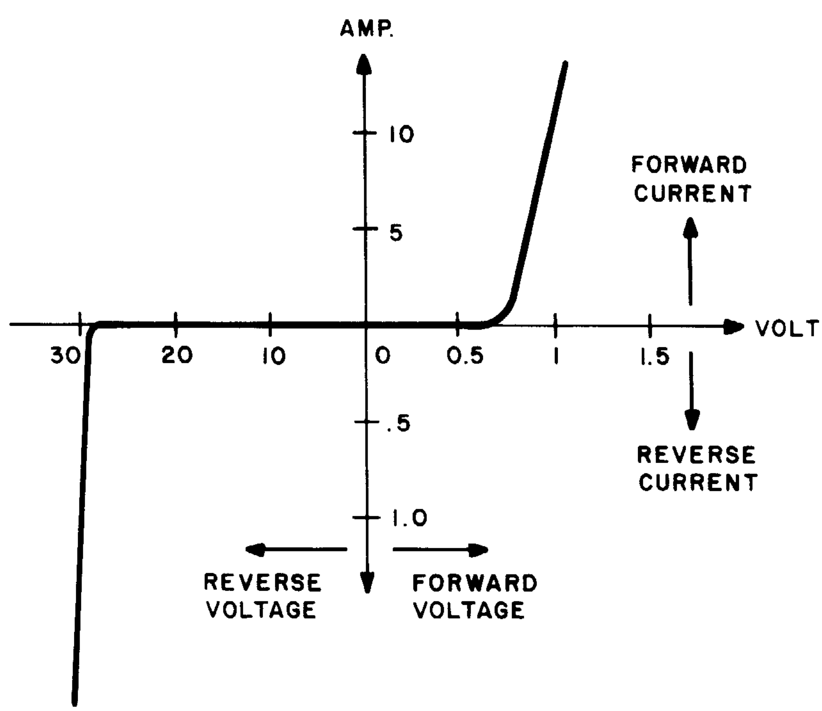


Figure 4-11. V-I Characteristics of a 30V Zener diode

Figure 4-11 shows that the zener diode conducts current in both directions with the forward current being a function of the forward voltage (V_f). Note that this current is small until V_f is approximately +0.65V, then the current increases rapidly. When V_f is greater than 0.65V, the forward current is limited primarily by the circuit resistance external to the diode.

The reverse current is a function of the reverse voltage (V_r) and, for most practical purposes, is zero until such time as the reverse voltage equals the junction breakdown voltage. At this point, the reverse current increases rapidly. The junction breakdown voltage is usually called the zener voltage (V_Z). Commercial zener diodes are available with zener voltages from 2.4V to 200V. The Tracker 2000 is an excellent tool for checking zener diodes. It displays the zener voltage (V_Z) and the forward voltage (V_f) on the CRT display.

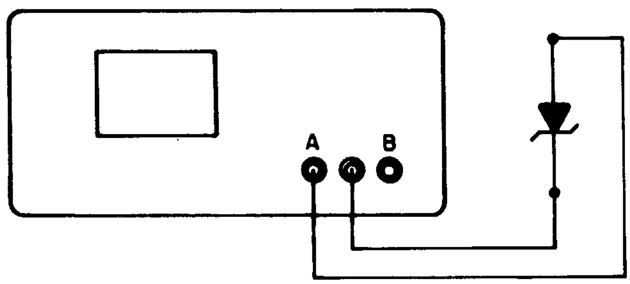
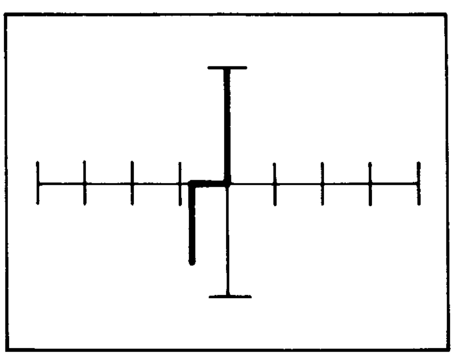
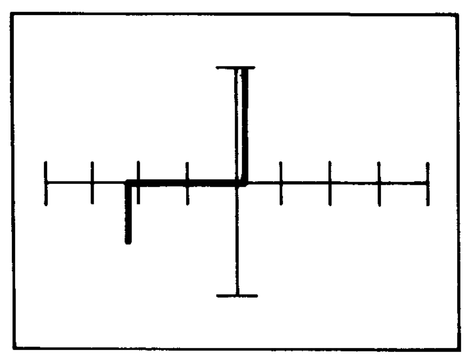


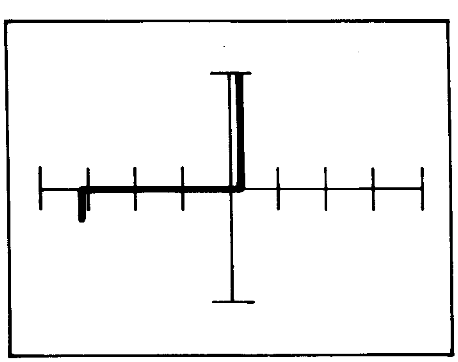
Figure 4-12. Zener Diode Text Connections



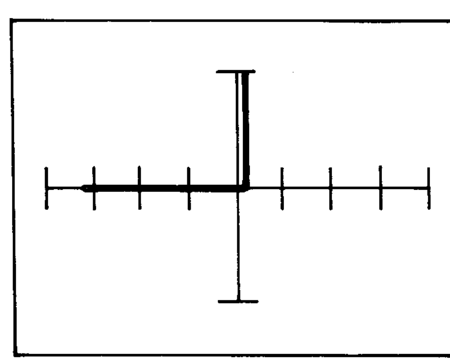
High Range, 60Hz



Medium 2 Range, 60Hz



Medium 1 Range, 60Hz



Low Range, 60Hz

Figure 4-13. Signatures of a Zener Diode

Figure 4-12 shows the Tracker 2000 connections to test a zener diode. Figure 4-13 shows the signatures produced by a 12 Volt zener diode (1N5242) in each range. In the low range, the signal at the test terminals is 20 Volts peak-to-peak (+ 10 Volts peak), and is insufficient to cause zener breakdown. As a result, the trace looks identical to that of a general purpose diode. However, in the medium 1 range, the test signal is 30 Volts peak-to-peak (± 15 Volts peak) and the zener voltage (V_Z) can be seen. The medium 2 range and high ranges also have test signals that are high enough to show the zener voltage. As the range is increased the horizontal sensitivity drops and the zener breakdown region moves closer to the vertical axis.

It is easy to examine zener diode quality with the Tracker 2000. A good zener diode gives a sharp, defined zener breakdown voltage, while an inferior zener device gives a rounded corner (Refer to Figures 4-14a and 4-14b).

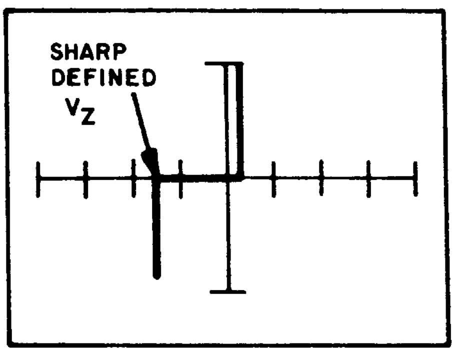


Figure 4-14a.

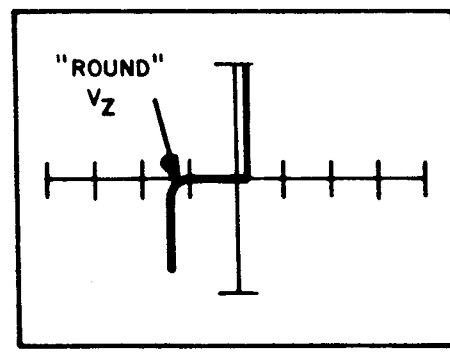
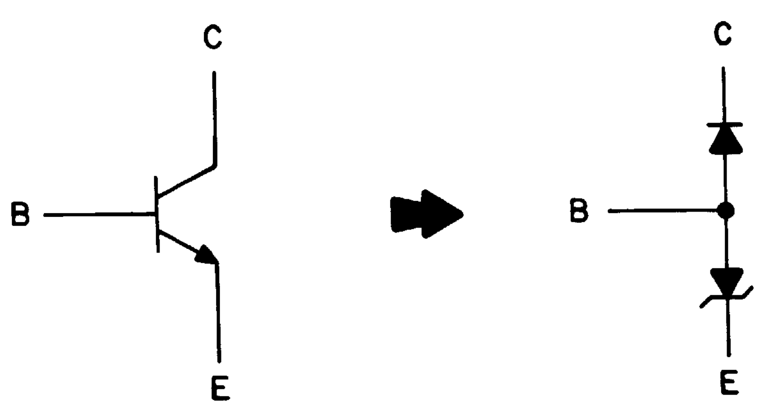


Figure 4-14b.

4-7. TESTING BIPOLAR TRANSISTORS

A bipolar transistor consists of two PN junctions which the Tracker 2000 can examine in a manner similar to that used for testing diodes. Figure 4-15 shows an equivalent circuit for an NPN bipolar transistor.



Symbol

Equivalent Circuit

Figure 4-15. NPN Transistor

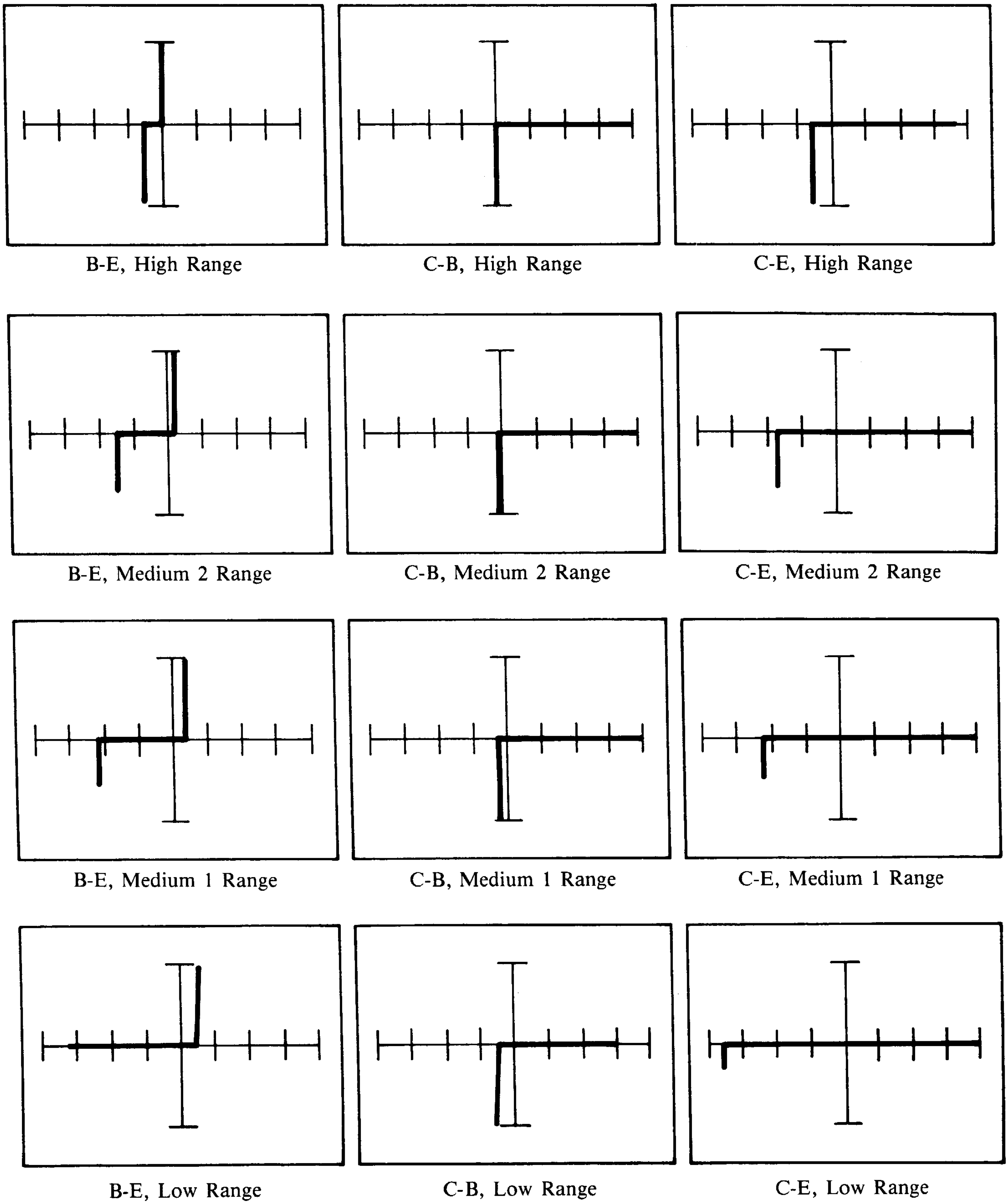


Figure 4-16. NPN Transistor Signatures (60Hz)

To test a transistor, all combinations of pins have to be examined, i.e. base to emitter (B-E), collector to base (C-B), and collector to emitter (C-E).

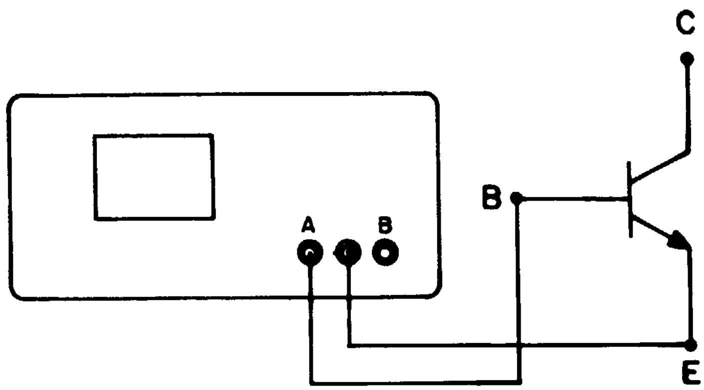


Figure 4-17. Base-Emitter Test Connections

To test the B-E junction, the test circuit in Figure 4-17 should be used. The B-E junction exhibits a zener diode characteristic (see Figure 4-15) i.e. normal diode voltage drop under forward bias, and zener breakdown when under reverse bias, V_Z is usually in the range of 6 to 10 Volts. Figure 4-16 shows the signatures produced by the B-E junction of a 2N3904 NPN transistor in each range.

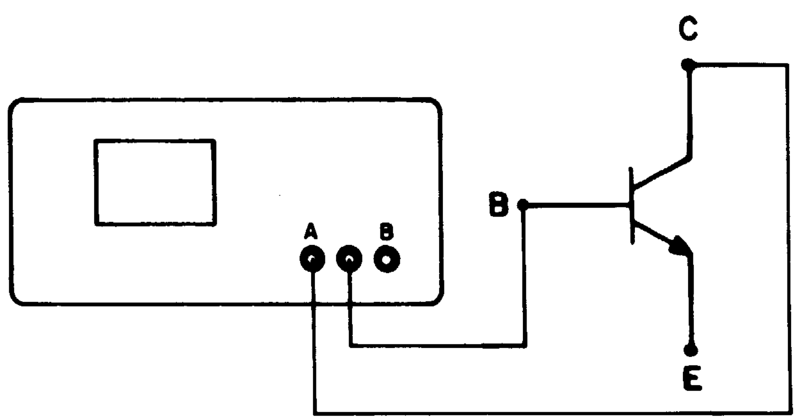


Figure 4-18. Collector-Base Test Connections

The C-B junction can be examined using the test circuit shown in Figure 4-18. From Figure 4-15, 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 4-16).

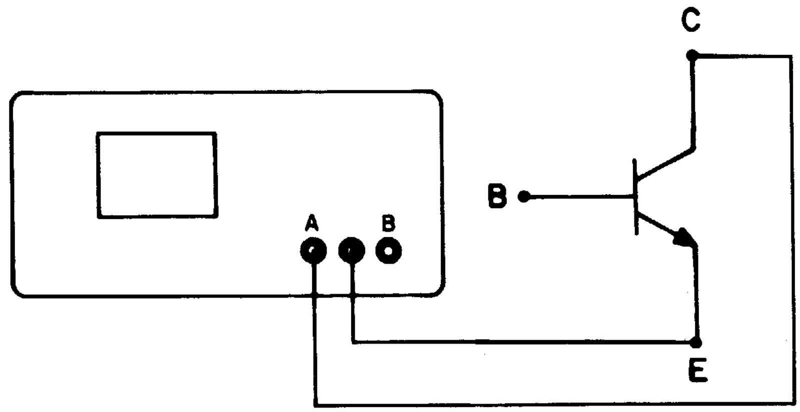
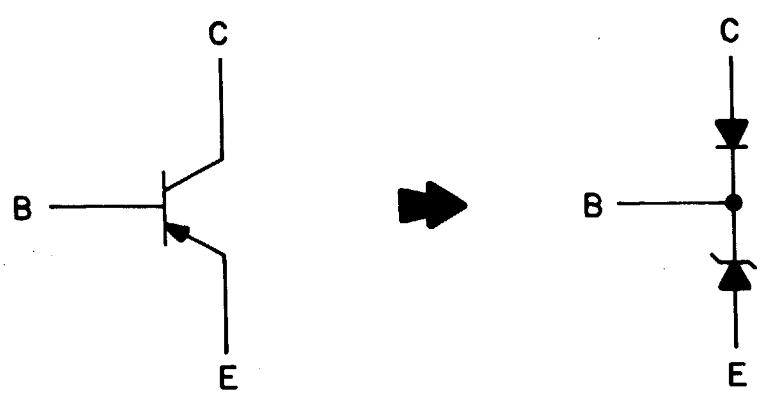


Figure 4-19. Collector-Emitter Test Connections

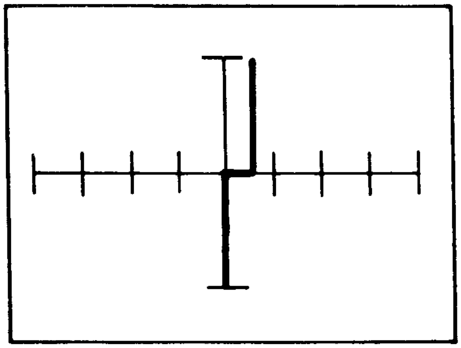
The test circuit for the C-E connection is shown in Figure 4-19. Referring to Figure 4-15, this test examines a series connection of the two junctions, i.e. a simple diode in series with a zener diode. The resulting signatures are also shown in Figure 4-16. When the collector is positive with respect to the emitter (right 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 left of the vertical axis by the sum of the voltage drop across the two junctions.

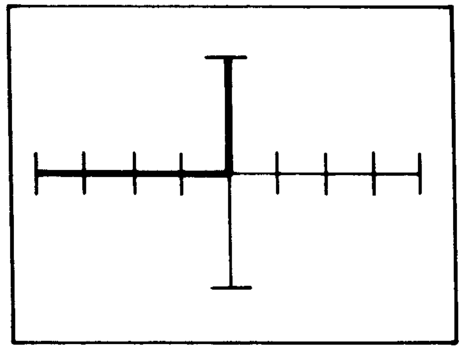


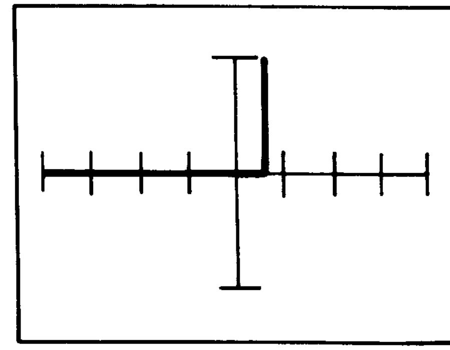
Symbol Equivalent Circuit

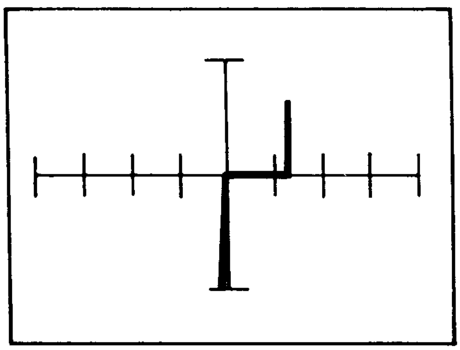
Figure 4-20. PNP Transistor

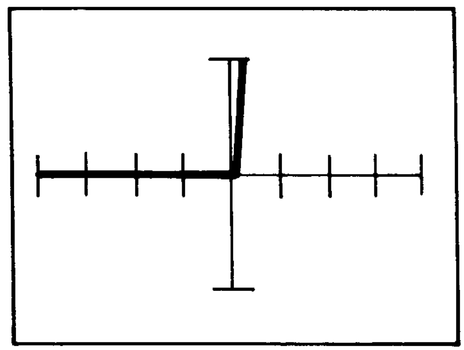
The testing of PNP transistors is the same as that described for NPN transistors, except that the signatures are reversed from those of an NPN device. This is because in the equivalent circuit of a PNP transistor, the polarity of the two diodes is reversed (see Figure 4-20). Figure 4-21 shows the signatures of a 2N3906 PNP transistor.

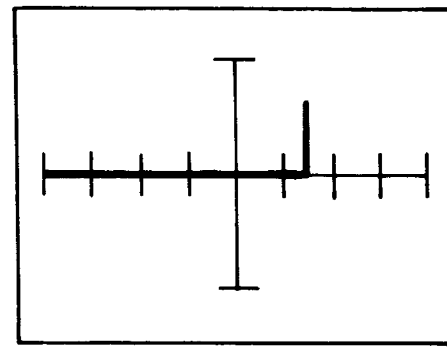

B-E, High Range

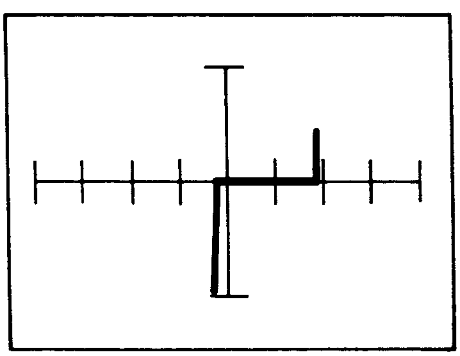

C-B, High Range

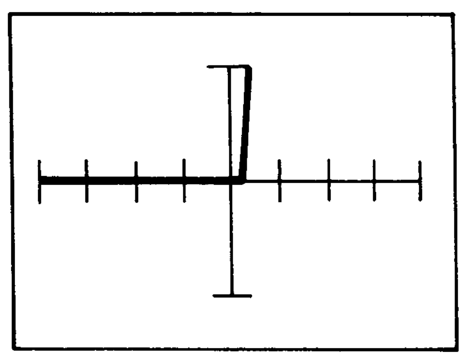

C-E, High Range

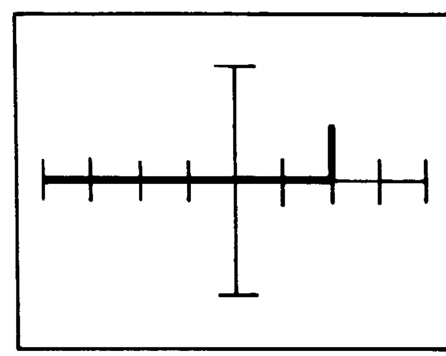

B-E, Medium 2 Range

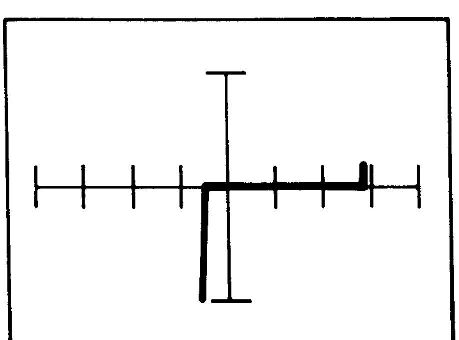

C-B, Medium 2 Range

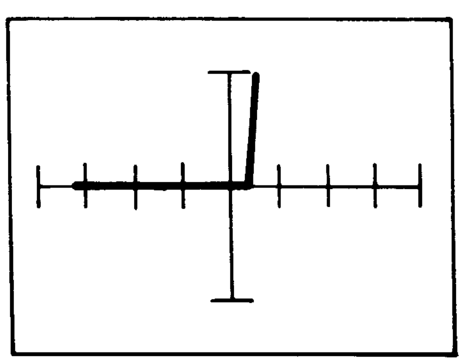

C-E, Medium 2 Range


B-E, Medium 1 Range


C-B, Medium 1 Range


C-E, Medium 1 Range


B-E, Low Range


C-B, Low Range

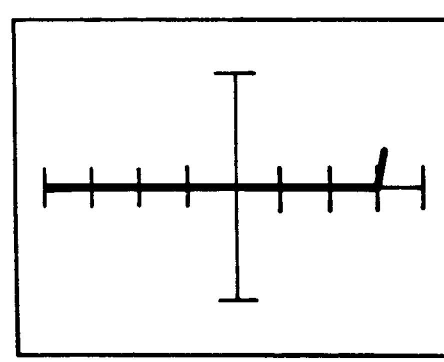
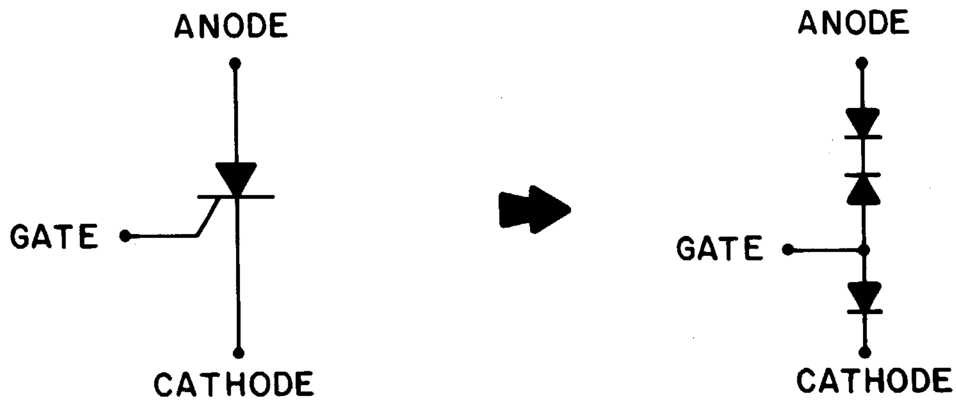

C-E, Low Range

Figure 4-21. PNP Transistor Signatures (60Hz)

4-8. TESTING SILICON CONTROLLED RECTIFIERS (SCRs)

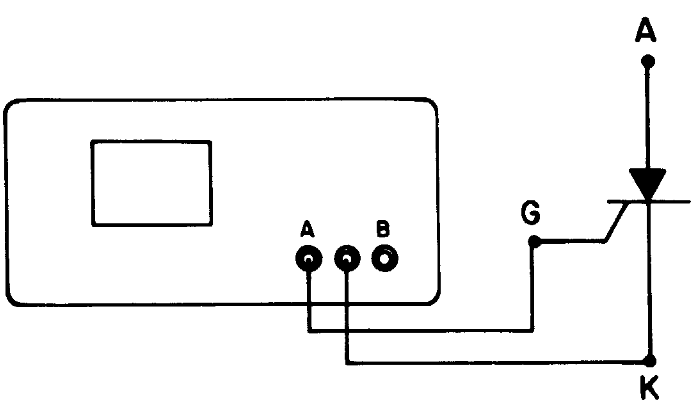


Symbol

Equivalent Circuit

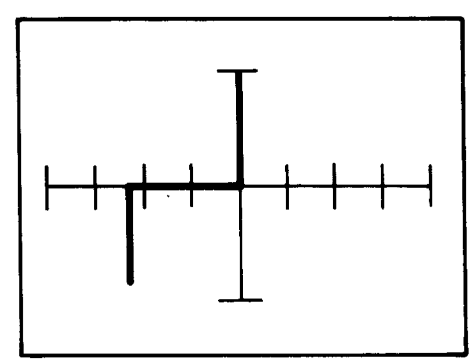
Figure 4-22. Silicon Controlled Rectifier

The symbol and equivalent circuit of a silicon controlled rectifier is shown in Figure 4-22. Between the gate and cathode, an SCR looks like a diode. If the Tracker 2000 is connected to the gate and cathode as shown in Figure 4-23a, a diode signature appears on the display as shown in Figure 4-23b. Note that the gate-cathode breakdown voltage can be observed.



Gate-Cathode Test Connections

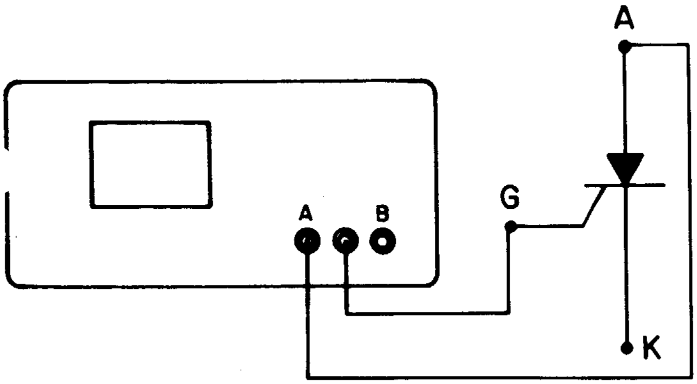
Figure 4-23a.



Gate-Cathode Signature (High Range)

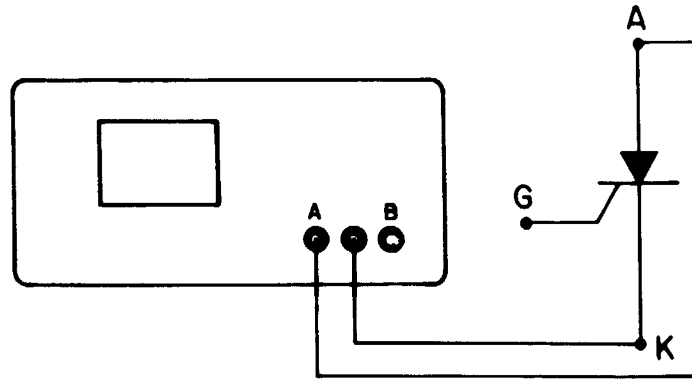
Figure 4-23b.

Between the gate and anode, two diodes are connected back to back (See Figure 4-22). The Tracker 2000 sees these back to back diodes as an open circuit. Figure 4-24a shows the connections to test the anode and gate, while Figure 4-24b shows the connections to test the anode and cathode. The signatures for either connection are the open circuit horizontal trace in all ranges.



Anode-Gate Test Connections

Figure 4-24a.



Anode-Cathode Test Connections

Figure 4-24b.

4-9. TESTING TRIACS

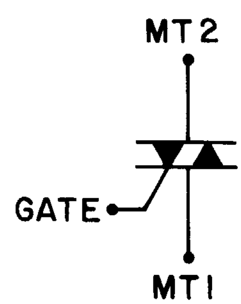
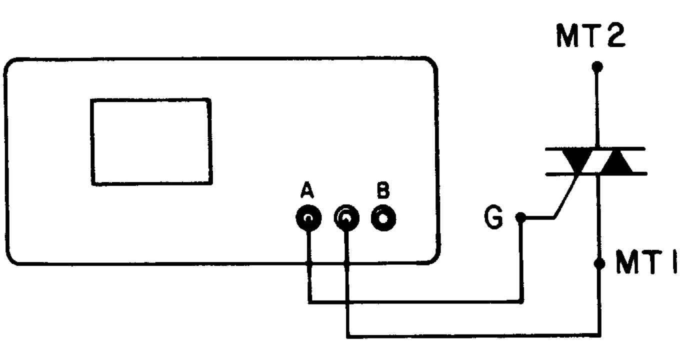


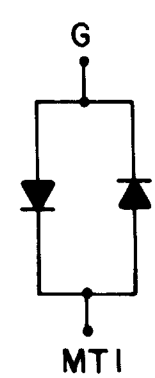
Figure 4-25. The Symbol of a Triac

The triac is a bidirectional thyristor that was developed to extend the positive or negative supply of an SCR and to allow firing with either positive or negative gate current pulses. Figure 4-25 shows the symbol of a triac. The Tracker 2000 circuit for testing the gate-MT1 connection of a Triac is shown in Figure 4-26a. Figure 4-26b shows that there are two diodes in parallel between the gate and MT2. The resulting signatures are shown in Figure 4-27.



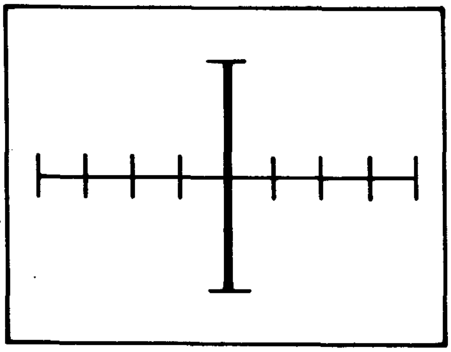
Gate-MT1 Test Connections

Figure 4-26a.

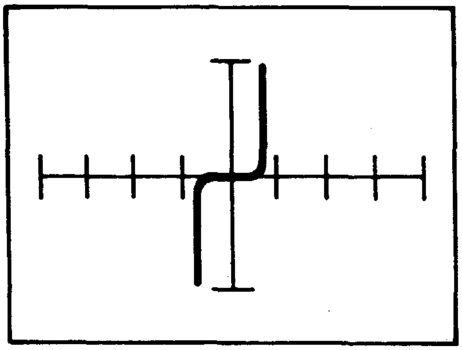


Gate-MT1 Equivalent Circuit

Figure 4-26b.



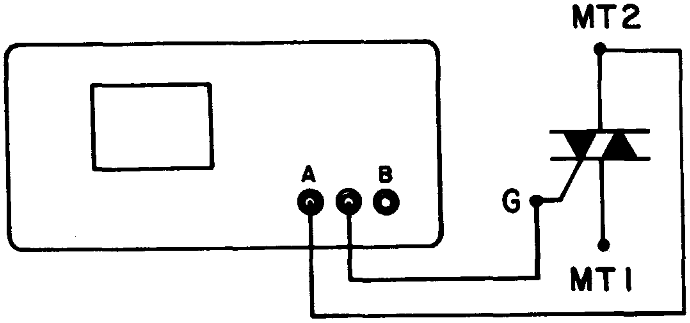
High Range



Low Range

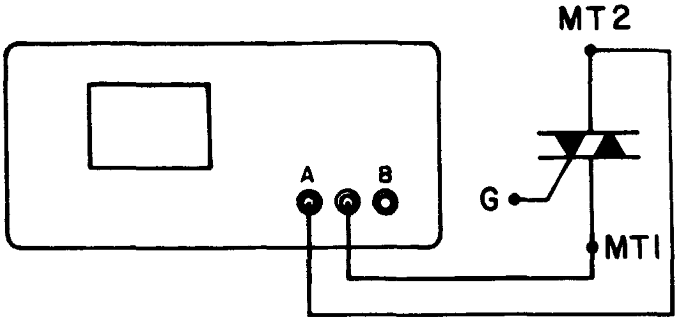
Figure 4-27. Gate-MT1 Signatures

Using either Figure 4-28a or Figure 4-28b as a triac test circuit, the Tracker 2000 should see an open circuit in all ranges.



MT2–Gate Test Connections

Figure 4-28a.

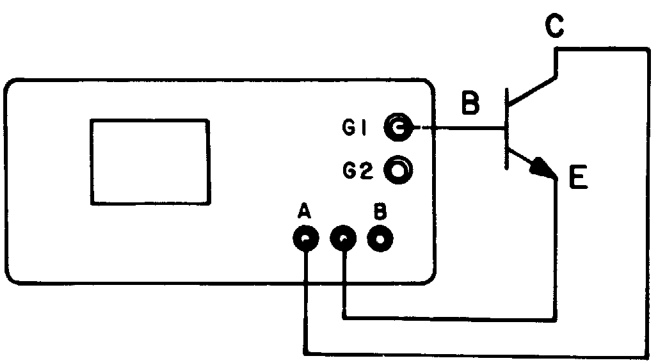


MT2–MT1 Test Connections

Figure 4-28b.

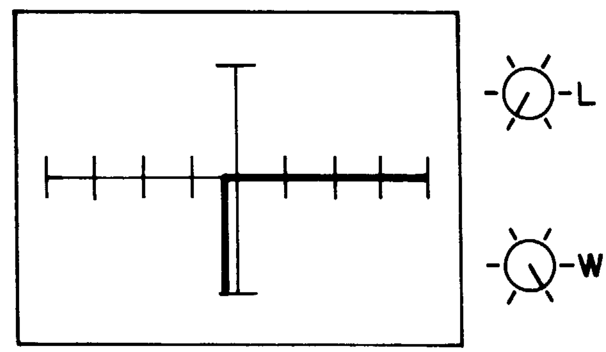
4-10. USING THE PULSE GENERATOR

The previous sections have dealt with using the Tracker 2000 with two test leads to check components. This method is all that is necessary to test two terminal components, and yields useful information for many three terminal components as well. However, the Tracker 2000 has additional capability to test three terminal devices using the built-in pulse generator. The pulse generator provides a signal to the control input of a device while the normal test terminals of the Tracker 2000 are used to examine the outputs of the device. This method puts the device under test in its active region and the user gets a signature that is the result of the device turning on and off. The following paragraphs discuss several devices that were examined earlier in this section to demonstrate the additional information that is available from the three terminal test mode using the pulse generator. Also covered is a device that is uniquely suited to testing in the three terminal mode. The theory of operation of the pulse generator is covered in Section 3-6.



NPN Test Connections
Using Pulse Generator

Figure 4-29a.

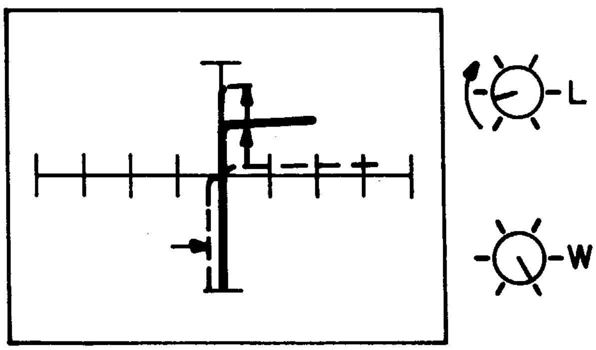


Medium 1 Range, 60Hz

Figure 4-29b.

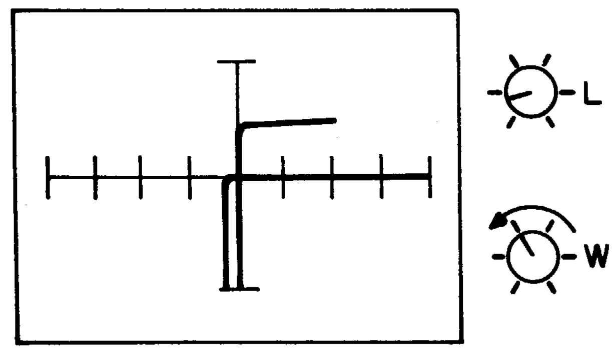
Figure 4-29a shows the test circuit for an NPN transistor using the pulse generator to drive the base. With the Level control at zero (fully counterclockwise), the display shows the signature of Figure 4-29b. This signature is the same as that shown in Figure 4-16 for the collector-base junction of an NPN transistor in the medium 1 range. This is because the pulse generator output (G1) at zero level is equivalent to a 100 ohm resistor connected to common, and 100 ohms appears as a short circuit in that range.

With the Width control turned fully clockwise, as the level is increased slowly from zero, the low impedance vertical line in the third quadrant will move towards and become even with the vertical axis, and then the "open circuit" horizontal line in the first quadrant will begin to move upward (see Figure 4-30a). This constant current signature is like that produced by a transistor curve tracer except that only one curve is shown instead of a family of curves. If the level is increased further, the horizontal portion of the signature will eventually move above the top end of the vertical axis. In the medium 1 range, the signature will then appear as a nearly vertical line indicating a low impedance.



Effect of Level Control
(Width = Max)
Medium 1 Range, 60Hz

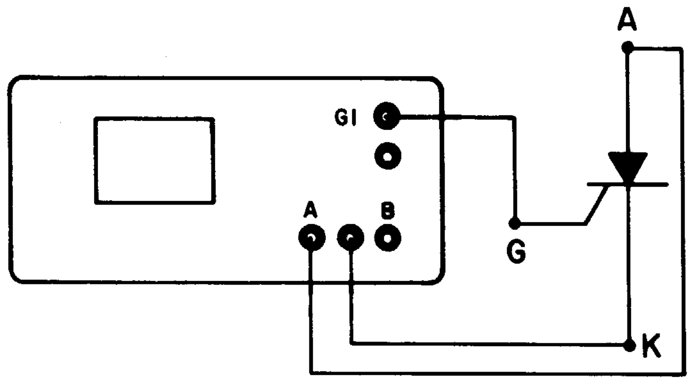
Figure 4-30a.



Effect of Width Control
at Constant Level
Medium 1 Range, 60Hz

Figure 4-30b.

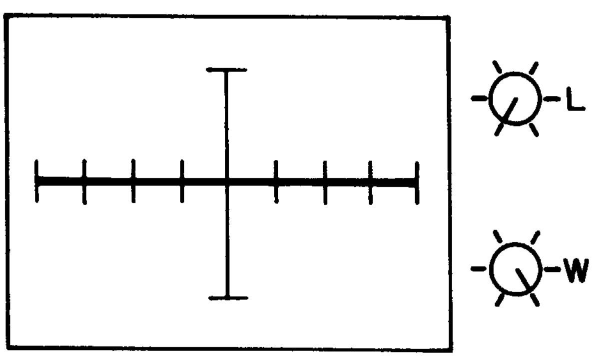
The solid signature in Figure 4-30a is the result of a DC stimulus. If the Width control is reduced from its maximum to about 40%, the signature shown in Figure 4-30b results. This display essentially shows the signatures of Figure 4-29b and 4-30a superimposed over one another with each one at half intensity. This composite signature means that the transistor is actually switching on and off with the pulse stimulus. Thus, the Tracker 200 can test an NPN transistor in its active mode with either an AC or a DC stimulus using the pulse generator.



SCR Test Connections Using Pulse Generator

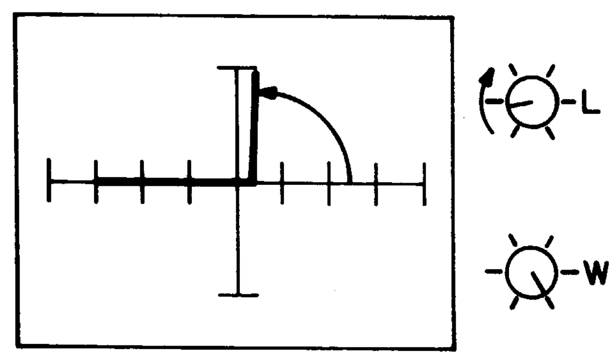
Figure 4-31.

The pulse generator can drive the gate of an SCR as shown in the test circuit of Figure 4-31. With the Level control at zero, a horizontal trace is displayed (see Figure 4-32a). This is expected since SCRs normally show an open circuit between anode and cathode or between anode and gate (see section 4-8). Using DC stimulus (width = max), a point is reached as the level is increased where the SCR turns on and the signature becomes like that of a diode. This is shown in Figure 4-32b for an SCR in the low range.



Zero Level
All Ranges

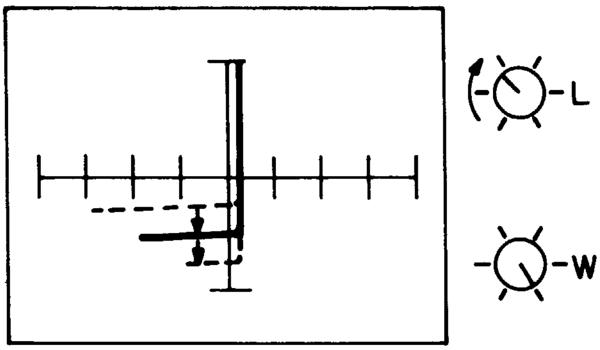
Figure 4-32a.



Effect of Level Control
(Width = Max)
Low Range, 60Hz

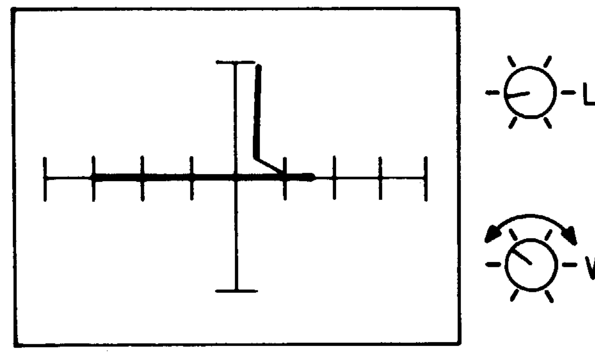
Figure 4-32b.

In medium 1 range (or higher), if the level is increased beyond the point where the SCR turns on, the horizontal portion of the signature will begin to move downward as shown in Figure 4-33a. This is due to a parasitic transistor action that exists outside the normal first quadrant operating parameters for an SCR. This effect is not especially relevent to determining whether an SCR is good or bad, and the user should simply note that it does not indicate a bad device. This effect is minimal in the low range.



Medium 1 Range, 60Hz

Figure 4-33a.

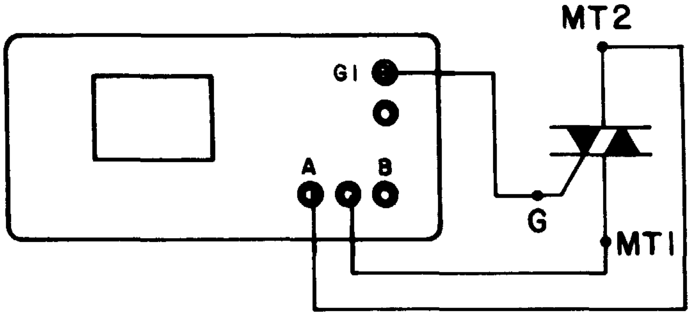


Low Range, 60Hz

Figure 4-33b.

The Width control can be varied over most of its range of adjustment without producing any change in the low range signature shown in Figure 4-33b. This indicates a normal SCR that is switched on by any pulse that exceeds some minimum duration and remains in conduction until the anode-cathode signal changes polarity.

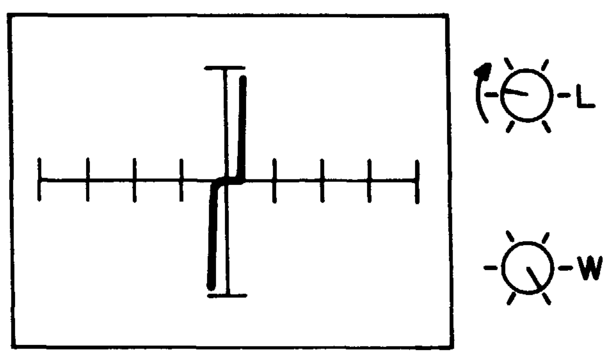
The best ranges for testing SCRs are the low and medium 1 ranges because those ranges have sufficient available current to produce normal action in many typical SCRs. In the medium 2 and high ranges, the maximum available current is much less than the minimum holding current of most SCRs and therefore the SCR switching characteristic cannot be observed.



Triac Test Connections Using Pulse Generator

Figure 4-34.

The test circuit for triacs is shown in Figure 4-34. With the Level control at zero, an open circuit trace will be displayed (refer to Section 4-9). As the level is increased from zero (width = max) the triac will initially turn on in the first quadrant just like an SCR (Figure 4-32b). Then with a slight increase in level, the triac turns on in the third quadrant also which produces the back-to-back diode characteristic shown in Figure 4-35 (low range). This signature demonstrates the normal bidirectional conduction that is characteristic of a triac in the on state.

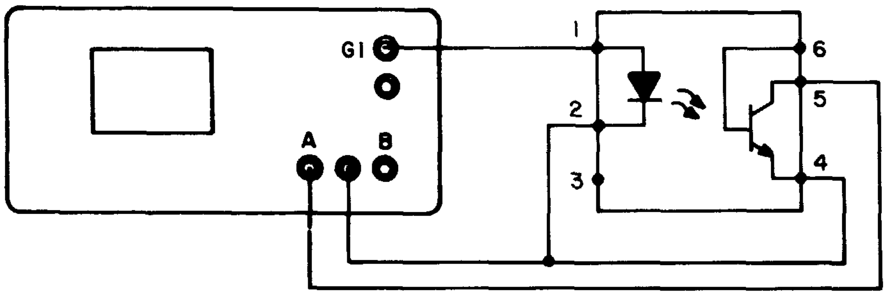


Effect of Level Control
(Width = Max)
Low Range, 60Hz

Figure 4-35.

In all other ways, triacs are quite similar to SCRs. There is little change in the low range signature with various settings of the Width control once the triac has turned on, which verifies that a triac will continue to conduct after a pulse fires the gate. Also the medium 2 and high ranges have insufficient current to detect typical triac switching action and should not be used.

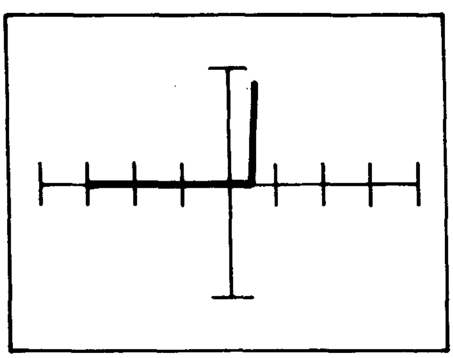
Figure 4-36 shows the test connections to an optocoupler using the pulse generator. The optocoupler shown has an NPN phototransistor as its output device, and is representative of a large percentage of the optocouplers used in modern electronic equipment. The user should note that pin 2 and pin 4 need to be connected with a jumper to establish a common point for the Tracker 2000.



Optocoupler Test Connections Using Pulse Generator

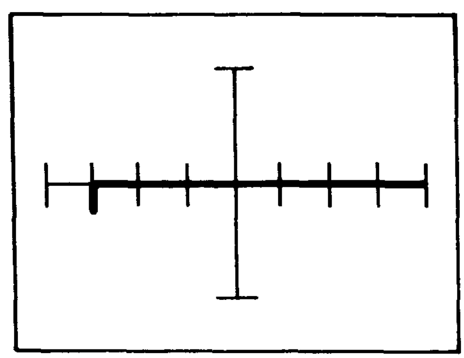
Figure 4-36

Using the Tracker 2000 in the two terminal mode, some data about optocouplers can be learned. The input LED of the optocoupler can be tested as a stand alone diode and the signature shown in Figure 4-37a is the result. In a similar manner the output NPN transistor can be tested using the methods discussed in section 4-7. The collector-emitter connection in the medium 1 range produces the signature shown in Figure 4-37b. These two terminal techniques can check the LED and the phototransistor, but they cannot verify the optical link between the two devices. This is why the optocoupler is uniquely suited to testing in the three terminal mode of the Tracker 2000.



Input LED (Pins 1 & 2)
Low Range, 60Hz

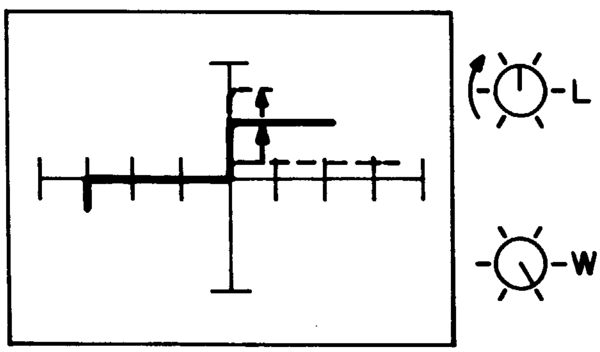
Figure 4-37a.



Output Phototransistor
C-E Connection (Pins 5 & 4)
Medium 1 Range, 60Hz

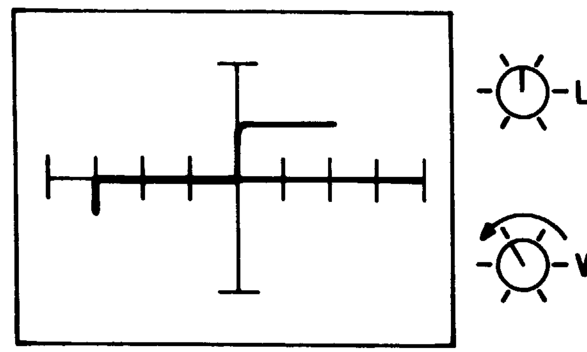
Figure 4-37b.

Using the test circuit in Figure 4-36, if the Level control is at zero and the Width control is at maximum, the same signature is produced that was shown in Figure 4-37b. This is not unexpected since there is zero drive to the LED and therefore, zero base current in the phototransistor. As the level is increased from zero, the horizontal portion of the trace in the first quadrant will move upward just like an NPN transistor driven directly by the pulse generator (see Figure 4-38a). There are two main differences between the transistor driven directly and the optocoupler transistor. First, the Level control does not affect the signature in the third quadrant with the optocoupler under test, whereas the transistor with direct drive has a different signature in the third quadrant and it moves as the Level control is increased. Second, the sensitivity of the first quadrant signature to the position of the Level control is much lower with the optocoupler than with the transistor. This is because of the optocoupler parameter known as "current transfer ratio" or CTR which is the ratio of collector current in the phototransistor to the forward current in the LED. CTR for common optocouplers is approximately one, whereas the corresponding parameter for the transistor alone is the forward current gain (beta) which is usually in the range from 50 to 200. This accounts for the decreased Level control sensitivity when testing optocouplers.



Effect of Level Control
(Width = Max)
Medium 1 Range, 60Hz

Figure 4-38a.



Effect of Width Control
at Constant Level
Medium 1 Range, 60Hz

Figure 4-38b.

The optocoupler can be tested with an AC stimulus by turning the Width control to approximately 40% duty cycle. The resulting composite signature (shown in Figure 4-38b) is equivalent to the signatures of Figure 4-37b and 4-38a superimposed on each other. The first quadrant curves are at half intensity due to the switching action caused by the pulse generator, while the third quadrant is at full intensity because the pulse generator does not affect the signature there.

Using the second pulse generator output and the Alternate mode, two devices of the same type can be checked and compared to each other. The test connections for this method are shown in Figure 2-7 of the operating instructions (section 2).

This section has shown how to use the pulse generator to test devices in the three terminal mode using either DC or AC stimulus. This test method is capable of placing semiconductor devices in their active region which gives the user a signature that is the result of a dynamic test rather than a static test.

SECTION 5
MAINTENANCE

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

5-1. INTRODUCTION

This section of the manual 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.

5-2. SERVICE INFORMATION

The Tracker 2000 is warranted for a period of one year upon shipment of the instrument to the original purchaser. Conditions of the 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. For in-warranty repair, call (toll-free) 800-426-9265 for shipping instructions (In Alaska, Hawaii, Washington or Canada call 206-743-3171). Ship the instrument postpaid in the original shipping container (if available). Dated proof-of-purchase may be required for in-warranty repairs.

Huntron Service is also available for adjustment and/or repair of instruments that are beyond the warranty period. Call the numbers listed above for shipping information. Ship the instrument and remittance in accordance with instructions received.

5-3. 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 adjustment, 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. Throughout these procedures, the Tracker 2000 being tested is referred to as the UUT (Unit Under Test).

LOGIC SECTION:

1. The UUT should come on in channel A, low range, and 50/60Hz.

2. Press 400Hz, 2000Hz, and 50/60Hz. The corresponding LED should illuminate when the button is pressed and should stay on until another frequency button is pressed.

3. Press the ALT button. The ALT LED should illuminate and the channel A and channel B LEDs should be alternately on. Verify that the alteration rate increases with clockwise rotation of the Rate control. Then press the channel A button. The ALT LED should go off and the channel A LED should stay on. Press the ALT button again and then press the channel B button to make sure it also cancels the Alternate function.

4. Press the AUTO button. The AUTO LED should illuminate and the UUT should scan through the ranges as follows: low, medium 1, medium 2, high, back to low, and repeat. Verify that the scanning rate increases with clockwise rotation of the Rate control. Then press the low button. This should cancel the Auto function and set the UUT to the low range. Repeat this procedure for the other three ranges (i.e. select Auto, then a range).

5. The UUT should be in the high range. Press the HIGH LOCKOUT button. This should illuminate the HIGH LOCKOUT LED and set the UUT to the medium 2 range. Then press the AUTO button. The UUT should scan through the low, medium 1, and medium 2 ranges, and bypass the high range. Press the HIGH LOCKOUT button again. The HIGH LOCKOUT LED should go out and the UUT should go back to scanning all four ranges.

6. The UUT should be in Auto. Press the ALT button. This will put the UUT in the Auto/Alternate mode. For the Auto/Alternate sequence, see Figure 3-2. Varying the Rate control should increase the scan/alternate rate with clockwise rotation.

7. Check channel A lock operation. Select ALT (front panel) and set the Ch. A Lock switch on the back panel to ON. Both the channel A LED and the ALT LED should be illuminated.

SIGNAL SECTION:

1. Select 50/60Hz, channel B, and High Lockout = off on the front panel. Select Ch. A Lock = off and Mode 2 (Diode) on the back panel. Adjust the CRT controls (Intensity, Focus, and Astigmatism) for a sharp trace on the CRT display.

2. Measure the sine wave voltage between the channel B 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 AC input impedance of your scope or DMM is at least 10 Megohm.

Range	V_{pp}	V_{rms}
High	120	42.43
Medium 2	40	14.14
Medium 1	30	10.61
Low	20	7.07

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

Range	mA_{rms}
High	0.6
Medium 2	0.6
Medium 1	9.0
Low	135

4. Use a scope or frequency counter to measure the test signal frequencies. When a 50Hz or 60Hz power line is used the 50/60Hz test signal frequency should be locked to the line frequency. To verify this, check the 50/60Hz test signal using a scope with the trigger set to LINE. If the test signal is stationary, then the signal is locked to the line. If a 400Hz power line is used, the 50/60Hz test signal frequency should be 80Hz and will not be locked to the line. Verify the following test signal frequencies:

Test Signal Frequencies

Frequency Select	Power Line Frequency (Hz) 50Hz	60Hz	400Hz
50/60	50	60	80
400	400	400	400
2000	2000	2000	2000

5. Remove the DMM, scope, and/or frequency counter. Turn the Rate control fully clockwise, select Auto and verify that there is only slight movement in the open circuit horizontal traces. Then select channel A, and short the channel A and common test terminals together and verify that there is only slight movement in the short circuit vertical traces.

PULSE GENERATOR:

1. Connect Ch. 1 of a dual trace scope to G1 (pulse generator terminal), Ch. 2 to the channel A test terminal, and scope ground to the common test terminal. Set the scope trigger to Ch. 2.

2. Select 50/60Hz and channel A. Adjust the Pulse Width control to its maximum. Vary the Pulse Level control and verify that the minimum is zero and the maximum is between +4.5VDC and +5.5VDC on the scope. At the maximum setting of the Pulse Level control, the scope should show a solid DC line on Ch. 1.

3. Vary the Pulse Width and compare the scope display to Figure 3-6. The rising edge of each pulse should always start at each zero crossing of the test signal (scope Ch. 2). Repeat this step for 400Hz and 2000Hz. Slope in the rising and falling edges of the pulses is acceptable at 2000Hz.

5-4. CMOS HANDLING PRECAUTIONS

CAUTION

This instrument contains CMOS components which can be damaged by static discharge. To prevent damage, take the following precautions when troubleshooting and/or repairing the instrument:

* Perform all work at a static-free work station.
* Do not handle components or PCB assemblies by their connectors.
* Wear static ground straps.
* Use conductive foam to store components.
* Remove all plastic, vinyl and styrofoam from the work area.
* Use a grounded, temperature-regulated soldering iron.

5-5. INTERNAL ADJUSTMENTS

If your Tracker 2000 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 remove the front and back case bezels, then lift off the top cover (see Figure 5-1). In the following procedure, the Tracker 2000 that is being adjusted is referred to as the UUT (Unit Under Test).

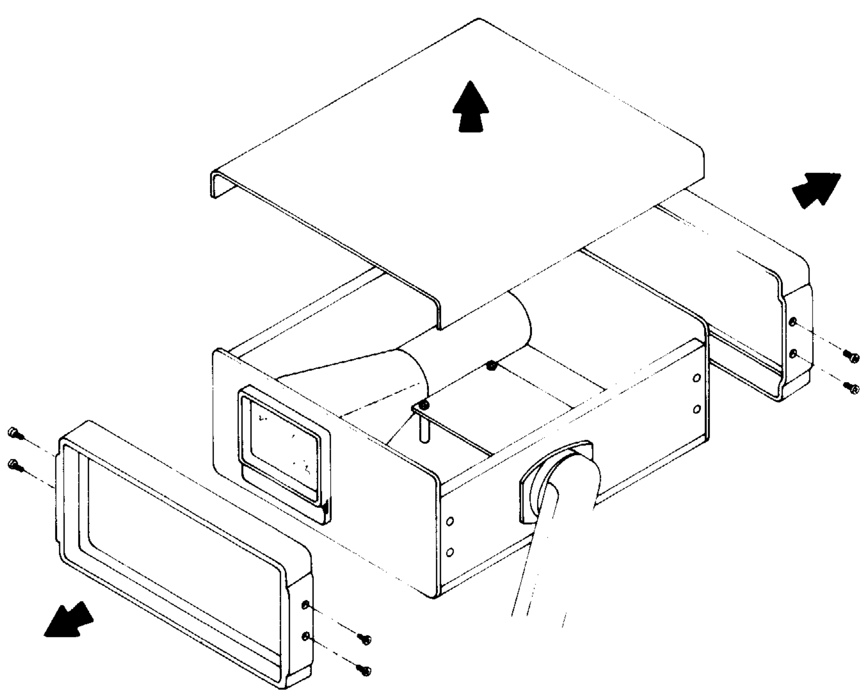


Figure 5-1. Adjustment Access Procedure

A. POWER SUPPLY SECTION:

The High Voltage is factory adjusted to -1350 Volts, and the user is advised to not readjust trimpot R85 unless it is absolutely necessary. This adjustment requires a digital multimeter (DMM) and a high voltage probe.

WARNING: HAZARDOUS HIGH VOLTAGE.

PROCEDURE:

1. Connect the common lead of the high voltage probe to the common test terminal on the front panel.
2. Connect the high voltage probe to Test Point #1 (TP1) on the Main PCB.
3. Turn power on.
4. Adjust R85 (Main PCB) until the DMM reads -1350VDC (including the gain of the probe).

B. OSCILLATOR SECTION:

All adjustments in this section are located on the Oscillator PCB Assembly. Refer to Figure 5-2 for adjustment locations and to Figure 7-4 for schematic.

PROCEDURE:

1. Select 400Hz, turn R33 fully CCW, and connect a scope to the base of Q1.
2. The base of Q1 should be a 380mV_{pp} triangle wave. If not, adjust R22 for a 380mV_{pp} triangle wave.
3. Check the oscillator output (J2-pin 8) with the scope. It should be a sine wave with small points on each peak. If the points are not equal on the positive and negative peaks, or the waveform is not symmetric, adjust R30 for best symmetry. Then adjust R33 until the small points on the sine wave disappear leaving a low distortion sine wave. The sine wave should have an amplitude of 500mV_{pp} to 800mV_{pp}.
4. Connect a frequency counter to the oscillator output. If it is not 400Hz, then adjust R17 until the counter reads 400Hz. Then select 2000Hz and adjust R15 (if necessary) until the counter reads 2000Hz. Select 50/60Hz. Verify that the counter reads the same frequency as the power line in use. This should also be checked by switching to LINE trigger on the scope. The output waveform should be stationary which indicates that it is synchronized with the power line. Verify that the amplitude does not change as the different frequencies are selected.

5. When 50/60Hz is selected, and a 400Hz power line is in use, R11 is factory adjusted to produce an output frequency of 80Hz. If not, adjust R11 until the counter reads 80Hz. Disconnect the scope and/or frequency counter from the UUT.

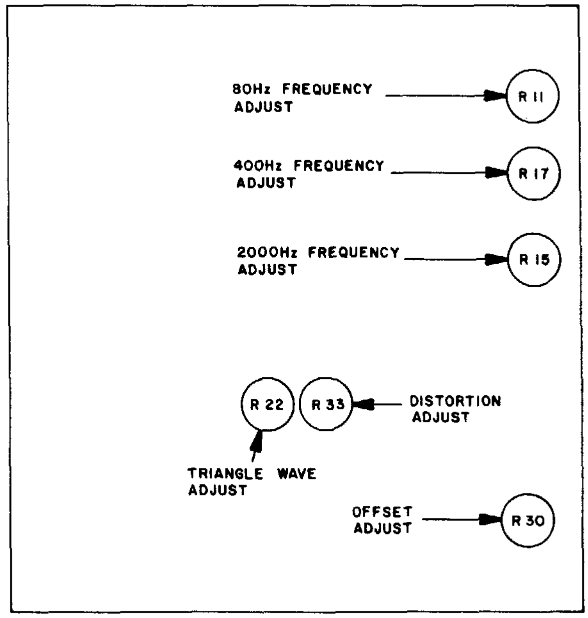


Figure 5-2. Oscillator PCB Adjustment Locations

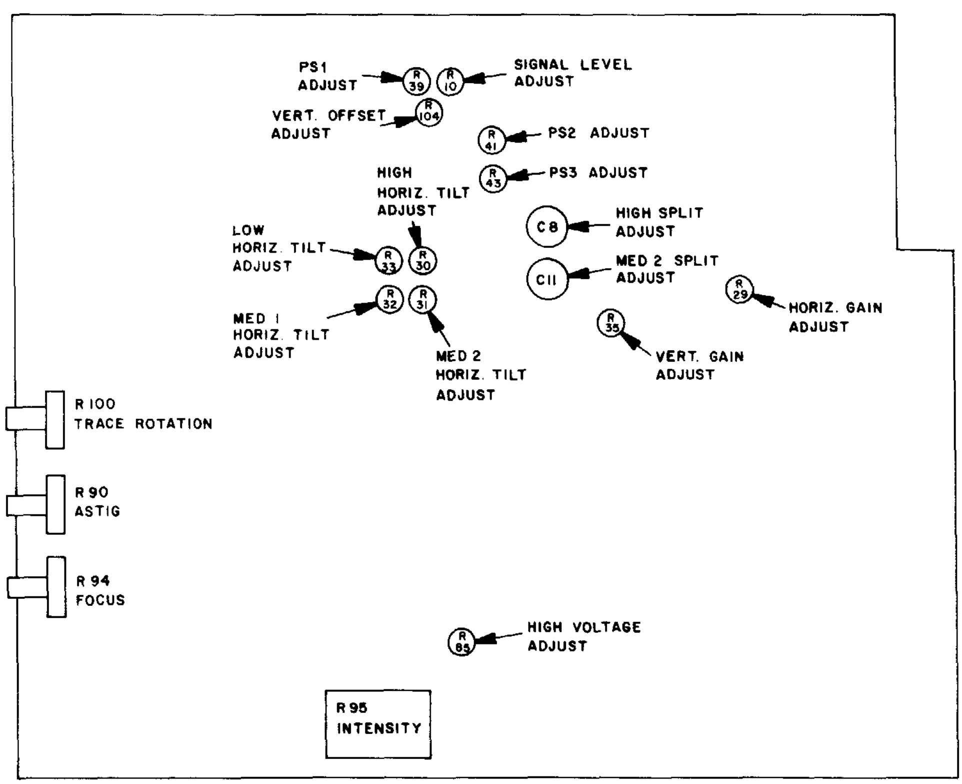


Figure 5-3. Main PCB Adjustment Locations

C. SIGNAL SECTION

All adjustments in this section are located on the Main PCB Assembly. Refer to Figure 5-3 for adjustment locations and to Figure 7-2 for schematic. To gain access to the adjustments under the Oscillator PCB, remove the four screws retaining the Oscillator PCB and then tilt the PCB up and out of the way of the adjustments. Be careful not to short the oscillator PCB to the case.

PROCEDURE:

1. Select the low range, 50/60Hz, channel A, and High Lockout off on the front panel. Select Ch. A Lock off and MODE 2 (Diode) on the back panel. Adjust the CRT controls (Intensity, Focus, and Astigmatism) 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. Adjust R10 (Signal Level) to give $20V_{pp}$ (scope) or $7.071V_{rms}$ (DMM).

3. 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_{pp}	V_{rms}
Medium 1	30	10.61
Medium 2	40	14.14
High	120	42.43

4. Short the channel A test terminal to the common test terminal and adjust the Trace Rotate control on the back panel (R100) until the CRT trace is lined up with the vertical axis of the CRT graticle.

5. Adjust R35 (Vertical Gain) until the endpoints of the trace match the endpoints of the graticle. Select Auto and verify that the trace length is the same in each range and that each trace is parallel to the vertical axis.

6. Select the low range again. This cancels the Auto function. Remove the short between Channel A and common.

7. Adjust R33 (Low Horizontal Tilt) until the trace is parallel to the horizontal axis.

8. Adjust R29 (Horizontal Gain) until the endpoints of the trace match the endpoints of the graticle.

9. Select the medium 1 range. Adjust R32 (Medium 1 Horizontal Tilt) until the trace is parallel to the horizontal axis.

10. Select the medium 2 range. Adjust R31 (Medium 2 Horizontal Tilt) until the trace is parallel to the horizontal axis.

11. Select the high range. Adjust R30 (High Horizontal Tilt) until the trace is parallel to the horizontal axis.

12. Select Auto and verify that the trace length is the same in each range and that each trace is parallel to the horizontal axis.

NOTE: For steps 13-16, remove all test leads or cables from the test terminal banana jacks of the UUT.

13. Select the high range and 2000Hz. The horizontal trace may become an ellipse with a small vertical component. If so, adjust C8 (High Split) until the ellipse becomes a line again. Select 400Hz and verify that there is no ellipse in the trace.

14. Select the medium 2 range and 2000Hz. If the horizontal trace becomes an ellipse. adjust C11 (Medium 2 Split) until the trace is a line. Select 400Hz and verify that there is no ellipse in the trace.

15. Scan all twelve combinations of range and frequency and verify that the horizontal trace is always a line (no ellipsoids).

16. Select the high range and 400Hz. Set the MODE switch on the back panel to Mode 1. The horizontal trace may make a vertical shift either up or down. If so, adjust R104 (Vertical Offset) while switching back and forth from Mode 1 to Mode 2 until the vertical shift is eliminated and the trace remains stationary.

17. Connect a 51K resistor between the channel A and common terminals using short leads. This produces a trace with a rotation of approximately 45 degrees from the horizontal axis. The trace may be an ellipse rather than a straight line. If so, adjust R39 (PS1) until the trace becomes a line.

18. Select 2000Hz while still in the high range. The angle of the trace should remain unchanged, but an ellipse may reappear. If so, adjust R41 (PS2) until the ellipse becomes a straight line.

19. Select the medium 2 range and 2000Hz. Connect a 15K resistor to the channel A and common terminals and verify that the trace is rotated approximately 45 degrees from the horizontal axis. If the trace is an ellipse, adjust R43 (PS3) until the trace becomes a line.

5-6. TROUBLESHOOTING

CAUTION

Static discharge can damage CMOS components. Follow the handling precautions for static sensitive devices previously described in this section. Never remove, install, or otherwise connect or disconnect components without first turning the instrument off.

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 7.

This section assumes that the user has done the performance tests in Section 5-3 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 5-5 and noted any problems found.

The troubleshooting guides that follow refer to the location of possible defective components by assembly number:

A2	- Main PCB Assembly	A7	- Back Panel Assembly
A4	- Oscillator PCB Assembly	A10	- CRT Assembly
A5	- Front Panel Assembly	A11	- CRT Harness

These are the same assembly numbers that are used in the list of replaceable parts in Section 6. The components referred to in the guides are usually the major ones within a section of the circuit. Other miscellaneous components (e.g. diodes, resistors, and capacitators) connected to the indicated parts should also be checked for possible failure. The following outline should be followed sequentially until all faults are corrected:

1. Check and verify the power supply voltages listed in Table 5-1. If any voltage is out of tolerance, use the power supply troubleshooting guide (Table 5-2).

2. Using the performance test discrepancies from Section 5-3, go through the performance test troubleshooting guide in Table 5-3.

3. If indicated in Table 5-3, the following horizontal/vertical tests should be performed:

   With an open circuit on the test terminals, check the horizontal output at either end of R49 with a scope. The signal at this point should be an undistorted sine wave with the same amplitude in all ranges at a particular frequency. The amplitude should be approximately $1.2V_{pp}$. The amplitude may change slightly when the test signal frequency is changed, but it should not change noticeably from range to range.

Now short the test terminals. The signal at R49 should go to zero in all ranges.

With the short circuit still on the test terminals, check the vertical output at either end of R48 with the scope. Again, this signal should have equal amplitude regardless of range and change only slightly with different frequencies. The amplitude should be approximately $0.5V_{pp}$.

Now open the test terminals. The signal at R49 should go to a small value less than $20mV_{pp}$ in amplitude.

If these tests check out properly, then any problem with the display is related to the CRT circuits.

4. Using the suggestions from Table 5-3 and the preceding tests (if applicable), follow the additional troubleshooting guide (Table 5-4).

Table 5-1. Power Supply Limits

SUPPLY	MINIMUM	MAXIMUM
+5V (V+)	+4.5V	+5.5V
−5V (V−)	−4.5V	−5.5V
+12V	+11V	+15V
−12V	−11V	−15V
+180V	+170V	+190V
−1350V	−1340V	−1360V

Table 5-2. Power Supply Troubleshooting Guide

VOLTAGE OUT OF TOLERANCE	POSSIBLE CAUSE/SUGGESTIONS
All are zero with power on	A7: F2 (line fuse)
+5V (+12V is OK)	A2: U15
−5V (−12V is OK)	A2: U16
+12V	A2: C47, D11, D13, T2
−12V	A2: C48, D10, D12, T2
+180V	A2: C46, D6, D7, D8, D9, T2
−1350V	A2: D4, D5, Q7, R85, T2, U14

Table 5-3. Performance Test Troubleshooting Guide

TEST AND SYMPTOM	POSSIBLE CAUSE/SUGGESTIONS
LOGIC SECTION	
1. The UUT does not have proper initial conditions and steps 2 through 7 of the logic section performance test are correct	A2: U12
2. The frequency buttons or LEDs do not function properly	A2: U18, U19, U20, U31, U32 A5: S1, S2, S3, D1, D2, D3
3. The channel control buttons or LEDs do not function properly	A2: U18, U19, U21, U31, U32, Q12 A5: S4, S5, S6, D4, D5, D6
4. The AUTO or range selection buttons or LEDs do not function properly	A2: U18, U19, U20, U22, U23, U24, U26, U27, U31, U32, Q8, Q9, Q10, Q11 A5: S8, S9, S10, S11, S12, D8, D9, D10, D11, D12, R3
5. The HIGH LOCKOUT button or LED does not function properly	A2: U21, U22, U26, U30, U31, U32 A5: S7, D7
6. The AUTO/ALT mode does not function properly	Check steps 3 and/or 4 above
7. The Ch. A Lock switch does not function properly	A2: Q13, Q15 A5: switch assembly (A9)
SIGNAL SECTION	
2. All ranges produce zero 3. voltage and current and the CRT display shows a dot	A2: F1 (signal fuse)
Proper voltages and/or currents are not produced in all ranges	A2: U1, U2, T1, K1, K2, K3, K4 A4: Check oscillator
4. Incorrect frequencies are produced	A4: Check oscillator
5. Tests 2, 3, and 4 above are correct, but the CRT does not display the proper signatures	A4: Perform the horizontal/ vertical tests (step 3, page 5-9) to determine the location of the problem
PULSE GENERATOR	
2. The pulse generator does not 3. function properly	A2: U10, U11, U12, U13, U25 A5: R1, R2

Table 5-4. Additional Troubleshooting Guide

SYMPTOM	POSSIBLE CAUSE/SUGGESTIONS
OSCILLATOR	
50/60Hz does not function properly (400Hz and 2000Hz are OK)	A4: U1, U2, U3, U4, U6
400Hz and 2000Hz do not function properly (50/60Hz is OK)	A4: U5, U6
No frequency functions properly	A4: U6, U7, Q1, Q2
HORIZONTAL/VERTICAL	
The horizontal output does not funtion properly	A2: U3, U4
The vertical output does not function properly	A2: U5, U6, U7, U8, U9
CRT	
Trace rotate does not function properly	A2: U17, R100 A10: L1
Display does not function properly (horizontal and vertical outputs are OK)	A2: Q1, Q2, Q3, Q4, Q5, Q6, R90, R94, R95 A5: R4, R5 A10: CRT1, A11

SECTION 6
LIST OF REPLACEABLE PARTS

6-1. INTRODUCTION

This section contains the parts list for the Tracker 2000. 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.

6-2. 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 ordered 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

CAUTION

Indicated devices are subject to damage by static discharge.

TRACKER 2000 FINAL ASSEMBLY:

(Refer to Figure 6-1)

REF. DES.		DESCRIPTION	HUNTRON PART NO.
A1	⊘	Final Assembly, Tracker 2000	01-2069
		2000E	01-2068
		2000J	01-2067
A2	⊘	Main PCB Assembly, 2000	07-1061
		2000E	07-1062
		2000J	07-1063
A4	⊘	Oscillator PCB Assembly	07-1055
A5		Front Panel Assembly	01-3112
A7		Back Panel Assembly	01-3113
A10		CRT Assembly	07-1059
MP1		Top, Case	01-3015
MP2		Bottom, Case	01-3016
MP3	(2)	Side, Case	01-3017
MP4		Handle, Case	01-3018
MP5	(2)	Bezel, Case	01-3019
MP6	(2)	Channel, Case	01-3020
MP7	(6)	Spacer, Board, Nylon	01-3021
MP8	(4)	Feet, Case	01-3022
MP9	(4)	Screw, Feet	01-3023
MP10	(12)	Screw, Panel	01-3024
MP11	(8)	Screw, Bezel	01-3025
MP12	(8)	Screw, Handle	01-3026
MP13		Bezel, CRT	01-1151
MP14		Lens, Glass	01-1086
MP15		Graticule	01-2005
MP16		Decal, Bezel, CRT	01-1090
MP17	(2)	Screw, Bezel, CRT	07-7294
MP18	(6)	Screw, 6-32, ⅜"	07-7172
MP19	(2)	Screw, 4-40, ⅜"	07-7086
MP20	(4)	Screw, 4-40, 1½"	07-7325
MP21	(2)	Screw, 4-40, 1 3/16"	07-7326
MP22	(4)	Spacer, Oscillator, Nylon	07-7327
MP23		Coupler, Shaft	07-7147
MP24		Shaft, Intensity	07-7328
MP25	(6)	Knob, Black	01-1081
MP26	(2)	Cap, Knob, Black	01-1083
MP27	(2)	Cap, Knob, Blue W/Line	01-1084
MP28		Cap, Knob, Red	01-1085
MP29		Cap, Knob, Black W/Line	01-1094
MP30	(2)	Cap, Switch, Brown	07-7293
MP31	(10)	Cap, Switch, Ivory	07-7292
MP32		Clamp, CRT, Front	07-7300
MP33		Pad, 2¼" x ½" x 1/16", Foam	07-7312
MP34	(2)	Pad, 2¾" x ½" x 1/16", Foam	07-7313
MP35		Pad, 2" x 5/16" x ¼", Foam	07-7314
MP36	(2)	Clamp, Yoke Half	01-1114
MP37	(2)	Standoff, Yoke, Steel	07-7358

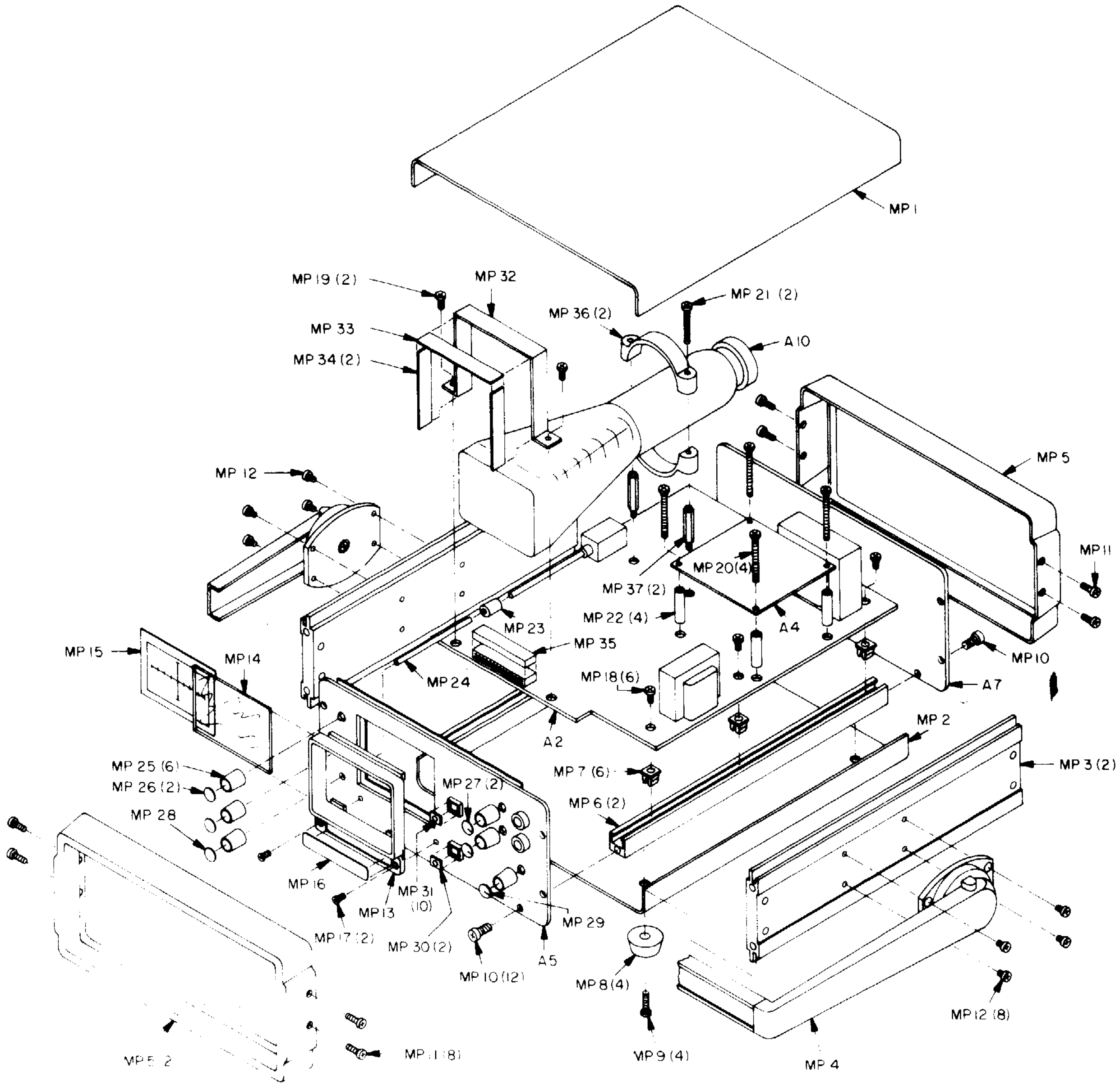


Figure 6-1. Tracker 2000 Final Assembly

ACCESSORIES (Not Shown):		**HUNTRON PART NO.**
Manual, Operating & Maintenance		21-1040
Cord, Power	2000	01-1091
	2000E	01-1092
	2000J	01-1091
Microprobes, Pair		10-1999
Lead, Common Test		10-1088
Lead, Micro Clip, Blue, Pair		10-1076
Cable, Pwr/Clk, Switcher 410		10-1075

MAIN PCB ASSEMBLY:

(Refer To Figure 7-1 and 7-2)

REF. DES.	DESCRIPTION		HUNTRON PART NO.
A2	Main PCB Assembly, 2000		07-1061
	2000E		07-1062
	2000J		07-1063
A3	Power Harness Assembly		07-1067
C1	Cap, Tantalum	10μF, 25V	03-3011
C2	Cap, Ceramic	.1μF, 50V	03-3028
C3	Cap, Tantalum	10μF, 25V	03-3011
C4	Cap, Ceramic	.1μF, 50V	03-3028
C5	Cap, Tantalum	10μF, 50V	03-3011
C6	Cap, Ceramic	.1μF, 50V	03-3028
C7	Cap, Tantalum	10μF, 25V	03-3011
C8	Cap, Trimmer	10-180pF	03-3060
C9	Cap, Ceramic	820pF, 50V, 5%	03-3061
C10	Cap, Factory Selected		
C11	Cap, Trimmer	10-180pF	03-3060
C12	Cap, Ceramic	330pF, 50V, 5%	03-3062
C13	Cap, Factory Selected		
C14	Cap, Factory Selected		
C15	Cap, Factory Selected		
C16	Cap, Ceramic	.1μF, 50V	03-3028
C17	Cap, Tantalum	10μF, 25V	03-3011
C18	Cap, Ceramic	.1μF, 50V	03-3028
C19	Cap, Tantalum	10μF, 25V	03-3011
C20	Cap, Polyester	.1μF, 50V, 5%	03-3063
C21	Cap, Polyester	.1μF, 50V, 5%	03-3063
C22	Cap, Polyester	.1μF, 50V, 5%	03-3063
C23	Cap, Ceramic	.1μF, 50V	03-3028
C24	Cap, Tantalum	10μF, 25V	03-3011
C25	Cap, Ceramic	.1μF, 50V	03-3028
C26	Cap, Tantalum	10μF, 25V	03-3011
C27	Cap, Ceramic	.1μF, 50V	03-3028
C28	Cap,, Ceramic	.1μF, 50V	03-3028
C29	Not Used		
C30	Cap, Ceramic	.1μF, 50V	03-3028
C31	Cap, Ceramic	.1μF, 50V	03-3028
C32	Cap, Ceramic	.001μF, 50V	03-3027
C33	Cap, Ceramic	.001μF, 50V	03-3027
C34	Cap, Polyester	.01μF, 50V, 5%	03-3057
C35	Cap, Polyester	1000pF, 100V, 5%	03-3059
C36	Cap, Ceramic	270pF, 50V, 5%	03-3058
C37	Cap, Ceramic	.1μF, 500V	03-3007
C38	Not Used		
C39	Not Used		
C40	Not Used		
C41	Cap, Electrolytic	1μF, 450V	03-3040
C42	Cap, Electrolytic	1μF, 450V	03-3040
C43	Cap, Electrolytic	1μF, 450V	03-3040

MAIN PCB ASSEMBLY (CONT.):

REF. DES.	DESCRIPTION		HUNTRON PART NO.
C44	Cap, Electrolytic	1μF, 450V	03-3040
C45	Cap, Ceramic	.01μF, 2KV	03-3042
C46	Cap, Electrolytic	22μF, 250V	03-3043
C47	Cap, Electrolytic	2200μF, 25V	03-3056
C48	Cap, Electrolytic	2200μF, 25V	03-3056
C49	Cap, Tantalum	10μF, 25V	03-3011
C50	Cap, Tantalum	10μF, 25V	03-3011
C51	Cap, Ceramic	.1μF, 50V	03-3028
C52	Cap, Ceramic	.1μF, 50V	03-3028
C53	Cap, Tantalum	10μF, 25V	03-3011
C54	Cap, Tantalum	10μF, 25V	03-3011
C55	Cap, Electrolytic	1μF, 450V	03-3040
C56	Cap, Ceramic	.001μF, 50V	03-3027
C57	Cap, Electrolytic	2.2μF, 50V	03-3046
C58	Cap, Ceramic	.1μF, 50V	03-3028
C59	Cap, Ceramic	.1μF, 50V	03-3028
C60	Cap, Ceramic	.1μF, 50V	03-3028
C61	Cap, Ceramic	.1μF, 50V	03-3028
D1	Diode, Signal	1N914	04-4007
D2	Diode, Signal	1N914	04-4007
D3	Diode, Signal	1N914	04-4007
D4	Diode, 3KV	HV30	04-4016
D5	Diode, 3KV	HV30	04-4016
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, 50V	1N4001	04-4006
D11	Diode, 50V	1N4001	04-4006
D12	Diode, 50V	1N4001	04-4006
D13	Diode, 50V	1N4001	04-4006
D14	Diode, Signal	1N914	04-4007
D15	Diode, Signal	1N914	04-4007
D16	Diode, Signal	1N914	04-4007
D17	Diode, Signal	1N914	04-4007
D18	Diode, Signal	1N914	04-4007
D19	Diode, Signal	1N914	04-4007
D20	Diode, Signal	1N914	04-4007
D21	Diode, Signal	1N914	04-4007
D22	Diode, Signal	1N914	04-4007
D23	Diode, Signal	1N914	04-4007
F1	Fuse, AGX	¼A 250V	02-2132
J3	Header, 12 Pin Polarized		07-7158
J4	Header, 12 Pin Polarized		07-7158
J5	Header, 6 Pin Polarized		07-7224
J6	Header, 6 Pin Polarized		07-7224
J7	Header, 3 Pin Recessed		07-7321

MAIN PCB ASSEMBLY (CONT):

REF. DES.		DESCRIPTION		HUNTRON PART NO.
K1		Relay, 1 Form C	5V	07-7904
K2		Relay, 1 Form C	5V	07-7904
K3		Relay, 1 Form C	5V	07-7904
K4		Relay, 1 Form C	5V	07-7094
K5		Relay, 1 Form C	5V	07-7094
MP1		PCB, Main		07-7712
MP2		Insulator, Regulator		07-7084
MP3	(6)	Screw, 4-40, 3/8"		07-7086
MP4	(2)	Nut, 4-40, Hex		07-7087
MP5	(2)	Washer, Lock, #4		07-7089
MP6		Bushing, Shoulder, Nylon		07-7119
MP7		Test Pin		07-7153
MP8	(2)	Screw, 8-32, ½"		07-7174
MP9	(5)	Insulator, Capacitator		07-7226
MP10		Heat Sink		07-7315
MP11		Heat Sink W/Nutserts		07-7316
MP12	(2)	Fuse Clips		02-2044
P1		Socket, 40 Pin		07-7284
P2		Socket, 8 Pin		07-7286
Q1		Transistor, NPN, 300V	MPSA42	05-5003
Q2		Transistor, NPN, 300V	MPSA42	05-5003
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, 500V	TIP50	05-5016
Q8		Transistor, NPN	PN2222	05-5013
Q9		Transistor, NPN	PN2222	05-5013
Q10		Transistor, NPN	PN2222	05-5013
Q11		Transistor, NPN	PN2222	05-5013
Q12		Transistor, PNP	2N3906	05-5039
Q13		Transistor, NPN	PN2222	05-5013
Q14		Not Used		
Q15		Transistor, NPN	PN2222	05-5013
R1		Resistor	180K	02-2124
R2		Resistor	1	02-2164
R3		Resistor	1	02-2164
R4		Resistor	1	02-2164
R5		Resistor	1	02-2164
R6		Resistor	2.7	02-2165
R7		Resistor	5.6, 1W	02-2209
R8		Resistor, Metal Film	10.0K, 1%	02-2189
R9		Resistor, Metal Film	100K, 1%	02-2190
R10		Pot, Trimmer	100K	02-2169
R11		Resistor, Metal Film	1.96M, 1%	02-2150
R12		Resistor, Metal Film	86.6K, 1%	02-2136

MAIN PCB ASSEMBLY (CONT.):

REF. DES.	DESCRIPTION		HUNTRON PART NO.
R13	Resistor, Metal Film	604K, 1%	02-2217
R14	Resistor, Metal Film	28.0K, 1%	02-2191
R15	Resistor, Metal Film	392K, 1%	02-2211
R16	Resistor, Metal Film	1.21K, 1%	02-2192
R17	Resistor, Metal Film	48.7K, 1%	02-2218
R18	Resistor, Metal Film	10.0, ½W, 1%	02-2193
R19	Resistor, Metal Film	3.01K, 1%	02-2196
R20	Resistor, Metal Film	499K, 1%	02-2197
R21	Resistor, Metal Film	2.49K, 1%	02-2198
R22	Resistor, Metal Film	10.0, 1%	02-2194
R23	Resistor, Metal Film	7.50K, 1%	02-2199
R24	Resistor, Metal Film	10.0K, 1%	02-2189
R25	Resistor, Metal Film	15.0K, 1%	02-2200
R26	Resistor	10	02-2097
R27	Resistor	10	02-2097
R28	Resistor, Metal Film	10.0K, 1%	02-2189
R29	Pot, Trimmer	10K	02-2170
R30	Pot, Trimmer	100K	02-2169
R31	Pot, Trimmer	100K	02-2169
R32	Pot, Trimmer	100K	02-2169
R33	Pot, Trimmer	100K	02-2169
R34	Resistor	1K	02-2125
R35	Pot, Trimmer	10K	02-2169
R36	Resistor	10	02-2097
R37	Resistor	10	02-2097
R38	Resistor, Metal Film	340K, 1%	02-2201
R39	Pot, Trimmer	100K	02-2169
R40	Resistor, Metal Film	15.0K, 1%	02-2200
R41	Pot, Trimmer	10K	02-2170
R42	Resistor, Metal Film	15.0K, 1%	02-2200
R43	Pot, Trimmer	10K	02-2170
R44	Resistor, Metal Film	20.0K, 1%	02-2188
R45	Resistor, Metal Film	20.0K, 1%	02-2188
R46	Resistor	10	02-2097
R47	Resistor	10	02-2097
R48	Resistor	10	02-2097
R49	Resistor	10	02-2097
R50	Resistor	100K	02-2139
R51	Resistor	10K	02-2137
R52	Resistor	10K	02-2137
R53	Resistor	47K	02-2143
R54	Resistor	47K	02-2143
R55	Resistor	47K	02-2143
R56	Resistor	1M	02-2130
R57	Not Used		
R58	Resistor	100, 1W	02-2205
R59	Resistor	100, 1W	02-2205
R60	Not Used		
R61	Resistor	180K	02-2124
R62	Resistor	180K	02-2124
R63	Resistor	1K	02-2125

MAIN PCB ASSEMBLY (CONT.):

REF. DES.		DESCRIPTION		HUNTRON PART NO.
R64		Resistor	1K	02-2125
R65		Not Used		
R66		Resistor	1.6K	02-2135
R67		Resistor	3.6K	02-2202
R68		Resistor	15K	02-2151
R69		Not Used		
R70		Resistor	180K	02-2124
R71		Resistor	180K	02-2124
R72		Resistor	1K	02-2125
R73		Resistor	1K	02-2125
R74		Not Used		
R75		Resistor	1.6K	02-2135
R76		Resistor	10M, ½W	02-2102
R77		Resistor	10M, ½W	02-2102
R78		Resistor	10M, ½W	02-2102
R79		Resistor	10M, ½W	02-2102
R80		Resistor	2M	02-2129
R81		Resistor	1K	02-2125
R82		Resistor	2.2M	02-2131
R83		Resistor	2.2K	02-2079
R84		Resistor	10K	02-2137
R85		Pot, Trimmer	10K	02-2170
R86		Resistor	1.8M, ½W	02-2203
R87		Resistor	1.6M, ½W	02-2206
R88		Resistor	1.6M, ½W	02-2206
R89		Resistor	180K	02-2124
R90		Pot, Trimmer, W/ Shaft	1M	02-2207
R91		Resistor	1.6M, ½W	02-2206
R92		Resistor	1.6M, ½W	02-2206
R93		Resistor	1.8M, ½W	02-2203
R94		Pot, Trimmer, W/ Shaft	1M	02-2207
R95	(S1)	Pot, Control, W/ Switch	500K	02-2171
R96		Resistor	68K	02-2103
R97		Resistor	4.7M	02-2127
R98		Resistor	220K	02-2204
R99		Resistor	100K	02-2139
R100		Pot, Trimmer, W/ Shaft	10K	02-2208
R101		Not Used		
R102		Resistor	1.8K	02-2128
R103		Resistor	1.8K	02-2128
R104		Pot, Trimmer	10K	02-2170
R105		Resistor	33K	02-2216
R106		Resistor, Metal Film	590K, 1%	02-2154
R107		Not Used		
R108		Not Used		
R109		Not Used		
R110		Resistor	10K	02-2137
R111		Resistor	10K	02-2137
R112		Resistor	10K	02-2137
R113		Resistor	10K	02-2137
R114		Resistor	10K	02-2137

MAIN PCB ASSEMBLY (CONT.):

REF. DES.	DESCRIPTION		HUNTRON PART NO.
R115	Resistor	10K	02-2137
R116	Resistor	10K	02-2137
R117	Resistor	10K	02-2137
R118	Resistor	10K	02-2137
R119	Resistor	10K	02-2137
R120	Resistor	10K	02-2137
R121	Resistor	10K	02-2137
R122	Resistor	10K	02-2137
R123	Resistor	10K	02-2137
R124	Resistor	10K	02-2137
R125	Resistor	10K	02-2137
R126	Resistor	10K	02-2137
R127	Resistor	10K	02-2137
R128	Resistor	10K	02-2137
R129	Resistor	10K	02-2137
R130	Resistor	10K	02-2137
R131	Resistor	10K	02-2137
R132	Resistor	10K	02-2137
R133	Resistor	10K	02-2137
R134	Resistor	24K	02-2179
R135	Resistor	24K	02-2179
R136	Resistor	10K	02-2137
R137	Resistor	10K	02-2137
R138	Resistor	180	02-2101
R139	Resistor	180	02-2101
R140	Resistor	180	02-2101
R141	Resistor	180	02-2101
R142	Resistor	180	02-2101
R143	Resistor	180	02-2101
R144	Resistor	180	02-2101
R145	Resistor	180	02-2101
R146	Resistor	180	02-2101
R147	Resistor	10K	02-2137
R148	Resistor	10K	02-2137
R149	Resistor	10K	02-2137
R150	Resistor	10K	02-2137
R151	Resistor	10K	02-2137
R152	Resistor	10K	02-2137
R153	Resistor	10K	02-2137
R154	Resistor	10K	02-2137
R155	Resistor	2.2K	02-2079
R156	Resistor	180	02-2101
R157	Resistor	180	02-2101
R158	Resistor	180	02-2101
R159	Resistor	100	02-2181
R160	Resistor	100K	02-2139
R161	Resistor	10K	02-2137
S1 (R95)	Switch, DPDT, Push/Pull, W/ Pot		02-2171

MAIN PCB ASSEMBLY (CONT.):

REF. DES.		DESCRIPTION		HUNTRON PART NO.
T1		Transformer, Signal		06-6053
T2		Transformer, Power	2000	06-6031
			2000E	06-6032
			2000J	06-6033
U1		IC, Power Op-Amp	uA759	05-5019
U2		IC, Power Op-Amp	uA759	05-5019
U3		IC, Dual Op-Amp	LF353	05-5035
U4	Ⓢ	IC, Analog Multiplexer	4052B	05-5020
U5	Ⓢ	IC, Analog Multiplexer	4052B	05-5020
U6	Ⓢ	IC, Analog Multiplexer	4052B	05-5020
U7		IC, Op-Amp	LF351	05-5034
U8		IC, Quad Analog Switch	4016B	05-5029
U9		IC, Op-Amp	LF351	05-5034
U10		IC, Comparator	LM311	05-5030
U11	Ⓢ	IC, Dual Monostable	4538B (see note)	05-5028
U12	Ⓢ	IC, Dual Monostable	4538B (see note)	05-5028
U13		IC, Power Op-Amp	uA759	05-5019
U14		IC, Op-Amp	LF351	05-5034
U15		IC, Regulator +5V	7805	05-5017
U16		IC, Regulator -5V	7905	05-5037
U17		IC, Power Op-Amp	uA759	05-5019
U18	Ⓢ	IC, Quad AND	4081B	05-5038
U19	Ⓢ	IC, Quad R-S Latch	4044B	05-5022
U20	Ⓢ	IC, Dual Decoder	4555B	05-5023
U21	Ⓢ	IC, Dual J-K Flip-Flop	4027B	05-5024
U22	Ⓢ	IC, Quad NAND	4011B	05-5025
U23	Ⓢ	IC, Quad NAND	4011B	05-5025
U24	Ⓢ	IC, Quad NAND	4011B	05-5025
U25	Ⓢ	IC, Analog Switch	4016B	05-5029
U26	Ⓢ	IC, Quad NOR	4001B	05-5026
U27	Ⓢ	IC, Dual J-K Flip-Flop	4027B	05-5024
U28	Ⓢ	IC, Dual Triple AND	4073B	05-5031
U29	Ⓢ	IC, Dual Triple NOR	4025B	05-5032
U30	Ⓢ	IC, Hex Schmitt Trigger	74C14	05-5018
U31	Ⓢ	IC, Hex Inverter	4069	05-5040
U32	Ⓢ	IC, Hex Driver	4049	05-5027

NOTE: Do not replace U11 or U12 with RCA part number CD4538B. RCA parts do not work in this circuit.

OSCILLATOR PCB ASSEMBLY:

(Refer to Figure 7-3 and Figure 7-4)

REF. DES.		DESCRIPTION		HUNTRON PART NO.
A4	(S)	Oscillator PCB Assembly		07-1055
C1		Cap, Ceramic	.001µF, 50V	03-3027
C2		Cap, Ceramic	.1µF, 50V	03-3028
C3		Cap, Ceramic	.1µF, 50V	03-3028
C4		Cap, Tantalum	10µF, 25V	03-3011
C5		Cap, Tantalum	10µF, 25V	03-3011
C6		Cap, Tantalum	10µF, 25V	03-3011
C7		Cap, Ceramic	.1µF, 50V	03-3028
C8		Cap, Ceramic	.1µF, 50V	03-3028
C9		Cap, Ceramic	.1µF, 50V	03-3028
C10		Cap, Polyester	.22µF, 50V, 5%	03-3054
C11		Cap, Ceramic	.1µF, 50V	03-3028
C12		Cap, Ceramic	.1µF, 50V	03-3028
C13		Cap, Ceramic	.1µF, 50V	03-3028
C14		Cap, Polyester	.22µF, 50V, 5%	03-3054
C15		Cap, Ceramic	.1µF, 50V	03-3028
C16		Cap, Ceramic	.1µF, 50V	03-3028
C17		Cap, Ceramic	.1µF, 50V	03-3028
C18		Cap, Ceramic	.1µF, 50V	03-3028
C19		Cap, Ceramic	.1µF, 50V	03-3028
C20		Cap, Ceramic	.1µF, 50V	03-3028
C21		Cap, Tantalum	10µF, 25V	03-3011
C22		Not Used		
C23		Cap, Tantalum	10µF, 25V	03-3011
D1		Diode, Signal	1N914	04-4007
D2		Diode, Signal	1N914	04-4007
D3		Diode, Signal	1N914	04-4007
D4		Diode, Signal	1N914	04-4007
D5		Diode, Signal	1N914	04-4007
D6		Diode, Signal	1N914	04-4007
D7		Diode, Signal	1N914	04-4007
D8		Diode, Signal	1N914	04-4007
D9		Diode, Signal	1N914	04-4007
J2		Cable, Flat Flex, 8 Pin		07-7287
MP1		PCB, Oscillator		07-7713
Q1		Transistor, NPN	2N3904	05-5033
Q2		Transistor, NPN	2N3904	05-5033

OSCILLATOR PCB ASSEMBLY (CONT.):

REF. DES.		DESCRIPTION		HUNTRON PART NO.
R1		Resistor	10K	02-2137
R2		Resistor	4.7K	02-2145
R3		Resistor	47K	02-2143
R4		Resistor	100K	02-2139
R5		Resistor	10K	02-2137
R6		Resistor	1M	02-2130
R7		Resistor	100K	02-2139
R8		Resistor	1K	02-2125
R9		Resistor	75K	02-2180
R10		Resistor, Metal Film	73.2K 1%	02-2215
R11		Pot, Trimmer	20K	02-2214
R12		Resistor	10K	02-2137
R13		Resistor	1M	02-2130
R14		Resistor	2K	02-2184
R15		Pot, Trimmer	2K	02-2213
R16		Resistor	6.2K	02-2182
R17		Pot, Trimmer	10K	02-2170
R18		Resistor	1M	02-2130
R19		Resistor	10K	02-2137
R20		Resistor	1M	02-2130
R21		Resistor	360	02-2183
R22		Pot, Trimmer	500	02-2212
R23		Resistor	51	02-2175
R24		Resistor	39	02-2176
R25		Resistor	2K	02-2184
R26		Resistor	39	02-2176
R27		Resistor	470	02-2098
R28		Resistor	51	02-2175
R29		Resistor	15K	02-2151
R30		Pot, Trimmer	100K	02-2169
R31		Resistor	18K	02-2177
R32		Resistor	22K	02-2157
R33		Pot, Trimmer	10K	02-2170
R34		Resistor	1M	02-2130
R35		Resistor	4.7K	02-2145
R36		Resistor	10K	02-2137
R37		Resistor	10K	02-2137
R38		Resistor	10K	02-2137
U1		IC, Comparator	LM311	05-5030
U2	⊗	IC, Dual J-K Flip-Flop	4027B	05-5024
U3		IC, Op-Amp	LF351	05-5034
U4		IC, Oscillator	XR-2209	05-5036
U5		IC, Oscillator	XR-2209	05-5036
U6	⊗	IC, Quad Analog Switch	4016B	05-5029
U7		IC, Dual Op-Amp	LF-353	05-5035

FRONT PANEL ASSEMBLY:

REF. DES.		DESCRIPTION	HUNTRON PART NO.
A5		Front Panel Assembly	01-3112
A6		Front Panel PCB Assembly	07-1056
MP1		Front Panel, Aluminum	01-3010
MP2		Overlay, Front Panel	01-1152
MP3	(7)	Screw, 4-40, ¼"	07-7085
MP4	(7)	Washer, Lock, #4	07-7089
MP5	(2)	Banana Jack, Blue	01-1082
MP6		Banana Jack, Red	01-1030
MP7		Banana Jack, Black	01-1031
MP8		Banana Jack, Yellow	01-1032
MP9	(12)	Bezel, Switch, Ivory	07-7291
P5		Socket, 6 Pin	07-7225

NOTE: This assembly is included for reference only. Only the Front Panel Assembly (01-3112) can be ordered from the factory.

FRONT PANEL PCB ASSEMBLY:

(Refer to Figure 7-5 and Figure 7-6)

REF. DES.	DESCRIPTION		HUNTRON PART NO.
A6	Front Panel PCB Assembly		07-1056
J1	Header, Dual Row, 20 Pin		07-7285
MP1	PCB, Front Panel		07-7711
MP2	Bushing, Panel		01-1059
R1	Pot, Control	50K	02-2185
R2	Pot, Control	1M	02-2187
R3	Pot, Control	1M	02-2187
R4	Pot, Control	1K	02-2186
R5	Pot, Control	1K	02-2186
S1	Switch, Push Button, W/ LED (Yellow)		07-7290
S2	Switch, Push Button, W/ LED (Yellow)		07-7290
S3	Switch, Push Button, W/ LED (Yellow)		07-7290
S4	Switch, Push Button, W/ LED (Yellow)		07-7290
S5	Switch, Push Button, W/ LED (Green)		07-7289
S6	Switch, Push Button, W/ LED (Red)		07-7289
S7	Switch, Push Button, W/ LED (Red)		07-7288
S8	Switch, Push Button, W/ LED (Green)		07-7289
S9	Switch, Push Button, W/ LED (Green)		07-7289
S10	Switch, Push Button, W/ LED (Green)		07-7289
S11	Switch, Push Button, W/ LED (Green)		07-7289
S12	Switch, Push Button, W/ LED (Yellow)		07-7290

NOTE: This assembly is included for schematic reference only. None of these parts are replaceable at this assembly level. See Front Panel Assembly (A5).

BACK PANEL ASSEMBLY:

REF. DES.		DESCRIPTION		HUNTRON PART NO.
A7		Back Panel Assembly		01-3113
A8		Power Receptacle Assembly		07-1051
A9		Switch Assembly		07-1058
F2		Fuse, GMA	¼A, 250V	02-2178
		Fuse, GMA (Spare)	¼A, 250V	02-2178
MP1		Panel, Back		01-3011
MP2	(2)	Screw, 4-40, 3/8"		07-7086
MP3	(2)	Nut, 4-40, Hex		07-7087
MP4	(2)	Washer, Lock, #4		07-7089
MP5	(4)	Screw, 2-56, ¼"		07-7322
MP6	(4)	Nut, 2-56, Hex		07-7324
MP7	(4)	Washer, Lock, #2		07-7323
MP8		Block, Foam		01-1029

CRT ASSEMBLY:

REF. DES.	DESCRIPTION	HUNTRON PART NO.
A10	CRT Assembly	07-1059
A11	CRT Harness Assembly	07-1050
CRT1	Cathode Ray Tube	07-7059
L1	Coil, Rotation	07-7012
MP1	Shield, Tube	07-1060
MP2	Shield, Half	07-1011

SECTION 7
SCHEMATIC DIAGRAMS

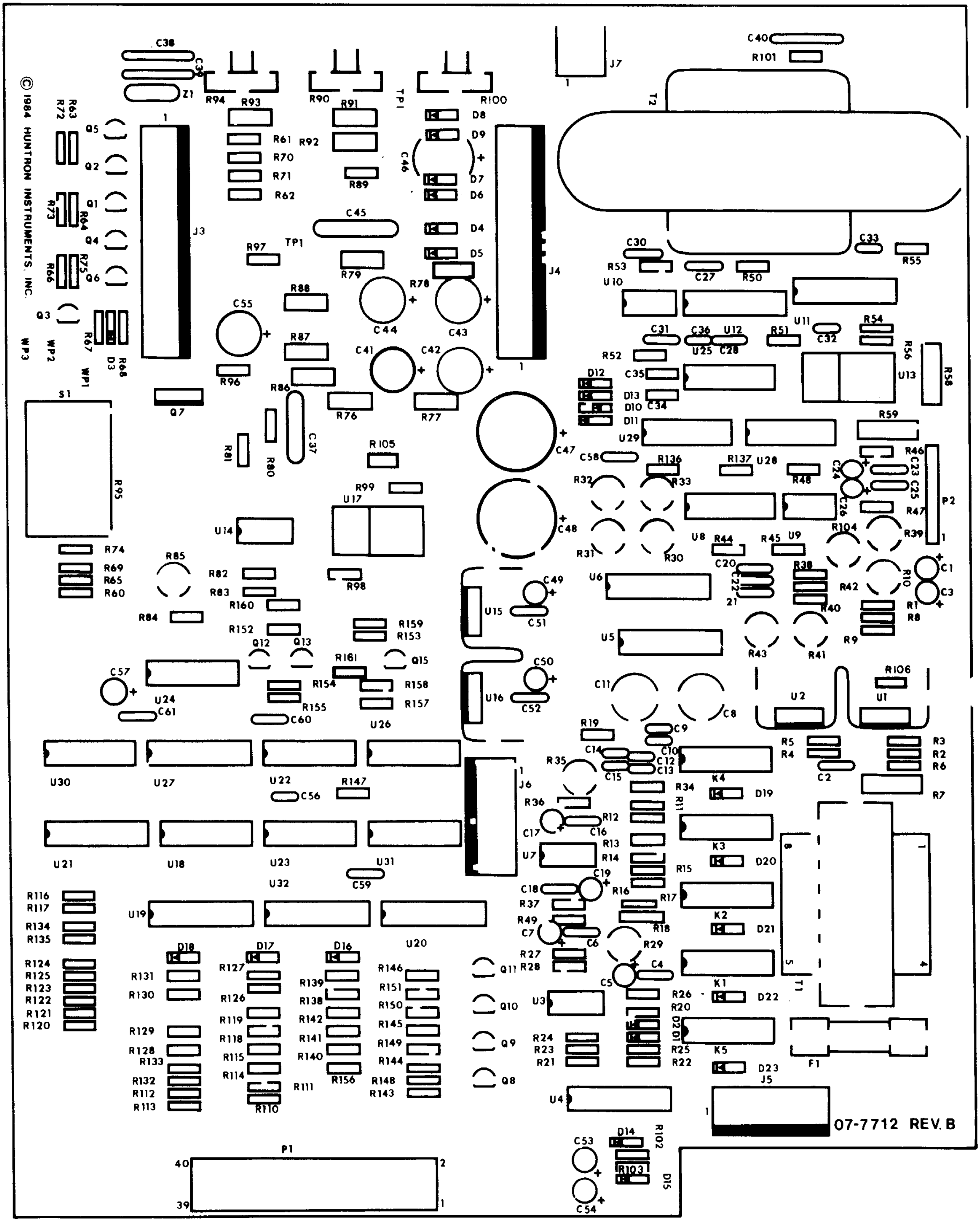


Figure 7-1. Main PCB Component Locations

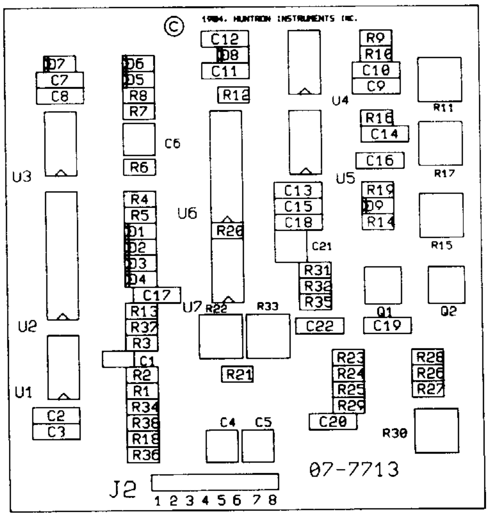
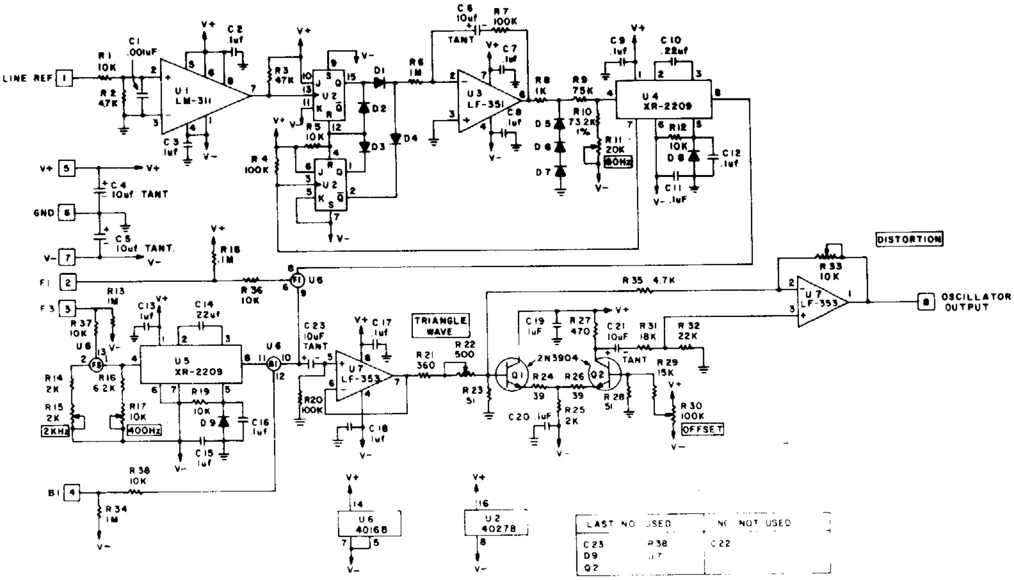


Figure 7-3. Oscillator PCB Component Locations



NOTES

1 ALL RESISTORS ARE ¼W 5% UNLESS OTHERWISE SPECIFIED

2 ALL DIODES ARE IN914

3 [ ] OSCILLATOR CONNECTOR TO MAIN PCB (J2)

Figure 7-4. Oscillator PCB Schematic

(Open for page 7-3)

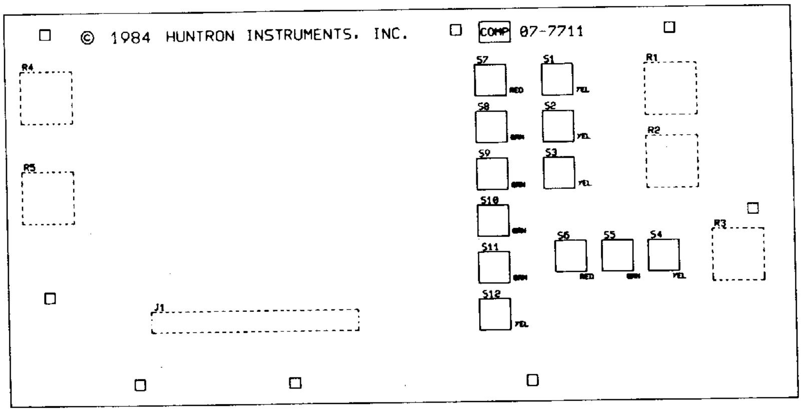


Figure 7-5. Front Panel PCB Component Locations

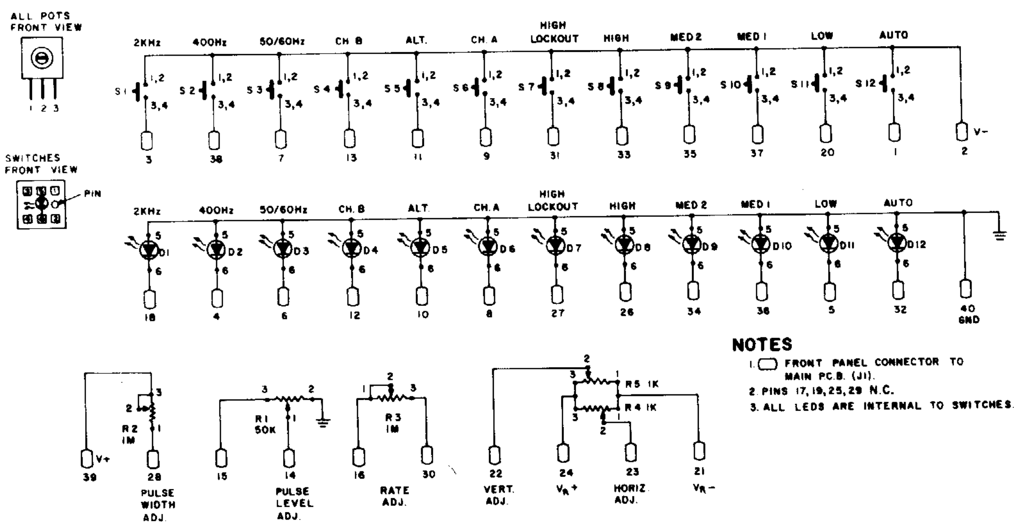
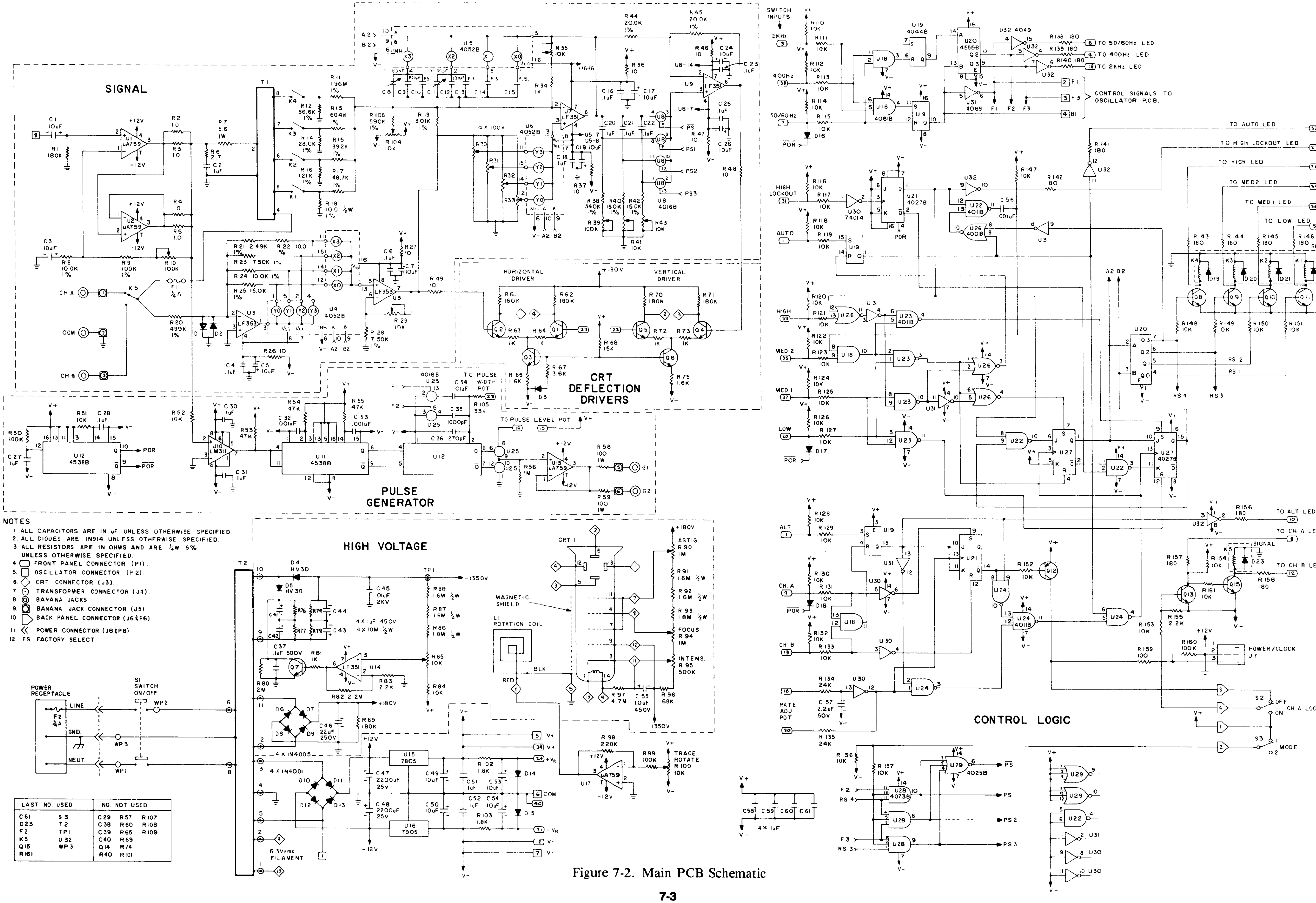


Figure 7-6. Front Panel PCB Schematic



NOTES

1. ALL CAPACITORS ARE IN uF UNLESS OTHERWISE SPECIFIED.
2. ALL DIODES ARE IN914 UNLESS OTHERWISE SPECIFIED.
3. ALL RESISTORS ARE IN OHMS AND ARE ¼W 5% UNLESS OTHERWISE SPECIFIED.
4. FRONT PANEL CONNECTOR (P1).
5. OSCILLATOR CONNECTOR (P2).
6. CRT CONNECTOR (J3).
7. TRANSFORMER CONNECTOR (J4).
8. BANANA JACKS
9. BANANA JACK CONNECTOR (J5).
10. BACK PANEL CONNECTOR (J6 & P6)
11. POWER CONNECTOR (J8 & P8)
12. FS. FACTORY SELECT

LAST NO. USED		NO. NOT USED		
C61	S3	C29	R57	R107
D23	T2	C38	R60	R108
F2	TP1	C39	R65	R109
K5	U32	C40	R69	
Q15	WP3	Q14	R74	
R161		R40	R101	

Figure 7-2. Main PCB Schematic