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Access Explore Discover

TRACKER 2700/2700S
USER'S MANUAL

21-1321
Rev. 3   11/2005

HUNTRON, INC.

TRACKER® 2700/2700S

LIMITED WARRANTY

Huntron, Inc. believes in the quality of its products. Accordingly, Huntron provides the following non-transferable warranties for the benefit of the original end-use purchaser of the Huntron® Tracker 2700 (including the Tracker 2700S) instrument.

Huntron warrants that the Huntron Tracker 2700 hardware shall be free from defects in material and workmanship for one (1) year from the date of purchase.

The above warranties are in lieu of all other warranties, express or implied, including all warranties of merchantability and/or fitness for a particular purpose. Huntron's liability under these warranties, including any damages sustained by the customer through malfunction or failure of the Huntron Tracker 2700, shall not exceed the amount of the purchase price of the Huntron Tracker 2700, regardless of the extent of any such damage, including any special, consequential, or incidental damages of any kind.

This warranty shall only apply to products in ordinary use. Huntron shall have no obligation under this warranty with respect to damage caused by accident, transportation, neglect, misuse, unauthorized alterations or repair, improper installation, or operating conditions.

Products purchased in the United States are to be returned to Huntron, Inc. at its factory, transportation prepaid. Products purchased outside the United States are to be returned to the source of purchase for warranty repair.

Written notice of, and an explanation of the circumstances of, any defect believed to be covered by this agreement shall be provided promptly to Huntron by the customer following discovery of the defect. In satisfaction of its warranty liability, Huntron agrees to take reasonable and prompt action to correct the defect, either by repair or replacement, at its option.

CONTACTING HUNTRON

To obtain information about service, accessories and other products, contact:

> Huntron, Inc.
> 15720 Main Street, Suite #100
> Mill Creek, WA 98012
> USA

In North America, call 800-426-9265 or worldwide 425-743-3171.

Huntron is also accessible by:

- ◆ FAX: 425-743-1360
- ◆ Internet E-mail: info@huntron.com
- ◆ Web site: http://www.huntron.com

ABOUT THIS MANUAL

This manual covers the general operation of the Tracker 2700 and the Tracker 2700S.

This manual also covers the subject of troubleshooting using Tracker Signature Analysis (TSA) technology at the fundamental level. More in-depth and comprehensive hands-on instruction on TSA troubleshooting is available.

Contact Huntron for more information, applications and other training available for the Tracker 2700 and other Huntron products.

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SECTION 1
INTRODUCTION AND SPECIFICATIONS

1-1.   INTRODUCTION

The Huntron Tracker 2700 and 2700S are versatile troubleshooting tools with the following features:

- Multiple test signal frequencies (20Hz, 50Hz, 60Hz, 200Hz, 2000Hz).
- Six voltage ranges (200mV, 3V, 5V, 10V, 15V,20V).
- Five resistance ranges (10Ω, 100Ω, 1kΩ, 10 kΩ, 100 kΩ).
- Automatic resistance, voltage, or frequency scanning.
- STAR (Smart Tracker Active Range). Automatic lockout of certain range combinations for limiting the maximum power output at the test terminals.
- Rate of channel alternation and range scanning is adjustable.
- DC voltage source for testing of three terminal devices.
- LED indicators for button functions.
- Dual channel capability for simple comparison testing.
- Color Liquid Crystal Display (LCD) with easy to operate controls.
- SigAssist ^{TM} for numeric value indication and range selection.
- Scan and compare up to 40 pins with the **Tracker 2700S**

Figure 1-1. Huntron Tracker 2700 (2700S shown)

1-2. SPECIFICATIONS

The specifications for the Tracker 2700/2700S are listed in Table 1-1.

Table 1-1
Tracker 2700/2700S Specifications

ELECTRICAL

Channels

Number		2 (A, B)
Common		Earth ground

Test Signal

Waveform		Sine wave
Frequency		2000Hz
		200Hz
		60Hz
		50Hz
		20Hz
Open Circuit Voltage(Peak AC)		20V
		15V

10V
5V
3V
200mV

Source Resistance   100kΩ
                                     10kΩ
                                     1kΩ
                                     100Ω
                                     10Ω

Table 1-1 (continued)
Tracker 2700/2700S Specifications

ELECTRICAL

    Access

Channel A & B	Shrouded Red Banana jacks
Common	Shrouded Black Banana jack
Ch. A and Ch. B scanning interfaces	40 pin IDC connectors (2700S only)
DC Voltage Source	Shrouded Blue Banana jack

    Display

LCD	Color 3.8in 240X320 Pixel

    DC Source

Output	Resistively coupled
Level	0 to 5VDC
Output Impedance	24Ω
Short Circuit Current	200 mA max

    Power Requirements

AC Line Voltage	115VAC/230VAC
Line Frequency	50/60 Hz
Power	40 watts Maximum
Line Protection	400mA Fuse

Table 1-1 (continued)
Tracker 2700/2700S Specifications

MECHANICAL

      Size   11.5" W x 4.5"H x 10.8" D
(29cm W x 11.4cm H x 27.4cm D)

      Weight   6 lbs. (2.72kg)

ENVIRONMENTAL

Altitude	<2000m (<6560')
Operating Temperature	0ºC to +50ºC (32ºF to 122ºF)
Storage Temperature	-10ºC to +60ºC (26ºF to +140ºF)
Relative Humidity	0 to 80% from 0ºC to +31ºC (32ºF to 88ºF) Maximum R.H. decreases linearly to 50% at 40ºC

SAFETY APPROVALS

CE approved (Tracker 2700 only)	Safety: IEC 61010-1 Emissions: EN61326 Class A, Group 1
ETL certification	UL3111-1 and CAN/CSA C22-2+ No. 1010-1-92

1-3.   SAFETY CONSIDERATIONS

Safety Terms and Symbols

**Terms in this Manual.** These terms may appear in this manual:

⚠️**WARNING**
**Warning statements identify conditions or practices that
could result in injury or loss of life.**

⚠️**CAUTION**
**Caution statements identify conditions or practices that
could result in damage to this product or other property.**

Symbols on the Instrument. These symbols may appear on the instrument:

⏚   Earth Terminal

⏚   Protective Ground
(Earth) Terminal

⚠️   CAUTION
Refer to Manual

⊟   Fuse
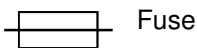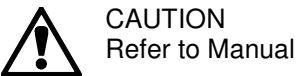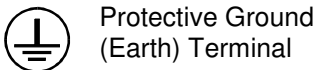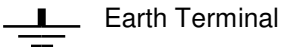
Review the following safety precautions to avoid injury and prevent damage to this instrument. The user shall be made aware that, if the instrument is used in a manner not specified by the manufacturer, the protection provided by the instrument may be impaired.

Only qualified personnel should perform service procedures.

TO AVOID FIRE OR PERSONAL INJURY

Use Proper Power Cord. Use only the power cord certified for the country of use.

⚠️**WARNING**
**The detachable power cord is the means with which to
disconnect the instrument from the mains voltage supply.
Therefore do not position the instrument and power cord so
that it is difficult to pull the power cord out of the back panel
power connector.**

Ground the Instrument. Before any other connection is made, the instrument must be connected to a protective earth conductor via the three-wire power cable. The power plug shall be inserted only into a grounded outlet. Do not defeat the protective action by using an extension cord without a grounded connector.

⚠️**WARNING**
Any interruption of the protective ground conductor inside

or outside the instrument or disconnection of the protective ground terminal is likely to make the instrument dangerous. Intentional interruption is prohibited.

Do Not Operate Without Covers. Do not operate this instrument with covers or panels removed.

Use Proper Fuse. Use only the fuse type and rating specified for this instrument. (see "Fuse Replacement" below)

Avoid Exposed Circuitry. Do not touch exposed connections and components when power is present.

Do Not Operate With Suspected Failures. If you suspect there is damage to this instrument, have it inspected by qualified service personnel.

Do Not Operate in Wet/Damp Conditions.

Do Not Operate in an Explosive Atmosphere.

Keep Product Surfaces Clean and Dry.

⚠ **Fuse Replacement:**

Line Fuse tray

The power entry module on the Tracker 2700 includes the power switch (0 = OFF, 1 = ON), power cord connector, and a removable tray which holds the line fuse.
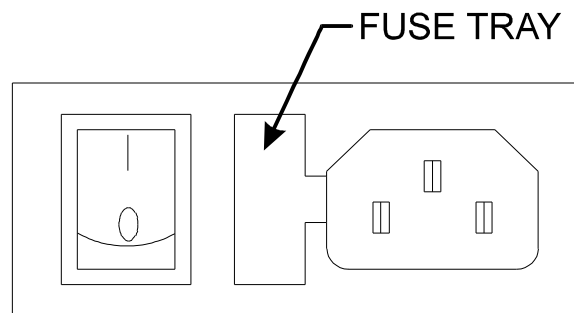

FUSE TRAY

Figure 1-1. Power Entry Module with Fuse Tray.

Make sure that replacement fuse is of the type and current rating specified. If necessary, insert the specified line fuse (T400mA according to IEC 127) into the fuse tray.

Internal Signal Fuses

The Tracker 2700 has two internal signal fuses. Make sure the Tracker 2700 is turned off and the power cord is disconnected before opening the case. The fuses are located in the back right hand corner of the Tracker 2700 as shown below.
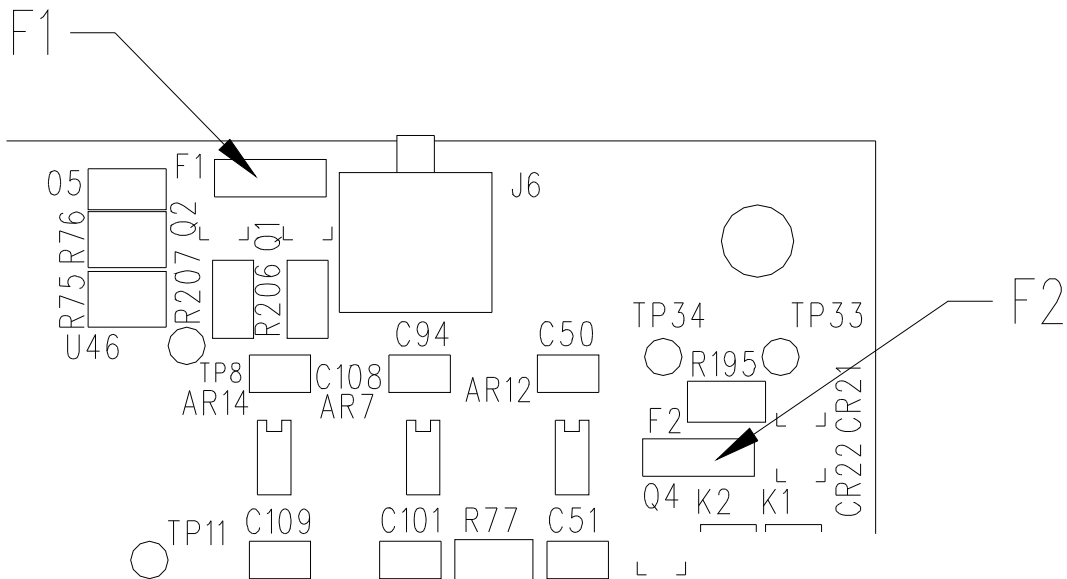

Figure 1-2. Internal Signal Fuse Locations

Note: There can be two styles of fuses used at these locations. Older units will have the fast blow Wickman style fuses (red in color that mount into sockets). Newer units will have surface mounted, self-resetting type fuses that are directly soldered onto the PCB. Self-resetting fuses don't need to be replaced. When the fault condition is removed, these fuses will reset to the normal operating condition. The resistance of these fuses increases dramatically when a fault condition occurs causing no current to flow through the probes. For example, probing charged capacitors may blow the fast blow fuses and you will see no trace on the LCD. The self-resetting fuse restricts the current flow and you will see either no signature or a vertical line moved to either side of the LCD. If you remove the probes from the charged capacitor, the open circuit horizontal trace will return after a recovery time of a few seconds. If the system does not recover, you may need to power off and wait a few seconds before powering up again.

If you have the older style Wickman fuses and wish to replace them with self-resetting fuses, there is a Fuse Replacement Kit (p/n 98-0417) available from Huntron. Please read the instruction sheet that is included in the kit.

The new self-resetting fuse at F1 is 30V, 100mA Raychem p/n MICROSMD010-2, and the fuse at F2 is a 30V 50mA Raychem p/n MICROSMD005-2. Both these fuses are included in the Fuse Replacement Kit.

1-4 WEEE and RoHS Status
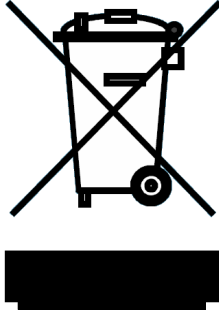
We, at Huntron are aware of the recycling needs for Waste Electronic and Electrical Equipment (WEEE) and Restriction of certain Hazardous Substances (RoHS) and are co-operating with systems established, worldwide for the collecting and recycling of our products.

Huntron has applied the Wheeled bin recycle mark (EN50419) to our products. At the present time, most European countries are not complete in their compliance with the European WEEE legislation and they do not have collective systems fully operational and registration initiated. Further recycling information will be added to our website www.huntron.com as it becomes available.

Huntron products, being electronic test equipment, are classified as monitoring and control instruments and are presently exempt from the RoHS directives. Huntron is currently using leaded solder in the construction of our products but we are working for total compliance to RoHS to be completed by July 2006.

Recycling is important to all communities, therefore we ask our customers to be responsible in recycling. Please check your local recycling laws for further information.

SECTION 2
OPERATING INSTRUCTIONS

2-1.   Introduction

This section describes the basic operation of the Tracker 2700 and 2700S.

2-2.   Unpacking Your Instrument

Your Tracker 2700 or 2700S was shipped with the following items:

QTY	DESCRIPTION	HUNTRON P/N
1	Manual (CD)	06-5217
1	Power Cord	98-0265
2	Common test leads (black)	98-0043
1	Shrouded Test Lead (blue)	98-0284
1	Huntron Probe Set (red & black)	98-0249

Additional items with Tracker 2700S

QTY	DESCRIPTION	HUNTRON P/N
2	20 pin DIP clip cable	98-0290
2	40 pin DIP clip cable	98-0026
2	20 pin DIP clip	07-1234
2	40 pin DIP clip	07-1230

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.

To order any of the above items, or for further information, please contact Huntron.

2-3.   General Operation

Components are tested by the Tracker 2700 using a two terminal system (three terminal system when the built-in DC Voltage Source is used), where two test leads are placed on the leads of the component under test. The Tracker 2700 tests components in-circuit using a test clip on a common reference point, even when there are several components in parallel.

Note: All operational descriptions in this manual relate to both the Tracker 2700 and Tracker 2700S. The Tracker 2700S contains all features of the Tracker 2700. Features that are specific to the Tracker 2700S will be noted when applicable.

CAUTION

The device to be tested must have all power turned off, and have all high voltage capacitors discharged before connecting the Tracker 2700 to the device. The maximum external fault voltage is 20VDC or 20V(peak AC).

The line fuse should only open when there is an internal failure. Therefore, the problem should always be located and corrected before replacing this fuse.

2-4.   Line Fuse

The power entry module on the Tracker 2700 includes the power switch (0=OFF, 1=ON), power cord connector, and a removable tray which holds the line fuse. Make sure that replacement fuses are of the type and current rating specified.

2-5.   Physical Features

Before you begin to use the Tracker 2700, please take a few minutes to familiarize yourself with the instrument. All of the externally accessible features are discussed in Sections 2-6, 2-7 and 2-8.

2-6.   Front Panel

The front panel of the Tracker 2700 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 2-1 and Table 2-1 for a detailed description of each item on the front panel.
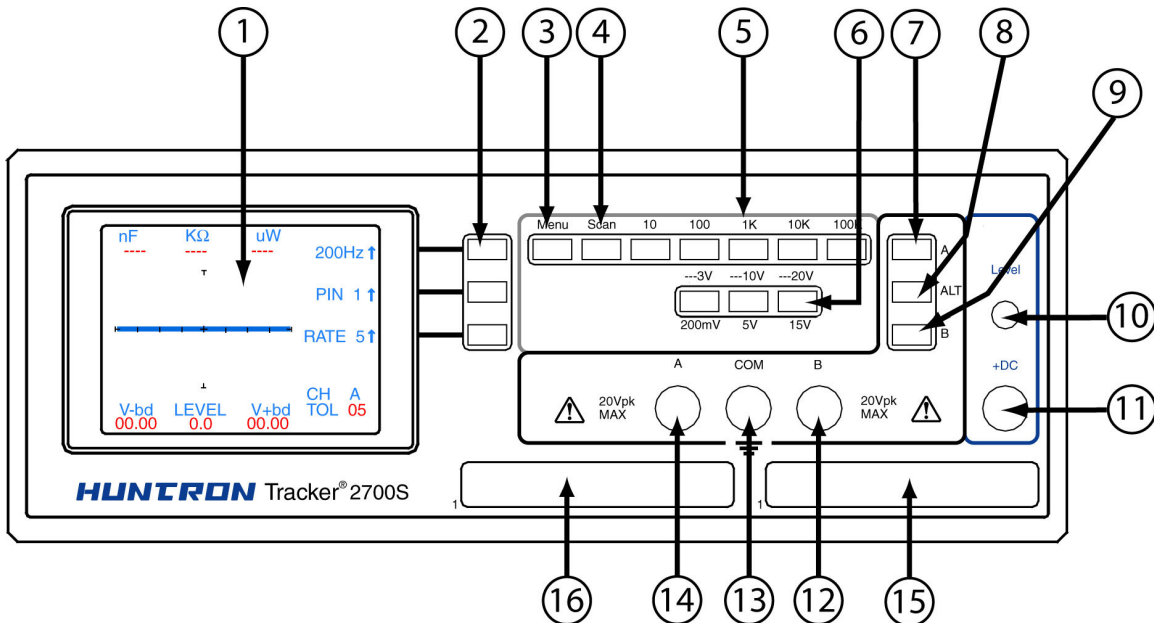

Figure 2.1 Tracker 2700 (2700S shown) Front Panel with call-outs.

Table 2-1
Front Panel Controls and Connectors

Item No.	Name	Function
1	Color LCD	Displays signatures, menu items, SigAssist^{TM} values, etc.
2	LCD Buttons	Used for selection of menu items
3	Menu Button	Displays main menu mode on LCD, stops scan function
4	Scan Button	Cycles through signatures, restarts scan
5	Resistance Selection Buttons	Selects source resistance portion of test sinewave
6	Voltage Selection Buttons	Selects source voltage portion of test sinewave
7	Channel A Button	Selects Channel A

Item No.	Name	Function
8	ALT Button	Selects alternating mode to switch between Channels
9	Channel B Button	Selects Channel B
10	DC Source level potentiometer	Adjusts level of DC Source output
11	DC Source Output Jack	Allows for banana plug connection to DC Source
12	Channel B banana Jack	Connection of Probe
13	Common banana Jack	Connection of Clip Lead/Probe
14	Channel A banana Jack	Connection of Probe
15	Ch. B 40 pin IDC connector (2700S only)	Connection of DIP Clip cable
16	Ch. A 40 pin IDC connector (2700S only)	Connection of DIP Clip cable

2-7.   Back Panel

Secondary controls and connectors are on the back panel. Refer to Figure 2-2 and Table 2-2 for a detailed description of each item on the back panel.
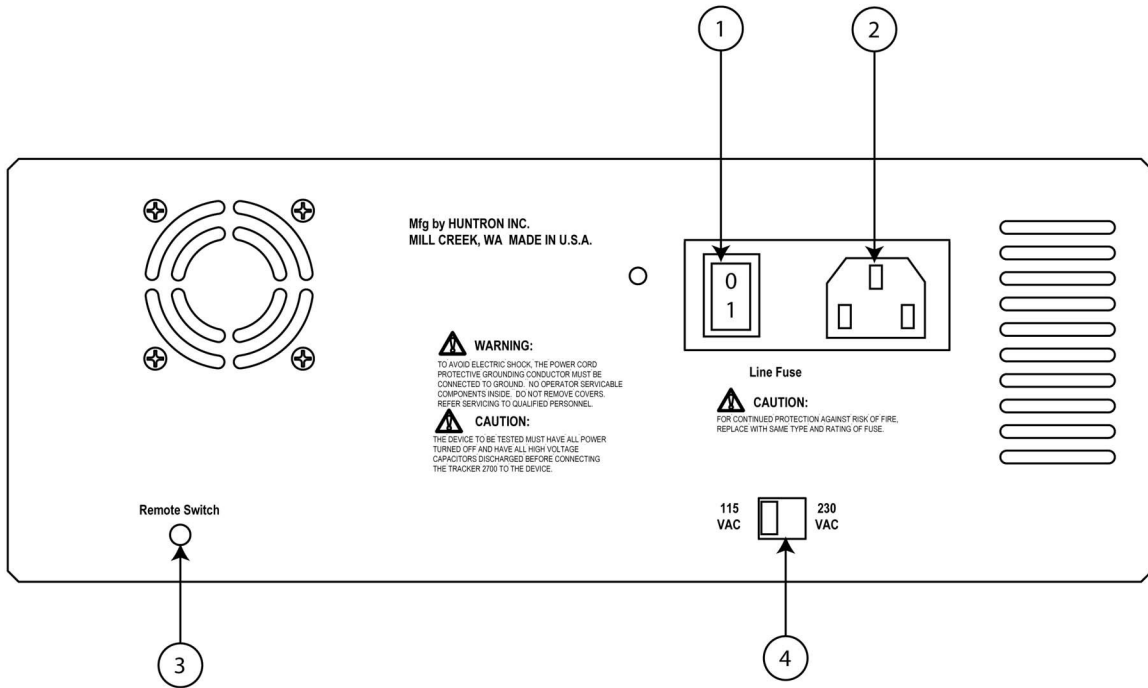
Figure 2-2. Tracker 2700 Back Panel With Call-outs.

Item No.	Name	Function
1	Power Switch	Power Off/On for Tracker 2700
2	Power Cord Connector	Power connection for any CEE-22 power cord
3	Footswitch Connector	External control switch
4	Voltage Switch	Configures Voltage Supply

Table 2-2. Tracker 2700 Back Panel Connections.

2-8.   LCD Quadrants and Axes

The LCD displays the signature of the component(s) 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 2-3.

The horizontal axis is divided in eight divisions, which allows 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.
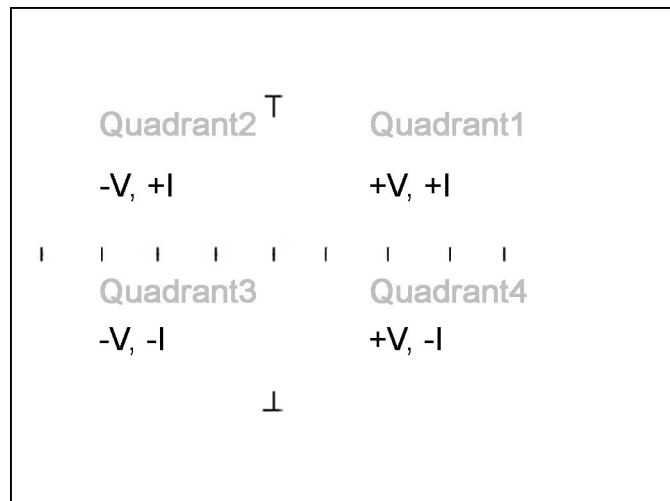
Quadrant2 ⊤   Quadrant1

-V, +I   +V, +I

Quadrant3   Quadrant4

-V, -I   +V, -I

⊥

Figure 2-3. Graticule Quadrants.

Range	Volts/Div
20V	5.00
15 V	3.75
10 V	2.50
5 V	1.25
3 V	0.75
200 mV	0.05

Table 2-3 Tracker 2700 Horizontal Sensitivities

2-9.   Power-Up

Turn the Power switch (located on the back panel) to the "ON" position. The Tracker 2700 should come on with the LEDs for channel A, 200mV, and 10Ω illuminated. The frequency parameter will automatically be set to the last selected frequency before power-down.

2-10. Channel Selection

There are two channels on the Tracker 2700 (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 or common test lead 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 or a common reference (i.e. cathode, ground). Following this procedure should assure that the signature appears in the correct quadrants of the LCD display.

2-11. Alternate Mode

The Alternate mode of the Tracker 2700 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 pressing the rate control button on the Startup screen until the desired alternation frequency is reached. The **RATE** is numbered from 1 to 9. This number indicates the number of times the signature will be updated before changing to the next channel. Figure 2-4 shows how the instrument is connected to a known good board and a board under test. This test mode uses the supplied common test leads to connect two equivalent points on the boards to the common test terminal. Note that the black probe is
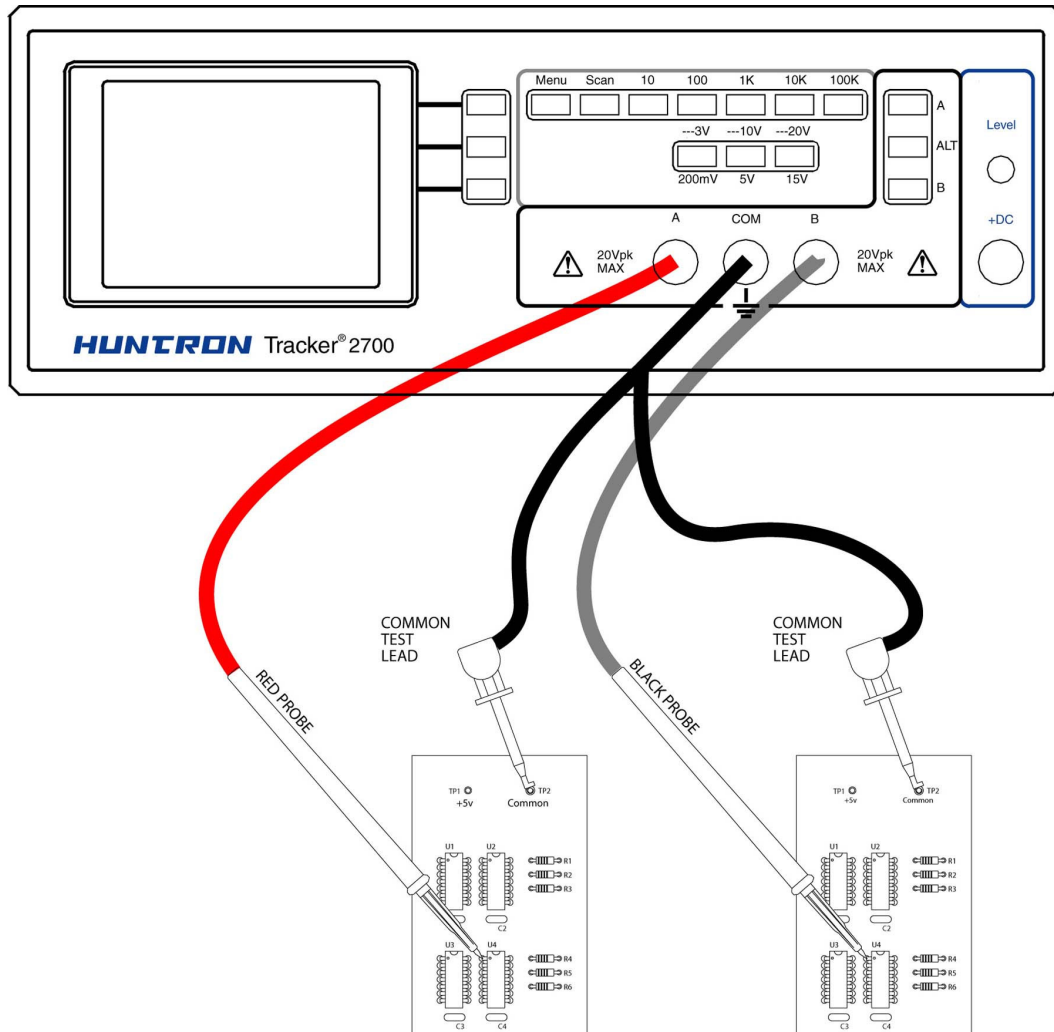
plugged into the channel B test terminal.

Figure 2-4. Alternate Mode connection.

2-11. Resistance Selection

The Tracker 2700 is designed with five resistance ranges **(10Ω, 100Ω, 1kΩ, 10kΩ, and 100kΩ).** A resistance range is selected by pressing the appropriate button on the front panel. It is best to start with one of the middle resistance values **(i.e. 100Ω or 1kΩ).** If the signature on the LCD display is close to an open (horizontal trace), go to the next higher resistance for a more descriptive signature. If the signature is close to a short (vertical trace), go the next lower resistance. An optimum resistive signature is approximately at a 45° angle to the horizontal and vertical lines of the graticule.
See SigAssist ^{TM} section (4-5) for help on selecting appropriate resistive parameter.

The **SCAN** feature will allow for sequencing through the resistance ranges at a speed set by the **RATE** selected. This feature allows the user to see the signature of a component in different resistance ranges while keeping their hands free to hold the test leads.

2-13. Frequency Selection

Five test signal frequencies can be selected by pressing the appropriate button on the front panel. The upper button just right of the LCD is used to set the test signal frequency.

Press this button until the desired test frequency is displayed on the LCD.
See SigAssist ^{TM} section (4-5) for help on selecting appropriate frequency parameter.

2-14. Voltage Selection.

The voltage selector buttons **(3V/200mV,10V/5V, 20V/15V)** allows the user to select the peak applied sine-wave voltage. Each button has a dual function. For example, pressing the **5V** button **(steady LED indication)** selects **5 Volts** as the test signal's peak value. Pressing it again **(blinking LED indication)** selects **10 Volts** as the test signal peak value. See SigAssist ^{TM} section (4-5) for help on selecting appropriate voltage parameter.

2-15. DC Voltage Source

The built-in DC voltage source of the Tracker 2700 allows in-circuit testing of certain devices in their active mode. In addition to using the red and black probes, the output of the DC voltage source is connected to the control input of the device to be tested with the blue clip lead provided. The DC voltage source has one positive DC output. Figure 2-5 shows how to connect the Tracker 2700 to the device under test, using the DC voltage source.
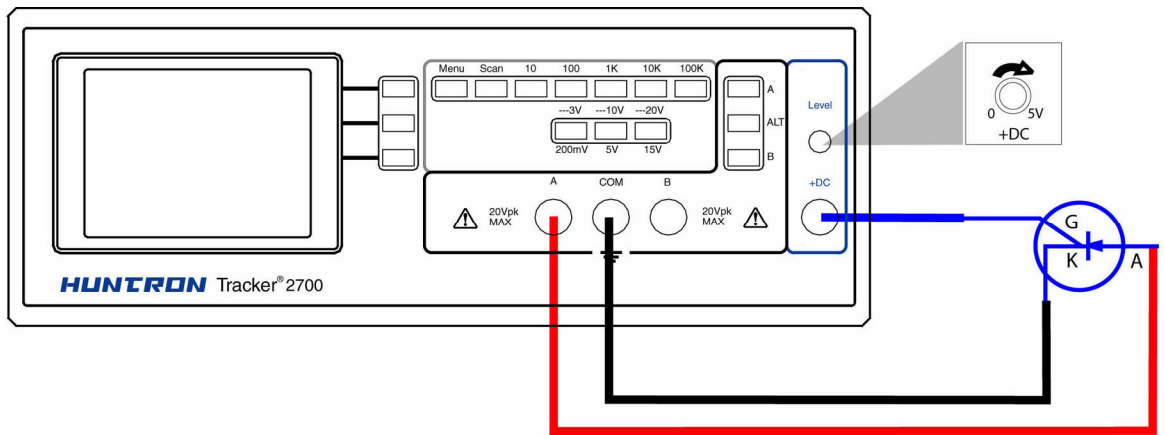
Figure 2-5. Tracker 2700 DC Source Typical Setup.

The DC Voltage Source output is set using the DC Level control. The level control varies the magnitude of output amplitude from zero to + 5 volts. The corresponding DC level will be displayed on the LCD.

2-16. Scanning with a Tracker 2700S

The Tracker 2700S is a scanning version of the Tracker 2700. It can automatically scan and compare up to 40 pins using standard IDC connections on the front panel. Figure 2-6 shows a typical Tracker 2700S configuration using standard DIP clips.
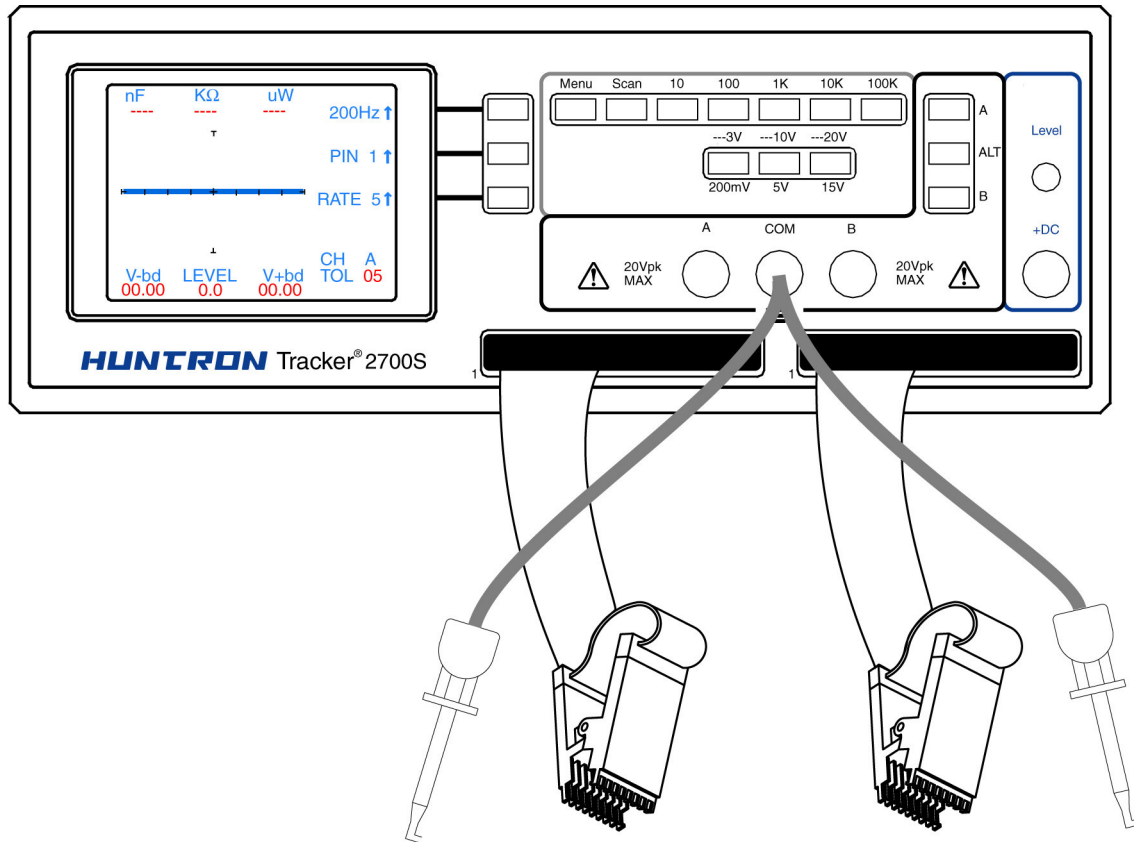
Figure 2-6. Typical 2700S setup with DIP clips

Using the scanning capabilities of the Tracker 2700S is very easy. It is possible to scan using one channel or both and also make signature comparisons between channel A and channel B.

To scan a component using the front panel cable interface, the package type and number of pins must first be configured. For more information on the Tracker 2700 menu structure, see section 4 of this manual. Connect an IC cable and clip from each Tracker channel to ICs on side-by side boards. Connect a Common lead to a common connection such as ground on each board.

Press the **Menu** button to display the Main menu (first image in figure 2-7). Select **SCAN** from the Main menu to display the SCAN menu (second image in figure 2-7). Select **PACKAGE** from the Scan menu to display the Package menu (third image in figure 2-7). Use the corresponding LCD buttons to configure the number of pins, package type (DIP, SIP, BOTH or FRONT) and the scan mode (SINGLE or LOOP).
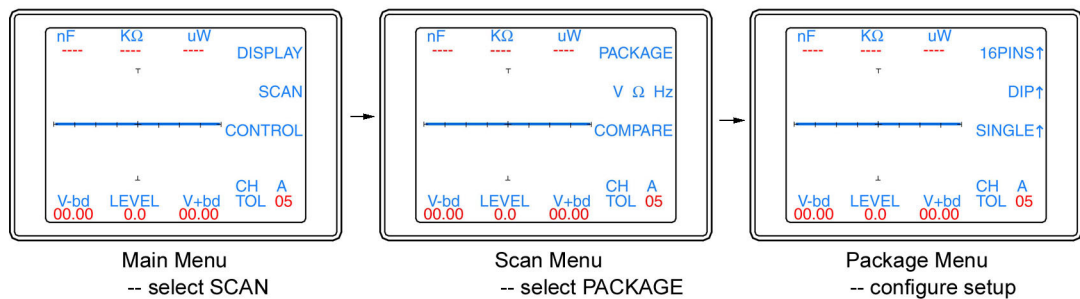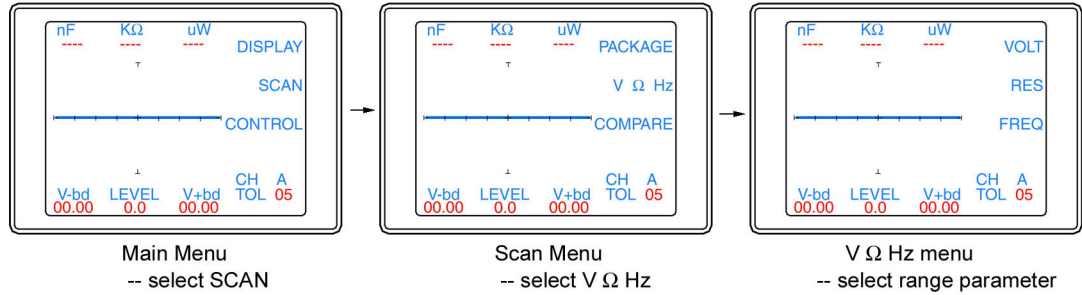

Figure 2-7. Scan component configuration

Press the menu button until the power-up menu is reached (the signature will become live at this point). The pins can be manually scanned by pressing the LCD button corresponding with PIN 00↑. The signature for each pin will be displayed on the LCD. Press **A** to view only channel A, **B** to view only channel B or press the **ALT** button to view signatures on channel A and channel B.

To scan without having to increment the PIN button on the power-up menu, press the **Scan** button and the 2700S will step through the pins automatically. Press the **Scan** button again to stop the scanning. By default, selecting the **Scan** button will test each pin in each 2700 resistance range before stepping to the next pin. To change which range parameter (voltage, resistance or

| Main Menu | Scan Menu | V Ω Hz menu |
| -- select SCAN | -- select V Ω Hz | -- select range parameter |

frequency) is incremented during scanning refer to figure 2-8.

Figure 2-8. Selecting range parameter used while scanning

From the V Ω Hz menu, select **VOLT** for the 2700 voltage to be incremented while scanning, select **RES** for the 2700 resistance to be incremented while scanning or select **FREQ** for the 2700 frequency to be incremented while scanning. Deselect all of the buttons and the 2700S will scan only in the currently selected range. Press the **Menu** button until the power-up menu is reach (the signature will become live at this point). Pressing the **Scan** button will now scan through the component pins using the range parameter selected in the Scan / V Ω Hz menu.

The Tracker 2700 can also make signature comparisons and indicate the comparison results on the LCD as PASSED or FAILED. To set the 2700 to Compare mode, refer to figure 2-9.
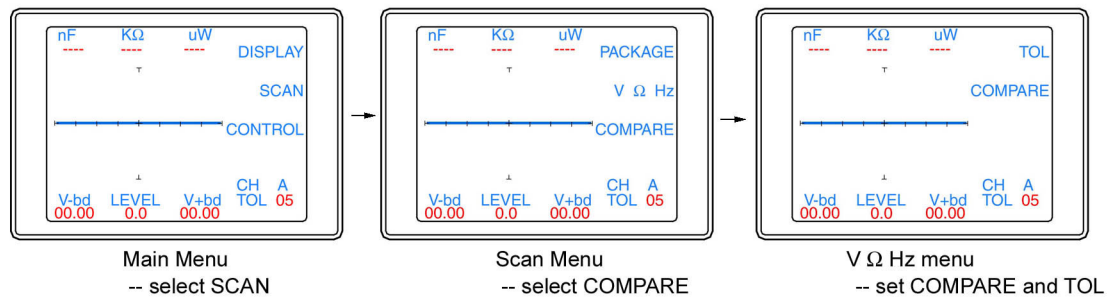
Figure 2-9. Selecting Compare mode and setting Tolerance

The Tracker 2700 can be set to compare mode by pressing the **COMPARE** button so the LED is lit. The tolerance allowed during comparison is also set in the menu. Press the **TOL** while noting the TOL value on the LCD. The Tolerance value will step 0-5 by 1, 5-20 by 5 and 20-90 by 10. Press the **Menu** until the power-up menu is reached (the signature will become live). Press the **ALT** and **Scan** buttons and the 2700 will make signature comparisons between the A and B channels. If a 2700S is being used, scanning will continue stepping through all of the configured pins. The comparison result will be displayed on the LCD as either PASSED or FAILED as shown
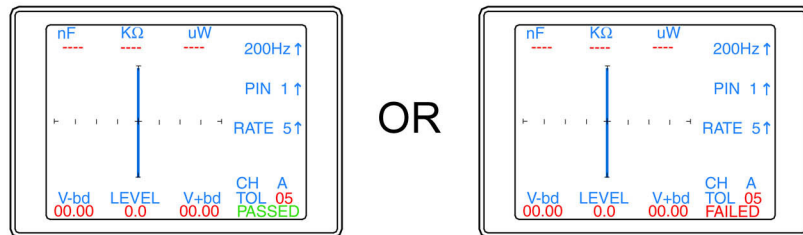
in figure 2-10.

Figure 2-10. Scan results displayed on 2700 LCD

Press the Scan button to stop the scan. The Tracker 2700S can be set to single test or loop test by setting the scan mode in the Package menu (refer to figure 2-7).

SECTION 3
USING YOUR TRACKER 2700

3-1.   Introduction

Electronic troubleshooting is a skilled art, based largely on logical deduction, experience, and intuition. The Huntron Tracker 2700 uses Tracker Signature Analysis or TSA to take full advantage of a technician's skills. TSA is the examination of the current verses voltage characteristic of a component under power-off conditions for the purpose of troubleshooting. The component's Tracker signature is displayed for visual analysis and indicates its relative health and condition. For solid state components, TSA enables you to visualize component leakage and substrate damage that is difficult to find with conventional test methods.
With TSA, you can troubleshoot components without applying power, saving circuits from possible further damage. By comparing the signatures of a questionable component with those of a known-good component, you can quickly locate failed and marginal components. The Tracker 2700 also makes troubleshooting without schematic diagrams a reality.
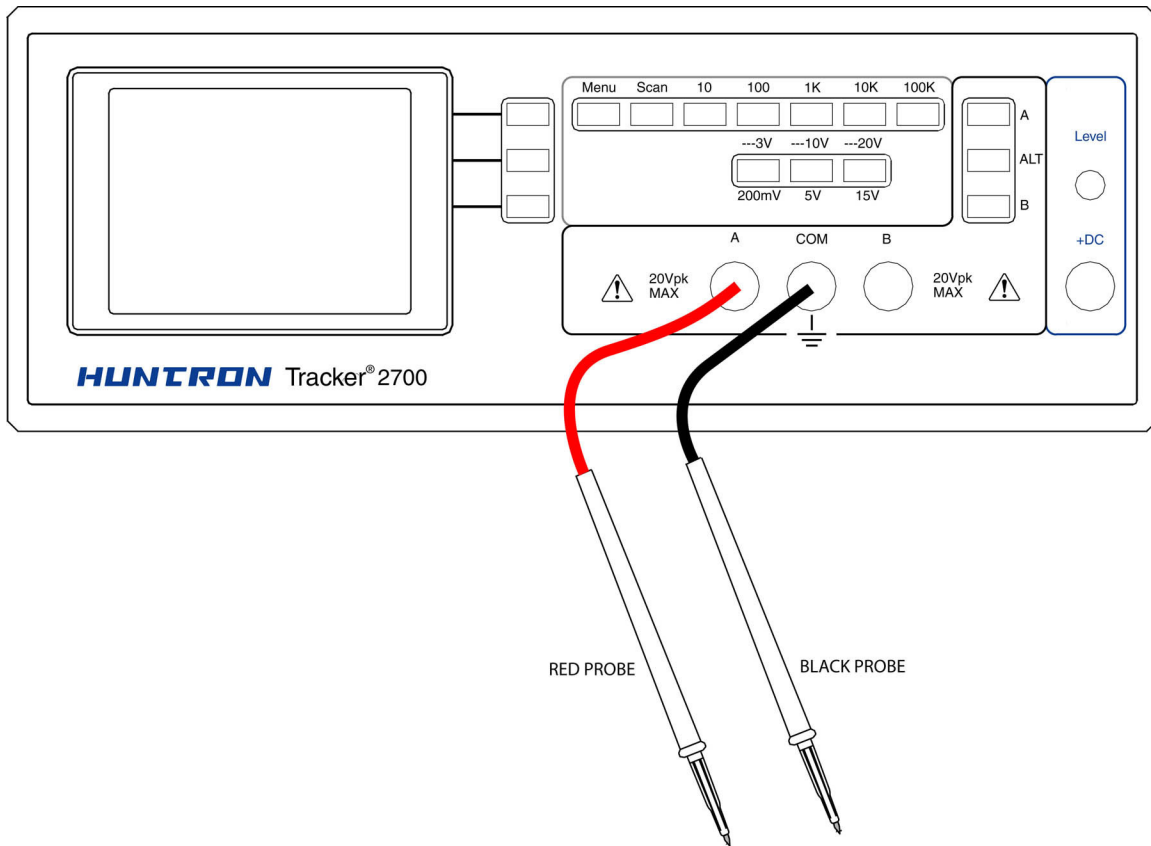

Figure 3-1. Tracker 2700 with Test Probes.

3-2. Basics Of TSA - How It Works

Here's how TSA and power-off testing works:

The Tracker 2700 outputs a precision current-limited AC sine wave signal to a component and displays the resulting current flow, voltage drop and any phase shift on the internal LCD's display. The current flow causes a vertical trace deflection on the display, while the voltage across the component causes a horizontal trace deflection. This resultant trace on the display is called a Tracker signature.

Understanding the Tracker 2700's basic core circuit is the key to understanding how Tracker signatures respond to different types of components. Since the induced current is a function of the impedance of the circuit, the Tracker signature displayed can be thought of as a visual representation of Ohm's Law,

$$V = IR \text{ where } V = \text{voltage}, I = \text{current and } R = \text{resistance}$$

The next figure shows a simplified diagram of the Tracker's core circuit. The sine wave generator is the test signal source and is connected to a resistor voltage divider made up of R_s and R_L. The load impedance, R_L, is the impedance of the component under test. R_L is in series with the Tracker 2700's internal or source impedance R_s. Because R_s is constant, both the voltage across the component under test and the current through it is a sole function of R_L.
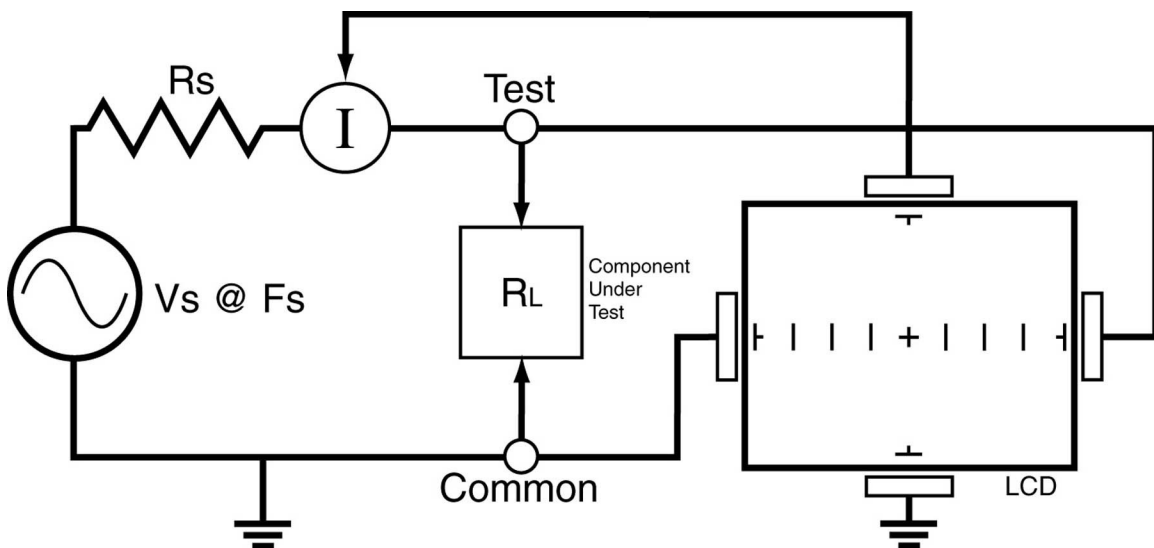

Figure 3-2. Tracker 2700 Core Circuit Block Diagram
R_s= Source Resistance, V_s= Source Voltage, R_L= Load Resistance, F_s= Source Frequency

Each test signal or range has three parameters: source voltage V_s, resistance R_s and source frequency F_s. When using TSA for troubleshooting, the objective is to select the range that will display the most descriptive Tracker signature information. The Tracker 2700 can readily accomplish this by changing the proper range parameter. The source voltage V_s of the test signal can be used to enhance or disregard semiconductor switching and avalanche characteristics. The F_s or frequency of the test signal source can be used to enhance or disregard the reactive factor (capacitance or inductance) of a component or circuit node.

3-3. Horizontal Axis

The voltage across the component under test controls the amount of horizontal trace deflection on the LCD display. When the component under test is removed, creating an open circuit (e.g., $R_L = \infty$), the voltage at the output terminals is at its maximum and thus the trace on the display is a straight horizontal line with its maximum width.

The horizontal axis is divided up by small graticule lines similar to those on a conventional oscilloscope CRT. Each mark is approximately 1/4 of the peak range voltage. For example, in the 10 V range, each division is approximately 2.5 V. You can use these graticule marks to get a rough estimate of the voltage drop across the component under test. Changing the V_s of the test range effectively acts the same as changing the Volts-per-division on an oscilloscope.

The Signature viewing area of the LCD screen can also be set up in quadrants to show positive and negative current and voltage characteristics. Refer to figure 3.3.
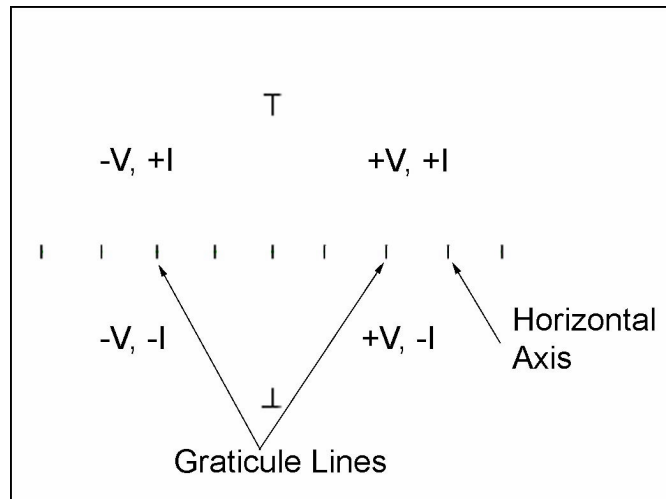
Figure 3-3. LCD Display Horizontal Axis And Graticule Lines.

When the test signal is positive, this means that the voltage and current are positive so the signature's trace is on the right hand side of the LCD display. When the test signal is negative, the voltage and current are negative so the trace is in the left hand side of the display.

Turn on the Tracker 2700 and observe the LCD display. With nothing connected to its test terminals, the display trace is a horizontal line (that is, $R_L = \infty$).
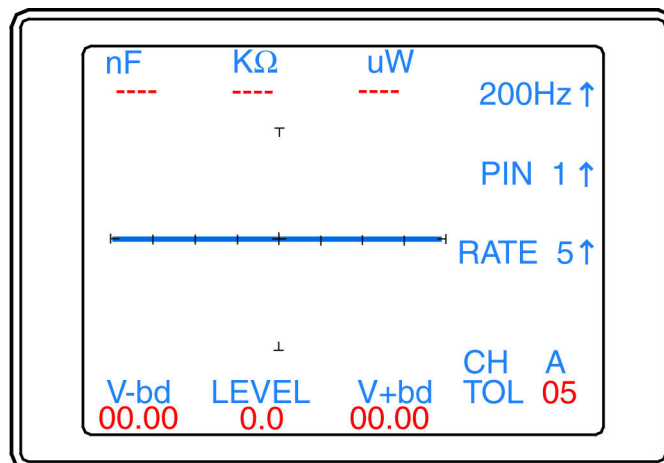
3-4.   Vertical Axis

The amount of vertical trace deflection on the LCD display is controlled by the voltage dropped across the internal impedance R_s of the Tracker 2700. Because R_s is in series with the load R_L, this voltage will be proportional to the current flowing through R_L. This current that flows through the component under test is the vertical part of the Tracker signature.

When the R_L is zero ohms (0 Ω) as when you short an output terminal to the common terminal, there is no voltage dropped across R_L, so there is no horizontal component in the Tracker signature. This short circuit signature is a vertical line trace on the LCD display.

Connect the red microprobe to the output channel A jack on the Tracker 2700 and the black microprobe to the Common jack.
1.   Touch and hold the probes together and observe the Tracker signature on the LCD display.
2.   You will see a vertical line trace in the middle of the LCD display.
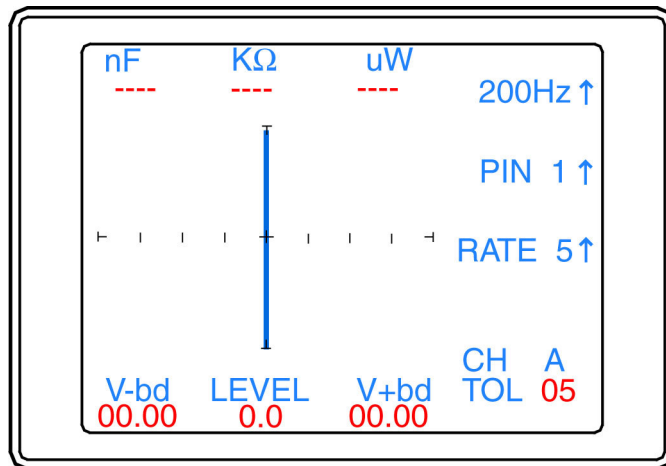
Figure 3-5.   LCD Display With Vertical Axis, Graticule Lines displaying a short circuit.

3-5.   Basic Tracker Signatures - Open and Short

In TSA, the two most basic Tracker signatures are the open and the short. The open signature occurs when an output terminal is not connected to anything. The short signature occurs when an output terminal is directly connected to the common terminal. In the following figures, the upper screen represents the Tracker 2700's LCD X-Y display and the lower screen is a graphical plot of the sine wave test signal at the output terminal showing its current and voltage relationship. The current and voltage graphical plots shown in Figs. 3-8 and 3-10 are for illustration purposes only and cannot be displayed on the LCD.
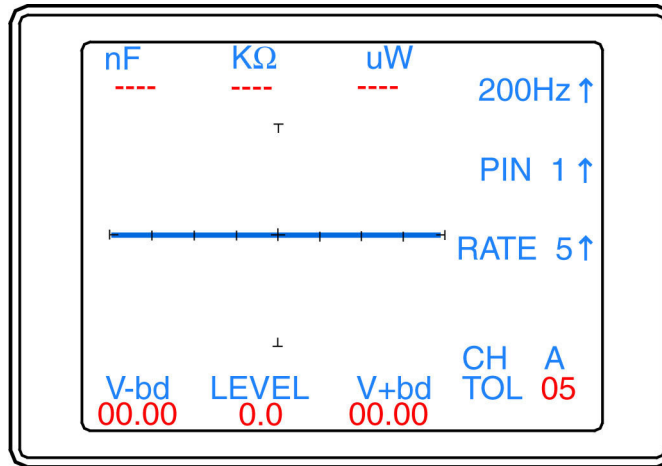
Figure 3-6. "OPEN" Tracker Signature On LCD Display (Horizontal Line)
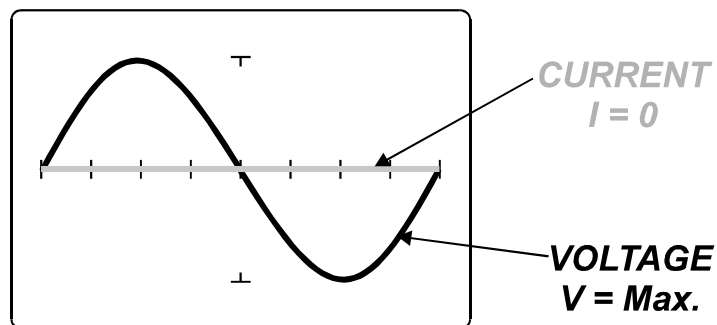
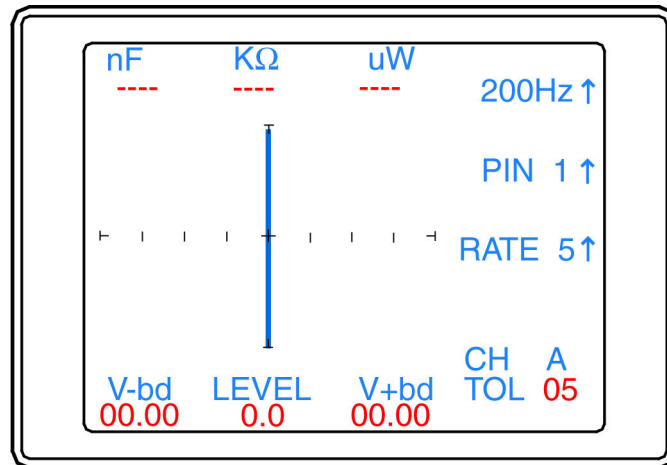Figure 3-7. Test Signal (Open Circuit) With Current And Voltage Waveforms.

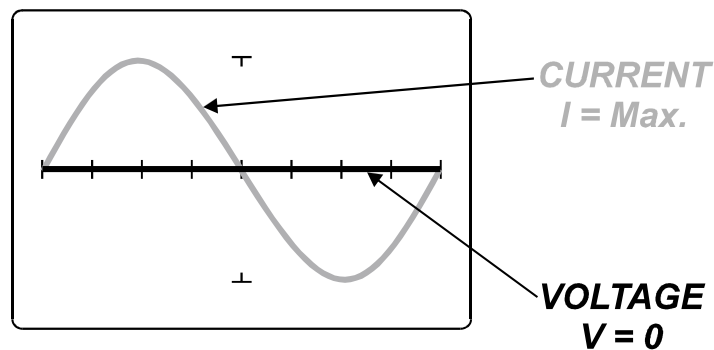Figure 3-8. "SHORT" Tracker Signature On LCD Display (Vertical Line).

Figure 3-9. Test Signal (Short Circuit) With Current And Voltage Waveforms.

3-6.   Four Basic Component Tracker Signatures

All Tracker signatures are a composite of one or more of the four basic component signatures which are: resistance, capacitance, inductance and semi-conductance. Refer to Fig 3-11. Each one of these basic components responds differently to the Tracker 2700's test signal. Recognizing these four basic unique signatures on the LCD display is one of the keys to successful TSA troubleshooting. When components are connected together to form a circuit, the signature at each circuit node is a composite of the basic component signatures in that circuit. For example, a circuit with both resistance and capacitance will have a signature that combines the Tracker signatures of a resistor and capacitor. The signature of a resistor is always indicated by a straight line at an angle from 0 to 90 degrees. The signature of a capacitor is always in the form of a circle or ellipse shape. The signature of an inductor is also a circle or ellipsoid shape, that may also have internal resistance. Finally, the semiconductor diode signature is always made up of two or more linear line segments that most of the time form an approximate right angle. Semi-

conductance signatures can show conduction in both forward and reverse-bias. This will form a zener semiconductor pattern which will show both junctions.
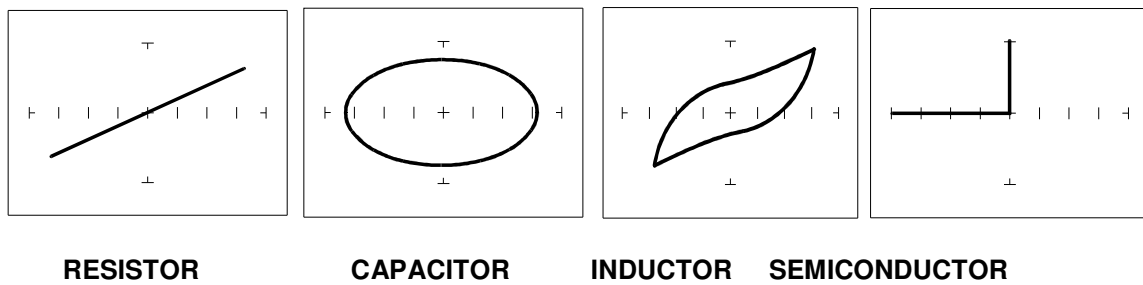

RESISTOR   **CAPACITOR**   **INDUCTOR**   **SEMICONDUCTOR**

Figure 3-10. Tracker Signatures of 4 Basic Components.

3-7.   Smart Tracker Active Range (STAR) feature.

The Tracker 2700 has a built-in operating feature called STAR (**S**mart **T**racker **A**ctive **R**ange). This important feature protects sensitive components from possible exposure to excessive power (for example, 15V and 10Ω).

The table below specifies the active and disabled voltage & resistance test range combinations.

	10Ω	**100Ω**	**1kΩ**	**10kΩ**	**100kΩ**
200mV	Enabled	Enabled	Enabled	Enabled	Enabled
3 V	**Disabled**	Enabled	Enabled	Enabled	Enabled
5 V	**Disabled**	Enabled	Enabled	Enabled	Enabled
10 V	**Disabled**	Enabled	Enabled	Enabled	Enabled
15 V	**Disabled**	**Disabled**	Enabled	Enabled	Enabled
20 V	**Disabled**	**Disabled**	**Disabled**	**Disabled**	Enabled

Table 3-1. Valid Tracker 2700 Ranges (STAR)

To illustrate the STAR feature, do the following:

1.   Select the **200mV, 10Ω** range. This is a valid range shown by the LEDs being illuminated on the **200mV** and **10Ω** buttons.

2.   Press the **5V** button. Notice that the **5V** LED is on and the resistance range changes to **100Ω** automatically. The **5V, 10Ω** range is disabled.

3.   Now press the **15V** button. Notice that the **1kΩ** resistance is automatically selected. The **15V, 100Ω** range is disabled and the next valid resistance range was activated at the selected voltage.

4.   **20V** only allows 100**kΩ** to be used.

SECTION 4
MENUS AND SETTINGS

4-1. Menu Structure

The Tracker 2700 has several different menus to allow for the selection of range parameters, display parameters, compare tolerances, scan parameters, DC source function and footswitch (optional accessory) selection parameters. This section will discuss the menu structure and LCD Button functions. Figure 4.1 shows the LCD Buttons that will be used to navigate through those menus. Buttons are labeled with the adjacent text on the LCD.
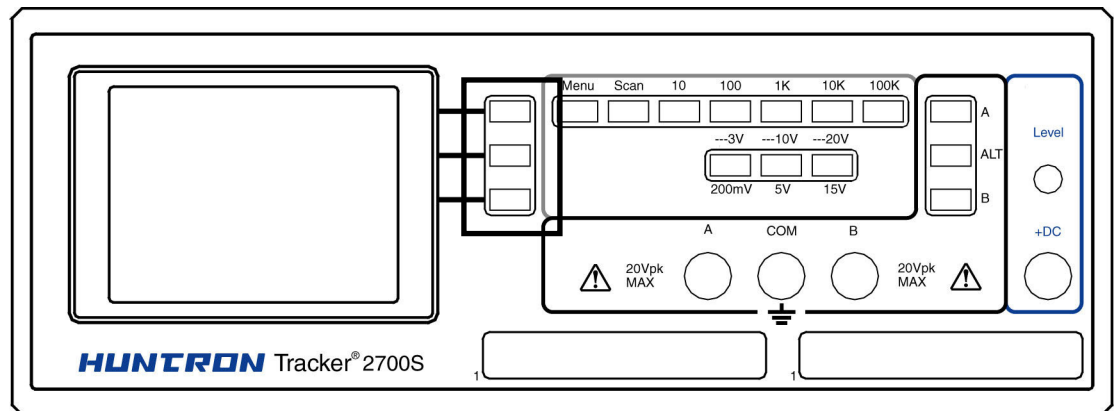

Figure 4-1. Front Panel (Tracker 2700S shown) with LCD Buttons Highlighted (in black)

4.2   Menu Navigation

The following paragraphs explain the navigation of the various menus contained in the firmware of the Tracker 2700 and 2700S.

For a single-page menu breakdown chart, please refer to the Quick Reference sheet supplied on your Tracker 2700 CD.

4.3   Power-Up Menu

This menu contains the range frequency (top LCD button) selection, the pin number selection (Tracker 2700S) and the alt/scan rate adjustment (bottom LCD button).   Figure 4.2 shows the main menu.
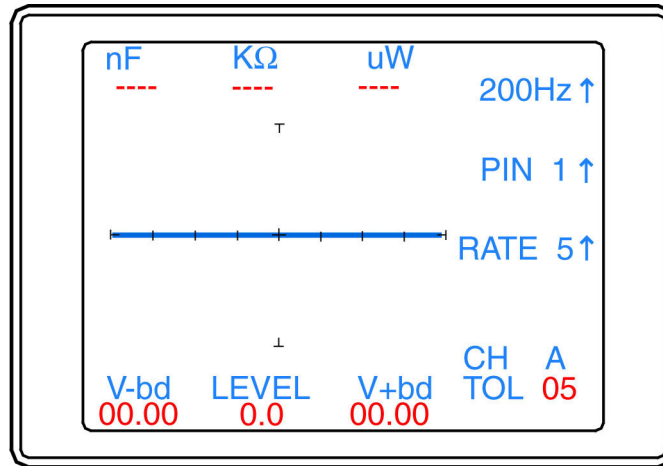

Figure 4-2. Power-up Menu.

Five frequencies can be selected by pressing the top LCD Button. 20Hz, 50Hz, 60Hz, 200Hz, and 2000Hz. Continue to press this button until the desired frequency setting is displayed on the LCD. The value is stored in memory until changed.

The middle LCD button is used to increment the scanner pin number for Tracker 2700S. The pin number will increment one pin position each time the middle button is pressed until the maximum number of pins is reached (set in the Scan Package menu; see section 4.4) and then return to pin 00. Pressing the PIN button will also stop the Scan function on the Tracker 2700S.

The bottom LCD button in this menu (labeled Rate) is used to adjust the switching frequency of the alternation and scan modes. The rate values are numbered from 1 to 9. This number indicates the number of times the signature will be updated before the setting switches. Continue to press this button until the desired switching rate is reached. **Scan** and/or **Alt** button must be pressed to see results of this change. The value is stored in memory until changed.

The other items you will see on the main menu screen are the channel (CH A or B), the compare tolerance (TOL 05), and the DC Voltage Source level (LEVEL 0.0) and the numeric SigAssist™ values (see section 4.5).

4.4   Tracker 2700 Sub-menus

Main menu

The Main menu (figure 4-3) can be accessed by pressing the **Menu** button (yellow LED) on the front panel.
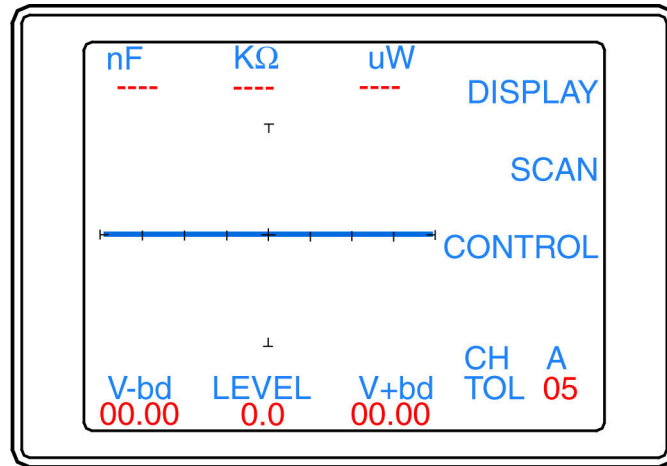

Figure 4-3. Main Menu.

The Main Menu functions are as follows:
- Display: Presents the Display menu for configuring LCD brightness, colors and values display.
- Scan: Presents the Scan menu for configuring component package (2700S only), range parameters and comparison.
- Control: Presents the Control menu for selection of Foot Switch mode, Pulse Generator and Diagnostic function.

The Display Menu

The Display menu is displayed when the Display button (figure 4-4) is selected from the main menu.
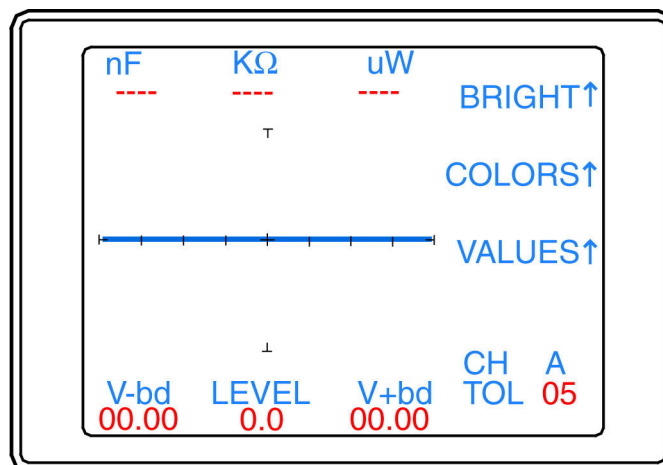
Figure 4-4. Display Submenu.

The Display menu functions are as follows:
- Bright: Scrolls through the contrast settings. The setting will wrap-around if the button pushed continually. The Brightness value will be store in memory until changed.
- Colors: Scrolls through the Tracker 2700 color schemes. Settings are stored in memory until changed.
    Color Schemes:
    1. Menu = magenta; Sig A/Passed = green; Sig B/Failed = red; Readings = blue
    2. Menu = green; Sig A/Passed = blue; Sig B/Failed = red; Readings = cyan
    3. Menu = blue; Sig A/Passed = black; Sig B/Failed = magenta; Readings = red
    4. Menu = black; Sig A/Passed = blue; Sig B/Failed = magenta; Readings = cyan
    Background = always white
    Graticule = always black

- Values: Toggles the display of measurements on or off. The options are None, Level, or SigAssist™ and Level. The settings are stored in memory until changed.
- Menu button: Press the Menu button to return to the Main menu.

The Scan Menu

The Scan menu (figure 4-5) is displayed by selecting Scan from the Main menu.
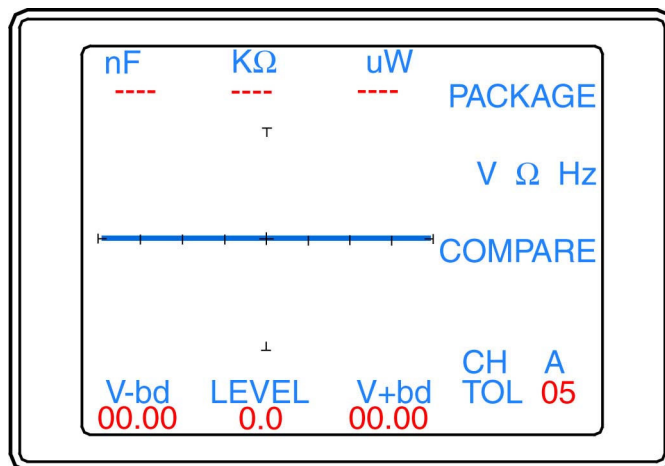
Figure 4-5. Scan menu

The Scan menu functions are as follows:
- Package: Displays the Package menu for configuring the scanning of component pins (2700S only).
- V Ω Hz: Displays the V Ω Hz menu for configuring scanning parameters
- Compare: Displays the Compare menu for configuring comparison settings.
- Menu button: Press the Menu button to return to the Main menu.

The Scan/Package menu

The Tracker 2700S Scan/Package menu (figure 4-6) is displayed by pressing the Package button while in the Scan menu.
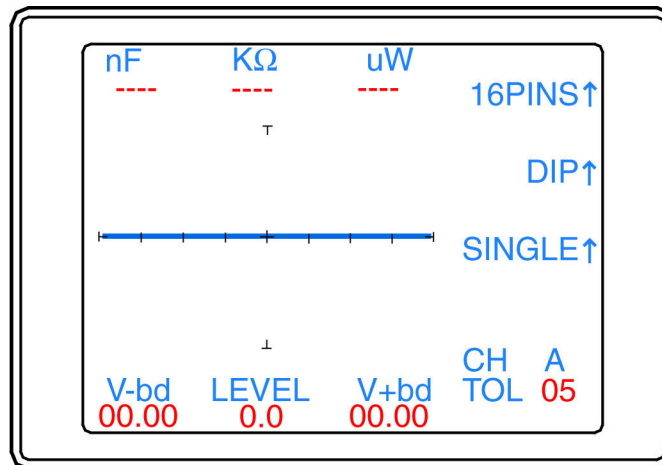

Figure 4-6. Scan / Package menu

The Scan/Package menu functions are as follows:
- 16PINS↑: Sets the number of pins (0-40) to scan. Press the corresponding button to scroll the pin count. The pin number automatically wraps around to 1pin if 40 pins is surpassed. The number of pins is stored in memory until changed.
- DIP↑: Sets the package style to scan with the available selections being DIP, SIP, BOTH and FRONT. For the Tracker 2700S, pin 1 is located in the lower left corner of the IDC connectors. A DIP package will scan starting with pin 1 and count to the right across the bottom row for half of the configured pins then move to the top row and count right to left for the second half of the configured pins. A SIP package will count all odd pins on the bottom row and all even pins on the top row left to right. The BOTH package will scan starting with pin 1 and count to the right across the bottom row for half of the configured pins then move to the top row and count left to right for the second half of the configured pins. A FRONT package will count left to right on the bottom row pins only.
- SINGLE↑: Configures the Tracker to scan the pins one time or to repeat until cancelled or a pin comparison fails. Press the corresponding button to select SINGLE or LOOP. The setting is stored in memory until changed.
- Menu Button: Press the Menu button to return to the Scan menu.

The Scan/ V Ω Hz menu

The Scan/ V Ω Hz menu (figure 4-7) is displayed by pressing the V Ω Hz button in the Scan menu.
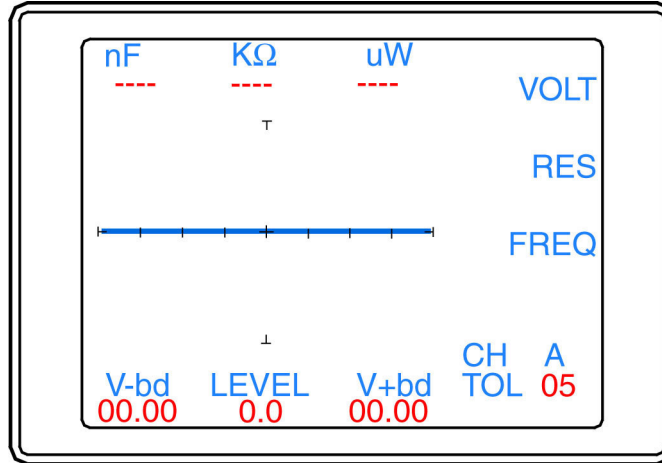

Figure 4-7. Scan / V Ω Hz menu

The functions of the Scan/ V Ω Hz menu are as follows:
- VOLT: Selects scanning of the voltage levels and disables resistance and frequency scanning. Select the corresponding button (the LED will light) to enable VOLT scanning. The setting is stored in memory until changed.
- RES: Selects scanning of the resistance levels and disables voltage and frequency scanning. Select the corresponding button (the LED will light) to enable RES scanning. The setting is stored in memory until changed.
- FREQ: Selects scanning of the frequency levels and disables voltage and resistance scanning. Select the corresponding button (the LED will light) to enable FREQ scanning. The setting is stored in memory until changed.
- **Note:** Disabling all of the selections by pressing the lit button will cause the 2700S to scan only in the currently selected range.
- Menu Button: Press the Menu button to return to the Scan menu.

The Scan/Compare menu

The Scan/Compare menu (figure 4-8) is displayed by pressing the Compare button in the Scan menu.
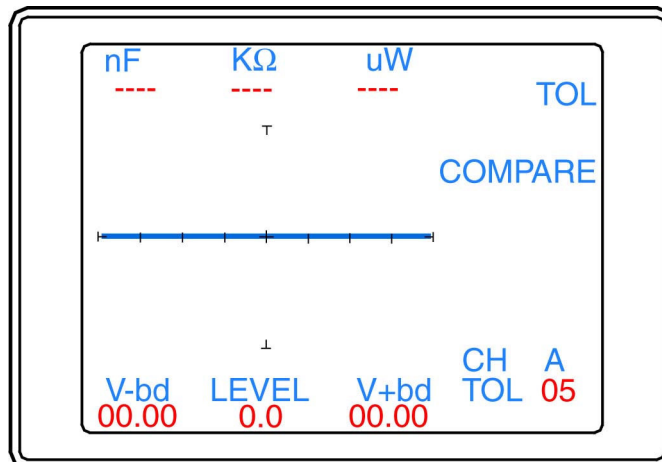
Figure 4-8. Scan / Compare menu

The functions of the Scan/Compare menu are as follows:
- TOL↑: Sets the comparison tolerance used when testing signatures and is variable from 0-5 by 1, 5-20 by 5 and 20-90 by 10. The tolerance value is stored in memory until changed.
- COMPARE: Toggles the comparison of signatures ON or OFF. The corresponding button LED indicates the compare ON/OFF state. When scanning, the compare mode will stop if a signature comparison fails. Press the Scan button continue the scan. The Compare setting is stored in memory until changed.
- Menu Button: Press the Menu button to return to the Scan menu.

The Control Menu

The Control menu (figure 4-9) is displayed by pressing the Control button in the Main menu (see figure 4-3).
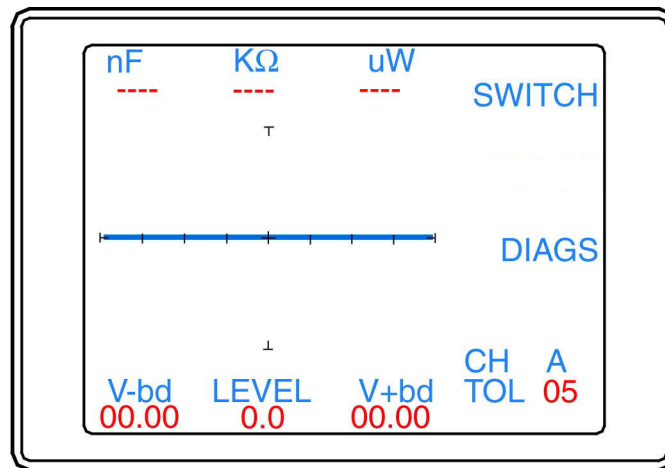
Figure 4-9. Control menu

The functions of the Control menu are as follows:
- SWITCH: Displays the Switch menu for configuring foot switch jack mode.
- DIAGS: Displays the Diagnostics menu for testing the Tracker 2700 function.
- Menu button: Press the Menu button to return to the Main menu.

The Control/Switch menu
The Control/Switch menu (figure 4-10) is displayed by pressing the Switch button in the Control menu.
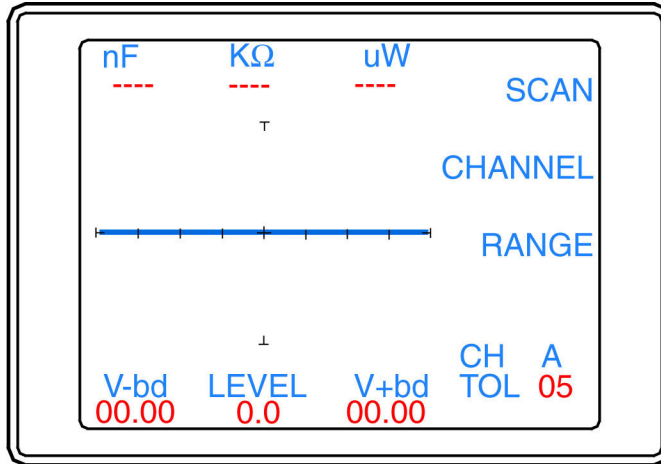

Figure 4-10. Control/Switch menu

The functions of the Control/Switch menu are as follows:

- SCAN: Configures the function of an optional foot switch to increment to next scan step based on the Scan settings (see Scan menu). The button LED is ON when enabled. This setting is stored in memory until changed.
- CHANNEL: Configures the optional foot switch to changes channels. The button LED is ON when enabled. This setting is stored in memory until changed.
- RANGE: Configures the optional footswitch to change to the range selected on the Range menu (see Control/Switch/Range menu). The button LED is ON when enabled. This setting is stored in memory until changed.
- Menu button: Press the Menu button to return to the Control menu.

The Control/Switch/Range menu

The Control/Switch/Range menu (figure 4-11) is displayed when the Range button is selected in the Control/Switch menu (see figure 4-10).
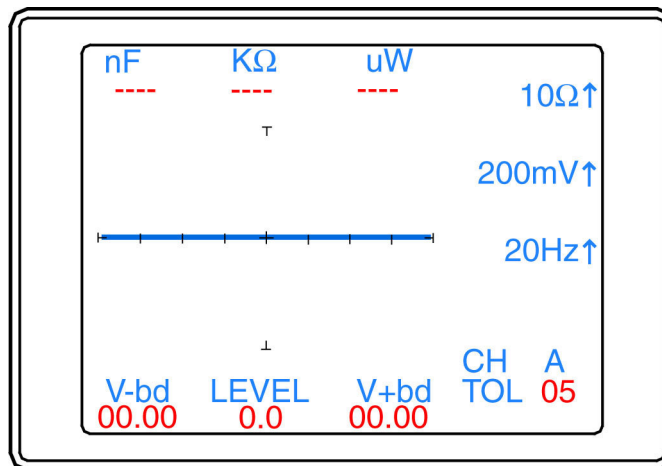
The functions of the Control/Switch/Range menu are as follows:
- 10Ω↑: Sets the resistance to be selected when the foot switch is pressed. This setting is stored in memory until changed.
- 200mV↑: Sets the voltage to be selected when the foot switch is pressed. This setting is stored in memory until changed.
- 20Hz↑: Sets the frequency to be selected when the foot switch is pressed. This setting is stored in memory until changed.
- Menu button: Press the Menu button to return to the Switch menu.

Note: Safe Tracker Active Ranging (STAR) is in effect when configuring range combinations (see section 3-7).

The Control/Diags menu

The Control/Diags menu (figure 4-12) is display by pressing the Diags button in the Control menu.
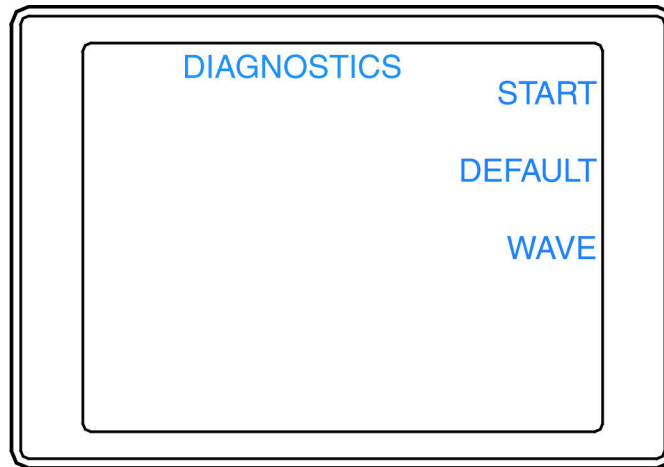
Figure 4-12. Control/Diags menu

The functions of the Control/Diags menu are as follows:
- START: Starts the Diagnostics that checks the Tracker 2700 LEDs, power supplies, and waveform offsets. It also will adjust the waveform offsets and perform loop compensation. If a test fails, select the corresponding button for PROCEED or CANCEL. Restart the Tracker 2700 after running diagnostics.
- DEFAULT: Sets all user settings and the diagnostic signatures adjustments to the factory settings.
- WAVE: Toggles the display of signatures or waveforms (the horizontal and vertical waveforms used to create a signature).
- Menu button: Press the Menu button to return to the Control menu.

NOTE: Huntron recommends the diagnostics routines not be interrupted by pressing the CANCEL button or powering off the unit. Doing so could cause incorrect setup information to be stored in the unit memory. However, if this should occur, rerun the Tracker 2700 diagnostics without interruption.

4.5   SigAssist^{TM}

The following paragraphs explain the concept of the SigAssist^{TM} feature of the Tracker 2700. SigAssist^{TM}
can help with:

♦   Determining proper range selection

♦   Teaching/Learning Signature Analysis

♦   Comparing values to see the amount of change

The values consist of Resistance, Capacitance, Power, Forward Breakdown Voltage, and
Reverse Breakdown Voltage. The formulas use the signature data and the range parameters to
calculate the approximate values.

Resistance is calculated when the signature is a sloping line that is not close to vertical or
horizontal.
Power is always calculated.
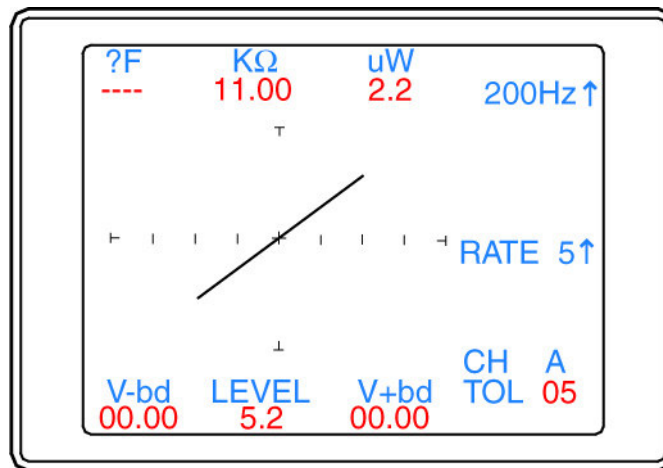
Fig. 4-13 SigAssist™ example with resistive signature

Capacitance is calculated when the signature is a capacitive elliptical that is not close to a vertical or horizontal line. It will also not calculate capacitance if the signature contains dominating resistance.
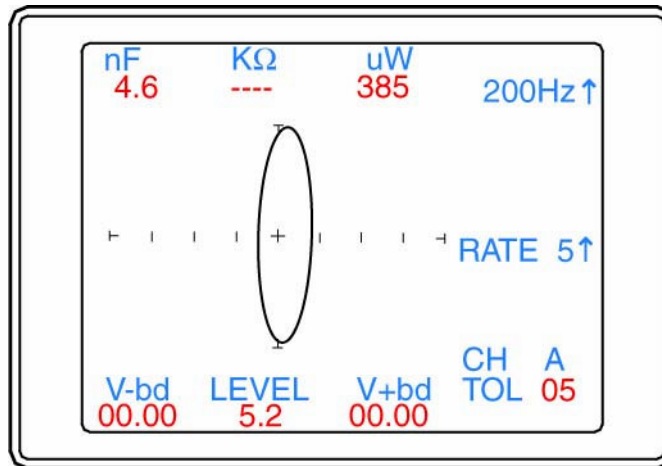

Fig. 4-14 SigAssist™ example with capacitive signature

Forward and reverse breakdown voltages will be calculated for diode and zener type signatures. The voltages will be calculated when the vertical portion of the signature is not close to a short or open.
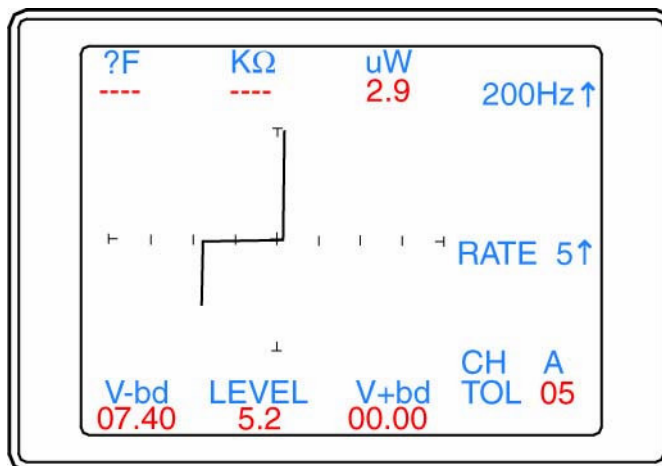

Fig. 4-15 SigAssist™ example with zener diode signature

To enable SigAssist^{TM}, select the Menu button then the Display menu item. Press the Values menu item to toggle the SigAssist^{TM} (along with the Level display) on or off.

SECTION 5
TESTING PASSIVE COMPONENTS

5-1.   Resistors

Exploring how the Tracker 2700 ranges interact with different resistance values is a good
introduction on how basic TSA troubleshooting is applied.   This section will briefly familiarize you
with Tracker 2700 basic operation and teach you how resistor signatures relate to both test range
and the resistance of the circuit under test. After completing this section, you will know how to:

- Apply test probes across a resistor
- Identify a pure resistive signature
- Analyze and predict resistive signatures

Turn power on to your Tracker 2700. Put the red test lead in the **A** jack, and the black test lead in
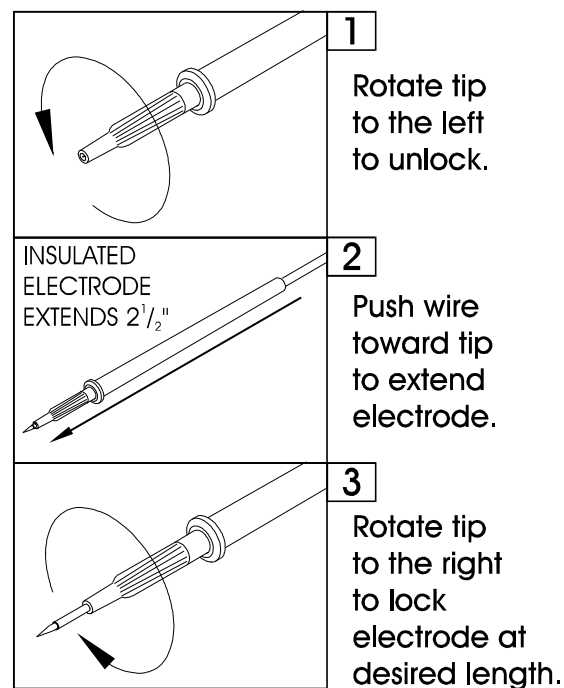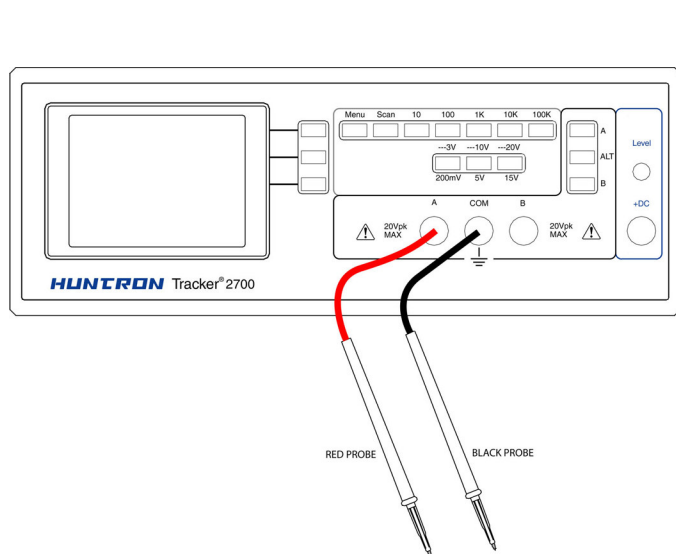the **Common** jack.

Figure 5-1. Tracker 2700 with Test
Probe Leads and Probe Adjustment

1 Rotate tip to the left to unlock.

INSULATED ELECTRODE EXTENDS $2\frac{1}{2}$"

2 Push wire toward tip to extend electrode.

3 Rotate tip to the right to lock electrode at desired length.

To display the tracker signature of a resistor:

1. Press the appropriate resistance range button. Select the **200mV** voltage range.

2. Place or clip a test lead on the opposite ends of a resistor and observe the signature on the Tracker 2700 LCD display. Make sure Channel A is selected.
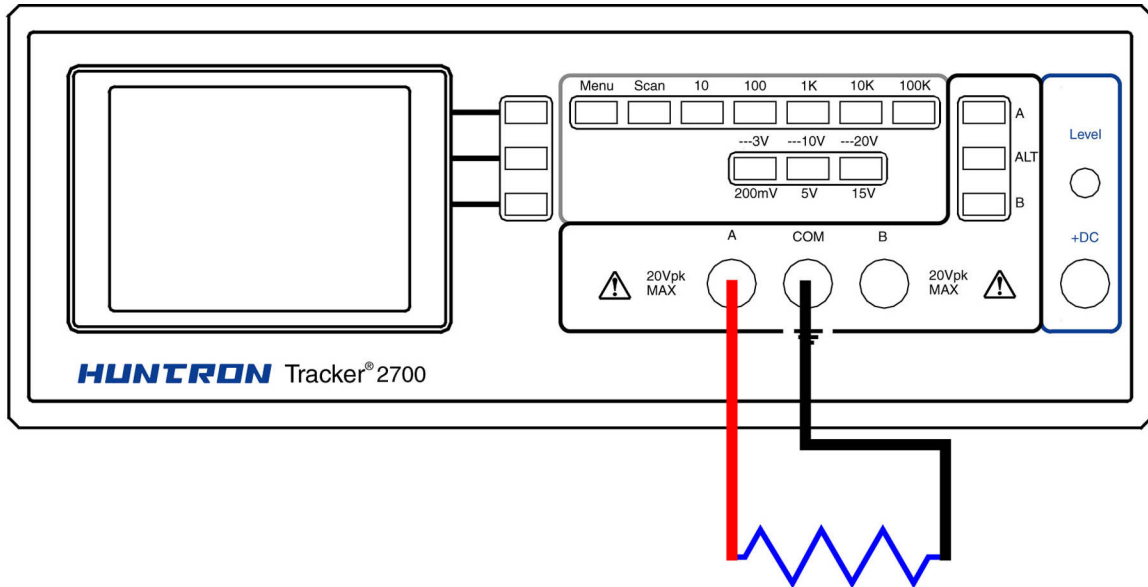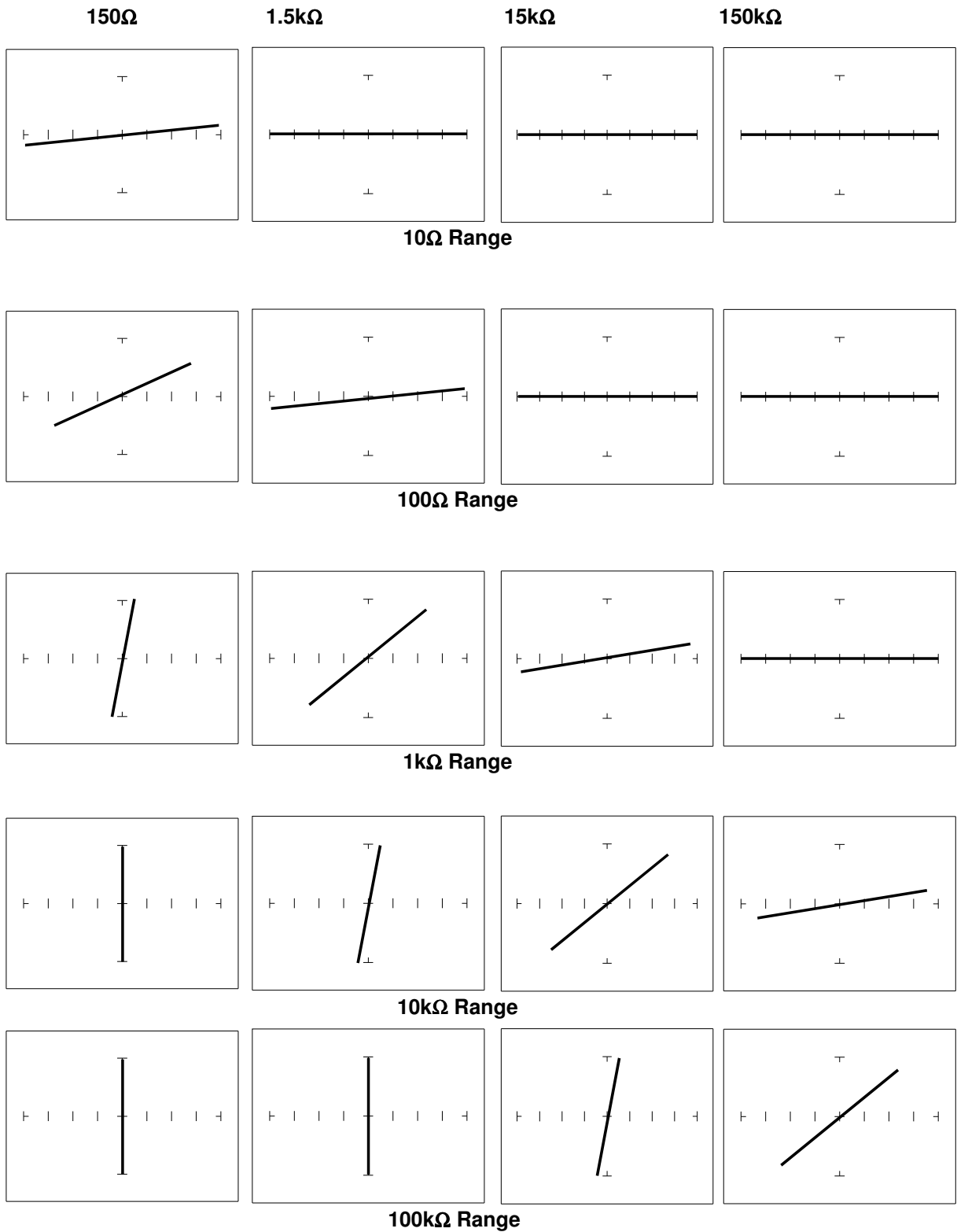

Figure 5-2. Tracker 2700 Connected to a Resistor

Below are four Tracker signatures of different resistors, 150Ω, 1.5kΩ, 15kΩ and 100kΩ in each of the five Resistance ranges. Note how the slope or angle of each tracker signature changes with each resistor's value.

150Ω   **1.5kΩ**   **15kΩ**   **150kΩ**

10Ω Range

100Ω Range

1kΩ Range

10kΩ Range

100kΩ Range

Understanding Resistive Signatures

The Tracker 2700's signature is a visual representation of Ohm's Law in the circuit under test. The amount of voltage applied to the circuit is shown along the horizontal axis, and the resultant current is shown along the vertical axis. The signature is a straight line because the relationship between voltage and current in a purely resistive circuit is linear. The slope changes as we change the internal resistance of the Tracker 2700.
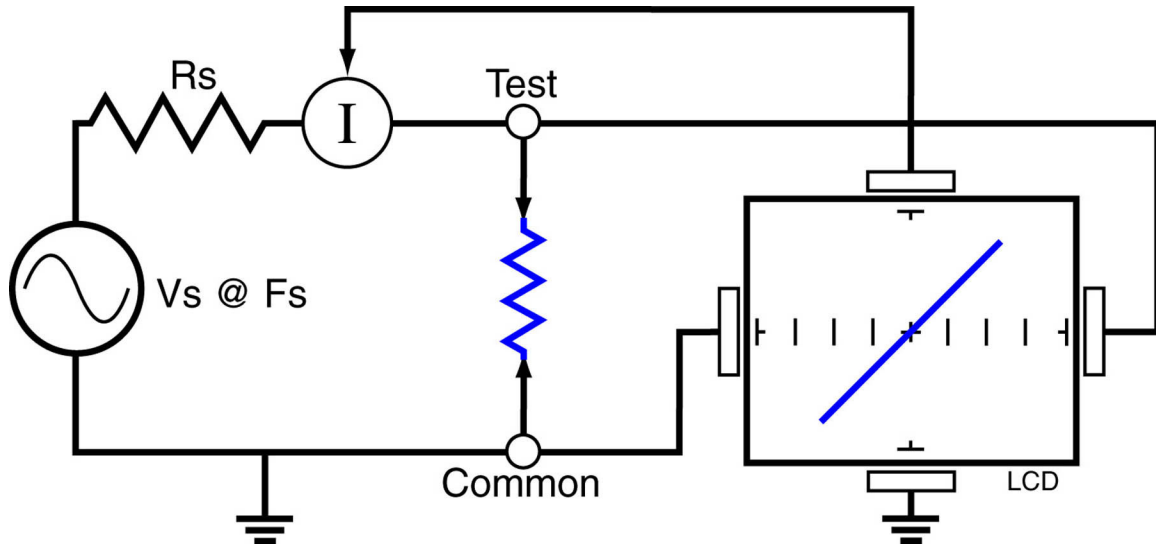

Figure 5-7. Tracker Core Circuit Block Diagram with a Resistor

The Effect of V$_S$ on Resistor Tracker Signatures.

Press the **10V/5V** button.   The 5V range is indicated by the LED on the button being continuously on. To select the 10V range, press this button again. Notice that the LED is now flashing on and off.
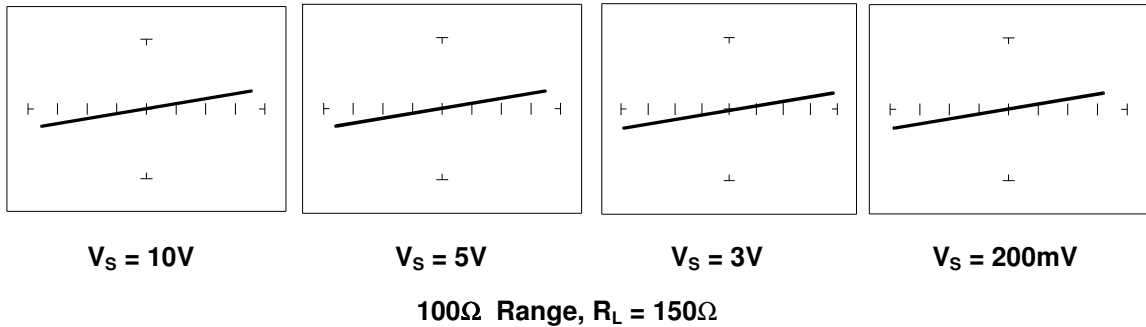

| V$_S$ = 10V | V$_S$ = 5V | V$_S$ = 3V | V$_S$ = 200mV |

100Ω Range, R$_L$ = 150Ω

Figure 5-5. Effect of Varying V$_S$ on a Resistor Signature

Observe that these signatures do not change with the changing voltage. Note that when Vs is set at 15V, the resistance range Rs automatically changes to 1kΩ. This limit on range parameter combinations is a result of the Tracker 2700's STAR feature, it protects components from possible excessive power (see section 3-7). In order to set V$_S$ to a higher voltage, you must change R$_S$ to a higher value first.

The Effect of F$_S$ on Resistor Tracker Signatures.

In the Startup Screen, press the **Frequency Select** button to change the frequency of the applied test signal. Notice that the frequency changes with each successive press of the button. Observe that the resistor signatures in the following figures do not change as F$_S$ changes.
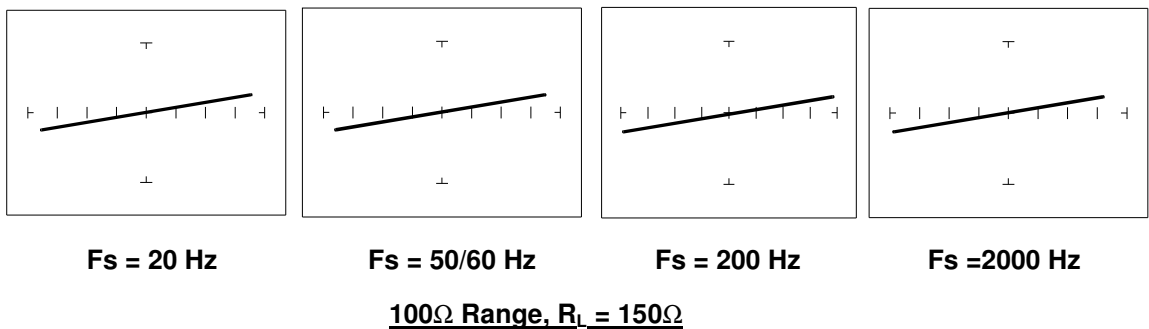

| Fs = 20 Hz | Fs = 50/60 Hz | Fs = 200 Hz | Fs =2000 Hz |

100Ω Range, R$_L$ = 150Ω

Figure 5-6. Effect of Varying F$_S$ on a Resistor Signature

The next figure shows what happens to the LCD display when the different parameters change. The parameter values increase from left to right displaying source voltage (V_s), source frequency (F_s), and source resistance (R_s).

A pure resistance across the test terminals will cause the trace on the Tracker 2700 LCD to rotate in a counter clockwise direction around its center axis from horizontal open circuit position (high value resistance) to a vertical short circuit (low value resistance). The degree of rotation is a function of the resistance value.
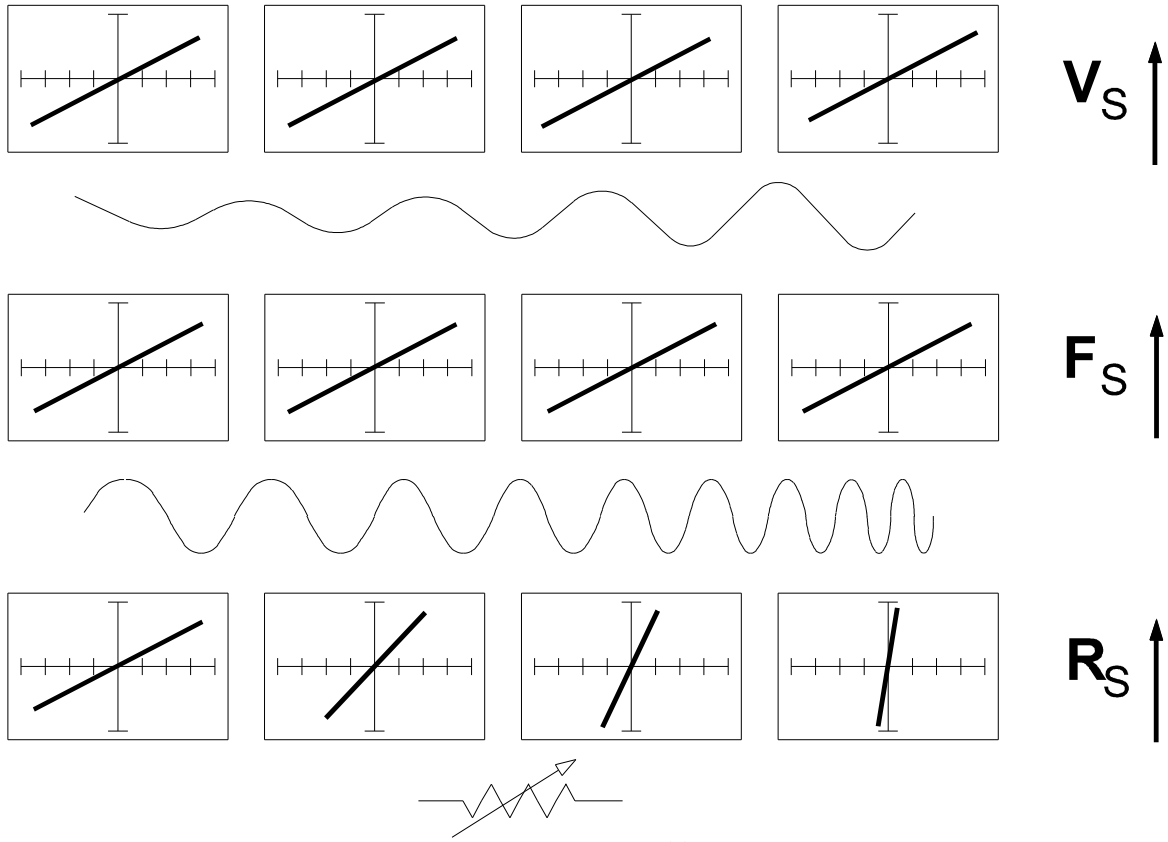
How Range Parameter Changes Effect Resistive Signatures

Figure 5-8. Range Parameters Changes and Effects on Resistive Signatures

Shorts and Opens, Resistor Faults

Two of the most common faults that occur in electronic components and circuits are shorts and opens. A short circuit is typically a 0 Ω to 10 Ω low resistive path between two points in a component or circuit that normally would have a higher resistance between them. An open circuit is a break between two points in a component or circuit that prevents current from flowing.
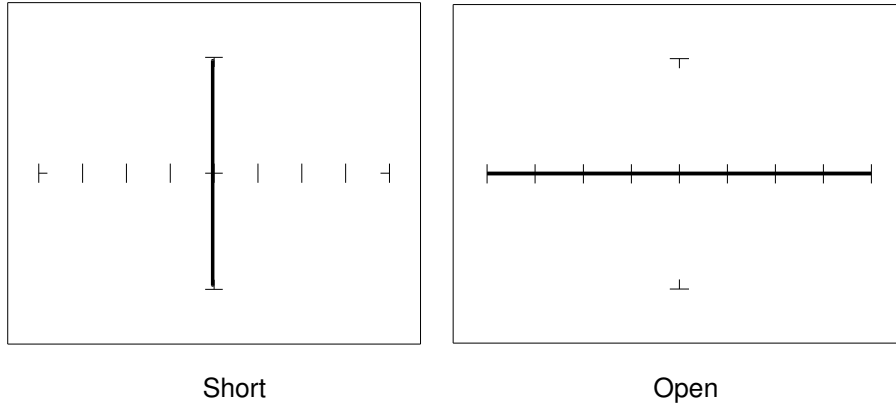

Short   Open

Figure 5-9. Short and Open Signature

Review

- The signature of a purely resistive circuit is a straight line because the relationship between voltage and current in a purely resistive circuit is linear.

- This straight line signature can vary from

  - completely horizontal (an open)

  - completely vertical (a short)

- As resistance increases

  - current decreases

  - the signature becomes more horizontal

- As the voltage increases

  - the volts per division of the horizontal axis increases

  - the internal resistance increases

Troubleshooting Applications

- The Tracker 2700 is a fast and efficient continuity tester, providing real time information.

- The Tracker 2700 will quickly locate resistor defects, shorts, opens and degradation that other testers cannot find.

- A majority of component failures are resistive in nature. This is important to remember; a component fault may only appear in one range because of the resistive nature of the fault.

- The Tracker 2700's ability to determine the approximate fault resistance value greatly enhances the troubleshooting capability if the correct value is known.

The Tracker 2700's LCD is a real time display and using the Tracker 2700 for testing noisy or dirty potentiometer (variable resistors) is an excellent application. Connect Tracker 2700's test terminals to one fixed pot lead and the other to the pot's wiper lead. Simply monitor the wiper signature while rotating the pot back and forth. A flawed pot would have the telltale intermittent
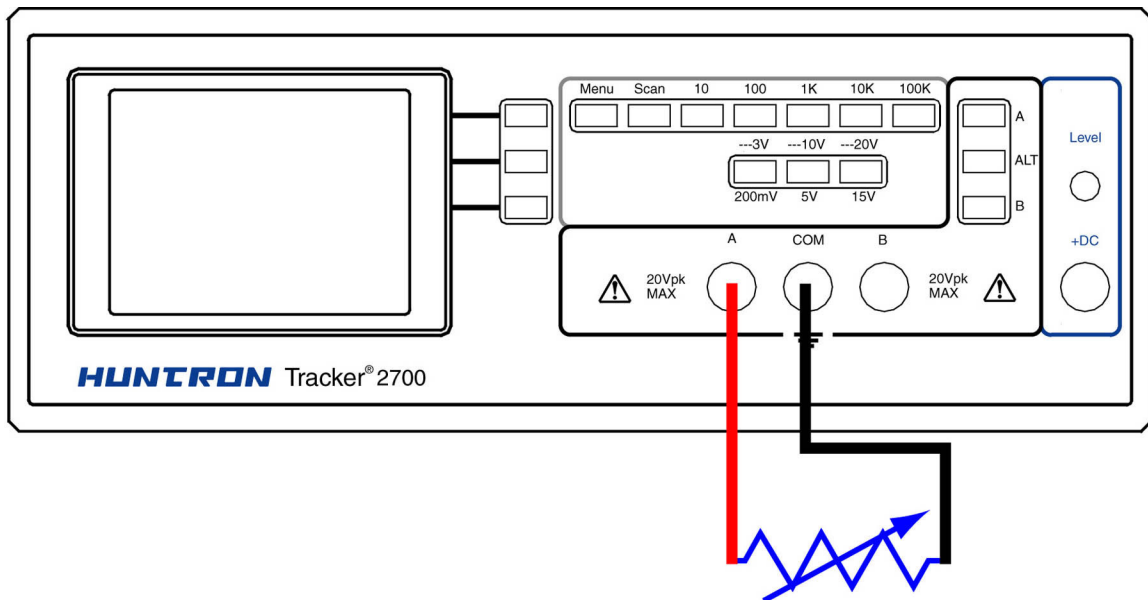
angular signature.

Figure 5-10. Using Tracker 2700 to Test a Potentiometer

- The Tracker 2700 can be used to adjust a potentiometer in circuit to an approximate operational setting. This application requires a known good board. Adjust each potentiometer on the board under repair to match the settings on a known good operational board. In most cases, the board under repair can now be powered up to an operational state where it can be adjusted to true specifications.

5-2.   Capacitors

With a capacitor connected to the Tracker 2700, the test signal across it responds quite differently than a resistor. The typical tracker signature of a capacitor is an elliptical circular pattern and this is due to the fact that relationship between the test signal current and voltage are non linear. The current waveform is 90 degrees out of phase with respect to the voltage. The diagram below illustrates this basic principle for capacitors.
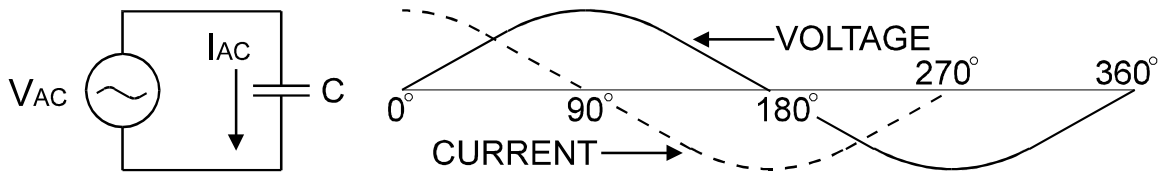

Figure 5-12. Capacitor Circuit with Test Signal's Current and Voltage Waveforms

As the test signal's voltage crosses zero volts and becomes more positive, the current flowing in the circuit is at its maximum and becoming smaller. By the time the voltage has reached its maximum value, the current in the circuit has ceased flowing. As the voltage begins decreasing toward zero, the current begins increasing toward maximum. When the voltage reaches zero, the current is at its maximum value. Similarly, this same pattern follows as the voltage goes negative.

Because the current is at its maximum value when the voltage is at zero, the current leads the voltage. This is called phase shift and in a purely capacitive circuit, this phase shift equals 90°. On the Tracker 2700, this tracker signature appears as a circular waveform. The actual shape and slope of the elliptical signature depends on the capacitance and impedance value of the component and the test signal's internal resistance and frequency.

Capacitor Tracker Signatures

The goal of this part is to explore some capacitive signatures and to help you understand how capacitor signatures are related to:

- The capacitance (µf) of the circuit under test

- The frequency (F_s) of the test signal

- The voltage (V_s) of the test signal

- The internal resistance (R_s) of the Tracker 2700

Turn power on to your Tracker 2700. Plug the red test microprobe in the A jack, and the black test clip lead in the Common jack.

⚠CAUTION

The device to be tested must have all power turned off, and have all high voltage capacitors discharged before connecting the Tracker 2700 to the device.

Input Protection

The Tracker 2700 has input protection circuitry which protects the Tracker 2700's test terminals from external excessive voltage. The Tracker 2700 is a power-off tester requiring no other external power being applied to the device-under-test. For example, large value capacitors may still have a charge in them and can cause potential damage to the Tracker 2700.

Do the following to display the tracker signature of a capacitor:

1. Press the **5V/10V** button so that the button's LED is blinking indicating that the 10V range is active.

2. Press the **100Ω** Button.

3. Place or clip a test lead on the opposite ends of a capacitor and observe the signature on the Tracker 2700's LCD display.
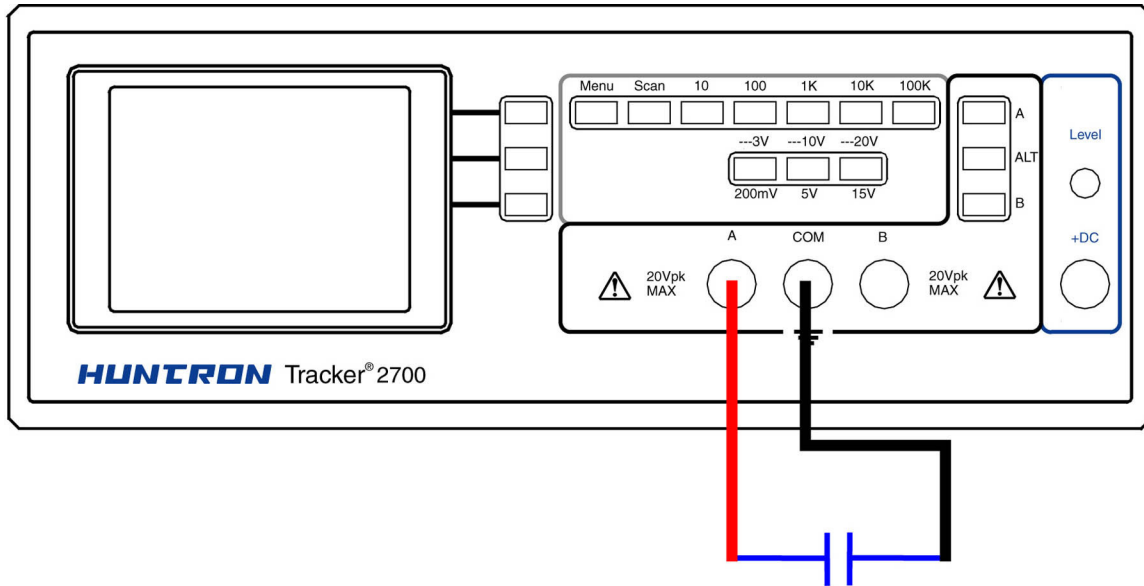

Figure 5-13. Tracker 2700 with Test Probes Connected to a Capacitor

The Signatures Of Different Capacitors at 10V/100ΩRange

The figure below shows tracker signatures for four different value capacitors, 1000 µf, 100 µf, 10 µf and 1µf. The Tracker 2700 **10V/100Ω** range is selected.
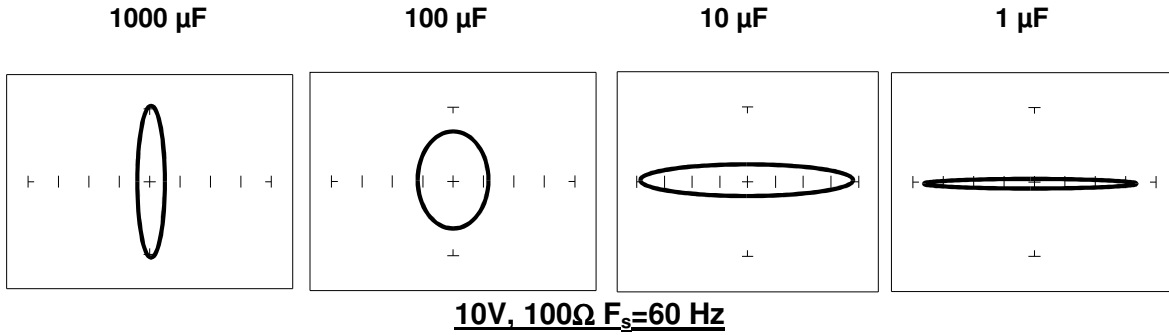
1000 µF	100 µF	10 µF	1 µF

10V, 100Ω F$_S$=60 Hz

Figure 5-14. Signatures of 4 Capacitors

Note that as the capacitance values decrease, each signature changes from a vertical elliptical pattern to a horizontal elliptical pattern. In TSA, a large value capacitor has a signature that looks similar to a short circuit. And likewise, a small value capacitor has a signature that's similar to an open circuit.

Effect of Frequency (F$_s$) on the Signature of a 10 µF Capacitor

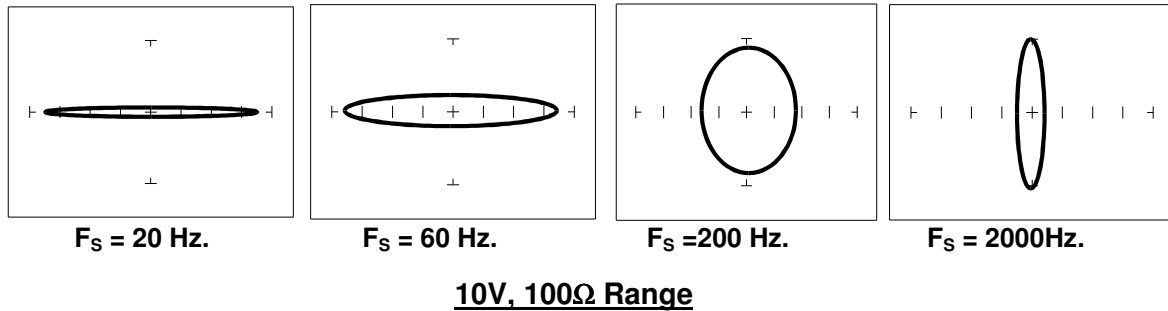| F$_S$ = 20 Hz.	F$_S$ = 60 Hz.	F$_S$ =200 Hz.	F$_S$ = 2000Hz.

10V, 100Ω Range

Figure 5-15. Signatures of a 10 µF Capacitor at Different Frequencies

Note that as the test signal frequency increases, the 10 µF capacitor's signature changes from a horizontal elliptical pattern to a vertical elliptical pattern. In TSA, a capacitor at a low test frequency has a signature that looks similar to an open circuit. And likewise, the same capacitor at a high frequency has a signature that's similar to a short circuit.

Effect of Frequency (F$_s$) on the Signature of a 0.1 µF Capacitor

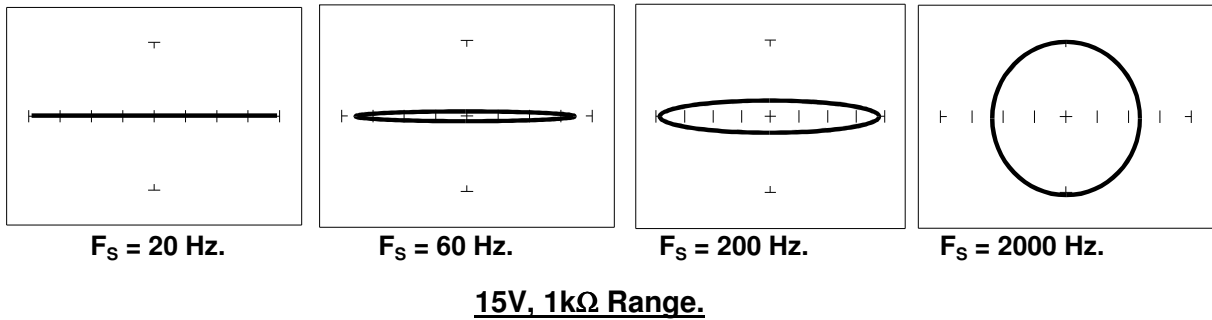| F$_S$ = 20 Hz. | F$_S$ = 60 Hz. | F$_S$ = 200 Hz. | F$_S$ = 2000 Hz. |

15V, 1kΩ Range.

Figure 5-16. Signatures of a 0.1 µF Capacitor at Different Frequencies

Note that as the test signal frequency increases, each signature changes from a horizontal elliptical pattern to a vertical elliptical pattern. In TSA, a small value capacitor at a low test frequency has a signature that looks similar to an open circuit. Likewise, a small value capacitor at a high test frequency has a signature that's similar to a short circuit. The signature of the 0.1µF capacitor is similar to the 10 µF capacitor in shape but not in size due to the differences in their value.

Effect of Voltage (V$_S$) on the Signature of a 1 µF Capacitor

| V$_S$ = 200 mV | V$_S$ = 5 V | V$_S$ = 10V | V$_S$ = 15 V |

10kΩ Range, F$_s$ = 60Hz
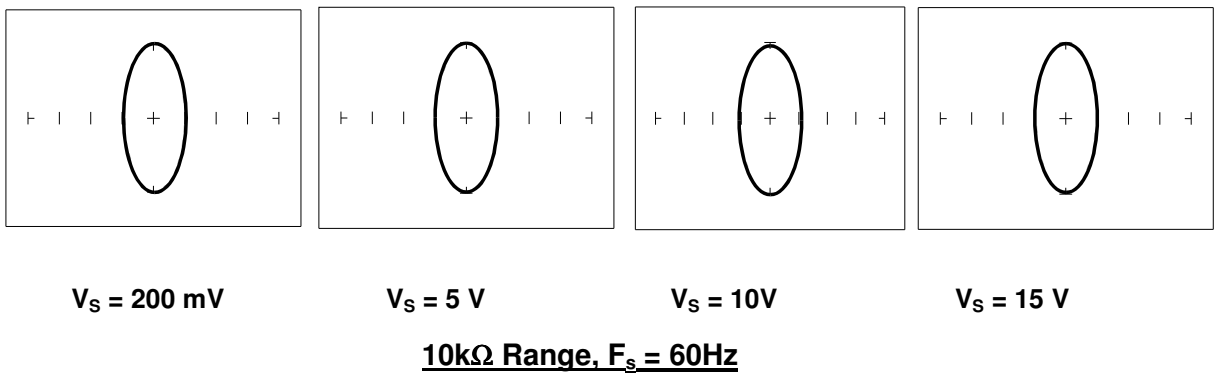
Figure 5-17. Signatures of a 1 µF Capacitor at Different Test Signal Voltages

Notice that as V$_s$ changes there is no effect on the component signatures.

Effect of Resistance (R$_s$) on the Signature of a 1μF Capacitor

R$_S$ = 1kΩ	R$_S$ = 10kΩ	R$_S$ = 100kΩ

<u>15 V Range, F$_s$ = 60Hz</u>

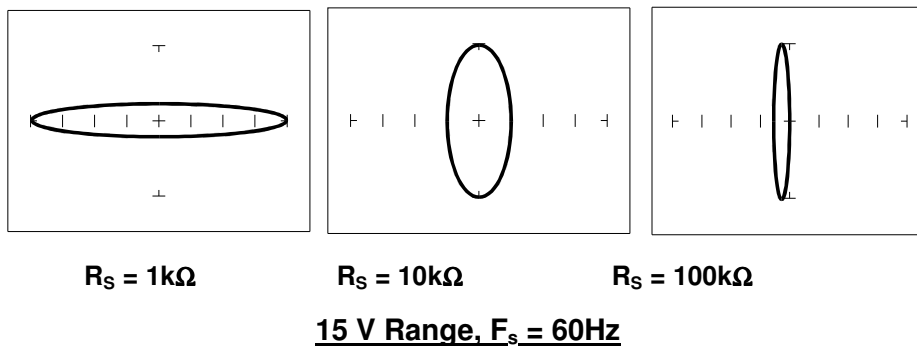Figure 5-18. Signatures of a 1μF Capacitor at Different Internal Resistances

As the Tracker 2700's internal resistance R$_S$ increased, the capacitor's signature changes from a horizontal elliptical pattern to a vertical elliptical pattern.
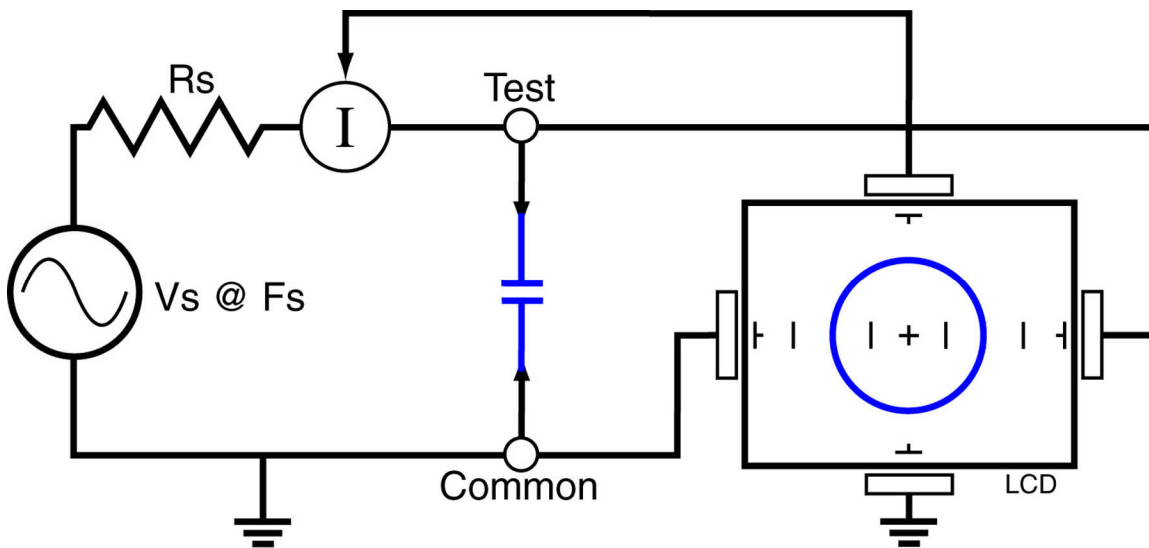
Understanding Capacitor Tracker Signatures

Figure 5-19. Tracker Core Circuit Block Diagram with a Capacitor.

The Tracker 2700 LCD displays as a response to its test signal, a tracker signature that represents the relationship between voltage, current and resistance of a component. For circuits that contain capacitors, the effective resistance is called capacitive reactance, X$_C$. The mathematical formula is:

$$X_c = \frac{1}{2\pi fC}$$

X_C is inversely related to both capacitance and frequency. So to review and summarize capacitive tracker signatures up to this point:

- Changing capacitance: As the capacitance of a circuit increases, the capacitive reactance X_C decreases. This means that when capacitance increases, the amount of current in the component or circuit will increase. On the Tracker 2700, the elliptical signature will become increasingly vertical which implies more current flow.

- Changing frequency F_S: As the frequency of the test signal increases, the capacitive reactance X_C will decrease and the amount of current in the circuit will increase. On the Tracker 2700, the elliptical signature will become increasingly vertical which implies more current flow.

- Changing voltage V_S: As the test signal voltage is changed from 200 mV to 20 V, the following occurs:

  – X_C of the capacitor is not affected

  – The applied Voltage increases

  – The elliptical signature is not affected

- Changing source resistance R_S: As the resistance is changed from 1 kΩ to 100 kΩ, the following occurs:

  – X_C of the capacitor is not affected

  – The elliptical signature becomes increasingly vertical
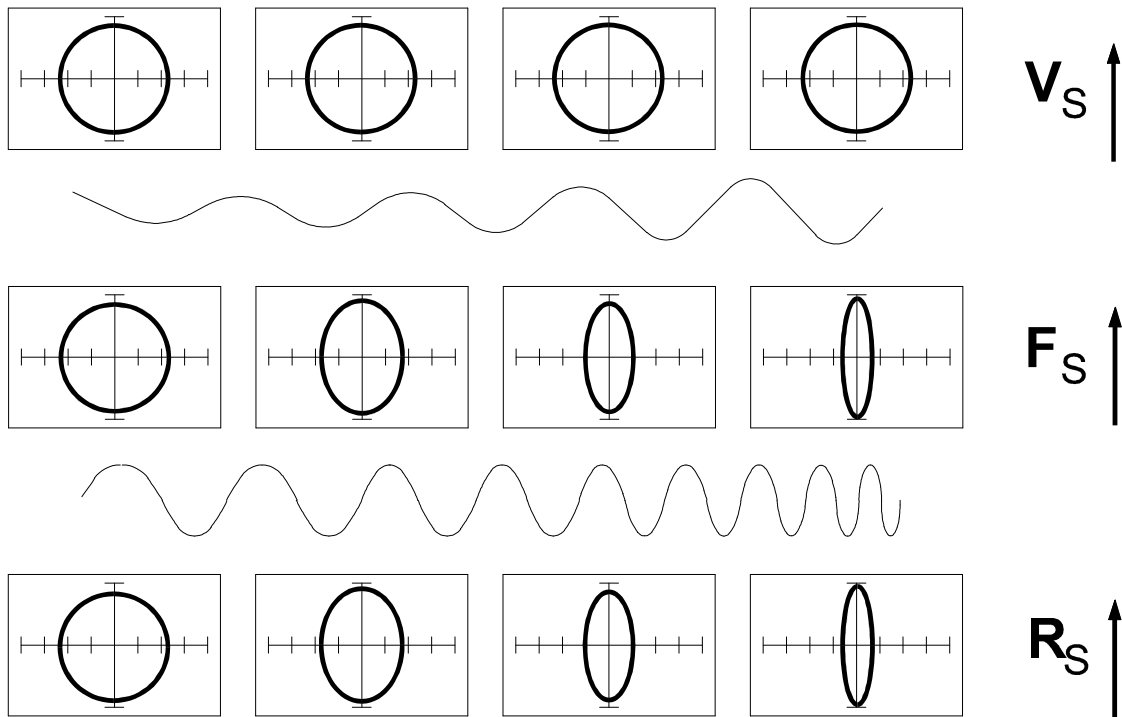
How Range Parameter Changes Effect Capacitive Signatures

Figure 5-20. Range Parameters Changes and Effects on Capacitive Signatures.

The figure above shows how the three variable parameters affect the capacitive signature. Frequency F_S and internal resistance R_S has the greatest effect, while increasing voltage V_S has no effect.

Minimum and Maximum Capacitor Values

Because of the flexibility of the Tracker 2700 range selection, a wide range of capacitive values can be tested. Usable signatures can be obtained from very large or very small capacitors as shown in figures 5.21.

Capacitance = **10pF**   Capacitance=**16000μF**

<u>**V$_s$=3V, R$_s$=100KΩ, F$_s$=2000Hz**</u>   <u>**V$_s$=200mV, R$_s$=10Ω,**</u>
<u>**F$_s$=20Hz**</u>
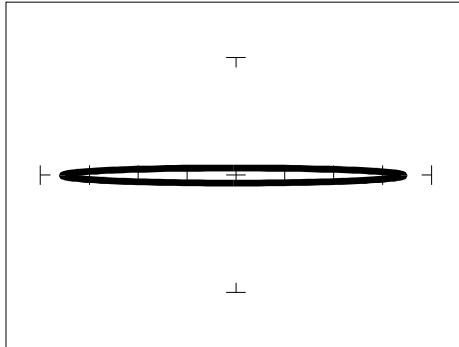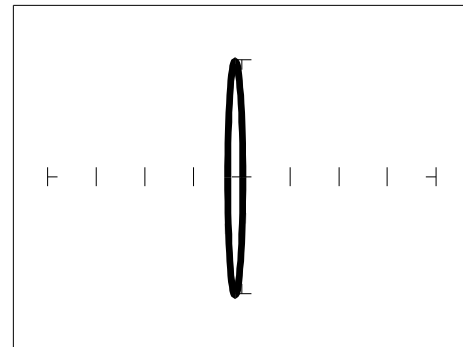
Fig 5.21 Minimum and Maximum Capacitance that will Display a Loop Type Signature

Note: Be sure to discharge large capacitors before testing to avoid damaging the Tracker 2700.

Capacitor Failures - Leakage

One common physical failure in capacitors is dielectric leakage. The dielectric or insulator in a capacitor normally acts as a non conductor between the capacitor's two plates. A flawed capacitor develops a conductive or leakage path between its two plates. This can be thought of as a resistance in parallel with the capacitance when observing its tracker signature. The following examples show what some capacitor leakage problems may look like on the Tracker 2700 display.
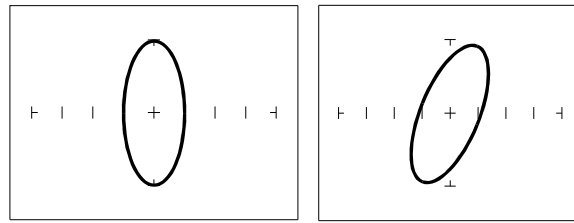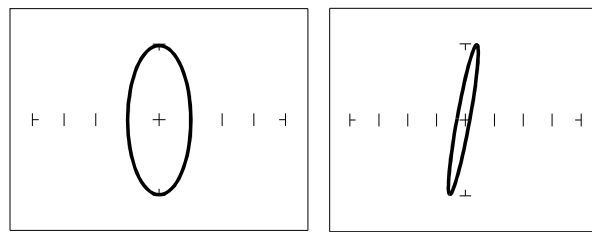
Normal Capacitor   Leaky Capacitor

10V, 100Ω Range, F$_S$ = 60 Hz

Figure 5-22. Signatures of a 100 µF Capacitor with Dielectric Leakage

This example only simulates the leakage flaw by adding a 100 Ω resistor in parallel to a 100 µF capacitor. It shows the signature change from a normal circular ellipse pattern to a sloped and depressed vertical pattern. The signature of a real capacitive leakage would be quite similar to this example.

Another example of capacitive leakage is shown for a 10 µF capacitor.

Normal Capacitor   Leaky Capacitor

10V, 100Ω Range, F$_S$ = 60 Hz

Figure 5-23. Signatures of a 10 µF Capacitor with Dielectric Leakage

Again, this example only simulates the leakage flaw by adding a 68 Ω resistor in parallel to a 10 µF capacitor. It shows the signature change from a normal circular ellipse pattern to a sloped and depressed vertical pattern. The signature of a real capacitive leakage would be quite similar to this example.

As you can see from the two previous examples, adding resistance in parallel to a capacitor distorts the normal signature with a diagonal bend to it. This is our first look at a composite signature, the kind of signature the Tracker 2700 displays when there are several components connected together in a circuit.

Review

- Capacitors have elliptical signatures due to the current and voltage phase shift.

- As the test signal's frequency increases, the capacitor's signature becomes more vertical due to decreasing X_C of the component.

- Capacitors with leakage flaws have their ellipses tilted diagonally due to an internal resistance in parallel with the capacitance.

Applications

- The Tracker 2700 can locate defective capacitors in or out of circuit. The ranges cover approximately 10pF to 16,000 μF.

- When analyzing a capacitor's signature, adjust the Tracker 2700's R_S and F_S for the most pronounced ellipse.

- The test signal frequency F_S can be changed to enhance a composite signature by emphasizing or de-emphasizing the capacitance.

- Besides resistance, faulty capacitor signatures often exhibit other irregularities such as non-symmetry, broken or distorted ellipse and saw-toothed shapes that can be seen on the LCD display.

5-3. Inductors

Inductors, like capacitors, have elliptical Tracker signatures and respond to Tracker 2700's test signal non-linearly. Also like capacitors, an inductor's reactance (resistance to an AC test signal) is dependent on the test signal's frequency. Because of the way they are constructed using wire which has some amount of resistance in it, it is hard to find an inductor with a pure inductance. An inductor's Tracker signature will usually be an elliptical pattern with a some slope or tilt to it due to the resistance of the coil wire.

Inductor Tracker Signatures

The goal of this part is to explore some inductive signatures and to help you understand how inductor signatures are related to:

- The inductance L μH of the circuit under test

- The frequency F_S of the test signal

- The voltage V_S of the test signal

- The internal resistance R_S of the Tracker 2700
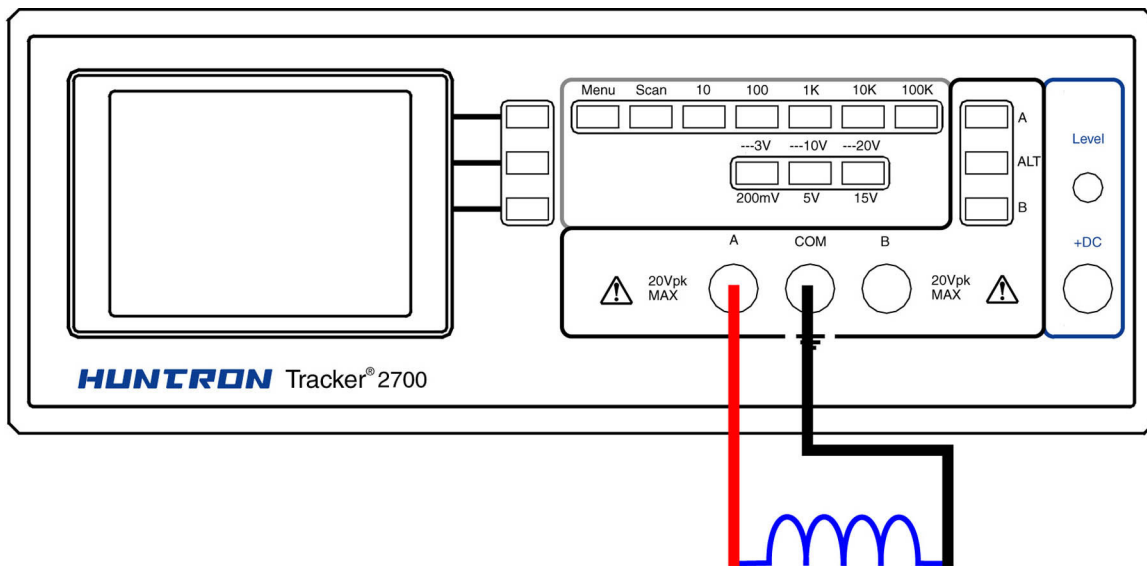
Figure 5-24. Tracker 2700 connected to an Inductor

The figure below shows Tracker signatures for four different value inductors, 12,000µH, 1200µH, 120µH and 12µH in the 10V, 100Ω Range.

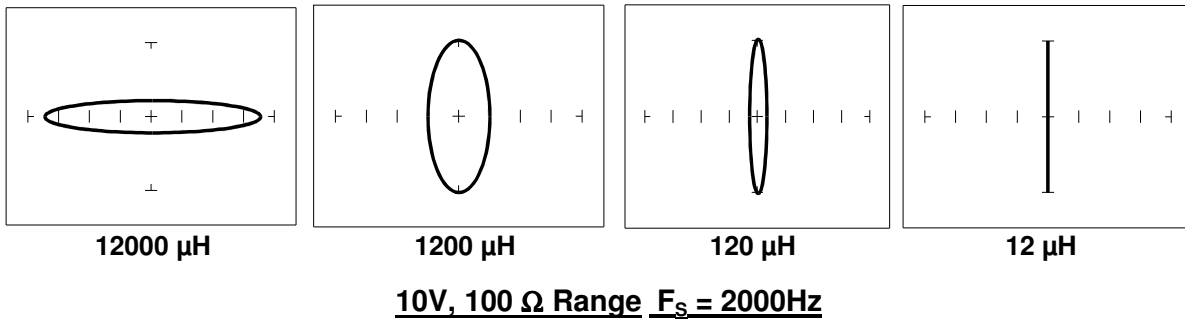| 12000 µH | 1200 µH | 120 µH | 12 µH |

10V, 100 Ω Range F$_S$ = 2000Hz

Figure 5-24. Signatures of 4 Inductors

Note that as the inductance values decrease, each signature changes from a horizontal elliptical pattern to a vertical elliptical pattern. In TSA, a large value inductor has a signature that looks similar to an open circuit. And likewise, a small value inductor has a signature that's similar to a short circuit.

Effect of Frequency F$_s$ on Inductor Signatures

| F$_S$ = 60 Hz. | F$_S$ = 200 Hz. | Fs=2000Hz. |

10V, 100 Ω Range, L = 12,000 µH
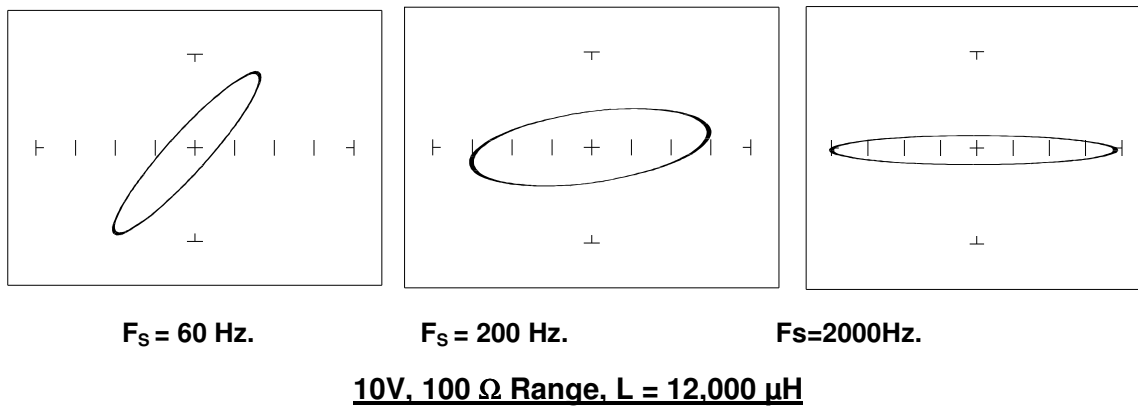
Figure 5-25. Effect of Varying F$_S$ on Inductor Signatures

Note that the signature changes from a vertical position to a horizontal position as the frequency increases. This means the resistance of an inductor increases as frequency increases.

Effect of Voltage V$_s$ on Inductor Signatures
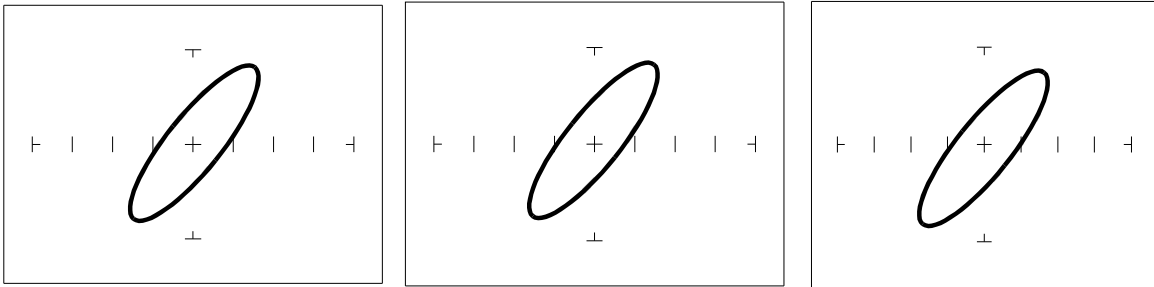
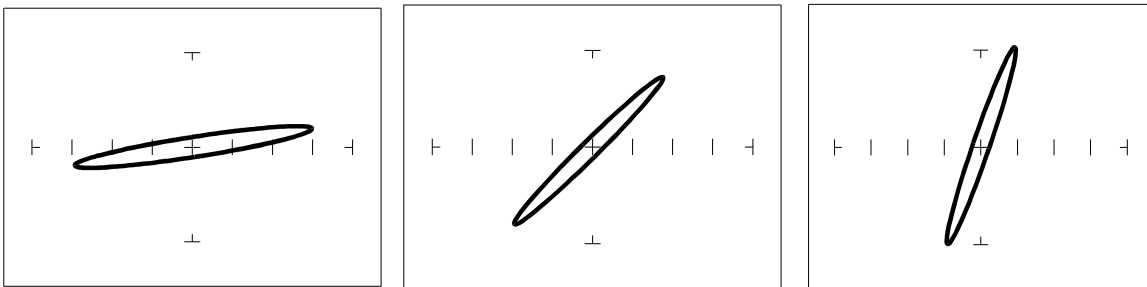V_S = 200 mV V_S = 5 V V_S = 10 V

100 Ω Range, F$_S$ = 60 Hz, L = 12,000 µH

Figure 5-26. Effect of Varying V$_S$ on Inductor Signatures

Note that the signature does not change at the three test signal voltages. This means that the inductor's resistance is not affected by changes in the test voltage.

Effect of Internal Resistance R$_s$ on Inductor Signatures

R$_S$ = 10 Ω   R$_S$ = 100 Ω   R$_S$ = 1kΩ

V$_S$ = 200mV, F$_S$ = 60 Hz, L = 12,000 µH

Figure 5-27. Effect of Varying R$_S$ on Inductor Signatures

Note that the signature changes from a horizontal to a vertical position as the Tracker 2700's internal resistance R$_S$ increases. This means the inductor's resistance can be analyzed by matching it with the Tracker 2700's test signal resistance.

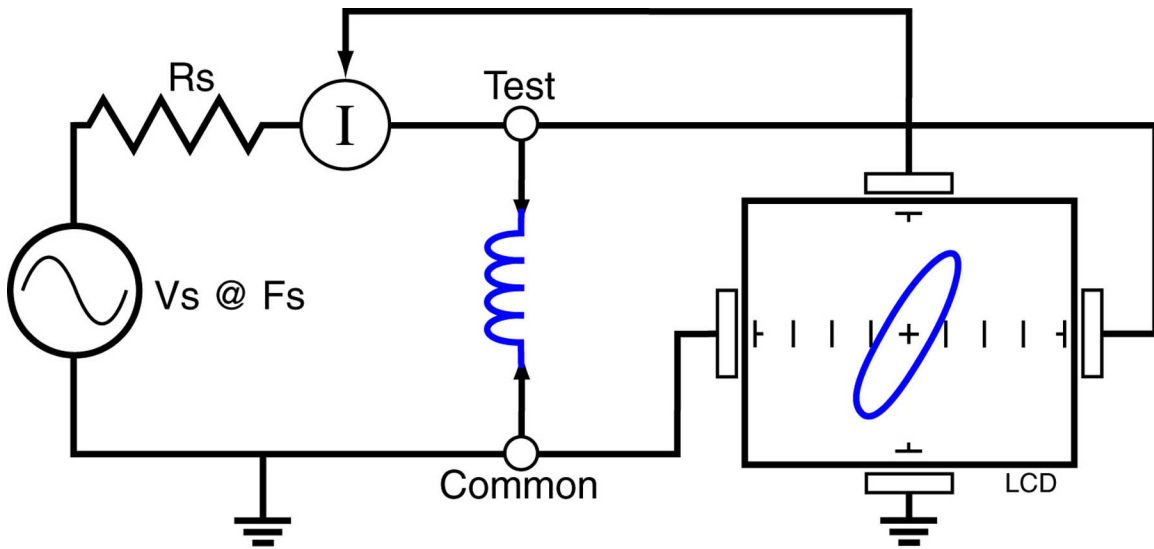**Understanding Inductive Signatures**

Figure 5-28. Tracker Core Circuit Block Diagram with an Inductor

The Tracker 2700's block diagram shows an inductor between the test terminals. The current is represented by the vertical axis and is derived as a series current that flows through Tracker 2700's internal resistance, R_S. The voltage is represented by the horizontal axis and is derived as a voltage across the inductor.

The formula for the reactance X_L of an inductor is:

$$X_L = 2\pi fL$$

As the test signal frequency increases, the inductive reactance X_L becomes larger. As a result, the inductor's Tracker signature will change from a rounder elliptical to a flatter resistive type pattern. The size and shape of the ellipse depend on the inductor value, test signal frequency, and the selected resistance R_S.

Since inductors in reality are not pure inductors, the elliptical signatures they form on the Tracker 2700 display usually are distorted. Inductors constructed with a ferrite core make the inductive characteristics different from those constructed without. The Tracker 2700 responds with a unique Tracker signature for each inductor type.
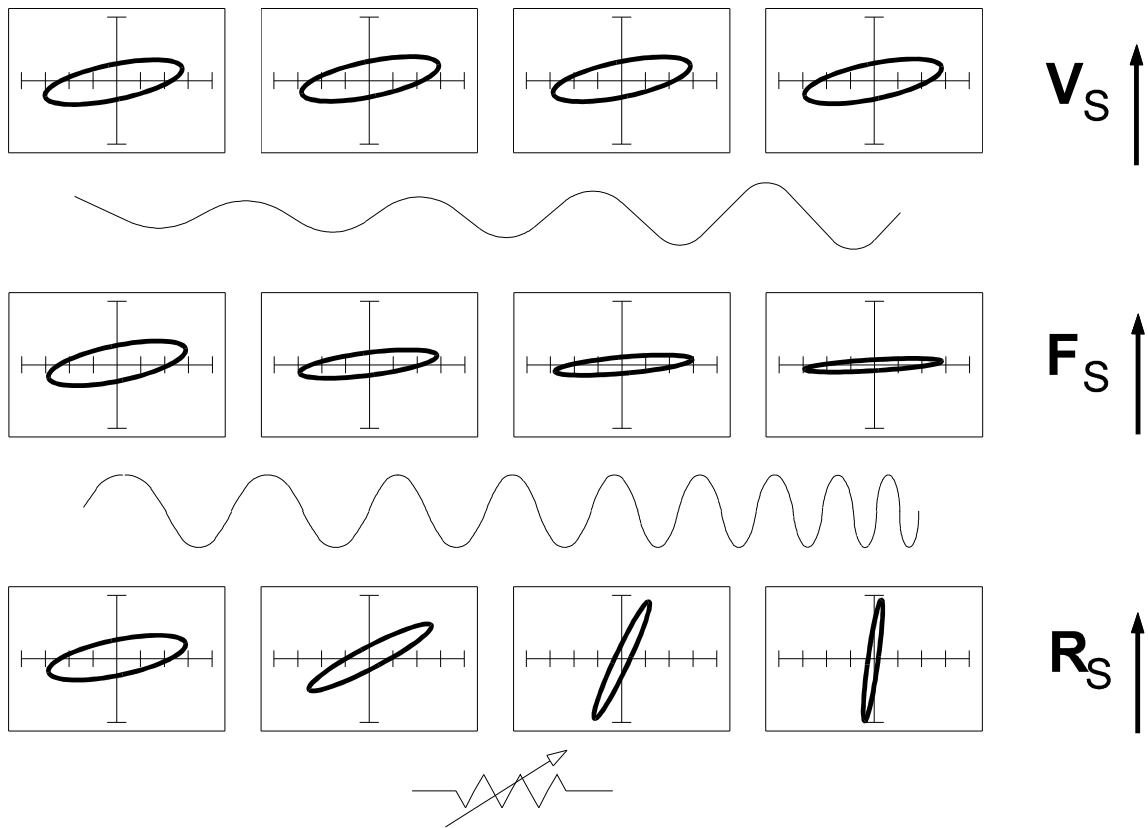
How Range Parameter Changes Effect Inductive Signatures

Figure 5-29. Range Parameters Changes and Effects on Inductive Signatures
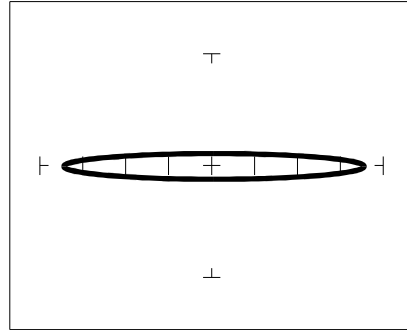
Minimum and Maximum Inductor Values

Because of the flexibility of the Tracker 2700 range selection, a wide range of inductive values can be tested. Usable signatures can be obtained from very large or very small inductors as shown in figures 5.30.
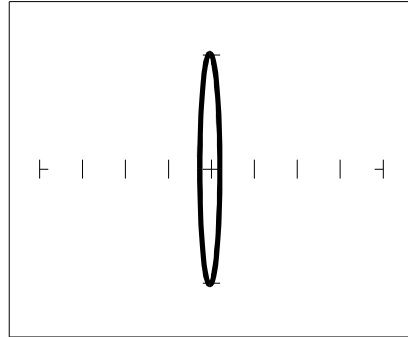
Inductance=**15μH**   Inductance=**47000μH**

V$_s$=200mV, R$_s$=10Ω, F$_s$=2000Hz   **V$_s$=200mV, R$_s$=10Ω,**
F$_s$=20Hz

Fig. 5-30; Minimum and Maximum Inductance that will Display a Loop Type Signature.

Review

- Inductors display elliptical signatures similar to capacitors. Since the inductor also exhibits resistance, due to its construction, the ellipse may be distorted.

- As the Tracker 2700 test signal's frequency is increased, the ellipse signature becomes flatter. This response is opposite to that of a capacitor.

- As the Tracker 2700 internal resistance R_S increases, an inductor's signature becomes more vertical (like the capacitor signature).

- When an inductor has a ferrite core, its signature distorts from a non ferrite inductor's ellipse.

Applications

- The Tracker 2700 is excellent for troubleshooting inductors. It can reveal shorted or open windings in large variety of inductive components.

- Components that are inductors or have inductive characteristics can be found in many real world applications. A few examples are, power transformers, relays, solenoids, flyback transformers, speakers, magnetic sensors, stepping motors and motor windings.

- The best technique for testing inductors is the comparison of a known good component's signature to a suspect component. For example, a motor armature has typically numerous windings so every winding should have a similar Tracker signature. This fact is true whether it's from an elevator or a tape deck. The armature of a DC motor can be tested by simply connecting to the motor brush leads and then adjusting the test range for the most pronounced or descriptive signature. Slowly turn the armature. Observe the Tracker 2700's LCD display. This test will check continuity, the inductance, and the condition of each brush contact without disassembling the motor.

- A computer switching power supply contains inductors. For example, a computer is reported "dead." To make a quick diagnosis of the possible problem first make sure the computer is disconnected from AC power. Then connect the red and black test probes across the prongs on the AC line cord going to the computer. Turn the computer power switch to the On position. If there is a response on the Tracker 2700's display, adjust the test range for the most pronounced inductive signature. Flick the power switch off and on and watch for noisy switch contacts. If there is no response, start by checking each component up to the primary winding of the transformer. With this technique, we have just verified the AC cord, the AC noise filter, the fuse, the power switch and the primary winding of the transformer, without removing the cover of the computer.

- Another simple test for a speaker or microphone is to apply the Tracker 2700 signal in 10V, 100Ω, 60 Hz range to the device input leads and listen for the 60 Hz tone or audible hum.

- To test solenoids, connect the test probes to the coil leads and manually move the plunger or activator in and out while observing if its signature changes.

5-4. Electromechanical Switching Components

Switches are electrical devices that either stop or allow current to flow in a circuit. They are either in an on or off state. Switching devices come in all types and sizes. There are simple mechanical switches, relays, optical switches, and many kinds of semiconductor switches. They are different because each uses a different kind of stimulus to turn them on or off. Because there are so many kinds of switching devices, there is no single testing procedure that will test them all completely. With the Tracker 2700, the test signal can be setup so that the switch's Tracker signature will verify its switching function. The goal of this section is to develop a test strategy using TSA to test the switching function. This is not a complete test, but it will be enough to determine whether or not the device is functioning as a switch.

Manually Operated Mechanical Switches

A mechanical switch has two states: it is either open or closed. When open, no current can flow; when closed, it acts as a short and allows current to flow. The Tracker 2700 can test the switching function of mechanically activated switches easily. Unlike the DVM that samples and gives a continuity measurement, the Tracker 2700 displays real time activity. If a switch has noisy, resistive or intermittent operation, its Tracker signature on Tracker 2700's display will reflect these conditions.
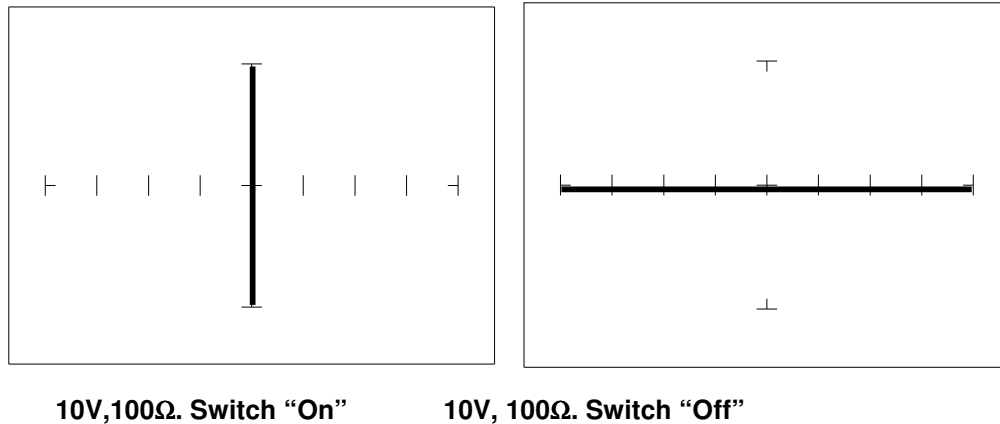

10V,100Ω. Switch "On"   **10V, 100Ω. Switch "Off"**

Figure 5-32. Signatures of a Push-button Switch. SPST Type

Review

- The switch displays an open or short circuit signature.

- Dirty or damaged switch contacts will show a resistive or erratic signature.

Electromechanical Relays

A relay is a switch that's activated by an electrical control input. The relay consists of switch contacts, magnets and an electromagnetic coil. The Tracker 2700 can test the coil part of the relay by looking at its inductive Tracker signature. You can also connect the Tracker 2700's DC Source to the magnetic coil and while at the same time connecting the Tracker's test signal to the relay contacts to test the relay's switching action directly.

Using the DC Source to Test a Reed Relay

Note that the maximum output voltage of the DC source is 5 Volts, so the relay coil must activate at 5V or less. Refer to figure 5-33.

Do the following:

1. Select the 10V, 100Ω range.

2. Connect the Tracker 2700 DC Source output +DC to the positive (+) lead of the relay coil.

3. Connect the Tracker 2700 COMMON to the relay's negative (-) lead).

4. Connect the black test lead from Tracker 2700's COMMON terminal to the wiper side of the relay switch contact.

5. Connect the red test lead from Tracker 2700's TEST terminal to the other side of the relay switch contact.

6. Rotate the DC level knob all the way counter-clockwise. Now rotate the knob slowly clockwise and observe the relay contacts' signature. When a short circuit signature (vertical line) is displayed, turn the DC level knob back and forth and watch the relay relay's signature change between an open and a short.
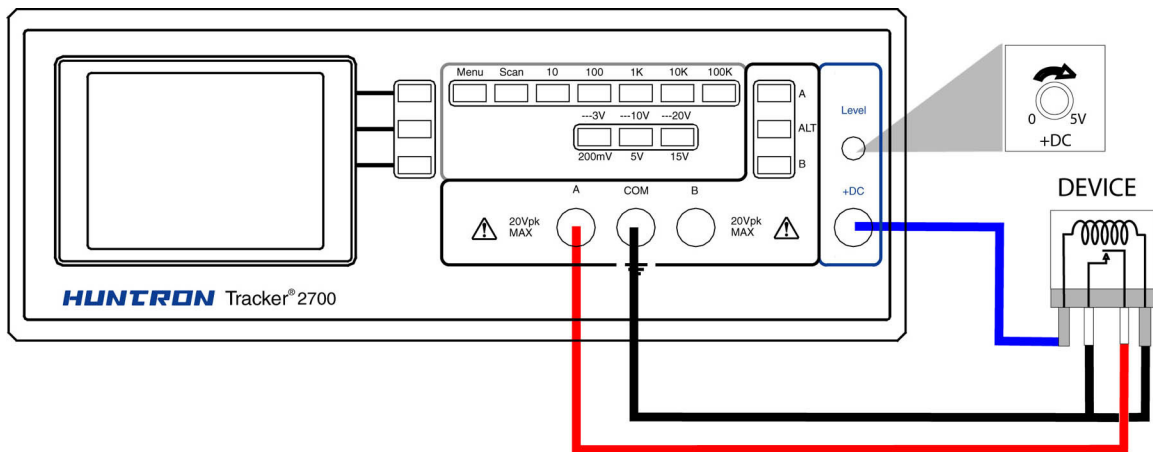

Figure 5-33. Tracker 2700 with Test Leads Connected to Relay's Coil

When applying Tracker 2700's test signal to the coil, there may be an audible ringing sound generated from the relay under test from the switch contacts being excited.

Review

- The Tracker 2700 can test switches in real time. This makes an excellent test for micro-switches, power switches, control switches, pressure and heat sensor switches.

- As the mechanical switch closes, watch for erratic or discontinuous signature. Switch bounce will display as multiple closure signatures.

SECTION 6
TESTING DISCRETE SEMICONDUCTORS

6-1.   Diodes

The most basic type of solid state semiconductor component is the diode. Diodes are formed by creating a junction between p-type and n-type semiconductor material. The PN junction gives diodes and semiconductor components polarity characteristics that allow them to conduct current when an external voltage is applied. They conduct current in one direction, but not in the other. Current flows in a diode when the positive terminal (anode) is made more positive than the negative terminal (cathode) by a predetermined value according to the specifications of the device. Figure 6-1 shows how the diode symbol indicates the polarity of the diode.

Figure 6-1. Diode and Schematic Symbol

DIODE TRACKER SIGNATURES

Diode signatures demonstrate the fundamental operation of a semiconductor junction. There is a threshold or forward voltage V_F (about 0.6V for a silicon diode) at which the diode begins to conduct current. The diode acts as an open circuit and no current flows as long as the voltage differential between the anode and cathode is below that threshold. As the anode to cathode voltage becomes more positive, the diode will begin to conduct current. Once current begins to flow in the diode, very small increases in anode voltage will cause very large increases in current. In Tracker Signature Analysis, this is called the "knee" effect in which is the characteristic of a good semiconductor junction.
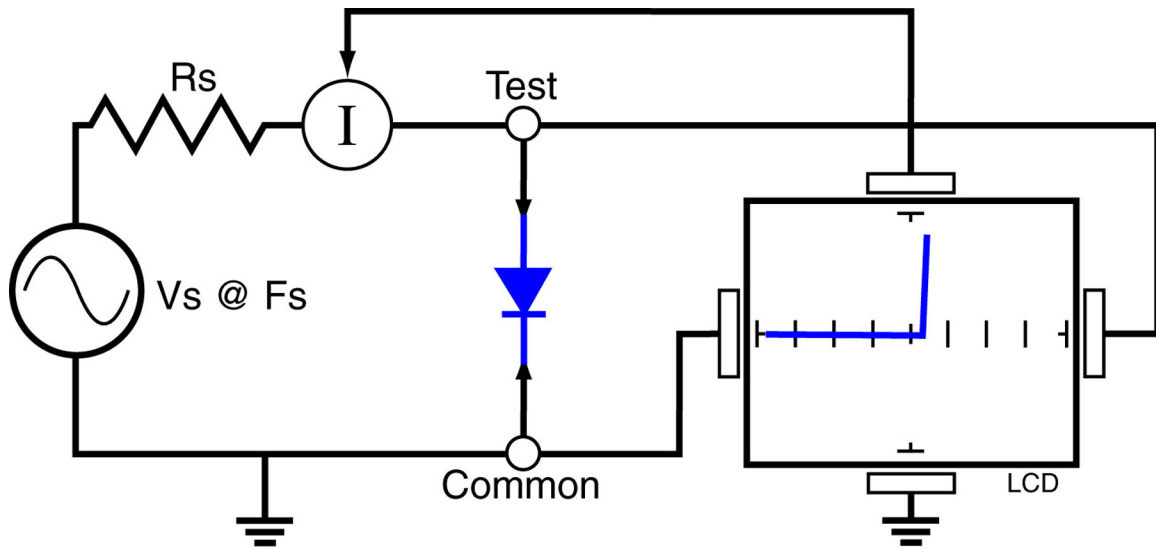
Figure 6-2. Tracker Core Circuit Block Diagram with a Diode

You can see this "knee" signature on some diodes in the next section.

1. Turn power on to your Tracker 2700.

2. Select the **10V, 100Ω** range. Select **60HZ.**

3. Place or clip the red test lead from the Tracker 2700's A test terminal to anode lead of the diode.

4. Place or clip the black test lead from the Tracker 2700's Common terminal to cathode lead of the diode.
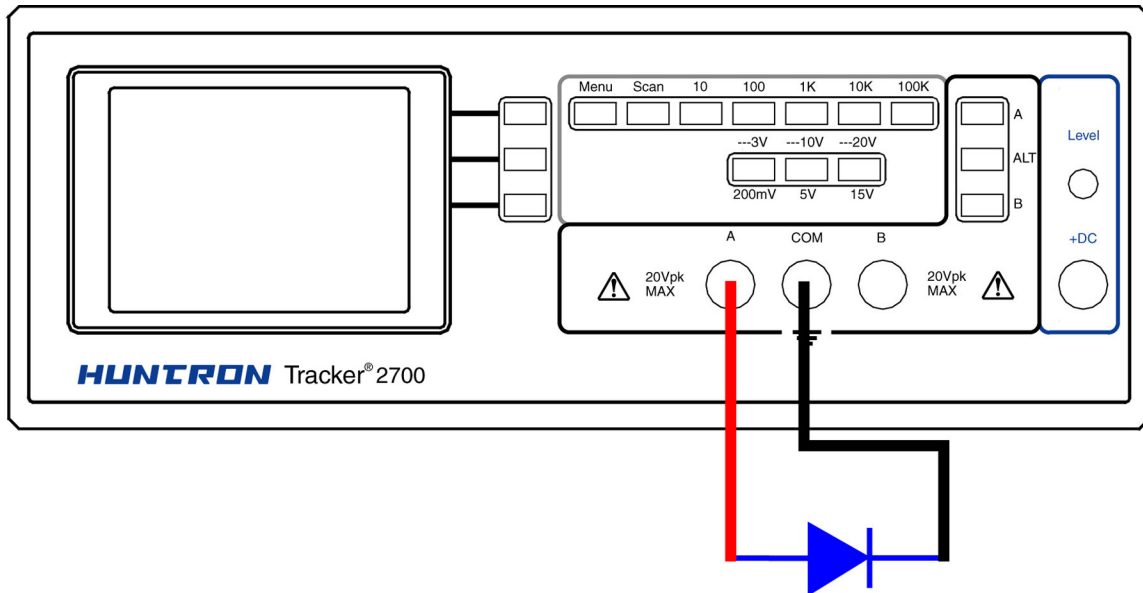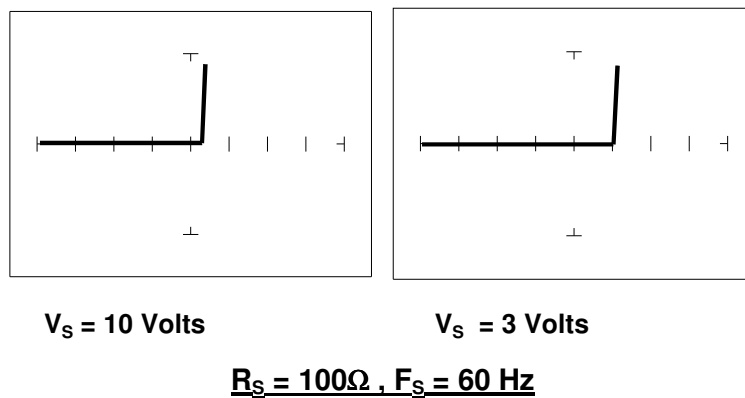
Figure 6-3. Tracker 2700 with Probes to a Diode

V_S = 10 Volts   **V_S = 3 Volts**

$$\underline{R_S = 100\Omega , F_S = 60 \text{ Hz}}$$

Figure 6-4. Signature of a 1N914 Type Silicon Diode

The diode signatures shown above are similar. The test signal voltage for the signature on the left is 10 V_P. Each horizontal division on the display equals approximately 2.5 V. In this range the diode's signature shows that its threshold or forward voltage is approximately 0.6 Volts. By selecting the 3V test signal voltage, the 0.6 volt threshold is clearly visible for easier analysis.

Effects of Frequency (F$_s$) on the Diode Signature

Signatures of the same diode at different frequencies are shown below.

At F$_S$ = 2000Hz, the diode's signature has a slight circular loop added to it. This loop in the signature is due to a physical characteristic of diodes called junction capacitance.

60 Hz   **2000 Hz**

V$_S$ = 3 V, R$_S$ = 100Ω
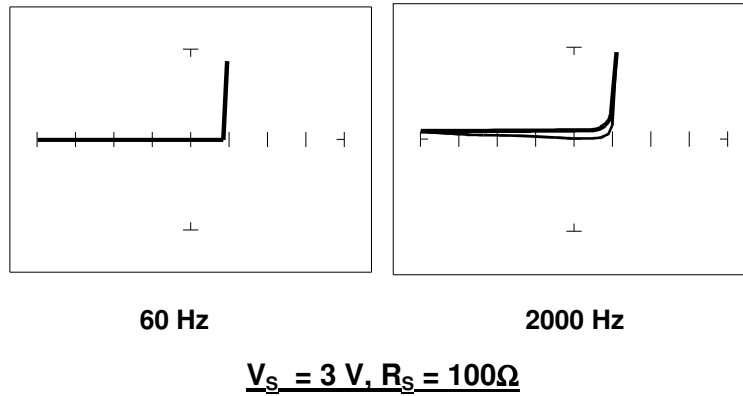
Figure 6-5. Signature of a 1N914 Diode at Different Range Frequencies

Effects of Internal Resistance (R$_s$) on the Diode Signature

Changing Tracker 2700's internal resistance R$_S$ moves the vertical knee portion of the diode's Tracker signature. As R$_S$ increases, the knee of the signature moves inward toward the origin. R$_S$ controls the current that's flowing through the diode so the forward diode voltage changes in response to the current change.

R$_s$= 100Ω   **R$_S$ = 100 kΩ**

V$_S$ = 3 V, F$_S$ = 60 Hz
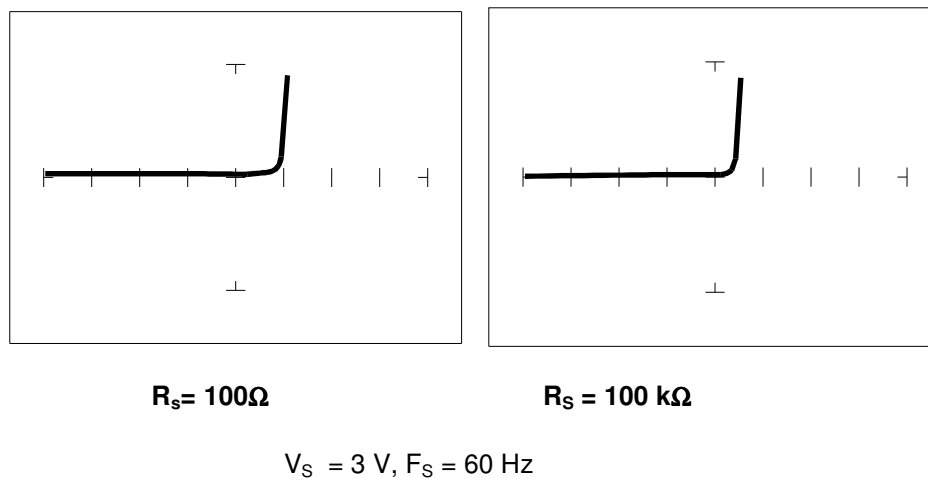
Figure 6-6. Signature of a 1N914 Diode at Different Range Resistances

Understanding Diode Signatures

Figure 6-7 reviews the Tracker 2700's three range parameters and how they affect the diode signature.
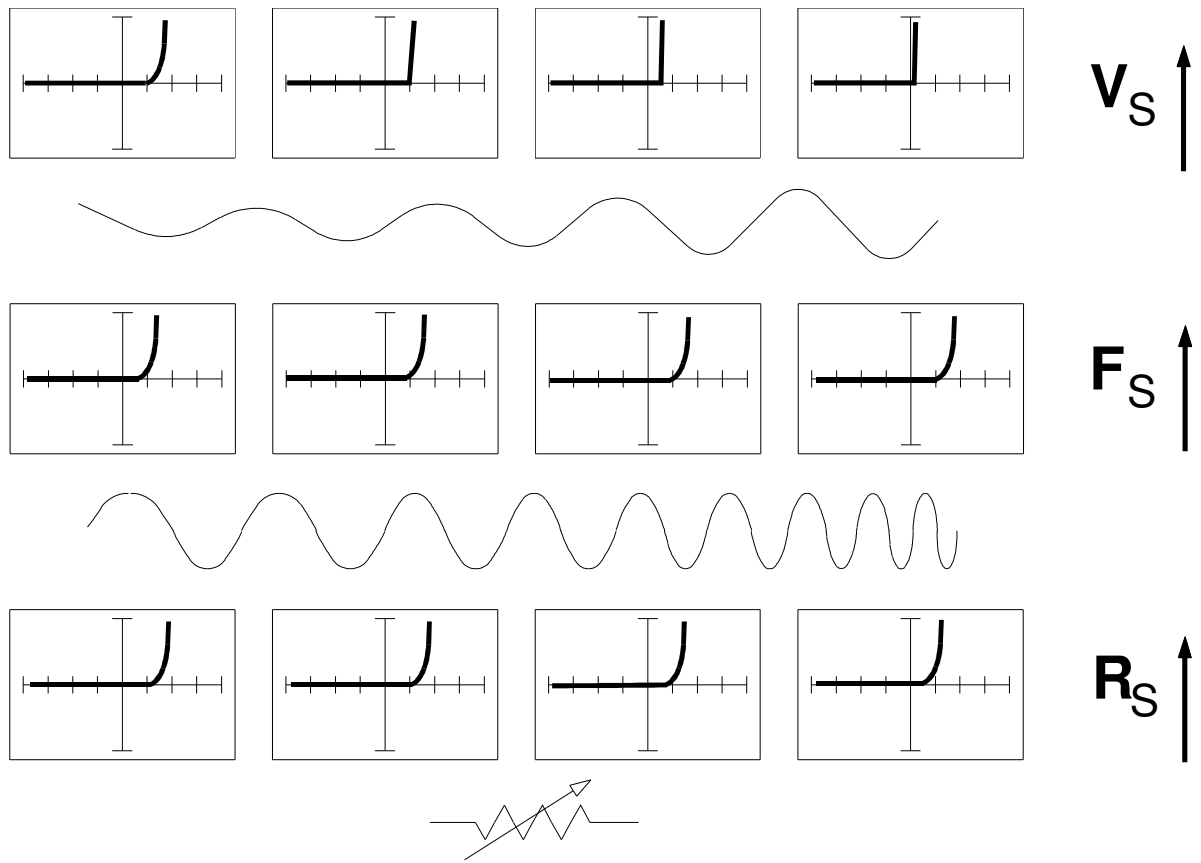

Figure 6-7. Range Parameters Changes and Effects on Diode Signatures

The Composite Diode Signature

A composite Tracker signature is a combination of several components connected together in an electronic circuit. Up to this point, we have been showing you what the basic component signatures look like out of circuit. In the real world of electronics troubleshooting, components are connected together in a circuit and when testing with TSA, the signatures are a composite that may appear quite complex. However, with knowledge of TSA fundamentals and experience you will find that even the most complex looking signatures can be analyzed quickly and efficiently.

This section will introduce you to some examples of composite diode signatures.
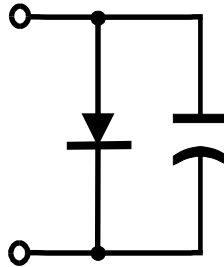
Figure 6-8. Composite Model of a Diode and Capacitor in Parallel
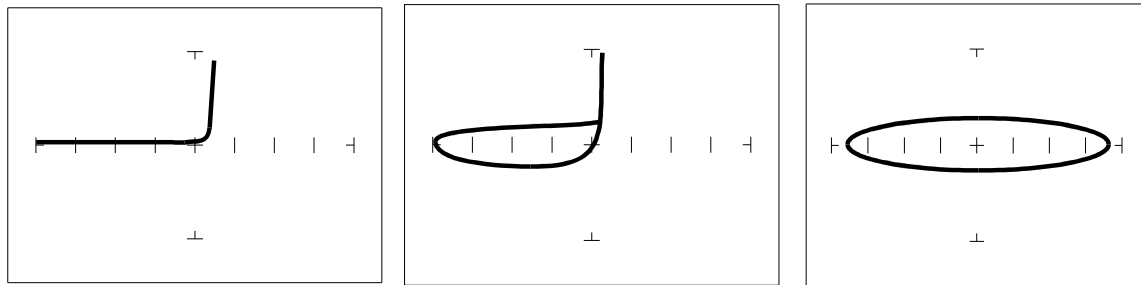
V_s=10V, F_s=20Hz V_s=10V, Fs=200Hz V_s=200mV, Fs=200Hz

Figure 6-9. Composite Signature - 1N914 Diode and 1μF Capacitor in Parallel

$\underline{R_S = 100\Omega}$

The signature on the left shows only the diode signature because the test signal frequency is set below any visible contribution due the capacitive reactance. The composite signature in the center consists of the distinctive loop of the capacitor and the "knee" pattern of the diode. The signature on the right shows only the capacitor signature because the test signal voltage is below the diode's voltage threshold. When multiple components are connected together, it's important to realize that the Tracker 2700 has the ability to selectively display the signature of a single component.
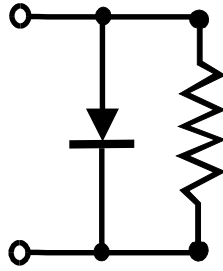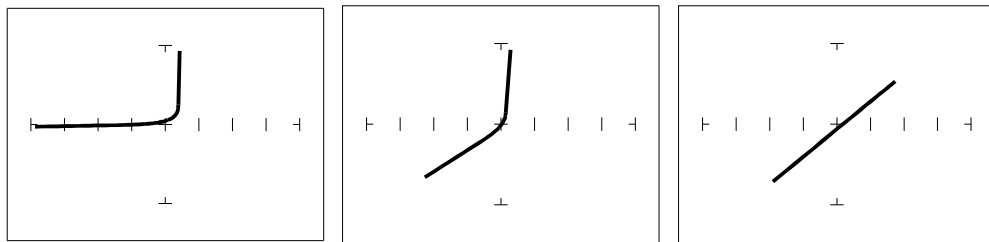
Figure 6-10. Composite Model of a Diode and Resistor in Parallel

V$_S$ = 10V, R$_S$ = 100Ω   V$_S$=10 V, R$_S$= 1 kΩ   V$_S$ =200 mV, R$_S$= 1 kΩ

F$_S$ = 60 Hz

Figure 6-11. Composite Signature - 1N914 Diode and 1.5 kΩ Resistor in Parallel

The signature on the left shows only the diode signature because the test signal resistance is set below any visible contribution due to the 1.5 kΩ resistor. The composite signature in the center consists of the distinctive slope of the resistor and the "knee" pattern of the diode. The signature on the right shows only the resistor signature because the test signal voltage is below the diode's threshold voltage. Again, when multiple components are connected together, it's important to realize that the Tracker 2700 has the ability to selectively display the signature of a single component.

Diode Failures

Diodes can fail in a number of ways, and each type of failure will cause the signature to change. The defective diodes often appear as open and short signatures. Two other types of flaws are internal resistance and leakage.
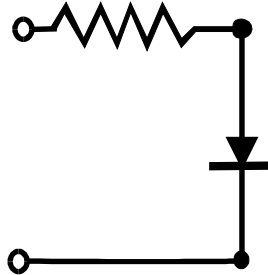
Internal Resistance Flaw in a Diode

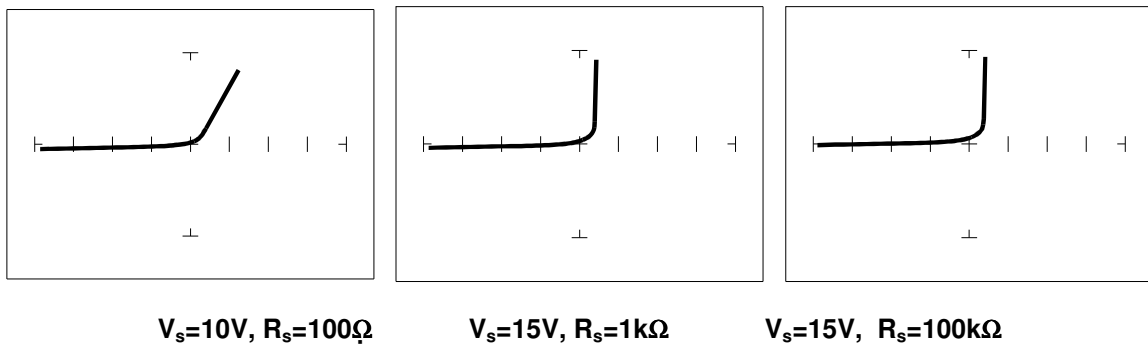Figure 6-12. Defective Diode Model with a Small Series Resistor

$V_s=10V, R_s=100\Omega$ $V_s=15V, R_s=1k\Omega$ $V_s=15V, R_s=100k\Omega$

Figure 6-13. Defective Diode Signature With A 50Ω series Resistor

The **10V,100Ω** range shows that there is a resistive component to the signature when the diode is conducting. This is the result of a defect in the diode's internal PN junction. The resistance is visible only in this range because the voltage drop across it is small. In the other two ranges, the diode's series resistance is masked due to the internal resistances being too large to show such a small voltage drop.
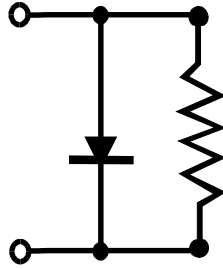
Internal Leakage Flaw in a Diode

Figure 6-14. Defective Diode Model with an Internal Leakage Resistance

V$_s$=10V, R$_s$=100 Ω　　**V$_s$=15V, R$_s$=1 kΩ**　　**V$_s$=15V, R$_s$=10 kΩ**
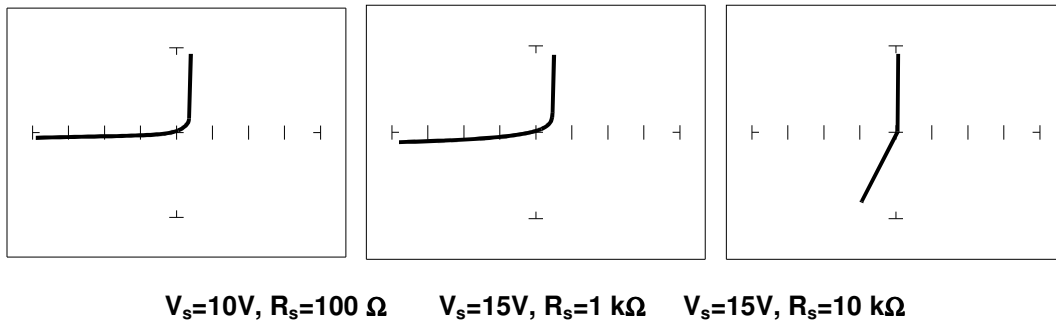
Figure 6-15. Signature of a Diode with Internal Leakage Flaw. 1N914 Diode with a 10kΩ Resistor in Parallel

Notice that in the **10V,100Ω** range there does not seem to be any problem, but that in the other two ranges, you can see the diode conducting when it should be acting like an open. This is called leakage. The diode acts like a diode when it is forward biased. When reverse biased, the diode acts like a resistor when it should be acting as an open.

Zener Diodes

Normal switching and signal diodes conduct when forward biased only. When reverse biased, they act as opens unless they are operated outside design limits. If this condition occurs then so much voltage is applied that they break down and can no longer prevent current flow.

A zener diode is a different type of diode and is designed for operation when reverse biased (diode's cathode connected to positive and anode to negative), but under carefully controlled conditions. When the zener diode is forward biased (diode's cathode connected to negative and anode connected to positive), they act as regular diodes and begin to conduct at approximately 0.6V.

When reverse biased, it acts as an open circuit until the applied voltage reaches it's specified zener voltage, at which time the zener diode begins to conduct current. Even if the reverse voltage is increased, the voltage across the zener remains constant. This characteristic of a zener diode allows it to be used as a voltage regulator and reference. The zener diode conducts in both directions, resulting in it's Tracker signature having two knees, one at 0.6V and the other at the zener voltage of the diode. In TSA terminology, this two knee signature is known as the classic "chair" pattern that is common in many solid state semiconductor components.
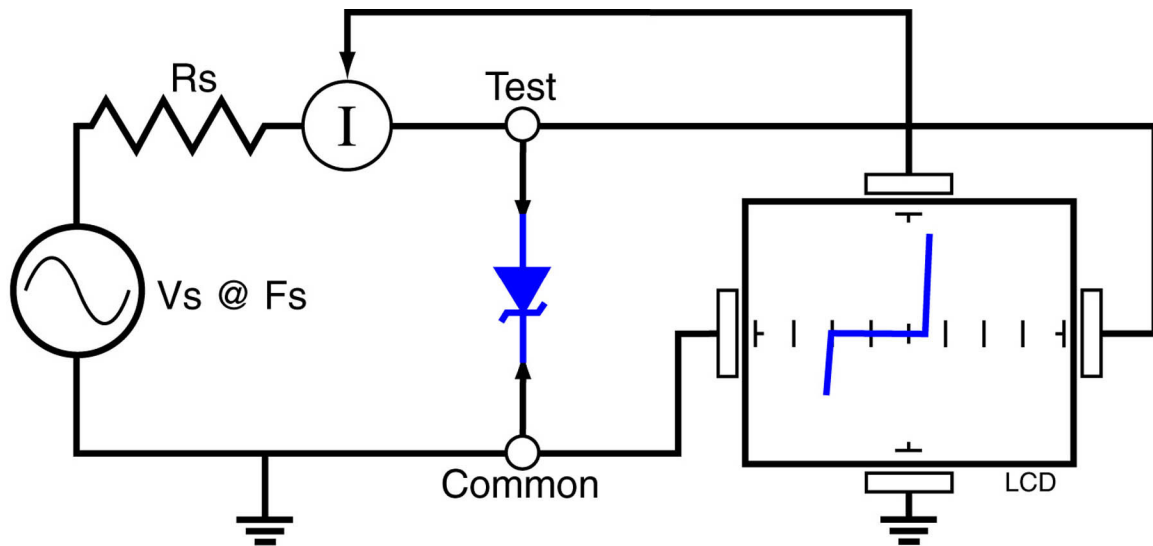

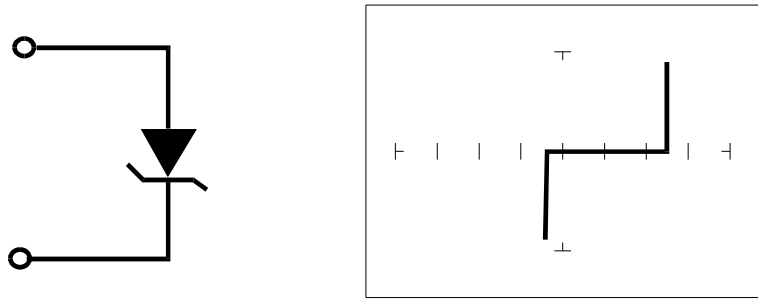Figure 6-16. Tracker Core Circuit Block Diagram with a Zener Diode.

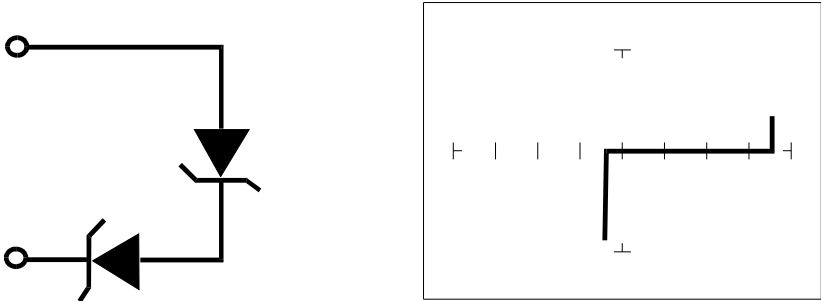Figure 6-17. Single Zener Diode 1N5239B and corresponding signature

Figure 6-18. Two Zener Diodes in series and corresponding signature.

Since each horizontal division on the LCD graticule (in **15V,1kΩ** range) is approximately 3.75 Volts, you can estimate that this is about a 9 volt zener diode. By connecting two Zener diodes in series, the rated voltage thresholds are doubled.

Review

- Diodes conduct current in one direction (forward biased) and not the other. The diode's Tracker signature displays this characteristic as the "knee" effect or pattern.

- Diodes have polarity, an anode and a cathode.

- Diode defects, other than opens and shorts, are usually resistive.

- A diode in series or parallel with a resistor or capacitor will create a composite signature displaying both characteristics. The Tracker 2700 makes it easier to separate these characteristics from composite signatures by adjusting F_S, R_S and V_S.

- Zener diodes are special diodes that conduct when reverse biased at a specific voltage.

Applying What We Have Learned

- Diode damage or degradation can appear as a loss of sharpness or rounding in the "knee".

- While faulty diodes display resistive current and voltage legs, they are usually nonlinear or curved.

- The polarity of an unmarked diode can be determined by the orientation of the display with a known diode.

- The Tracker 2700 can be used to identify an unknown zener diode. If the zener diode is damaged, locate a good one, possibly on another board or in the same circuit and use the Tracker 2700 to approximate the voltage.

- Look for the zener effect when checking voltage regulators such as the 7805 type. This can help determine an unknown or faulty device.

- The Tracker 2700 can be used to test and determine the four pin connections on a bridge rectifier, (AC1, AC2, + and -).

6-2. Transistors

A bipolar transistor is a three layer device. There are two basic types. A PNP transistor has a layer of n-type silicon material sandwiched between two layers of p-type material. An NPN transistor has a layer of p-type silicon material sandwiched between two layers of n-type material. Figure 6-19 shows the relationship between type of material and circuit symbol for a PNP and a NPN transistor.
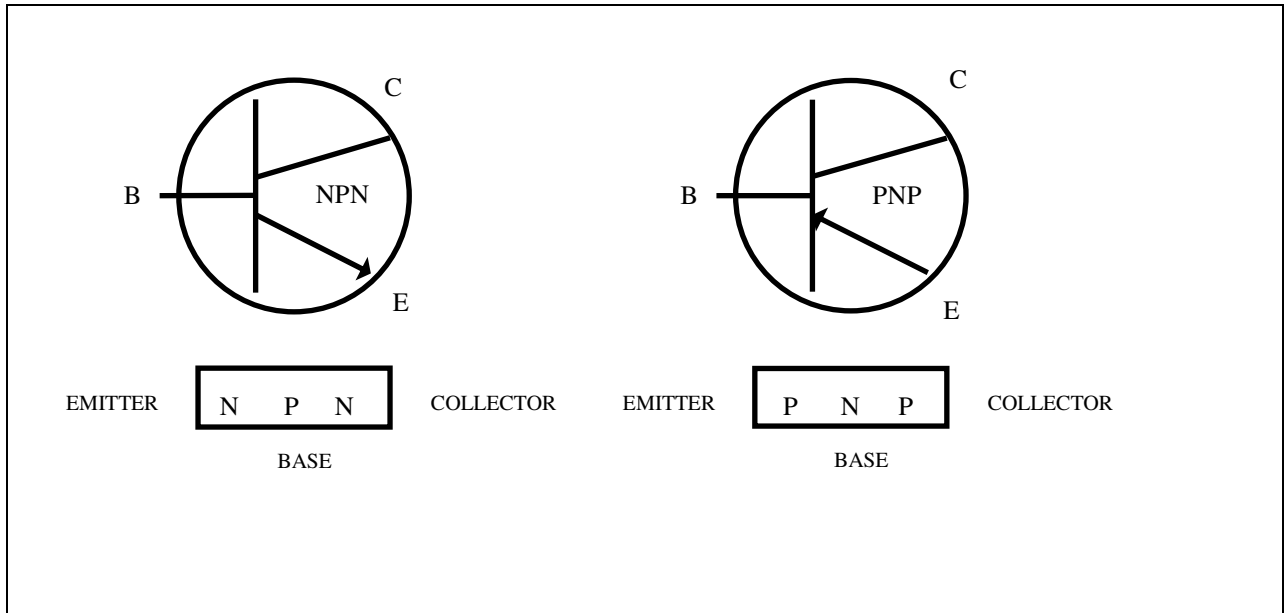

Figure 6-19. Diagram of an NPN and PNP Bipolar Transistor

Important Note

Use of this instrument may alter the current gain (h_{FE} or ß) of a bipolar transistor whenever the emitter is tested. Either the base-emitter or collector-emitter test circuits satisfy this criterion. While heating of the device due to the current produced by the instrument may cause a temporary change in h_{FE} (most noticeable in the low range), a permanent shift in h_{FE} may occur whenever the base-emitter junction is forced into reverse breakdown (~6-20 Volts). If the voltage is above 6 Volts, then the magnitude of the shift depends on the duration of the test and the resistance selected. Reducing the voltage to 5 Volts or less will avoid this problem.

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

Suggestions to minimize effects on bipolar transistors:

1. Use 5 Volts or less for testing the base-emitter or collector-emitter.

2. If using 6 Volts or greater, then keep the duration of the test as short as possible.

3. Identify the base, emitter and collector pins of the device and then test the collector-base junction to determine whether it is an NPN or PNP. Since the emitter is not tested there will be no effect on h_{FE} regardless of the selected voltage. Then use the three terminal test described in the "Using The DC Source To Test Transistor Operation" later in this section.

Bipolar Transistor Signatures

In order to better understand the signatures that transistors create on the Tracker 2700, we can model these devices in terms of equivalent diode circuits. These are shown in figure 6-20. These figures show that the collector-base junction Tracker signature looks similar to a diode signature and the emitter-base junction signature looks similar to a zener diode signature.
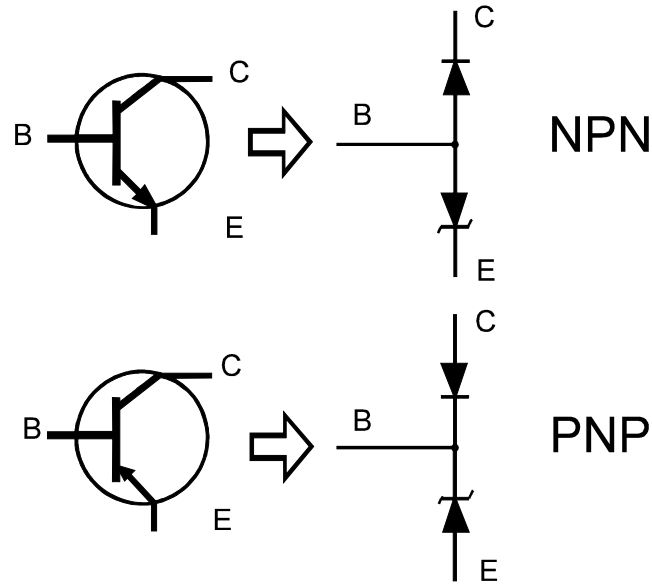

Figure 6-20. NPN and PNP Bipolar Transistors' Equivalent Circuits

Bipolar Transistor Base-Collector Signatures

1. Select the **15V, 10kΩ** range.

2. Place or clip the red test lead from the Tracker 2700's A test terminal to the Collector lead of the transistor.

3. Place or clip the black test lead from the Tracker 2700's Common terminal to Base lead of the transistor.
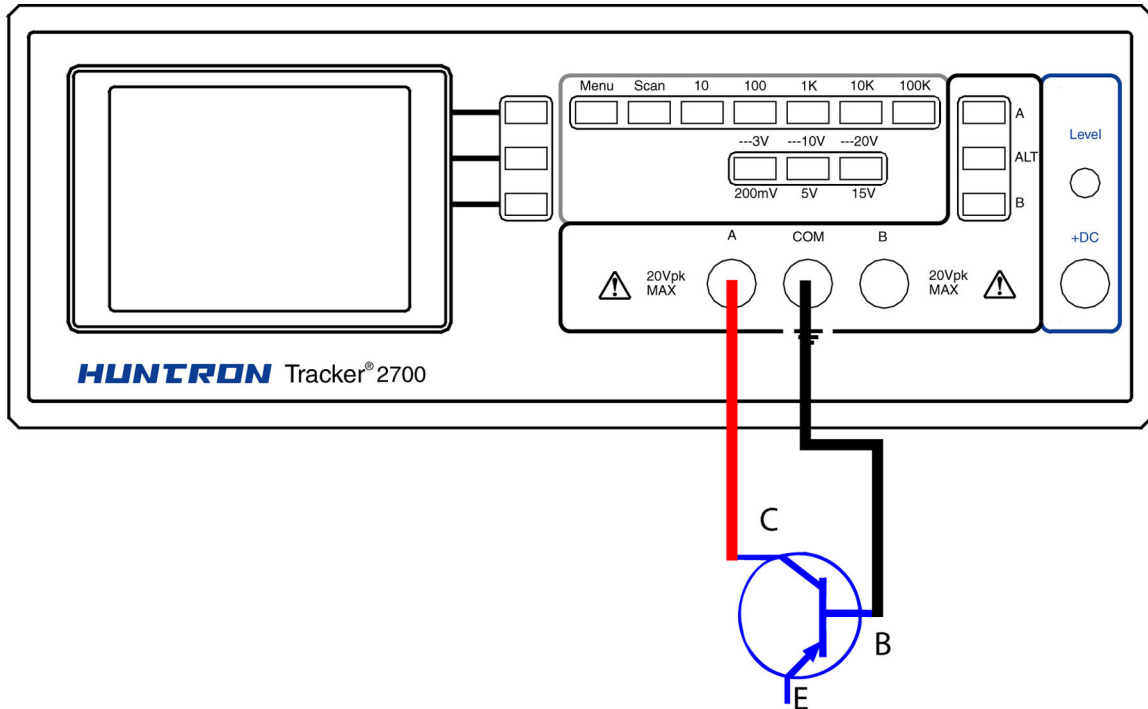

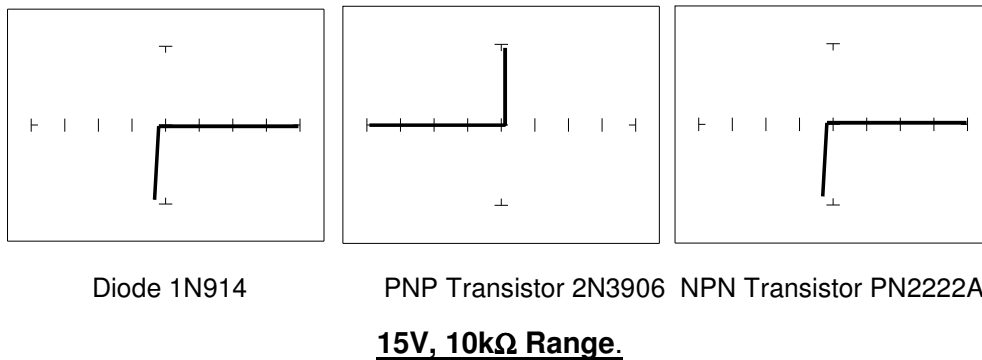Figure 6-21. Tracker 2700 Connected to the Collector and Base Leads of a Transistor

Diode 1N914   PNP Transistor 2N3906   NPN Transistor PN2222A
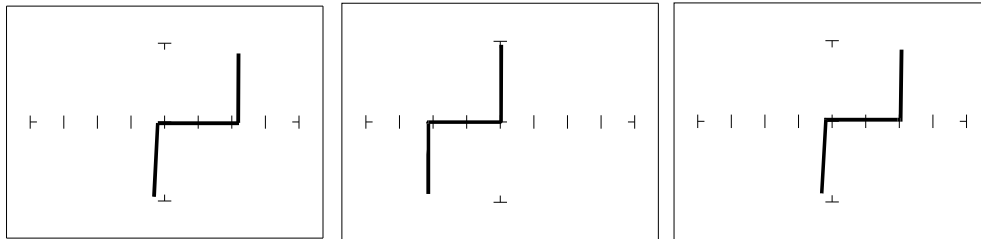
15V, 10kΩ Range.

Figure 6-22. Signature of a Diode and Collector-Base of a Transistor

Notice that the collector-base signature of a NPN transistor is identical to the signature of diode. The collector-base signature of a PNP transistor, which has opposite polarity from a NPN, looks

similar to a diode with its polarity reversed. These are the signatures we expected from our circuit modeling. We can do the same kind of comparison with the emitter-base circuits.

Zener Diode 1N5239B   PNP Transistor 2N3906 NPN Transistor PN2222A

5V, 10kΩ Range

Figure 6-23. Signature of a Diode and Emitter-Base of a Transistor

We can see that the base-emitter signature of the NPN transistor is nearly identical to the signature of the zener diode. The emitter-base signature of a PNP transistor is also nearly identical but opposite in polarity to the zener diode.
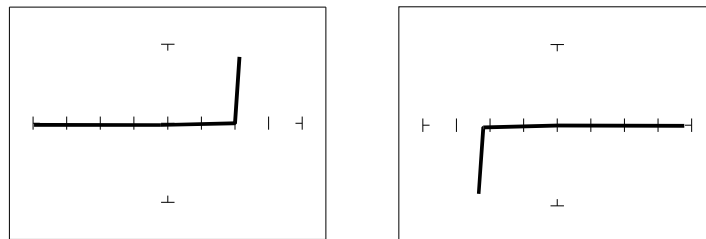
PNP Transistor - 2N3906   NPN Transistor - PN2222A

15V, 10kΩ Range

Figure 6-24 Signature of the Collector-Emitter of a PNP and NPN Transistor Emitter to Common

You can see that the collector-emitter signature of a PNP transistor looks like a forward biased diode with the knee at approximately +7 Volts. The collector-emitter signature of a NPN transistor looks similar to a reverse biased diode with the knee at approximately -7 Volts.

All bipolar junction transistors have essentially the same looking signatures.

Identifying Unknown Transistors

Sometimes, we need to identify unknown transistors. We may need to replace one in a circuit for which we do not have a schematic. The Tracker 2700 makes this a relatively simple procedure because each type of junction has a characteristic signature. This makes it possible to identify each of the terminals and the polarity of the transistor.

Do the following:

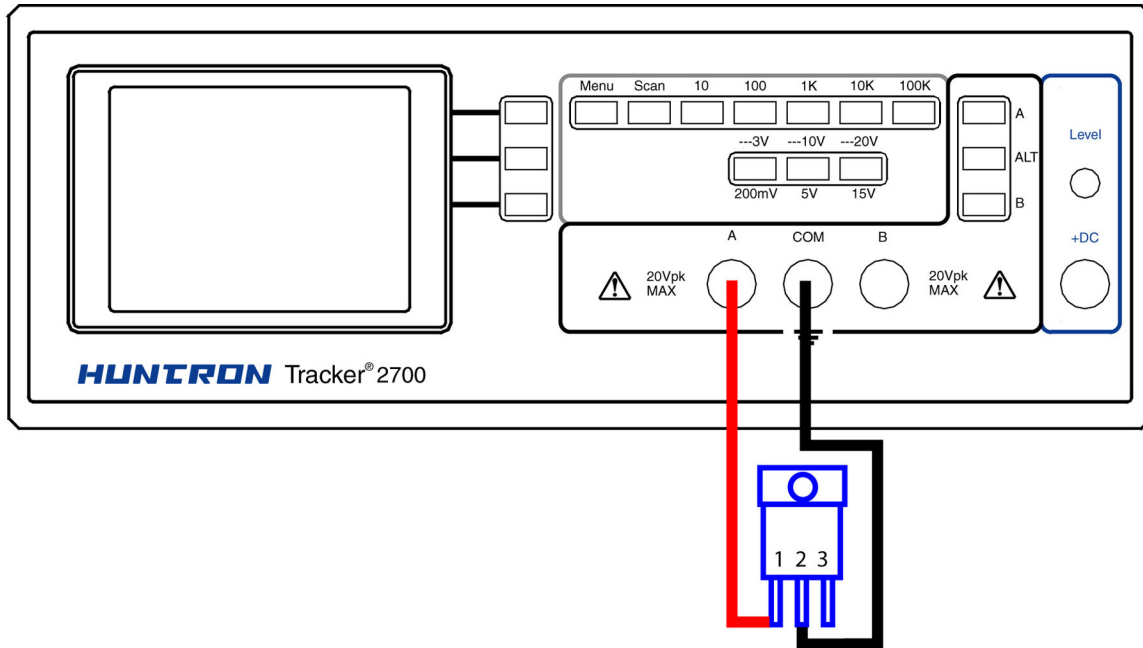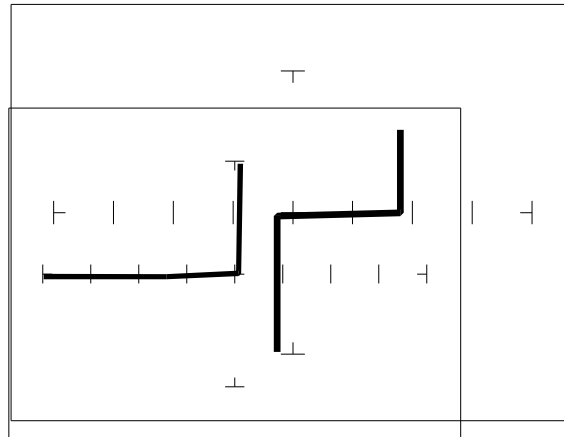1. Select the **15V, 10 kΩ** Range.

2. Set the frequency to **60 Hz**.

Figure 6-25. Tracker 2700 with Probes to an Unmarked Transistor

Do the following:

1. Probe pin 1 with the red probe and pin 2 with the black probe.

2. Identify the signature.

Figure 6-26. Signature of Pins 1 And 2 of an Unknown Transistor

This looks like a collector-base signature. What you do not know yet is which pin is the collector and which pin is the base.

3. Probe pin 3 with the red probe and pin 2 with the black probe.
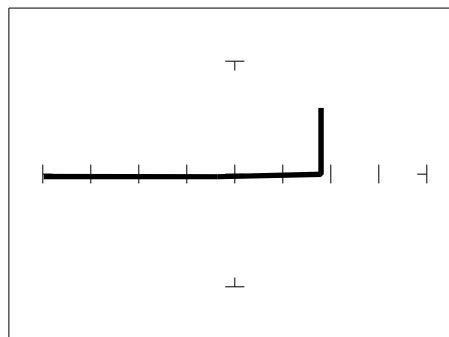
4.   Identify the signature.

Figure 6-27. Signature of Pins 2 and 3 of an Unknown Transistor

5. Now that you know that pin 2 of the unknown transistor is the collector, place the black probe to the base on pin 1 and move the red probe to the emitter on pin 3. A base to emitter signature will be displayed. This transistor is a NPN type since the base-emitter signature matches a NPN transistor.

Figure 6-28. Signature of Pins 1 and 3 of an Unknown Transistor

Darlington Bipolar Transistor Signatures

The Darlington transistor is basically two transistors paired together in a special configuration. The emitter of the first transistor is connected to the base of the second transistor. The collectors of both transistors are connected together. The base of the first transistor serves as the external base lead and the emitter of the second transistor serves as the external emitter lead. A block diagram of a darlington transistor and its Tracker signature are shown in the following figures.
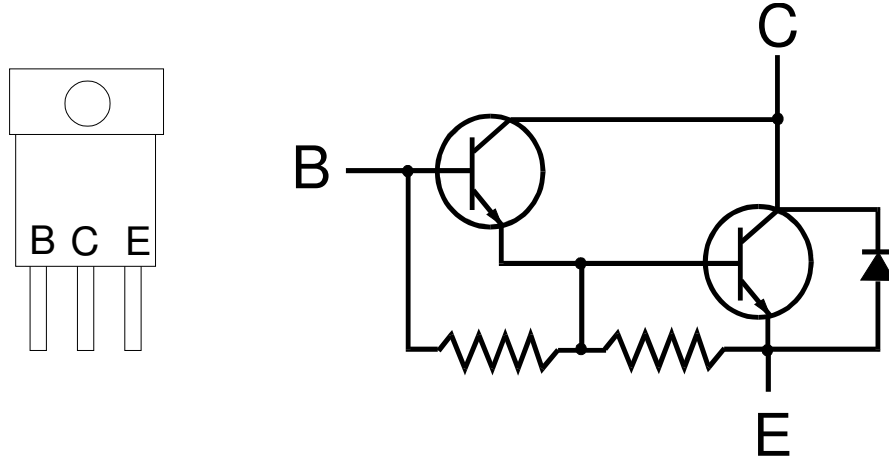

Figure 6-29. Diagram of a Darlington Transistor

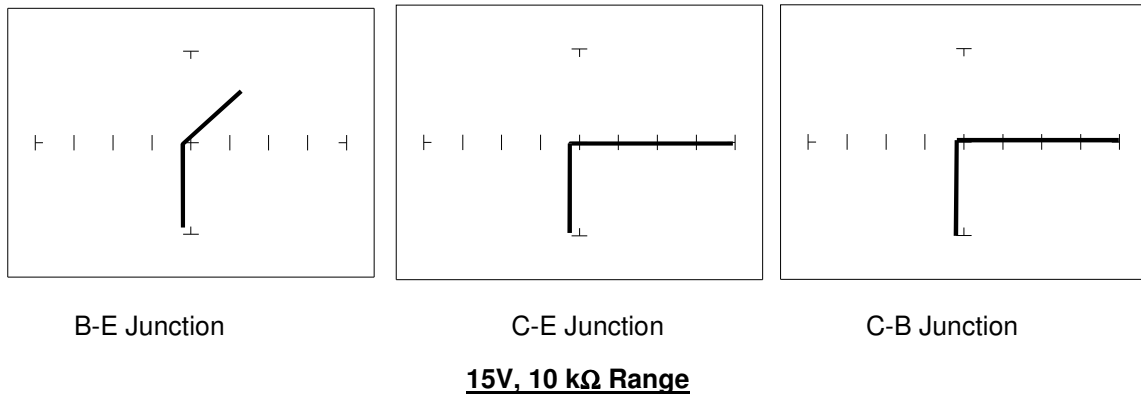| B-E Junction | C-E Junction | C-B Junction |

15V, 10 kΩ Range

Figure 6-30. Signature of a Darlington Transistor, TIP112 NPN Type. Base to Common, Emitter to Common

Note that the B-E junction has a sloped leg bend in its signature caused by internal resistors R1 and R2.

Using the DC Source to Test Transistor Operation

Figure 6-31a shows the test circuit for an NPN transistor using the DC Source to drive the base. The constant current signature produced is similar to that produced by a transistor curve tracer except that only one curve is shown instead of a family of curves. This technique can be useful for functionally testing and matching transistor gain characteristics.
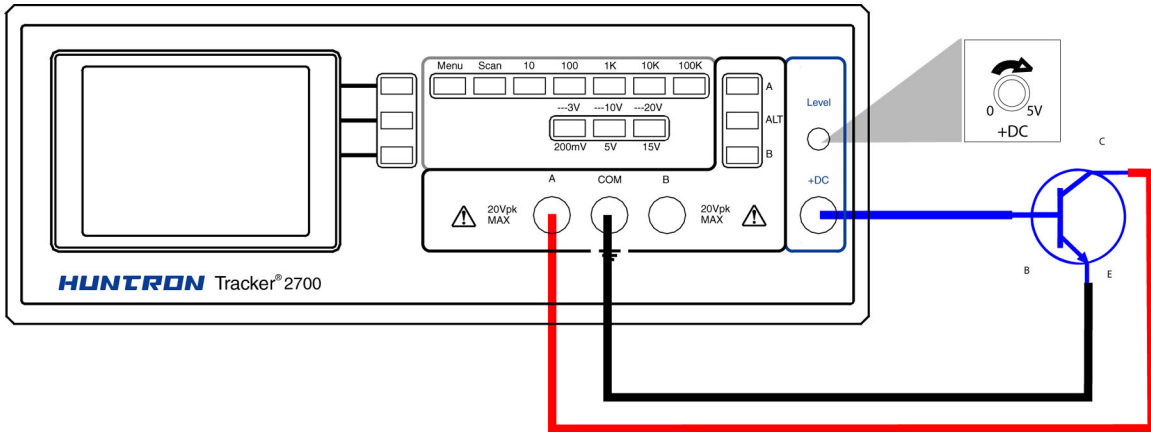

Figure 6-31a. DC Source Test Circuit for an NPN Transistor
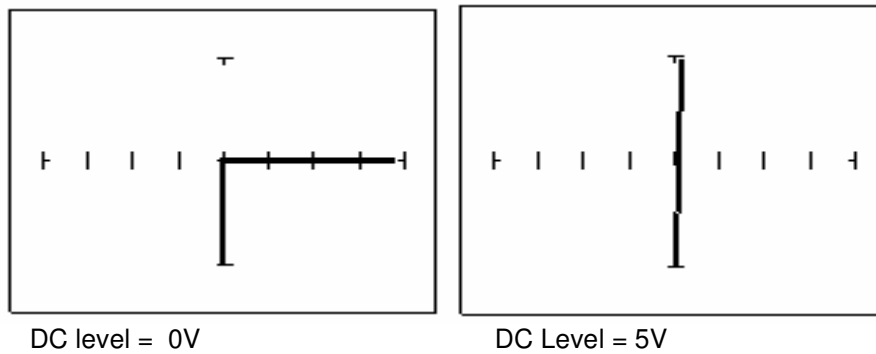

DC level = 0V   DC Level = 5V

Figure 6-31b. Signatures for Test Circuit with an NPN Transistor

Figure 6-32a shows the test setup for a PNP transistor. The displayed signature will be the result of the collector-base junction of the transistor.
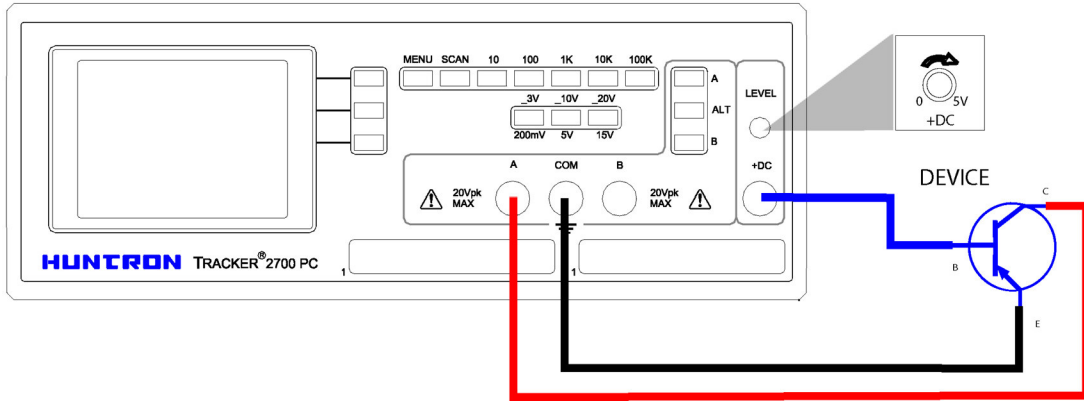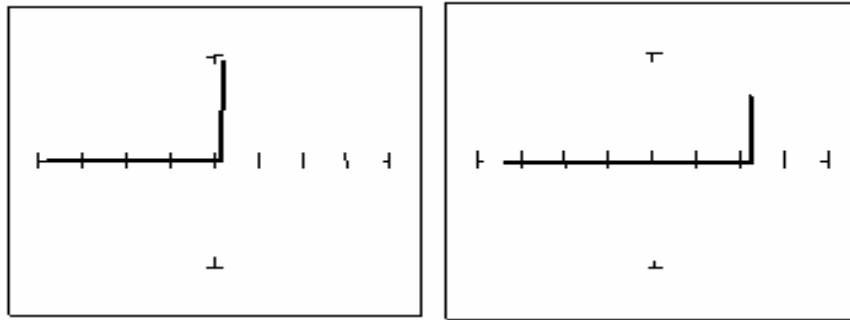

Figure 6-32a. DC Source Test Circuit for a PNP Transistor

DC Level = 0V   DC Level = 5V

Fig 6-32b. Test Circuit Signatures for PNP Transistor

Applying What We Have Learned

- Transistors will display the same type of faulty signature as diodes, with a rounded "knee" and non-linear or resistive current and voltage legs.

- The Tracker 2700 can be used to determine the type of transistor; bipolar, Darlington, FET, etc.

- The Tracker 2700 can be used to identify the polarity of a transistor (PNP or NPN).

- The Tracker 2700 can be used to determine the base, collector and emitter on an unknown transistor.

- The Tracker 2700 can be used to match the gain (beta) of two transistors.

- The above techniques of identification are invaluable when repairing foreign electronics and systems without schematics.

6-3. Solid State Switching Components

Optical Switches

There are two types of optical switches: phototransistors and optocouplers. Phototransistors can be used in two modes depending on the application. It can be used as either a light activated transistor or as a light activated diode. In either mode, light is used to turn it on and allow current to flow.

The optocoupler consists of a light emitting diode and a phototransistor in the same package. They are electrically isolated. When the diode is turned on by an external signal, it radiates light. This light falls on the phototransistor base junction that results in the device turning on.

Optocoupler Dynamic Testing

The Tracker 2700's DC Source can perform a dynamic test of optocouplers. Apply the DC Source's output to the control input of a switching device and connect Tracker 2700's test leads across the component's switch terminals. Observe the optocoupler's signature for on and off states.
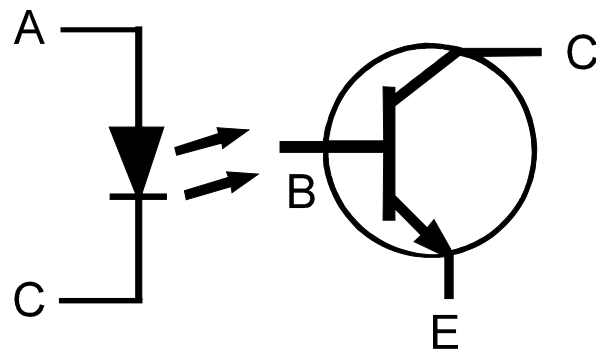

Figure 6-33. Diagram of an Optocoupler

Optocoupler Signatures

1. Select the **10V, 1kΩ** range.

2. Connect the black test lead or easy grabber from the Tracker 2700's Common test terminal to the transistor emitter lead and the diode cathode lead of the optocoupler.

3. Connect the red test lead or easy grabber from Tracker's A to the transistor collector lead.

4. Connect the DC Source +DC output using the blue easy grabber test clip to the diode anode lead.
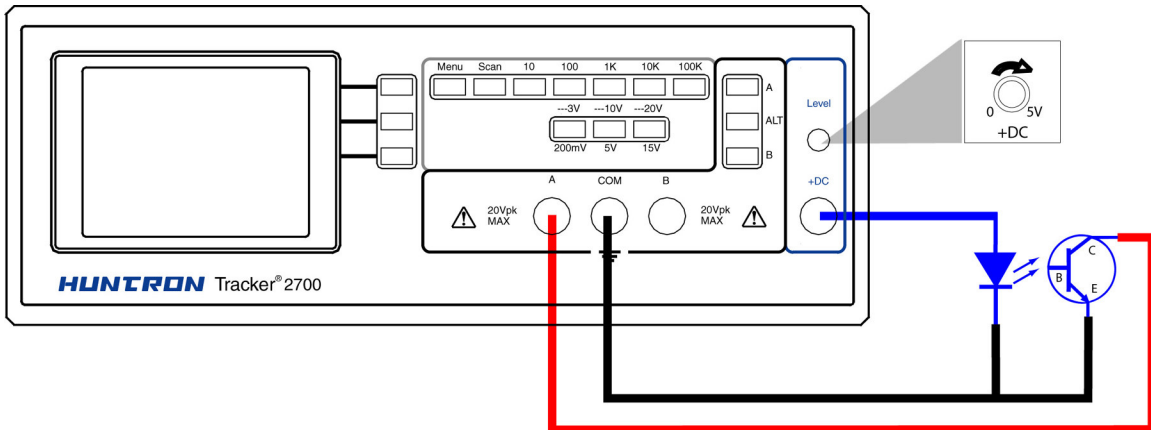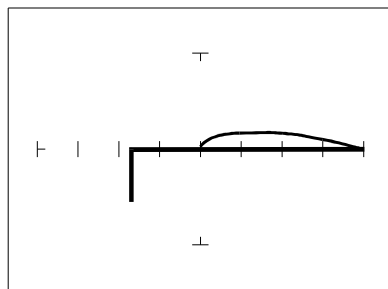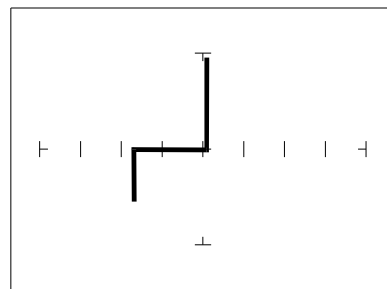

Figure 6-34. DC Source test for Optocoupler

Rotate the DC level knob all the way counter-clockwise to start at 0 V DC.

1. Rotate the knob clockwise to approximately halfway.

DC Level = 0V   DC level = 5V

10V, 1 kΩ Range

Figure 6-35. Signatures of an Optocoupler - 4N33 Type

SCRs And Triacs

SCRs and triacs are semiconductor components that are used in switching applications. A SCR (silicon controlled rectifier) is used for DC switching circuits. A triac is used for AC switching circuits. This section will demonstrate how to dynamically test these components.

Silicon Controlled Rectifiers (SCR's)

The SCR is a switching semiconductor device that conducts positive current only. Its symbol and equivalent circuit can be seen below. When the gate (G) is at the same voltage level as the cathode (K), the SCR acts as an open. When the gate is forced more positive than the cathode, positive current flows between the anode (A) and the cathode.
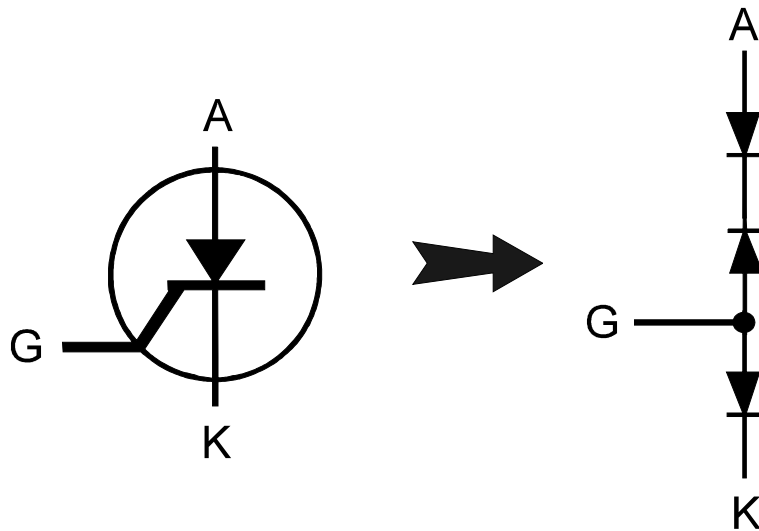

Figure 6-36. Diagram of a Silicon Controlled Rectifier

1. Select the **15V, 10 kΩ** range.

2. Place or clip the red test probe from the Tracker 2700's A test terminal to gate lead (G) of the component.

3. Place or clip the black test probe from the Tracker 2700's Common terminal to anode lead (A) of the component.

4. Observe the gate-anode signature of the SCR.

5. Move the black test probe from the SCR's anode lead to cathode lead (K) of the component.

6. Observe the anode-cathode signature.

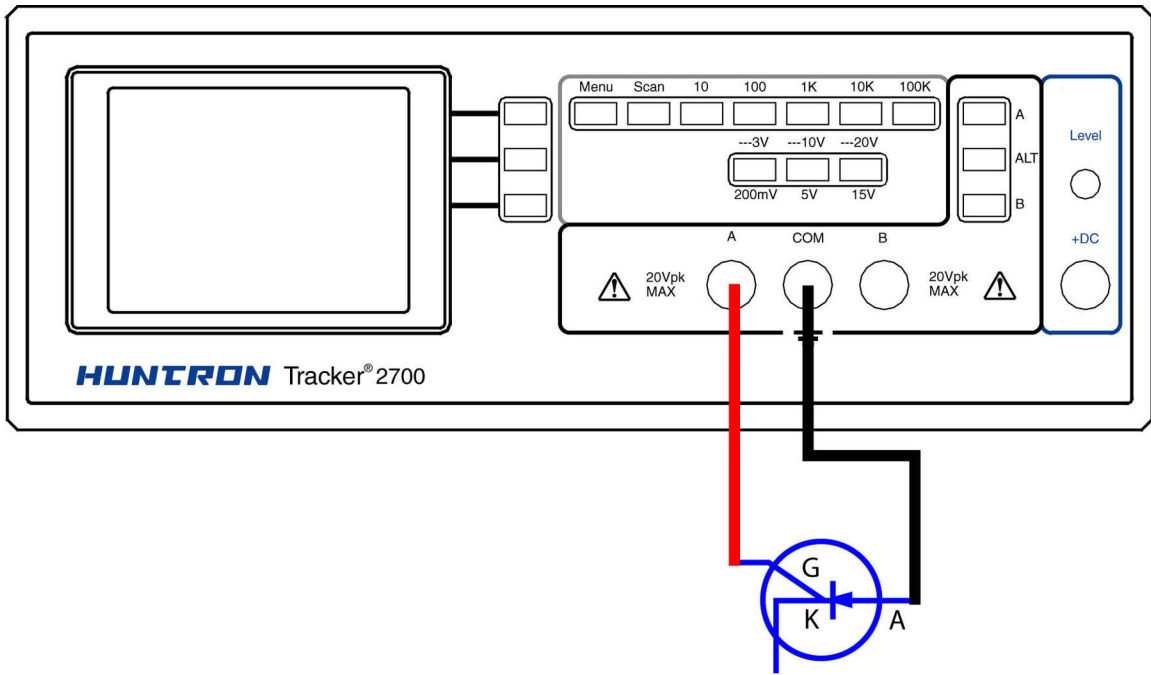7. Observe the gate-cathode signature of the SCR.

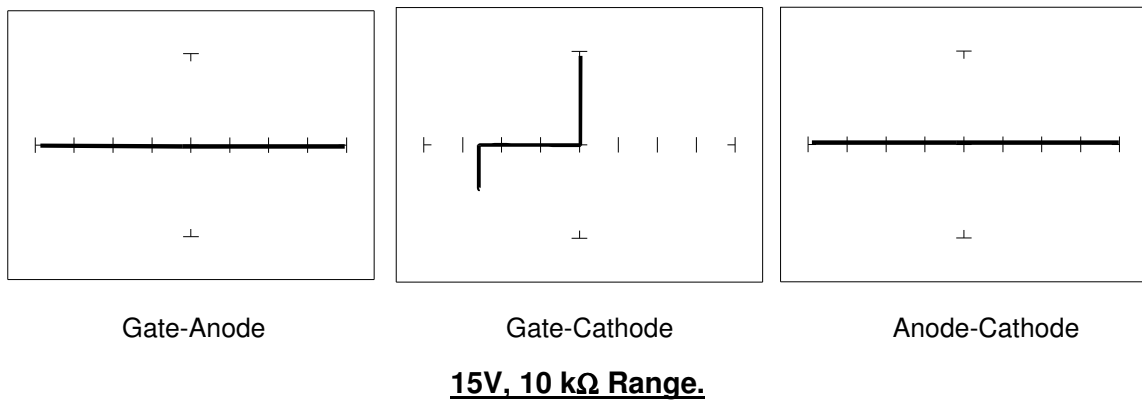Figure 6-37. Tracker 2700 with Test Leads to a SCR

| Gate-Anode | Gate-Cathode | Anode-Cathode |

15V, 10 kΩ Range.

Figure 6-38. Signatures of a SCR - C106B Type

Active Testing of a SCR

Connect the SCR to the Tracker 2700 as illustrated below:
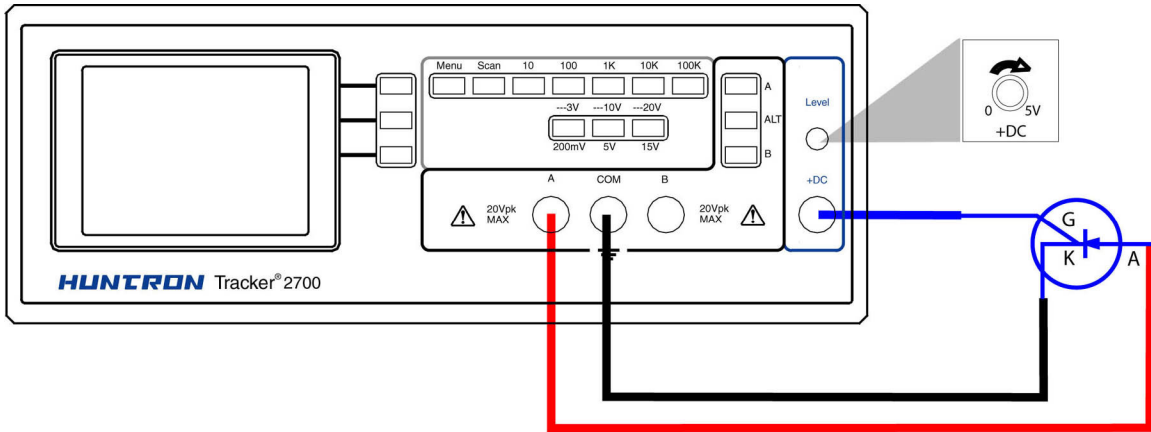
Figure 6-39. DC Source Test Circuit for a SCR

Do the following to dynamically test a SCR using the Tracker 2700:

1. Select the **10V, 1 kΩ** range.

2. Set the frequency to **60 Hz**.

3. Connect the blue easy grabber from Tracker 2700's DC Source +DC output terminal to the component's gate lead.

4. Connect the red test probe from Tracker 2700's A test terminal to the SCR's anode lead.

5. Connect the black test probe from Tracker 2700's Common test terminal to the SCR's cathode lead.

6. Turn the DC Level knob clockwise to increase the voltage level from 0 VDC.
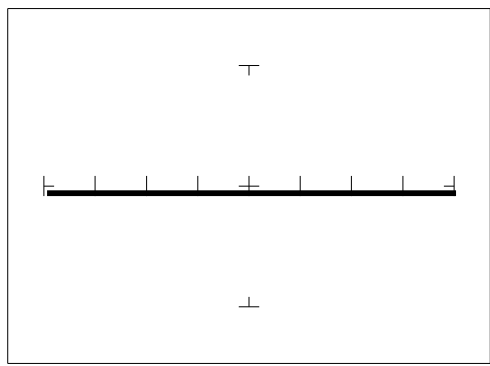
DC Level = 0V   DC Level = 5V
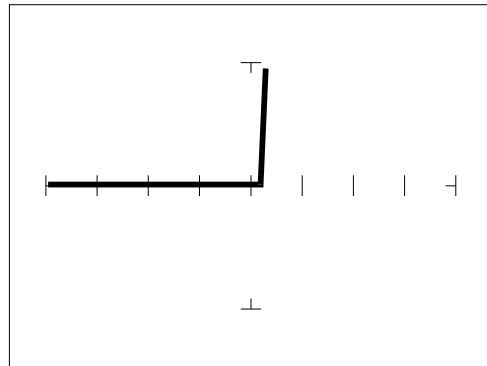
10V, 1 kΩ range

Figure 6-40. Signature of a SCR (C106B Type) with the DC Source Test

Observe that as the test voltage increases to about 0.6 Volts, the SCR begins to turn on. Watch the signature change from an open signature to a diode signature.

Applying What We Have Learned

• The Tracker 2700 can also dynamically test optocouplers and phototransistors. These components are commonly found in isolation and switching circuits. Their operation can slowly deteriorate making them intermittent. This type of problem is extremely difficult to troubleshoot. With Tracker signature analysis, the Tracker 2700 will detect small amounts of degradation in an optocoupler's LED and the phototransistor's emitter-collector junction.

• The SCR and TRIAC can also be a problem to troubleshoot. They may be used to switch large currents. Quite often these components are susceptible to degradation and eventual failure. The Tracker 2700 can easily show these failures.

   Triacs are similar to SCRs and defective ones can be found in a similar fashion.

SECTION 7
TESTING INTEGRATED CIRCUITS

7-1.   Integrated Circuits

Digital integrated circuit (IC) chips are made from transistors on a common substrate. Their Tracker signatures are typically variations of the discrete diode and transistor signatures. Most logic ICs contain multiple circuits on one chip. These chips can have pins from 8 to over 200, although quite often many pins share quite similar signatures. This can make troubleshooting easier by giving us an easy-to-find signature to use as a comparison. In this section, it is important to understand how the Tracker 2700 and TSA respond to these circuits.

Integrated Circuit Failures

A functioning IC may stop working for a number of reasons. Some of the most common causes of IC failures are:

•   EOS: Electrical Over Stress. The IC's maximum electrical specifications have been exceeded. This condition may result in the IC developing internal shorts and opens.

•   ESD: Electrostatic Discharge. Repeated exposure may cause internal resistance to develop in the IC junctions. This internal resistance may vary from 5 kΩ to 25 kΩ with a typical value of 20 kΩ. ESD exposure can cause internal flaws such as resistance, opens and shorts.

•   Dendrites: A process flaw that results in particles growing between conductors on a substrate causing shorts.

•   Ionic Contamination: Contamination introduced at the time of manufacturing that develops into leakage between substrate channels. This causes 5 kΩ to 25 kΩ of resistance.

•   Purple Plague: Destructive interaction between gold and aluminum metal layers. Junction connections become very brittle and may cause internal opens.

•   Corrosion or Another process flaw in which aluminum metalization causes Electromigration pinholes, corrosion and resistance. This will create opens and resistance.

Important Note:

Occasionally, the signatures of ICs may exhibit discontinuities or fuzziness due to oscillation. Most often this occurs in the zener or avalanche breakdown region of the signature. To obtain a more stable signature, simply reduce the selected test voltage.

Digital Integrated Circuit Signatures

Before we examine the Tracker signatures of an IC, let's study the block diagram of a 74LS245 octal bi-directional bus buffer to introduce some basic concepts. This IC is a member of the low power Schottky transistor-transistor logic family (LSTTL). Examine the block diagram for this chip below. You will see that there are only four different kinds of circuits on this chip.
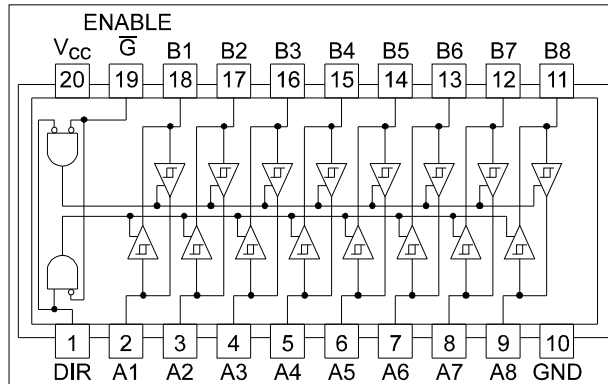

Figure 7-1. Digital IC 74LS245 Block Diagram

- Circuit 1 - Pins 2 through 9 and 11 through 18 are all the same function. Each pin is connected to both an input and an output of a buffer.

- Circuit 2 - Pins 1 and 19, although they have different names, are both enables and are inputs to AND gates.

- Circuit 3 - Power supply ground input, pin 10.

- Circuit 4 - Power supply V_{CC} input, pin 20.

Each circuit type will produce a different Tracker signature. Because there are only four types of circuits on the chip, there will be only four unique Tracker signatures when out of circuit.

Signatures Of A Digital IC

1. Select the **15V, 10 kΩ** range.

2. Place or clip the black test lead from the Tracker 2700's Common terminal to the IC's ground pin. For this example, the ground pin of the 74LS245 is pin 10.

3. Use the red test lead from the Tracker 2700's A test terminal. Probe each pin of the IC and view its signature on Tracker 2700's LCD display. For this example, pins 2 to 9 and 11 to 18 are all buffer circuits so they will have identical signatures. (Note: This is only for ICs out of circuit.)

4. Use the red test lead from the Tracker 2700's A test terminal. Probe the enable input pins of the IC and view their signatures on the LCD display. For this example, the enable pins of the 74LS245 are pin 1 and 19 and will have the same signatures. (Note: This is only for ICs out of circuit.)

5. Select the **10V, 100Ω** range. Use the red test lead from the Tracker 2700's A test lead. Probe the power supply V_{CC} input pin and view its signature on the LCD display. For this example, the V_{CC} pin of the 74LS245 is pin 20.
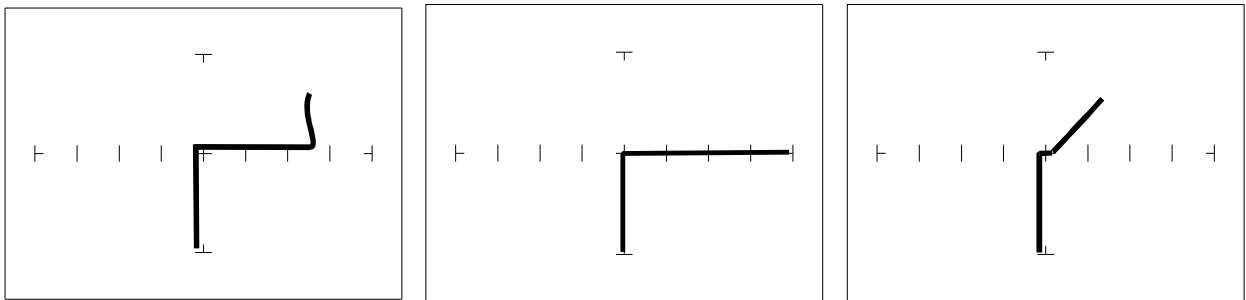
Buffer pins - **15V,10kΩ**   Enable pins - **15V,10kΩ** V_{CC} Power pin - **10V,100Ω**

Figure 7-2. Signatures of A Digital IC, 74LS245. Common To Pin 10 (Gnd)

Compare these signatures with other signatures of discrete components such as transistors and diodes. Note that there are quite a few similarities here.

Signatures For Different Logic Chip Families

There are a wide variety of logic circuit families. Each has its special functions, advantages, and limitations. They range from TTL and its variations (F, LS, S, etc.), emitter-coupled logic (ECL), to the complementary metal oxide semiconductor (CMOS) and its variations (C, HC, HCT, VC, etc.).

Comparing Two TTL Families

Although the logic function is the same, there are differences in the circuitry of each logic family. These differences can be readily seen in their signatures using the Tracker 2700.

We will illustrate these concepts with the following example of two hex inverters, a 7404 and a 74LS04 from different logic families. From the logic diagram below, you can see that they have the same logic functions and pin order. The difference is that the LS chip uses Schottky transistors in its internal construction for increased performance and reduced power consumption. Note that there are only four types of circuit connections and therefore only four signatures on this chip: inverter inputs, inverter outputs, V_{CC} and ground.

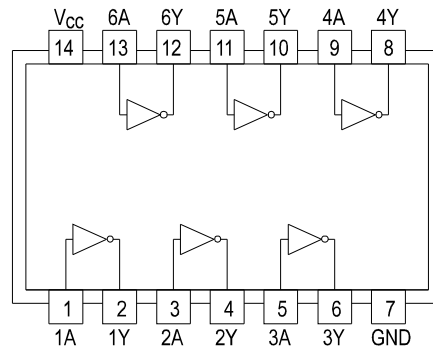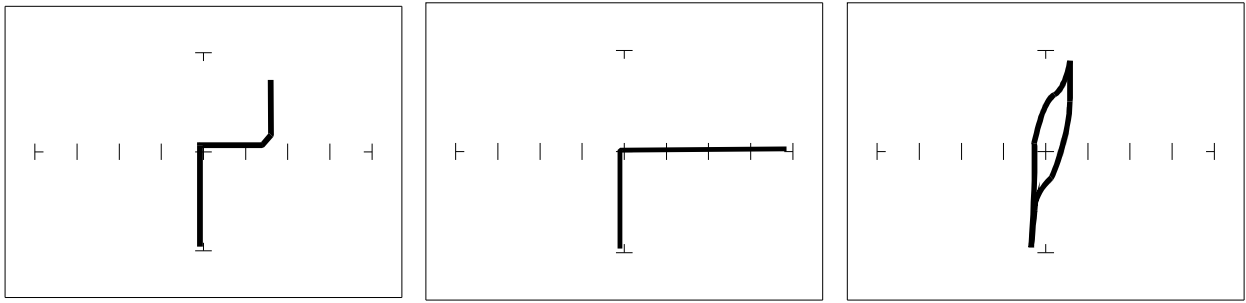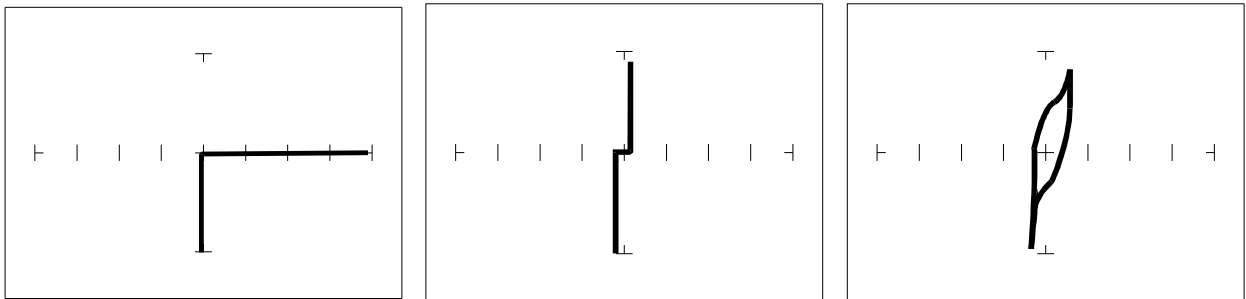Figure 7-3. Diagram Of 7404 & 74LS04

Pin 1 input - **15V,10 kΩ**   Pin 2 output - **15V,10 kΩ**   Pin 14 power - **10V, 100Ω**

Figure 7-4. Signatures Of A 7404 Hex Inverter. Common To Pin 7(Gnd)

Pin 1 input - **15V,10 kΩ**   Pin 2 output - **15V,10 kΩ**   Pin 14 power - **10V,100Ω**

Figure 7-5. Signatures Of A 74LS04 Hex Inverter. Common To Pin 7 (Gnd)

Note the differences between the two logic families. They have the same logic function but different construction, therefore different signatures. To test one of these chips without another reference chip available just compare each input's signature with the other five inputs. Similarly, compare each output's signature with the other five outputs.

CMOS Logic Family

CMOS circuits are constructed differently than TTL circuits. The inputs to CMOS transistors are capacitive due to the use of field-effect transistors (FET) instead of bipolar transistors used in TTL.

In this example, we will choose a 74HC14 Schmidt Trigger Hex Inverter. The HC designation means that it's a member of the high-speed CMOS logic family. From the block diagram of this part, you can see that it has only four different circuit functions. They are inverter input, inverter output, power supply V_{CC} input, and power supply ground.

V_{CC}	6A	6Y	5A	5Y	4A	4Y
14	13	12	11	10	9	8

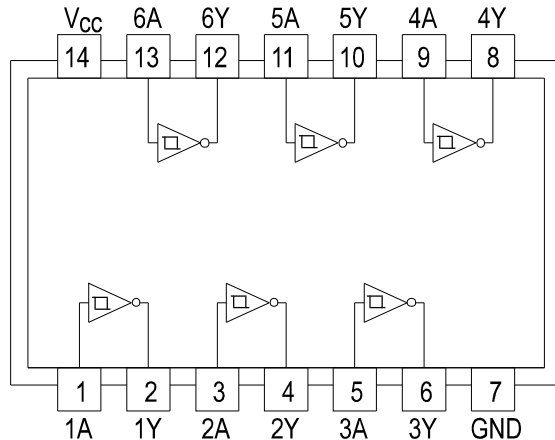| 1	2	3	4	5	6	7
1A	1Y	2A	2Y	3A	3Y	GND

Figure 7-6. Diagram Of 74HC14

1. Select the **10V, 100Ω** Range.

2.   Set the test signal frequency to **60 Hz**.

3. Place or clip the black test lead from the Tracker 2700's Common terminal to the IC's ground pin. For this example, the ground pin of the 74HC14 is pin 7.

4. Use the red test lead from the Tracker 2700's A test terminal and probe each pin of the IC. For this example, pins 1, 3, 5, 9, 11, and 13 are all input buffer circuits so they will have identical signatures. (Note: This is only for ICs out of circuit.)

5. Similarly, use the red test lead and probe the output buffer pins 2, 4, 6, 8, 10, and 12. These pins will have the same signatures. (Note: This is only for ICs out of circuit.)

6. Use the red test lead from the Tracker 2700's A test terminal and probe the power supply V_{CC} input pin. For this example, the V_{CC} pin of the 74HC14 is pin 14.
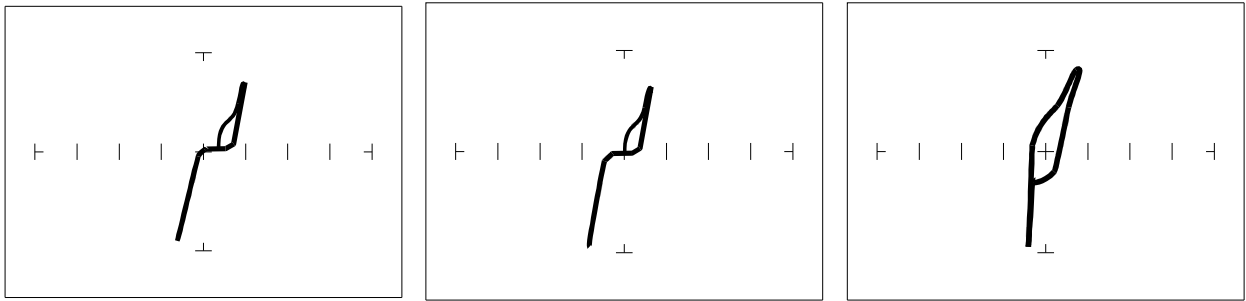
Pin 1 Input - **10V,100Ω**   Pin 2 Output - **10V,100Ω**   Pin 14 V_{CC} - **10V,100Ω**

Figure 7-7. Signatures Of A 74HC14 CMOS Hex Inverter. Common to Pin 7(GND)

CMOS Components And Test Signal Frequency F_s

CMOS logic circuits inherently have a significant amount of internal capacitance. This junction capacitance is visible in the CMOS signatures when using the Tracker 2700. Capacitance in CMOS circuitry may be emphasized or de-emphasized by changing the frequency of the test signal.
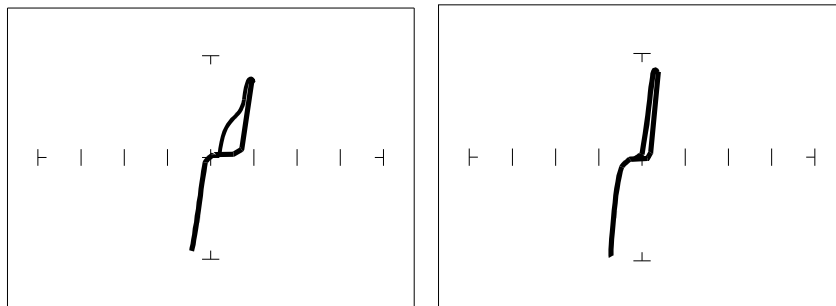
F_S = 20 Hz   **F_S = 200 Hz**

10V, 1 KΩ Range

Figure 7-8. Signatures Of A 74HC14 Input Pin At Different Frequencies

Troubleshooting Digital Logic ICs

Comparison testing is a very powerful and effective test strategy when troubleshooting digital logic using TSA. The Tracker 2700's Alt feature makes this technique quick and simple.   Instead of having to remember the specific signatures of a good component, all that's needed is to have a reference component or board along side the one that's suspect.   This section gave many examples of signatures from TTL, Schottky TTL and CMOS logic families. Although from first inspection, these signatures appear to be complex, remember that each of the ICs in the examples had really only four unique signatures (buffer input, buffer output, power supply VCC and power supply ground). We can use this characteristic to develop an effective model for troubleshooting digital logic chips.
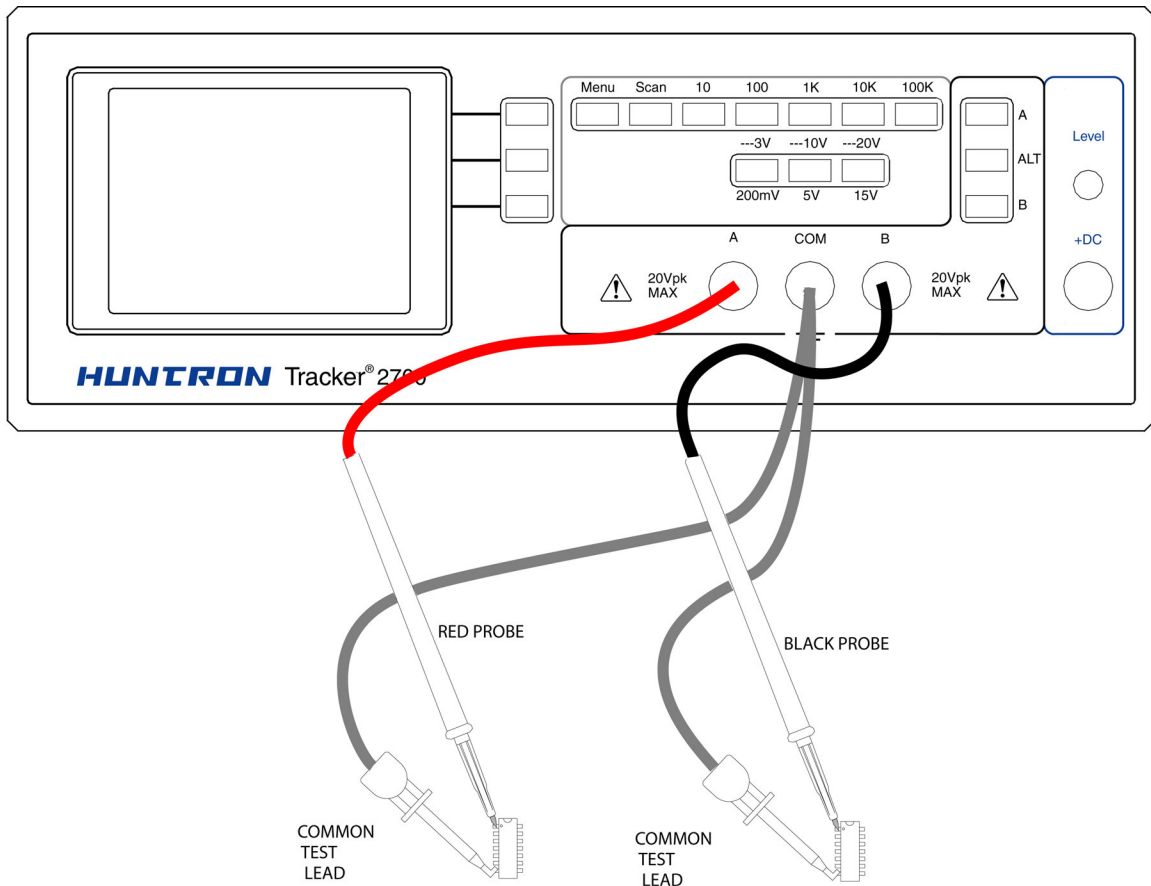

Figure 7-9. Tracker 2700 With Test Leads Setup For Comparing 2 ICs

Comparison Testing For Digital ICs

1. Set the test signal frequency to 60 Hz.

2. Place a black clip lead from the Tracker 2700's Common terminal to both reference and suspect IC or boards ground pin.

3. Place the black test lead from the Tracker 2700's B test terminal to the suspect IC's pin. For this example, start with pin 1 of the suspect IC.

4. Place the red test lead from the Tracker 2700's A test terminal to the reference or known good IC's pin. For this example, start with pin 1 of the known good IC.

5. Push the Channel **A** button. Observe the signature. This is the signature of the pin of the known good component.

6. Push the Select the **10V, 100Ω** Range.

7. Channel **B** button. Observe the signature. This is the signature of the pin of the suspect component.

8. Press the press the **Alt** button to display the A and B channels on the LCD alternately. If needed, adjust the Rate to adjust the display speed.

9. Visually compare the reference signature (channel A) with the suspect signature (channel B) or toggle the Compare Mode on to give PASS/FAIL indication. Make sure to set the compare tolerance to your desired level. Recommended tolerance is 5.

10. Keep the red probe on pin 1, an input pin. Probe all the other input pins of the suspect component with the black probe until you have identified all the pins that have signatures that are the same as pin 1.

11. Move the red probe on pin 2, an output pin. Probe all the other output pins of the suspect component with the black probe until you have identified all the pins that have signatures that are the same as pin 2.

Review

- Integrated circuits are complex devices that are built using basic electronic components.

- The IC signatures resemble zener diodes.

- There are many causes for IC failures and the Tracker 2700 can display its "health" as resistive leakage, an open or a short.

- Functionally identical pins on a single IC out-of-circuit will display the same signature.

- The most common point for reference is ground, but V_{CC} or another point might give a more informative signature.

- Different logic families exhibit different characteristic signatures.

- To simplify the large number of signature variations, use the comparison test strategy with the Tracker 2700. The Tracker 2700 features alternate switching and display of the A and B channels to allow comparison of two individual signatures.

- Testing for faulty IC's is one of the more common uses for the Tracker 2700. A technician can compare IC's in or out of circuit.

7-2. Analog Circuits

Analog components and circuits represent another family of integrated circuit components and include operational amplifiers (op amps), comparators, references, regulators, timers and many other specialized functions. These components and circuits present more troubleshooting challenges that are unique to this particular family of ICs.

Op Amps

Frequently, each pin of an op amp creates a different signature on the Tracker 2700. This signature is the result of the internal design of the chip and both the internal and external circuit elements connected to it. This type of analog component typically has many internal junctions connected to each pin and each pin may also be connected to numerous external components.

The following example will demonstrate TSA with a commonly used 741 type op amp. In this case it is configured as an inverting amplifier circuit as in the schematic below.
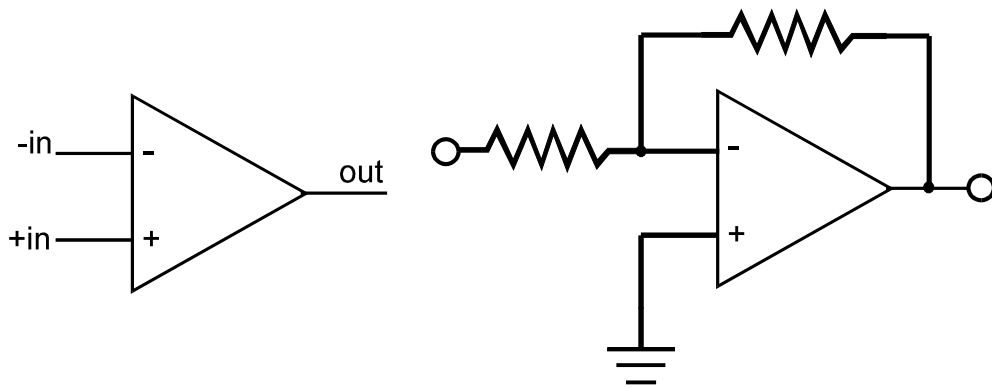
Figure 7-10. Op Amp Symbol And Schematic Diagram Of An Inverter Circuit

We will examine the signatures of this analog IC and present some troubleshooting concepts for this type of component.
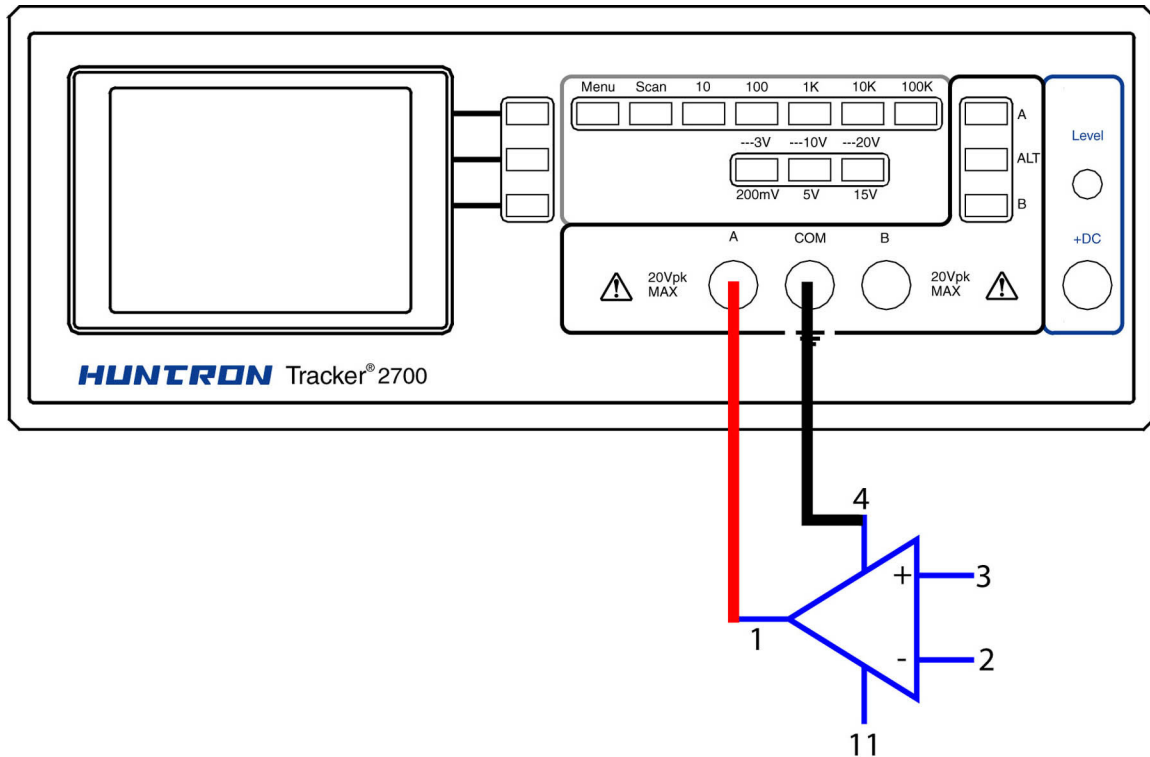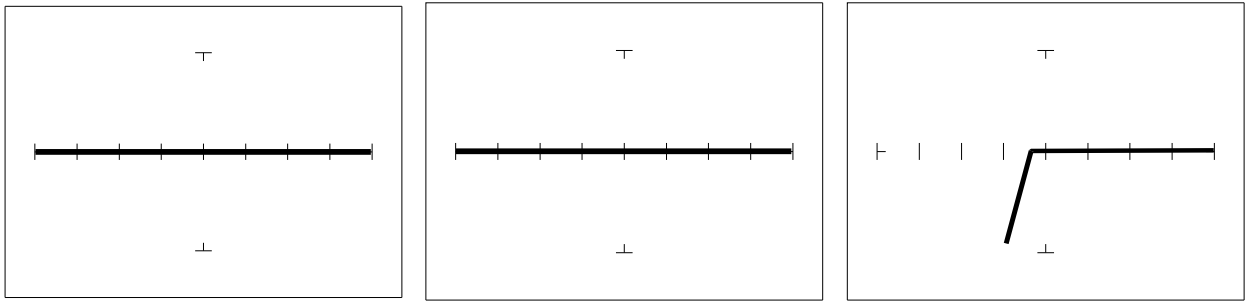
Op Amp Signatures

Figure 7-11. Tracker 2700 With Test Leads To An Op Amp

Do the following to display the Tracker signatures of an op amp:

1.   Select the **15V, 1 kΩ** range.

2.   Set the test signal frequency to **60 Hz**.

3.   Place or clip the black test lead from the Tracker 2700's Common terminal to the IC's ground or a power supply pin. For this example, the negative power supply pin of the 741 is pin 4 and the positive power supply is pin 11.

4.   Use the red test lead from the Tracker 2700's A test terminal and probe each pin of the IC.

5.   Observe that the signature of each of the op amp's pins are unique.

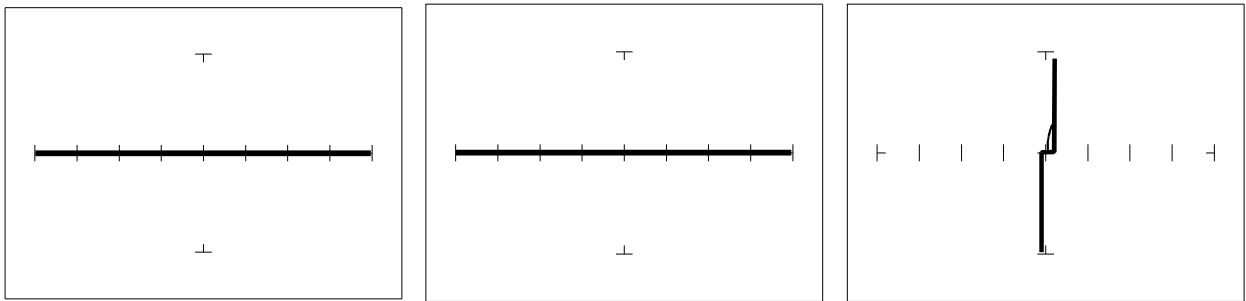Pin 2 -Input   Pin 3 +Input   Pin 6 Output

10V, 100Ω Range

Figure 7-12. Signatures Of An Op Amp (741 Type), Common to Pin 4

Pin 2 -Input   Pin 3 +Input   Pin 6 Output

15V, 10 kΩ Range

Figure 7-13. Signatures Of An Op Amp (741 Type), Common to Pin 4

Troubleshooting Op Amp Circuits

Troubleshooting an op amp in-circuit may be very challenging. These circuits usually have numerous connections that act as feedback or compensation loops. This results in almost an infinite number of possible Tracker signatures. Use the comparison test method when troubleshooting op amps in-circuit. In this case, components on a suspect board are compared to those on a known good board. The Tracker 2700 can help locate the defective component quickly.

The op amp has three main terminals; + input, - input and output. An alternative way to perform TSA on the op amp is to connect Tracker 2700's Common terminal to the op amp's output while making a comparison with the red test probe to the " + " and then the " - " leg. This eliminates problems encountered when probing op-amps that are isolated from power and common. When there is more than one op amp in a package, compare one with the other. The dual op amp and quad op amps are very common. This technique also works with comparators.

Linear Voltage Regulators

Voltage regulators are commonly found in many electronic assemblies. One of the most popular integrated circuit of this type is the three terminal device like the 7805, a +5 volt DC regulator.

The next figure shows the schematic and pin layout of the 7805 regulator. Different manufacturers implement their products with different topologies and manufacturing processes. So it's not unexpected that the same functionally equivalent component from different manufacturers may have different signatures.
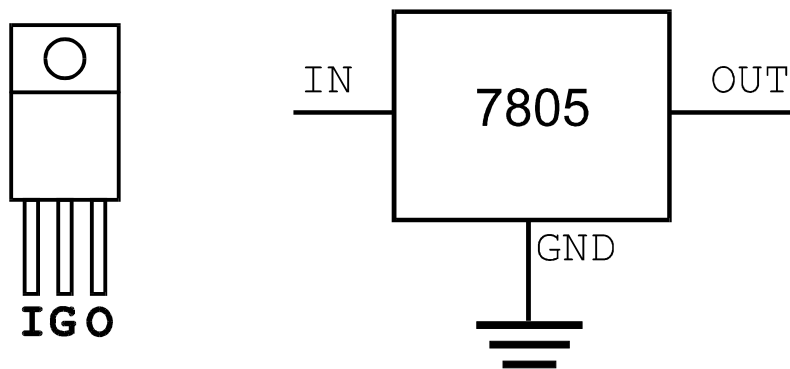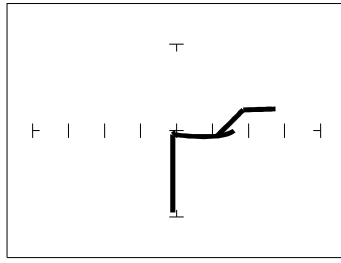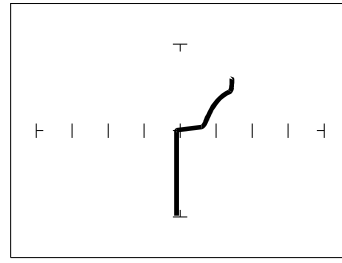

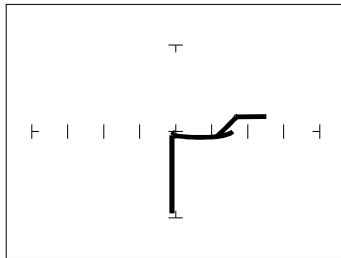Figure 7-14. Diagram And Symbol Of A Linear Voltage Regulator, 7805 Type
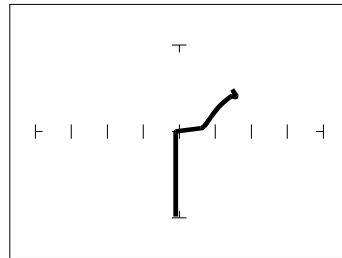
Input - **15V, 1 kΩ** range   Output pin - **15V, 1 kΩ** range

Figure 7-15. Signatures Of A 7805 Voltage Regulator By SGS Thomson.
Ground Pin To Common

Input - **15V,1 kΩ** range   Output pin - **15V,1 kΩ** range

Figure 7-16. Signatures Of A 7805 Voltage Regulator By Motorola.
Ground Pin To Common

Review

- Integrated circuits are complex devices that are built using basic electronic components.

- The IC signatures resemble zener diodes.

- There are many causes for IC failures and the Tracker 2700 can display its "health" as resistive leakage, an open or a short.

- Functionally identical pins on a single IC out-of-circuit will display the same signature.

- The most common point for reference is ground, but V_{CC} or another point might give a more informative signature.

- Different analog IC families exhibit different characteristic signatures.

- To simplify the large number of signature variations, use the comparison test strategy with the Tracker 2700. The Tracker 2700 features alternate switching and display of the A and B channels to allow comparison of two individual signatures.
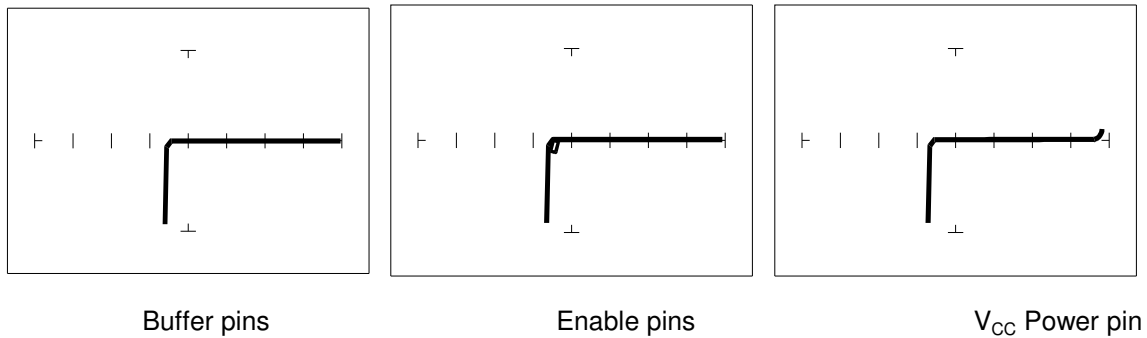
7-3. Low Voltage

There is a new family of logic that offers lower dynamic power consumption, lower operating voltages, higher output drive, faster AC speed, lower noise and better dynamic thresholds than HC CMOS. These features make this family attractive for low power applications such as battery operated portable applications (that is, laptop computers, pagers, phones, etc.).

In order to achieve this new improved level of performance, the manufacturers of this LV (low voltage) family of logic ICs have redesigned the internal structure of the device. Some manufacturers have changed the input structure by eliminating the input protection diode to V_{CC}. Similarly, the design of the output structure also has changed by eliminating the output protection diode to V_{CC} and replacing it with a N-Channel pull-up transistor. As a result of these changes, the Tracker signatures of the LV logic family are different from the conventional HC logic family.

The Tracker 2700 has a **"3V"** test range which has been optimized for this LV logic. SMT is an abbreviation for surface mount technology and refers to the manufacturing technology type in which the LV logic family is commonly available.

1. Select the **3V 10 kΩ** Range.

2. Set the test signal frequency to **60 Hz**.

3. Place or clip the black test lead from the Tracker 2700's Common terminal to the IC's ground pin. For this example, the ground pin of the 74LVQ245 is pin 10.

4. Use the red test lead from the Tracker 2700's A test terminal and probe each pin of the IC. For this example, pins 2 to 9 and 11 to 18 are all buffer circuits so they will have identical signatures. (Note: This is only for ICs out of circuit.)

5. Use the red test lead from the Tracker 2700's A test terminal and probe the enable input pins. For this example, the enable pins of the 74LVQ245 are pin 1 and 19 and will have the same signatures. (Note: This is only for ICs out of circuit.)

6. Use the red test lead from the Tracker 2700's A test terminal and probe the power supply V_{CC} input pin. For this example, the V_{CC} pin of the 74LVQ245 is pin 20.

| Buffer pins | Enable pins | V_{CC} Power pin |

3V, 10 kΩ Range

Figure 7-18. Signatures Of A Low Voltage IC (74LVQ45 Type).
Ground Pin To Test Common

The **3V** test range **(100 kΩ , 10 kΩ, 1 kΩ, 100Ω)** has been developed to enhance the resistive fault signatures that are commonly found when troubleshooting this logic family. The test signal voltage V_S is lower to ensure that the most descriptive signature is displayed. A higher V_S may result in a signature going toward a short which would mask out flaws. The short signature can be attributed by the LV family's lower voltage characteristics.

Compare these signatures with the CMOS logic family and other discrete components such as transistors and diodes. Note that these signatures have some common similarities with the other component Tracker signatures we have seen already.

Review

• Integrated circuits are complex devices that are built using basic electronic components.

• The IC signatures resemble regular and zener diode signatures.

• There are many causes for IC failures and the Tracker 2700 can display its "health" as resistive leakage, an open or a short.

• Functionally identical pins on a single IC out-of-circuit will display the same signature.

• The most common point for reference is ground, but V_{CC} or another point might give a more informative signature.

• To simplify the large number of signature variations, use the comparison test strategy with the Tracker 2700. The Tracker 2700 features alternate switching and simultaneous display of the A and B channels to allow comparison of two individual signatures.

SECTION 8
MAINTENANCE

8-1.   Introduction

This section provides information on user maintenance items for this instrument.

8-2.   External cleaning/lubrication

⚠Warning
**To avoid electric shock or instrument damage, never get
water inside the case. To avoid instrument damage, never
apply solvents to the instrument.**

Should the Tracker 2700 case require cleaning, wipe the instrument with a cloth that is lightly
dampened with water or mild detergent solution. The instrument requires no lubrication.

8-3.   Storage Instructions

For optimum protection, store the unit indoors in a dry place.

8-4.   Service Information

Tracker 2700 Warranty information is 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 Inc. Huntron service is also available for repair of instruments that are
beyond the warranty period. In either case, please describe clearly the problems encountered
with the instrument.

For in-warranty or out of warranty service in the United States, call 1-800-426-9265 (in North
America) or 425-743-3171 to describe the malfunction and request an RMA number and shipping
instructions prior to shipment. This number must be clearly displayed on the exterior of the
shipping carton. Only parcels displaying an RMA number will be accepted.

For in-warranty or out of warranty service outside the United States, contact the Point of
Purchase for the product.

8-5.   Contact Information

Huntron is accessible by phone at 1-800-426-9265 or 425-743-3171
Fax: 425-743-1360
Email: info@huntron.com
Web site: http://www.huntron.com