



# Tracker 3200S User's Manual

**P/N 21-2614**

**Rev. C**

**Version 1.3**

**February 2022**

**Copyright © 2018 Huntron, Inc. All rights reserved.**

**Huntron, Tracker and SigAssist are registered trademarks of Huntron, Inc. All other names are trademarks or registered trademarks of their respective companies.**

**This document may not be copied in whole or in part, or otherwise reproduced except as specifically permitted under U.S. copyright law, without the prior written consent of Huntron, Inc.,**

**15720 Main Street, Suite#100, Mill Creek, WA, 98012, USA.**

## **HUNTRON, INC.**

### **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 3200S instrument.

Huntron warrants that the Huntron Tracker 3200S 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 shall not exceed the amount of the purchase price of the Huntron Tracker 3200S, regardless of the extent of any such damage, including any special, consequential, or incidental damages of any kind.

These warranties shall only apply to products in ordinary use. Huntron shall have no obligation under these warranties 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  
Phone: 800-426-9265 or 425-743-3171  
FAX: 425-743-1360  
E-mail: [info@huntron.com](mailto:info@huntron.com)  
Website: [www.huntron.com](http://www.huntron.com)

## Table of Contents

<b><u>SECTION 1 INTRODUCTION.....</u></b>	<b><u>5</u></b>
1-1 WHAT IS A TRACKER 3200S?.....	5
1-2 SPECIFICATIONS .....	6
1-3 SAFETY INFORMATION (INFORMATION SUR LA SÉCURITÉ ).....	8
1-4 ENVIRONMENT CONFORMITY QUALITY .....	9
ENVIRONMENT .....	10
CONFORMITY.....	10
QUALITY .....	10
1-5 WORKSTATIONS SOFTWARE.....	11
HUNTRON WORKSTATION SOFTWARE FEATURES .....	11
<b><u>SECTION 2 USING THE TRACKER 3200S.....</u></b>	<b><u>12</u></b>
2-1 UNPACKING AND WHAT IS INCLUDED.....	12
2-2 GETTING STARTED WITH THE TRACKER 3200S .....	13
FRONT PANEL OVERVIEW .....	13
PROBING WITH MICROPROBES .....	14
2-3. CHANNEL SELECTION .....	16
2-4 ALTERNATE MODE AND A+B MODE.....	16
2-5 RESISTANCE SELECTION.....	17
2-6 FREQUENCY SELECTION.....	18
2-7 VOLTAGE SELECTION .....	18
2-8 ANALOG SIGNATURE ANALYSIS (ASA) BASICS.....	18
2-9 FOUR BASIC COMPONENT ANALOG SIGNATURES .....	22
2-10 SMART TRACKER ACTIVE RANGE (STAR) FEATURE .....	23
2-11 PULSE GENERATOR.....	24
2-12 SCANNING WITH A TRACKER 3200S.....	25
2-13 AUXILIARY (AUX) CONNECTOR DESCRIPTION .....	28
2-14 USING THE FOOTSWITCH WITH THE TRACKER 3200S.....	28
2-15 TRACKER 3200S TOUCH SCREEN MENUS.....	29
DEFAULT POWER-UP MENU AND FULL SCREEN SIGNATURE MODE.....	29

RATE (ALTERNATE SPEED) CONTROLS .....	29
SIGASSIST CONTROL .....	30
VOLUME CONTROL .....	31
LCD BACKLIGHT INTENSITY CONTROL .....	31
SIGNATURE TRACE SEPARATION CONTROL.....	31
COMP – TOL (TOLERANCE) CONTROLS .....	32
COMP – LOOP CONTROLS .....	33
COMP – MAX V CONTROLS .....	33
SETTING THE DEFAULT RANGES .....	33
<b>OTHER TOUCH SCREEN MENUS – SETUP.....</b>	<b>34</b>
DIAGNOSTICS .....	34
DEFAULTS .....	34
RTEST .....	35
WAVE MODE.....	36
<b><u>SECTION 3 TESTING PASSIVE COMPONENTS.....</u></b>	<b><u>37</u></b>
<b>3-1. RESISTORS .....</b>	<b>37</b>
<b>3-2. CAPACITORS .....</b>	<b>42</b>
<b>3-3. INDUCTORS .....</b>	<b>48</b>
<b>3-4. ELECTROMECHANICAL SWITCHING COMPONENTS.....</b>	<b>53</b>
<b><u>SECTION 4 TESTING DISCRETE SEMICONDUCTORS.....</u></b>	<b><u>55</u></b>
<b>4-1. DIODES .....</b>	<b>55</b>
<b>4-2. TRANSISTORS .....</b>	<b>63</b>
<b>4-3. SOLID STATE SWITCHING COMPONENTS.....</b>	<b>69</b>
<b><u>SECTION 5 TESTING INTEGRATED CIRCUITS.....</u></b>	<b><u>72</u></b>
<b>5-1. DIGITAL INTEGRATED CIRCUITS .....</b>	<b>72</b>
<b>5-2. ANALOG CIRCUITS.....</b>	<b>77</b>
<b>5-3. LOW VOLTAGE.....</b>	<b>80</b>

# Section 1 Introduction

## 1-1 What is a Tracker 3200S?



A Huntron Tracker 3200S is a troubleshooting instrument that is used manually to troubleshoot printed circuit boards to the component level. Throughout this manual it will be referred to as the Tracker 3200S. This instrument uses a troubleshooting technique called Analog Signature Analysis (ASA) for applying a current limited sine-wave voltage to an un-powered circuit or electronic component. The resulting Current (I) and Voltage (V) characteristic (analog Signature) is then displayed and used for comparing known good signatures of a good circuit card

or electronic component to those of a suspect circuit board. This comparison allows you to troubleshoot circuit cards and electronic components without applying external power or requiring circuit cards to “start up”.

Each pin of a component can have a unique signature. When components fail, their signatures change so troubleshooting using ASA is simply a matter of finding the defective component by analyzing its signature. The Tracker 3200S implements the ASA technique of troubleshooting.

The built-in current limited stimulus sine-wave of the Tracker 3200S ensures non-destructive testing and does not damage any components. ASA has many advantages as a proven, fast, and effective troubleshooting technique:

- Troubleshoot circuitry that cannot be powered up due to a shorted condition.
- Troubleshoot in a qualitative mode, allowing you to see physical problems with a suspect component.
- Compare device characteristics with known types for better matching.
- Investigate intermittent problems by seeing marginal indicators, such as small amounts of leakage, noise, etc.
- Eliminate risk of accidental shorting across other points during POWER ON testing which could further damage the component or other components on the board.
- Minimize the risk of shock hazard since the ASA troubleshooting approach requires no power applied to the circuitry.
- Perform preventative maintenance by seeing flaws in components that could possibly lead to untimely failures.
- Look at replacement components before they are installed in circuitry to reduce the risk of installing defective ones.

ASA may be universally applied to any type of passive component like a resistor, capacitor, or inductor, or a solid state semiconductor component like a diode, transistor, SCR, digital, analog, or mixed-signal IC. When troubleshooting a circuit card, the resultant signature is a composite of various component signatures at a particular node in the circuitry. By understanding what different signatures mean, you can determine which components are faulty.

You can manually connect the Tracker 3200S front panel test terminals directly to the circuit card or component that you are testing. You can automate the test process by connecting to boards under test via custom cabling or IC clip and cables. The Tracker 3200S has internal switch cards and external, front panel IDC connectors to which custom interfaces or DIP clip cables can be connected. The Tracker 3200S can also be connected to Huntron Access Probers via rear panel BNC connections for full test automation.

## 1-2 Specifications

ELECTRICAL (Note: Test Signal is a sine wave.) Specifications subject to change without notice	
Open Circuit Voltage (Vs):	
24 selections of peak voltage:	200mV, 400mV, 600mV, 800mV, 1V to 20V in 1V steps including LOW (10V), MED1 (15V), MED2 (20V)
Source Resistance (Rs):	
16 selections of resistance:	10 $\Omega$ , 20 $\Omega$ , 50 $\Omega$ , 100 $\Omega$ , 200 $\Omega$ , 500 $\Omega$ , 1k $\Omega$ , 2k $\Omega$ , 5k $\Omega$ , 10k $\Omega$ , 20k $\Omega$ , 50k $\Omega$ , 100k $\Omega$ , 54 $\Omega$ (LOW)*, 1.2k $\Omega$ (MED1)*, 26.7k $\Omega$ (MED2)* *Using Huntron Workstation only
Short circuit current (Vs divided by Rs)	
Maximum	200 mApk
Frequency (fs):	
40 selections of frequency:	20Hz to 190Hz in 10Hz steps; 200Hz to 1.9kHz in 100Hz steps; 2kHz to 5kHz in 1kHz steps
Channels	
Number	2, Channel A and Channel B
Connections	
Front Panel	Banana (Channel A, Common, Channel B); Two (Ch. A and Ch. B) 64pin pin IDC connectors
Rear Panel	BNC (Channel A, Common, Channel B) for connection to Access Probers; AUX (for footswitch); USB for PC control
Overvoltage Protection	Circuit breaker
Auxiliary (AUX) Connection	9 pin mini jack with ground, Trigger IN, Trigger OUT, Calibration TP, Sine wave zero-crossing, Signal ON, Line IN and Line OUT

Pulse Generator	Level: 0 to +/- 10V DC or Square wave; Pulse mode width: 2% to 50% duty cycle; Source Resistance: 100Ω; Maximum current: 100mA per channel
PC Interface	USB 2.0
GENERAL	
Power Requirements	100/115V~ 0.2A 50/60Hz, 230V~ 0.1A 50Hz
Fuse	T400mA 5x20mm 250V
Operating Temperature	59 degrees F to 86 degrees F (+15 degrees C to +30 degrees C)
Storage Temperature	-58 degrees F to 140 degrees F (-50 degrees C to +60 degrees C)
Humidity	0 to 50% R.H.
Dimensions	11.1" W x 4.4" H x 8.5" D (28.2cm W x 11.2cm H x 22.1cm D)
Weight	8 lbs. (3.63Kg)
Warranty	1 year limited

## 1-3 Safety Information (Information sur la sécurité )

### Symbols and Warnings: (Symboles et avertissements):

The following symbols are used either in this manual or on the unit:

Les symboles suivants sont utilisés soit dans ce manuel ou sur l'appareil:



Protective Ground (Earth) Terminal. **Do not disconnect any protective ground wires.**

Rez de protection (terre). Ne débranchez pas de câbles de garde protectie.



**CAUTION** This symbol is used in the user's manual as a warning that improper use could result in unit malfunctioning. For your safety always follow the instructions next to the symbol on the unit and in the manual.

**ATTENTION** Ce symbole est utilisé dans le manuel de l'utilisateur comme un avertissement que l'usage abusif peut entraîner des dysfonctionnements unité. Pour votre sécurité toujours suivre les instructions à côté du symbole de l'unité et dans le manuel.



The Huntron Tracker 3200S conforms to the following Standards:

EN/IEC 55011

EN 61000-3-2

EN 61000-3-3

EN/IEC 61000-4-2

EN/IEC 61000-4-3

EN/IEC 61000-4-4

EN/IEC 61000-4-5

EN/IEC 61000-4-6

EN/IEC 61000-4-8

EN/IEC 61000-4-11

IEC 61010-1:2010 (Third Edition)

UL 61010-1 Issued: 2012/05/11 Ed:3

CSA C22.2 No. 61010-1 Issued:2012/05/11 Ed:3

EN 61326-1: 2013

IEC 61326-1: 2012





Intertek Meets the Standard for Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use; Part 1 General Requirements – UL 61010-1, 2<sup>nd</sup> Ed., with revisions through 07/22/2005, and CAN/CSA-C22.2 No. 61010-1, 2<sup>nd</sup> Ed., dated 07/12/2004.

**⚠ Line Fuse Replacement: (Line Remplacement des fusibles):**

**Line Fuse tray:** The power entry module includes a power cord connector, and a removable tray which holds the line fuses.

**Ligne bac Fuse:** Le module d'entrée comprend un connecteur d'alimentation cordon d'alimentation, et un plateau amovible qui contient les fusibles en ligne.

Make sure that replacement fuses are of the type and current rating specified. If necessary, insert a T400mA 5x20mm 250V fuse into the fuse tray.

Assurez-vous que les fusibles de remplacement sont de type et leur courant nominal spécifié. Si nécessaire, ajouter un 5x20mm T400mA 250V dans le bac à fusibles.

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

**Ne pas fonctionner sans Covers.** Ne pas utiliser cet instrument avec ou panneaux enlevés.

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

**Évitez les circuits à découvert.** Ne touchez pas les exposés et les composants lorsque la puissance est présente.

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

**Ne pas utiliser Avec les échecs présumés.** Si vous pensez que il ya des dommages à cet instrument, le faire inspecter par un technicien qualifié.

**Do Not Operate in Wet/Damp Conditions.**

Ne pas opérer dans les conditions humides ou humides.

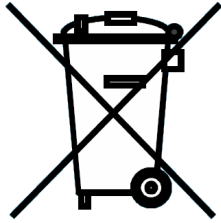
**Do Not Operate in an Explosive Atmosphere.**

Ne pas opérer dans une atmosphère explosive.

## **1-4 Environment Conformity Quality**

For more information see our website [www.huntron.com/corporate/environment.htm](http://www.huntron.com/corporate/environment.htm)

## Environment



Huntron is aware of the recycling needs for Waste Electronic and Electrical Equipment (WEEE) and is 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.



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.

Huntron wants to make sure that old Huntron products are responsibly recycled.

As part of that goal, Huntron offers a trade-in for any one used Tracker or Prober when a new Tracker or Prober is purchased. All trade-in products are responsibly recycled. More information on Trade-in program go to [www.huntron.com/sales-support/repairpolicy.htm](http://www.huntron.com/sales-support/repairpolicy.htm).

## Conformity

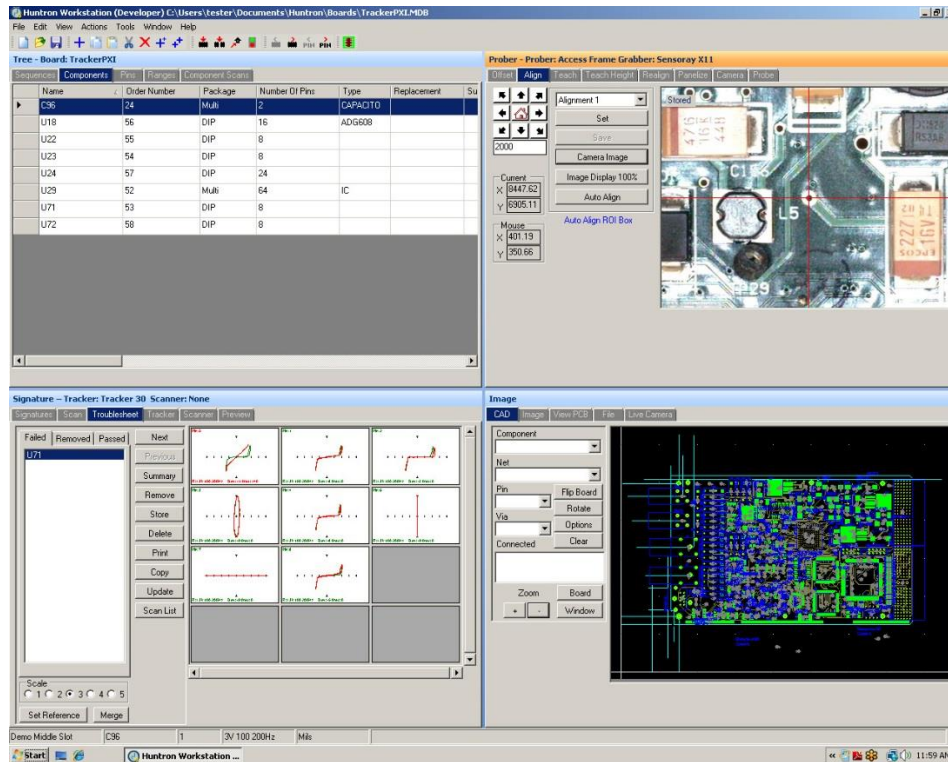
Huntron products are classified as Category 9 industrial monitoring and control instruments. Our manufacturing processes conform to our standards. These include regulation and directives like RoHS2, REACH and Conflict Minerals. See our Declaration of Conformity to Huntron Quality Standard at [www.huntron.com/corporate/docs/conformity.pdf](http://www.huntron.com/corporate/docs/conformity.pdf).

## Quality

Huntron has been producing quality products and supporting customers all over the world for several decades. Our products conform to our Quality Manual. For information see our Quality Statement at [www.huntron.com/corporate/docs/quality-statement.pdf](http://www.huntron.com/corporate/docs/quality-statement.pdf).

## 1-5 Workstations Software

The Tracker 3200S can be used with Huntron Workstation Software. For instructions on installing the software, see the Getting Started document that comes with the Tracker 3200S.



### Huntron Workstation software features

- Create custom test routines for low volume manufacturing, repair and rework applications
- Easily create, modify and save test databases
- View, print and store test results immediately
- Interactive application panes automatically update as selections are made
- Includes an easy to use Test Only pane better suited to test execution in a production environment

## **Section 2    Using the Tracker 3200S**

### ***2-1    Unpacking and what is included***

To set up and use your Tracker 3200S, you will need the following:

- One set of Microprobes (Huntron MP20).
- This manual (Tracker 3200S User's manual)
- Cables to connect to a PCB connector or DIP clip cables and clips (These are not included)
- Common test lead
- Blue test lead for use with Pulse Generator

Using the unpacking list, verify that all that all pieces are included in the shipping container. Contact Huntron immediately if pieces are missing.

## 2-2 Getting started with the Tracker 3200S

### Front Panel Overview

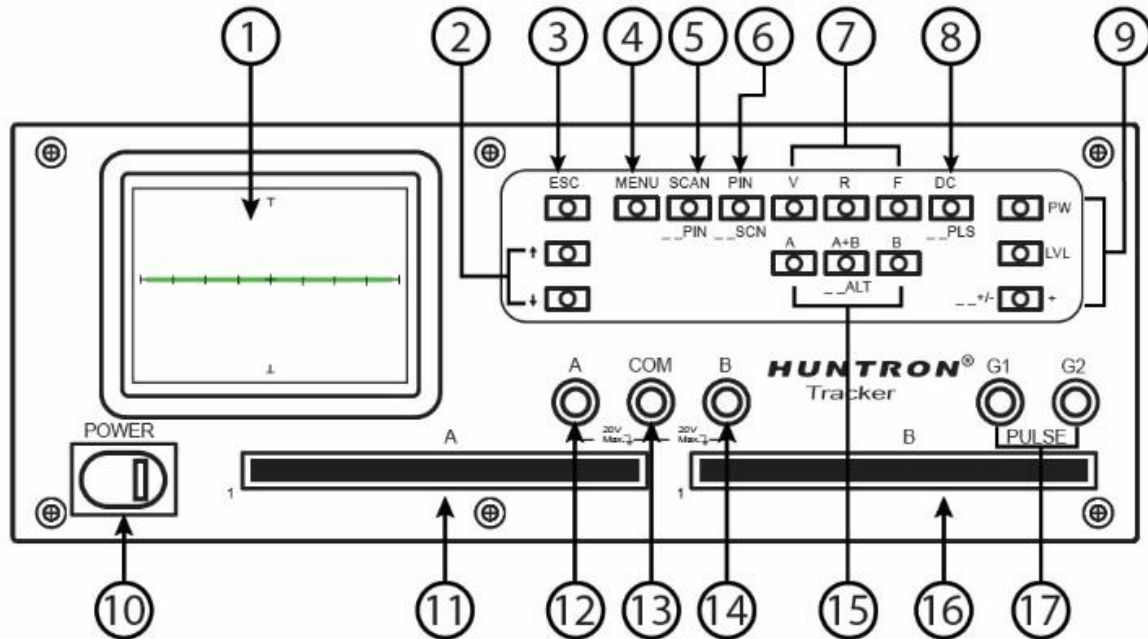


Figure 2-2 Tracker 3200S Front panel Overview

### Front Panel Breakout

**Note:** Many of the front panel buttons have two states, solid LED and flashing LED. In most cases press once for solid LED and twice for flashing LED.

1. LCD Display
2. Up/Down Arrows buttons
3. **ESC** button used to reverse Touch Screen menus one step at a time
4. **MENU** button displays Main menu on LCD
5. **SCAN/ \_\_PIN** Button: **SCAN** (solid LED) steps through the 4 default ranges; **\_\_PIN** (flashing LED) steps through each pin with the 4 default ranges
6. **PIN/ \_\_SCN** Button: **PIN** (solid LED) allows for stepping through pins using Up/Down arrows buttons with the current range; **\_\_SCN** (flashing LED) steps through pins with the current range
7. **V, R, F** buttons (solid LED): Selects **V**(oltage), **R**(esistance), or **F**(requency) to be manually incremented using the Up/Down arrows buttons; **V, R, F** buttons (flashing LED): The selected range parameter will step through available setting automatically
8. **DC/ \_\_PLS** button: Toggles the Pulse Generator to DC mode (solid LED) or Pulse mode (flashing LED)
9. **PW** enables adjustment of the Pulse Width (Pulse mode only) using the Up/Down arrow buttons; **LVL** enables adjustment of the Pulse Generator voltage level using the Up/Down arrow buttons;

\_ \_+/- / + button; (flashing LED) set Pulse mode to square wave with + and – pulses; (solid LED) sets Pulse mode to square wave with + pulses only or +DC in DC mode; (LED off) sets Pulse mode to square wave with – pulses or –DC in DC mode

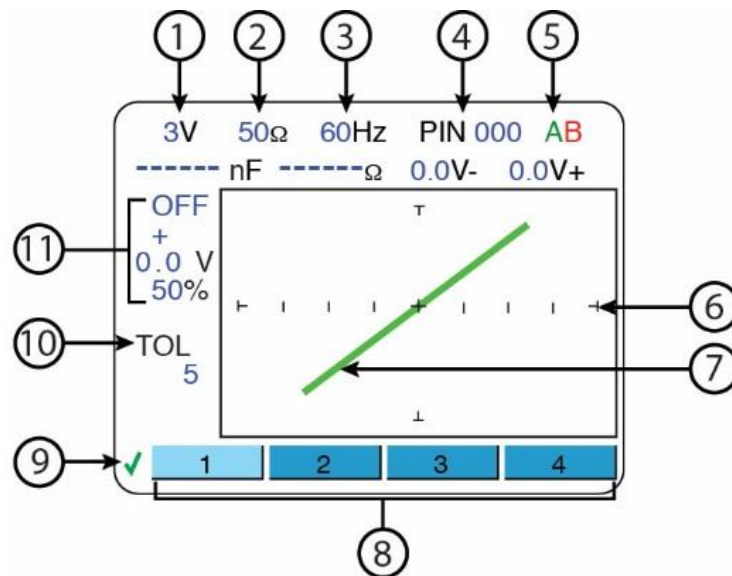
10. Power switch 11. Channel A Scanner 64 pin IDC connector 12. Channel A banana jack

13. Common banana jack 14. Channel B banana jack

15. Channel selection buttons: **A** selects Channel A; **A+B** (solid LED) selects Channel A and Channel B display mode; \_ \_**ALT** (flashing LED) selects Channel A/Channel B alternate mode; **B** selects Channel B

16. Channel B Scanner 64 pin IDC connector

17. Pulse Generator Outputs G1 and G2; both outputs operate simultaneously



### LCD Display Breakout

1. Current Voltage range 2. Current Resistance range 3. Current Frequency range

4. Current Pin number 5. Current Channel selected 6. Signature box graticule

7. Signature (resistor shown) 8. Default Range selection buttons

9. Signature comparison Pass/Fail indication: green check mark is pass, red X is failed

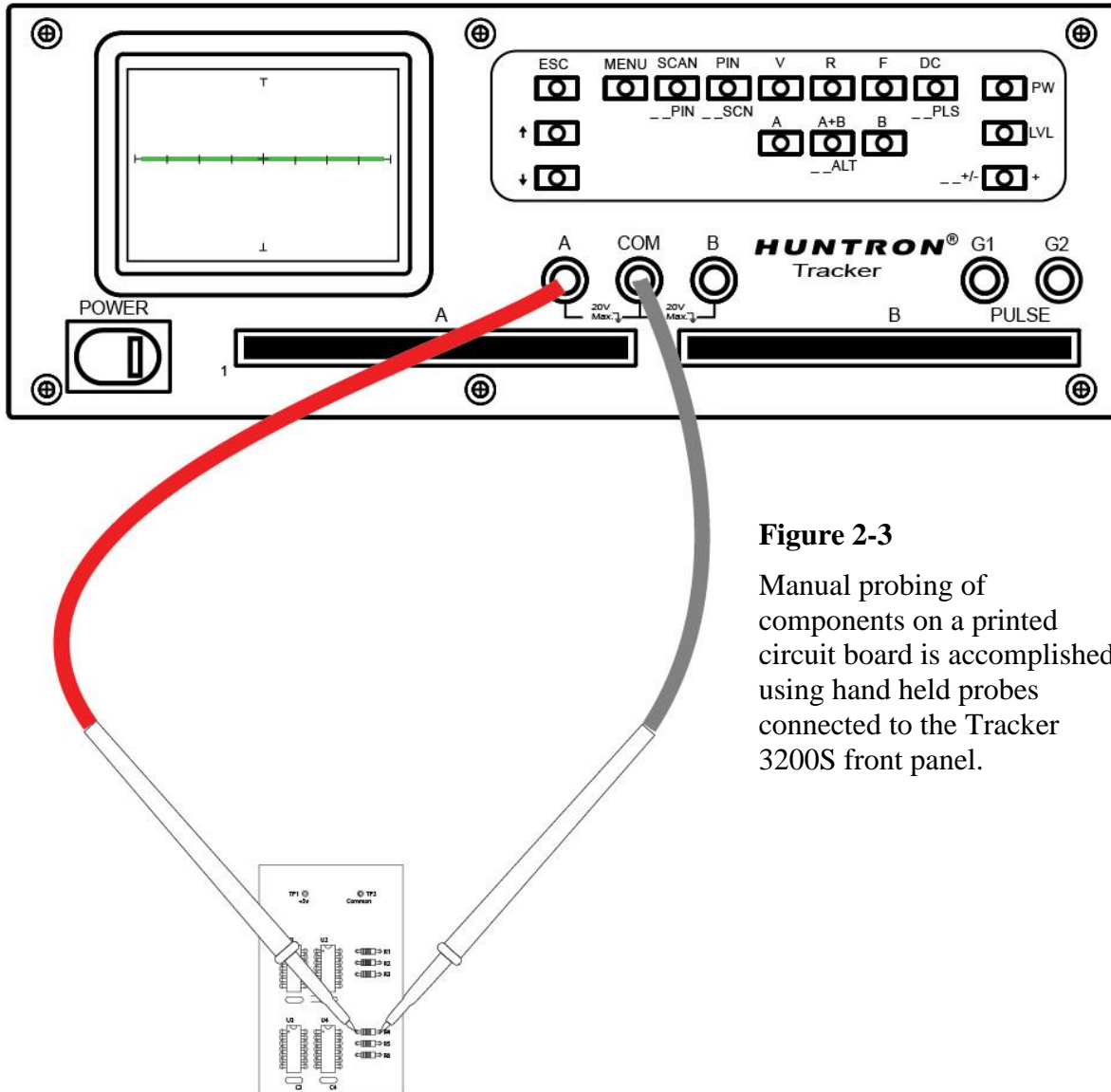
10. Current comparison Tolerance setting 11. Current Pulse Generator settings

### Probing with Microprobes

- Connect the Tracker 3200S to power.
- Turn the Tracker 3200S ON using the front panel power switch. The “**Power-up**” menu will be displayed on the LCD touch screen.
- Insert your Huntron Microprobes into the shrouded banana jacks marked Channel A (or Channel B) and Common as shown in Figure 2-3. Typically, the red Microprobe lead will be

used in the Channel A (or B) connection and the black Microprobe used in the Common connection.

- Proceed to test components on a powered off circuit board by holding the tips of the test probes to the component pins.
- Touching the signature area on the LCD touch screen will toggle from full screen signature display to signature display with text information. **NOTE: Use only your fingers to activate the Tracker touch screen. Using pens, probes or any sharp device can result in damage to the screen.**



**Figure 2-3**

Manual probing of components on a printed circuit board is accomplished using hand held probes connected to the Tracker 3200S front panel.

### 2-3. Channel Selection

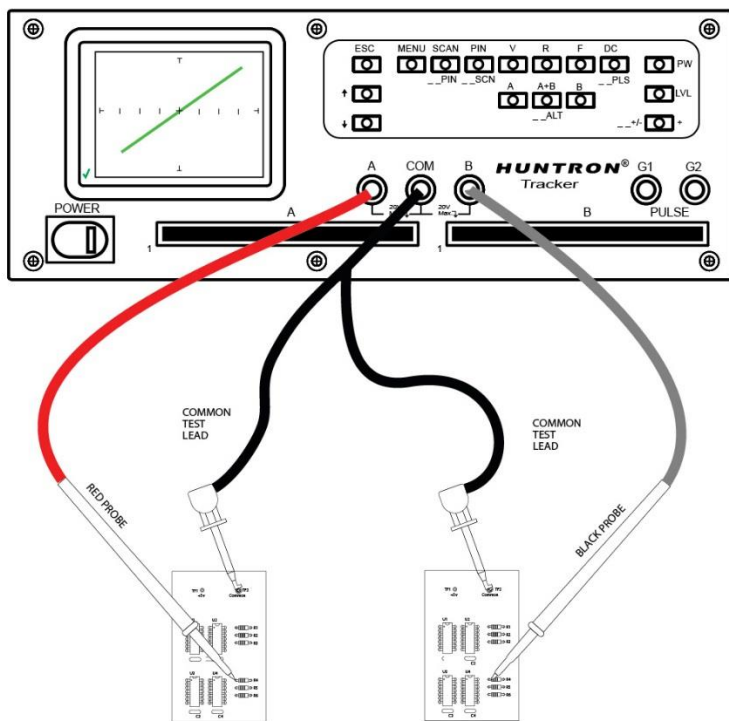
There are two channels on the Tracker 3200S (channel **A** and channel **B**) which are selected by pressing the appropriate front panel button. When using a single channel, the red probe should be plugged into the corresponding channel test terminal and the black probe or common test lead should be 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.

### 2-4 Alternate Mode and A+B Mode

The Alternate (ALT) mode of the Tracker 3200S 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 **A+B/\_ALT** button on the front panel twice so the LED is flashing. The alternation frequency is varied by pressing the **MENU** button, selecting **COMP** then **RATE** on the LCD touch screen and using the **↑** and **↓** arrow buttons until the desired alternation frequency is reached. The **RATE** is numbered from 1 (fastest) to 9 (slowest). Press the **ESC** button twice to return to the power-up menu.

The **A+B** mode will display the Channel A and Channel B signatures on the LCD at the same time. To select **A+B** mode press **A+B/\_ALT** button on the front panel until the LED is solid.

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.

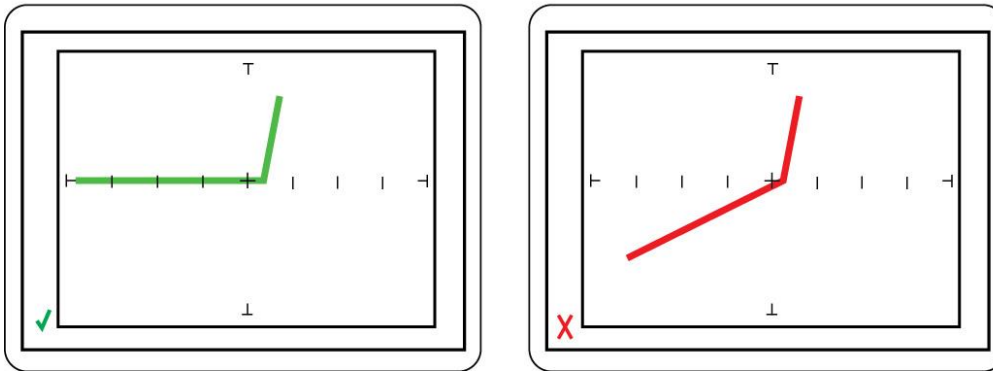


**Figure 2-4**

Channel A and B with the ALT or A+B mode can be used to make direct comparisons of two PCBs.

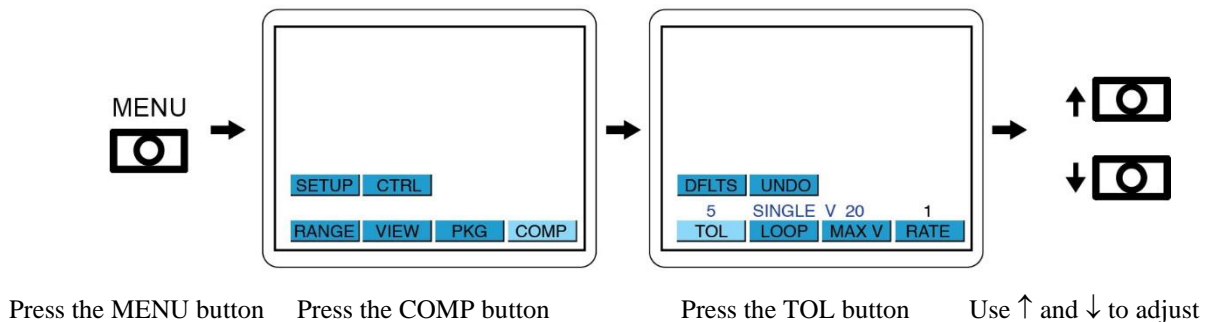


When using ALT or A+B mode, a green check mark or red “X” on the bottom left portion of the LCD will indicate a pass or fail comparison.



**Figure 2-5**  
LCD displays indicating a pass A/B comparison (green check mark – left image) and fail A/B comparison (red X – right image).

To set the allowed maximum deviation or “Tolerance” when comparing the A channel versus the B channel select the **MENU** front panel button, select the **COMP** on the LCD, select **TOL** on the LCD and adjust the tolerance value using the front panel **↑** and **↓** arrow buttons. It is adjustable from 0 to 90. Press the **ESC** button twice to return to the main LCD screen.



**Figure 2-6.** Selecting tolerance setting used during A vs. B comparison

## 2-5 Resistance Selection

The Tracker 3200S is designed with nine resistance ranges (10Ω, 20 Ω, 50Ω, 100Ω, 200Ω, 500Ω, 1kΩ, 2k Ω, 5kΩ, 10kΩ, 20k Ω, 50kΩ, 100kΩ, 54 Ω (LOW)\*, 1.2k Ω (MED1)\*, 26.7k Ω (MED2)\*

\*Using Huntron Workstation only). A resistance range is selected by pressing the appropriate buttons on the front panel. Press the **R** button on the front panel (solid LED) and use the **↑** and **↓** arrow buttons to adjust the resistance value. The value will be displayed on the top row of the LCD. 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) select 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.

Press the **R** button again (flashing LED) 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. The resistances available will be limited by the selected voltage.

## 2-6 Frequency Selection

Forty test signal frequencies (20Hz to 190Hz in 10Hz steps; 200Hz to 1.9kHz in 100Hz steps; 2kHz to 5kHz in 1kHz steps) can be selected by pressing the **F** button (solid LED) on the front panel and using the **↑** and **↓** arrow buttons to change the level. Pressing the **F** button again (flashing LED) will allow for sequencing through the frequency ranges at a speed set by the **RATE** selected. Frequency is primarily used to enhance the signatures of reactive components such as capacitors and inductors.

## 2-7 Voltage Selection

Pressing the **V** button (solid LED) and using the **↑** and **↓** arrow buttons will allow the user to select from 24 voltages (200mV, 400mV, 600mV, 800mV, 1V to 20V in 1V steps including LOW (10V), MED1 (15V), MED2 (20V)). Pressing it again (flashing LED indication) will allow for sequencing through the available voltage ranges at a speed set by the **RATE** selected. Selection of the voltage value is generally based on the signature shape of tested semiconductors and the internal operating voltage of a device. It is best to start with a lower voltage of 3V or 5V.

## 2-8 Analog Signature Analysis (ASA) Basics

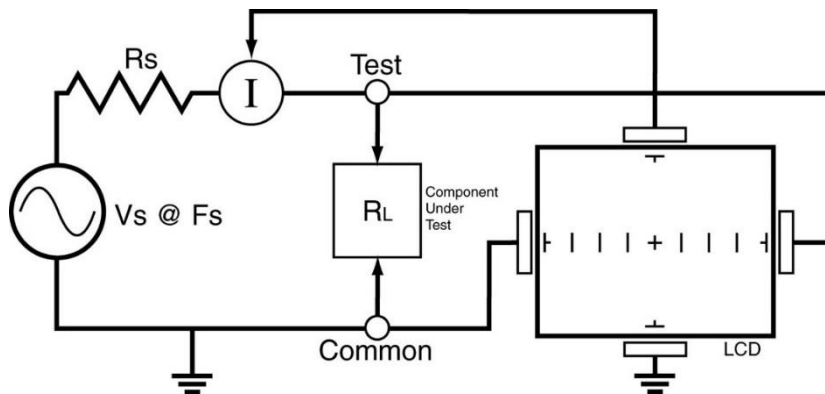
Here's how ASA and power-off testing works:

The Tracker 3200S 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 LCD 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 an analog signature.

Understanding the Tracker 3200S's basic core circuit is the key to understanding how analog signatures respond to different types of components. Since the induced current is a function of the impedance of the circuit, the analog signature displayed can be thought of as a visual representation of Ohm's Law,

$V = IR$  where  $V$  = voltage,  $I$  = current and  $R$  = 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 3200S'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 2-7:** Tracker 3200S 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 ASA for troubleshooting, the objective is to select the range that will display the most descriptive Tracker signature information. The Tracker 3200S user 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.

### Horizontal Axis

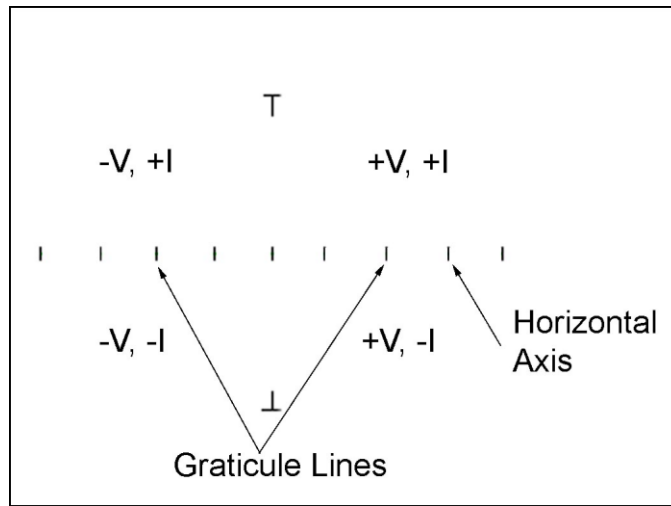
The voltage across the component under test controls the amount of horizontal trace deflection on the LCD display. When the component under test is removed, creating an open circuit (e.g.,  $R_L = \infty$ ), the voltage at the output terminals is at its maximum and thus the trace on the display is a 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. Table 2-3 shows the volts per division for some of the Tracker voltage ranges.

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 3200S Horizontal Sensitivities

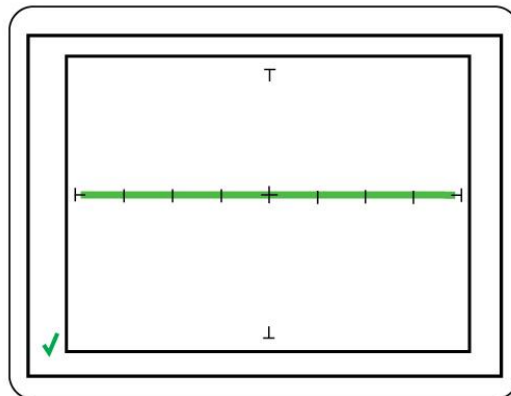
The Signature viewing area of the LCD screen can also be set up in quadrants to show positive and negative current and voltage characteristics. Refer to figure 2-8.



**Figure 2-8.** 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 3200S and observe the LCD display. With nothing connected to its test terminals, the display trace is a horizontal line ( $R_L = \infty$ ) as shown in figure 2-9.



**Figure 2-9** Tracker 3200S LCD Display with Open Test Terminals.

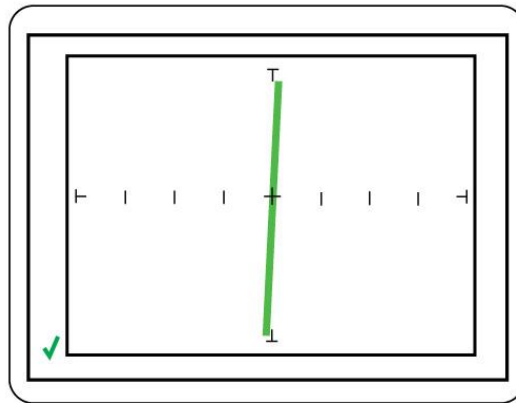
### Vertical Axis

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. 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 signature.

When the  $R_L$  is zero ohms ( $0\Omega$ ) by shorting the output terminal to the common terminal, there is no voltage dropped across  $R_L$  causing no horizontal component displayed 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 3200S and the black microprobe to the Common jack. Touch and hold the probes together and observe the Tracker signature on the LCD display.

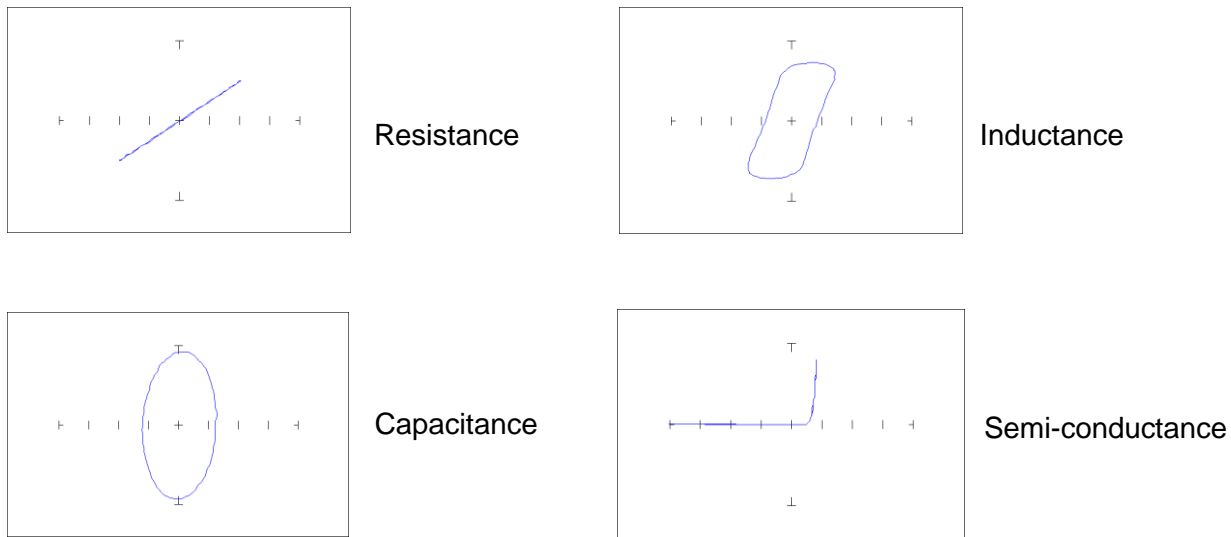
You will see a vertical line trace in the middle of the LCD display.



**Figure 2-10.** LCD Display with Vertical Axis, Graticule Lines displaying a short circuit.

## 2-9 Four Basic Component Analog Signatures

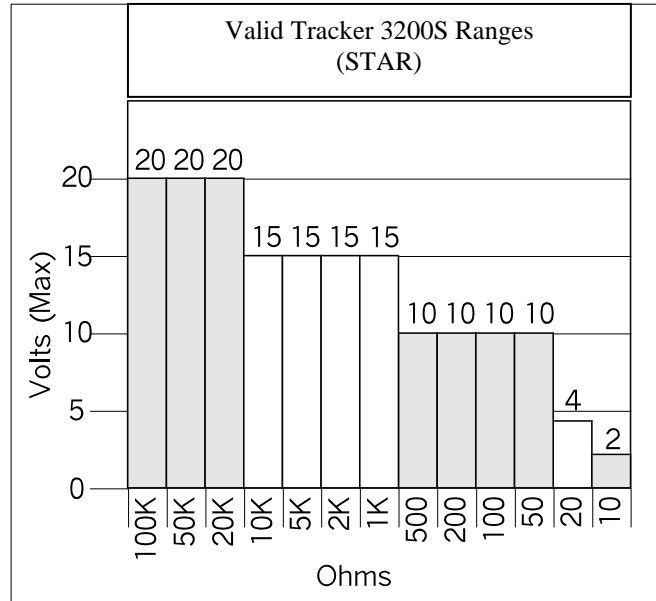
All Tracker signatures are a composite of one or more of the four basic component signatures which are: resistance, capacitance, inductance and semi-conductance. Refer to Fig 2-11. Each one of these basic components responds differently to the Tracker 3200S test signal. Recognizing these four basic unique signatures on the LCD display is one of the keys to successful ASA 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 analog 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.



**Figure 2-11.** Analog Signatures of the Four Basic Components

## 2-10 Smart Tracker Active Range (STAR) feature

The Tracker 3200S has a built-in operating feature called STAR (Smart Tracker Active Range). This important feature protects sensitive components from possible exposure to excessive power (for example, 15V and 10Ω).



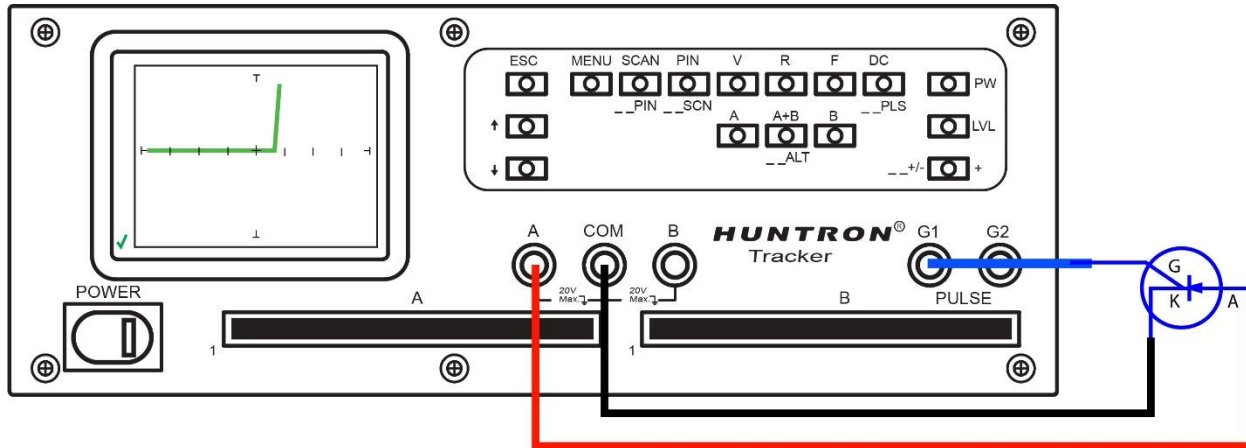
To illustrate the STAR feature, do the following:

Select the **3V**, **1kΩ** range using the front panel buttons. The range setting will be displayed on the top row of the LCD. Press the R button (solid LED) and use the ↓ arrow button to lower the resistance.

Notice you cannot select the **10Ω** range. To enable selection of the **10Ω** range you will need to lower the Tracker voltage to **2V**. The main factor in the STAR feature is limiting available current as it will only allow voltage/resistance range combinations to 200mA or less.

## 2-11 Pulse Generator

The built-in Pulse Generator of the Tracker 3200S allows in-circuit testing of certain devices in their active mode. In addition to using the red and black probes, the output of the Pulse Generator is connected to the control input of the device to be tested with the blue clip lead provided. The Pulse Generator has two outputs enabling you to test two devices at the same time (comparison testing) or double the output current level by connecting both outputs to one device. Figure 2-12 shows how to connect the Tracker to the device under test (a SCR is used in this example) using the Pulse Generator.



**Figure 2-12.** Tracker 3200S Pulse Generator Typical Setup

The Pulse Generator output is set using front panel buttons. The **DC/\_ PLS** button sets the output to DC (solid LED) or Pulse (flashing LED). The **LVL** (level) button enables you to change the output amplitude from zero to 10 volts using the **↑** and **↓** arrow buttons. The voltage level will be displayed on the LCD. The **+/- |+** button (below the **LVL** button) is a three state control that sets the Pulse Generator polarity to positive output (solid LED), negative output (no LED) or positive/negative output (flashing LED; used in Pulse mode only). When using the Pulse Generator in Pulse mode, the **PW** (Pulse Width) button can be pressed and the **↑** and **↓** arrow buttons used to change the duty cycle of the pulsed output. The Pulse Width setting will be displayed on the LCD and is variable from 2% to 50%. The frequency of the pulse will be the same as the Tracker frequency setting.

The Pulse Generator can be used to test gated devices such as SCRs, TRIACS, optocouplers and relays. It can also be used “bias test” transistors by applying voltage to the base while monitoring the collector-emitter signature with the Tracker. This test method works similar to the basic functions of a curve tracer.

### CAUTION

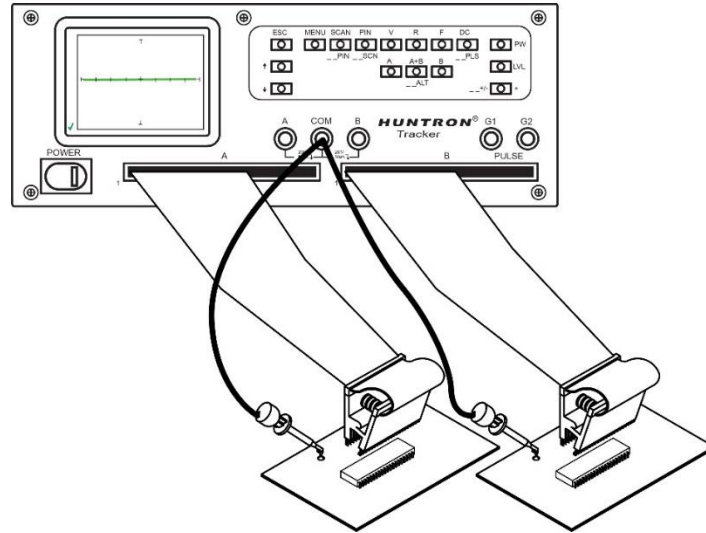
The device to be tested must have all power turned off and all high voltage capacitors discharged before connecting the Tracker to the device. Failure to do so may cause damage to the Tracker and void the warranty.



## 2-12 Scanning with a Tracker 3200S

The Tracker 3200S is a scanning version of the Tracker 3200S. It can automatically scan and compare up to 64 pins using standard IDC connections on the front panel. Common uses include connecting to PCB connectors and IC clips using custom ribbon cables.

Figure 2-13 shows a typical Tracker 3200S configuration using standard DIP clips attached to through-hole ICs.

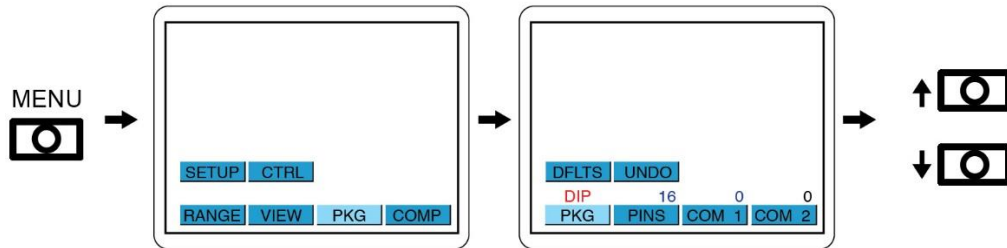


**Figure 2-13.** Typical 3200S setup with DIP clips

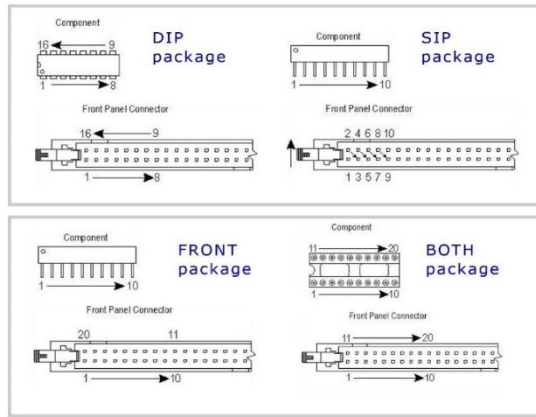
Using the scanning capabilities of the Tracker 3200S is very easy. It is possible to scan using one channel or both and also make signature comparisons between channel A and channel B.

To scan a component using the front panel cable interface, the package type and number of pins must first be configured (the Tracker 3200S default configuration is a 16 pin DIP package). 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** front panel button to display the Main menu. Select **PKG** from the touch screen Main menu to display the PKG menu. Select **PKG** (the text above the button will turn red) and use the **↑** and **↓** front panel buttons to step up or down through the package choices of DIP, SIP, BOTH or FRONT.

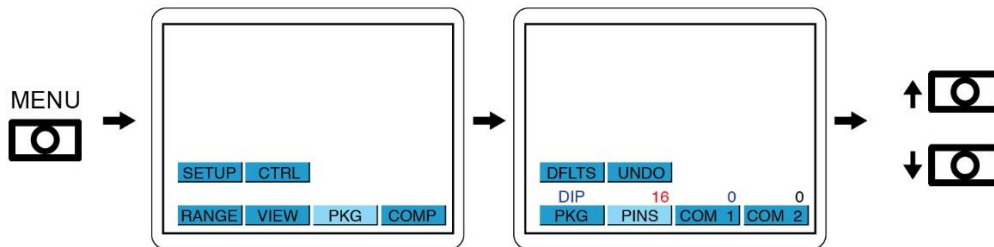


**Figure 2-14.** Changing Component Package (PKG) type



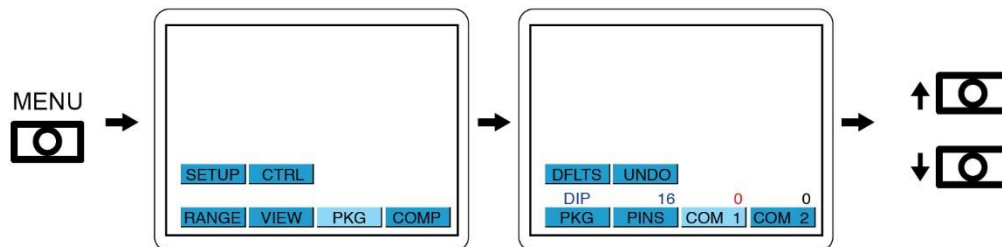
**Figure 2-15** Scan package types

Press the **PKG** button again or another button to exit the edit mode. Press the **PINS** button and use the **↑** and **↓** buttons to increase or decrease the numbers of pins to be scanned.



**Figure 2-16.** Changing Component Pins

Press the **COM1** button and use the **↑** and **↓** buttons to pin on the cable to be used as Common (disconnect any leads from the front panel COMMON jack if you are using this feature). The **COM2** selection is the same as COM1. Selecting a COM2 will enable the Tracker connect a second Common pin in addition to COM1.



**Figure 2-17.** Changing Component Common Pin

Press the **ESC** button until the power-up menu is reached. The pins can be scanned by using the front panel buttons. Make sure you have a Common connection to the PCBs or have a Common pin selected **PKG/COM1 (or COM2)** menu otherwise you will see only open circuit signatures (horizontal lines) on the Tracker display.

Select the channel or channels you wish to scan by pressing the A, B, A+B (solid LED) or **\_\_ALT** (flashing LED) buttons on the front panel. If A+B or **\_\_ALT** are used, a green check mark or red X will be displayed at the bottom left of the LCD indicating pass or fail.

**Tracker 3200S Scan modes:**



**SCAN** button (solid LED) – Scan through the 4 Default Ranges only

**\_\_PIN** button – Scan through the 4 Default ranges and increment to the next pin (pin number is displayed at the top of the LCD) automatically

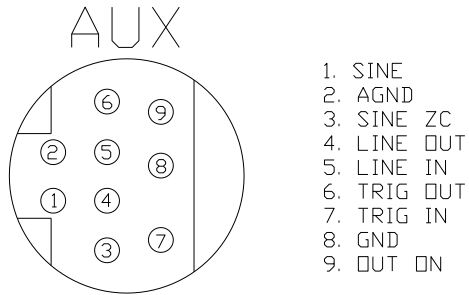
**PIN** button (solid LED) – Use the **↑** and **↓** arrow buttons to increment the pin up or down using the selected range (pin number is displayed at the top of the LCD)

**\_\_SCN** button (flashing LED) – Scan through the pins using the selected range (pin number is displayed at the top of the LCD); Pressing the **V**, **R** or **F** buttons twice (flashing LED) followed by the **\_\_SCN** button will enable the Tracker to scan through the available range settings before incrementing to the next pin

Press **ESC** to stop the scanning at any time.

### 2-13 Auxiliary (AUX) connector description

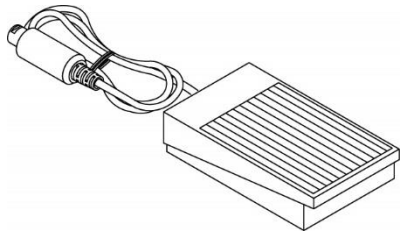
The rear panel Auxiliary (AUX) 9 pin Din connector pins are shown figure 2-18. This connection is used for control of the Tracker with the optional footswitch accessory.



**Figure 2-18**  
Auxiliary connector pin out diagram

### 2-14 Using the Footswitch with the Tracker 3200S

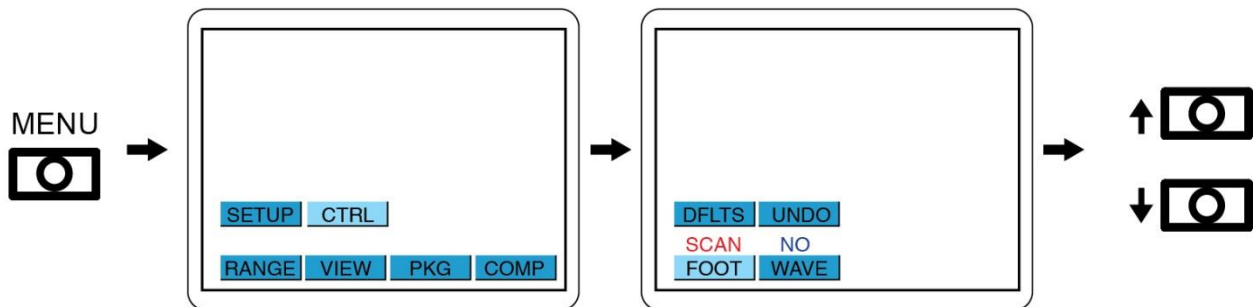
A footswitch (Huntron part number 98-0314) is included for controlling certain functions of the Tracker 3200S. It connects to the auxiliary port located on the Tracker back panel.



**Figure 2-19**  
Footswitch accessory for Tracker 3200S

The footswitch can be used for hands-free control of start/stop of scanning, changing the channel and changing the range.

To configure the footswitch control press the front panel **MENU** button to display the Main menu on the LCD. Press the **CTRL** button on the LCD to display the Control menu. Press the **FOOT** button on the LCD and use the **↑** and **↓** arrow buttons to select the footswitch control between **SCAN**, **CHAN** and **RANGE**.



**Figure 2-20** Tracker 3200S Footswitch Control Menus

Press the **ESC** button to return to the **CRTL** or main menu.

The footswitch controls work as follows:

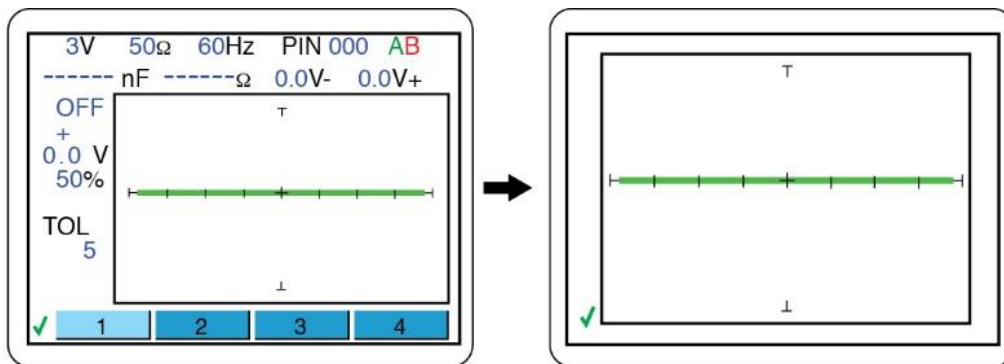
- **SCAN:** Pressing the footswitch will start the SCAN mode (same as manually pressing the front panel **\_PIN** button).
- **CHAN** (Channel): Pressing the footswitch will change the channel from A to B or vice versa.
- **RANGE:** Pressing the footswitch will step through the four Default ranges.

## 2-15 Tracker 3200S Touch Screen Menus

The Tracker 3200S utilizes a color LCD touch screen menu system for configuring operation of the Tracker 3200S. Many of the LCD menus will two button labelled **DFLTS** and **UNDO**. The **DFLTS** button set the current to the original factory default settings. The **UNDO** button will undo the last setting changes made for the current screen.

### Default Power-up menu and Full Screen Signature mode

Shown in figure 2-21 are the factory default power-up menu (left image) and the full screen signature screen mode (right image). Touch the signature portion of the screen to toggle between these two screens.

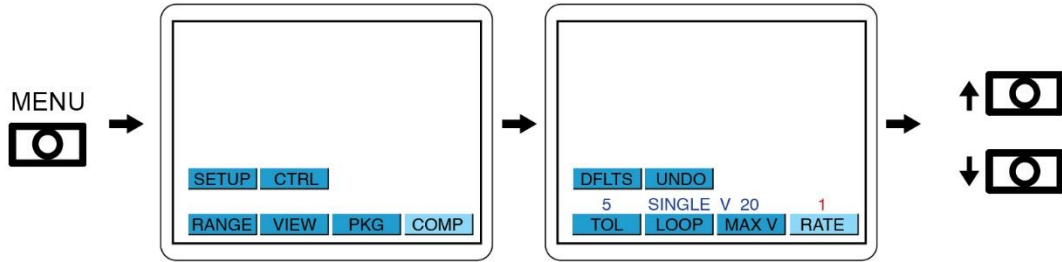


Press the center signature area of the LCD touch screen to change the LCD to Full Screen Signature mode

**Figure 2-21** Default Power-up screen (left) and Full Screen Signature mode (right)

### RATE (Alternate Speed) Controls

The Alternate (ALT) mode of the Tracker 3200S 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 alternation frequency is varied by pressing the **MENU** button, selecting **COMP** then **RATE** on the LCD touch screen and using the **↑** and **↓** arrow buttons until the desired alternation frequency is reached. The **RATE** is numbered from 1 (fastest) to 9 (slowest). Press the **ESC** button twice to return to the power-up menu.

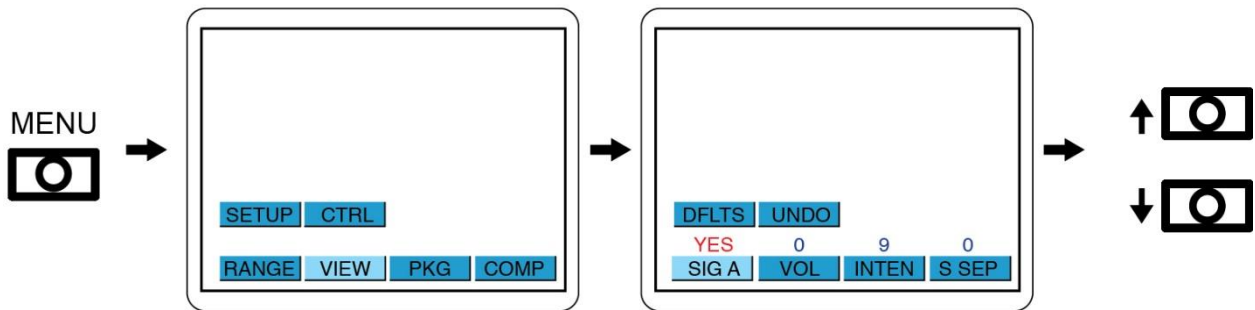


**Figure 2-22** Setting the RATE value

### SigAssist Control

SigAssist™ is a feature that displays values such as capacitance value, resistance value, forward breakdown voltage and reverse breakdown voltage on the LCD screen. You can turn the SigAssist feature on or off using the LCD menus.

Press the front panel **MENU** button to display the Main menu. Press the **VIEW** button on the touch screen to display the VIEW menu. Select the **SIG A** button and use the **↑** and **↓** arrow buttons to toggle the SigAssist to **YES** or **NO**



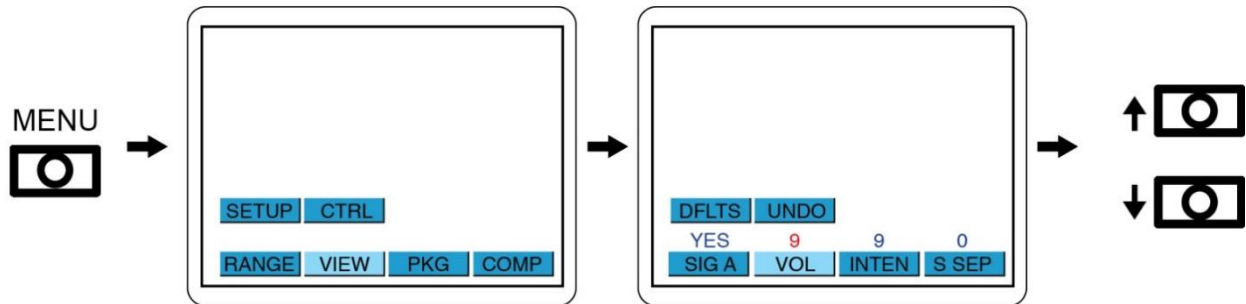
**Figure 2-23** Setting the SigAssist display

Press the **ESC** button to return to the Main menu.

## Volume Control

When using the front buttons or using some of the Scan functions, you will hear an audible tone. You can control the volume of the tone using the LCD menus.

Press the front panel **MENU** button to display the Main menu. Press the **VIEW** button on the touch screen to display the VIEW menu. Select the **VOL** button and use the **↑** and **↓** arrow buttons to toggle the volume value where **9** is the loudest and **0** is off.



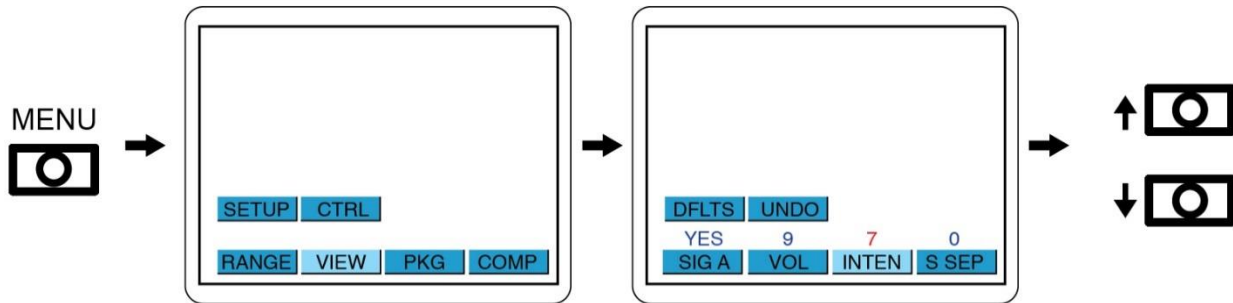
**Figure 2-24** Setting the VOL (volume) value

Press the **ESC** button to return to the Main menu.

## LCD Backlight Intensity Control

You can control the intensity of the LCD backlight using the LCD menus.

Press the front panel **MENU** button to display the Main menu. Press the **VIEW** button on the touch screen to display the VIEW menu. Select the **INTEN** button and use the **↑** and **↓** arrow buttons to toggle the volume value where **9** is the brightest and **1** is dimmest. **7** is a recommended setting.



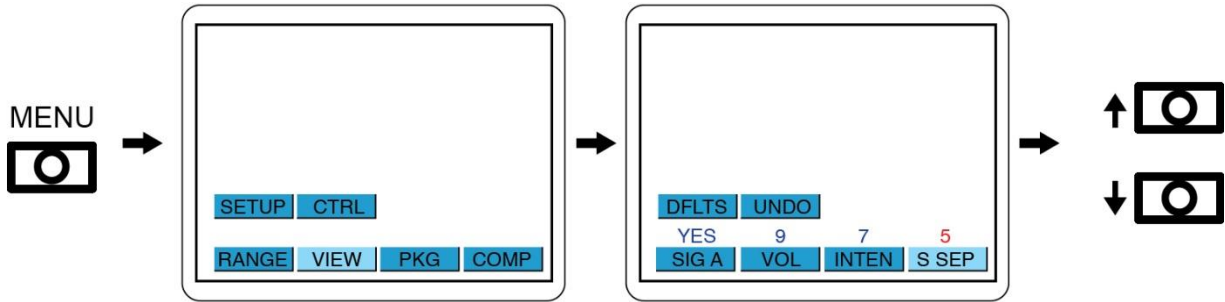
**Figure 2-25** Setting the INTEN (intensity) value

Press the **ESC** button to return to the Main menu.

## Signature Trace Separation Control

When using the A+B mode to view the Channel A and Channel B signatures at the same time, it may be useful to separate the two signature by a small amount. You can control the separation of the two signature traces using the LCD menus.

Press the front panel **MENU** button to display the Main menu. Press the **VIEW** button on the touch screen to display the VIEW menu. Select the **S SEP** button and use the **↑** and **↓** arrow buttons to toggle the volume value where **0** is no separation and **5** is maximum separation.

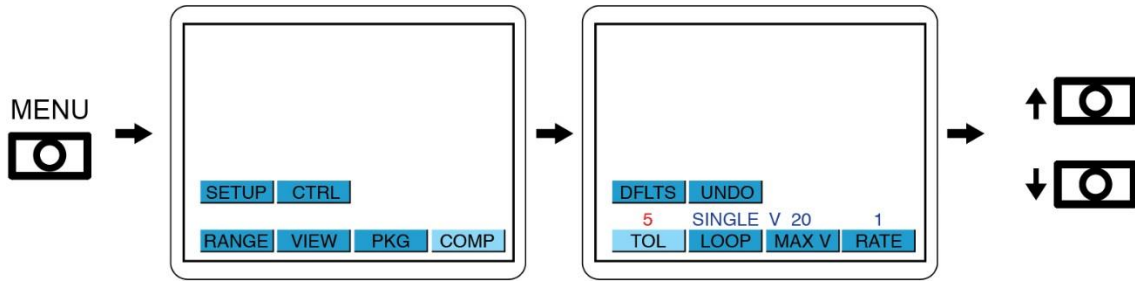


**Figure 2-26** Setting the **S SEP** (signature separation) value

Press the **ESC** button to return to the Main menu.

### COMP – TOL (Tolerance) Controls

Tracker 3200S users can set a tolerance value that allows for slight variation when the signature on channel A is compared against the signature on channel B. The tolerance is adjustable from 0 to 99 where 0 is no variation and 99 is maximum variation. The default tolerance setting is 5. The larger the tolerance, the greater the two signatures can differ and still be considered a “pass” when compared against each other. To adjust the Tolerance value press the **MENU** button then the **COMP** button on the LCD. Select the **TOL** button and use the **↑** and **↓** arrow buttons to adjust the Tolerance value.



**Figure 2-27** Setting the **TOL** (Tolerance) value

It is recommended that a low setting such as 5 or 10 be used for general purpose comparison troubleshooting.



## COMP – LOOP Controls

When scanning with the Tracker 3200S users can set the LOOP control to **STOP** (stop when a signature difference is detected), **SINGLE** (run a single scan and stop) and **LOOP** (continuously scan until stopped by the user). To adjust the LOOP setting press the **MENU** button then the **COMP** button on the LCD. Select the **LOOP** button and use the **↑** and **↓** arrow buttons to adjust the LOOP setting.

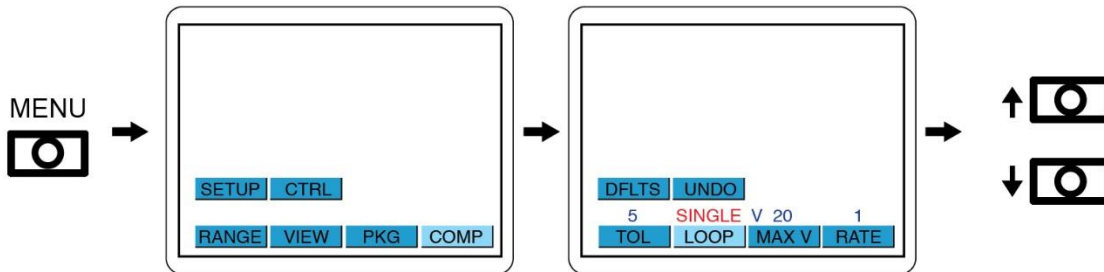


Figure 2-28 Setting the LOOP value

**LOOP** scanning can be stopped by pressing the **ESC** button.

## COMP – MAX V Controls

The Tracker 3200S can be set to not exceed a specific voltage if desired using the **MAX V** control. To adjust the **MAX V** setting press the **MENU** button then the **COMP** button on the LCD. Select the **MAX V** button and use the **↑** and **↓** arrow buttons to adjust the **MAX V** (maximum voltage) setting (.200V to 20V).

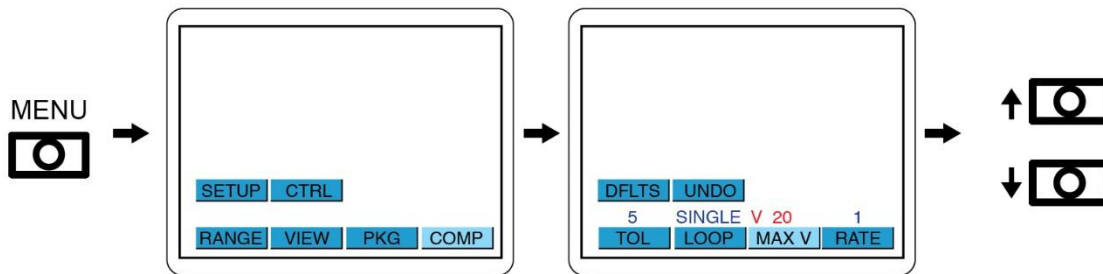


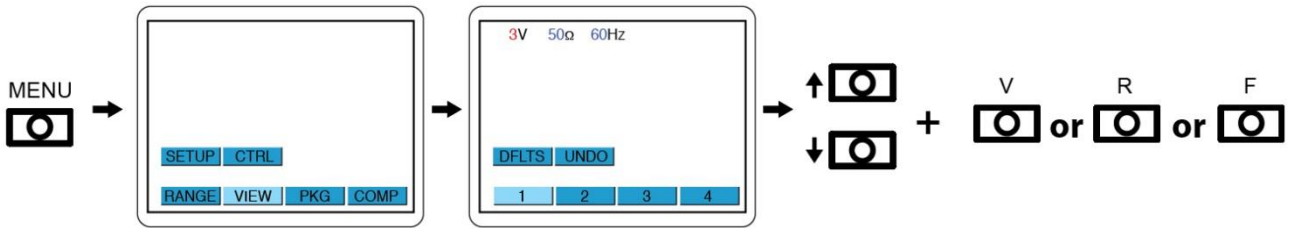
Figure 2-29 Setting the MAX V (maximum voltage) value

**MAX V** is used to restrict application of voltages that could exceed component specifications.

## Setting the DEFAULT Ranges

The main power up screen will display four default range buttons across the bottom of the LCD. The default ranges are **3V, 50ohms, 60Hz**; **3V, 1Kohms, 200Hz**; **3V, 50Kohms, 500Hz**; and **3V, 100Kohms, 200Hz**. If you want to change the default range settings press the front panel **MENU** button and select **RANGE** on the LCD. The LCD will display four range buttons across the bottom labeled 1 through 4. Select a Range button and the current settings will be displayed at the top of the LCD. To change a range parameter, press the corresponding **V**, **R**, or **F** button from the front panel and

use the **↑** and **↓** buttons to adjust the setting. Using Voltage as an example, you would press the **V** front panel button and use the **↑** and **↓** buttons to adjust the voltage setting up or down.



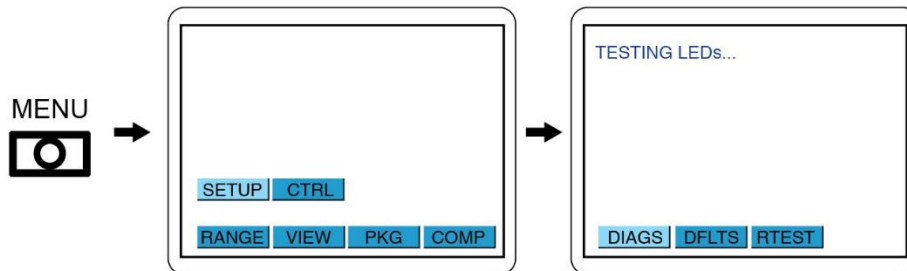
**Figure 2-30** Setting the Default Ranges (Range 1 used as an example above)

## Other Touch Screen Menus – **SETUP**

### Diagnostics

The Tracker 3200 has built-in diagnostics to ensure that the unit is functioning properly. The diagnostics can be accessed through the touch screen menus.

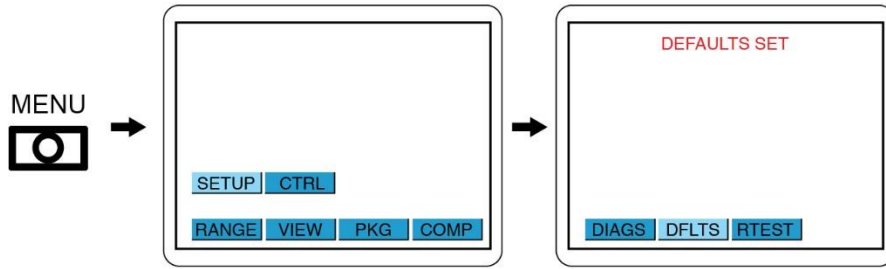
To access the diagnostics menus, press the **MENU** front panel button to display the Main menu. Select the **SETUP** button then select the **DIAGS** button. The Diagnostics will start automatically. Each step and the status are displayed on the LCD as they are run. There are **SKIP** and **ABORT** options on the DIAG menu. **SKIP** will stop the current diagnostic step and allow you to select the next step by selecting the **NEXT** button. Diagnostics will stop if there is an error detected. You will have the option to select **NEXT**, **SKIP** or **ABORT**.



**Figure 2-31** **SETUP** – **DIAGS** menu

### Defaults

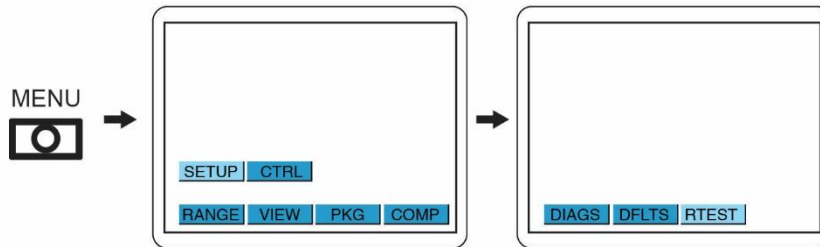
To set the Tracker 3200S to the original Factory defaults settings, press the front panel **MENU** button. Select the **SETUP** button and then the **DFLTS** button on the LCD. The Tracker will indicate that the defaults have been set.



**Figure 2-32** Setting Tracker to Factory Defaults

## RTEST

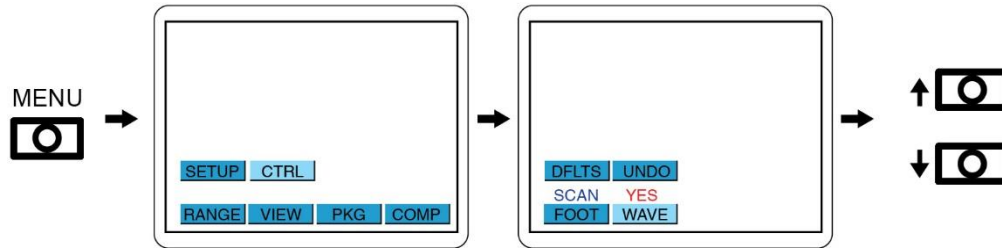
To run the Tracker 3200S range resistors test, press the front panel **MENU** button. Select the **SETUP** button and then the **RTEST** button on the LCD. The test will be run and the status indicated. Contact Huntron Technical Support if you see failures.



**Figure 2-33** Running RTEST (Resistor Test)

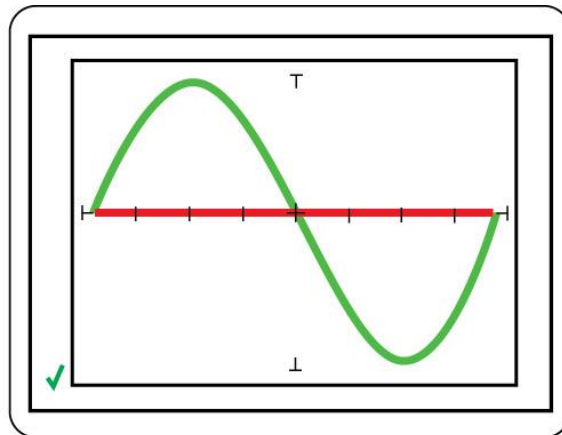
## WAVE Mode

The Tracker 3200S can be set to show the horizontal (voltage) and vertical (current) waveforms on the LCD in addition to the analog signatures. Press the front panel and then select **CTRL** on the LCD. Select the **WAVE** button on the LCD and use the **↑** and **↓** buttons to toggle the setting to **YES** or **NO**.



**Figure 2-34** Setting to Waveform mode

Press the ESC button to return to the signature screen. Tapping the center of the signature box will toggle the display between signature with values, signature only (zoom mode) and waveform mode. Waveform mode is primarily useful when diagnosing problems with the Tracker but can be interesting to use when dealing with reactive components such as capacitors and inductors.



**Figure 2-35** Tracker waveform display

## SECTION 3 TESTING PASSIVE COMPONENTS

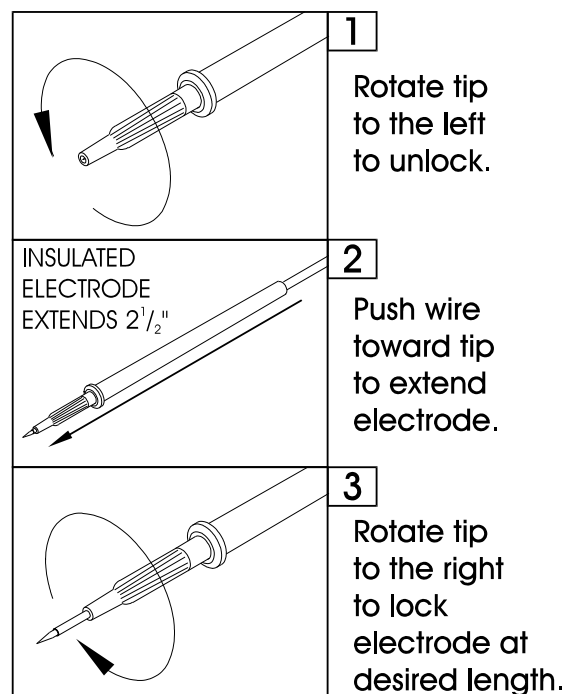
### 3-1. RESISTORS

Exploring how the Tracker 3200S ranges interact with different resistance values is a good introduction on how basic ASA troubleshooting is applied. This section will briefly familiarize you with Tracker 3200S basic operation and teach you how resistor signatures relate to both test range and the resistance of the circuit under test.

As you go through the following section, make a mental note on the relationship between the Tracker 3200S's test range parameters: voltage, resistance and frequency.

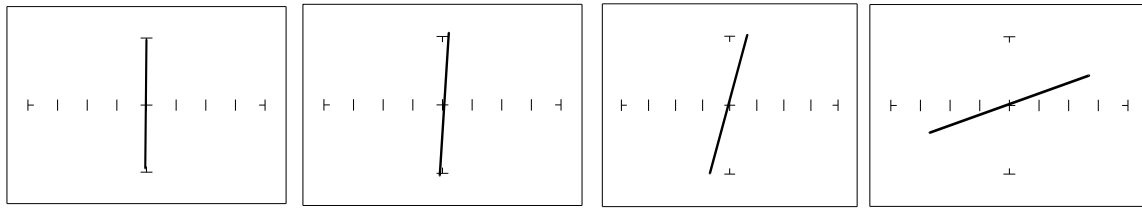
Put the red test lead in the **Channel A** jack, and the black test lead in the **Common** jack.

**Micro Probe Adjustment** (Do not over-tighten the tip in step 3):



**Figure 3-1.** Huntron MicroProbe Adjustment.

Below are four analog signatures of different resistors, 100, 1k, 10k and 100k ohms in each of the four Ranges. Note how the slope or angle of each analog signature changes with each resistor's value.



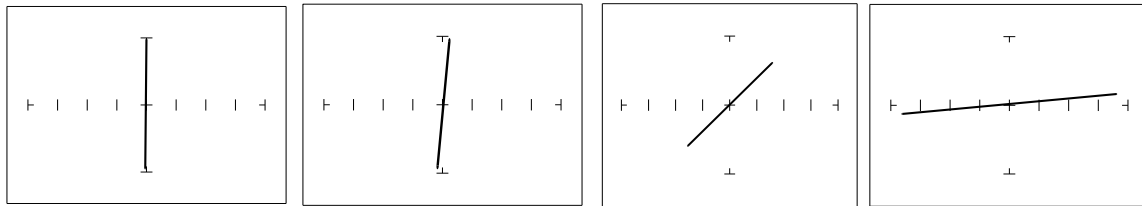
100  $\Omega$

1 k $\Omega$

10 k $\Omega$

100 k $\Omega$

**Tracker ranges:  $V_s=15V$ ,  $R_s=100k\Omega$ ,  $F_s=200Hz$**



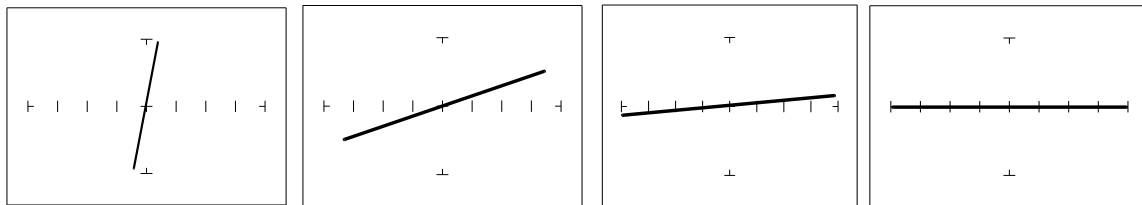
100  $\Omega$

1 k $\Omega$

10 k $\Omega$

100 k $\Omega$

**Tracker ranges:  $V_s=15V$ ,  $R_s=10k\Omega$ ,  $F_s=200Hz$**



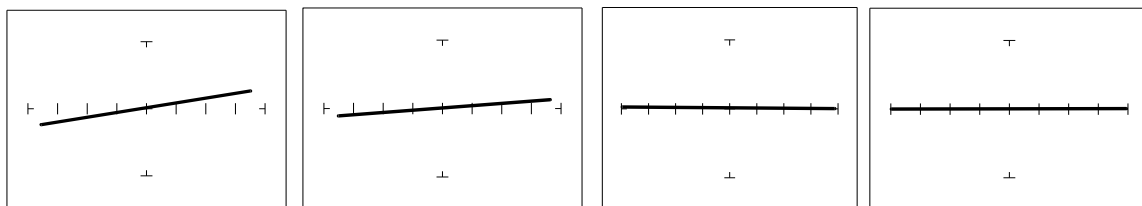
100  $\Omega$

1 k $\Omega$

10 k $\Omega$

100 k $\Omega$

**Tracker ranges:  $V_s=10V$ ,  $R_s=1k\Omega$ ,  $F_s=200Hz$**



100  $\Omega$

1 k $\Omega$

10 k $\Omega$

100 k $\Omega$

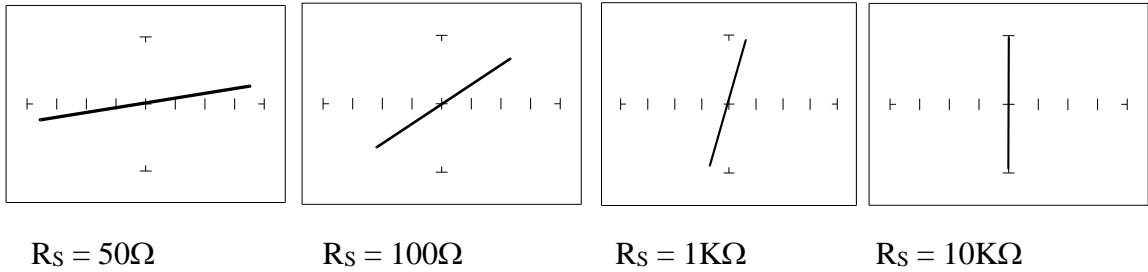
**Tracker ranges:  $V_s=3V$ ,  $R_s=10\Omega$ ,  $F_s=200Hz$**

**Figure 3-2.** Signatures of Different Resistors in 4 Ranges.

Now that you have an idea of what the signatures of different resistor values look like in different ranges, the next part will give you an idea of what happens when you vary  $R_s$  source resistance,  $V_s$  source voltage and  $F_s$  source frequency of the Tracker 3200S and how it affects the resistive analog signature.

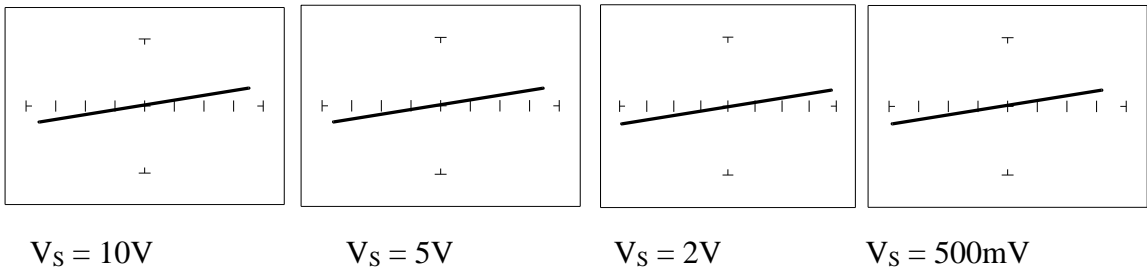
**The Effect of  $R_s$  on Resistor Analog Signatures.**

Observe the signatures for a 100 ohm resistor in the figure below as  $R_s$  varies. Note how these resistor signatures respond to changing Tracker 3200S's internal resistance.



**Figure 3-3.** Effect of Varying  $R_s$  on a  $100\Omega$  Resistor Signature

**The Effect of  $V_s$  on Resistor Analog Signatures.**

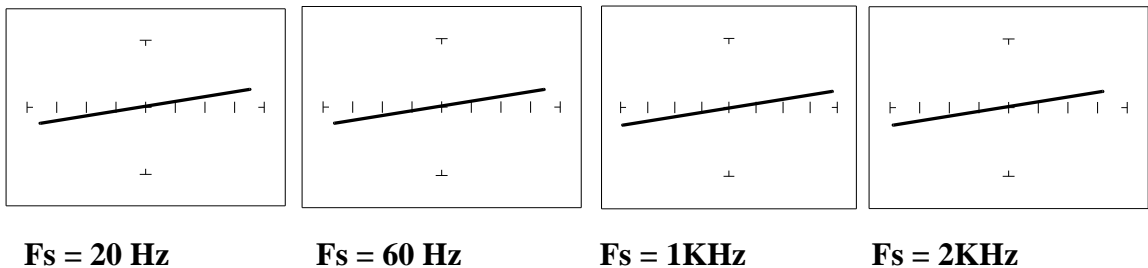


**Figure 3-4.** Effect of Varying  $V_s$  on a  $100\Omega$  Resistor Signature.

Observe that these signatures do not change with the changing voltage.

**The Effect of  $F_s$  on Resistor Analog Signatures.**

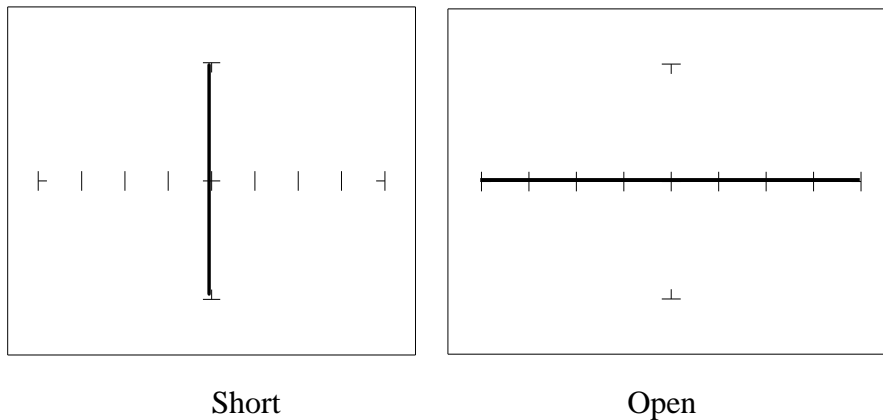
Changing the Frequency to 60Hz, 1KHz and 2KHz. Observe the resistor signatures in the following figures do not change as  $F_s$  changes.



**Figure 3-5.** Effect of Varying  $F_s$  on a  $100\Omega$  Resistor Signature.

## Shorts, Opens and 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  $0\ \Omega$  to  $10\ \Omega$  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.



**Figure 3-6.** 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 range increases
  - the volts per division of the horizontal axis increases
  - the internal resistance increases
  - the signature becomes more vertical

### Troubleshooting Applications

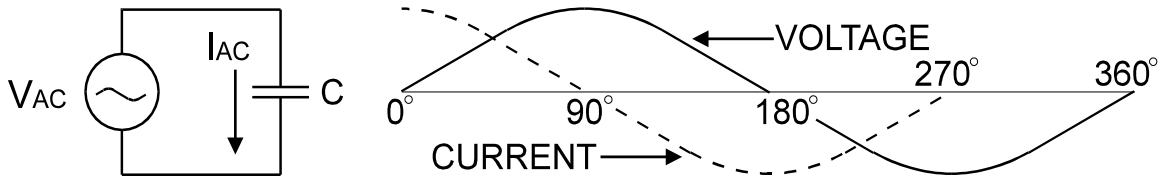
- The Tracker 3200S is a fast and efficient continuity tester, providing real time information.



- The Tracker 3200S 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 3200S's ability to determine the approximate fault resistance value greatly enhances the troubleshooting capability if the correct value is known.
- The Tracker 3200S 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.

## 3-2. CAPACITORS

With a capacitor connected to the Tracker 3200S, the test signal across it responds quite differently than a resistor. The typical analog signature of a capacitor is an elliptical or circular pattern due to the fact that relationship between the test signal's current and voltage are non linear. The current's waveform is 90 degrees out of phase with respect to the voltage. The diagram below illustrates this basic principle for capacitors.



**Figure 3-7.** 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  $90^\circ$ . On the Tracker 3200S, this analog 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 voltage, internal resistance and frequency.

### Capacitor Analog 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 ( $\mu\text{f}$ ) 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 3200S

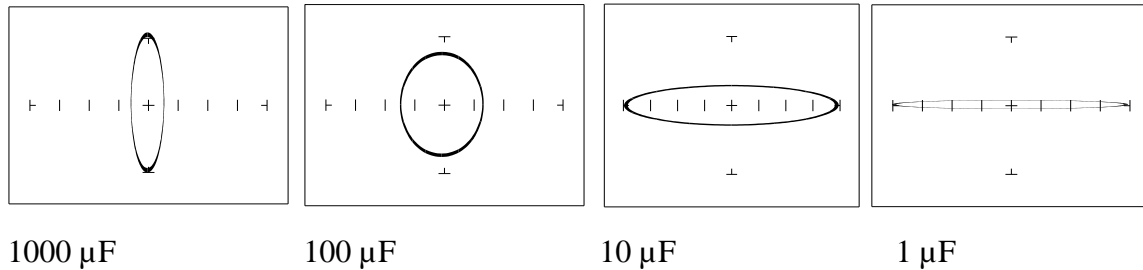
Plug the red test microprobe in the Channel A jack, and the black test clip lead in the Common jack.

### ⚠ CAUTION

The device to be tested must have all power turned off and have all high voltage capacitors discharged before connecting the Tracker 3200S to the device.

#### The Signatures of Different Capacitors

The figure below shows analog signatures for four different value capacitors, 1000  $\mu\text{f}$ , 100  $\mu\text{f}$ , 10  $\mu\text{f}$  and 1  $\mu\text{f}$  using a 10V, 50 $\Omega$  and 60Hz range

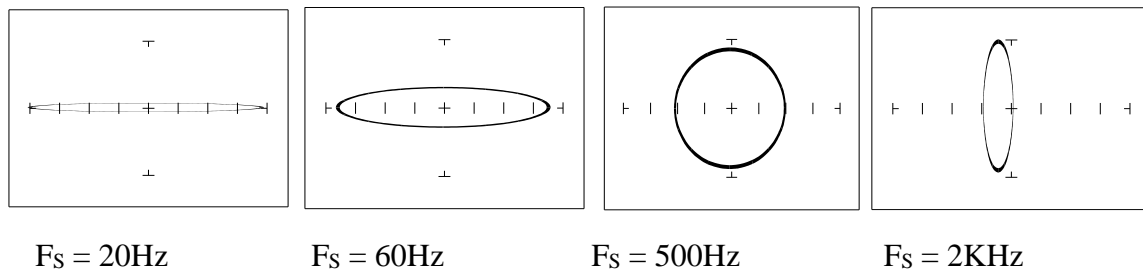


**Figure 3-8.** Signatures of 4 Capacitors in the 10V, 50 $\Omega$  and 60Hz Range.

Note that as the capacitance values decrease, each signature changes from a vertical elliptical pattern to a horizontal elliptical pattern. In ASA, 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 Changing Frequency on a 10 $\mu\text{F}$ Capacitor

Selected range 10V, 50 $\Omega$  and 20Hz. then changed to 60Hz, 500Hz and 2KHz.

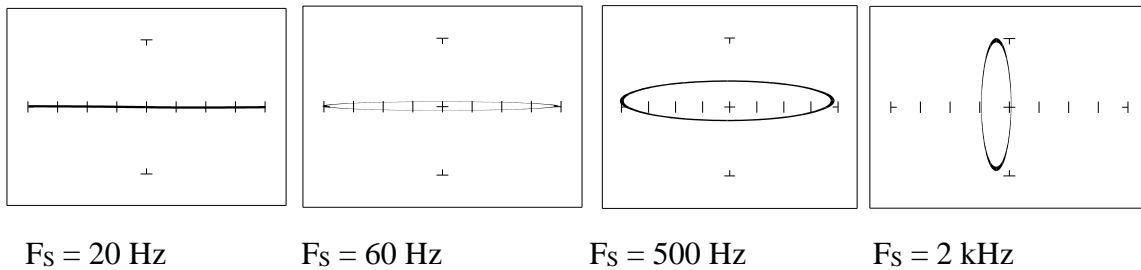


**Figure 3-9.** Signatures of a 10 $\mu\text{F}$  Capacitor at Different Frequencies

Note that as the test signal frequency increases, the 10  $\mu\text{F}$  capacitor's signature changes from a horizontal elliptical pattern to a vertical elliptical pattern. In ASA, 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 Changing Frequency on a 0.1 $\mu$ F Capacitor

Selected range 10V, 1K $\Omega$  and 20Hz then changed to 60Hz, 500Hz and 2KHz.

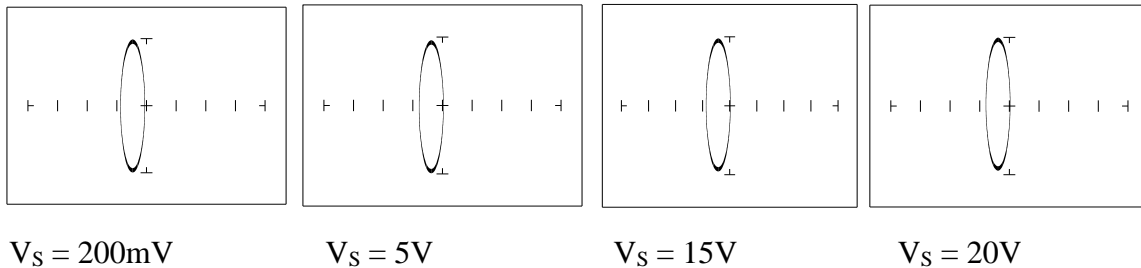


**Figure 3-10.** Signatures of a 0.1  $\mu$ F Capacitor at Different Frequencies.

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

### Effect of Changing Voltage on a 1 $\mu$ F Capacitor

Selected range 200mV, 20K $\Omega$  and 60Hz then changed to 5V, 15V and 20V.

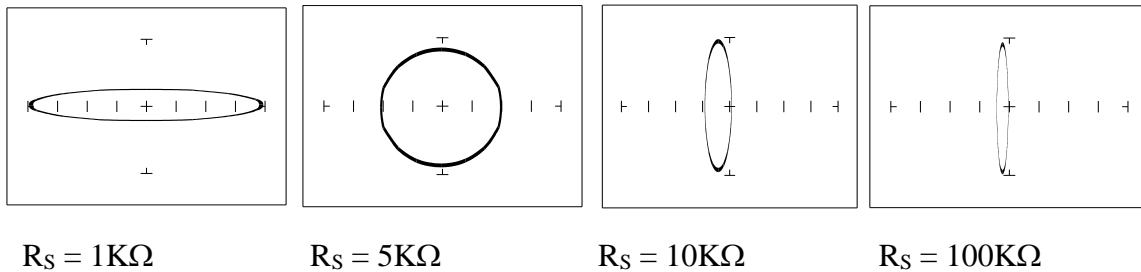


**Figure 3-11.** Signatures of a 1  $\mu$ F Capacitor at Different Test Signal Voltages.

As  $V_S$ , the test signal voltage increases from low to high, the signatures did not change.

### Effect of Changing Resistance on a 1μF Capacitor

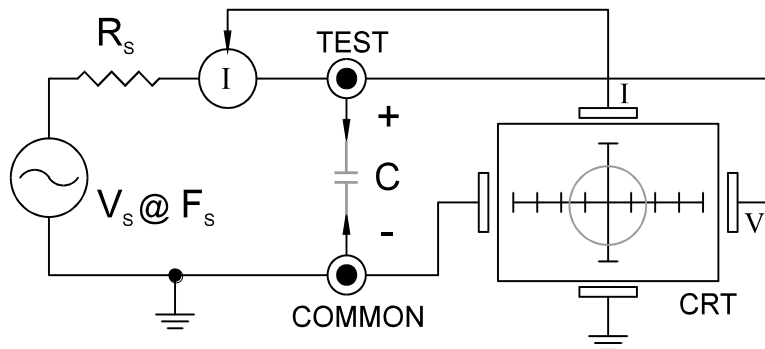
Selected range 15V, 1K and 60Hz then changed to 5K, 10K and 100K.



**Figure 3-12.** Signatures of a 1μF Capacitor at Different Internal Resistances.

As the Tracker 3200S's internal resistance  $R_S$  decreased, the capacitor's signature changes from a horizontal elliptical pattern to a vertical elliptical pattern. In ASA, a large internal resistance value results in a capacitor signature that looks similar to an open circuit. And likewise, a small internal resistance value results in a capacitor signature that's similar to a short circuit.

### Understanding Capacitive Signatures



**Figure 3-13.** Tracker 3200S Core Circuit Block Diagram with a Capacitor.

The Huntron Workstation Software displays the Tracker 3200S signature as a response to its test signal, an analog 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. To review and summarize capacitive analog 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 3200S, the elliptical signature will become increasingly vertical that 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 3200S, the elliptical signature will become increasingly vertical that 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 V increases
  - The elliptical signature is not affected
- Changing source resistance  $R_s$ : As the resistance is changed from 1 k $\Omega$  to 100 k $\Omega$ , the following occurs:
  - $X_C$  of the capacitor is not affected
  - $V_s$  increases so current decreases proportionately

The elliptical signature becomes increasingly vertical

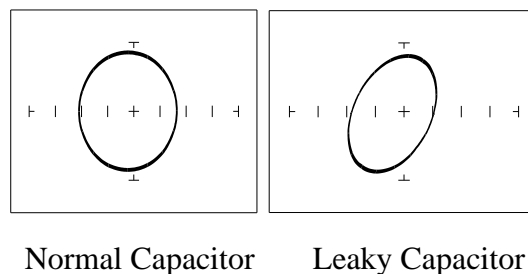
Table 3-1 shows the Tracker 3200S's limits for the minimum and maximum capacitance values that will display a usable signature on the Tracker display.

$R_s$	$F_s = 20 \text{ Hz.}$	$F_s = 2 \text{ kHz}$
100 k $\Omega$	0.01 $\mu\text{F}$ - 1 $\mu\text{F}$	100 pF - 0.01 $\mu\text{F}$
10 $\Omega$	15,000 $\mu\text{F}$ - 100 $\mu\text{F}$	0.1 $\mu\text{F}$ - 100 $\mu\text{F}$

**Table 3-1.** Tracker 3200S Minimum and Maximum Capacitor Values.

### Capacitor Failures – Leakage

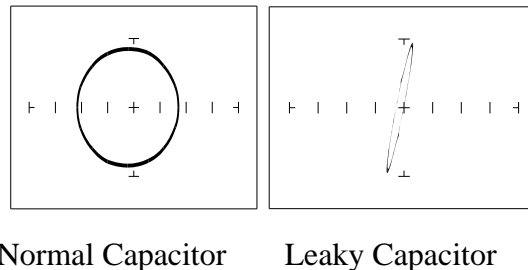
One common physical failure in capacitors is dielectric leakage. The dielectric or insulator in a capacitor normally acts as a non-conductor between the capacitor's two plates. A flawed capacitor develops a conductive or leakage path between its two plates. This can be thought of as a resistance in parallel with the capacitance when observing its signature. These examples show what some capacitor leakage problems may look like in the Tracker 3200S signature display with 50 $\Omega$ , 10V and 60Hz selected.



**Figure 3-14** Signatures Of A 100  $\mu\text{F}$  Capacitor With Dielectric Leakage.

This example only simulates the leakage flow by adding a  $100\ \Omega$  resistor in parallel to a  $100\ \mu\text{F}$  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  $10\ \mu\text{F}$  capacitor.



**Figure 3-15** Signatures of a  $10\ \mu\text{F}$  Capacitor with Dielectric Leakage at  $10\text{V}$ ,  $500\ \Omega$ ,  $60\text{Hz}$

Again, this example only simulates the leakage flow by adding a  $68\ \Omega$  resistor in parallel to a  $10\ \mu\text{F}$  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 3200S 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 3200S can locate defective capacitors in or out of circuit. The ranges cover  $100\ \text{pF}$  to  $15,000\ \mu\text{F}$ .
- When analyzing a capacitor's signature, adjust the Tracker 3200S'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 in the signature display.

### 3-3. INDUCTORS

Inductors, like capacitors, have elliptical analog signatures and respond to Tracker 3200S'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 with some amount of resistance in it, it is hard to find a pure inductance. An inductor's analog signature will usually be an elliptical pattern with some slope or tilt to it due to the resistance of the coil wire.

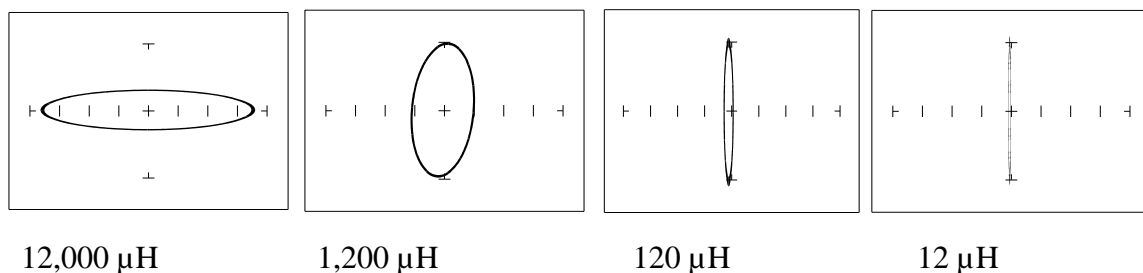
#### Inductive Signatures

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

- The inductance ( $L$   $\mu$ H) 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 3200S

#### Signatures of Different Inductor Values

The figure below shows analog signatures for four different value inductors, 12,000  $\mu$ H, 1200  $\mu$ H, 120  $\mu$ H and 12  $\mu$ H. Select 10V, 50 $\Omega$ , 2KHz.



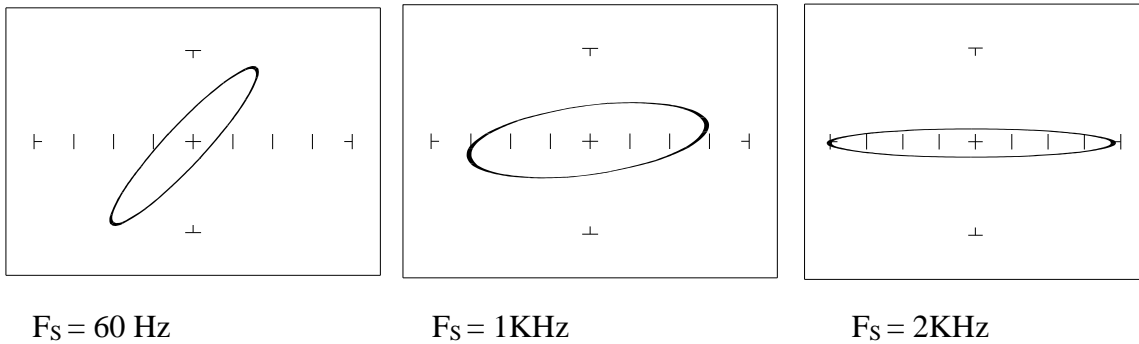
**Figure 3-16** Signatures of 4 Inductors at 10 V, 50 $\Omega$ , 2KHz.

Note that as the inductance values decrease, each signature changes from a horizontal elliptical pattern to a vertical elliptical pattern. In ASA, 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 Changes on Inductive Signatures

Selected range 10V, 50Ω, 60Hz then changed to 1KHz and 2KHz.

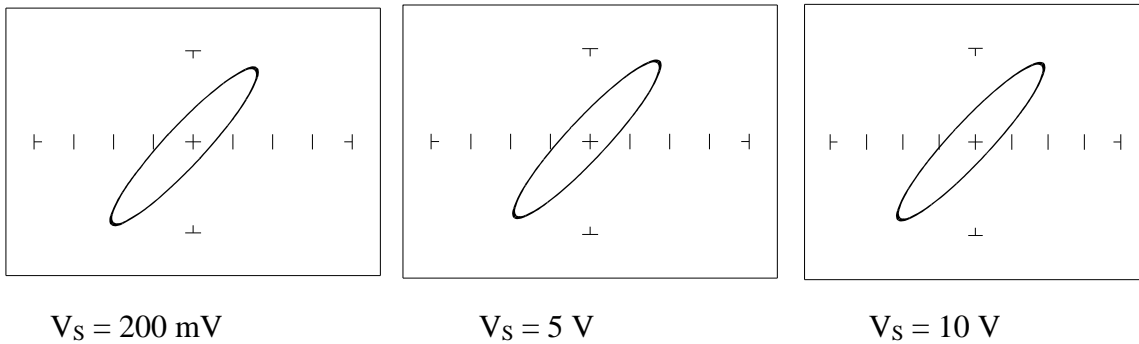


**Figure 3-17** Effect of varied  $F_S$  on 12,000  $\mu\text{H}$  Inductor Signatures.

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 Changes on Inductive Signatures

Selected range 200mV, 50Ω, 60Hz then changed to 5V and 10V.

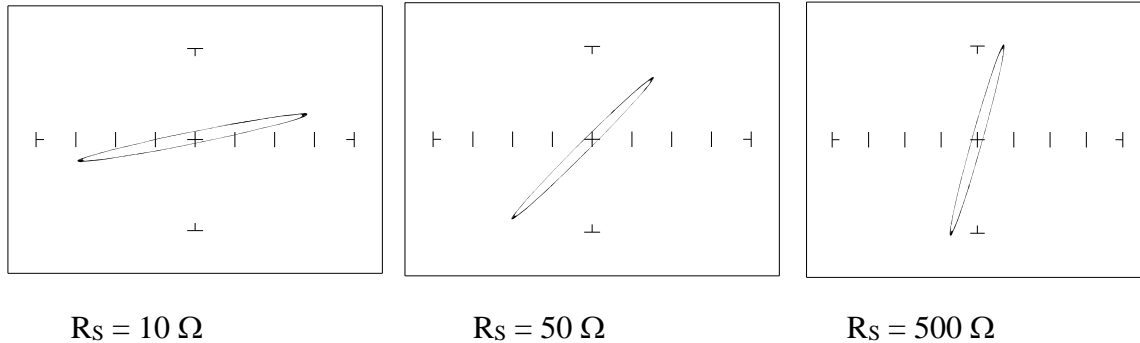


**Figure 3-18** Effect of varied  $V_S$  On 12,000  $\mu\text{H}$  Inductor Signatures.

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 Resistance Changes on Inductive Signatures

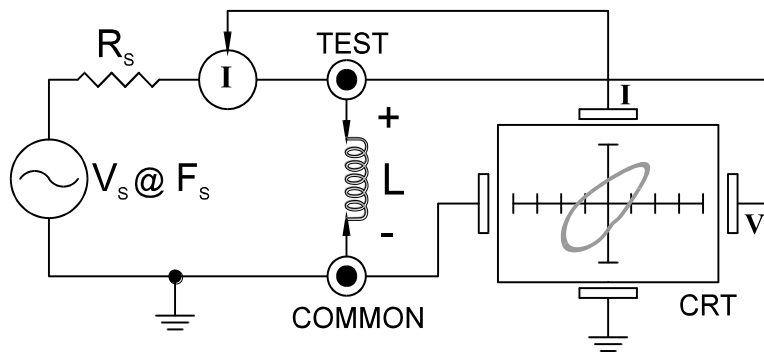
Selected range 2V, 10Ω, 60Hz then changed to 50Ω and 200Ω.



**Figure 3-19** Effect of Varying  $R_s$  on 12,000  $\mu\text{H}$  Inductor Signatures.

Note that the signature changes from a horizontal to a vertical position as the Tracker 3200S's internal resistance  $R_s$  increases. This means the inductor's resistance can be analyzed by matching it with the Tracker 3200S's test signal resistance.

## Understanding Inductive Signatures



**Figure 3-20** Tracker 3200S Tracker Core Circuit Block Diagram with an Inductor.

The Tracker 3200S'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 3200S'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 analog 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 3200S display usually is distorted. Inductors constructed with a ferrite core makes the inductive characteristics different from those constructed without. The Tracker 3200S responds with a unique analog signature for each inductor type.

<b>R<sub>s</sub></b>	<b>F<sub>s</sub> = 20 Hz.</b>	<b>F<sub>s</sub> = 2 kHz</b>
100 kΩ	100H – 1000H	50mH – 1000mH
10 Ω	1H – 100H	1uH – 10mH

**Table 3-2.** Tracker 3200S Minimum and Maximum Inductor Values.

## 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 3200S test signal's frequency is increased, the ellipse signature becomes flatter. This response is opposite to that of a capacitor.
- As the Tracker 3200S internal resistance R<sub>s</sub> 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 3200S 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. For example, some of these are power transformers, relays, solenoids, flybacks, 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 analog 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 3200S's signature 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 3200S signature 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 from the computer.

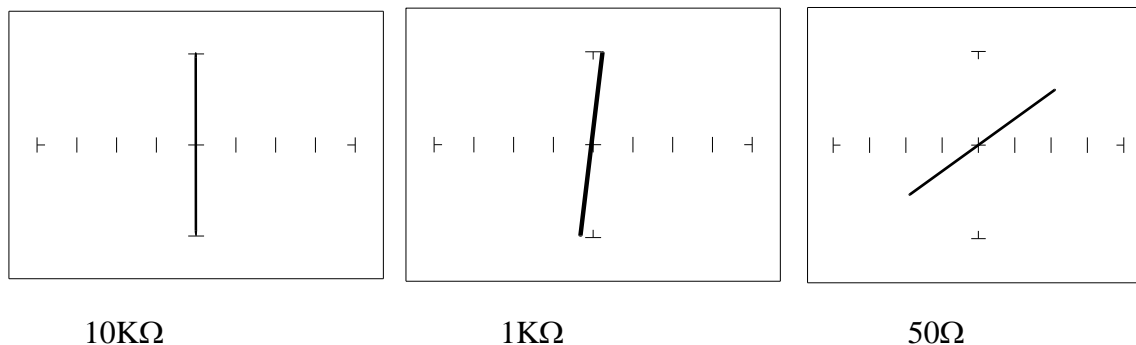
- Another simple test for a speaker or microphone is to apply the Tracker 3200S signal in  $V_S = 10\text{ V}$ ,  $R_S = 50\ \Omega$ ,  $F_S = 60\text{Hz}$  range to the device input leads and listen for the 60 Hz tone or audible hum.
- To test solenoids, connect the test probes to the coil leads and manually move the plunger or activator in and out while observing if its signature changes.

### 3-4. 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 3200S, the test signal can be setup so that the switch's analog signature will verify its switching function. The goal of this section is to develop a test strategy using ASA 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 3200S can test the switching function of mechanically activated switches easily. Unlike the DVM that samples and gives a continuity measurement, the Tracker 3200S displays real time activity so if a switch has noisy, resistive or intermittent operation, its analog signature on Tracker 3200S's display will reflect these conditions.



**Figure 3-21** Signatures of a pressed Keyboard Pushbutton Conductive Elastomer Switch.

Note that as the ranges change from 10KΩ to 1KΩ to 50Ω, the signature tilts away from the vertical. This characteristic is similar to other components with internal resistance.

#### Review

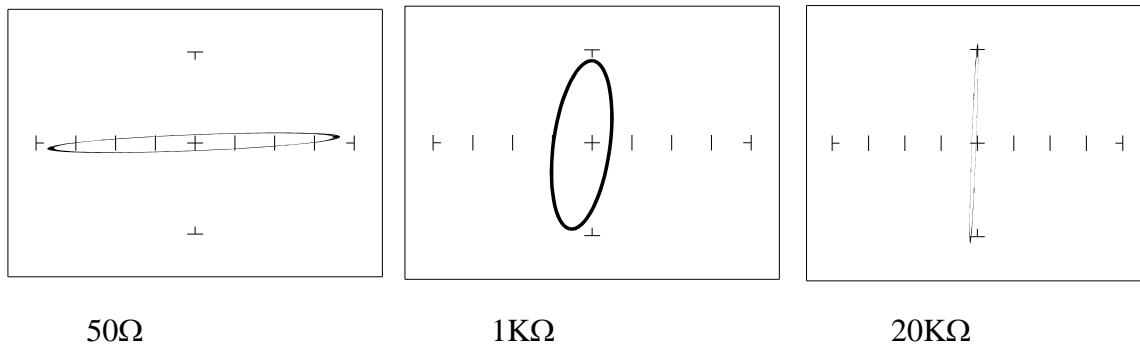
- The switch has internal resistance.
- As the test signal's voltage decreases with each range change, the volts per division of the horizontal axis also decreases so that its analog signature becomes more pronounced. This is caused by the small voltage drop across the switch's internal resistance.

#### Electromechanical Switches

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 3200S can test the coil part of the relay by looking at its inductive analog signature.

## Relay Coil Test

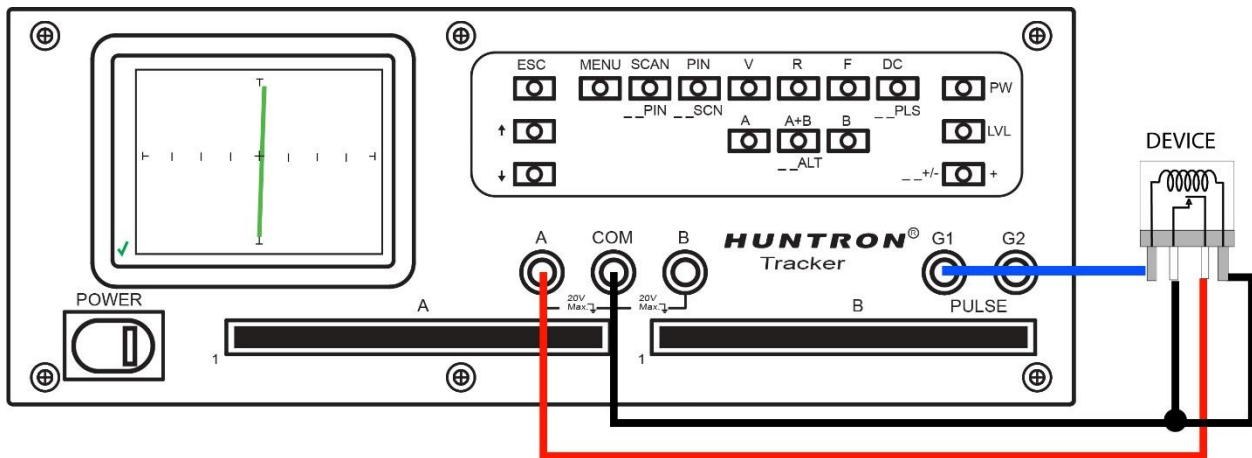
Observe the analog signatures of a magnetic reed type relay in the following figure.



**Figure 3-22** Signatures of a Magnetic Reed Relay Coil at 2KHz.

Note the characteristic inductive oval at 3 resistances. When applying Tracker 3200S'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.

To test the contacts of a relay, use the Tracker to monitor the relay contacts while applying voltage to the relay coil using the Tracker 3200S Pulse Generator.



**Figure 3-23** Using the Tracker 3200S Pulse Generator for Relay Testing

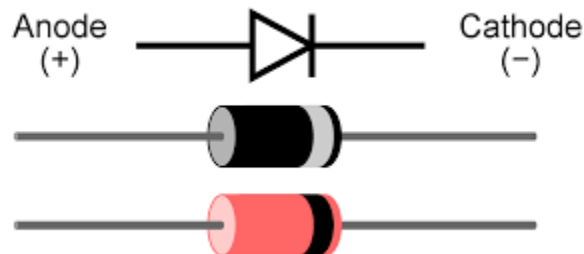
## Review

- The Tracker 3200S can test switches in real time. This makes an excellent test for microswitches, 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. Resistive contacts will display a resistive signature at 50Ω.

## SECTION 4 TESTING DISCRETE SEMICONDUCTORS

### 4-1. DIODES

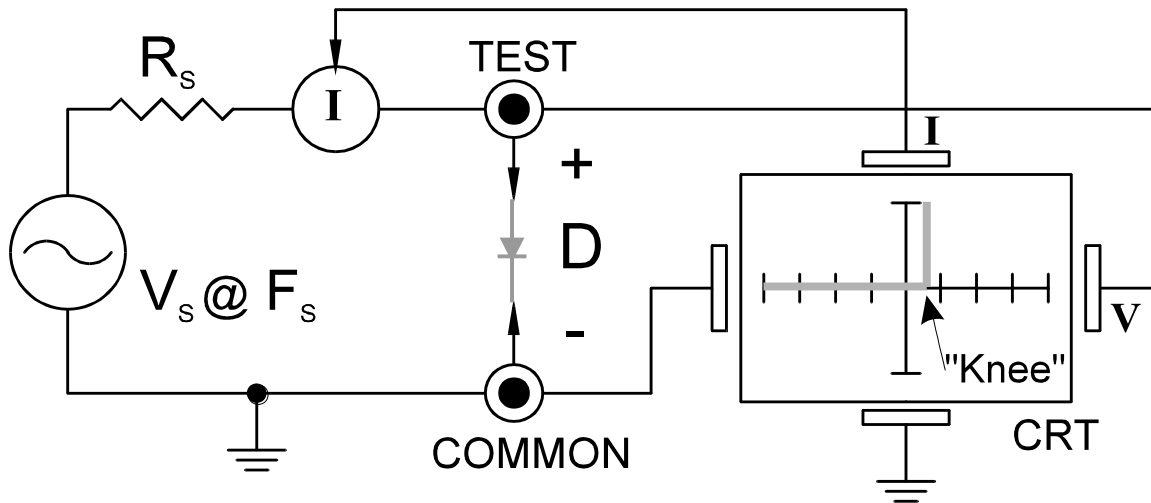
The most basic type of solid state semiconductor component is the diode. Diodes are formed by creating a junction between p-type and n-type semiconductor material. The pn junction gives diodes and semiconductor components polarity characteristics that allow them to conduct current when an external voltage 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). Figure 4-1 shows how the diode symbol indicates the polarity of the diode.



**Figure 4-1.** Diodes and symbol

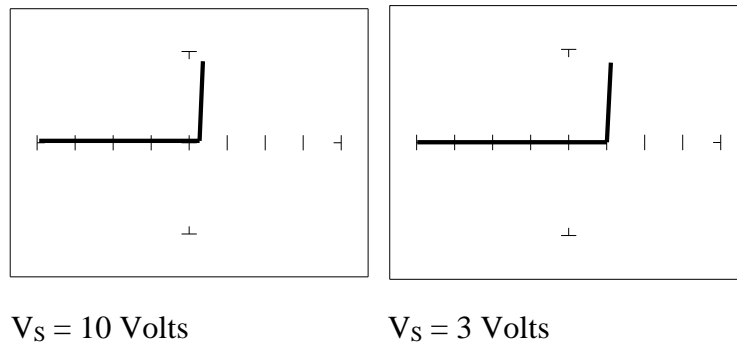
#### Diode Signatures

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 analog signature analysis, this is called the “knee” effect in which is characteristic of a good semiconductor junction.



**Figure 4-2.** Tracker 3200S Core Circuit Block Diagram with a Diode.

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



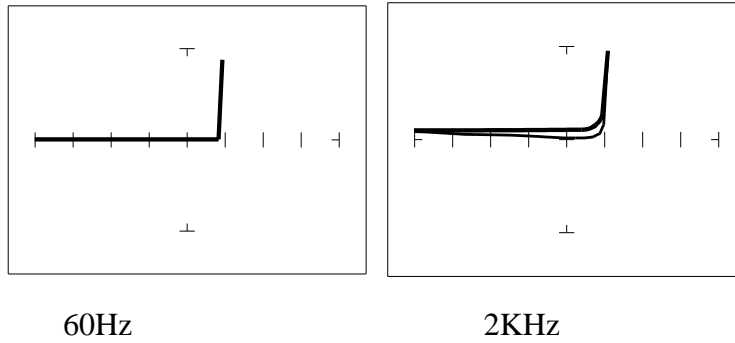
**Figure 4-3.** Signatures of a 1N914 type Silicon Diode at 50Ω and 60Hz.

The diode signatures are similar to each other. In the 50 Ohm range, the test signal voltage is 10 V<sub>P</sub>. 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 lowering the test voltage to 3 V with the encoder, the 0.6 volt threshold is clearly visible for easier analysis.

### Effects of Changing Frequency on Diode Signatures

With the 3V, 50Ω selected and the test signal frequency of 60 Hz, the signature of the diode is shown on the left figure below. Changing only the test signal frequency to 2kHz displays the signature on the right. At F<sub>s</sub> = 2kHz, the diode's signature has slight circular loop added to it. This loop in the signature is due to a physical characteristic of diodes called junction capacitance.

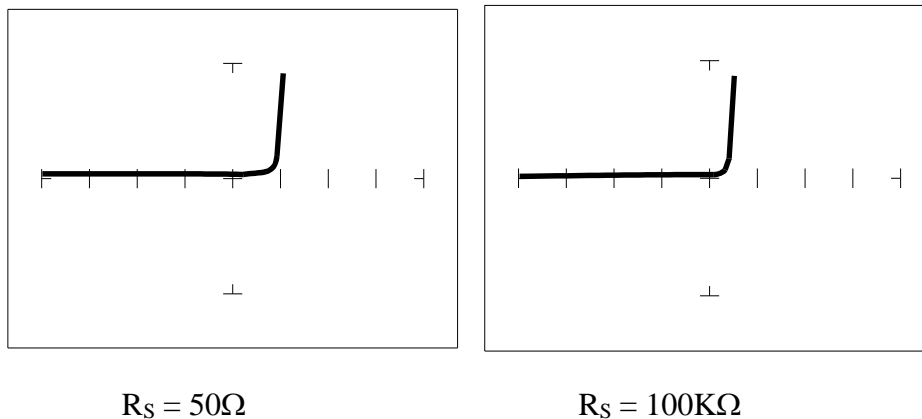




**Figure 4-4.** Signature of a 1N914 Diode at Different Frequencies at 3V and 50Ω.

### Effects of Changing Resistance on Diode Signatures

Changing Tracker 3200S's internal resistance  $R_S$  moves the vertical knee portion of the diode's analog 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.

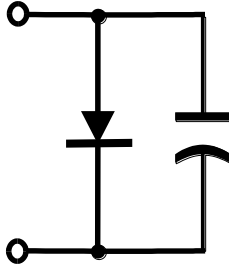


**Figure 4-5.** Signature of a 1N914 Diode at Different Resistances at 3V and 60Hz

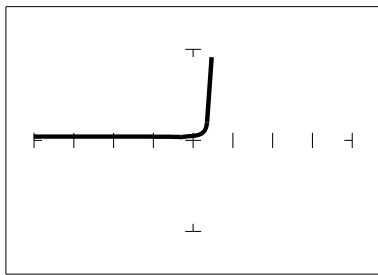
### Composite Diode Signatures

A composite analog 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 ASA, the signatures are a composite that may appear quite complex. However, with knowledge of ASA fundamentals and experience you will find that even the most complex looking signatures can be analyzed quickly and efficiently.

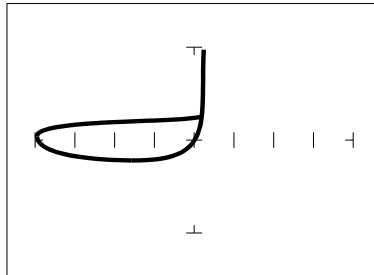
This section will introduce you to some examples of composite diode signatures.



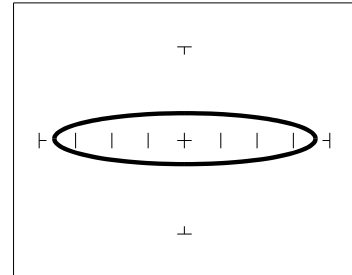
**Figure 4-6** Composite Model of a Diode and Capacitor in Parallel.



$V_S = 10\text{ V}, F_S = 20\text{ Hz}$



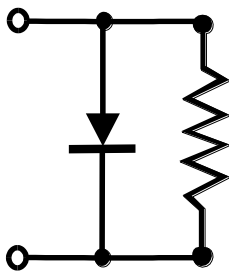
$V_S = 10\text{ V}, F_S = 1\text{ KHz}$



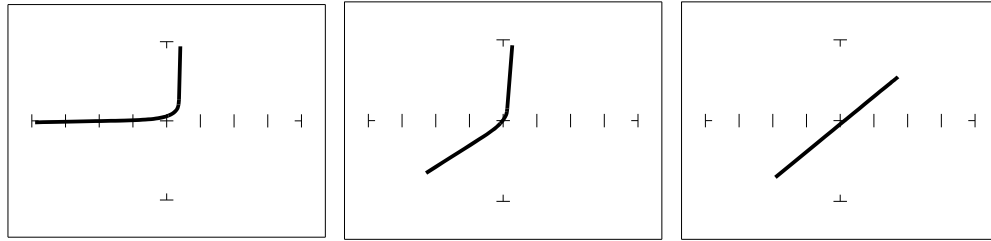
$V_S = 200\text{ mV}, F_S = 1\text{ KHz}$

**Figure 4-7** Composite Signature - 1N914 Diode and  $1\mu\text{F}$  Capacitor in Parallel.

The signature on the left shows only the diode signature because the test signal frequency is set below any visible contribution due to 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 turn on level. When multiple components are connected together, it's important to realize that the Tracker 3200S has the ability to selectively display the signature of a single component.



**Figure 4-8** Composite Model of a Diode and Resistor in Parallel.



$V_s = 10 \text{ V}, R_s = 50 \Omega$      $V_s = 10 \text{ V}, R_s = 1\text{K}\Omega$      $V_s = 200 \text{ mV}, R_s = 1\text{K}\Omega$

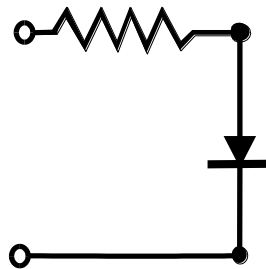
**Figure 4-9** Composite Signature - 1N914 Diode and 1KΩ Resistor in Parallel.

The signature on the left shows only the diode signature because the test signal resistance is set below any visible contribution due the 1kΩ 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 turn on level. Again, when multiple components are connected together, it's important to realize that the Tracker 3200S has the ability to selectively display the signature of a single component.

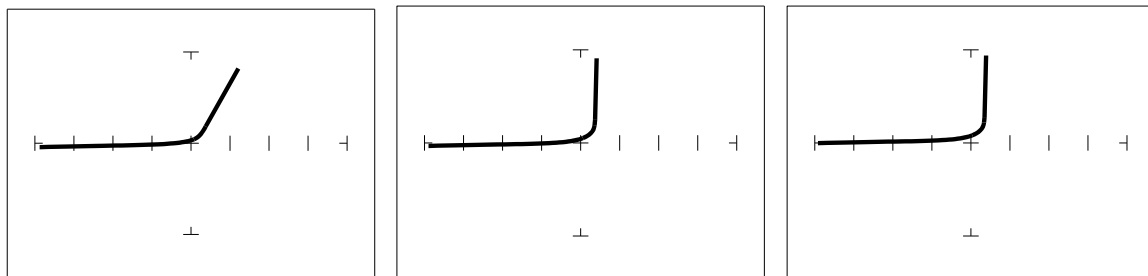
### Diode Failures

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 Fault in a Diode



**Figure 4-10** Defective Diode Model with a Small Series Resistor.



50Ω, 10V

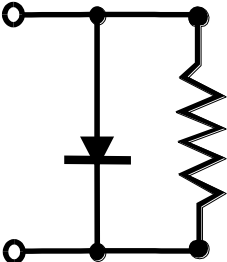
1KΩ, 15V

20KΩ, 20V

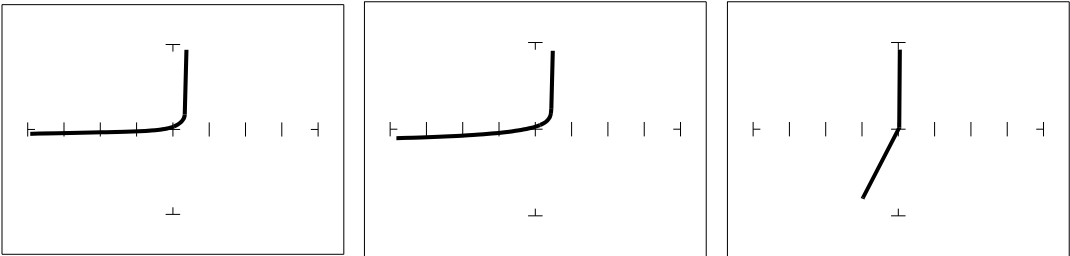
**Figure 4-11** Defective Diode Signature with a 50 Ω Series Resistor.

The 50Ω 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 50Ω range because the voltage drop across it is small. In the other two ranges, the resistance is masked due to the internal resistances being too large to show such a small voltage drop.

**Internal Leakage Fault in a Diode**



**Figure 4-12** Defective Diode Model with an Internal Leakage Resistance.



50Ω, 10V

1KΩ, 15V

50KΩ, 20V

**Figure 4-13** Signature Of A 1N914Diode With Internal Leakage (10KΩ In Parallel).

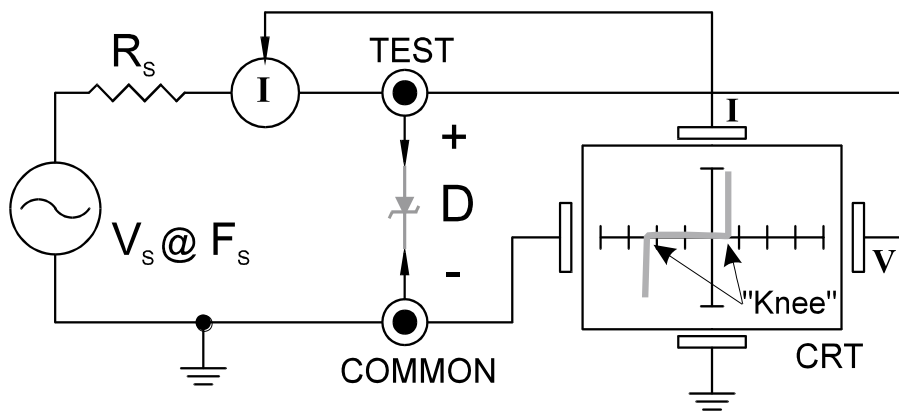
Notice that in the 50Ω range, there does not seem to be a problem. In the 1KΩ and 10KΩ ranges, you can see the diode conducting when it should be acting like an open. This is called leakage. The diode acts like a diode when it is forward biased. When reverse biased, the diode acts like a resistor when it should be acting as an open.

**Zener Diodes**

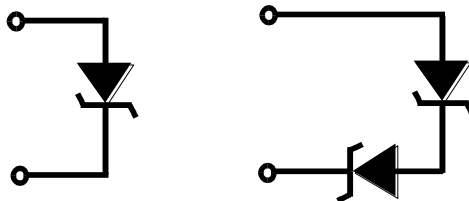
Normal switching and signal diodes conduct when forward biased only. When reverse biased, they act as opens unless they are operated outside design limits. If this condition occurs then so much voltage is applied that they break down and can no longer prevent current flow.

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.

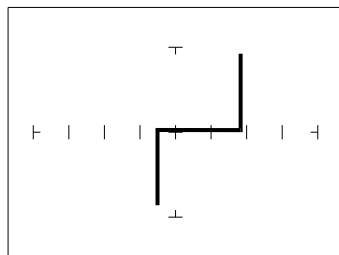
When reverse biased, they act as an open until the applied voltage reaches their specified zener voltage, at which time the zener diode begins to conduct current. Even if the reverse voltage is increased, the voltage across the zener remains constant. It is this feature of zener diodes that allows them to be used as voltage regulators and references. Because they conduct in both directions, the zener diode's analog signature has two knees, one at 0.6V and the other at the zener voltage of the diode. In ASA terminology, this two knee signature is known as the classic "chair" pattern that is common in many solid state semiconductor components.



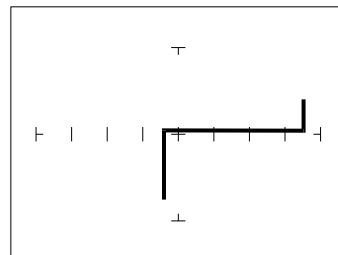
**Figure 4-14** Tracker 3200S Core Circuit Block Diagram with a Zener Diode.



**Figure 4-15** Single Zener Diode and two Zener Diodes in Series.



Single 1N5239B Zener Diode



2 Zener Diodes in Series, 1N5239B

**Figure 4-16** Signatures of a Zener Diodes at 20V, 10KΩ

Since each horizontal division on the Signature graticule (in 20V range) is approximately 5 Volts, from the signature on the left you can estimate that this is about a 9 volt zener diode. The signature at the right is the signature of two zener diodes connected in series. The Zener voltage ( $V_Z$ ) of this circuit is the sum  $V_Z$  of each of the separate diodes. The signature shows this voltage to be approximately 18 Volts.

## Review

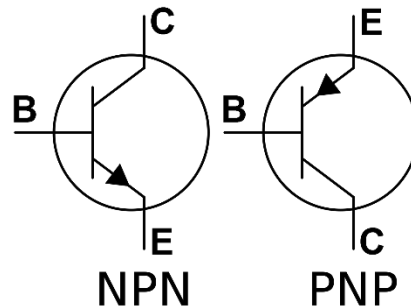
- Diodes conduct current in one direction (forward biased) and not the other. The diode's analog signature displays this characteristic as the “knee” effect or pattern.
- Diodes have polarity, an anode and a cathode.
- Diode defects, other than opens and shorts, are usually resistive.
- A diode in series or parallel with a resistor or capacitor will create a composite signature displaying both characteristics. The Tracker 3200S makes it easier to separate these characteristics from composite signatures using the three parameters  $F_S$ ,  $R_S$  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 3200S 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 3200S 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 3200S can be used to test and determine the four pin connections on a bridge rectifier, (AC1, AC2, + and -).

## 4-2. 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 4-17 shows circuit symbol for a PNP and an NPN transistor.



**Figure 4-17** Diagram of an NPN and PNP Bipolar Transistor.

### IMPORTANT NOTE

Use of this instrument may alter the current gain ( $h_{FE}$  or  $\beta$ ) 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 (~8-20 Volts). If the voltage is above 8 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 on the base-emitter junction as it may cause the  $h_{FE}$  to shift outside the limited range where calibration can correct for any change.

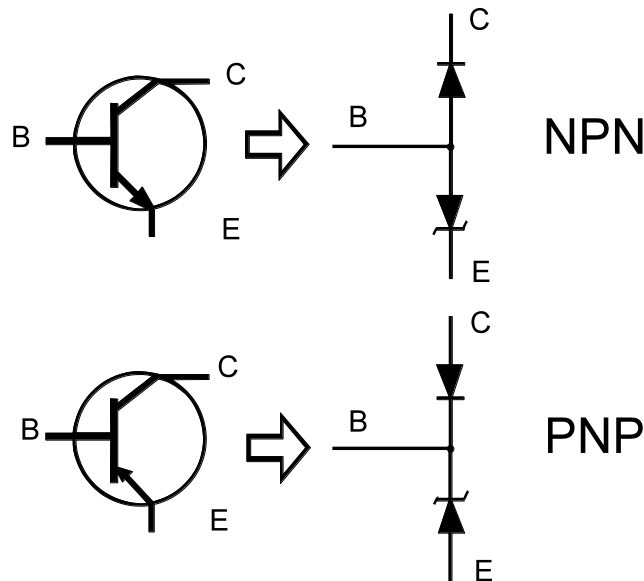
Suggestions to minimize effects on bipolar transistors:

1. Use 5 Volts or less for testing the base-emitter or collector-emitter.
2. If using 8 Volts or greater, then keep the duration of the test as short as possible.

- 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.

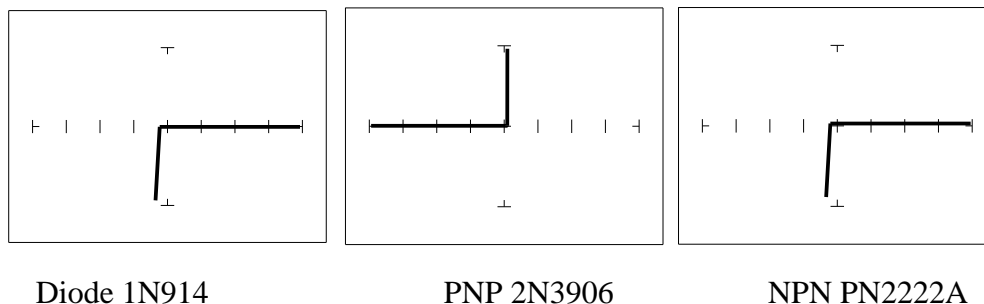
### Bipolar Transistor Signatures

In order to better understand the signatures that transistors create on the Tracker 3200S, we can model these devices in terms of equivalent diode circuits. These are shown in figure 4-18. These figures show that the collector-based junction analog signature looks similar to a diode signature, and the emitter-base junction signature looks similar to a zener diode signature. Because we have already seen the signatures of these two types of junctions when we tested diodes, they should be familiar to you.



**Figure 4-18** NPN and PNP Bipolar Transistor Equivalent Circuits

### Bipolar Transistor Base-Collector Signatures

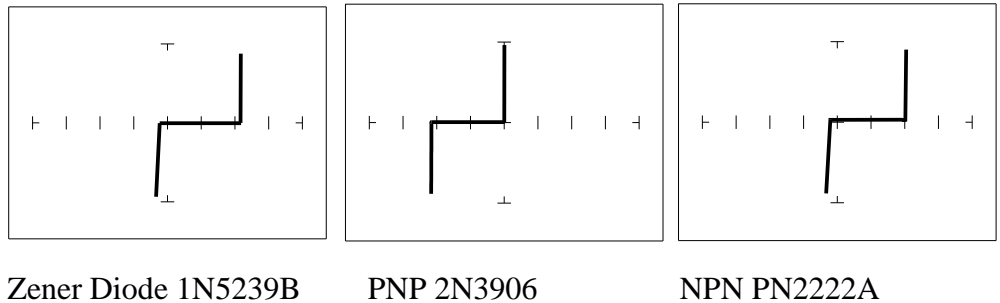


**Figure 4-19** Signatures of a Diode and Collector-Base of Transistors at  $1K\Omega$  and 15V.

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

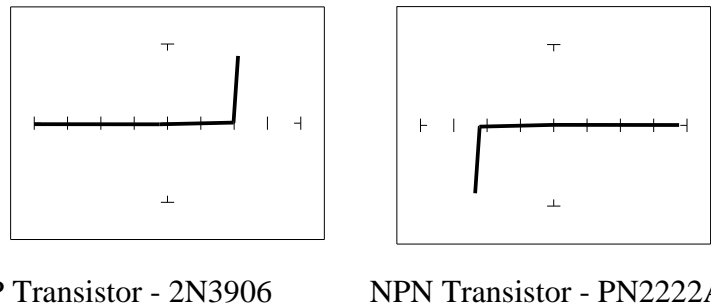


a diode with its polarity reversed. These are the signatures we expected from our circuit modeling. We can do the same kind of comparison with the emitter-base circuits.



**Figure 4-20** Signatures of a Diode and Emitter-Base of Transistors at 1KΩ and 15V.

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.



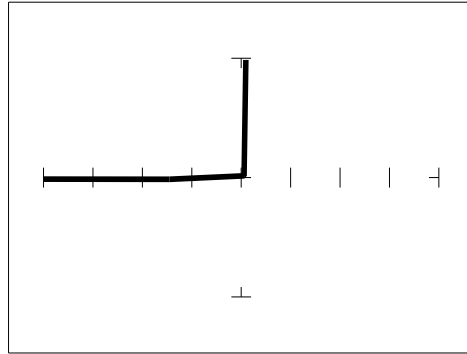
**Figure 4-21** Signatures of the Collector-Emitter of Transistors at 1KΩ and 15V.

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.

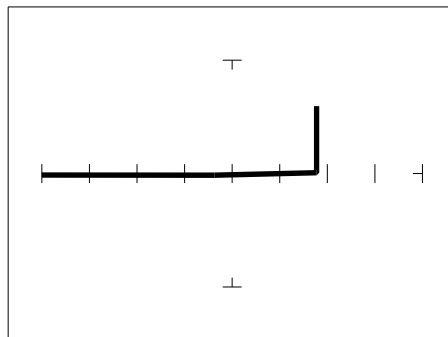
### Identifying Unknown Transistors

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 3200S 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.



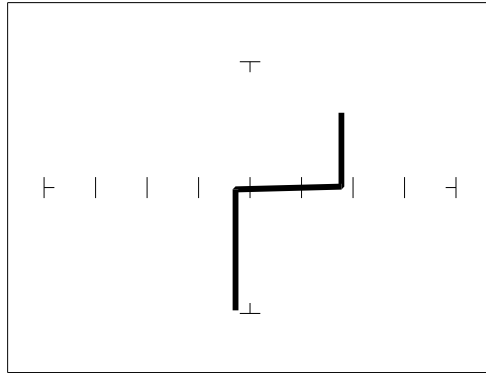
**Figure 4-22** Signature of Pins 1 And 2 of an Unknown Transistor.

- 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?
- Probe pin 3 with the red probe and pin 2 with the black probe.
- Identify the signature.
- This looks like a collector-emitter signature.



**Figure 4-23** Signature of Pins 3 and 2 of an Unknown Transistor.

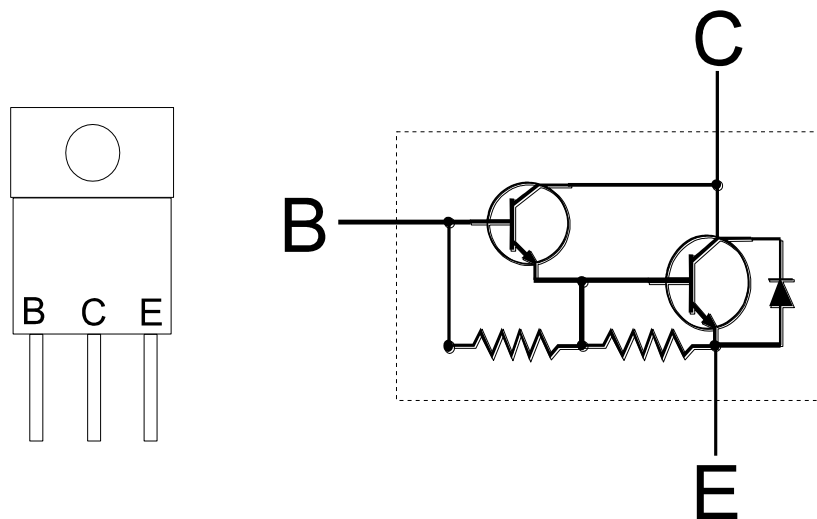
- Now that you know that pin 2 of the unknown transistor is the collector. Place the black probe to the base on pin 1 and move the red probe to the emitter on pin 3. A base to emitter signature will be displayed. This transistor is a NPN type since the base-emitter signature matches a NPN transistor.



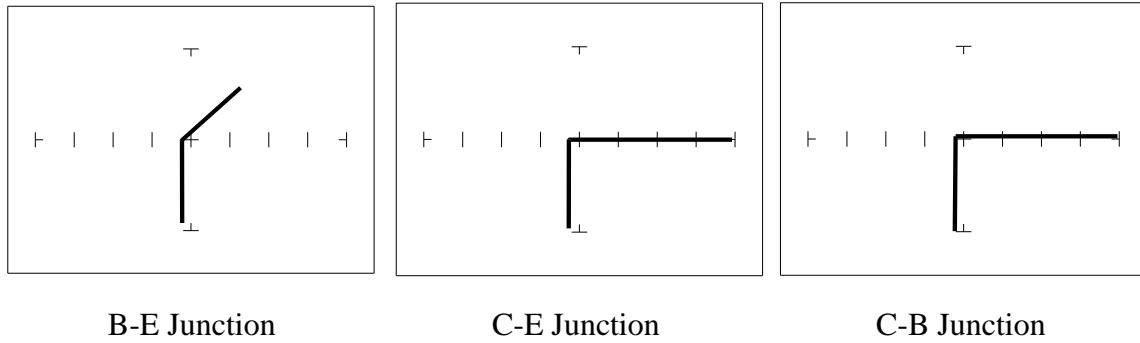
**Figure 4-24** Signature of Pins 1 and 3 of an Unknown Transistor.

### 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 analog signature are shown in the following figures.



**Figure 4-25** Diagram of a Darlington Transistor.



**Figure 4-26** Signature of a Darlington Transistor, TIP112 NPN Type at 20V and 20K $\Omega$ .

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

### Review

- A PNP bipolar transistor consists of a layer of N-type silicon sandwiched between two layers of P-type silicon.
- A NPN bipolar transistor consists of a layer of P-type silicon sandwiched between two layers of N-type silicon.
- To test a transistor, the base-emitter (B-E), collector-base (C-B) and collector-emitter (C-E) junctions all need to be examined.
- The transistor signature resembles the diode signatures previously examined. They have polarity and may exhibit the Zener effect.

### 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 3200S can be used to determine the type of transistor; bipolar, Darlington, FET, etc.
- The Tracker 3200S can be used to identify the polarity of a transistor (PNP or NPN).
- The Tracker 3200S can be used to determine the base, collector and emitter on an unknown transistor.
- The Tracker 3200S 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.

### 4-3. 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.

#### Phototransistor

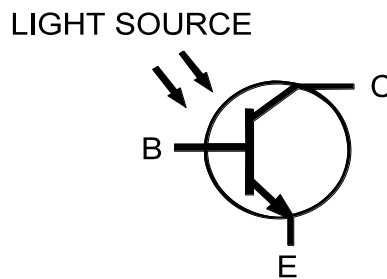


Figure 4-27 Phototransistor Schematic Diagram.

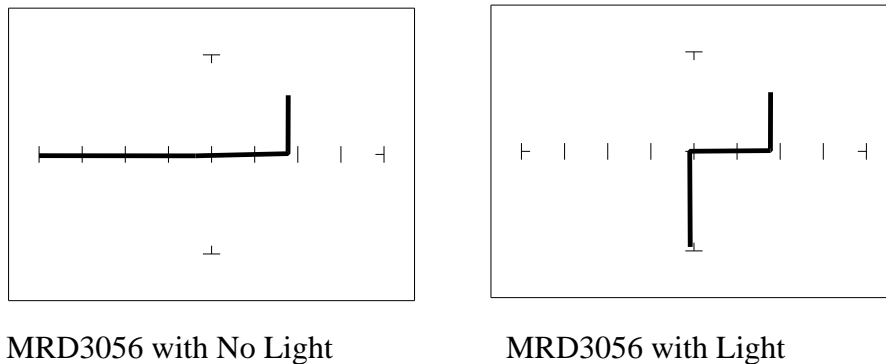


Figure 4-28 Signatures of a NPN C-E Junction Phototransistor at 15V and 1K $\Omega$ .

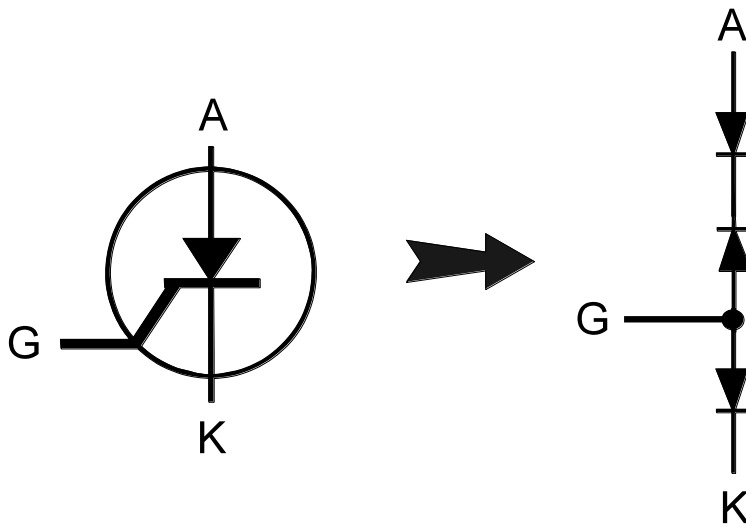
The phototransistor's signature is similar to a diode's signature in reverse breakdown mode when not activated by light and as a short signature when activated by a bright external light.

## SCRs and TRIACs

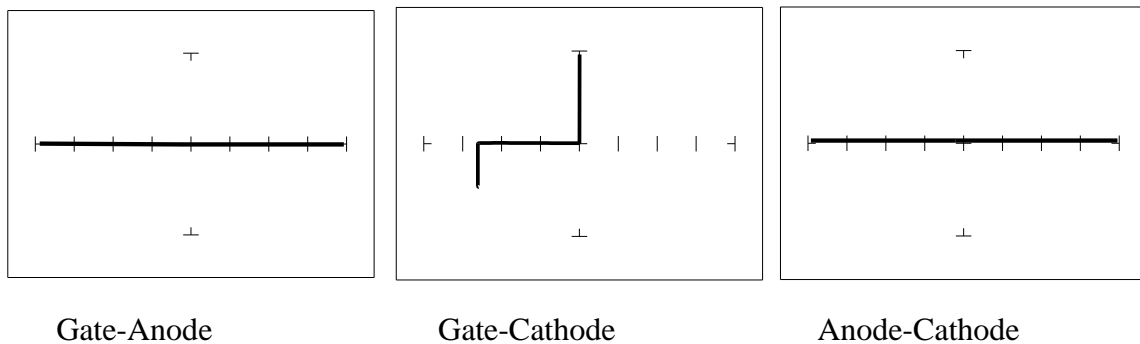
A SCR and TRIAC are semiconductor components that are used in switching applications. A SCR (silicon controlled rectifier) is used for DC switching circuits. A TRIAC is used for AC switching circuits. This section will demonstrate how to dynamically test these components.

### Silicon Controlled Rectifiers (SCR's)

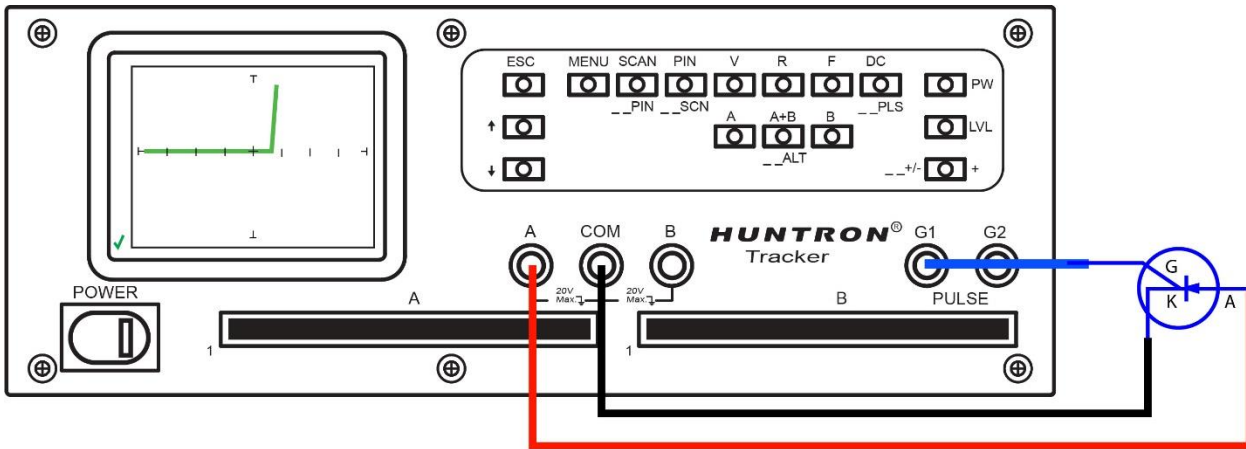
The SCR is a switching semiconductor device that conducts positive current only. Its symbol and equivalent circuit can be seen below. When the gate (G), is at the same voltage level as the cathode (K), the SCR acts like an open. When the gate (G) is forced more positive than the cathode (K), positive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



**Figure 4-29** Diagram of a Silicon Controlled Rectifier.



**Figure 4-30** Signatures of a SCR - C106B Type at 20V and 10KΩ.



**Figure 4-31** Testing a SCR using the Pulse Generator – Note the diode type signature

### Review

Solid state photosensitive switch components are turned on by light.

SCRs and TRIACs are solid state switches that are turned on by a control input pin called a gate. SCRs conduct current in one direction while TRIACs conduct current in both directions.

### Applications

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 can easily show these failure.

# SECTION 5 TESTING INTEGRATED CIRCUITS

## 5-1. DIGITAL INTEGRATED CIRCUITS

Digital integrated circuit (IC) chips are made from transistors on a common substrate. Their analog signatures are typically variations of the discrete diode and transistor signatures. Most logic ICs, contain multiple circuits in one chip. These chips can have pins from 14 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 3200S and ASA respond to these circuits.

### Integrated Circuit Failures

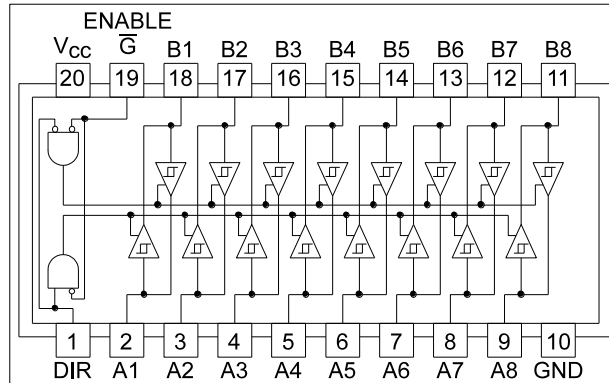
A functioning IC may stop working for a number of reasons. Some of the most common causes of IC failures are:

- 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 k $\Omega$  to 25 k $\Omega$  with a typical value of 20 k $\Omega$ . 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 introduced at the time of manufacturing, that contamination develops into leakage between substrate channels. This causes 5 k $\Omega$  to 25 k $\Omega$  of resistance.
- Purple Plague - Destructive interaction between gold and aluminum metal layers. Junction connections become very brittle and may cause internal opens.
- Corrosion or Electromigration - Another process flaw in which aluminum metallization causes pinholes, corrosion and resistance. This will create opens and resistance.



## Digital Integrated Circuits

Before we examine the analog 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.

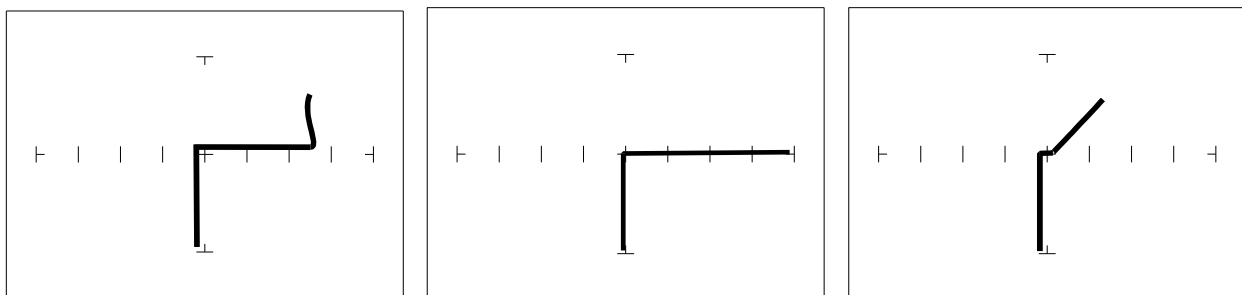


**Figure 5-1.** Digital IC 74LS245 Block Diagram.

- 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 analog signature. Because there are only four types of circuits on the chip, there will be only four unique analog signatures when out of circuit.

### Signatures of a Typical Digital IC



Buffer pins  
20V, 10K $\Omega$ , 200Hz

Enable pins  
20V, 10K $\Omega$ , 200Hz

$V_{CC}$  Power pin  
10V, 100 $\Omega$ , 200Hz.

**Figure 5-2.** Signatures of a Digital IC, 74LS245. Ground Pin to Test Common

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 Logic 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 3200S.

We will illustrate these concepts with the following example 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 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.

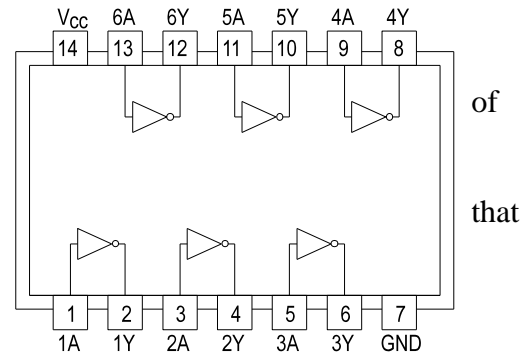


Figure 5-3. Diagram of 7404 & 74LS04.

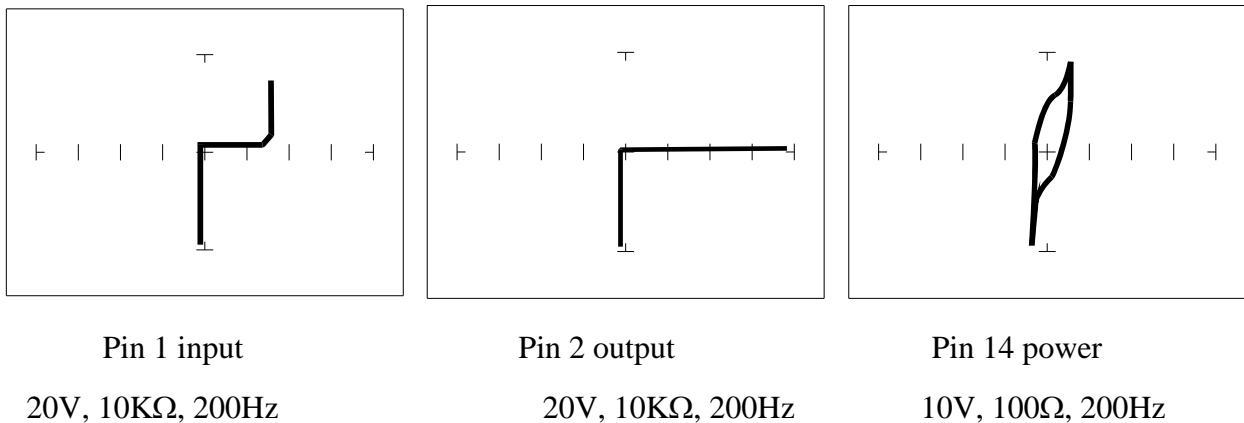
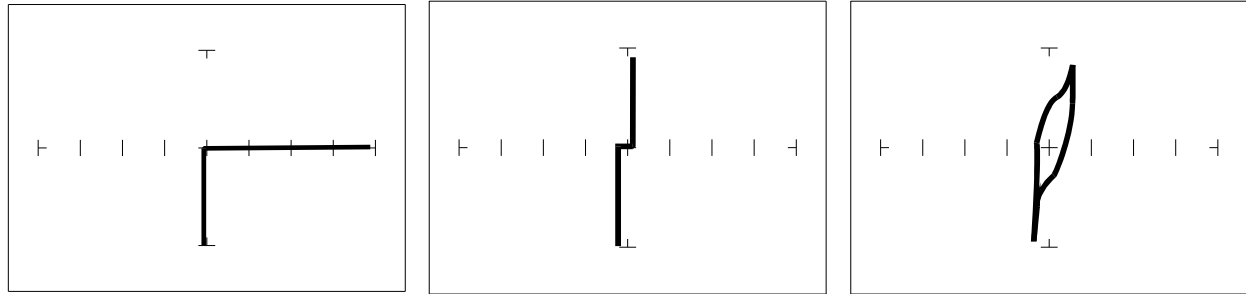


Figure 5-4. Signatures of a 7404 Hex Inverter.



Pin 1 input

20V, 10K $\Omega$ , 200Hz

Pin 2 output

20V, 10K $\Omega$ , 200Hz

Pin 14 power

10V, 100 $\Omega$ , 200Hz

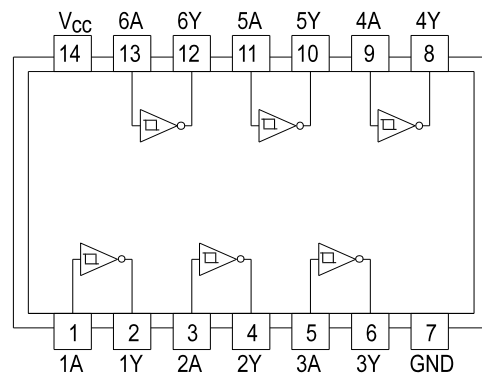
**Figure 5-5.** Signatures of a 74LS04 Hex Inverter.

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.

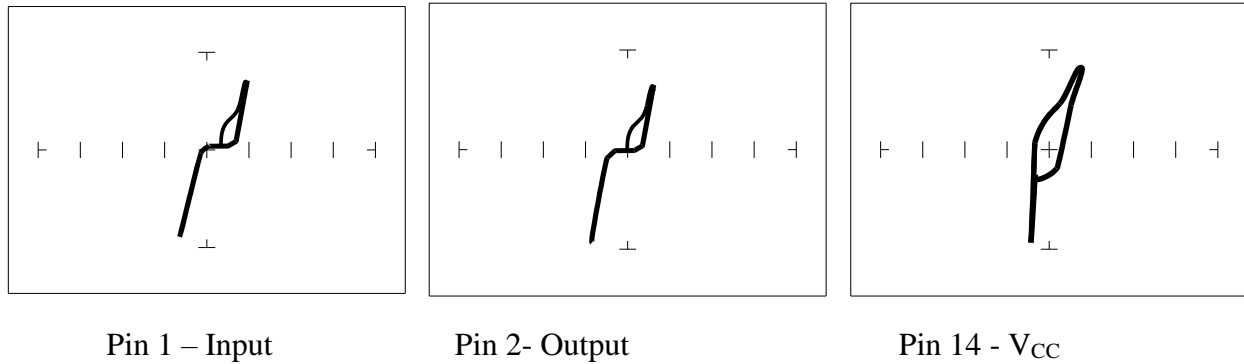
### CMOS Logic Family

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.



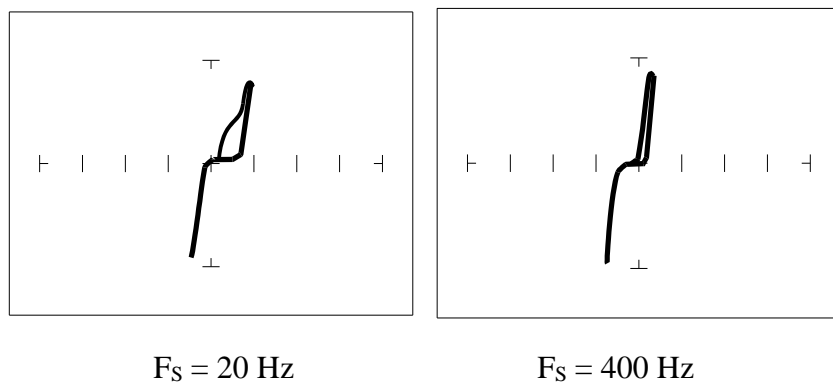
**Figure 5-6.** 74HC14 Block Diagram.



**Figure 5-7.** Signatures of a 74HC14 CMOS Hex Inverter in 50Ω, 10V, 60Hz Range

### 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 3200S. Capacitance in CMOS circuitry may be emphasized or de-emphasized by changing the frequency of the test signal.



**Figure 5-8.** Signatures of a 74HC14 Input Pin at Different Frequencies in 10V, 1KΩ Range

### Troubleshooting Digital Logic ICs

Comparison testing is a very powerful and effective test strategy when troubleshooting digital logic using ASA. The Tracker 3200S'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 beside 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.

1. Select the 10KΩ, 3V and 60 HZ range
2. Place or connect the black or blue ground clip lead from the Tracker 3200S's Common jack to both reference and suspect ICs or the board's ground pin.

3. Place or clip the red test lead from the Tracker 3200S's Channel A test terminal to the reference or known good IC's pin. For this example, start with pin 1 of the known good IC.
4. Observe the signature. This is the signature of the pin of the known good component.
5. 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.
6. 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 3200S 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.

## Applications

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

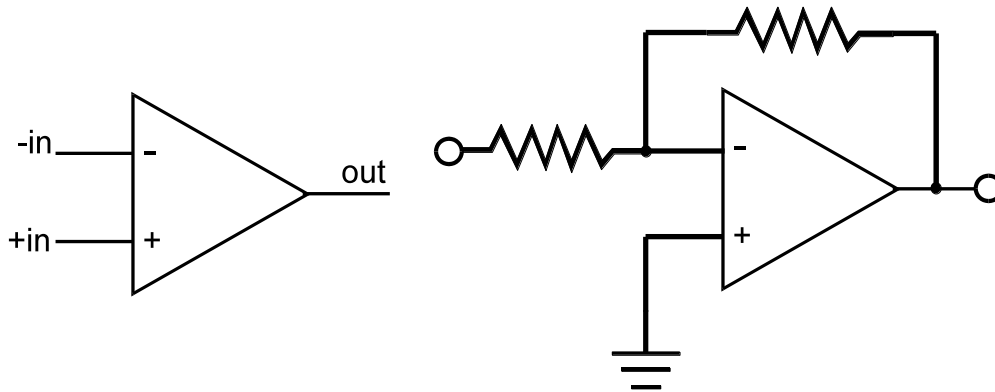
## 5-2. ANALOG CIRCUITS

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 3200S. 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.

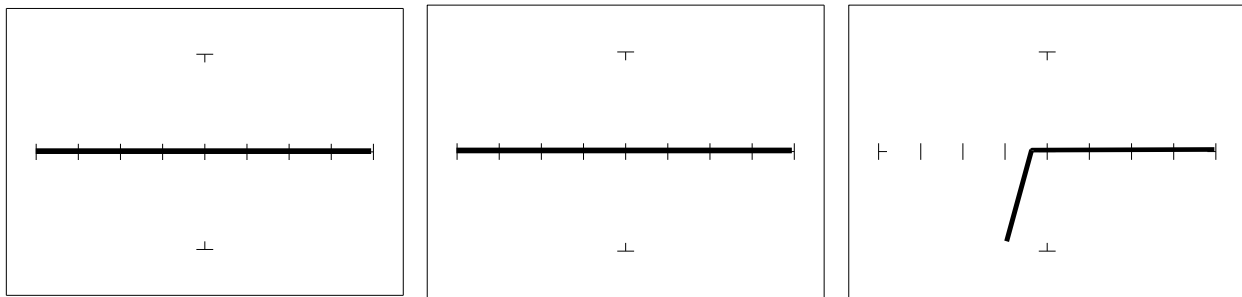
The following example will demonstrate ASA with a commonly used 741 type op amp. In this case it is configured as an inverting amplifier circuit as in the schematic below.



**Figure 5-9.** 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

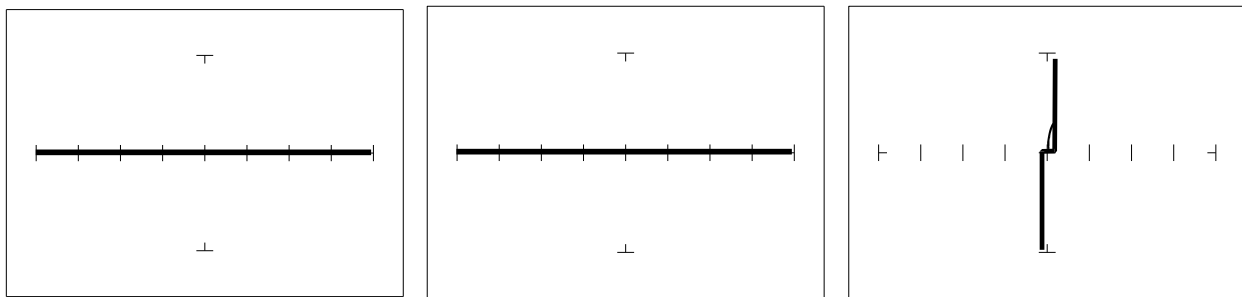


Pin 2 -Input

Pin 3 +Input

Pin 6 Output

**Figure 5-10.** Signatures of an Op Amp (741) at 10V, 50Ω, 60Hz with Common to Pin 4.



Pin 2 -Input

Pin 3 +Input

Pin 6 Output

**Figure 5-11.** Signatures of an Op Amp (741) at 20V, 10KΩ, 60Hz with Common to Pin 4.

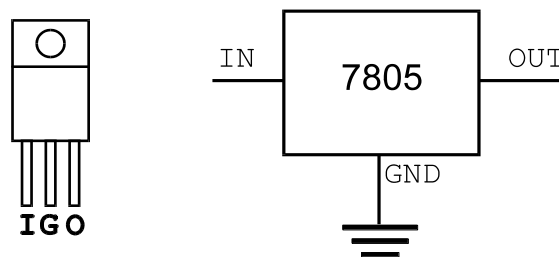
## Troubleshooting OP Amp Circuits

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 analog 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 3200S can help locate the defective component quickly.

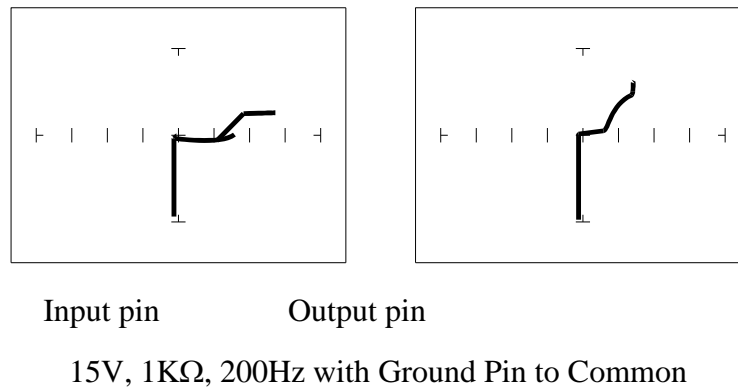
The op amp has three main terminals; + input, - input and output. An alternative way to perform ASA on the op amp is to connect Tracker 3200S's Common terminal to the op amp's output while making a comparison with the red test probe to the “+” and then the “-” leg. This eliminates problems encountered 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

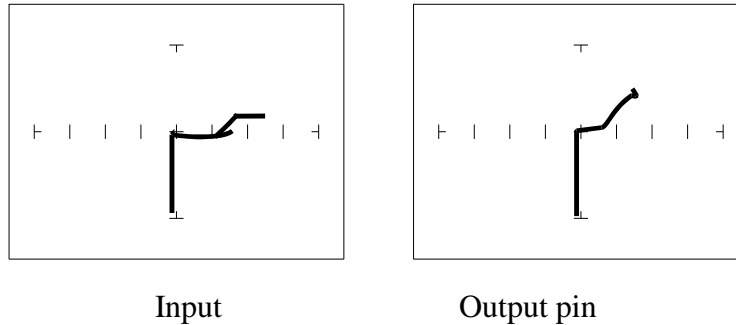
Voltage regulators are commonly found in many electronic assemblies. Some of the most popular integrated circuits of this type are three terminal devices like the 7805, a +5 volt DC regulator. The next figure shows the schematic and pin layout of the 7805 regulator. Different manufacturers implement 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 5-12.** Diagram and Symbol of a Linear Voltage Regulator, 7805 Type



**Figure 5-13.** Signatures of a 7805 SGS Thompson Voltage Regulator



15V, 1K $\Omega$ , 200Hz range, Ground Pin to Common

**Figure 5-14.** Signatures of a 7805 Motorola Voltage Regulator

## 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 3200S 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.

## Applications

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

### 5-3. LOW VOLTAGE

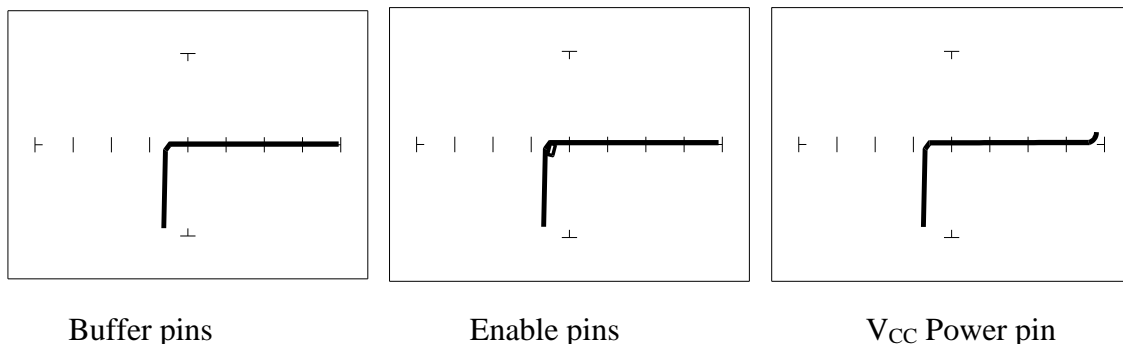
The low voltage family of logic that offers lower dynamic power consumption, lower operating voltages, higher output drive, faster AC speed, lower noise and better dynamic thresholds than HC CMOS. These features make this family attractive for low power applications such as battery operated portable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

In order to achieve this 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 analog signatures of the LV logic family are different from the conventional HC logic family.

Do the following to view signatures of low voltage logic:



1. Select the 3V, 10K $\Omega$  and 60Hz.
2. Place or clip the black test lead from the Tracker 3200S's Common jack to the IC's ground pin. For this example, the ground pin of the 74LVQ245 is pin 10.
3. Use the red test lead from the Tracker 3200S's Channel A jack 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.)
4. Use the red test lead from the Signal jack 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.)
5. Use the red test lead from the Tracker 3200S's Signal jack and probe the power supply  $V_{CC}$  input pin. For this example, the  $V_{CC}$  pin of the 74LVQ245 is pin 20.



3V, 10K $\Omega$ , 60Hz, Ground Pin to Test Common

**Figure 5-15.** Signatures of a Low Voltage IC (74LVQ45 Type).

The ranges used above enhance the resistive fault signatures that are commonly found when troubleshooting this logic family. The test signal voltage  $V_S$  is lower than the TTL range groups to ensure that most descriptive signature is displayed. A higher  $V_S$  may result in a signature going toward a short with 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 components' analog signature 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 3200S 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.

### Applications

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