Tracker 2800 and 2800S
User's Manual

P/N 21-2259

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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 2800/2800S instrument.

Huntron warrants that the Huntron Tracker 2800/2800S 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 2800/2800S, 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:

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Table Of Contents

Section 1 Introduction

1-1 What is a Tracker 2800?

A Huntron Tracker 2800 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 2800 or 2800S (where applicable). 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 2800 implements the ASA technique of troubleshooting.

The built-in current limited stimulus sine-wave of the Tracker 2800 ensures non-destructive testing and does not damage any components. ASA has many advantages as a proven, fast, and effective troubleshooting technique.

You can:

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 2800 front panel test terminals directly to the circuit card or component that you are testing. You can automate the test process to a certain degree by connecting to boards under test via custom cabling or IC clip cables using a Tracker 2800S. The Tracker 2800S is a modified version of the Tracker 2800 that has internal switch cards and external, front panel IDC connectors to which custom cable interfaces or DIP clip cables can be connected.

1-2 Specifications

Electrical (Note: Test Signal is a sine wave.) Specifications subject to change without notice	
Open Circuit Voltage (Vs):	
6 selections of peak voltage:	200mV, 3V, 5V, 10V, 15V, 20V
Source Resistance (Rs):	
9 selections of resistance:	10Ω, 50Ω, 100Ω, 500Ω, 1kΩ, 5kΩ, 10kΩ, 50kΩ, 100kΩ
Short circuit current (Vs divided by Rs)	
Maximum	200 mApk
Frequency (fs):	
6 selections of frequency:	20Hz, 50Hz, 60Hz, 200Hz, 500Hz, 2kHz
Channels	
Number	2
Connections	Banana (Channel A, Common, Channel B); Two (Ch. A and Ch. B) 40 pin IDC connectors (Tracker 2800S only)
Overvoltage Protection	Circuit breaker
Auxiliary Connection	9 pin mini jack with ground, Trigger IN, Trigger OUT, Calibration TP, Sine wave zero-crossing, Signal ON, Line IN and Line OUT
DC Voltage Source	0-10VDC + output @ 200mA max;
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)
Warranty	1 year limited

Supplied Accessories

Huntron P/N	QTY	Description
06-5217	1	User's Manual CD
98-0043	2	Test Lead Black
98-0249	1 pair	Huntron Microprobes MP20
98-0265	1	Power cord
98-0284	1	Shrouded blue test lead

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 2800 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, 2nd Ed., with revisions through 07/22/2005, and CAN/CSA-C22.2 No. 61010-1, 2nd 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.

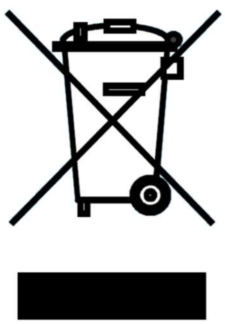
Do Not Operate in an Explosive Atmosphere.

Ne pas opérer dans une atmosphère explosive.

1-4 Environment Conformity Quality

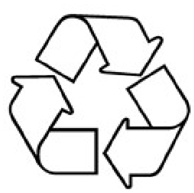
For more information see our website www.huntron.com/corporate/environment.htm

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.

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.

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.

1-5 Optional Workstations Software

The Tracker 2800/2800S can be used with Huntron Workstation Software.

Note: For instructions on installing the software, see the Getting Started document that comes with the Huntron Tracker 2800/2800S or Huntron Workstation Software.

Section 2 Using the Tracker 2800/2800S

2-1 Unpacking and what you need to get started

To set up and use your Tracker 2800 or 2800S, you will need the following:

- One set of Microprobes (Huntron MP20).
- This manual (Tracker 2800/2800S User's manual)
- For Tracker 2800S, 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 DC Voltage source

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 2800/2800S

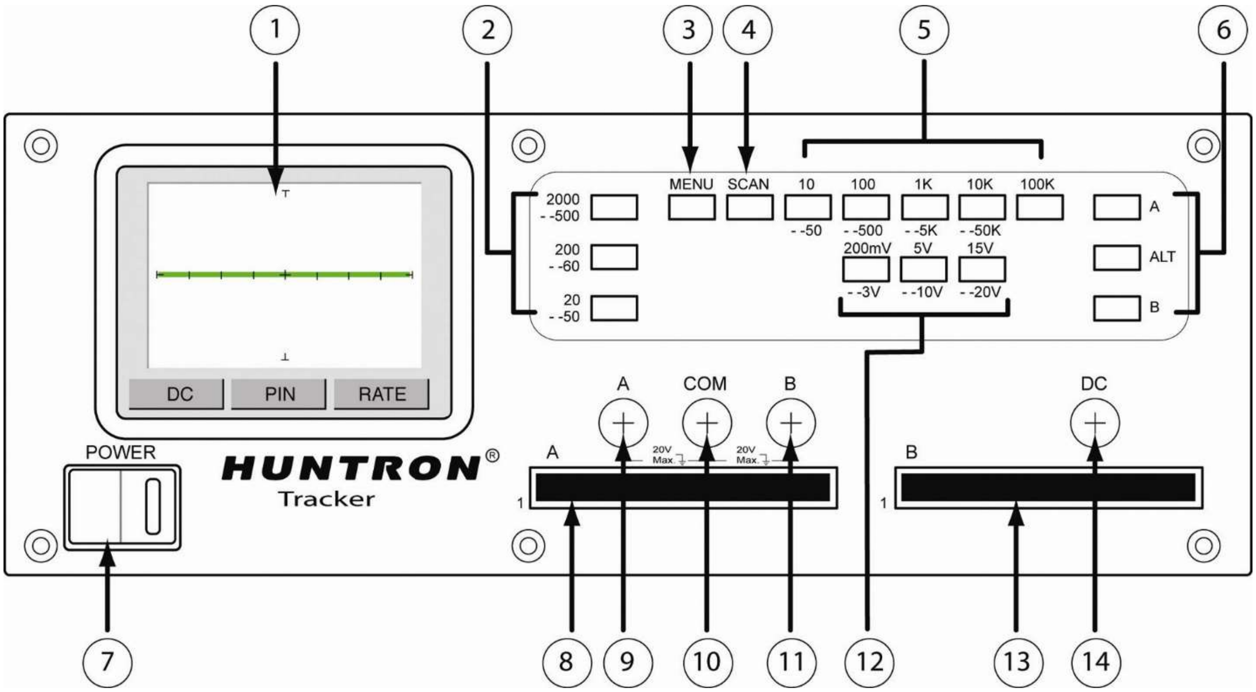


Figure 2-2 Tracker 2800/2800S Overview (Shown with "**Power-up**" menu on LCD)

1. LCD Display	**2.** Frequency buttons	**3.** Menu button
4. Scan button	**5.** Resistance buttons	**6.** Channel Select buttons
7. Power switch	**8.** Ch. A 2800S connector	**9.** Ch. A banana jack
10. Common banana jack	**11.** Ch. B banana jack	**12.** Voltage buttons
13. Ch. B 2800S connector	**14.** DC Voltage Source banana jack	

- Connect the Tracker 2800 or 2800S to power.
- Turn the Tracker 2800 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.**

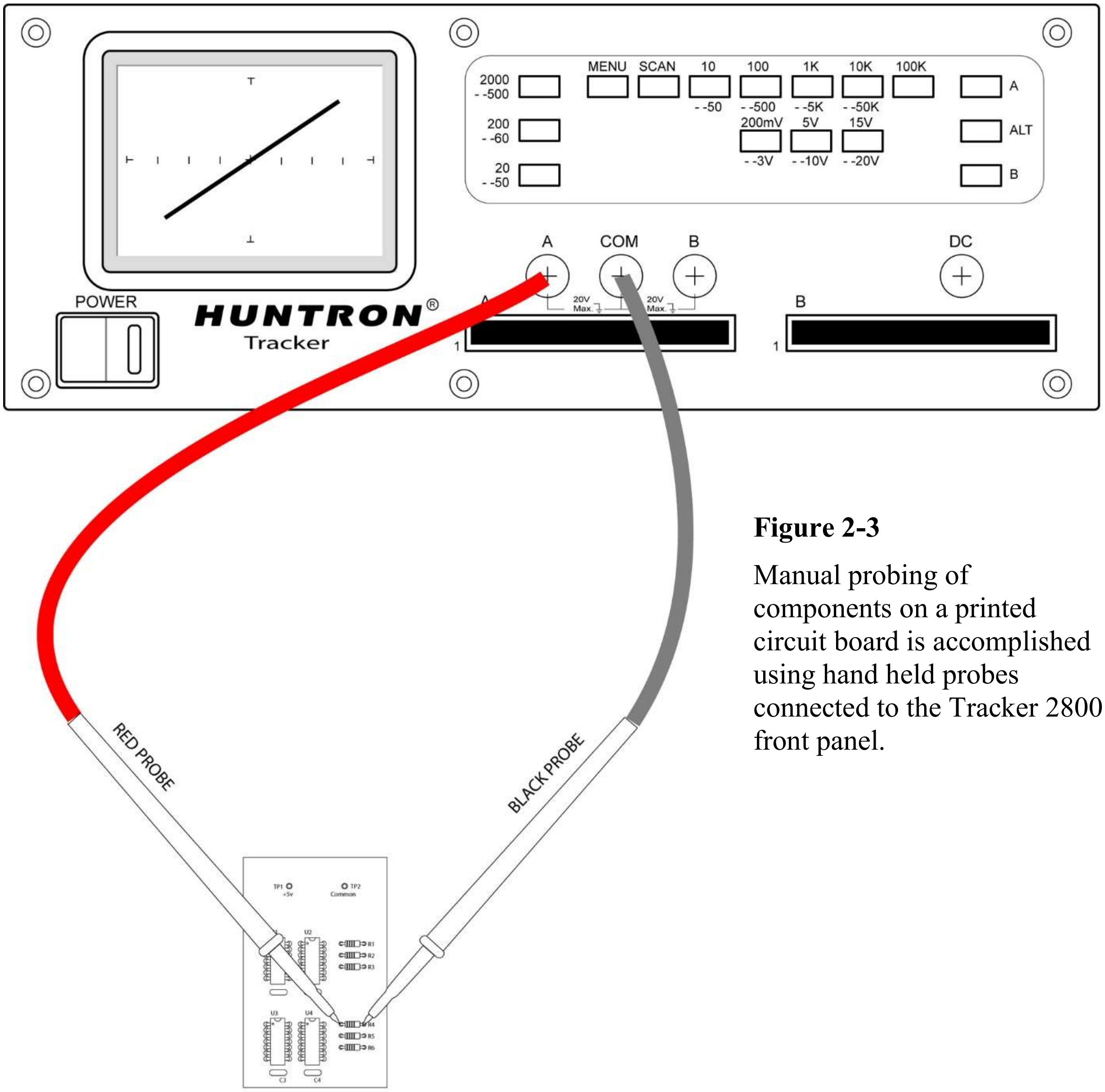


Figure 2-3

Manual probing of components on a printed circuit board is accomplished using hand held probes connected to the Tracker 2800 front panel.

2-3. Channel Selection

There are two channels on the Tracker 2800 (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

The Alternate (ALT) mode of the Tracker 2800 is provided to automatically switch back and forth between Channel A and Channel B. This allows easy comparison between two devices or the same points on two circuit boards. The Alternate mode is selected by pressing the **ALT** button on the front panel. The alternation frequency is varied by pressing the **RATE** control button on the Tracker LCD then pressing the ↑ **and** ↓ buttons until the desired alternation frequency is reached. The **RATE** is numbered from 1 (fastest) to 10 (slowest). Press the **RATE** button to return to the power-up menu. 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.

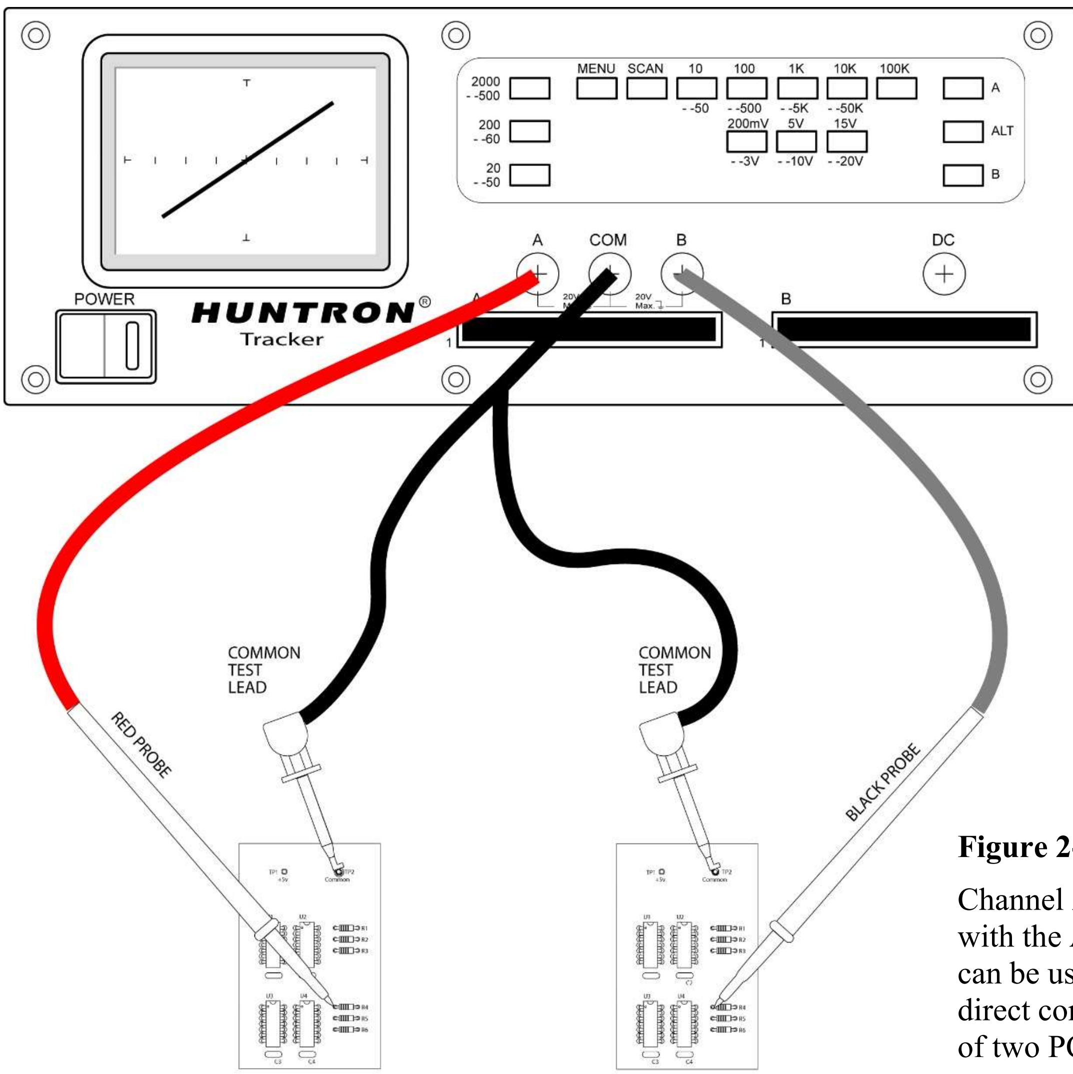


Figure 2-4

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

When using ALT mode, a green check mark or red "X" on the bottom right portion of the LCD will indicate a pass or fail comparison.

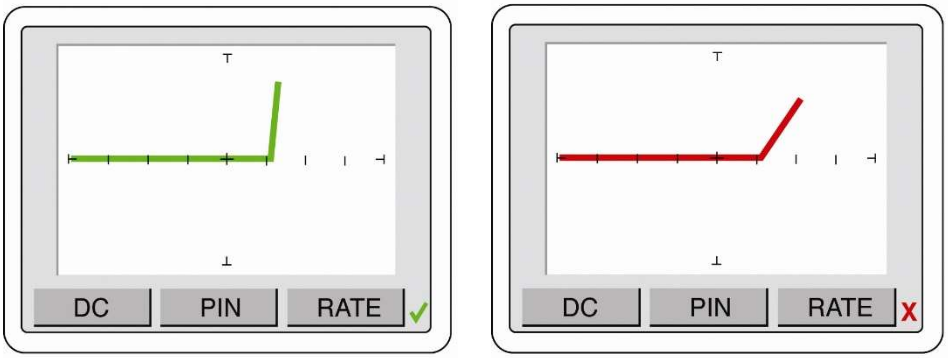


Figure 2-5

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 to display the Main menu on the LCD (left image in figure 2-6). Press the **SCAN** button on the LCD to display the Scan menu (middle image in figure 2-6). Press **TOL** to display the Tolerance menu (right image in figure 2-6). Use the ↑ **and** ↓ arrow buttons to adjust the tolerance allowed during comparison. It is adjustable from 0 to 90.

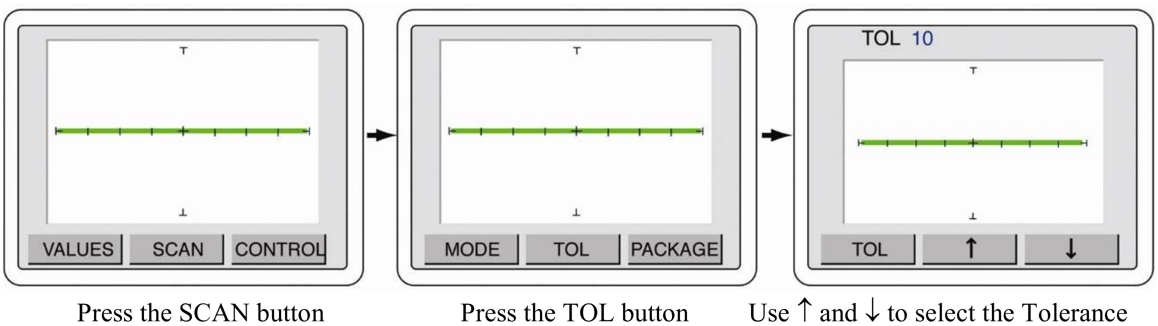


Figure 2-6. Selecting tolerance setting used during A vs. B comparison

2-5 Resistance Selection

The Tracker 2800 is designed with nine resistance ranges (10Ω, 50Ω 100Ω, 500Ω, 1kΩ, 5kΩ, 10kΩ, 50kΩ and 100kΩ). A resistance range is selected by pressing the appropriate button on the front panel. Each button has a dual function. For example, pressing the 100Ω button (steady LED indication) selects 100Ω as the resistance value. Pressing it again (blinking LED indication) selects 500Ω as the resistance value. 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.

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

2-6 Frequency Selection

Six test signal frequencies (20Hz, 50Hz, 60Hz, 200Hz, 500Hz and 2kHz) can be selected by pressing the appropriate button on the front panel. Each button has a dual function. For example, pressing the 20Hz button (steady LED indication) selects 20Hz as the test signal frequency. Pressing it again (blinking LED indication) selects 50Hz as the test signal frequency. Frequency is primarily used to enhance the signatures of reactive components such as capacitors and inductors.

2-7 Voltage Selection

The voltage selector buttons (200mV/3V, 5V/10V and 15V/20V) allow the user to select the peak applied sine-wave voltage. Each button has a dual function. For example, pressing the 5V button (steady LED indication) selects 5 Volts as the test signal's peak value. Pressing it again (blinking LED indication) selects 10 Volts as the test signal peak value.

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 2800 outputs a precision current-limited AC sine wave signal to a component and displays the resulting current flow, voltage drop and any phase shift on the internal LCD's display. The current flow causes a vertical trace deflection on the display, while the voltage across the component causes a horizontal trace deflection. This resultant trace on the display is called an analog signature.

Understanding the Tracker 2800'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 2800'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.

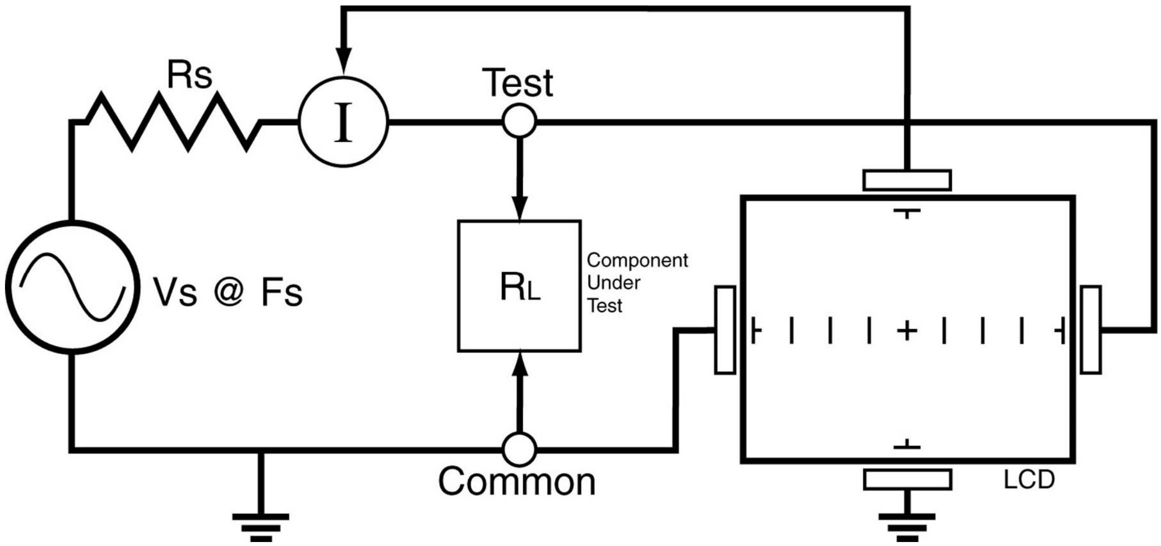


Figure 2-7: Tracker 2800 Core Circuit Block Diagram
R_s= Source Resistance, V_s= Source Voltage, R_L= Load Resistance, F_s= Source Frequency

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 2800 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 each Tracker voltage range.

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 2800 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.

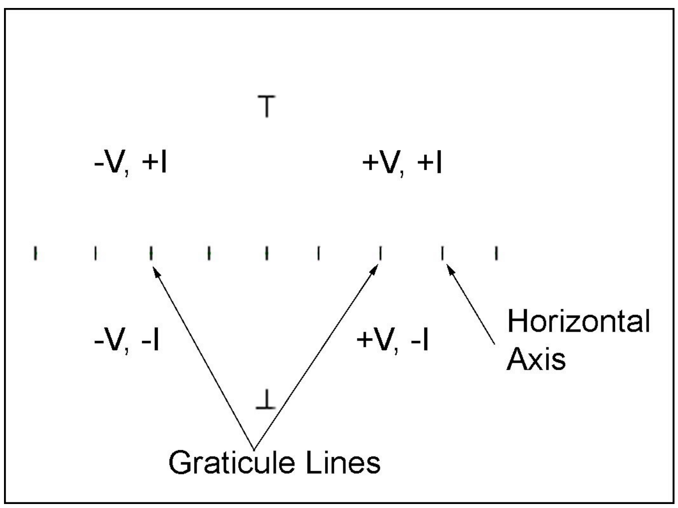


Figure 2-8. LCD Display Horizontal Axis and Graticule Lines.

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 2800 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.

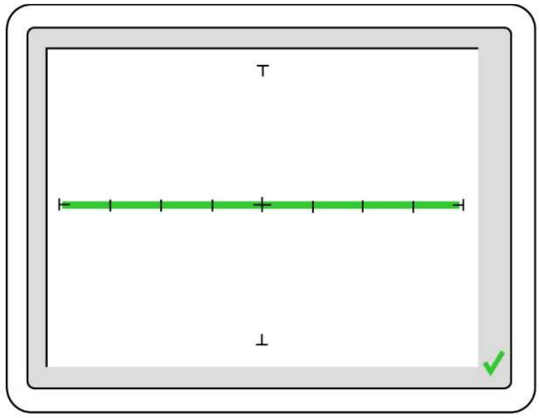


Figure 2-9 Tracker 2800 LCD Display with Open Test Terminals.

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 (0Ω) 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 2800 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.

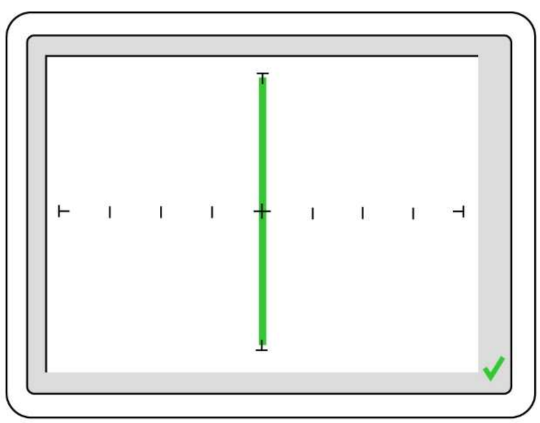


Figure 2-10. LCD Display with Vertical Axis, Graticule Lines displaying a short circuit.

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 2800's 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.

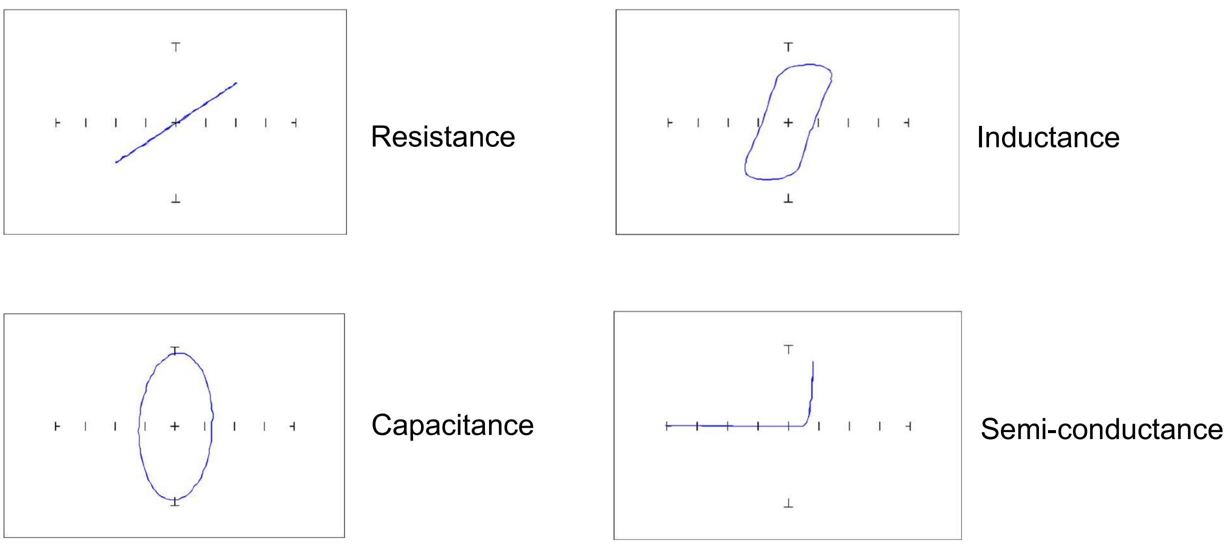


Figure 2-11. Analog Signatures of the Four Basic Components

2-10 Smart Tracker Active Range (STAR) feature

The Tracker 2800 has a built-in operating feature called STAR (**S**mart **T**racker **A**ctive **R**ange). This important feature protects sensitive components from possible exposure to excessive power (for example, 15V and 10Ω). The table 2-4 specifies the active and disabled voltage & resistance test range combinations.

	10Ω	**50Ω**	**100Ω**	**1kΩ**	**5kΩ**	**10kΩ**	**50kΩ**	**100kΩ**
200mV	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled
3 V	**Disabled**	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled
5 V	**Disabled**	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled
10 V	**Disabled**	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled
15 V	**Disabled**	**Disabled**	**Disabled**	Enabled	Enabled	Enabled	Enabled	Enabled
20 V	**Disabled**	**Disabled**	**Disabled**	**Disabled**	**Disabled**	**Disabled**	Enabled	Enabled

Table 2-4. Valid Tracker 2800 Ranges (STAR)

To illustrate the STAR feature, do the following:

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

Press the **5V** button. Notice that the **5V** LED is on and the resistance range changes to **50**Ω automatically. The **5V** at **10**Ω range is disabled.

Now press the **15V** button. Notice that the **1k**Ω resistance is automatically selected. The **15V** at **50**Ω range is disabled and the next valid resistance range was activated at the selected voltage.

2-11 DC Voltage Source

The built-in DC voltage source of the Tracker 2800 allows in-circuit testing of certain devices in their active mode. In addition to using the red and black probes, the output of the DC voltage source is connected to the control input of the device to be tested with the blue clip lead provided. The DC voltage source has one positive DC output. Figure 2-12 shows how to connect the Tracker to the device under test (a SCR is used in this example) using the DC voltage source.

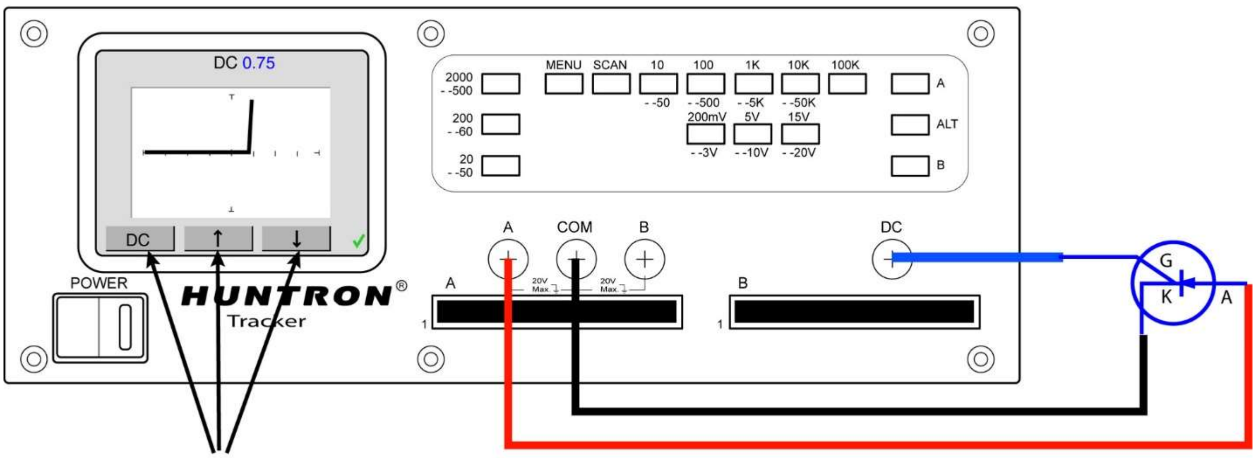


Figure 2-12. Tracker 2800 DC Source Typical Setup

The DC Voltage Source output is set using the DC Level controls (indicated by arrows) on the LCD touch screen. While in the power-up menu, press the **DC** button then use the ↑ **and** ↓ arrow buttons to increase or decrease the output voltage. The voltage level will be displayed at the top of the display. The level control varies the magnitude of output amplitude from zero to + 10 volts. Press the **DC** button to return to the power-up menu.

The DC Voltage Source 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 2800S

The Tracker 2800S is a scanning version of the Tracker 2800. It can automatically scan and compare up to 40 pins using standard IDC connections on the front panel. Common uses for scanning include connecting to PCB connectors and IC clips using custom ribbon cables.

Figure 2-13 shows a typical Tracker 2800S configuration using standard DIP clips attached to through-hole ICs.

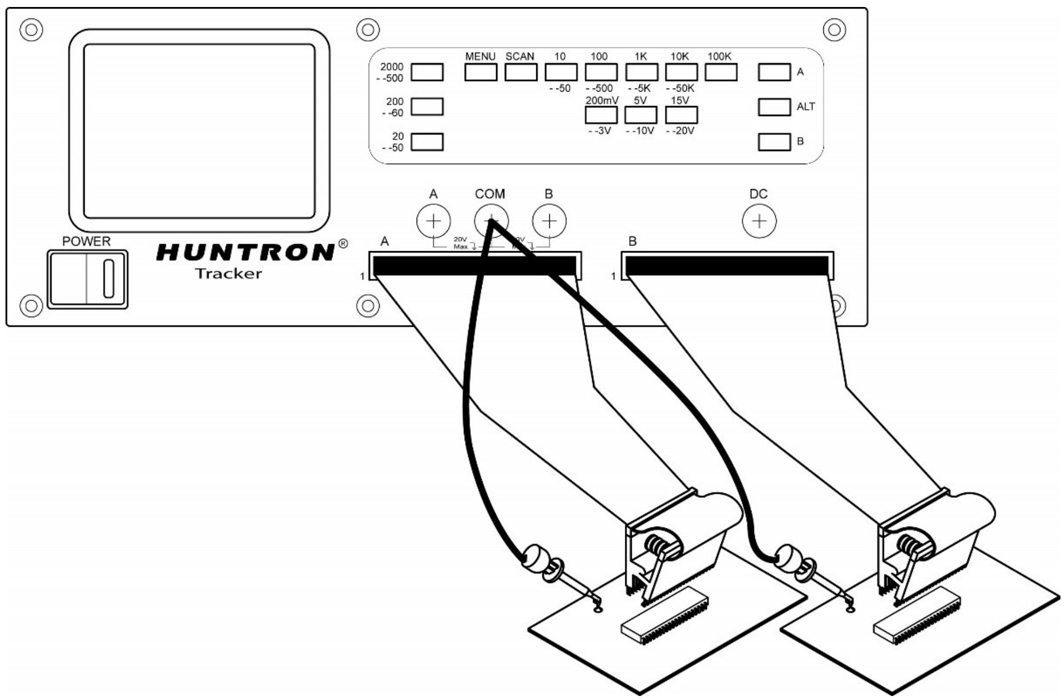


Figure 2-13. Typical 2800S setup with DIP clips

Using the scanning capabilities of the Tracker 2800S 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 2800S default configuration is a 16 pin DIP package). Using IC clips and cables as an example, 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 (first image in figure 2-14). Select **SCAN** from the touch screen Main menu to display the SCAN menu (second image in figure 2-14). Select **PACKAGE** from the SCAN menu to display the PACKAGE menu (third image in figure 2-14). Select **PACKAGE** to display the PACKAGE select menu (middle right image in figure 2-14). Use the ↑ **and** ↓ buttons to step up or down through the package choices of DIP, SIP, BOTH or FRONT. Press the **PACKAGE** button to return to the Package menu. Press the **PINS** button to display the PIN select menu (top right image in figure 2-14). Use the ↑ **and** ↓ buttons to increase or decrease the numbers of pins to be scanned. Press the **PINS** button to return to the PACKAGE menu. Press the **SINGLE** button to toggle (bottom right image in figure 2-14) between SINGLE (single pass then stop), LOOP (continuous scan) or STOP (stop on failure).

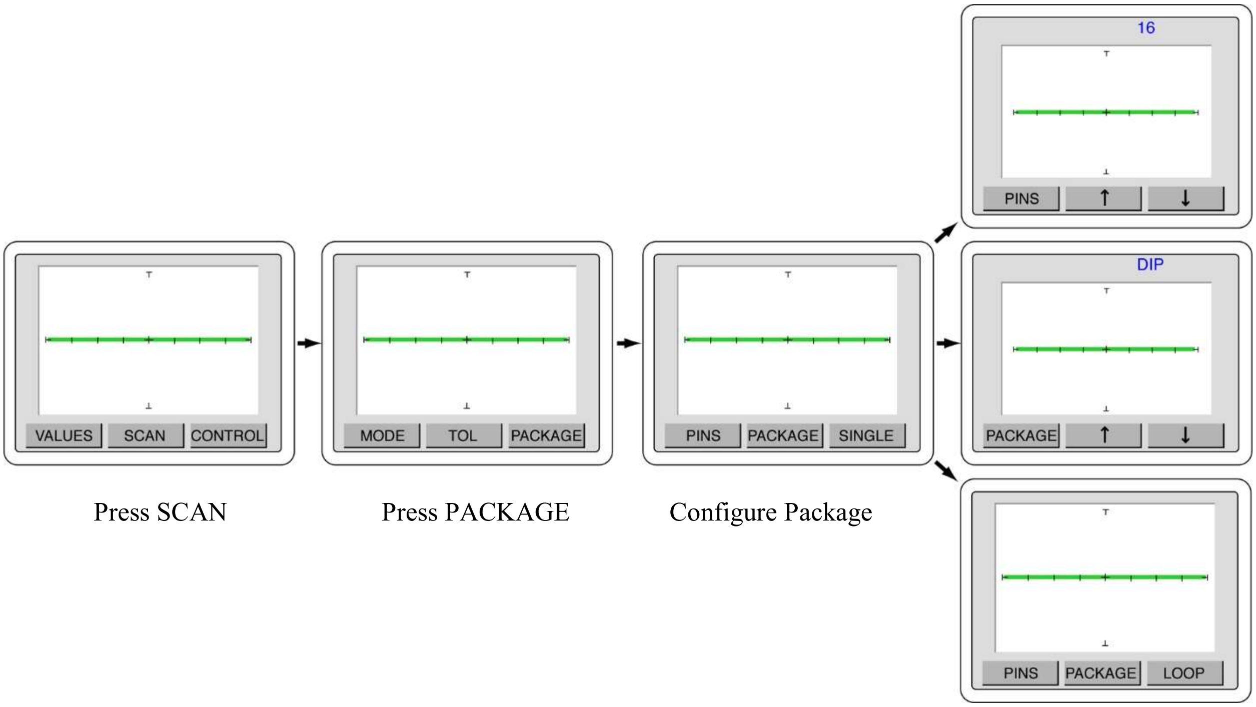
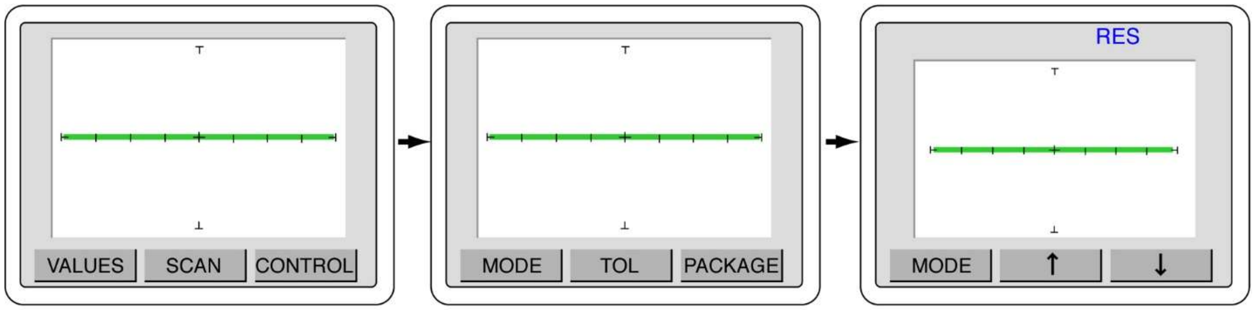


Figure 2-14. Scan/Package menus

Press the **MENU** button until the power-up menu is reached (the signature will become live). The pins can be manually scanned by pressing the **PIN** button on the LCD. Make sure you have a Common connection to the PCBs being tested otherwise you will see only open circuit signatures (horizontal lines) on the Tracker display. The display will change to show the current pin number at the top. Press the ↑ **and** ↓ arrow buttons to step manually through the pins on the connected device with the signature for each pin will be displayed on the LCD. Press **A** to view only channel A, **B** to view only channel B or press the **ALT** button to view signatures on channel A and channel B. Comparison of the A (green signature) and B (red signature) channels is automatic when the Tracker is in ALT mode. Note the green "check" or red "X" mark on the bottom right portion of the LCD will indicate a passed or failed comparison.

To scan without having to increment the ↑ **and** ↓ arrow buttons on the PIN menu, press the front panel **SCAN** button and the 2800S will step through the pins automatically. Press the **SCAN** button again to stop the scanning. By default, selecting the **SCAN** button will test each pin in each 2800S resistance range before stepping to the next pin. To change which range parameter is scanned, press the front panel **MENU** button to display the Main menu (left image in figure 2-15) on the LCD. Press the **SCAN** button on the LCD to display the SCAN menu (middle image in figure 2-15) and press the **MODE** button on the LCD to display the MODE menu (right image in figure 2-15). Use the ↑ **and** ↓ arrow buttons to change the scan mode between resistance (RES), frequency (FREQ), none (NONE) and voltage (VOLT).



Press the SCAN button | Press the MODE button | Use ↑ and ↓ to select the Scan mode

Figure 2-15. Selecting range parameter used while scanning

Press the **MENU** button until the power-up menu is reach (the signature will become live at this point). Pressing the **SCAN** button will now scan through the component pins using the range parameter selected in the Scan MODE menu.

2-13 Auxiliary (AUX) connector description

The rear panel Auxiliary (**AUX**) 9 pin Din connector pins are shown figure 2-16. This connection is used for control of the Tracker with the optional footswitch accessory.

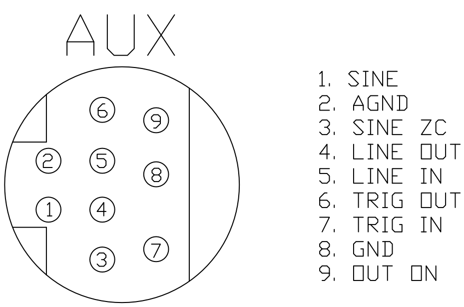


Figure 2-16

Auxiliary connector pin out diagram

2-14 Using the Optional Footswitch with the Tracker 2800/2800S

An optional footswitch (Huntron part number 98-0314) is available for controlling certain functions of the Tracker 2800. It connects to the auxiliary port located on the Tracker back panel.

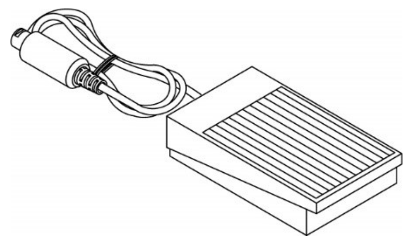
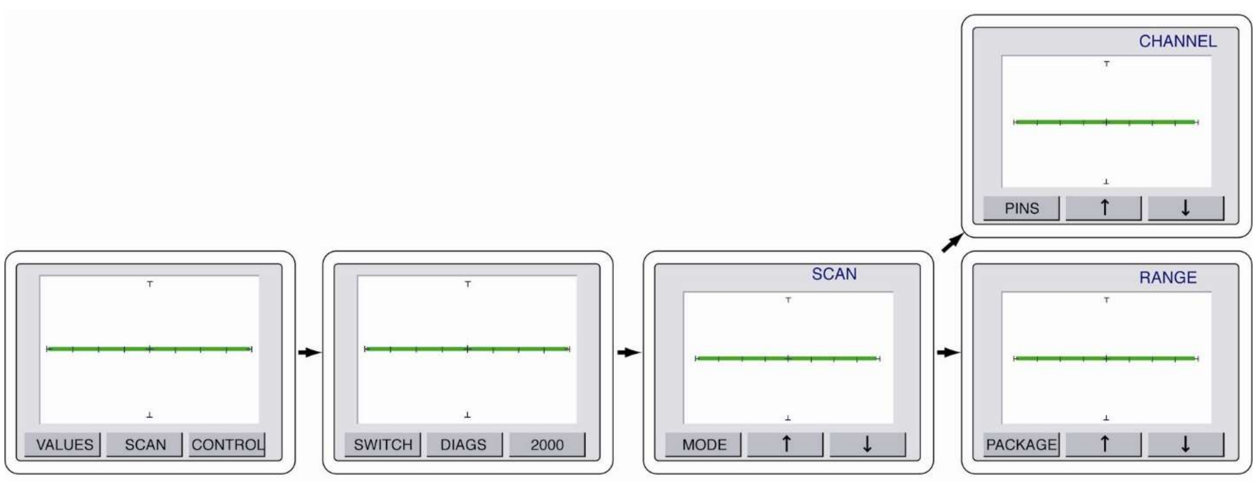


Figure 2-17

Footswitch accessory for Tracker 2800/2800S

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

To configure the footswitch control press the front panel **MENU** button to display the Main menu on the LCD (left image in figure 2-18). Press the **CONTROL** button on the LCD to display the Control menu (image second from left in figure 2-18). Press the **SWITCH** button on the LCD to display the Switch menu (image third from left in figure 2-18). Use the ↑ **and** ↓ arrow buttons to select the footswitch control between SCAN (image third from left in figure 2-18), CHANNEL (middle image on right in figure 2-18) and RANGE (bottom image on right in figure 2-18).



Press the CONTROL button Press the SWITCH button Use ↑ and ↓ to select the Switch mode

Figure 2-18 Tracker 2800 Footswitch Control Menus

Press the **MODE** button to return to the Control menu or press the front panel **MENU** continuously until the power-up menu is displayed.

The footswitch controls work as follows:

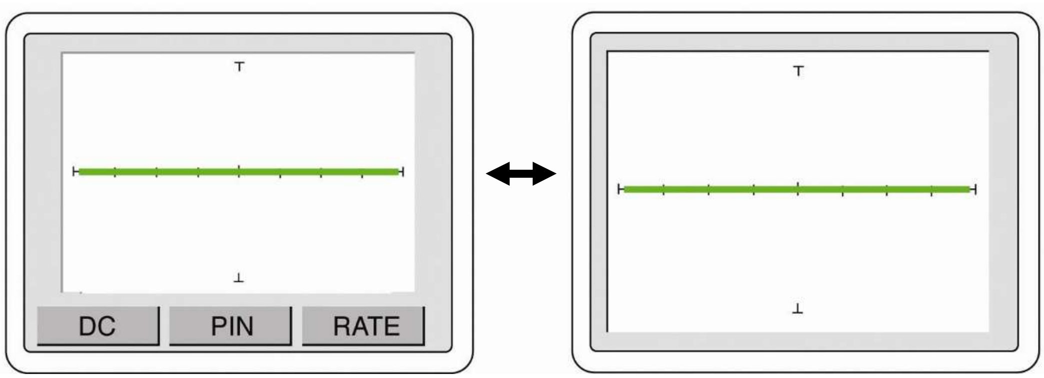
- **SCAN**: Pressing the footswitch will start and stop the SCAN mode (same as manually pressing the front panel **SCAN** button).
- **CHANNEL**: Pressing the footswitch will change the channel from A to B or vice versa.
- **RANGE**: Pressing the footswitch will change to the range set when the mode is selected (i.e., set the range to 3V, 10KΩ, 200Hz, select footswitch **RANGE** mode; pressing the footswitch will automatically change the Tracker to this range). This is useful for changing to a favorite range by simply pressing the footswitch.

2-15 Tracker 2800/2800S Touch Screen Menus

The Tracker 2800/2800S utilizes a color LCD touch screen menu system for configuring operation of the Tracker 2800/2800S.

Default Power-up menu and Full Screen Signature mode

Shown in figure 2-19 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 2-19 Default Power-up screen (left) and Full Screen Signature mode (right)

DC Voltage Source Menus

Control of the DC Voltage Source is accessed using the DC button on the touch screen power-up menu. Press the **DC** button to display the DC Voltage Source controls as shown in figure 2-20. Use the ↑ **and** ↓ arrow buttons to increase or decrease the voltage output from the DC Voltage source connection (labeled "DC") on the Tracker front panel. The voltage level will be displayed in the top portion of the screen. The voltage can be adjusted in 0.25V increments.

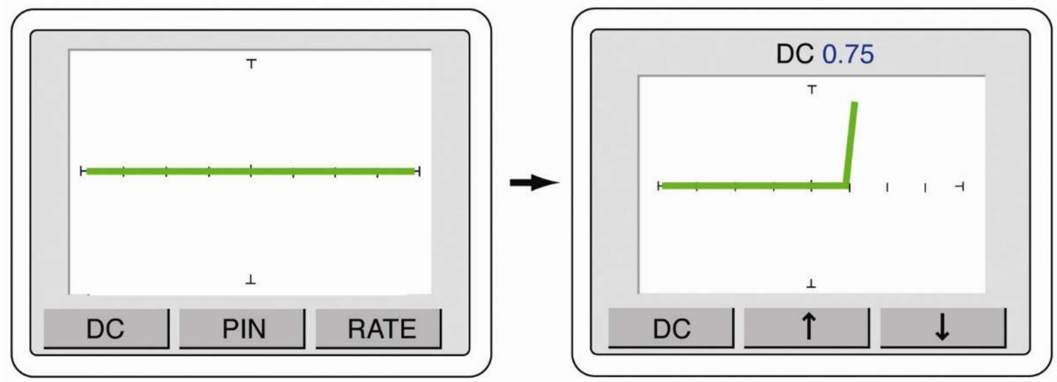


Figure 2-20 DC Voltage Source menu controls

Press the **DC** button to return to the power-up screen.

PIN Controls (Tracker 2800S)

Stepping through individual pins with the Tracker 2800S is accomplished using the touch screen PIN controls. Press the **PIN** button on the power-up menu to display the Pin controls as shown in figure 2-21. Use the ↑ **and** ↓ arrow buttons to step through the component pins. The pin number will be displayed in the top portion of the screen.

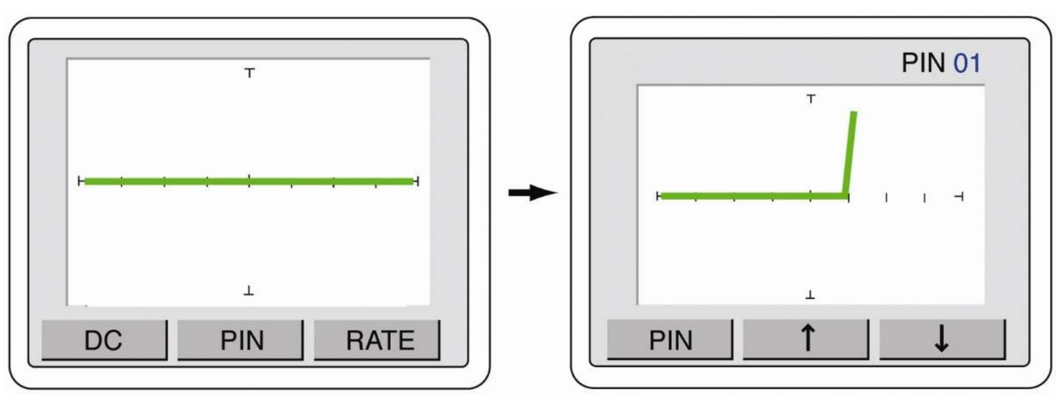


Figure 2-21 PIN menu controls

Press the **PIN** button to return to the power-up screen.

RATE (Alternate Speed) Controls

The speed of the Alternation (ALT) mode when comparing channel A versus Channel B is controlled with the RATE controls. Press the **RATE** button to display the RATE controls menu as shown in figure 2-22. Use the ↑ **and** ↓ arrow buttons to increase (lower number) or decrease (higher number – up to 10) the alternation speed. ALT mode must be activated by pressing the **ALT** button on the Tracker front panel.

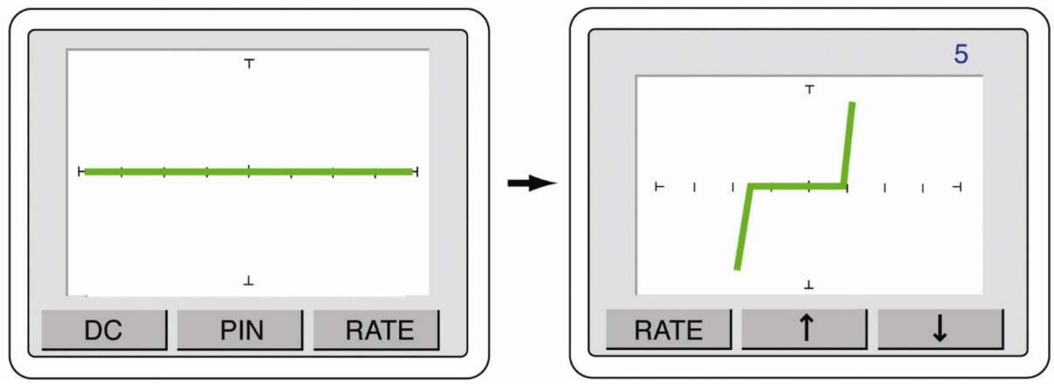


Figure 2-22 RATE Controls menu

Press the **RATE** button to return to the power-up menu.

VALUES Controls

The VALUES function allows you display on-screen parameters such as channel, tolerance, DC Voltage level and pin number (2800S) plus SigAssist™ values such as capacitance value, resistance value, forward breakdown voltage and reverse breakdown voltage.

To access the VALUES menu controls, press the front panel **MENU** button to display the Main menu (left image in figure 2-23). Press the **VALUES** button on the touch screen to display the VALUES menu (middle image in figure 2-23). Use the ↑ **and** ↓ arrow buttons to toggle the values displayed on the LCD (right images in figure 2-23). Note that the signature portion of the screen will become smaller as additional values are displayed.

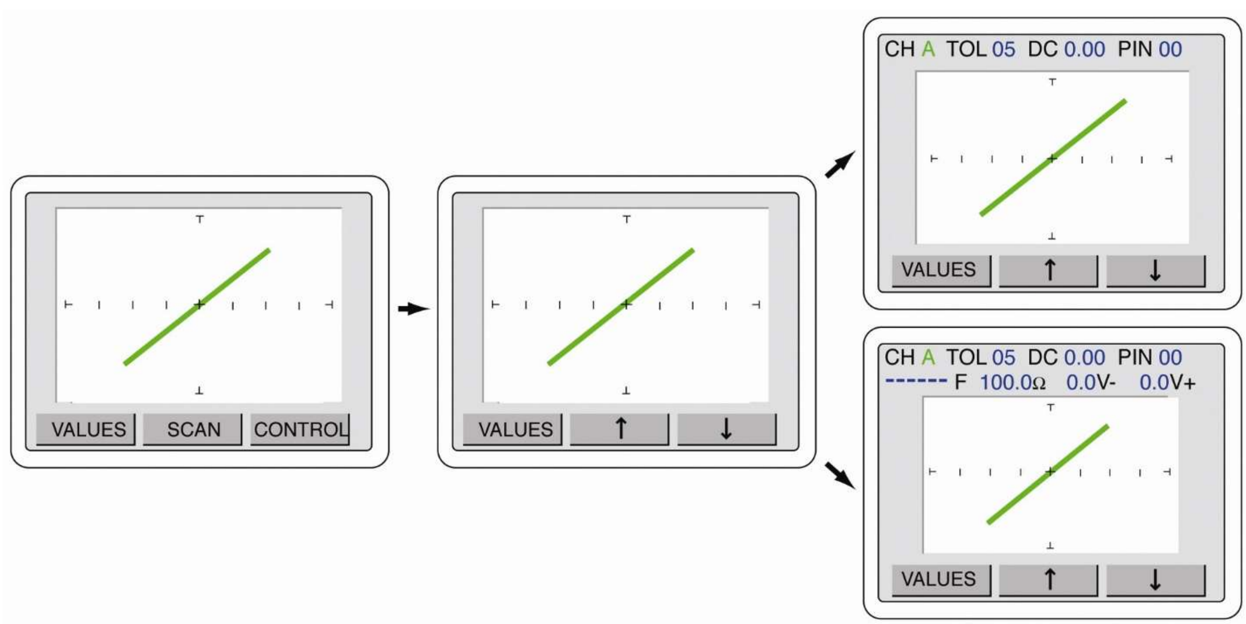


Figure 2-23 VALUES Control menus

Press the **VALUES** button to return to the Main menu or press the **MENU** front panel button twice to return to the power-up menu.

SCAN – MODE Controls

The SCAN – MODE controls how the Tracker will step through a selected range parameter when the Scan mode is started by pressing the **SCAN** front panel button. The SCAN mode can step through voltage (VOL), resistance (RES), frequency (FREQ) or NONE. To set the SCAN mode, press the **MENU** front panel button to display the Main menu (left image in figure 2-24). Press the **SCAN** button to display the SCAN menu (middle image in figure 2-24). Press the **MODE** button to display the MODE menu (right image in figure 2-24). Use the ↑ **and** ↓ arrow buttons to step the selections of voltage (VOLT), resistance (RES), frequency (FREQ) or NONE.

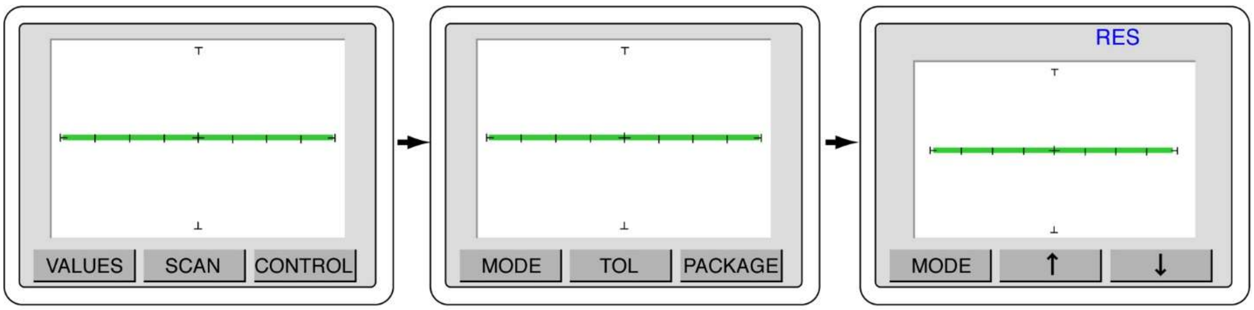


Figure 2-24 SCAN - MODE menus

Press the **MENU** front panel button three times to return to the power-up menu or press the **MODE** button to go back to the SCAN menu. The range combinations used when scanning are controlled within the Smart Tracker Active Range limits (see section 2-10).

SCAN – TOL (Tolerance) Controls

The SCAN – TOL controls the tolerance allows when the signature on channel A is compared against the signature on channel B. The tolerance is adjustable from 0 to 90. The larger the tolerance, the greater the two signatures can differ and still be considered a "pass" when compared against each other. To access the SCAN – TOL control menus, press the **MENU** front panel button to display the Main menu (left image in figure 2-25). Press the **SCAN** button to display the SCAN menu (middle image in figure 2-25). Press the **TOL** button to display the MODE menu (right image in figure 2-25). Use the ↑ **and** ↓ arrow buttons to adjust the tolerance value to the desired setting.

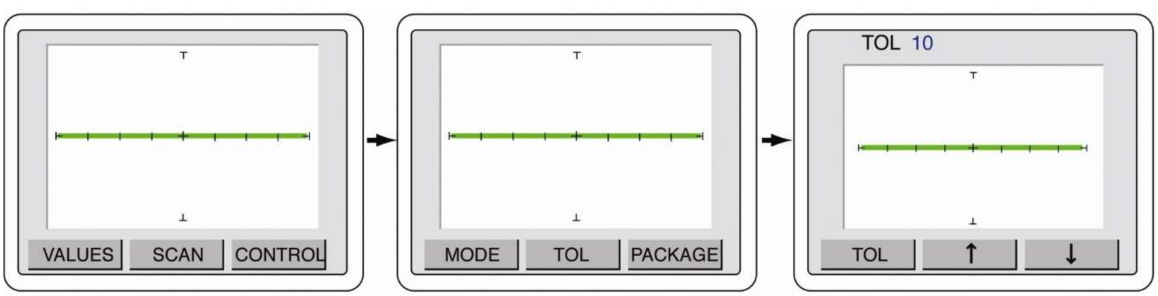


Figure 2-25 SCAN – TOL menus

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

SCAN – PACKAGE Controls (Tracker 2800S)

When scanning with a Tracker 2800S, it is possible to configure the pin counting order used on the front panel cable connections. Depending on the type of component that is connected to during scanning, the package type and number of pins will need to be configured.

To configure the scan package type press the **Menu** front panel button to display the Main menu (first image in figure 2-27). Select **SCAN** from the touch screen Main menu to display the SCAN menu (second image in figure 2-27). Select **PACKAGE** from the SCAN menu to display the PACKAGE menu (third image in figure 2-27). Select **PACKAGE** to display the PACKAGE select menu (middle right image in figure 2-26). Use the ↑ **and** ↓ buttons to step up or down through the package choices of DIP, SIP, BOTH or FRONT (see figure 2-26).

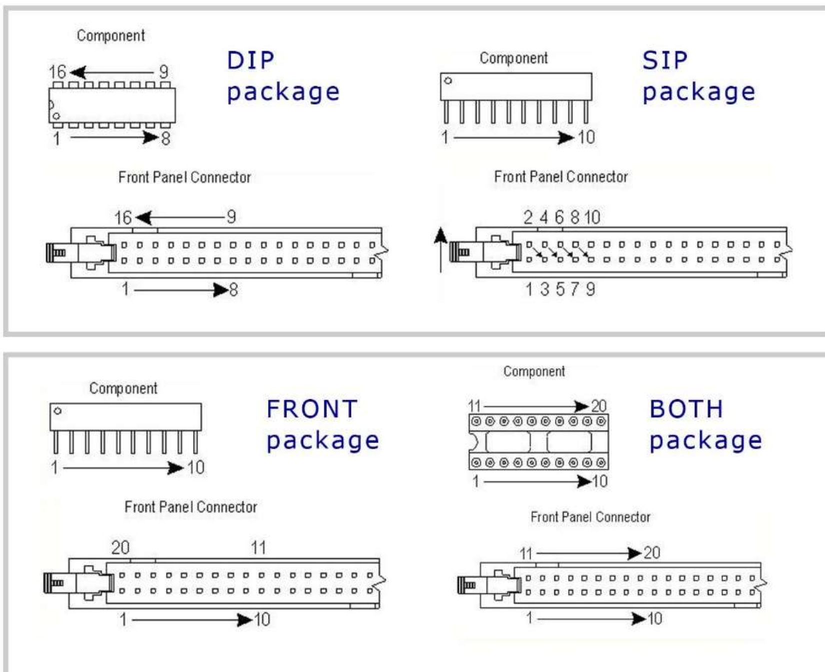


Figure 2-26 Scan package types

Press the **PACKAGE** button to return to the Package menu. Press the **PINS** button to display the PIN select menu (top right image in figure 2-27). Use the ↑ **and** ↓ buttons to increase or decrease the numbers of pins to be scanned. Press the **PINS** button to return to the PACKAGE menu.

You can also configure how the scan is executed when the SCAN button is pressed. Press the **SINGLE** button to toggle (bottom right image in figure 2-27) between SINGLE (single pass then stop), LOOP (continuous scan) or STOP (stop on failure).

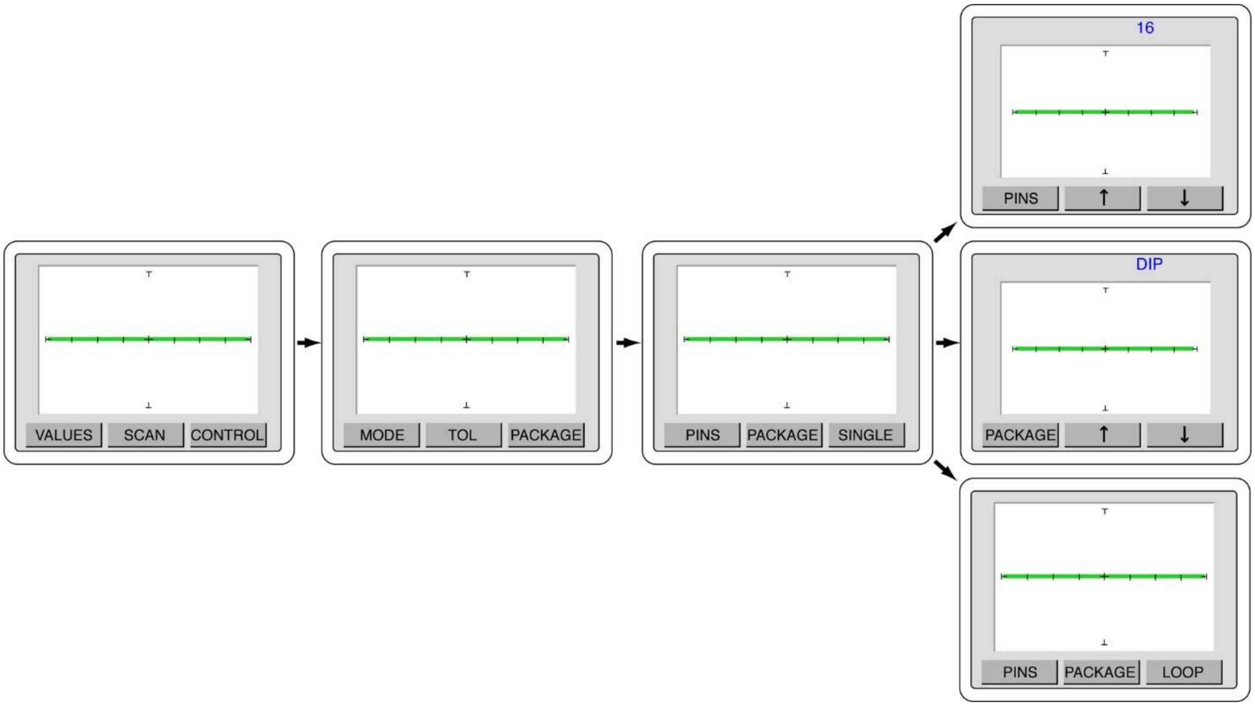


Figure 2-27. Scan/Package menus

Press the **MENU** front panel button three times to return to the power-up menu.

CONTROL – SWITCH Controls

The CONTROL – SWITCH menu controls the function of the optional footswitch when used with the Tracker 2800.

To configure the footswitch control press the front panel **MENU** button to display the Main menu on the LCD (left image in figure 2-28). Press the **CONTROL** button on the LCD to display the Control menu (image second from left in figure 2-28). Press the **SWITCH** button on the LCD to display the Switch menu (image third from left in figure 2-28). Use the ↑ **and** ↓ arrow buttons to select the footswitch control between SCAN (image third from left in figure 2-28), CHANNEL (middle image on right in figure 2-28) and RANGE (bottom image on right in figure 2-28).

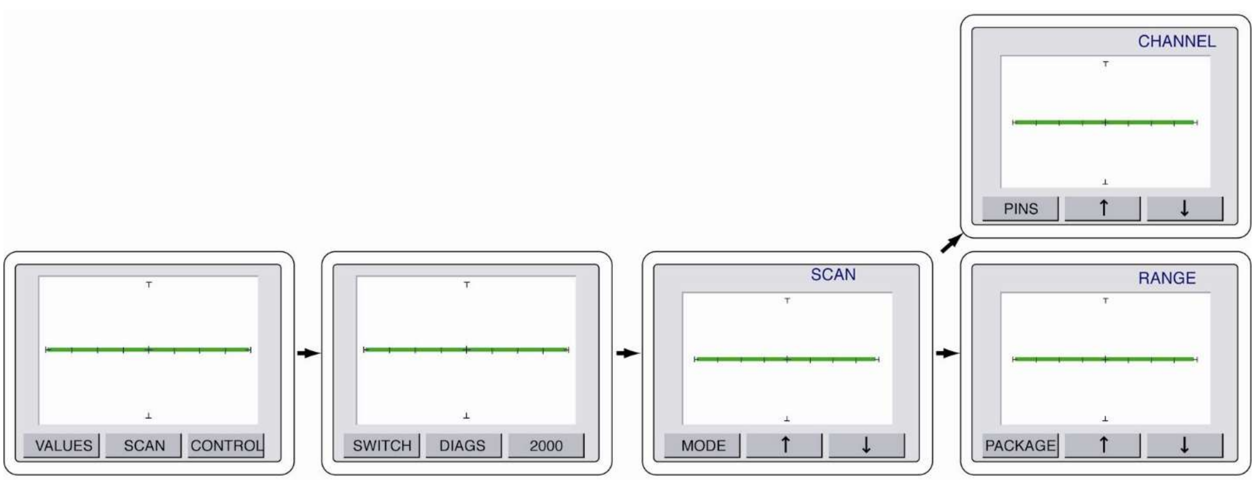


Figure 2-28 Tracker 2800 Footswitch Control Menus

The footswitch controls work as follows:

- **SCAN** mode: Pressing the footswitch will start and stop the SCAN mode (same as manually pressing the front panel **SCAN** button).
- **CHANNEL** mode: Pressing the footswitch will change the channel from A to B or vice versa.
- **RANGE** mode: Pressing the footswitch will change to the range set when the mode is selected (i.e., set the range to 3V, 10KΩ, 200Hz, select footswitch **RANGE** mode; pressing the footswitch will automatically change the Tracker to this range). This is useful for changing to a favorite range by simply pressing the footswitch.

Press the **MODE** button to return to the Control menu or press the front panel **MENU** three times to return to the power-up menu.

CONTROL – DIAGS Controls

The Tracker 2800/2800S 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. Press the **CONTROL** button (left image in figure 2-29) to display the Control menu. Press the **DIAGS** button (center image in figure 2-29) to display the Diagnostics menu (right image in figure 2-29).

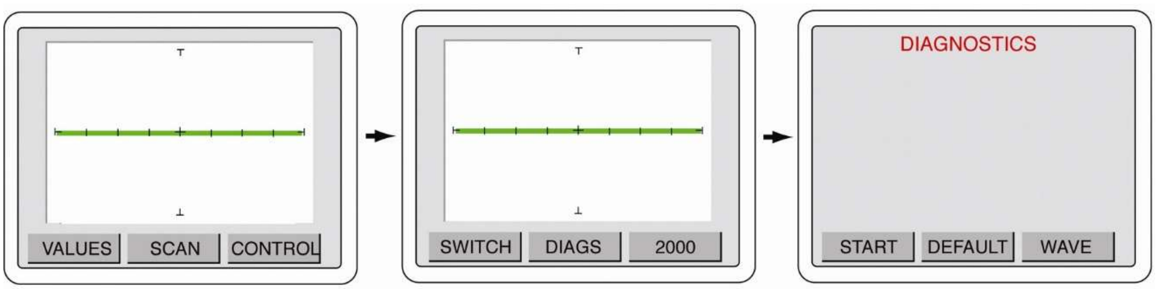


Figure 2-29 Control – Diags menus

Press the **START** button to display a diagnostics selection menu (shown in figure 2-30).

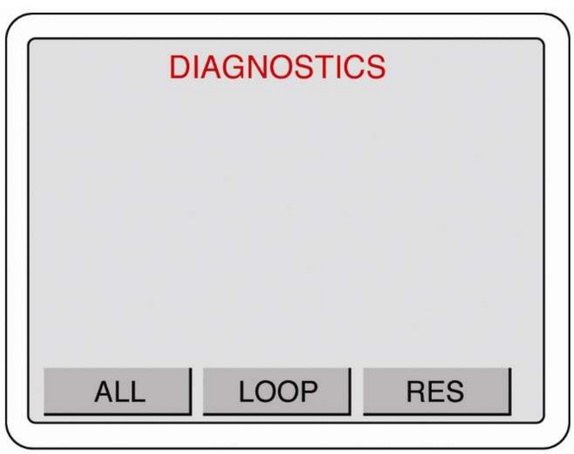


Figure 2-30 Diagnostics selections

- **ALL**: Executes all diagnostic routines
- **LOOP**: Executes the loop compensation routine that will “zero out” added capacitance on the test line from attached cables.
- **RES**: Executes the resistor diagnostics. Tests the front panel resistance values with internal reference resistors.

If any diagnostic routines fail, ensure that any cables attached to the front panel are removed and run the diagnostics again. If failures continue to occur then contact Huntron Technical Support for assistance.

In the Diagnostics menu, pressing **DEFAULT** will set the Tracker touch screen menus to the factory default settings.

Pressing the **WAVE** button will change the Tracker to waveform display as shown in figure 2-31. This button will change to SIG when waveform mode is enabled. Press **SIG** to return to signature mode. Waveform mode is primarily useful when diagnosing problems with the Tracker.

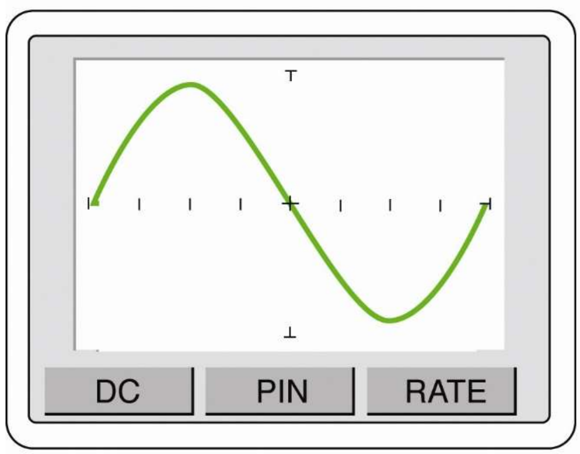


Figure 2-31 Tracker waveform display

CONTROL – 2000 Mode

The Tracker 2800/2800S can be set to display three of the ranges used with the popular Tracker 2000. To enable 2000 mode, press the **2000** button in the Control menu. The display will change to the Tracker 2000 ranges as shown in figure 2-32.

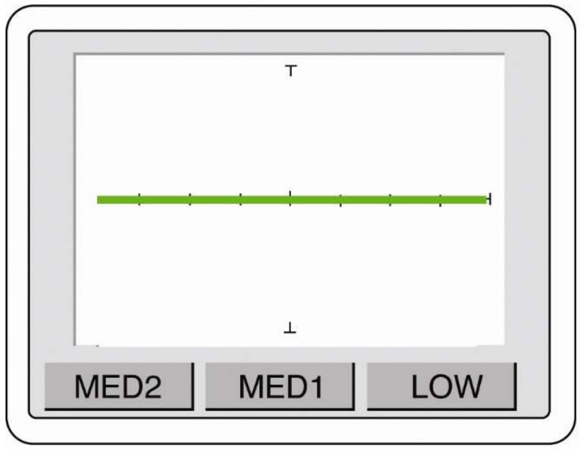


Figure 2-32 Tracker 2000 mode

- **LOW** range: 10V at 54Ω
- **MED1** range: 15V at 1.2KΩ
- **MED2** range: 20V at 26.7KΩ

SECTION 3 TESTING PASSIVE COMPONENTS

3-1. RESISTORS

Exploring how the Tracker 2800 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 2800 basic operation and teach you how resistor signatures relate to both test range and the resistance of the circuit under test. After completing this section, you will know how to:

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

As you go through the following section, make a mental note on the relationship between the Tracker 2800'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):

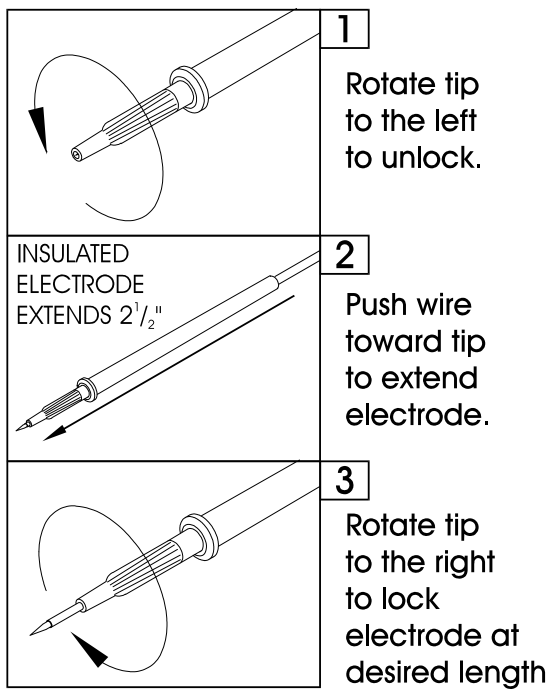
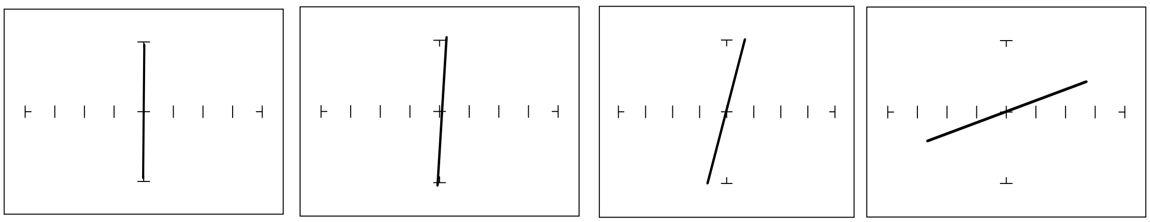


Figure 3-1. Huntron MicroProbe Adjustment.

To display the analog signature of a resistor:

1. Select the Tracker tab of the Signature pane of the Huntron Workstation Software.
2. Select the 50 ohm range by clicking the Resistance dropdown button and selecting 50.
3. Place or clip a test lead on the opposite ends of a resistor and observe the signature.

Below are four analog signatures of different resistors, 150, 1.5 k, 15 k and 150 k ohms in each of the four Ranges. Note how the slope or angle of each analog signature changes with each resistor's value.

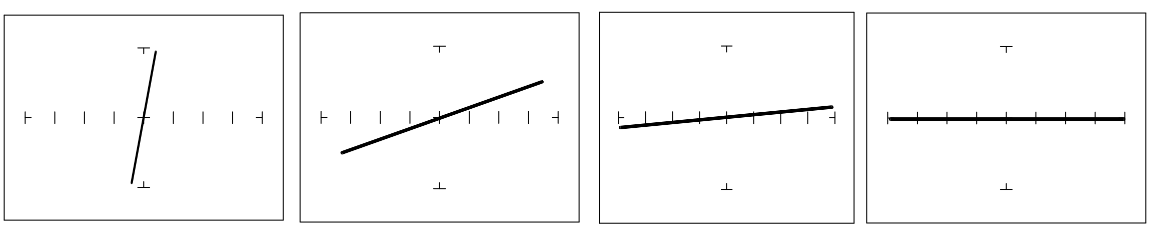


100 Ω | 1 kΩ | 10 kΩ | 100 kΩ

Vs=20V, Rs=100kΩ, Fs=200Hz

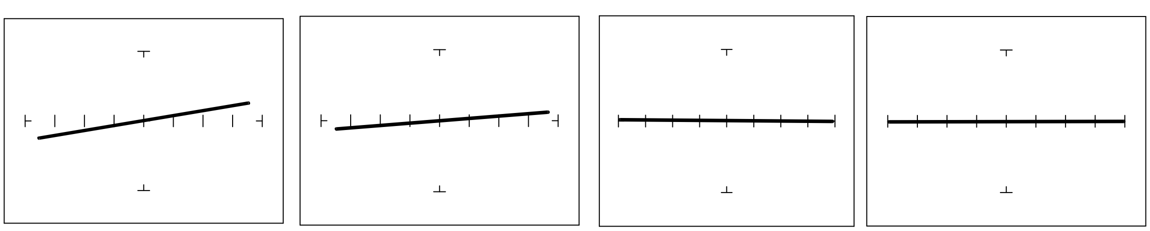
100 Ω | 1 kΩ | 10 kΩ | 100 kΩ

Vs=20V, Rs=10kΩ,□ Fs=200Hz



100 Ω | 1 kΩ | 10 kΩ | 100 kΩ

Vs=15V, Rs=1kΩ, Fs=200Hz



100 Ω | 1 kΩ | 10 kΩ | 100 kΩ

Vs=10V, Rs=10Ω, Fs=200Hz

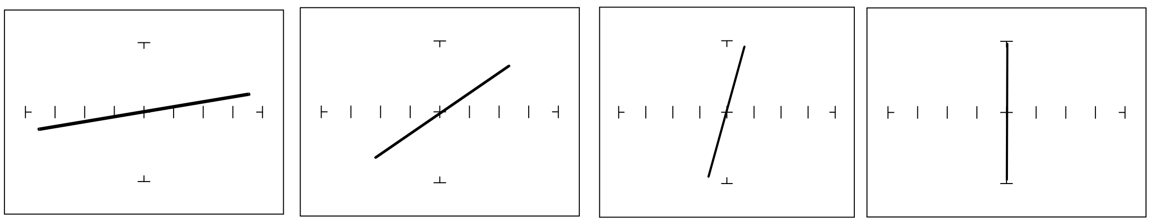
Figure 3-2. Signatures of Different Resistors in 4 Ranges.

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 2800 and how it affects the resistive analog signature.

The Effect of R_S on Resistor Analog Signatures.

Select the 10V, 50Ω and 200Hz. Change the resistance range to 200, 1K and 5K.

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 2800's internal resistance.

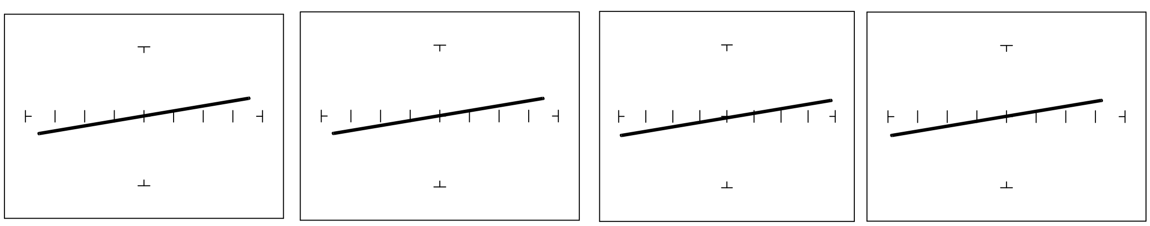


R_S = 50Ω R_S = 100Ω R_S = 1KΩ R_S = 10KΩ

Figure 3-3. Effect of Varying R_S on a 100Ω Resistor Signature

The Effect of V_S on Resistor Analog Signatures.

Select the 10V, 50Ω and 200Hz. Change the voltage range to 5V, 2V and 200mV.



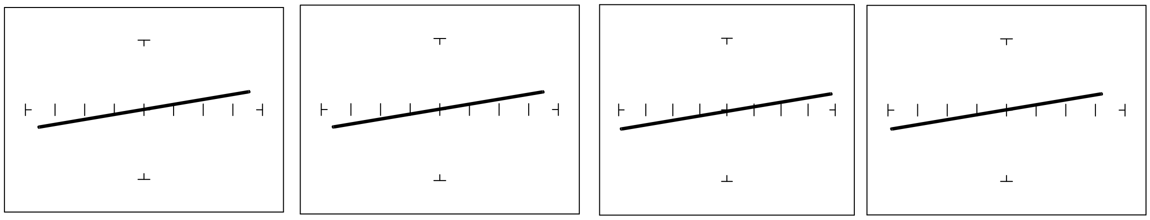
V_S = 10V V_S = 5V V_S = 2V V_S = 500mV

Figure 3-4. Effect of Varying V_S on a 100 Ω Resistor Signature.

Observe that these signatures do not change with the changing voltage. Note that Vs cannot be set above 10V because R_S is set to a value of 50 Ω. This limit on range parameter combinations is a result of the Tracker 2800's STAR feature. It protects components from possible excessive power levels. In order to set V_S to a higher voltage, you must change R_S to a higher value first.

The Effect of Fs on Resistor Analog Signatures.

Select the 10V, 50Ω and 20Hz range. Change the Frequency to 60Hz, 1KHz and 2KHz. Observe the resistor signatures in the following figures do not change as Fs changes.

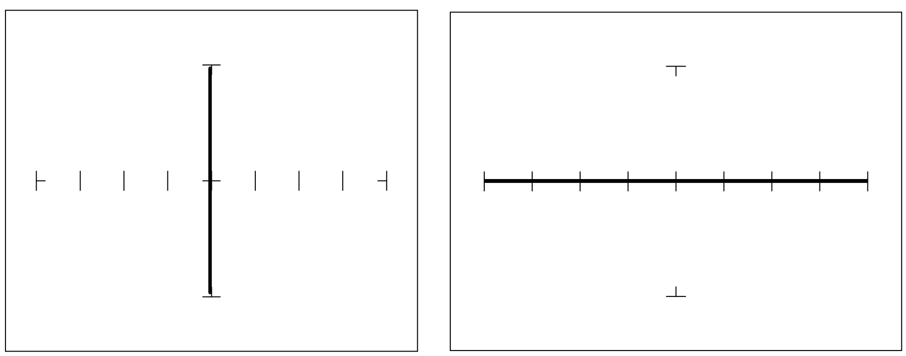


Fs = 20 Hz **Fs = 60 Hz** **Fs = 1KHz** **Fs = 2KHz**

Figure 3-5. Effect of Varying Fs on a 100Ω 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 Ω to 10 Ω low resistive path between two points in a component or circuit that normally would have a higher resistance between them. An open circuit is a break between two points in a component or circuit that prevents current from flowing.



Short Open

Figure 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 2800 is a fast and efficient continuity tester, providing real time information.
- The Tracker 2800 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 2800's ability to determine the approximate fault resistance value greatly enhances the troubleshooting capability if the correct value is known.
- The Tracker 2800 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 2800, 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.

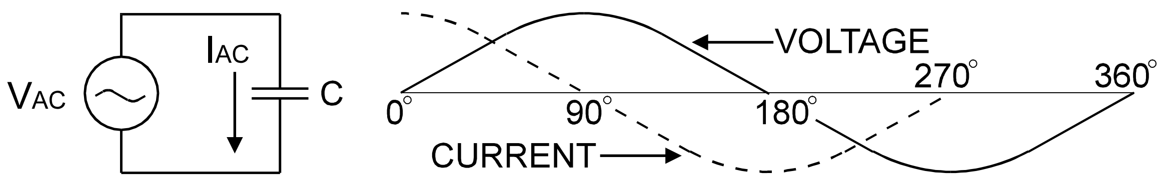


Figure 3-7. Capacitor Circuit with Test Signal's Current and Voltage Waveforms.

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°. On the Tracker 2800, 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 (µf) of the circuit under test
- The frequency (F_s) of the test signal
- The voltage (V_s) of the test signal
- The internal resistance (R_s) of the Tracker 2800

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

⚠CAUTION

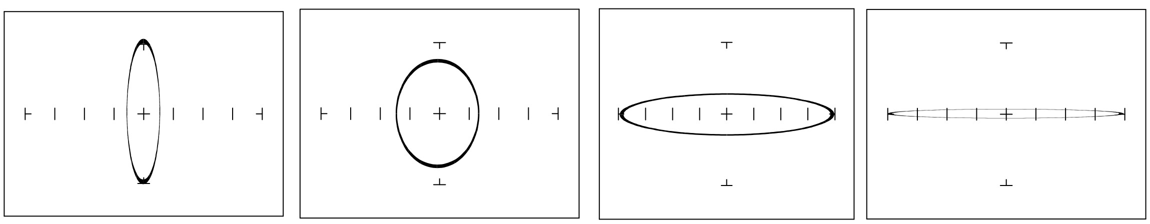
The device to be tested must have all power turned off and have all high voltage capacitors discharged before connecting the Tracker 2800 to the device.

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

1. Select the 10V, 50Ω and 60Hz range
2. Place or clip a test lead on the opposite ends of a capacitor and observe the signature.

The Signatures of Different Capacitors

The figure below shows analog signatures for four different value capacitors, 1000 μf, 100 μf, 10 μf and 1μf. Select 10V, 50Ω and 60Hz.



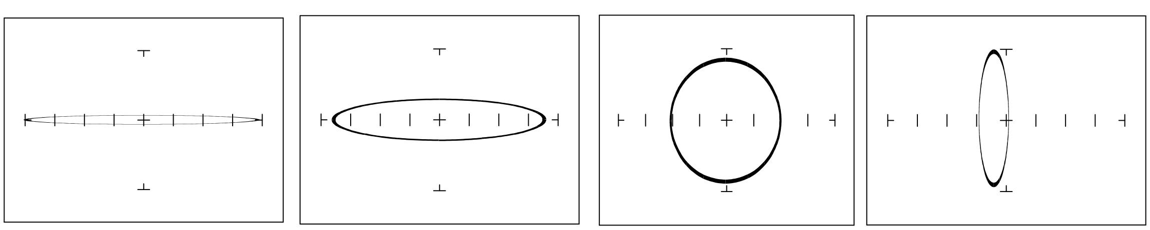
1000 μF 100 μF 10 μF 1 μF

Figure 3-8. Signatures of 4 Capacitors in the 10V, 50Ω 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 10μF Capacitor

Select 10V, 50Ω and 20Hz. Then select 60Hz, 500Hz and 2KHz.



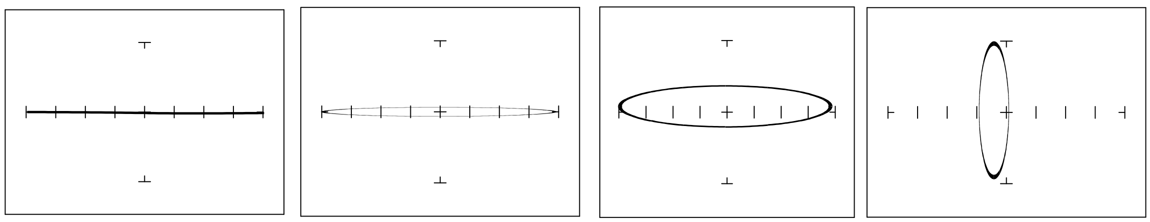
F_S = 20Hz F_S = 60Hz F_S = 500Hz F_S = 2KHz

Figure 3-9. Signatures of a 10μF Capacitor at Different Frequencies

Note that as the test signal frequency increases, the 10 μF capacitor's signature changes from a horizontal elliptical pattern to a vertical elliptical pattern. In 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 0.1μF Capacitor

Select 10V, 1KΩ and 20Hz. Then select 60Hz, 500Hz and 2KHz.



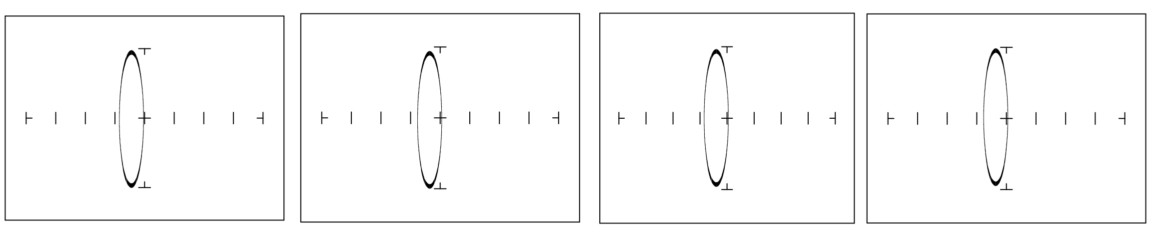
F_S = 20 Hz F_S = 60 Hz F_S = 500 Hz F_S = 2 kHz

Figure 3-10. Signatures of a 0.1 μF Capacitor at Different Frequencies.

Note that as the test signal frequency increases, each signature changes from a horizontal elliptical pattern to a vertical elliptical pattern. In 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 μF capacitor is similar to the 10 μF capacitor in shape but not in size due to the differences in their value.

Effect of Changing Voltage on a 1μF Capacitor

Select 200mV, 20KΩ and 60Hz. Then select 5V, 15V and 20V.



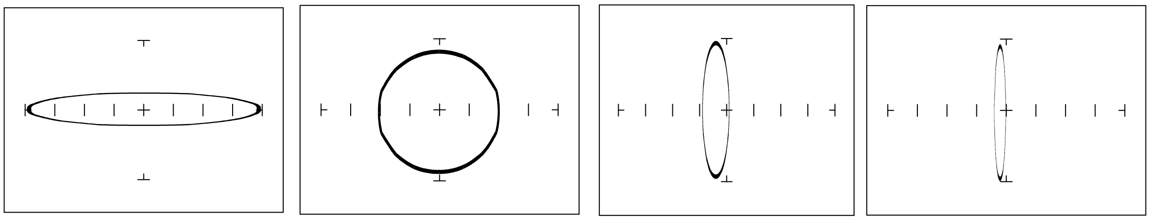
V_S = 200mV V_S = 5V V_S = 15V V_S = 20V

Figure 3-11. Signatures of a 1 μF 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

Select 15V, 1K and 60Hz. Then select 5K, 10K and 100K.



R_S = 1KΩ R_S = 5KΩ R_S = 10KΩ R_S = 100KΩ

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

As the Tracker 2800'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

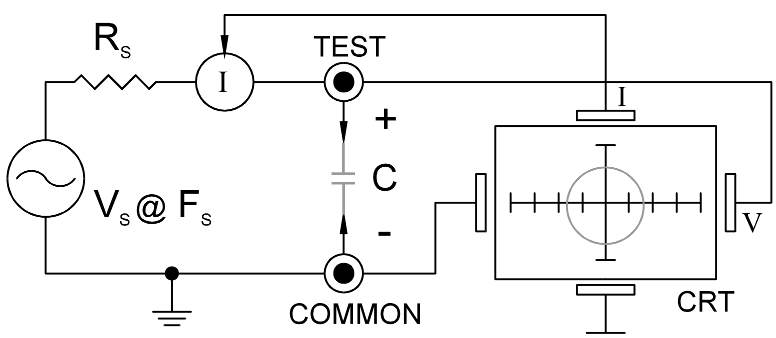


Figure 3-13. Tracker 2800 Core Circuit Block Diagram with a Capacitor.

The Huntron Workstation Software displays the Tracker 2800 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 2800, 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 2800, 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 kΩ to 100 kΩ, the following occurs:
  - X_C of the capacitor is not affected
  - V_S increases so current decreases proportionately

The elliptical signature becomes increasingly vertical

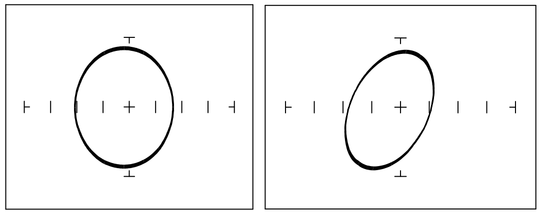
Table 3-1 shows the Tracker 2800's limits for the minimum and maximum capacitance values that will display a usable signature on the Tracker display.

R_S	F_S = 20 Hz.	F_S = 2 kHz
100 kΩ	0.01 μF - 1 μF	100 pF - 0.01 μF
10 Ω	15,000 μF - 100 μF	0.1 μF - 100 μF

Table 3-1. Tracker 2800 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 2800 signature display with 50Ω, 10V and 60Hz selected.

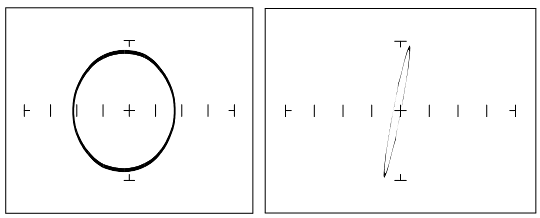


Normal Capacitor Leaky Capacitor

Figure 3-15. Signatures of A 100 μF Capacitor with Dielectric Leakage.

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

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



Normal Capacitor Leaky Capacitor

Figure 3-16. Signatures of a 10 μF Capacitor with Dielectric Leakage at 10V, 500Ω, 60Hz

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

As you can see from the two previous examples, adding resistance in parallel to a capacitor distorts the normal signature with a diagonal bend to it. This is our first look at a composite signature, the kind of signature the Tracker 2800 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 2800 can locate defective capacitors in or out of circuit. The ranges cover 100 pF to 15,000 μF.
- When analyzing a capacitor's signature, adjust the Tracker 2800'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 2800'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 µH) of the circuit under test
- The frequency (F_S) of the test signal
- The voltage (V_S) of the test signal
- The internal resistance (R_S) of the Tracker 2800

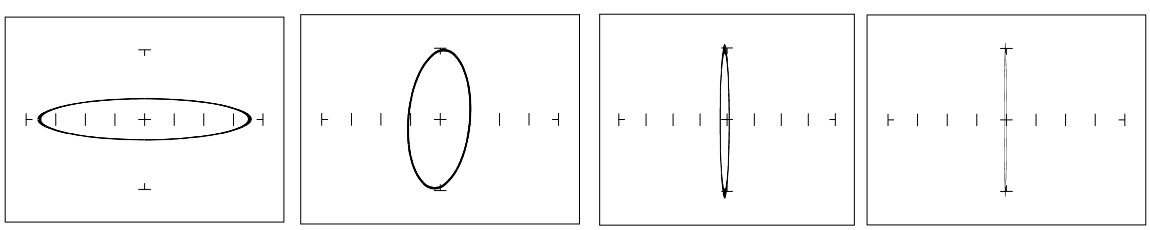
Plug the red test microprobe in the Channel A jack, and the black test clip lead in the Common jack.

Do the following to display the analog signature of an inductor:

1. Select 50Ω, 10V and 60Hz range (LOW Range)
2. Place or clip each test lead on the opposite ends of an inductor and observe the signature in the Tracker 2800 signature display.

Signatures of Different Inductor Values

The figure below shows analog signatures for four different value inductors, 12,000 µH, 1200 µH, 120 µH and 12 µH. Select 10V, 50Ω, 2KHz.



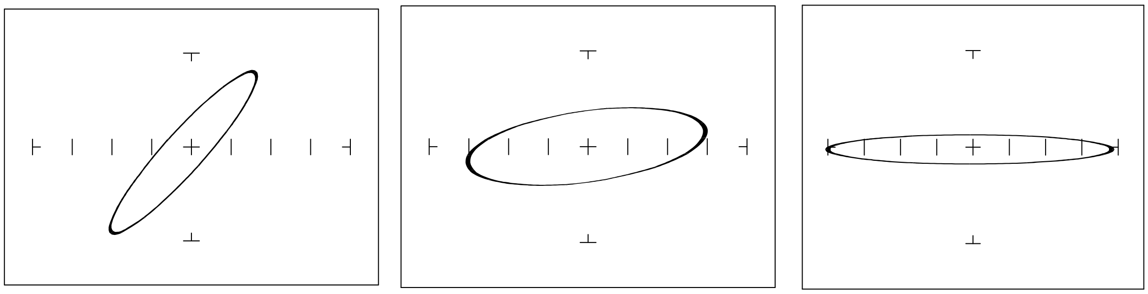
12,000 µH   1,200 µH   120 µH   12 µH

Figure 3-17. Signatures of 4 Inductors at 10 V, 50Ω, 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

Select 10V, 50Ω, 60Hz. Then Select 1KHz and 2KHz.



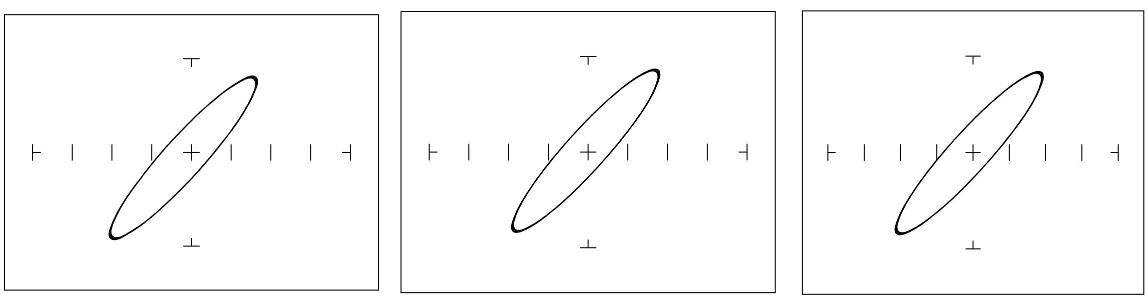
F_S = 60 Hz F_S = 1KHz F_S = 2KHz

Figure 3-18. Effect of varied F_S on 12,000 µH 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

Select 200mV, 50Ω, 60Hz. Then Select 5V and 10V.



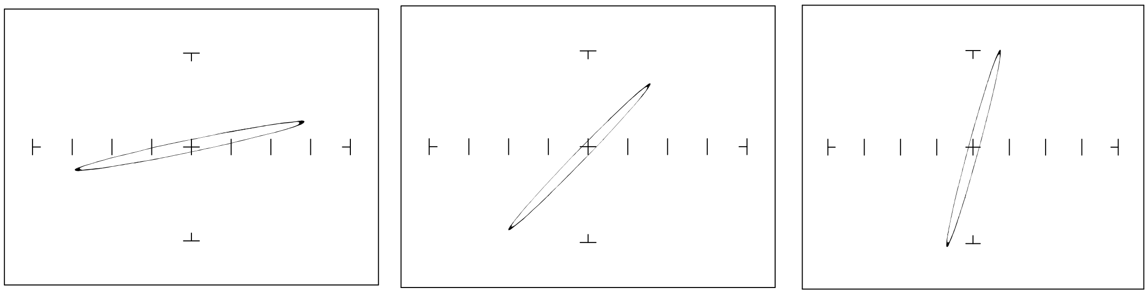
V_S = 200 mV V_S = 5 V V_S = 10 V

Figure 3-19. Effect of varied V_S On 12,000 µH 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

Select 2V, 10Ω, 60Hz. Then Select 50Ω and 200Ω.



R_S = 10 Ω R_S = 50 Ω R_S = 500 Ω

Figure 3-20. Effect of Varying R_S on 12,000 µH Inductor Signatures.

Note that the signature changes from a horizontal to a vertical position as the Tracker 2800's internal resistance R_S increases. This means the inductor's resistance can be analyzed by matching it with the Tracker 2800's test signal resistance.

Understanding Inductive Signatures

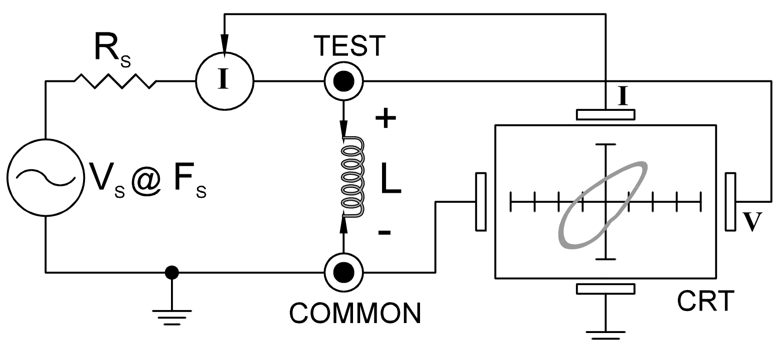


Figure 3-21. Tracker 2800 Tracker Core Circuit Block Diagram with an Inductor.

The Tracker 2800'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 2800'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 2800 display usually is distorted. Inductors constructed with a ferrite core makes the inductive characteristics different from those constructed without. The Tracker 2800 responds with a unique analog signature for each inductor type.

R_S	F_S = 20 Hz.	F_S = 2 kHz
100 kΩ	100H – 1000H	50mH – 1000mH
10 Ω	1H – 100H	1uH – 10mH

Table 3-2. Tracker 2800 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 2800 test signal's frequency is increased, the ellipse signature becomes flatter. This response is opposite to that of a capacitor.
- As the Tracker 2800 internal resistance R_S increases, an inductor's signature becomes more vertical (like the capacitor signature).
- When an inductor has a ferrite core, its signature distorts from a non-ferrite inductor's ellipse.

APPLICATIONS

- The Tracker 2800 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 2800'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 2800 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 2800 signal in $V_S = 10$ V, $R_S = 50\ \Omega$, $F_S = 60$Hz range to the device input leads and listen for the 60 Hz tone or audible hum.
- To test solenoids, connect the test probes to the coil leads and manually move the plunger or activator in and out while observing if its signature changes.

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 2800, 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.

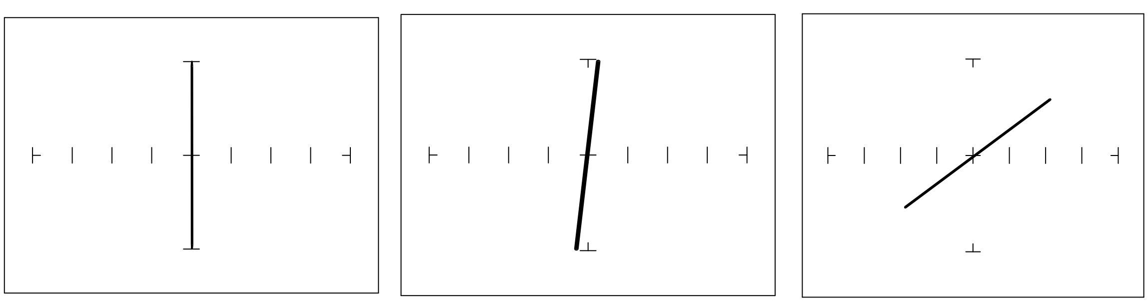
Manually Operated Mechanical Switches

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 2800 can test the switching function of mechanically activated switches easily. Unlike the DVM that samples and gives a continuity measurement, the Tracker 2800 displays real time activity so if a switch has noisy, resistive or intermittent operation, its analog signature on Tracker 2800's display will reflect these conditions.

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

Do the following to display the analog signature of a mechanical switch:

1. Select the V_S = 10 V, R_S = 50Ω, F_S = 60Hz range button.
2. Place or clip each test lead to the switch leads and observe its signature on the Tracker 2800 signature display.
3. Turn the switch to it’s on or off position.



10KΩ 1KΩ 50Ω

Figure 3-23. 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

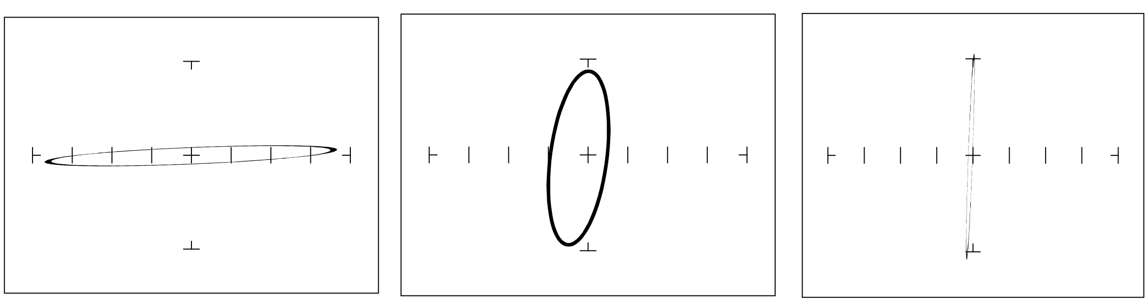
A relay is a switch that's activated by an electrical control input. The relay consists of switch contacts, magnets and an electromagnetic coil. The Tracker 2800 can test the coil part of the relay by looking at its inductive analog signature.

Relay Coil Test

Do the following:

1. Select the V_S = 10V, R_S = 50Ω, F_S = 2KHz range.
2. Connect the black test lead from Tracker 2800's Common jack to one side the relay coil (normally, the minus lead).
3. Connect the red test lead from Tracker 2800's Signal jack to the other side of the relay coil (normally, the plus lead).

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

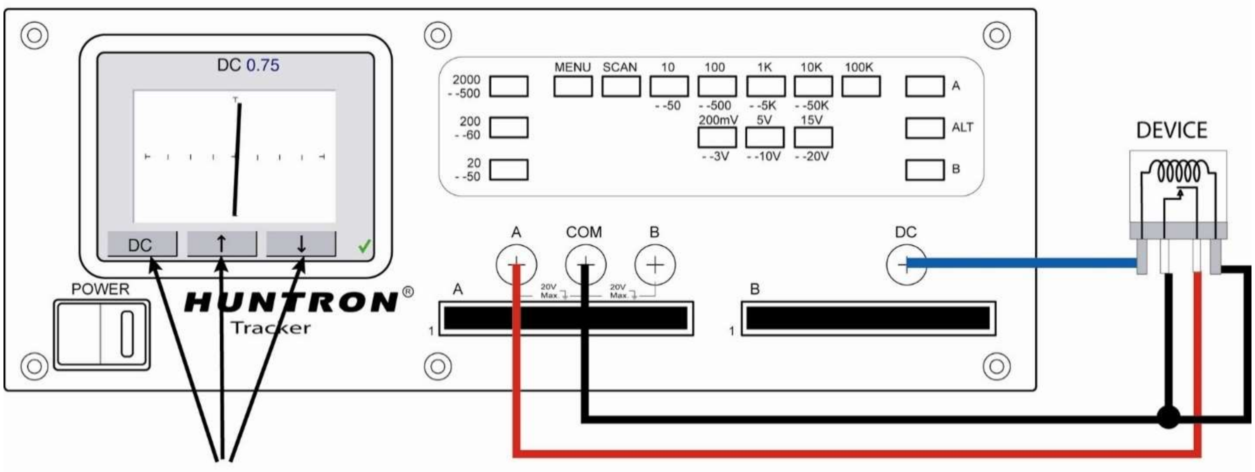


50Ω 1KΩ 20KΩ

Figure 3-24. Signatures of a Magnetic Reed Relay Coil at 2KHz.

Note the characteristic inductive oval at 3 resistances. When applying Tracker 2800'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 2800 DC Voltage Source.



Use the arrow buttons to increase/decrease
voltage level applied to relay

Figure 3-25. Using the Tracker 2800 DC Voltage Source for Relay Testing

Review

- The Tracker 2800 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.

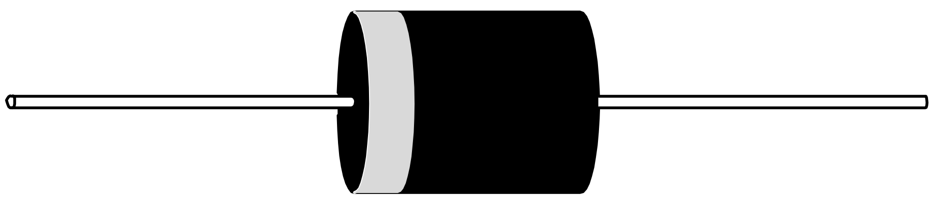


Figure 4-1. Diode and Schematic Symbol.

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.

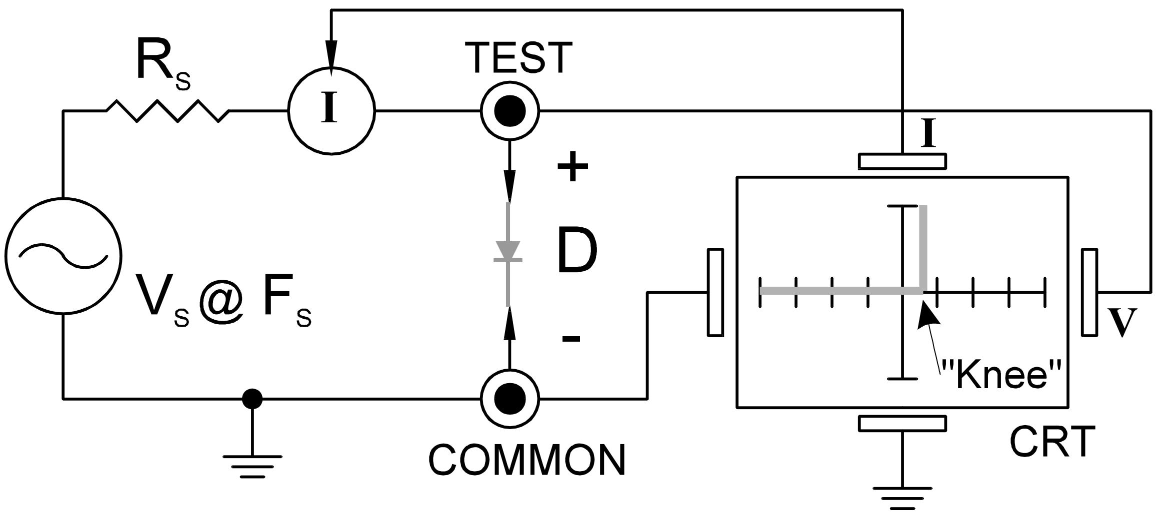
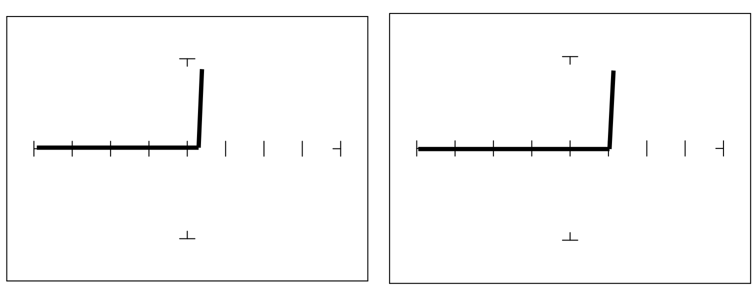


Figure 4-2. Tracker 2800 Core Circuit Block Diagram with a Diode.

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

Do the following to display the analog signature of a diode:

1. Select 50Ω, 10V and 60Hz.
2. Place or clip the red test lead from the Tracker 2800's Channel A jack to anode lead of the diode.
3. Place or clip the black test lead from the Tracker 2800's Common jack to anode lead of the diode.



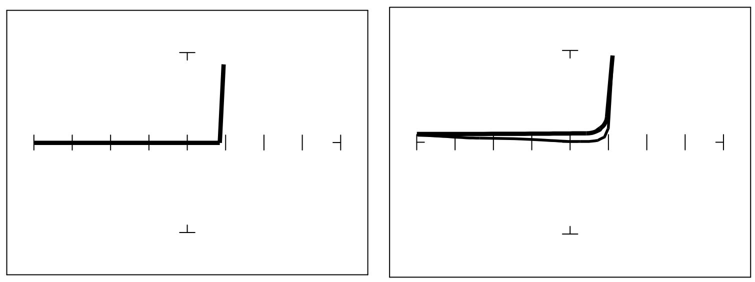
V_S = 10 Volts V_S = 3 Volts

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_P. Each horizontal division on the display equals approximately 2.5 V. In this range the diode's signature shows that its threshold or forward voltage is approximately 0.6 Volts. By 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_S = 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.

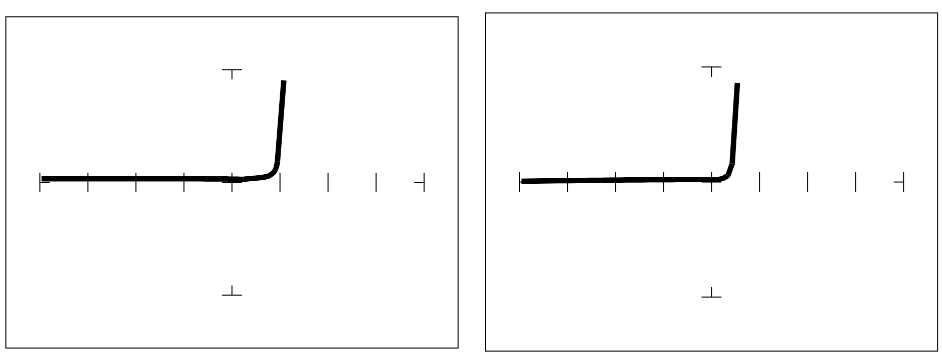


60Hz 2KHz

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

Effects of Changing Resistance on Diode Signatures

Changing Tracker 2800'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.



R_S = 50Ω R_S = 100KΩ

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.

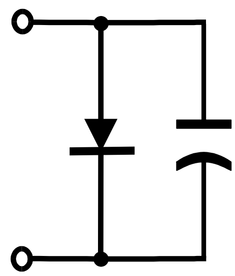
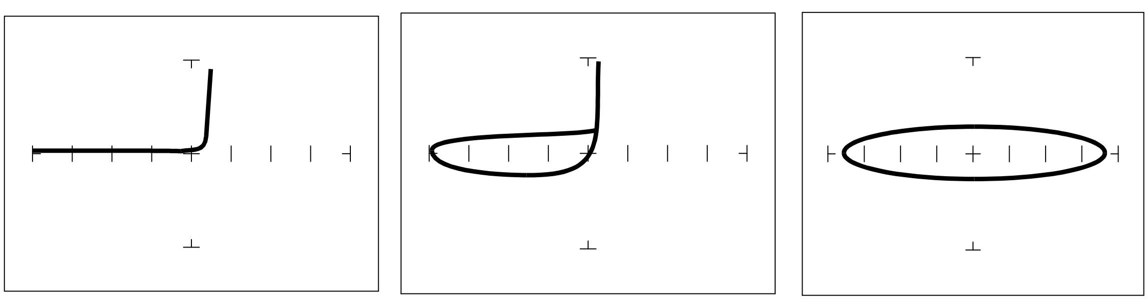


Figure 4-7. Composite Model of a Diode and Capacitor in Parallel.



V_S = 10 V, F_S = 20 Hz V_S = 10 V, F_S = 1KHz V_S=200 mV, F_S = 1KHz

Figure 4-8. Composite Signature - 1N914 Diode and 1μF 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 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 2800 has the ability to selectively display the signature of a single component.

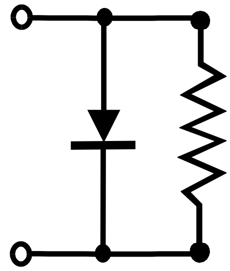
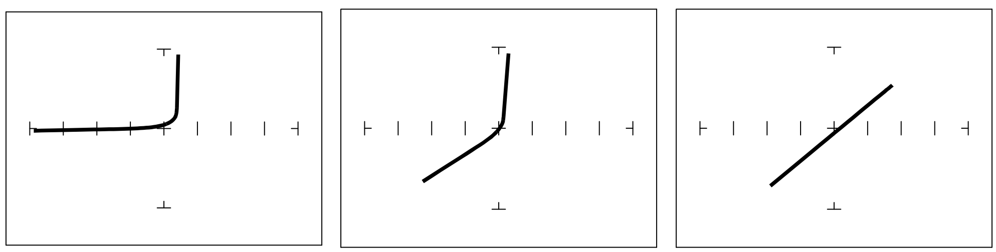


Figure 4-9. Composite Model of a Diode and Resistor in Parallel.



V_S = 10 V, R_S = 50 Ω V_S = 10 V, R_S = 1KΩ V_S = 200 mV, R_S = 1KΩ

Figure 4-10. 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 2800 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

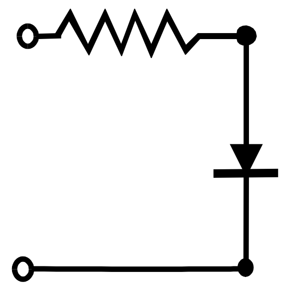
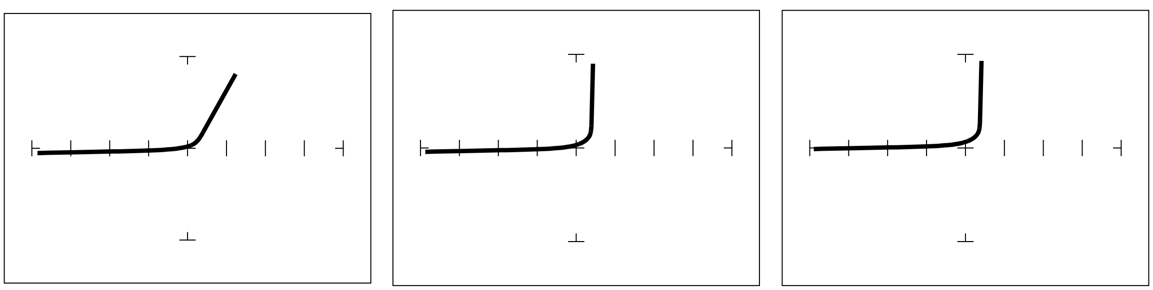


Figure 4-11. Defective Diode Model with a Small Series Resistor.



50Ω, 10V 1KΩ, 15V 20KΩ, 20V

Figure 4-12. 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

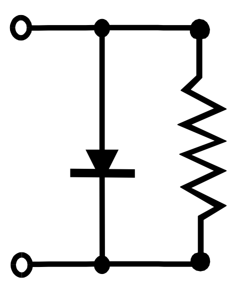


Figure 4-13. Defective Diode Model with an Internal Leakage Resistance.

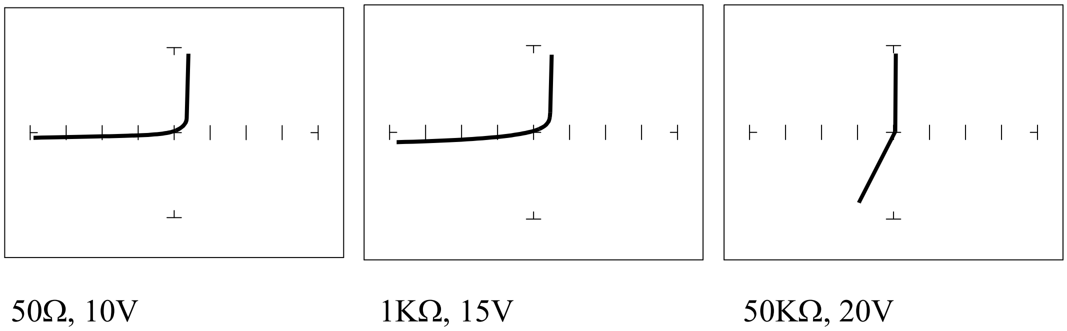


Figure 4-14. Signature of A 1N914Diode With Internal Leakage (10KΩ In Parallel).

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.

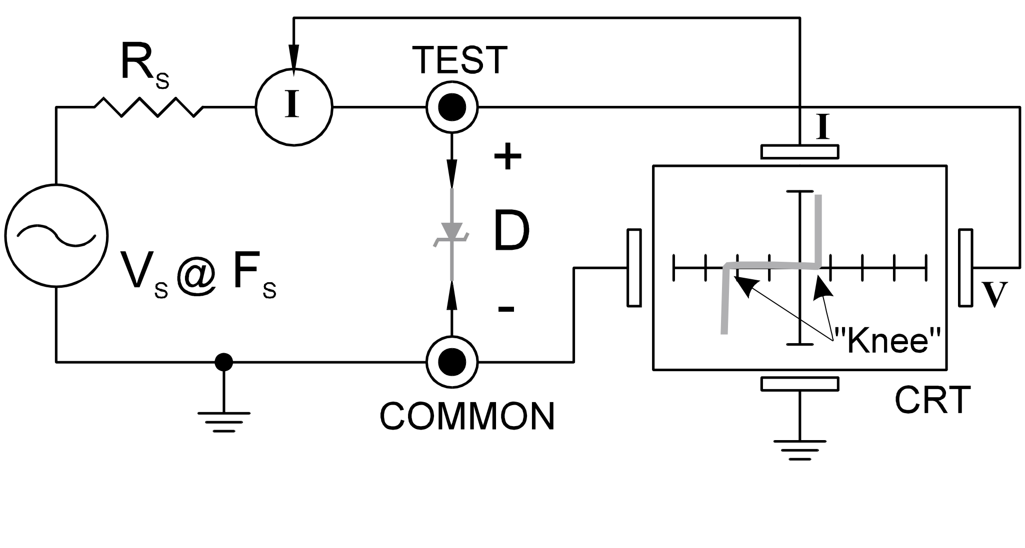


Figure 4-15. Tracker 2800 Core Circuit Block Diagram with a Zener Diode.

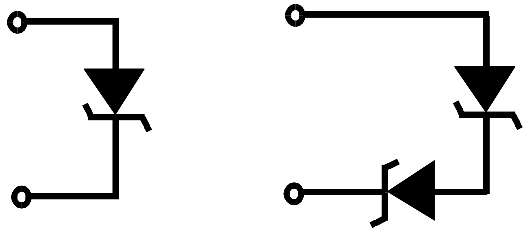
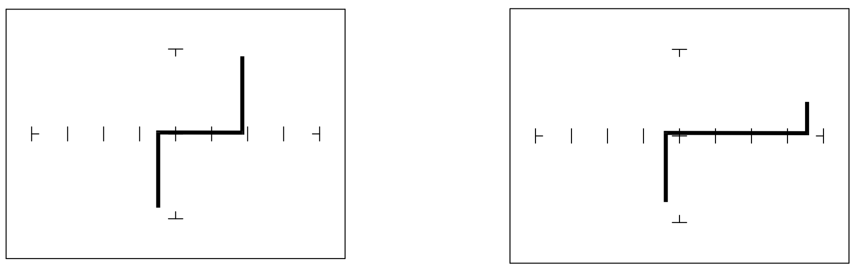


Figure 4-16. Single Zener Diode and two Zener Diodes in Series.



Single 1N5239B Zener Diode   2 Zener Diodes in Series, 1N5239B

Figure 4-17. 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 2800 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 2800 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 2800 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 2800 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 4-18 shows the relationship between type of material and circuit symbol for a PNP and an NPN transistor.

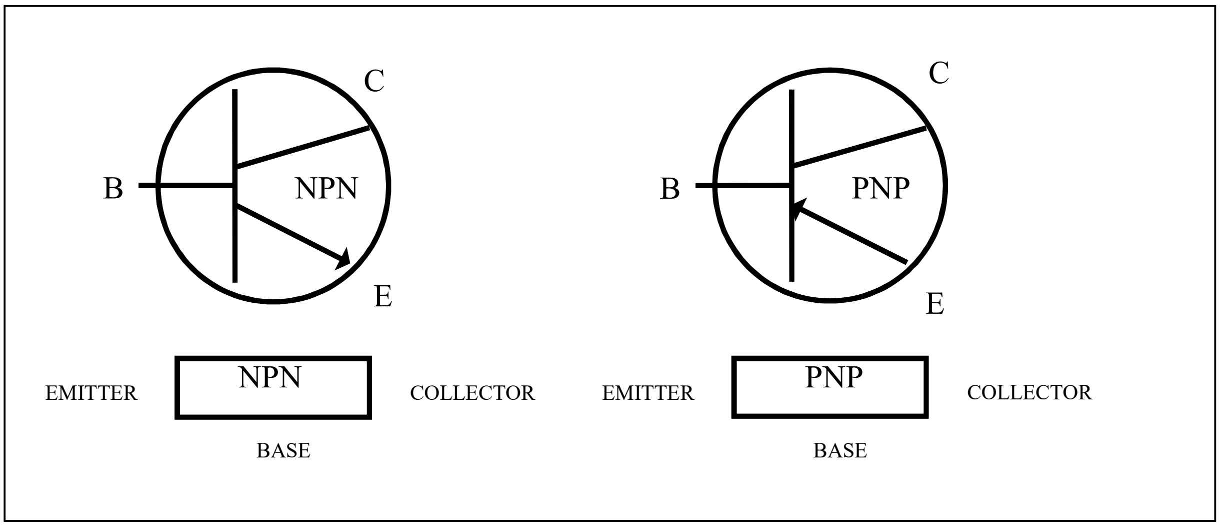


Figure 4-18. Diagram of an NPN and PNP Bipolar Transistor.

IMPORTANT NOTE

Use of this instrument may alter the current gain (h_{FE} or ß) of a bipolar transistor whenever the emitter is tested. Either the base-emitter or collector-emitter test circuits satisfy this criterion. While heating of the device due to the current produced by the instrument may cause a temporary change in h_{FE} (most noticeable in the low range), a permanent shift in h_{FE} may occur whenever the base-emitter junction is forced into reverse breakdown (~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.
3. Identify the base, emitter and collector pins of the device and then test the collector-base junction to determine whether it is an NPN or PNP. Since the emitter is not tested there will be no effect on h_{FE} regardless of the selected voltage.

Bipolar Transistor Signatures

In order to better understand the signatures that transistors create on the Tracker 2800, we can model these devices in terms of equivalent diode circuits. These are shown in figure 4-19. 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.

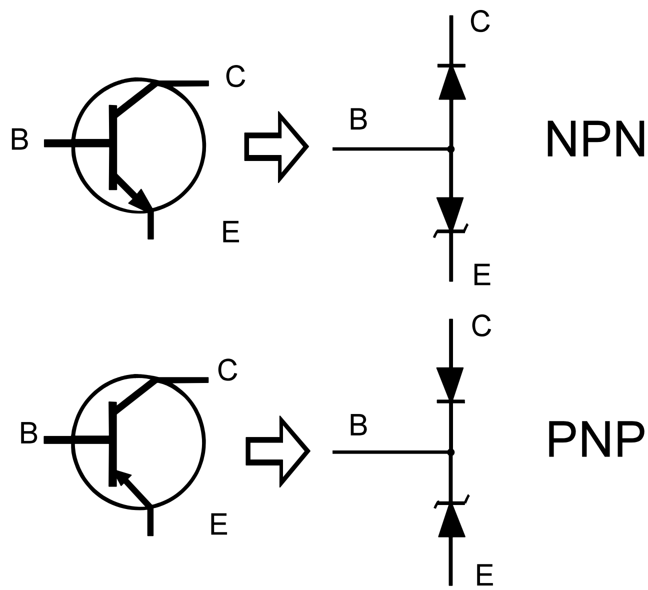
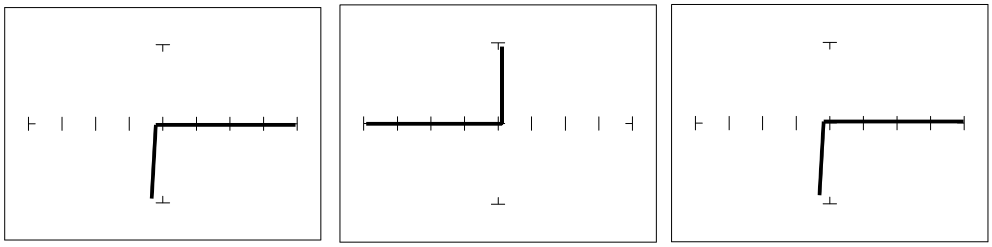


Figure 4-19. NPN and PNP Bipolar Transistor Equivalent Circuits

Bipolar Transistor Base-Collector Signatures

Do the following to display the analog signatures of a bipolar transistor:

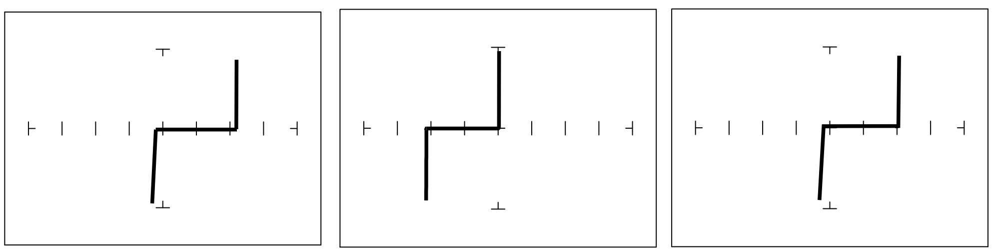
1. Select the 1KΩ and 15V.
2. Place or clip the red test lead from the Tracker 2800's Channel A jack to collector lead of the transistor.
3. Place or clip the black test lead from the Tracker 2800's Common jack to base lead of the transistor.



Diode 1N914 PNP 2N3906 NPN PN2222A

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

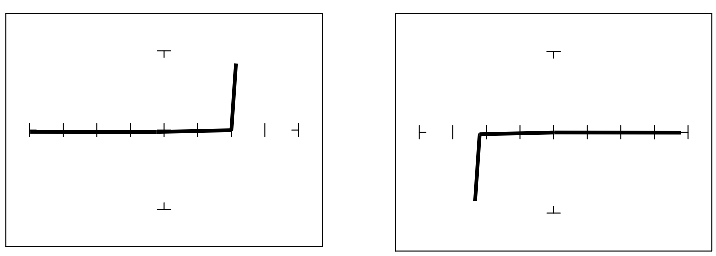
Notice that the collector-base signature of a NPN transistor is identical to the signature of diode. The collector-base signature of a PNP transistor, which has opposite polarity from a NPN, looks similar to a diode with its polarity reversed. These are the signatures we expected from our circuit modeling. We can do the same kind of comparison with the emitter-base circuits.



Zener Diode 1N5239B PNP 2N3906 NPN PN2222A

Figure 4-21. 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.



PNP Transistor - 2N3906 NPN Transistor - PN2222A

Figure 4-22. 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 2800 makes this a relatively simple procedure because each type of junction has a characteristic signature. This makes it possible to identify each of the terminals and the polarity of the transistor.

Do the following:

1. Select 20V, 10KΩ and 60Hz.
2. Probe pin 1 with the red probe and pin 2 with the black probe.
3. Identify the signature.

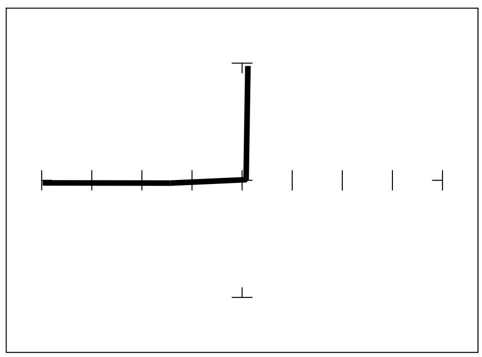


Figure 4-23. Signature of Pins 1 And 2 of an Unknown Transistor.

4. 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?
5. Probe pin 3 with the red probe and pin 2 with the black probe.
6. Identify the signature.
7. This looks like a collector-emitter signature.

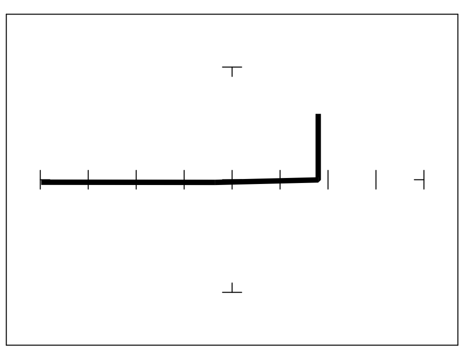


Figure 4-24. Signature of Pins 3 and 2 of an Unknown Transistor.

8. 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.

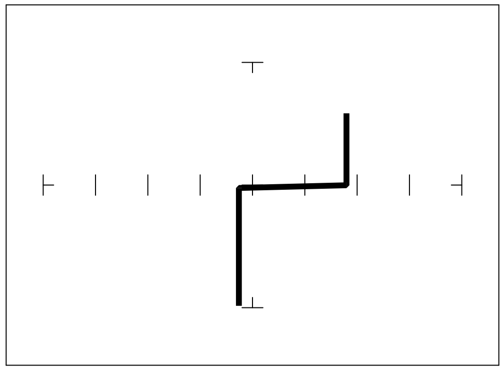


Figure 4-25. Signature of Pins 1 and 3 of an Unknown Transistor.

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.

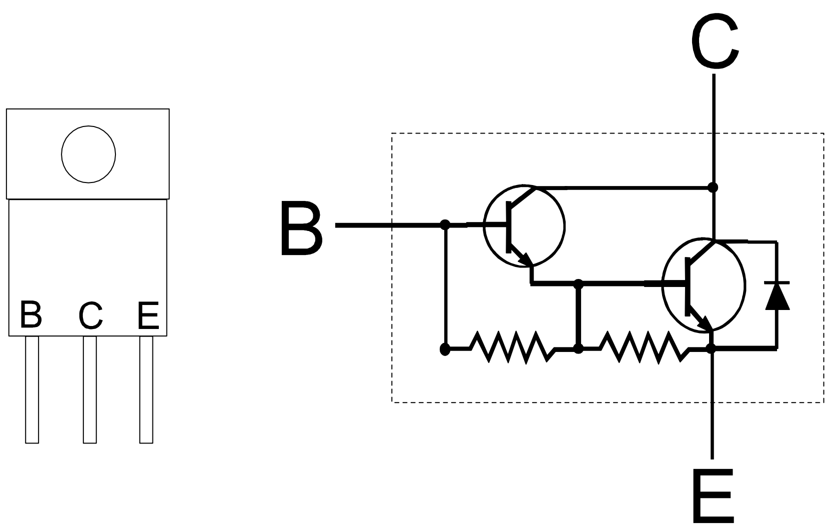
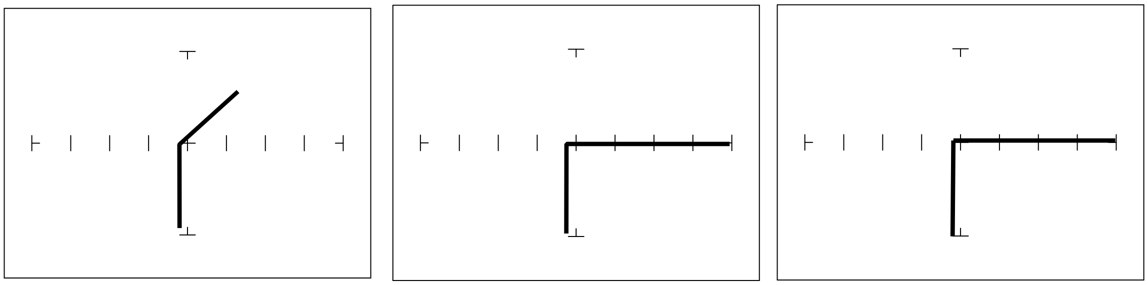


Figure 4-26. Diagram of a Darlington Transistor.



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

Figure 4-27. Signature of a Darlington Transistor, TIP112 NPN Type at 20V and 20KΩ.

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 2800 can be used to determine the type of transistor; bipolar, Darlington, FET, etc.
- The Tracker 2800 can be used to identify the polarity of a transistor (PNP or NPN).
- The Tracker 2800 can be used to determine the base, collector and emitter on an unknown transistor.
- The Tracker 2800 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

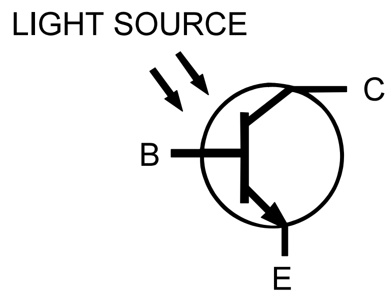
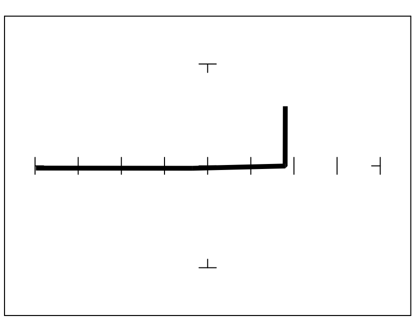
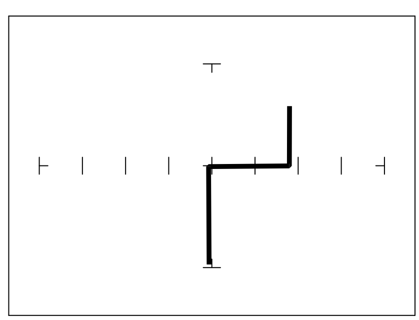


Figure 4-28. Phototransistor Schematic Diagram.

Do the following to display the analog signature of a phototransistor:

1. Select the 1KΩ and 15V.
2. Place or clip the red test lead from the Tracker 2800's Channel A jack to collector lead of the component.
3. Place or clip the black test lead from the Tracker 2800's Common jack to emitter lead of the component.
4. Observe the signature of the phototransistor
5. Direct a light source at the phototransistor and observe the signature change.





MRD3056 With No Light MRD3056 With Light

Figure 4-29. Signatures of a NPN C-E Junction Phototransistor at 15V and 1KΩ.

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).

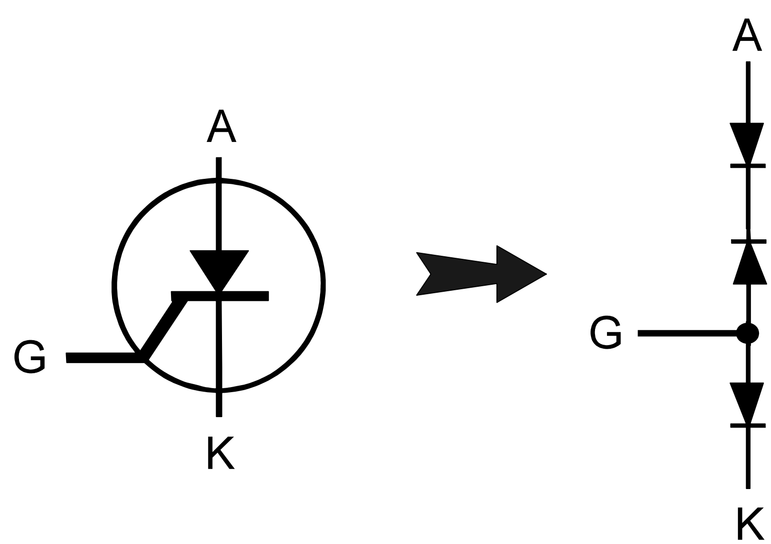
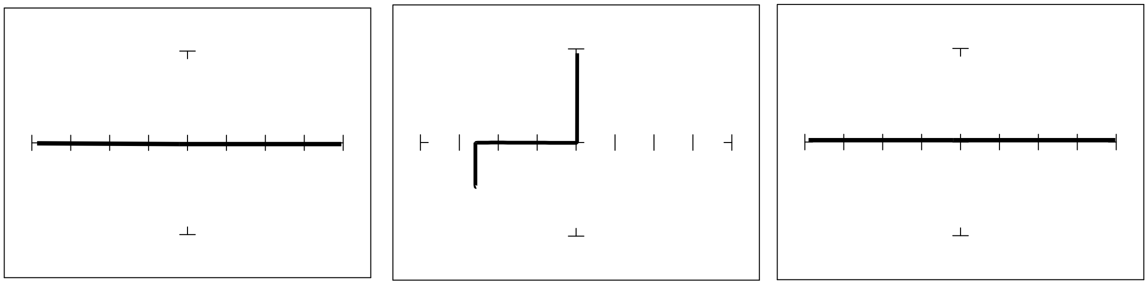


Figure 4-30. Diagram of a Silicon Controlled Rectifier.

Do the following to display the analog signature of a SCR:

1. Select the 20V, 10KΩ and 60Hz.
2. Place or clip the red test probe from the Tracker 2800's Channel A jack to gate lead (G) of the component.
3. Observe the gate-anode signature of the SCR.
4. Move the black test probe from the SCR's anode lead to cathode lead (K) of the component.
5. Observe the gate-cathode signature of the SCR.

6. Place the red test probe to the SCR's anode lead and the black test probe to the SCR's cathode lead.
7. Observe the SCR's anode-gate signature.



Gate-Anode Gate-Cathode Anode-Cathode

Figure 4-31. Signatures of a SCR - C106B Type at 20V and 10KΩ.

8. Connect the Tracker 2800 DC Voltage Source to the Gate. Increase the DC Voltage Source level while observing the anode-cathode signature.

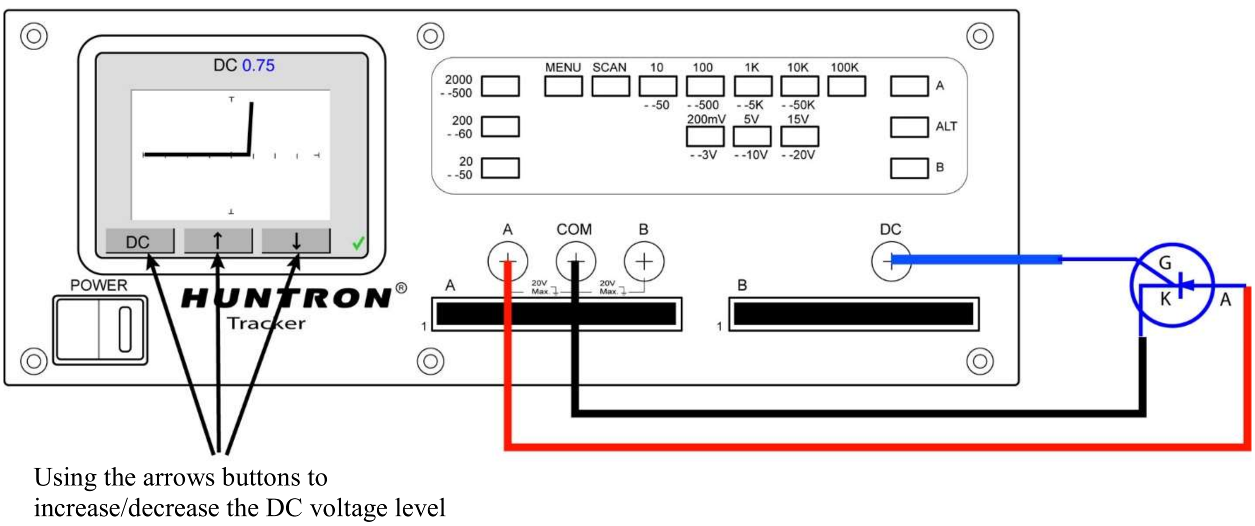


Figure 4-32. Testing a SCR using the DC Voltage Source

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 2800 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 kΩ to 25 kΩ with a typical value of 20 kΩ. ESD exposure can cause internal flaws such as resistance, opens and shorts.
- Dendrites - A process flaw, that results in particles growing between conductors on a substrate causing shorts.
- Ionic - Contamination introduced at the time of manufacturing that contamination develops into leakage between substrate channels. This causes 5 kΩ to 25 kΩ of resistance.
- Purple Plague - Destructive interaction between gold and aluminum metal layers. Junction connections become very brittle and may cause internal opens.
- Corrosion or 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.

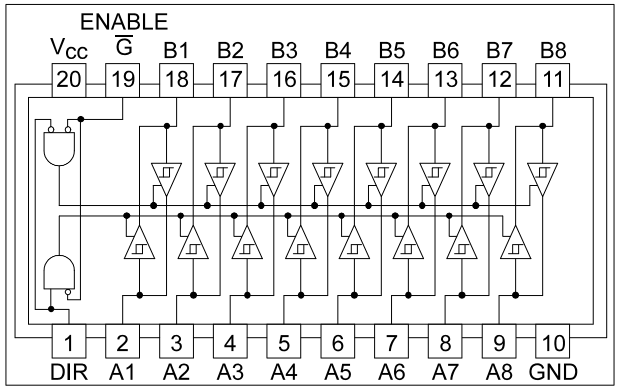


Figure 5-1. Digital IC 74LS245 Block Diagram.

- 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.

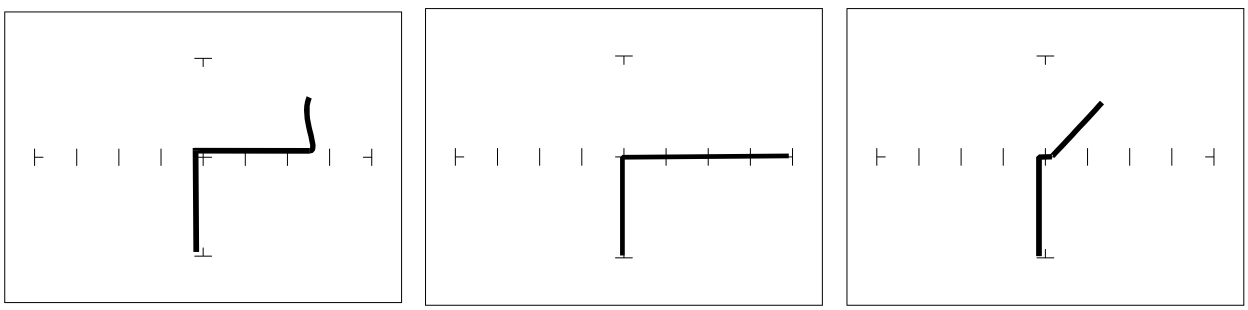
Each circuit type will produce a different analog signature. Because there are only four types of circuits on the chip, there will be only four unique analog signatures when out of circuit.

Signatures of a Digital IC

Do the following to display the analog signatures of a digital IC (out of circuit):

1. Select the 5V, 10KΩ, 200Hz Range.
2. Place or clip the black test lead from the Tracker 2800's Common jack to the IC's ground pin. For this example, the ground pin of the 74LS245 is pin 10.
3. Use the red test lead from the Tracker 2800's Channel A jack. Probe each pin of the IC and view its signature on Tracker 2800's signature display. For this example, pins 2 to 9 and 11 to 18 are all buffer circuits so they will have identical signatures. (Note: This is only for ICs out of circuit.)

4. Use the red test lead from the Tracker 2800's Signal jack. Probe the enable input pins of the IC and view their signatures on the signature display. For this example, the enable pins of the 74LS245 are pin 1 and 19 and will have the same signatures. (Note: This is only for ICs out of circuit.)
5. Change the range to 10V, 100Ω, 200Hz. Use the red test lead from the Tracker 2800's Signal jack. Probe the power supply V_{CC} input pin and view its signature on the signature display. For this example, the V_{CC} pin of the 74LS245 is pin 20.



Buffer pins	Enable pins	V_{CC} Power pin
20V, 10KΩ, 200Hz	20V, 10KΩ, 200Hz	10V, 100Ω, 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 2800.

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

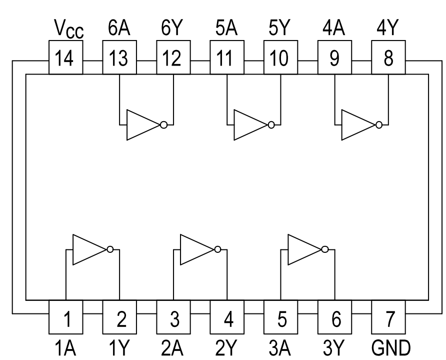
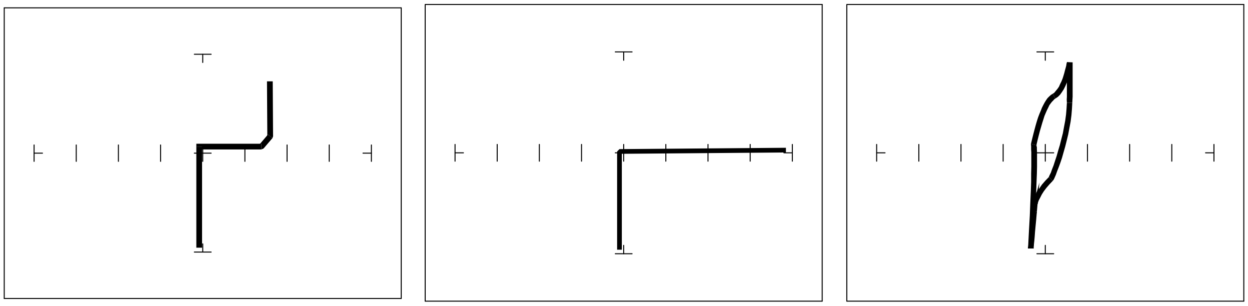


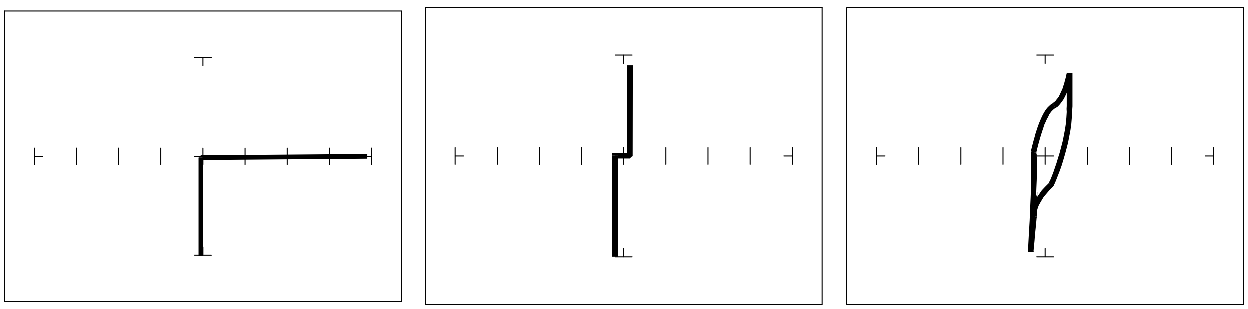
Figure 5-3. Diagram of 7404 & 74LS04.



Pin 1 input | Pin 2 output | Pin 14 power

20V, 10KΩ, 200Hz | 20V, 10KΩ, 200Hz | 10V, 100Ω, 200Hz

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



Pin 1 input | Pin 2 output | Pin 14 power

20V, 10KΩ, 200Hz | 20V, 10KΩ, 200Hz | 10V, 100Ω, 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.

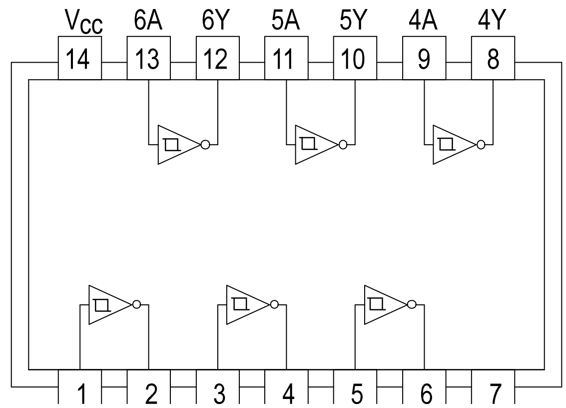
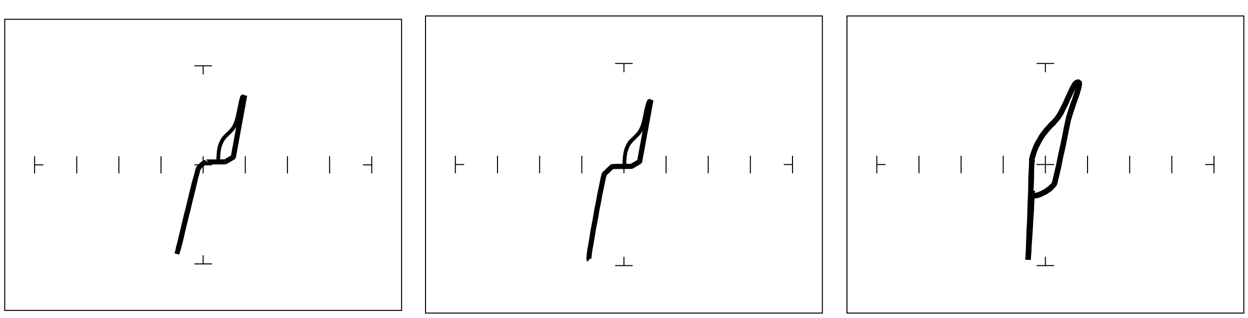


Figure 5-6. 74HC14 Block Diagram.

Do the following to display the analog signatures of a digital IC:

1. Select the 50Ω and 10V, 60 Hz range.
2. Place or clip the black test lead from the Tracker 2800's Common jack to the IC's ground pin. For this example, the ground pin of the 74HC14 is pin 7.
3. Use the red test lead from the Tracker 2800's Signal jack and probe each pin of the IC. For this example, pins 1, 3, 5, 9, 11, and 13 are all input buffer circuits so they will have identical signatures. (Note: This is only for ICs out of circuit.)
4. Similarly, use the red test lead and probe the output buffer pins 2, 4, 6, 8, 10, and 12. These pins will have the same signatures. (Note: This is only for ICs out of circuit.)
5. Use the red test lead from the Tracker 2800's Signal jack and probe the power supply V_{CC} input pin. For this example, the V_{CC} pin of the 74HC14 is pin 14.

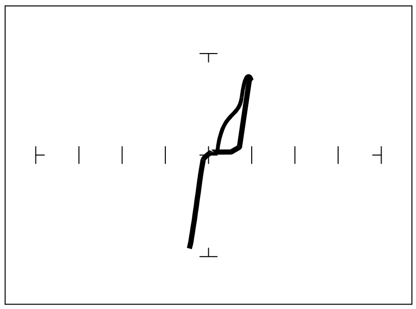


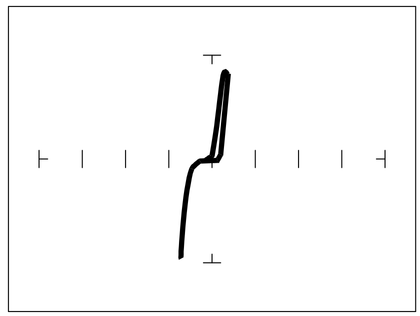
Pin 1 – Input   Pin 2- Output   Pin 14 - V_{CC}

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 2800. Capacitance in CMOS circuitry may be emphasized or de-emphasized by changing the frequency of the test signal.





F_S = 20 Hz F_S = 400 Hz

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 2800'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 50Ω, 10V and 60 HZ range
2. Place or connect the black or blue ground clip lead from the Tracker 2800'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 2800'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 2800 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 2800. 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.

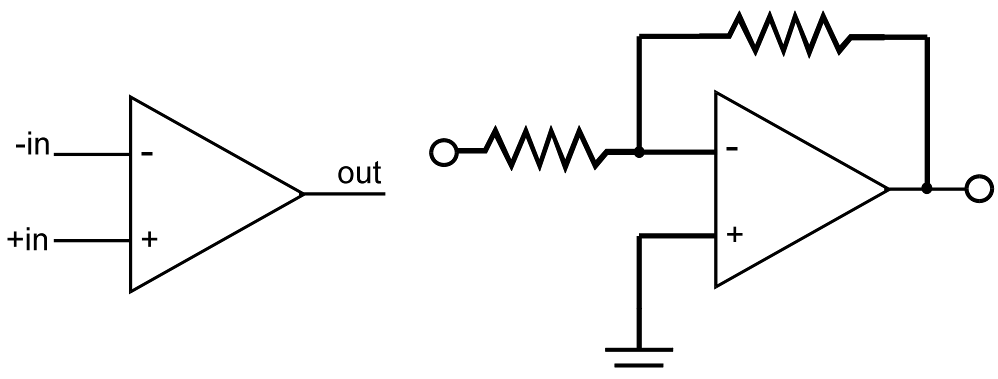


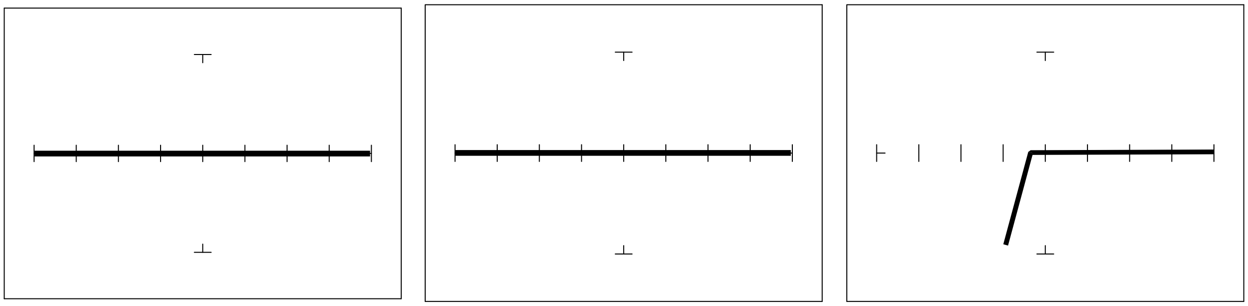
Figure 5-9. Op Amp Symbol and Schematic Diagram of an Inverter Circuit.

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

OP Amp Signatures

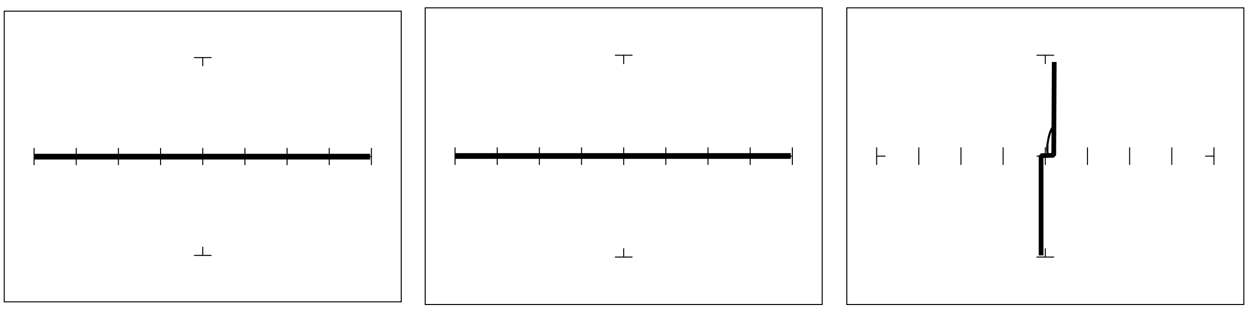
Do the following to display the analog signatures of an op amp:

1. Select the 1KΩ, 15V, 60Hz.
2. Place or clip the black test lead from the Tracker 2800's Common jack to the IC's ground or a power supply pin. For this example, the negative power supply pin of the 741 is pin 4 and the positive power supply is pin 8.
3. Use the red test lead from the Tracker 2800's Signal jack and probe each pin of the IC.
4. Observe that the signatures of each of the op amp's pins are unique.



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 2800 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 2800'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.

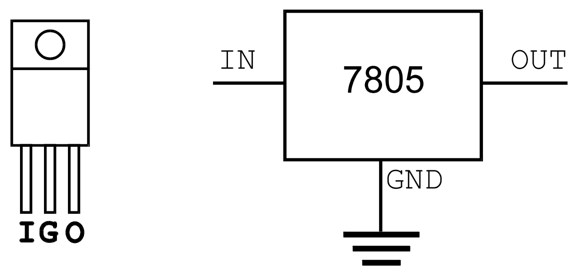
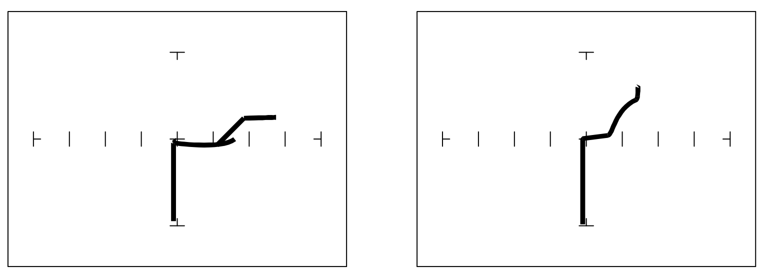


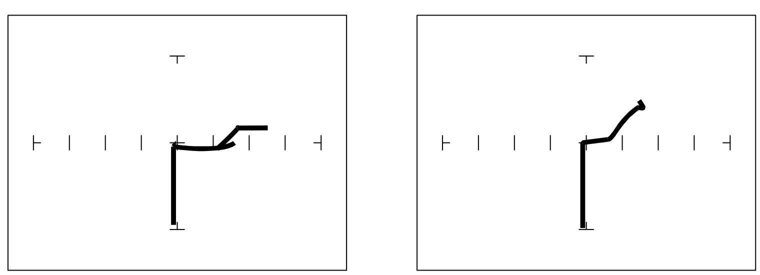
Figure 5-12. Diagram and Symbol of a Linear Voltage Regulator, 7805 Type



Input pin Output pin

15V, 1KΩ, 200Hz with Ground Pin to Common

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



Input Output pin

15V, 1KΩ, 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 2800 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.

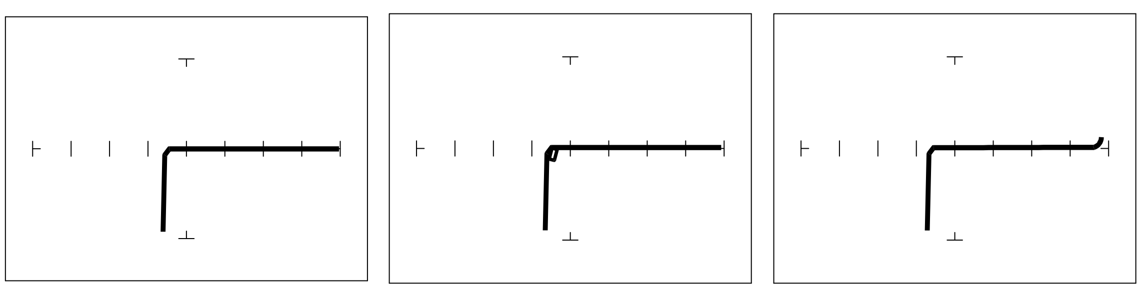
5-3. LOW VOLTAGE

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, 10KΩ and 60Hz.
2. Place or clip the black test lead from the Tracker 2800'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 2800'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 2800'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.



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

3V, 10KΩ, 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 is 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 2800 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.