HUNTRON
Access Explore Discover

Tracker Model 30
User's Manual

P/N 21-2562

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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 Model 30 instrument.

Huntron warrants that the Huntron Tracker Model 30 hardware shall be free from defects in material and workmanship for one (1) year from the date of purchase.

Huntron warrants that the CD containing the Huntron Workstation for Windows software shall be free from defects in material and workmanship for one (1) year from the date of purchase. Huntron further warrants that the software will perform in substantial conformance with the system specifications of the Huntron Tracker Model 30 at the time of purchase and for the period of one (1) year thereafter.

The above warranties are in lieu of all other warranties, express or implied, including all warranties of merchantability and/or fitness for a particular purpose. Huntron's liability under these warranties, including any damages sustained by the customer through malfunction or failure of the Huntron software, shall not exceed the amount of the purchase price of the Huntron Tracker Model 30, 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.

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Section 1. Introduction

1-1 What is a Tracker Model 30?

A Huntron Tracker Model 30 is a troubleshooting instrument that connects to a PC USB port. Throughout this manual it will be referred to as the Model 30. 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 stored and displayed for comparisons to known good signatures of a good circuit card or electronic component. This comparison allows you to troubleshoot circuit cards and electronic components without applying external power or requiring circuit cards to "boot 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 Model 30 and its related software application implement the ASA technique of troubleshooting.

The built-in current limited stimulus sine-wave of the Model 30 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.

The Huntron Workstation software graphically displays the Model 30 analog signature when connected to two terminals of a component for visual interpretation. 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 Model 30 front panel test terminals directly to the circuit card or component that you are testing. Or you can automate the test process by connecting the Model 30 to a Huntron Access Prober which automatically moves a test probe over designated test points on a circuit card. The Model 30 can be connected to a Huntron Scanner II (Model 30s) or Huntron Scanner (Model 31s). These scanners can be connected to boards under test via IC clip cables, custom cabling or bed-of-nails fixtures.

1-2 Specifications

Electrical (Note: Test Signal is a sine wave.) Specifications subject to change without notice	
Open Circuit Voltage (Vs):	
24 selections of peak voltage:	200mV, 400mV, 600mV, 800mV, 1V to 20V in 1V steps including 10V (Low), 15V (Med 1), 20V (Med 2)
Source Resistance (Rs):	
16 selections of resistance:	10Ω, 20Ω, 50Ω, 100Ω, 200Ω, 500Ω, 1kΩ, 2kΩ, 5kΩ, 10kΩ, 20kΩ, 50kΩ, 100kΩ, 54kΩ (Low), 1.2kΩ (Med 1), 26.7kΩ (Med 2)
Short circuit current (Vs divided by Rs)	
Maximum	200 mApk
Frequency (fs):	
40 selections of frequency:	20Hz to 190Hz in 10Hz steps; 200Hz to 1.9kHz in 100Hz steps; 2kHz to 5kHz in 1kHz steps
Channels	
Number	2
Connections	BNC and Banana (Channel A, Common, Channel B)
Overvoltage Protection	Circuit breaker
Auxillary Connection	9 pin mini jack with ground, Trigger IN, Trigger OUT, Calibration TP, Sine wave zero-crossing, Signal ON, Line IN and Line OUT
Scanner Connection	DB15 to Scanner II (Model 30s) or Scanner (Model 31s)
GENERAL	
PC Requirements	One USB port, 1GHz CPU, 512MB RAM, Windows 2000 / XP / Vista

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	1.2" W x 1.9" H x 8.5" D(28,45cm W x 4,83cm H x 21,59cm D)
Warranty	1 year limited

Supplied Accessories

Huntron P/N	QTY	Description
06-5217	1	User's Manual CD
21-1366	1	Getting Started
98-0028	1	10K Jumper
98-0029	1	1K Jumper
98-0043	2	Test Lead Black
98-0249	1 pair	Huntron Microprobes MP20
98-0418	1	USB Cable
98-0463	1 set	Huntron Workstation 4.0 Software

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 fils de terre de protection.**

⚠ 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.

CE The Huntron Tracker Model 30 conforms to the following Standards:

EN 55011
EN 61000-3-2:2000
EN 61000-3-3:1995/A1:2001
EN 61000-4-2
EN 61000-4-3
EN 61000-4-4
EN 61000-4-5
EN 61000-4-6
EN 61000-4-11
EN 61000-6-1:2001
EN 61000-6-2:2001
EN 61000-6-3:2001
EN 61000-6-4:2001
EN 61010-1:2001 (Second Edition)

ETL

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.

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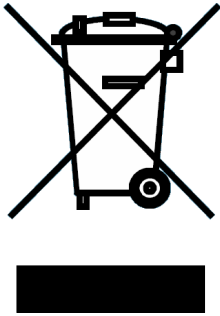
Huntron is aware of the recycling needs for Waste Electronic and Electrical Equipment (WEEE) and Restriction of certain Hazardous Substances (RoHS) and is co-operating with systems established, worldwide for the collecting and recycling of our products.

Huntron has applied the wheeled bin recycle mark (EN50419) to our products. At the present time, some European countries are not complete in their compliance with the European WEEE legislation and they do not have collective systems fully operational and registration initiated.

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. Further recycling information will be added to our website www.huntron.com as it becomes available.

Huntron products, being electronic test equipment, are classified as monitoring and control instruments and are presently exempt from the RoHS directives. We are working for total compliance to RoHS.

1-5 Huntron Workstation Software

The Huntron Workstation Software allows control of the Model 30 and uses Windows-like features to implement the troubleshooting process using ASA techniques.

Huntron Workstation Software Features

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

Section 2. Installation and Connections

2-1 Installation (Getting Started)

To set up and use your Model 30, you will need the following:

1) One set of Microprobes (Huntron MP20).

2) Huntron Workstation Software.

3) A PC.

4) This manual. (Model 30 user's manual)

5) Getting Started instructions for setting up a Model 30

Follow the Getting Started instructions for Hardware and Software installation.

2-2 Model 30 Signal connections

The Model 30 is a dual channel Instrument. The front panel BNC connectors are connections for the Huntron Access Prober. The Banana jacks on the front panel are for a set of Huntron Micro-probes. You can therefore manually probe using the Micro-probes without disconnecting the Access Prober BNC connections.

2-3 Auxiliary (AUX) connector description

The rear panel Auxiliary (**AUX**) 9 pin Din connector pins are shown below. These pins can be used for synchronizing and triggering other external Functional Test Instrumentation.
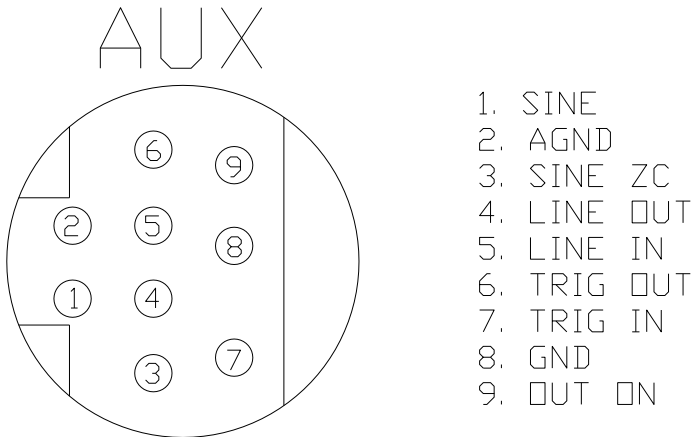

Fig 9. Rear panel 9 pin Din connector pinouts.

Pin 1: SINE. Output Sine wave synchronized with the applied sine wave signal at the BNC Signal or Banana jack Signal connector. This is used for externally verifying the internal digitizer operation.

Pin 2: AGND. Analog ground is the ground for the SINE and SINE ZC outputs.

Pin 3: SINE ZC. Output zero crossing signal for the sine wave signal of pin 1.

Pin 4: LINE OUT. The normally Low state can be driven to High state via software control for detection by external instrumentation.

Pin 5: LINE IN. The normally High state can be externally shorted to GND to drive it Low for detection by the software.

Pin 6: TRIG OUT. Similar to LINE OUT.

Pin 7: TRIG IN. Similar to LINE IN.

Pin 8: GND. Reference ground for ZC, LINE OUT, LINE IN, TRIG OUT and TRIG IN.

Pin 9: OUT ON. The normally Low state is automatically driven to High state whenever the output sine wave signals are present at the BNC or Banana connectors.
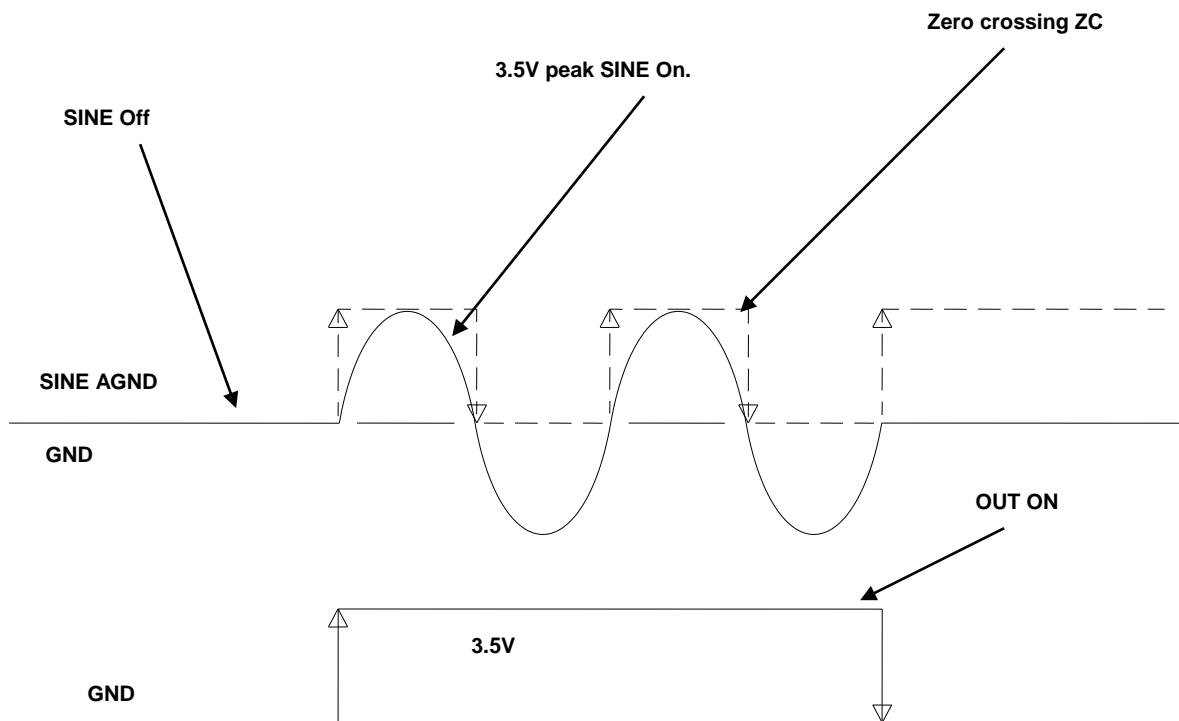
Fig 10. Signals SINE, ZC and OUT ON

2-4 Scanner connector description

The rear panel Scanner DB15 connector pins are shown below. These pins should only be used to connect to a Huntron Scanner II (Model 30s) or Huntron Scanner (Model 31s).

Pin 1: TSTCLK. Clock signal to set test relays.

Pin 2: TSTSTB. Strobe signal to set test relays.

Pin 3: COMCLK. Clock signal to set common relays.

Pin 4: COMSTB. Strobe signal to set common relays.

Pin 5: TSTDATA. Data to set test relays.

Pin 6: COMDATA. Data to set common relays.

Pin 7: OUTENB. Output Enable to turn on relays.

Pin 8: LOPBCK. Loop Back to determine if scanner is connected.

Pin 9: 5V. Power supply for the Scanner.

Pin 10: 5V. Power supply for the Scanner.

Pin 11: GND. Power supply ground for the Scanner.

Pin 12: GND. Power supply ground for the Scanner.

Pin 13: CHA. Channel A signal from the Tracker.

Pin 14: COM. Common from the Tracker.

Pin 15: CHB. Channel B from the Tracker.

SECTION 3 TESTING PASSIVE COMPONENTS

3-1. RESISTORS

Exploring how the Model 30 ranges interact with different resistance values is a good introduction on how basic ASA troubleshooting is applied.   This section will briefly familiarize you with Model 30 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 Model 30'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.
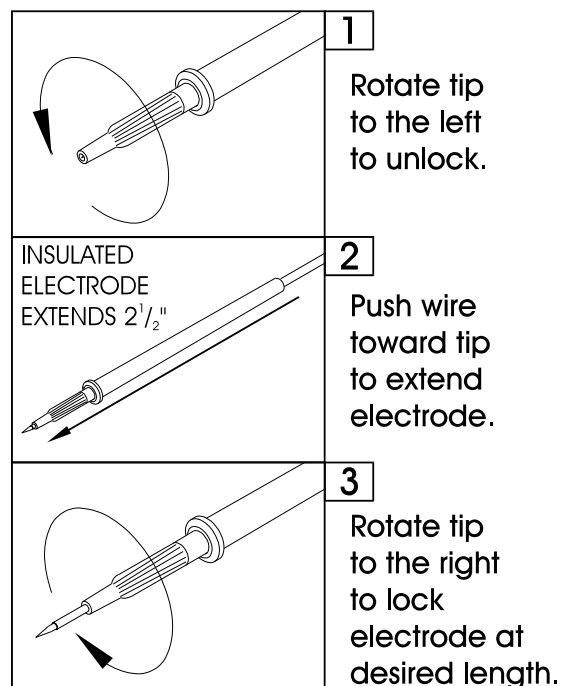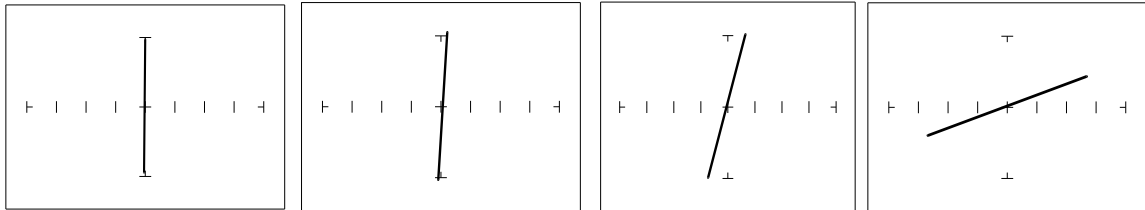
Micro Probe Adjustment:

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.
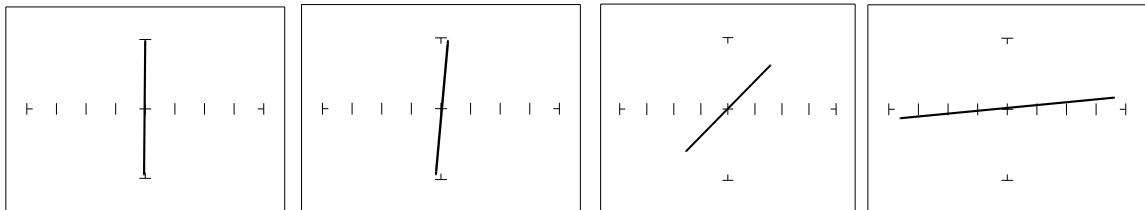

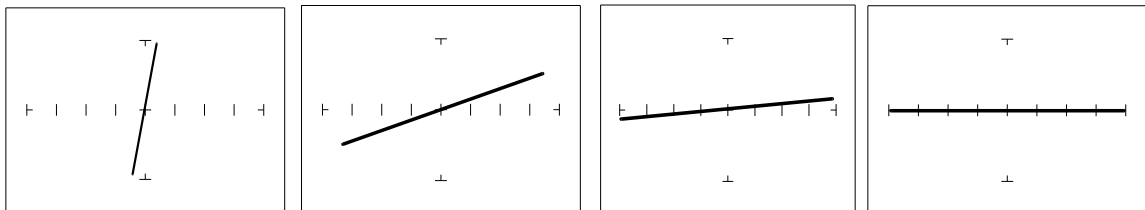| 150 Ω | 1.5 kΩ | 15 kΩ | 150 kΩ |

Vs=20V, Rs=100kΩ (Use 20V, 100K, 200Hz)

| 150 Ω | 1.5 kΩ | 15 kΩ | 150 kΩ |

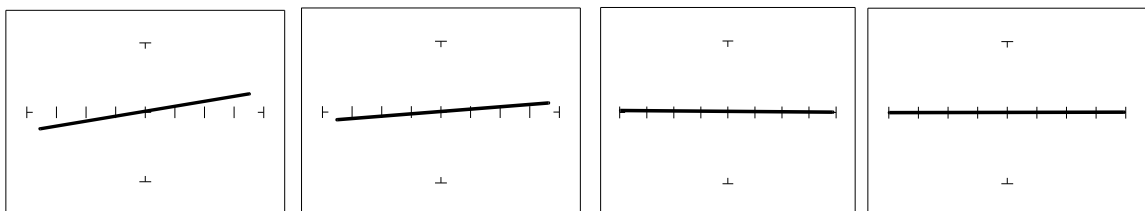**Vs=20V, Rs=27.6kΩ** (Use 20V, 20K, 200Hz)

| 150 Ω | 1.5 kΩ | 15 kΩ | 150 kΩ |

Vs=15V, Rs=1.24kΩ (Use 15V, 1K, 200Hz)

| 150 Ω | 1.5 kΩ | 15 kΩ | 150 kΩ |

Vs=10V, Rs=54Ω (Use 10V, 50, 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 Model 30 and how it affects the resistive analog signature.

The Affect 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 150 ohm resistor in the figure below as R_S varies. Note how these resistor signatures respond to changing Model 30's internal resistance.
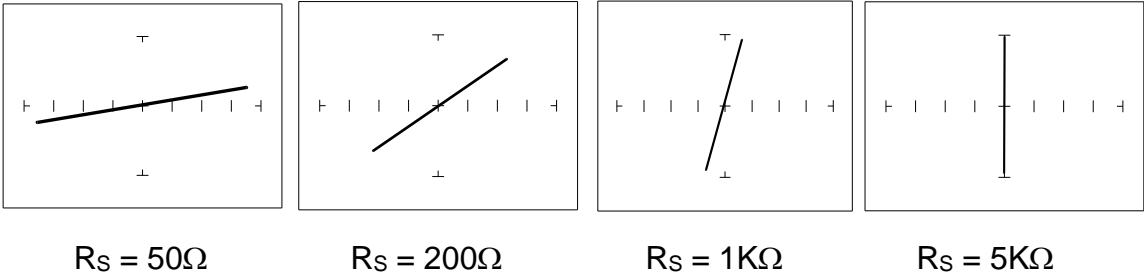

| $R_S = 50Ω$ | $R_S = 200Ω$ | $R_S = 1KΩ$ | $R_S = 5KΩ$ |

Figure 3-3. Affect Of Varying R_S On A 150 Ω Resistor Signature

The Affect of V_S on Resistor Analog Signatures.

Select the 10V, 50Ω and 200Hz. Change the voltage range to 5V, 2V and 500mV.

| $V_S = 10V$ | $V_S = 5V$ | $V_S = 2V$ | $V_S = 500mV$ |
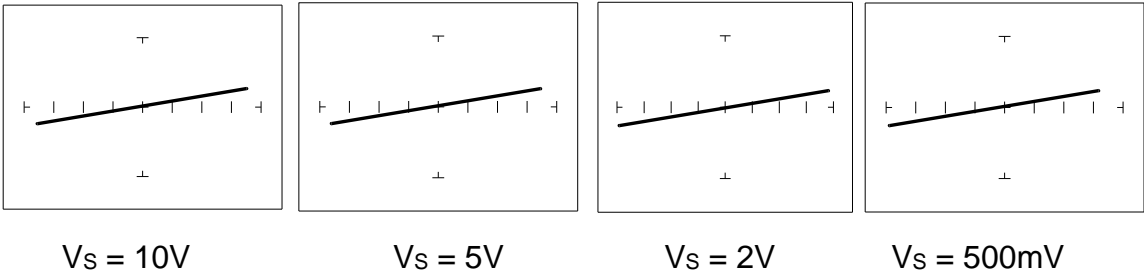
Figure 3-4. Affect Of Varying V_S On A 150 Ω Resistor Signature.

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 Model 30's STAR feature, it protects components from possible excessive power. In order to set V_S to a higher voltage, you must change R_S to a higher value first.

The Affect of F_S on Resistor Analog Signatures.

Select the 10V, 50Ω and 20Hz range. Change the Frequency to 60Hz, 1KHz and 5KHz. Observe the resistor signatures in the following figures do not change as F_S changes.

Fs = 20 Hz   **Fs = 60 Hz**   **Fs = 1KHz**   **Fs = 5KHz**

Figure 3-5. Affect Of Varying F_S On A 150 ΩResistor Signature.

SHORTS AND OPENS, RESISTOR FAULTS

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

Short   Open

Figure 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 Model 30 is a fast and efficient continuity tester, providing real time information.

- The Model 30 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 Model 30's ability to determine the approximate fault resistance value greatly enhances the troubleshooting capability if the correct value is known.

- The Model 30 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 Model 30, 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.
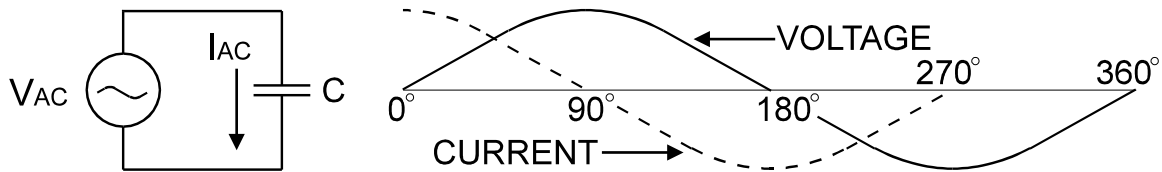
Figure 3-7. Capacitor Circuit With Test Signal's Current And Voltage Waveforms.

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 Model 30, 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 Model 30

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 Model 30 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
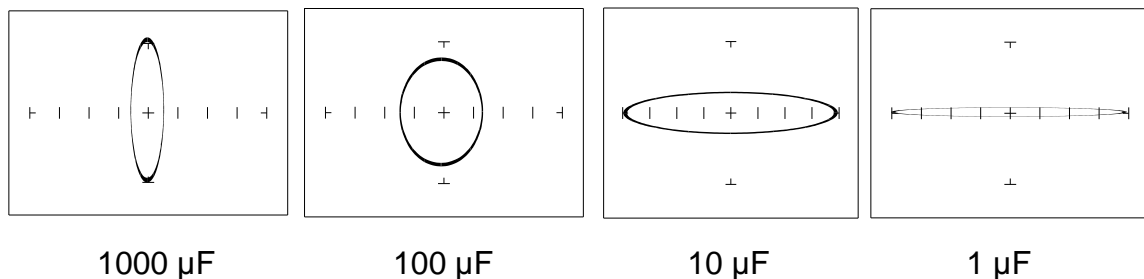
Figure 3-8. Signatures Of 4 Capacitors In 10V, 50Ω and 60Hz Range.

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.

AFFECT OF FREQUENCY (F_s) ON THE SIGNATURE OF A 10 µF CAPACITOR

Select 10V, 50Ω and 20Hz. Then select 60Hz, 500Hz and 5KHz.

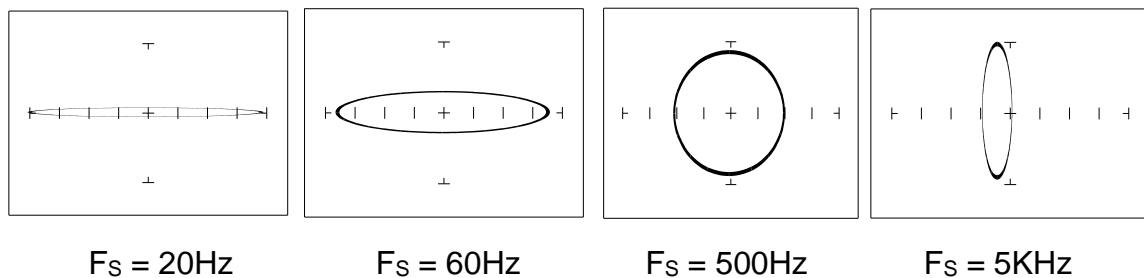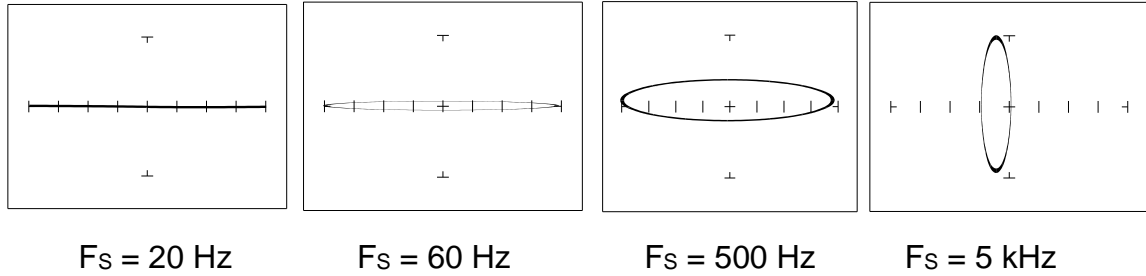| F_S = 20Hz	F_S = 60Hz	F_S = 500Hz	F_S = 5KHz

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.

AFFECT OF FREQUENCY (F_s) ON THE SIGNATURE OF A 0.1 μF CAPACITOR

Select 10V, 1KΩ and 20Hz. Then select 60Hz, 500Hz and 5KHz.

| F_S = 20 Hz | F_S = 60 Hz | F_S = 500 Hz | F_S = 5 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.

AFFECT OF VOLTAGE (V_s) ON THE SIGNATURE OF A 1 μF CAPACITOR

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

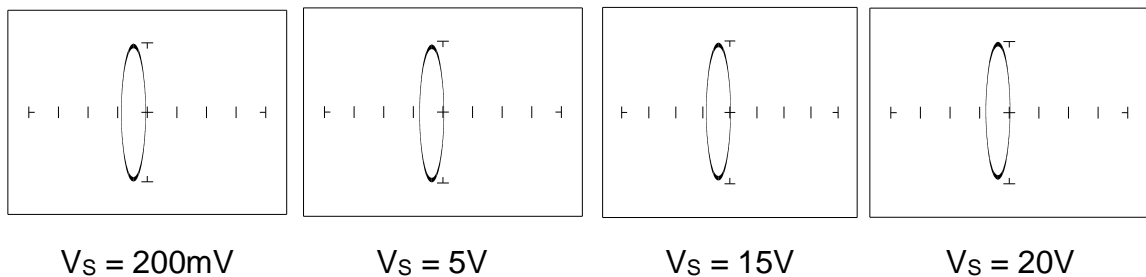| V_S = 200mV | V_S = 5V | V_S = 15V | V_S = 20V |

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.

AFFECT OF RESISTANCE (R$_s$) ON THE SIGNATURE OF A 1µF CAPACITOR

Select 15V, 1K and 60Hz. Then select 5K, 20K and 100K.

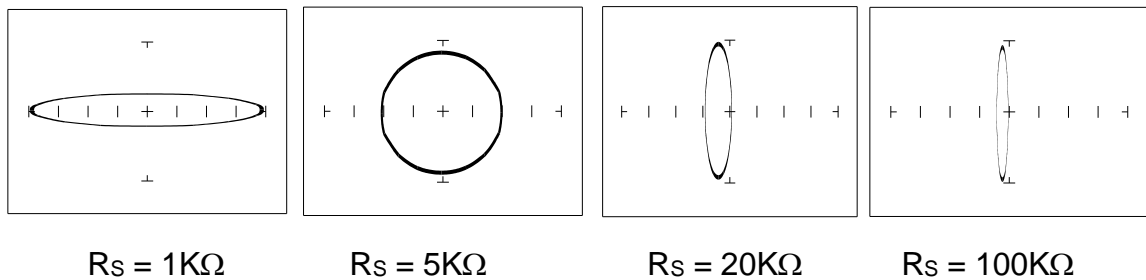| R$_S$ = 1KΩ | R$_S$ = 5KΩ | R$_S$ = 20KΩ | R$_S$ = 100KΩ |

Figure 3-12. Signatures Of A 1µF Capacitor At Different Internal Resistances.

As the Model 30'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.
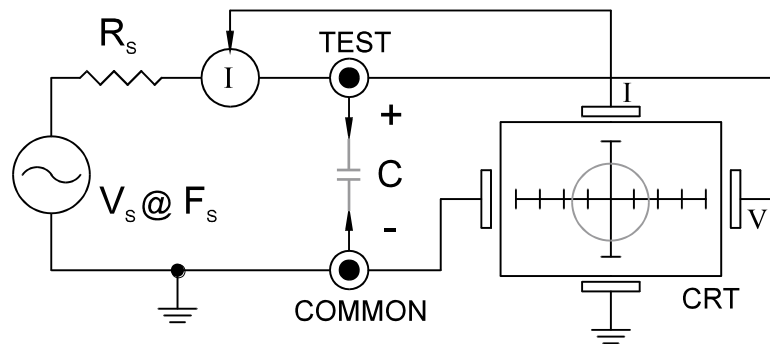
UNDERSTANDING CAPACITOR ANALOG SIGNATURES

Figure 3-13. Model 30 Core Circuit Block Diagram With A Capacitor.

The Huntron Workstation Software displays the Model 30 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. So 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 Model 30, 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 Model 30, 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
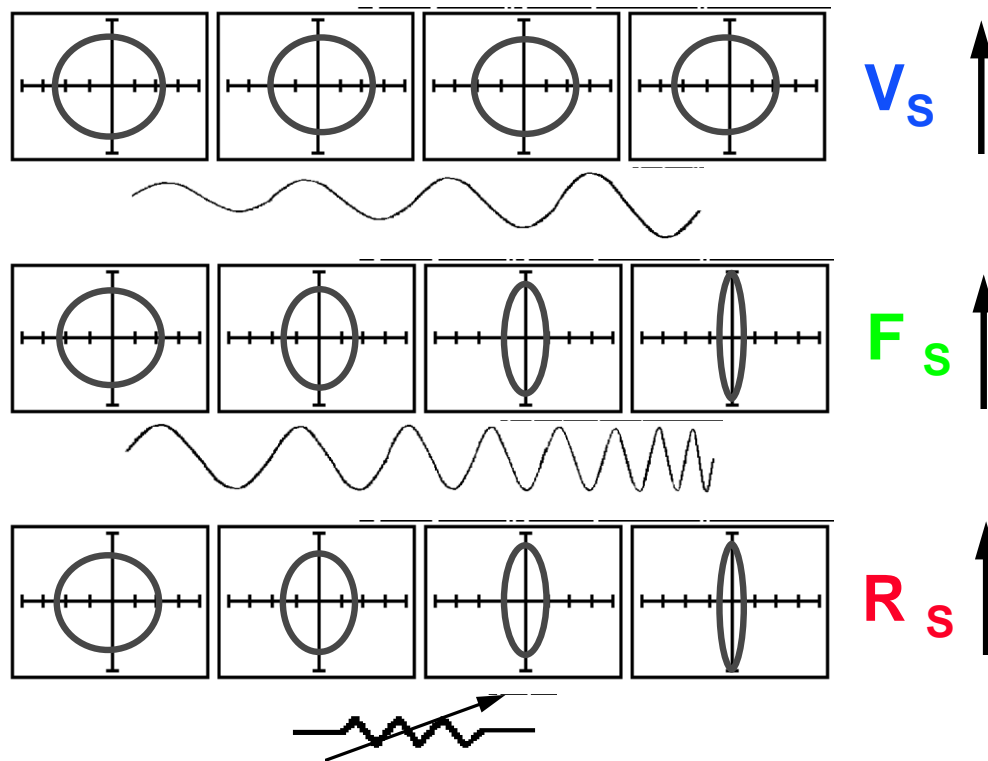
How Tracker Parameter Changes Affect Capacitive Signatures

Figure 3-14. Range Parameters Changes And Affects On Capacitive Signatures.

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

Table 3-1 shows the Model 30's limits for the minimum and maximum capacitance values it can handle.

R_S	$F_S = 20$ Hz.	$F_S = 5$ kHz
100 kΩ	0.01 μF - 1 μF	10 pF - 0.01 μF
10 Ω	20,000 μF - 100 μF	0.1 μF - 100 μF

Table 3-1. Model 30 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 analog signature. The following examples show what some capacitor leakage problems may look like in the Model 30 signature display with 50Ω, 10V and 60Hz selected.
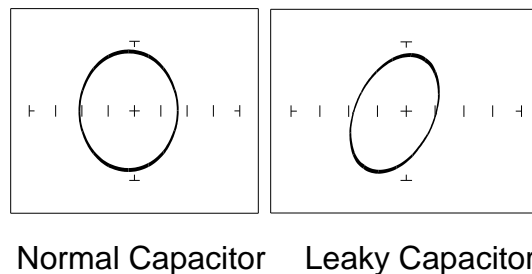

Normal Capacitor   Leaky Capacitor

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.

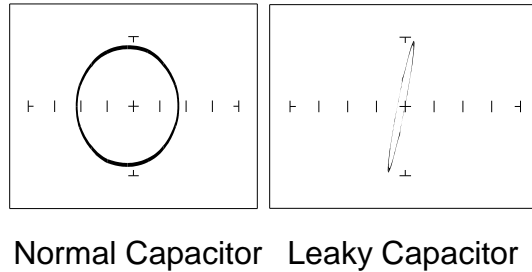Another example of capacitive leakage is shown for a 10 μF capacitor.

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 Model 30 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 Model 30 can locate defective capacitors in or out of circuit. The ranges cover 10 pF to 20,000 μF.

- When analyzing a capacitor's signature, adjust the Model 30'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 Model 30'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.

INDUCTOR ANALOG 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 Model 30

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 Model 30 signature display.

THE SIGNATURES OF DIFFERENT INDUCTORS IN 50Ω, **10V (LOW range)** and **2KHz**.

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.
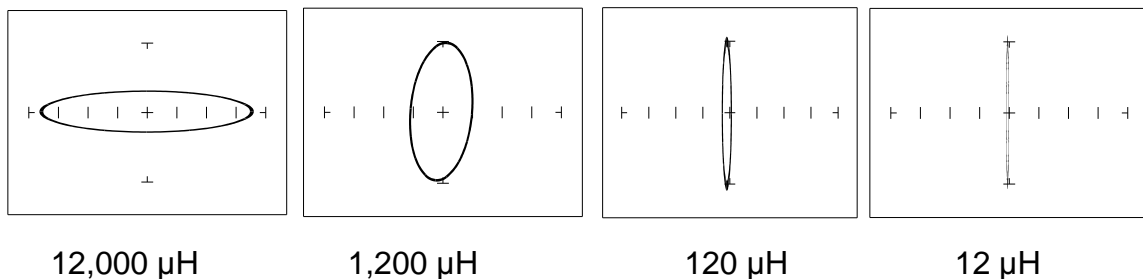

| 12,000 μH | 1,200 μH | 120 μH | 12 μH |

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.

AFFECT OF FREQUENCY F$_S$ ON INDUCTOR SIGNATURES

Select 10V, 50Ω, 60Hz. Then Select 1KHz and 5KHz.

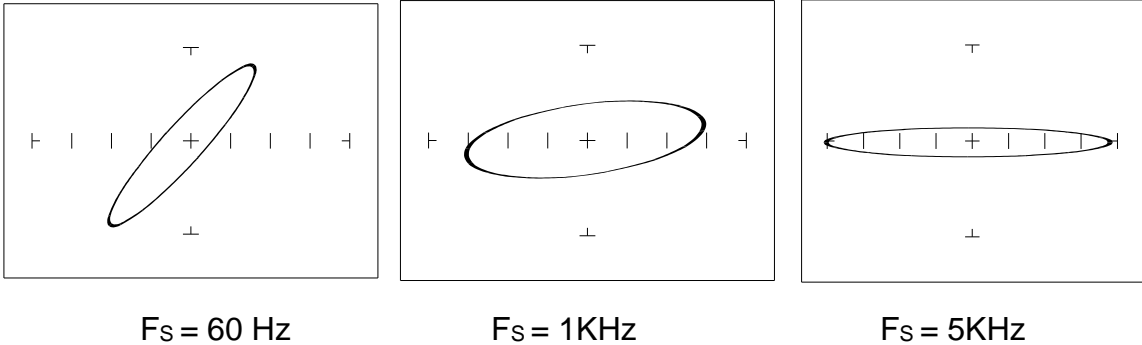F$_S$ = 60 Hz   F$_S$ = 1KHz   F$_S$ = 5KHz

Figure 3-18. Affect of Varying 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.

AFFECT OF VOLTAGE V$_S$ ON INDUCTOR SIGNATURES

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

V$_S$ = 200 mV   V$_S$ = 5 V   V$_S$ = 10 V
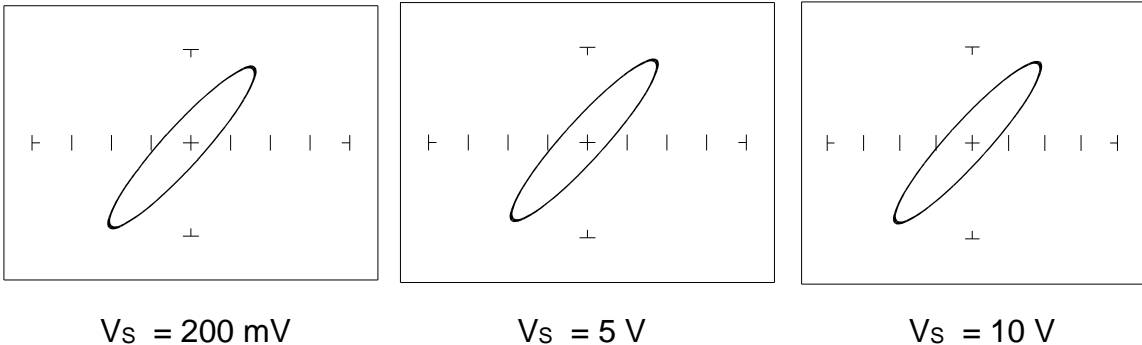
Figure 3-19. Affect Of Varying V$_S$ On 12,000 µH Inductor Signatures.

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.

25

AFFECT OF INTERNAL RESISTANCE R$_S$ ON INDUCTOR SIGNATURES

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

R$_S$ = 10 Ω   R$_S$ = 50 Ω   R$_S$ = 200 Ω
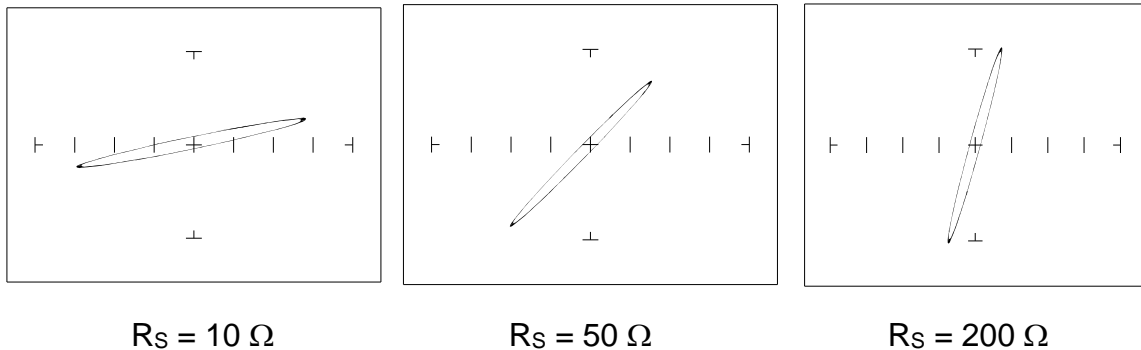
Figure 3-20. Affect Of Varying R$_S$ On 12,000 µH Inductor Signatures.

Note that the signature changes from a horizontal to a vertical position as the Model 30's internal resistance R$_S$ increases. This means the inductor's resistance can be analyzed by matching it with the Model 30's test signal resistance.

UNDERSTANDING INDUCTIVE SIGNATURES
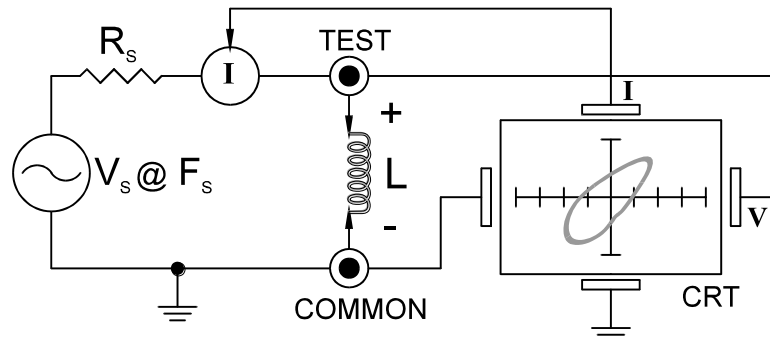
Figure 3-21. Model 30 Tracker Core Circuit Block Diagram With An Inductor.

The Model 30'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 Model 30'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 Model 30 display usually is distorted. Inductors constructed with a ferrite core makes the inductive characteristics different from those constructed without. The Model 30 responds with a unique analog signature for each inductor type.
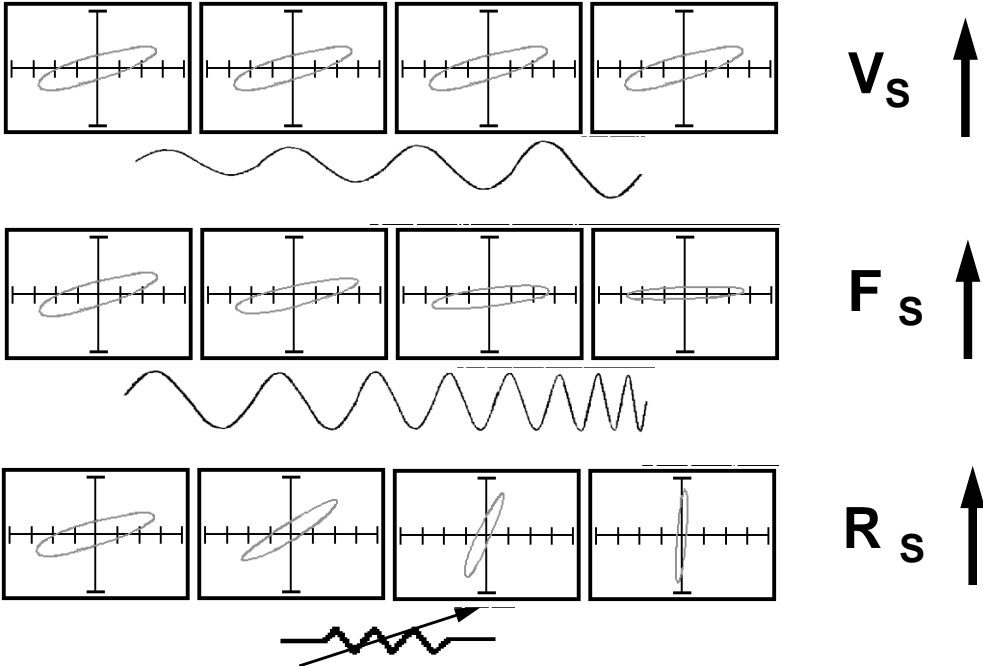
How Tracker Parameter Changes affect Inductive Signatures

Figure 3-22. Range Parameters Changes And Affects On Inductive Signatures.

R_S	F_S = 20 Hz.	F_S = 5 kHz
100 kΩ	100H – 1000H	50mH – 1000mH
10 Ω	1H – 100H	1uH – 10mH

Table 3-2. Model 30 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 Model 30 test signal's frequency is increased, the ellipse signature becomes flatter. This response is opposite to that of a capacitor.

- As the Model 30 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 Model 30 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 Model 30'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 Model 30 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 Model 30 signal in V_S = 10 V, R_S = 50 Ω, F_S = 60Hz 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 Model 30, 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 Model 30 can test the switching function of mechanically activated switches easily. Unlike the DVM that samples and gives a continuity measurement, the Model 30 displays real time activity so if a switch has noisy, resistive or intermittent operation, its analog signature on Model 30'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, $R_S = 50\Omega$, $F_S = 60$Hz range button.

2. Place or clip each test lead to the switch leads and observe its signature on the Model 30 signature display.

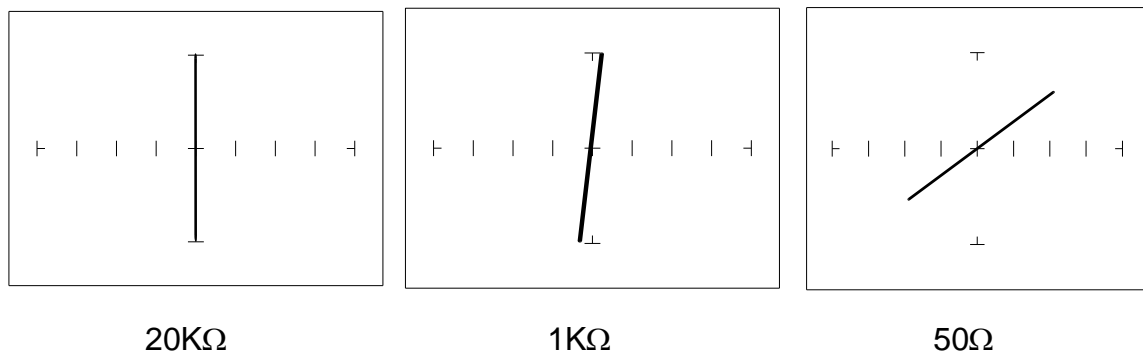3. Turn the switch to its on or off position.

| 20KΩ | 1KΩ | 50Ω |

Figure 4-23. Signatures Of A Pressed Keyboard Pushbutton Conductive Elastomer Switch.

Note that as the ranges change from 20KΩ 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 RELAYS

A relay is a switch that's activated by an electrical control input. The relay consists of switch contacts, magnets and an electromagnetic coil. The Model 30 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 = 1KHz range.

2. Connect the black test lead from Model 30's Common jack to one side the relay coil (normally, the minus lead).

3. Connect the red test lead from Model 30'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.

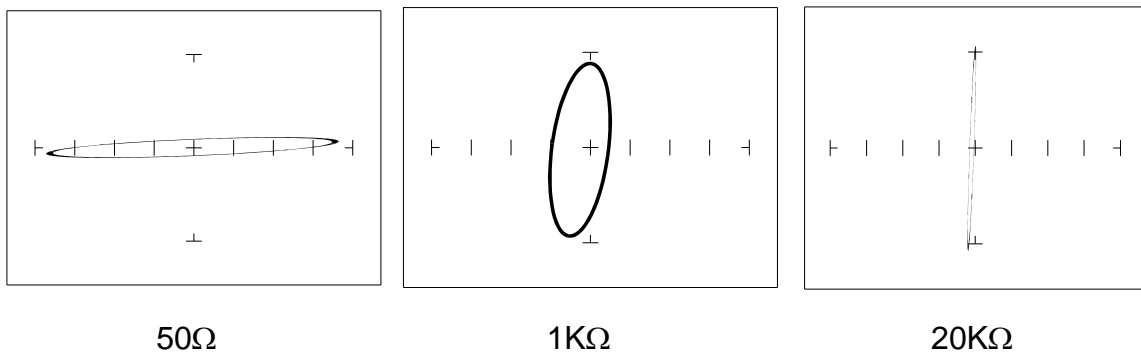| 50Ω | 1KΩ | 20KΩ |

Figure 4-24. Signatures Of A Magnetic Reed Relay Coil at 1KHz.

Note the characteristic inductive oval at 3 resistances. When applying Model 30's test signal to the coil, there may be an audible ringing sound generated from the relay under test from the switch contacts being excited.

REVIEW

- The Model 30 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 5-1 shows how the diode symbol indicates the polarity of the diode.
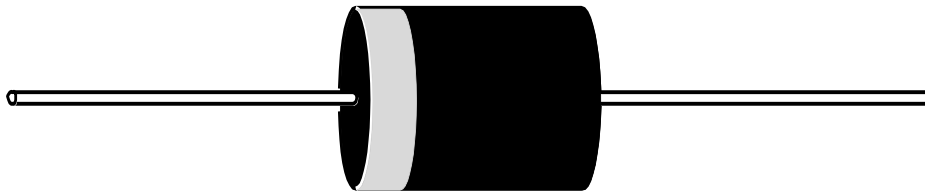
Figure 4-1. Diode And Schematic Symbol.

DIODE ANALOG 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.
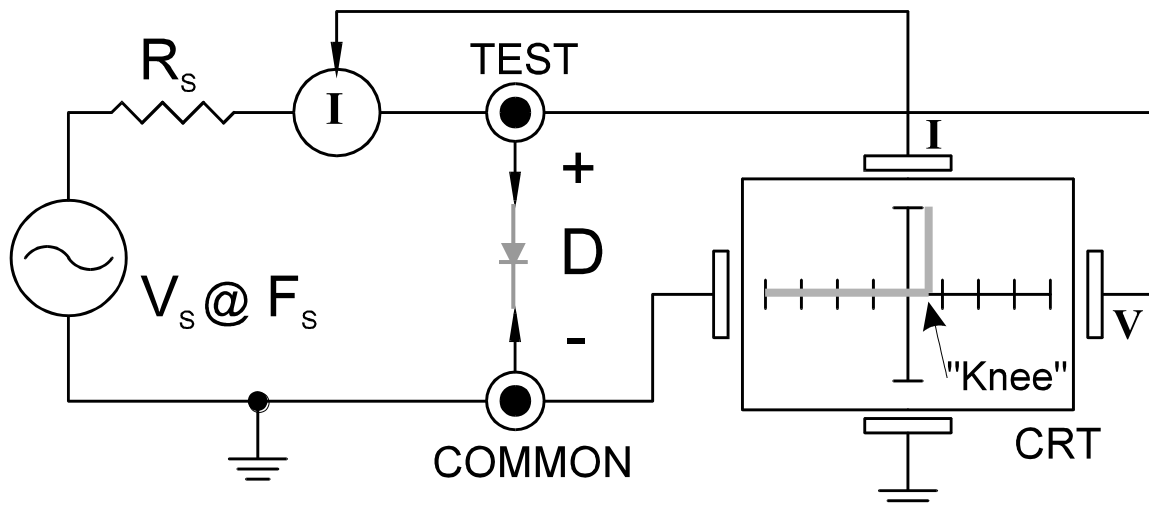
Figure 4-2. Model 30 Core Circuit Block Diagram With A Diode.

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 Model 30's Channel A jack to anode lead of the diode.

3. Place or clip the black test lead from the Model 30's Common jack to anode lead of the diode.
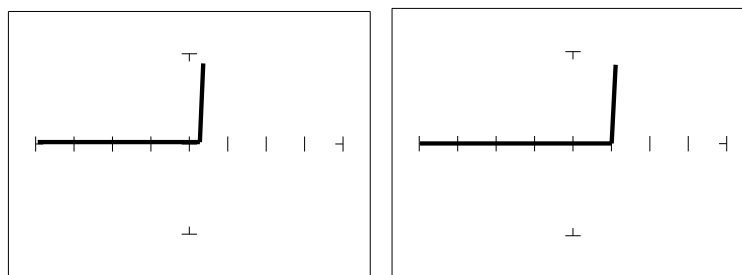
Vs = 10 Volts   Vs = 3 Volts

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.

AFFECTS OF FREQUENCY (F_S) ON THE DIODE SIGNATURE

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 5 kHz displays the signature on the right. At F_S = 5 kHz, 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.
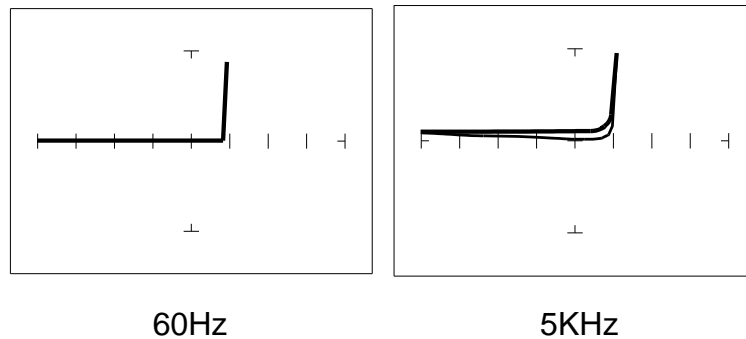

| 60Hz | 5KHz |

Figure 4-4. Signature Of A 1N914 Diode At Different Frequencies at 3V and 50Ω.

AFFECTS OF INTERNAL RESISTANCE (R_S) ON THE DIODE SIGNATURE

Changing Model 30'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.
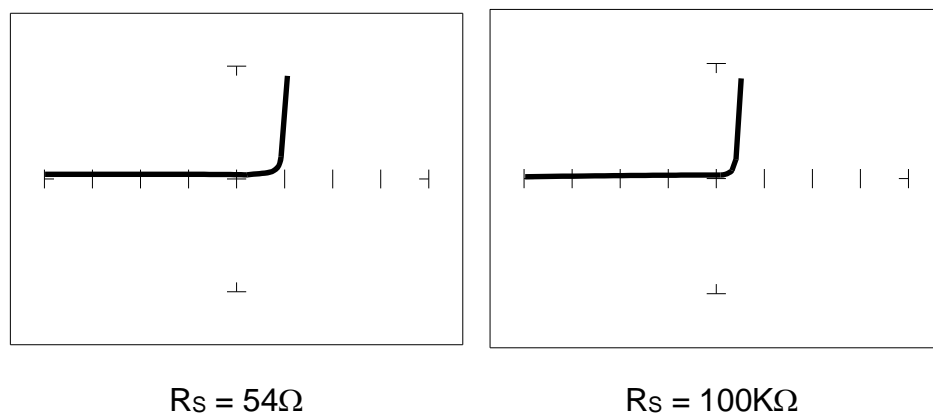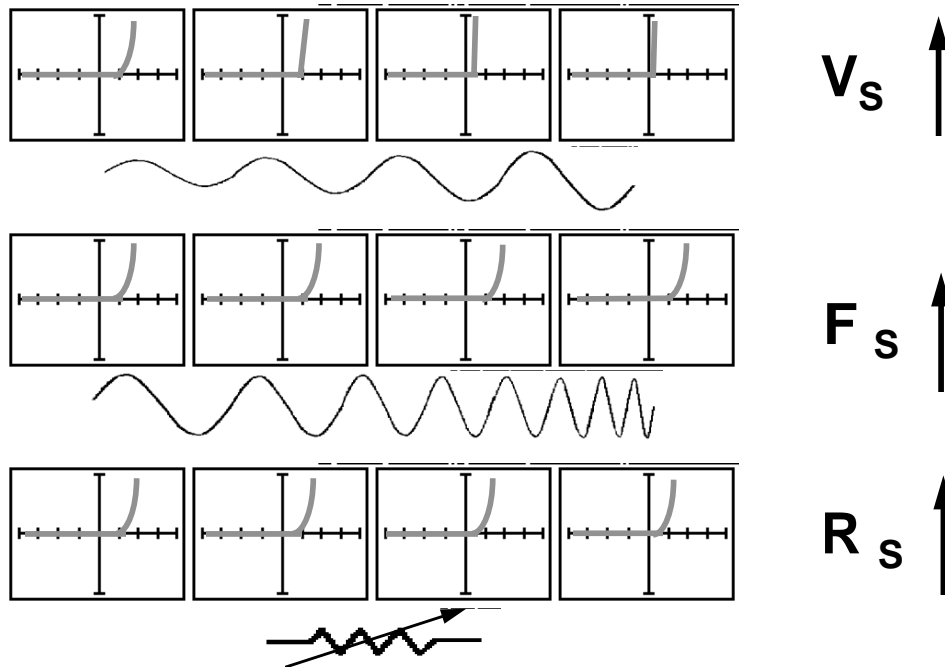

| R_S = 54Ω | R_S = 100KΩ |

Figure 4-5. Signature Of A 1N914 Diode At Different Resistances At 3V and 60Hz.

UNDERSTANDING DIODE SIGNATURES

Figure 5-6 reviews the Model 30's three range parameters and how they affect the diode signature.

How Tracker Parameter Changes affect Diode Signatures

Figure 4-6. Range Parameters Changes and Affects On Diode Signatures.

THE COMPOSITE DIODE SIGNATURE

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.

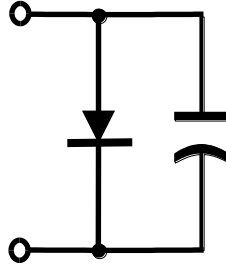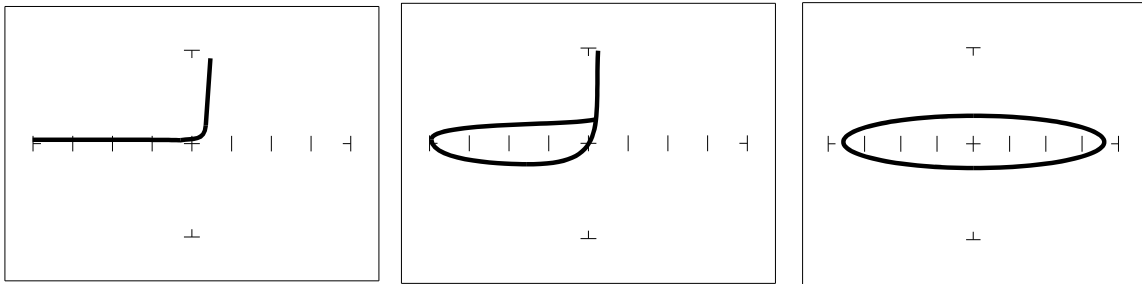This section will introduce you to some examples of composite diode signatures.

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 Model 30 has the ability to selectively display the signature of a single component.
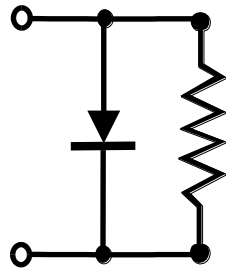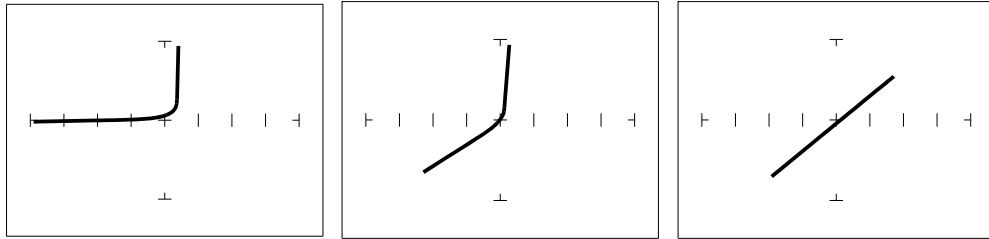

Figure 4-9. Composite Model Of A Diode And Resistor In Parallel.

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

Figure 4-10. Composite Signature - 1N914 Diode And 1.5KΩ 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 1.5 kΩ resistor. The composite signature in the center consists of the distinctive slope of the resistor and the "knee" pattern of the diode. The signature on the right shows only the resistor signature because the test signal voltage is below the diode's turn on level. Again, when multiple components are connected together, it's important to realize that the Model 30 has the ability to selectively display the signature of a single component.

DIODE FAILURES

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

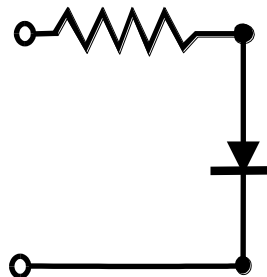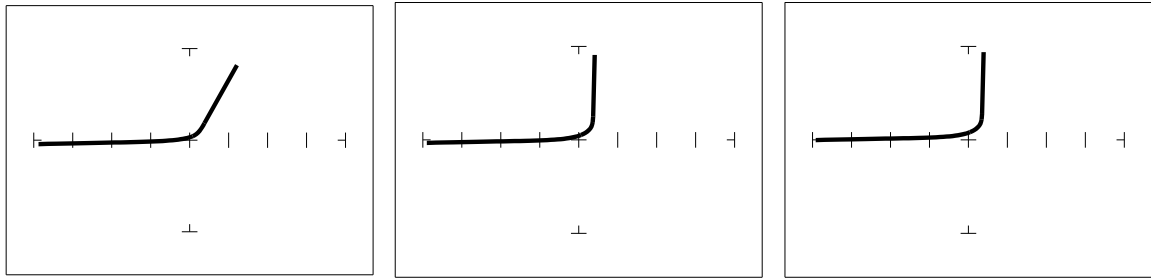## INTERNAL RESISTANCE FLAW IN A DIODE

Figure 4-11. Defective Diode Model With A Small Series Resistor.

54Ω, 10V   1KΩ, 15V   20KΩ, 20V

Figure 4-12. Defective Diode Signature With A 50 Ω Series Resistor.

The LOW 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 LOW 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.

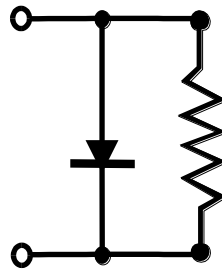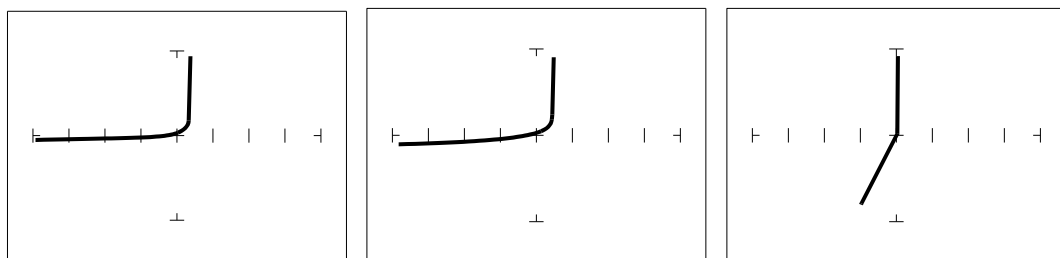**INTERNAL LEAKAGE FLAW IN A DIODE**

Figure 4-13. Defective Diode Model With An Internal Leakage Resistance.

50Ω, 10V   1KΩ, 15V   20KΩ, 20V

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 both medium 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.

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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.
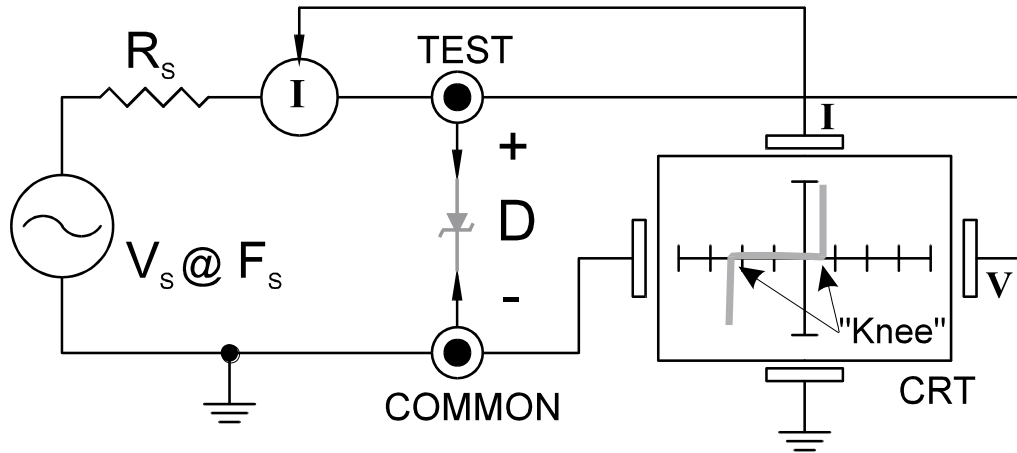

Figure 4-15. Model 30 Core Circuit Block Diagram With A Zener Diode.
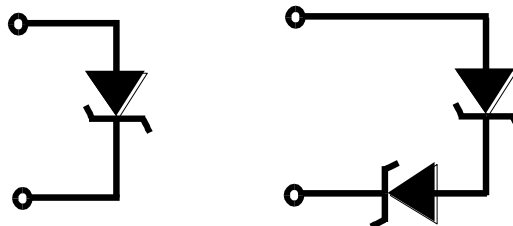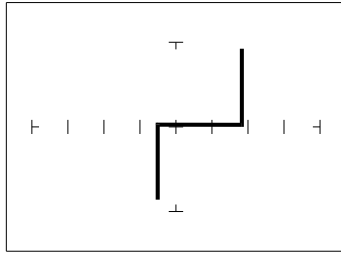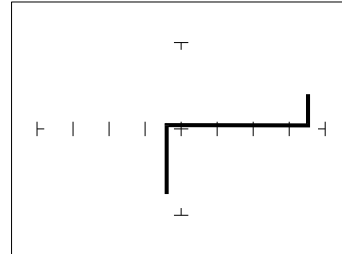

Figure 4-16. Single Zener Diode And 2 Zener Diodes In Series.

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

Figure 4-17. Signatures Of A Zener Diodes at 20V, 20KΩ

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 Model 30 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 Model 30 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 Model 30 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 Model 30 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 5-20 shows the relationship between type of material and circuit symbol for a PNP and an NPN transistor.
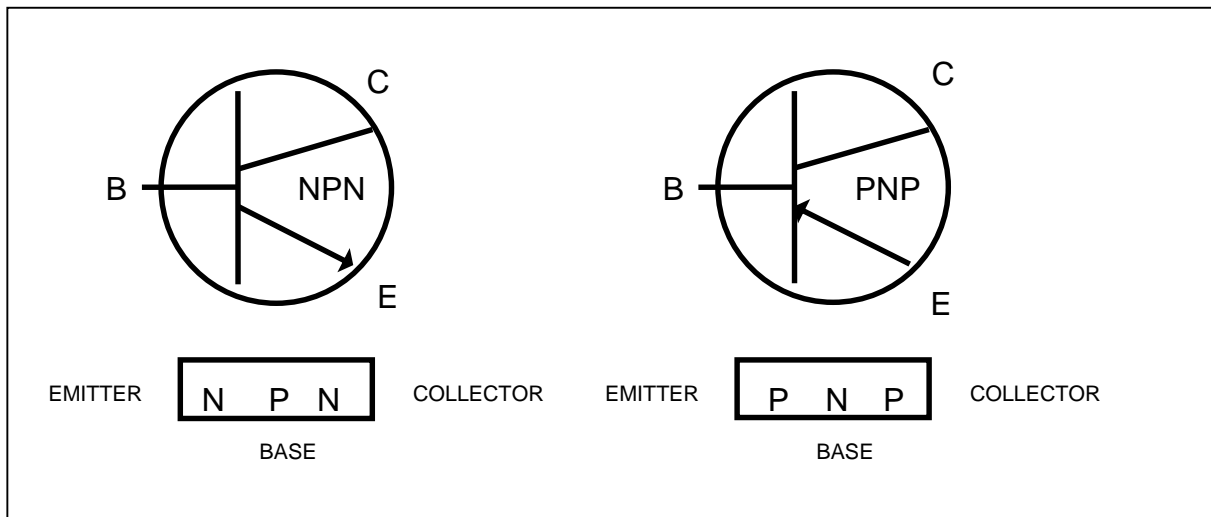

Figure 4-18. Diagram Of An NPN And PNP Bipolar Transistor.

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 (~6-20 Volts). If the voltage is above 6 Volts, then the magnitude of the shift depends on the duration of the test and the resistance selected. Reducing the voltage to 5 Volts or less will avoid this problem.

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

Suggestions to minimize effects on bipolar transistors:

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

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

3. Identify the base, emitter and collector pins of the device and then test the collector-base junction to determine whether it is an NPN or PNP. Since the emitter is not tested there will be no effect on h_{FE} regardless of the selected voltage.

BIPOLAR TRANSISTOR SIGNATURES

In order to better understand the signatures that transistors create on the Model 30, we can model these devices in terms of equivalent diode circuits. These are shown in figure 5-21. 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.
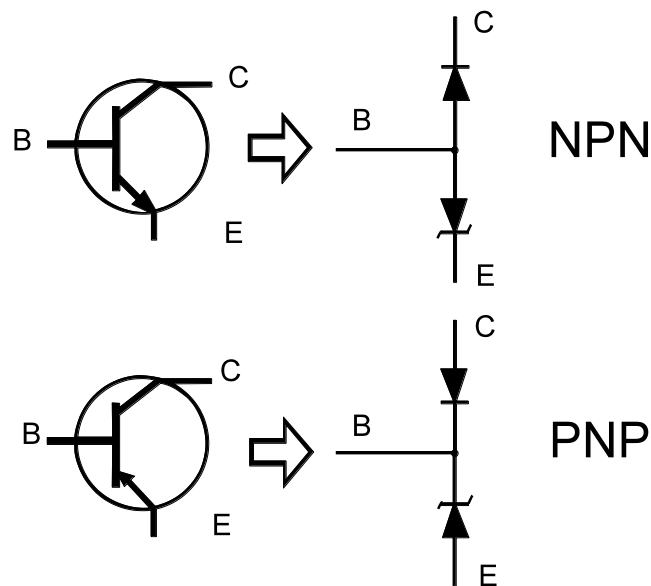

Figure 4-19. NPN And PNP Bipolar Transistor Equivalent Circuits

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 Model 30's Channel A jack to collector lead of the transistor.

3. Place or clip the black test lead from the Model 30's Common jack to base lead of the transistor.
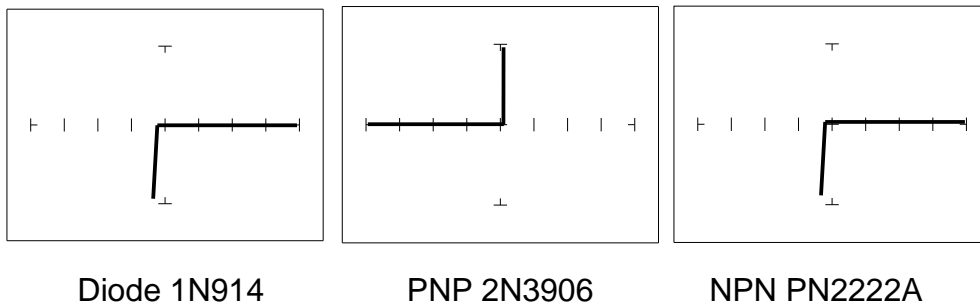

| Diode 1N914 | PNP 2N3906 | NPN PN2222A |

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.
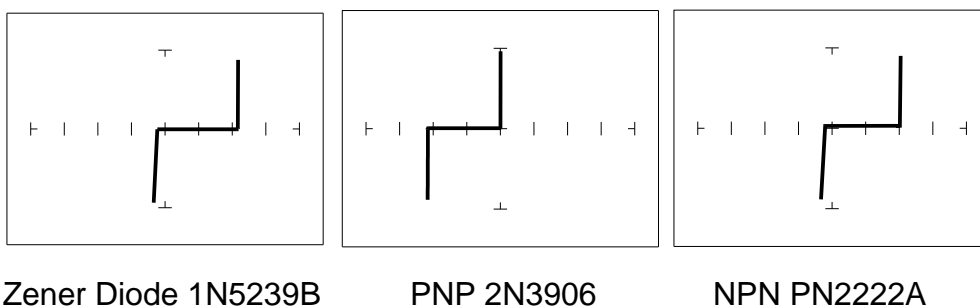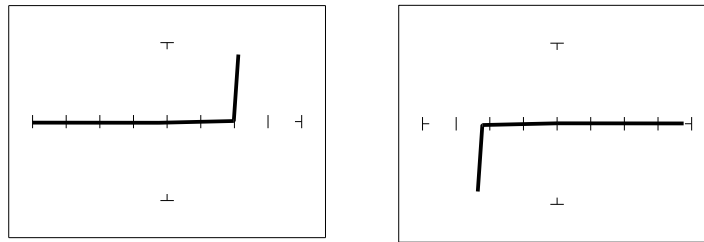

| Zener Diode 1N5239B | PNP 2N3906 | NPN PN2222A |

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 Model 30 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, 20KΩ and 60Hz.

2. Probe pin 1 with the red probe and pin 2 with the black probe.
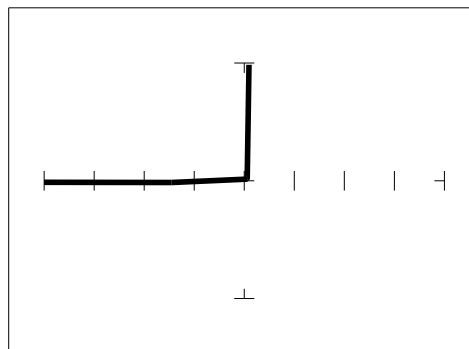
3. Identify the signature.

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.
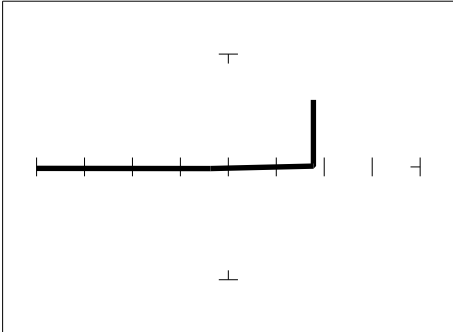
Figure 4-24. Signature Of Pins 3 And 2 Of An Unknown Transistor.

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.
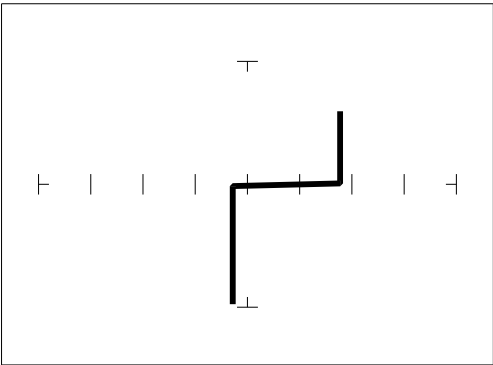

Figure 4-25. Signature Of Pins 1 And 3 Of An Unknown Transistor.

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.
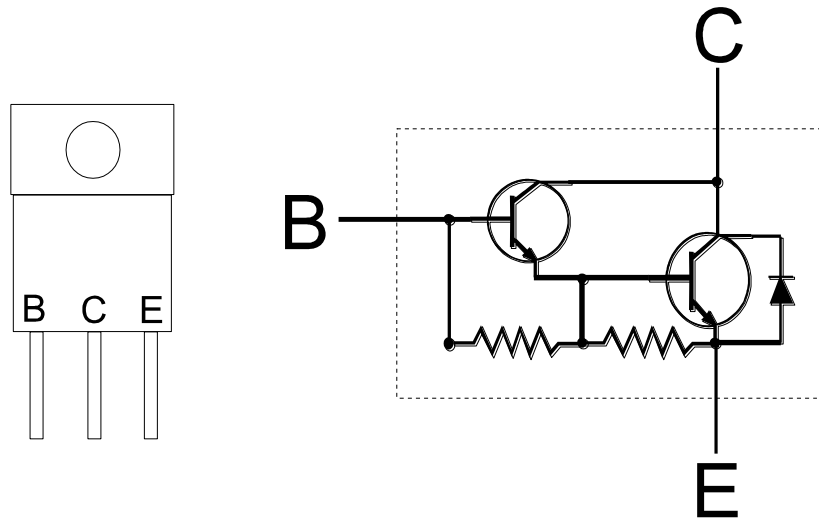
Figure 4-26. Diagram Of A Darlington Transistor.

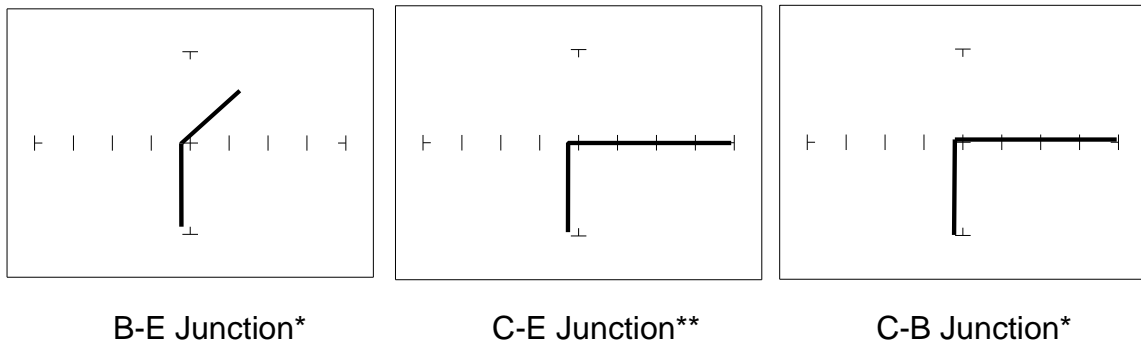| B-E Junction* | C-E Junction** | C-B Junction* |

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 Model 30 can be used to determine the type of transistor; bipolar, Darlington, FET, etc.

- The Model 30 can be used to identify the polarity of a transistor (PNP or NPN).

- The Model 30 can be used to determine the base, collector and emitter on an unknown transistor.

- The Model 30 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.

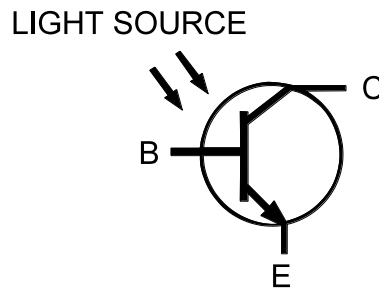**PHOTOTRANSISTOR**

LIGHT SOURCE

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 Model 30's Channel A jack to collector lead of the component.

3. Place or clip the black test lead from the Model 30's Common jack to emitter lead of the component.
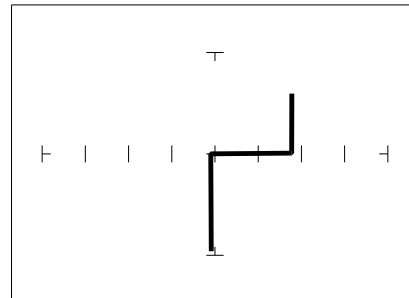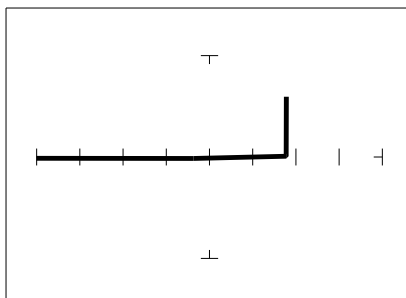
MRD3056 With No Light   MRD3056 With Light

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).
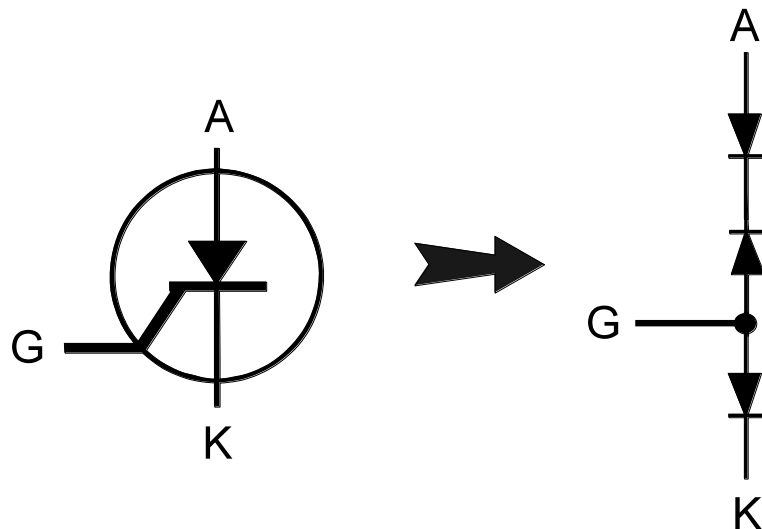
Figure 4-30. Diagram Of A Silicon Controlled Rectifier.

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

1. Select the 20V, 20KΩ and 60Hz.

2. Place or clip the red test probe from the Model 30'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
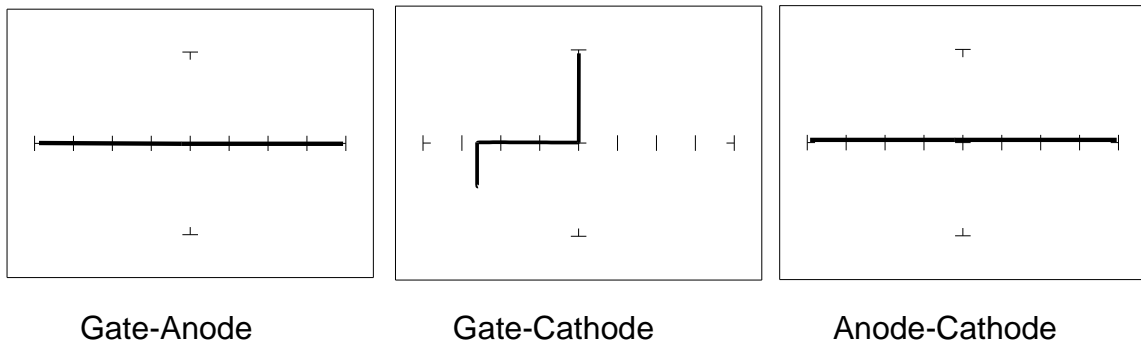
Figure 4-31. Signatures Of A SCR - C106B Type at 20V and 20KΩ.

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 ProTrack 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 Model 30 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 CIRCUIT SIGNATURES

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.
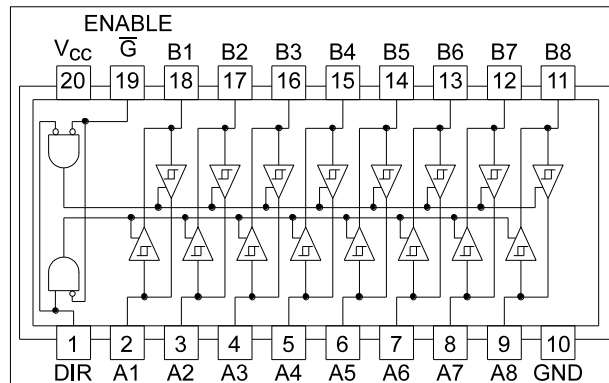

Figure 5-1. Digital IC 74LS245 Block Diagram.

- 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 20V, 10KΩ, 200Hz Range.

2. Place or clip the black test lead from the Model 30'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 Model 30's Channel A jack. Probe each pin of the IC and view its signature on Model 30'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 Model 30'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 Model 30'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.
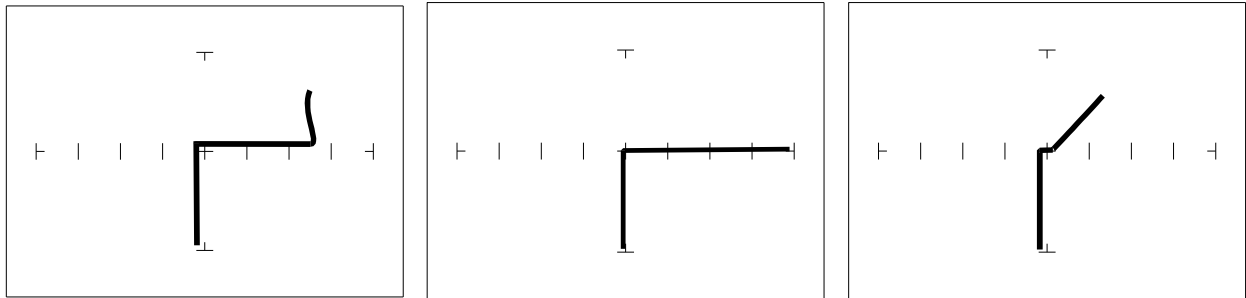
Buffer pins	Enable pins	V_{CC} Power pin
20V, 10KΩ, 200Hz	20V, 10KΩ, 200Hz	10V, 100Ω, 200Hz.

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 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 Model 30.

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

74LS04

same
the LS

only
four
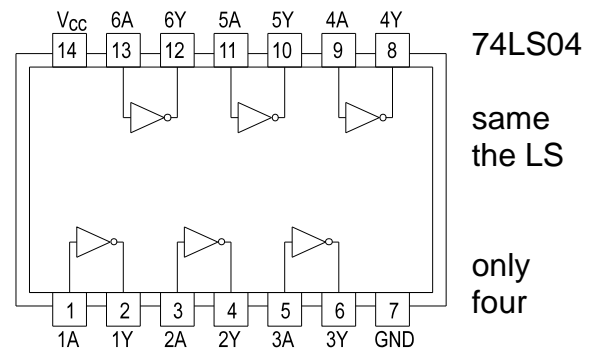
Figure 6-3. Diagram Of 7404 & 74LS04.

Pin 1 input

20V, 10KΩ, 200Hz

Pin 2 output

20V, 10KΩ, 200Hz

Pin 14 power

10V, 100Ω, 200Hz
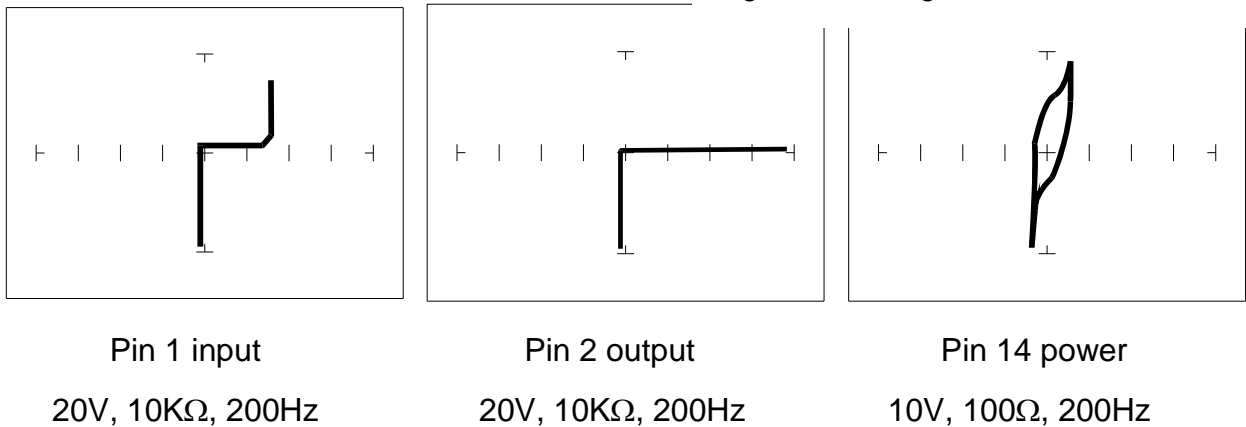
Figure 5-4. Signatures Of A 7404 Hex Inverter.

Pin 1 input

20V, 10KΩ, 200Hz

Pin 2 output

20V, 10KΩ, 200Hz

Pin 14 power

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

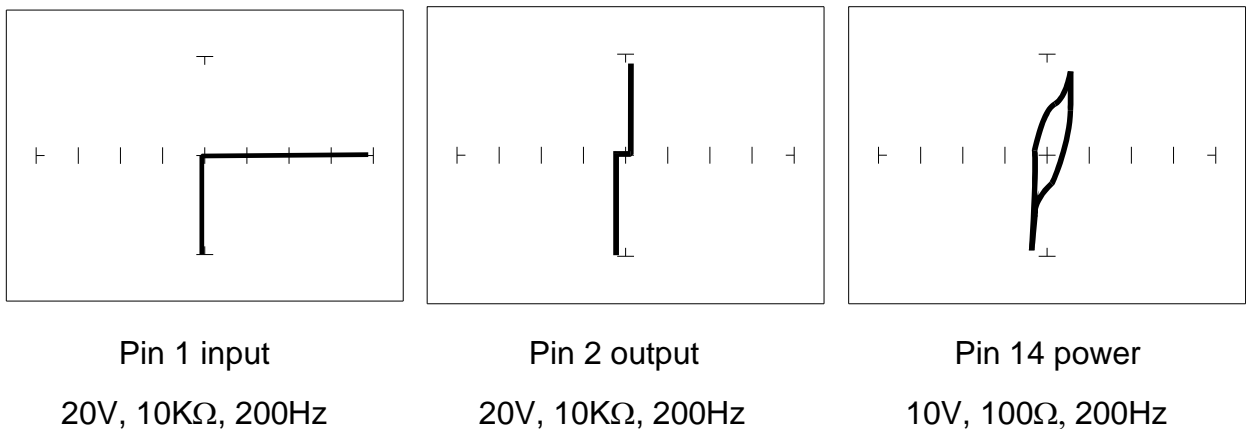CMOS circuits are constructed differently than TTL circuits. The inputs to CMOS transistors are capacitive due to the use of field-effect transistors (FET) instead of bipolar transistors used in TTL.

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.
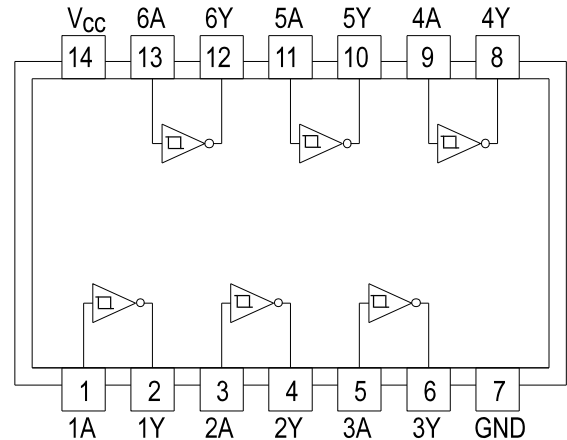

Figure 5-6. 74HC14 Block Diagram.

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 Model 30'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 Model 30'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 Model 30'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.
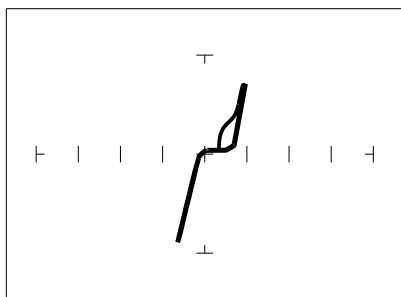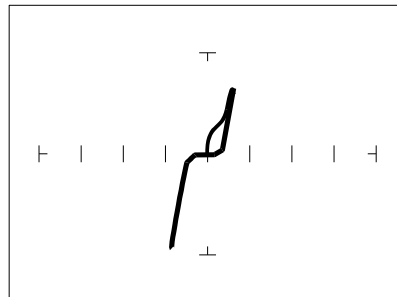
Pin 1 - Input.   Pin 2 - Output   Pin 14 - V_{CC}

55
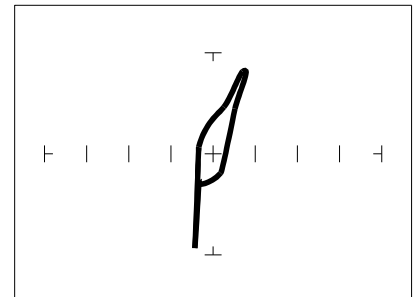
50Ω, 10V, 60Hz Range

Figure 5-7. Signatures Of A 74HC14 CMOS Hex Inverter.

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 Model 30. Capacitance in CMOS circuitry may be emphasized or de-emphasized by changing the frequency of the test signal.
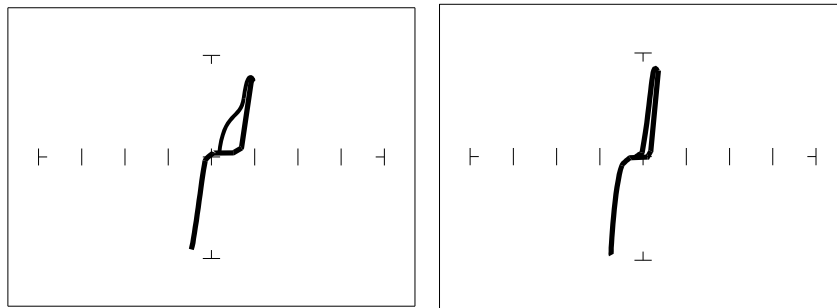
F$_S$ = 20 Hz   F$_S$ = 400 Hz

10V, 1KΩ Range

Figure 5-8. Signatures Of A 74HC14 Input Pin At Different Frequencies.

TROUBLESHOOTING DIGITAL LOGIC ICS

Comparison testing is a very powerful and effective test strategy when troubleshooting digital logic using ASA. The Model 30's Alt feature makes this technique quick and simple.
Instead of having to remember the specific signatures of a good component, all that's needed is to have a reference component or board along side the one that's suspect. This section gave many examples of signatures from TTL, Schottky TTL and CMOS logic families. Although from first inspection, these signatures appear to be complex, remember that each of the ICs in the examples had really only four unique signatures (buffer input, buffer output, power supply VCC and power supply ground). We can use this characteristic to develop an effective model for troubleshooting digital logic chips.

1. Select the 50Ω, 10V and 60 HZ range

2. Place or connect the black or blue ground clip lead from the Model 30'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 Model 30'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 Model 30 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 Model 30. 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.
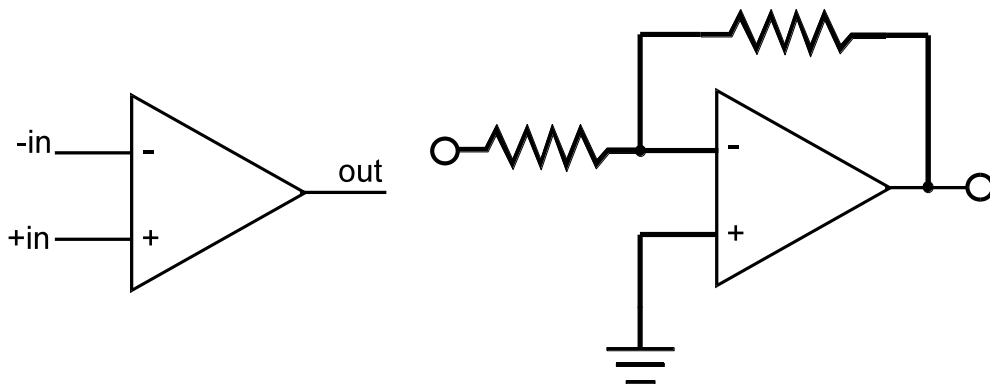
Figure 5-9. Op Amp Symbol and Schematic Diagram of an Inverter Circuit.

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 Model 30'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 Model 30'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
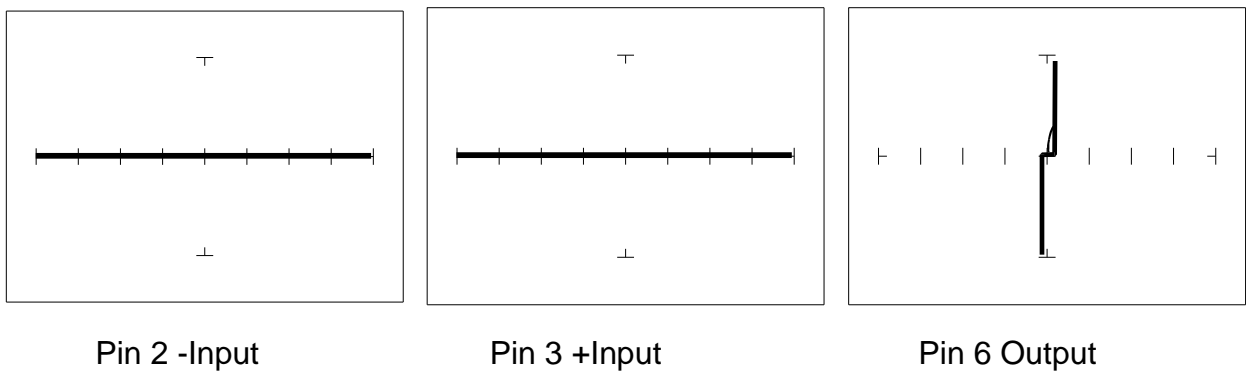
Figure 5-11. Signatures of an Op Amp (741) at 20V, 20KΩ, 60Hz with Common to Pin 4.

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 re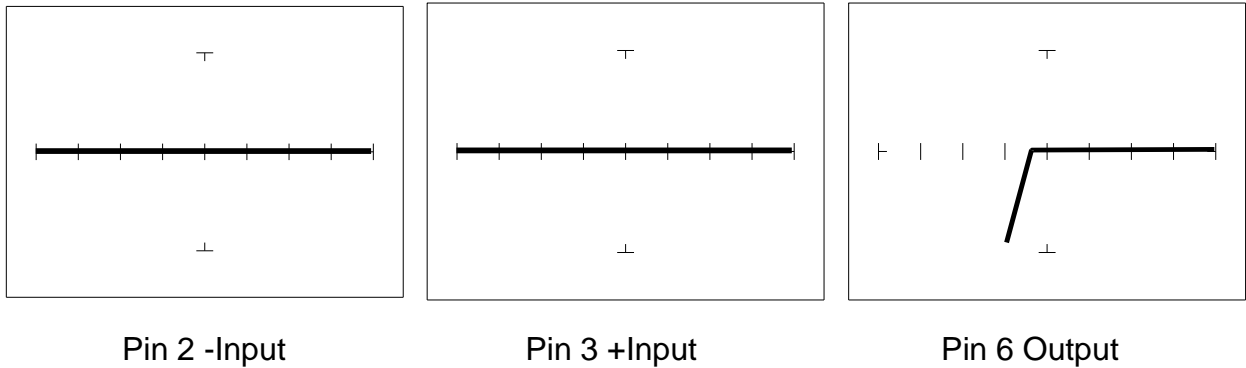sults in almost an infinite number of possible analog signatures. Use the comparison test method when troubleshooting op amps in-circuit. In this case, components on a suspect board are compared to those on a known good board. The Model 30 can help locate the defective component quickly.

The op amp has three main terminals; + input, - input and output. An alternative way to perform ASA on the op amp is to connect Model 30'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 Model 30 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.
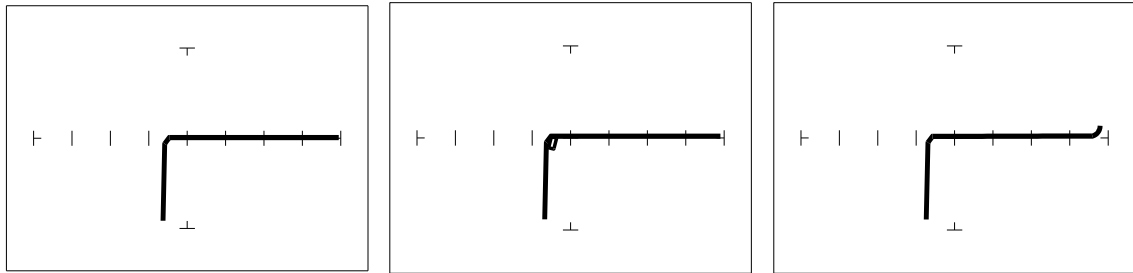
5-3. LOW VOLTAGE

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

In order to achieve this new improved level of performance, the manufacturers of this LV (low voltage) family of logic ICs have redesigned the internal structure of the device. Some manufacturers have changed the input structure by eliminating the input protection diode to V_{CC}. Similarly, the design of the output structure also has changed by eliminating the output protection diode to V_{CC} and replacing it with an 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 Model 30'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 Model 30'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 Model 30'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 Model 30 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.