

HUNTRON, INC.

TRACKER[®] 4000

USER'S MANUAL

**May 1998
P/N 21-1300
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CONTACTING HUNTRON

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SECTION 1	INTRODUCTION AND SPECIFICATIONS	PAGE
1-1	Introduction	1-1
1-2	What Is Analog Signature Analysis?.....	1-1
1-3	Specifications	1-3
1-4	Safety Considerations	1-5
1-5	Unpacking Your Tracker 4000	1-8
1-6	Accessories.....	1-8
1-7	Contacting Huntron	1-9
1-8	WEEE and RoHS Status	1-9
SECTION 2	A QUICK TOUR	
2-1	Introduction	2-1
2-2	Front Panel	2-4
2-3	Back Panel.....	2-6
2-4	CRT Display	2-7
2-5	LCD Display	2-8
2-6	Initial Setups.....	2-9
2-7	Menu Selection	2-12
2-8	Ranges.....	2-13
2-9	Range Groups.....	2-15
2-10	Range Voltage Selection.....	2-16
2-11	Range Frequency Selection.....	2-16
2-12	Range Resistance Selection.....	2-16
2-13	Channel Selection	2-17
2-14	Pulse Generator.....	2-19
SECTION 3	USING YOUR TRACKER 4000	
3-1	Introduction	3-1
3-2	Basics Of ASA - How It Works	3-2
3-3	Horizontal Axis	3-4
3-4	Vertical Axis	3-6
3-5	Basic Analog Signatures - Open And Short.....	3-8
3-6	Four Basic Component Signatures.....	3-10
3-7	Tracker 4000 Factory Range Group	3-11
3-8	Range Editing.....	3-12
3-9	Range Group Editing	3-16
3-10	Range Feature: STAR And MaxV.....	3-18
SECTION 4	TESTING PASSIVE COMPONENTS	
4-1	Resistors	4-1
4-2	Capacitors	4-11
4-3	Inductors	4-21
4-4	Electromechanical Switching Components.....	4-28

TABLE OF CONTENTS

SECTION 5	TESTING DISCRETE SEMICONDUCTORS	PAGE
5-1	Diodes	5-1
5-2	Transistors	5-14
5-3	Solid State Switching Components	5-29
SECTION 6	TESTING INTEGRATED CIRCUITS	
6-1	Digital Integrated Circuits	6-1
6-2	Analog Circuits	6-12
6-3	Low Voltage	6-19
SECTION 7	THEORY OF OPERATION	
7-1	Introduction	7-1
7-2	General Overview	7-1
7-3	Front Panel Block.....	7-2
7-4	CRT Display Block	7-2
7-5	Track Output Block	7-3
7-6	Pulse Generator Block	7-3
7-7	Range Control Block	7-3
7-8	Sine Wave Generator Block	7-3
7-9	Power Supply Block	7-4
7-10	Analog Control Block	7-4
7-11	Digital Control Block.....	7-4
SECTION 8	MAINTENANCE	
8-1	Introduction	8-1
8-2	External Cleaning And Lubrication.....	8-1
8-3	Storage Instructions	8-1
8-4	Service Information.....	8-1

LIST OF ILLUSTRATIONS

FIGURE	DESCRIPTION	PAGE
1-1	Power Entry Module With Fuse Tray	1-7
2-1	Tracker 4000 Front Panel	2-1
2-2	Tracker 4000 Front Panel With Callouts.....	2-4
2-3	Tracker 4000 Back Panel	2-6
2-4	CRT Display	2-7
2-5	Tracker 4000 Main Menu Screen	2-9
2-6	Tracker 4000 Menu1 Screen	2-9
2-7	Tracker 4000 Prefs Screen.....	2-10
2-8	Tracker 4000 CRT Adjustment Menu Screen.....	2-10
2-9	Tracker 4000 CRT Vertical Trace Adjustment.....	2-11
2-10	Tracker 4000 CRT Horizontal Trace Adjustment.....	2-11
2-11	Tracker 4000 CRT Trace Separation Adjustment	2-11
2-12	Main Menu Screen	2-12
2-13	Menu1 Menu Screen.....	2-13
2-14	GroupEdit Menu Screen	2-15
2-15	Comparison Testing With Alternate And A+B Display Mode	2-18
2-16	Comparison Test With The Pulse Generator.....	2-19
3-1	Tracker 4000 With Test Probes.....	3-1
3-2	Tracker Core Circuit Block Diagram	3-2
3-3	Tracker 4000 CRT Display Horizontal Axis And Graticule Lines	3-4
3-4	Tracker 4000 CRT Display With Open Test Terminals	3-5
3-5	Tracker 4000 CRT Display With Vertical Axis And Graticule Lines.....	3-6
3-6	Tracker 4000 CRT Display With Short Circuit Signature	3-7
3-7	"OPEN" Analog Signature On CRT Display (Horizontal Line)	3-8
3-8	Test Signal (Open Circuit) With Current And Voltage Waveforms	3-8
3-9	"SHORT" Analog Signature On CRT Display (Vertical Line)	3-9
3-10	Test Signal (Short Circuit) With Current And Voltage Waveforms	3-9
3-11	Analog Signatures Of 4 Basic Components	3-10
3-12	Menu1 Screen With RangeEdit Button Selected	3-12
3-13	RangeEdit Screen.....	3-12
3-14	RangeEdit Name Screen	3-13
3-15	RangeEdit Custom "AMUX6" Range	3-13
3-16	RangeEdit Name Screen Example	3-14
3-17	User Range With Frequency = *.* (Undefined).....	3-15
3-18	User Range With Frequency = 200 Hz (Defined)	3-15
3-19	User Range With Frequency = 200 Hz (Selected).....	3-15
3-20	Menu1 With GroupEdit Selection.....	3-16
3-21	GroupEdit Screen With Group01 Example	3-16
3-22	GroupEdit Name Screen With "FastLogic" Example	3-17
3-23	GroupEdit Screen Example	3-17
3-24	Prefs Screen With Advanced Selection	3-20
3-25	Advanced Screen With MaxV Selection	3-20
4-1	Tracker 4000 With Test Probe Leads And Setup	4-1
4-2	Tracker 4000 Main Menu Screen With Factory Defaults	4-2
4-3	Tracker 4000 Connected To A Resistor	4-2

LIST OF ILLUSTRATIONS (continued)

FIGURE	DESCRIPTION	PAGE
4-4	Signatures Of Different Resistors In Factory Range Group.....	4-3
4-5	Affect Of Varying R_S On A Resistor Signature.....	4-4
4-6	Affect Of Varying V_S On A Resistor Signature.....	4-5
4-7	Affect Of Varying F_S On A Resistor Signature.....	4-5
4-8	Tracker Core Circuit Block Diagram With A Resistor.....	4-6
4-9	Range Parameters Changes And Affects On Resistive Signatures.....	4-7
4-10	Short And Open Signature.....	4-8
4-11	Using Tracker 4000 To Test A Potentiometer.....	4-10
4-12	Using Tracker 4000 To Compare Two Potentiometers.....	4-10
4-13	Capacitor Circuit With Test Signal's Current And Voltage Waveforms.....	4-11
4-14	Tracker 4000 Main Menu Screen With Factory Defaults.....	4-12
4-15	Tracker 4000 With Test Probes Connected To A Capacitor.....	4-12
4-16	Signatures Of 4 Capacitors In Low Range.....	4-13
4-17	Signatures Of A 10 μ F Capacitor At Different Frequencies.....	4-14
4-18	Signatures Of A 0.1 μ F Capacitor At Different Frequencies.....	4-14
4-19	Signatures Of A 1 μ F Capacitor At Different Test Signal Voltages.....	4-15
4-20	Signatures Of A 1 μ F Capacitor At Different Internal Resistances.....	4-15
4-21	Tracker Core Circuit Block Diagram With A Capacitor.....	4-16
4-22	Range Parameters Changes And Affects On Capacitive Signatures.....	4-17
4-23	Signatures Of A 100 μ F Capacitor With Dielectric Leakage.....	4-19
4-24	Signatures Of A 10 μ F Capacitor With Dielectric Leakage.....	4-19
4-25	Main Menu Screen.....	4-21
4-26	Tracker 4000 With Probes To An Inductor.....	4-22
4-27	Signatures Of 4 Inductors In Low Range.....	4-23
4-28	Affect Of Varying F_S On Inductor Signatures.....	4-23
4-29	Affect Of Varying V_S On Inductor Signatures.....	4-24
4-30	Affect Of Varying R_S On Inductor Signatures.....	4-24
4-31	Tracker Core Circuit Block Diagram With An Inductor.....	4-25
4-32	Range Parameters Changes And Affects On Inductive Signatures.....	4-26
4-33	Main Menu Screen.....	4-28
4-34	Tracker 4000 With Probes To A Mechanical Switch - SPST Type.....	4-29
4-35	Signatures Of A Keyboard Pushbutton Conductive Elastomer Switch.....	4-30
4-36	Tracker 4000 With Test Leads Connected To Relay's Coil.....	4-31
4-37	Signatures Of A Magnetic Reed Relay Coil.....	4-32
5-1	Diode And Schematic Symbol.....	5-1
5-2	Tracker Core Circuit Block Diagram With A Diode.....	5-2
5-3	Main Menu Screen.....	5-2
5-4	Tracker 4000 With Probes To A Diode.....	5-3
5-5	Signature Of A 1N914 Type Silicon Diode.....	5-3
5-6	Signature Of A 1N914 Diode At Different Range Frequencies.....	5-4
5-7	Signature Of A 1N914 Diode At Different Range Resistances.....	5-5
5-8	Range Parameters Changes And Affects On Diode Signatures.....	5-6
5-9	Composite Model Of A Diode And Capacitor In Parallel.....	5-7
5-10	Composite Signature - 1N914 Diode And 1 μ F Capacitor In Parallel.....	5-7
5-11	Composite Model Of A Diode And Resistor In Parallel.....	5-8
5-12	Composite Signature - 1N914 Diode And 1.5 k Ω Resistor In Parallel.....	5-8
5-13	Defective Diode Model With A Small Series Resistor.....	5-9
5-14	Defective Diode Signature With A 50 Ω Series Resistor.....	5-9
5-15	Defective Diode Model With An Internal Leakage Resistance.....	5-10
5-16	Signature Of A Diode With Internal Leakage Flaw.....	5-10

LIST OF ILLUSTRATIONS (continued)

FIGURE	DESCRIPTION	PAGE
5-17	Tracker Core Circuit Block Diagram With A Zener Diode	5-11
5-18	Single Zener Diode And 2 Zener Diodes In Series	5-12
5-19	Signature Of A Single Zener Diode and 2 Zener Diodes In Series.....	5-12
5-20	Diagram Of An NPN And PNP Bipolar Transistor	5-14
5-21	NPN And PNP Bipolar Transistors' Equivalent Circuits	5-16
5-22	Main Menu Screen.....	5-17
5-23	Tracker 4000 Connected To The Collector And Base Leads Of A Transistor.....	5-17
5-24	Signature Of A Diode And Collector-Base Of A Transistor.....	5-18
5-25	Signature Of A Diode And Emitter-Base Of A Transistor	5-18
5-26	Signature Of The Collector-Emitter Of A PNP And NPN Transistor.....	5-19
5-27	Tracker 4000 With Probes To An Unmarked Transistor	5-20
5-28	Signature Of Pins 1 And 2 Of An Unknown Transistor	5-21
5-29	Signature Of Pins 3 And 2 Of An Unknown Transistor	5-21
5-30	Signature Of Pins 1 And 3 Of An Unknown Transistor	5-22
5-31	Diagram Of A Darlington Transistor.....	5-23
5-32	Signature Of A Darlington Transistor - TIP112 Type	5-23
5-33	Pulse Generator Test Circuit For An NPN Transistor	5-24
5-34	Pulse Generator Test Circuit For A PNP Transistor	5-25
5-35	Testing Transistors With The Pulse Generator - DC Mode.....	5-26
5-36	Testing Transistors With The Pulse Generator - Pulse Mode	5-27
5-37	Phototransistor Schematic Diagram	5-29
5-38	Main Menu Screen.....	5-29
5-39	Tracker 4000 With Test Leads To A Phototransistor	5-30
5-40	Signatures Of A NPN Phototransistor - MRD3056 Type	5-30
5-41	Diagram Of An Optocoupler	5-31
5-42	Main Menu Screen.....	5-31
5-43	Pulse Generator Test Circuit For An Optocoupler	5-32
5-44	Signatures Of An Optocoupler - 4N33 Type	5-33
5-45	Diagram Of A Silicon Controlled Rectifier.....	5-34
5-46	Main Menu Screen.....	5-35
5-47	Tracker 4000 With Test Leads To A SCR.....	5-35
5-48	Signatures Of A SCR - C106B Type.....	5-36
5-49	Pulse Generator Test Circuit For A SCR.....	5-37
5-50	Signature Of A SCR (C106B Type) With The Pulse Generator Test	5-38
5-51	Diagram And Symbol Of A TRIAC.....	5-38
5-52	Pulse Generator Test Circuit For A TRIAC.....	5-39
5-53	Signatures Of A TRIAC With The Pulse Generator Test.....	5-40
6-1	Digital IC 74LS245 Block Diagram.....	6-2
6-2	Main Menu Screen With TTL Range Group	6-3
6-3	Signatures of A Digital IC, 74LS245	6-4
6-4	Diagram Of 7404 & 74LS04.....	6-4
6-5	Signatures Of A 7404 Hex Inverter	6-5
6-6	Signatures Of A 74LS04 Hex Inverter.....	6-5
6-7	74HC14 Block Diagram	6-6
6-8	Main Menu Screen With MOS Range Group.....	6-6
6-9	Signatures Of A 74HC14 CMOS Hex Inverter	6-7
6-10	Signatures Of A 74HC14 Input Pin At Different Frequencies	6-8
6-11	Tracker 4000 With Test Leads Setup For Comparing 2 ICs	6-9
6-12	Main Menu With MOS Range Group	6-10
6-13	Op Amp Symbol And Schematic Diagram Of An Inverter Circuit	6-12

LIST OF ILLUSTRATIONS (continued)

FIGURE	DESCRIPTION	PAGE
6-14	Tracker 4000 With Test Leads To An Op Amp	6-13
6-15	Signatures Of An Op Amp (741 Type) In LOW Range	6-14
6-16	Signatures Of An Op Amp (741 Type) In MED2 Range	6-14
6-17	Diagram And Symbol Of A Linear Voltage Regulator, 7805 Type	6-16
6-18	Signatures Of A 7805 Voltage Regulator By SGS Thomson	6-17
6-19	Signatures Of A 7805 Voltage Regulator By Motorola.....	6-17
6-20	Tracker 4000 With Test Probes To A 20 Pin Surface Mount IC	6-19
6-21	Main Menu Screen With SMT Range Group	6-20
6-22	Signatures Of A Low Voltage IC (74LVQ45 Type).....	6-21
7-1	Tracker 4000 Operational Block Diagram.....	7-1

LIST OF TABLES

TABLE	DESCRIPTION	PAGE
1-1	Tracker 4000 Specifications	1-3
1-2	Tracker 4000 Shipping List	1-8
2-1	Front Panel Controls And Connections.....	2-5
2-2	Back Panel Items.....	2-6
2-3	Tracker 4000 Horizontal Sensitivities.....	2-7
2-4	Tracker 4000 Test Ranges	2-14
2-5	Tracker 4000 Factory Range Group	2-16
3-1	Tracker 4000 Factory Range Group (Default)	3-11
3-2	Tracker 4000's STAR Feature	3-19
4-1	Tracker 4000 Minimum And Maximum Capacitor Values	4-18

Notes:

SECTION 1

INTRODUCTION AND SPECIFICATIONS

1-1. INTRODUCTION

The Tracker 4000 is one of the most advanced troubleshooting tools developed to date. It provides maximum test flexibility and control while keeping its operation easy to use. Huntron's unique power-off testing challenges the belief that functional component testing is the most effective test method for isolating and determining failures. The core technology that's key to this instrument's powerful troubleshooting capabilities is called Analog Signature Analysis (ASA).

1-2. WHAT IS ANALOG SIGNATURE ANALYSIS?

Analog Signature Analysis or ASA is a unique, power-off troubleshooting technique. It uses an alternating current (AC) sinewave stimulus to show the current (I) vs. voltage (V) characteristic of an unpowered component on a CRT. The IV characteristic is called an analog signature and 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. You can compare signatures of suspect components to signatures of known-good components.

Because the test current applied across a component is limited, this technique is non-destructive, 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.

Huntron's Tracker 4000 graphically displays the 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 board, 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.

1-3. SPECIFICATIONS

The specifications for the Tracker 4000 are listed in Table 1-1.

Table 1-1. Tracker 4000 Specifications

ELECTRICAL

Test Signal:	Sine wave
Open Circuit Voltage (V_s): 24 peak voltage selections:	200 mV, 400 mV, 600 mV, 800 mV 1 Volt to 20 Volts in 1 Volt steps including 10V (LOW), 15V (MED1), 20V (MED2)
Source Resistance (R_s): 16 resistance selections:	10 Ω , 20 Ω , 50 Ω , 100 Ω , 200 Ω , 500 Ω 1 k Ω , 2 k Ω , 5 k Ω , 10 k Ω , 20 k Ω , 50 k Ω , 100 k Ω and 54 Ω (LOW), 1.24 k Ω (MED1), 26.7 k Ω (MED2)
Note: Short circuit current I_s is V_s divided by R_s	
Maximum current	10 V / 50 Ω = 200 mA _{PK}
Minimum current	200 mV / 100 k Ω = 2 μ A _{PK}
Frequency (F_s): 40 frequency selections:	20 Hz to 190 Hz in 10 Hz steps 200 Hz to 1.9 kHz in 100 Hz steps 2 kHz to 5 kHz in 1 kHz steps
Channels:	
Number	2
Display modes	A, B, Alt, A+B
Overvoltage Protection	Electronic circuit breaker
Pulse Generator:	
Number of Outputs:	2
Level	0 to \pm 10 Volts
Width (pulse mode)	2% to 50% duty cycle
Source resistance	100 Ω
Short circuit current	100 mA max.

Table 1-1. Tracker 4000 Specifications (continued)

ELECTRICAL (continued):

Displays:

CRT	monochrome, 2.8" (7 cm) diagonal
LCD	full graphic, 128 x 64 pixels

Power Requirements:

Line Voltage	90 V AC to 250 V AC
Frequency	47 Hz to 63 Hz
Power	45 Watts max.

GENERAL

Size	11.6" W x 4.5" H x 15" D (30 cm W x 11.5 cm H x 38 cm D)
Weight	10.5lb (4.8kg) net 15.0lb (6.8kg) shipping

ENVIRONMENTAL

Indoor Use	
Altitude	<2000m (<6560')
Temperature	
Operating	0°C to +40°C (32°F to 104°F)
Storage	-20°C to +60°C (-4°F to 140°F)
Relative Humidity	0 to 80% from 0°C to 31°C (32°F to 88°F) Maximum R.H. decreases linearly to 50% at 40°C.

SAFETY

OverVoltage Category	According to IEC1010-1 CAT II
Pollution Degree	2

1-4. SAFETY CONSIDERATIONS

Safety Terms and Symbols

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




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




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

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

 Earth Terminal

 Protective Ground
(Earth) Terminal

 **CAUTION**
Refer to Manual

 Fuse

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

Only qualified personnel should perform service procedures.

TO AVOID FIRE OR PERSONAL INJURY

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



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

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

 **WARNING**

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

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

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

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

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

Do Not Operate in Wet/Damp Conditions.

Do Not Operate in an Explosive Atmosphere.

Keep Product Surfaces Clean and Dry.

⚠ Fuse Replacement:**Line Fuse tray**

The power entry module on the Tracker 4000 includes the power switch (0 = OFF, 1 = ON), power cord connector, and a removable tray which holds the line fuse. Some trays also have a spare fuse.

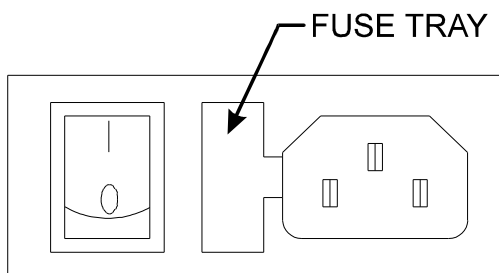


Figure 1-1. Power Entry Module With Fuse Tray.

Make sure that replacement fuses are of the type and current rating specified. If necessary, insert the specified line fuse (T1.6A according to IEC 127) into the fuse tray.

1-5. UNPACKING YOUR TRACKER 4000

Your instrument was shipped with the following items:

Table 1-2. Tracker 4000 Shipping List

<u>Huntron P/N</u>	<u>Description</u>	<u>Quantity.</u>
98-0249	Huntron Microprobes MP20	1 pair
98-0043	Ground Clip	2
98-0036	Blue Clip Leads	2
98-0015	Power Cord (115V)	1
06-5217	Manual CD	1
21-1193	Certificate of Compliance	1

Check the shipment carefully and contact the place of purchase if anything is missing. If there is shipping damage, then contact your freight company. If shipment is necessary, please use the original shipping carton and packing foam. If these are not available, be sure that the instrument is packed in a box with a minimum of two inches (5 cm) of cushioning material on all sides.

1-6. ACCESSORIES

Foot Switch (Huntron part number: 98-0314)

The foot switch accessory enables "hands free" operation for selecting ranges. Each push of the foot switch changes the range to the next one in the selected range group. This is handy when performing comparison troubleshooting using two test probes. The footswitch plugs into a jack located on the back panel jack of the Tracker 4000.

1-7. CONTACTING HUNTRON

To obtain technical support, application assistance, information about service, accessories, upgrades, training and other products, contact:

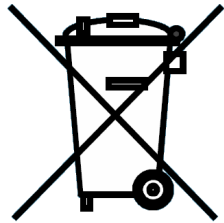
Huntron, Inc.
15720 Mill Creek Blvd. Suite #100
Mill Creek, WA 98012
USA

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

Huntron is also accessible by:

- ◆ FAX: 425-743-1360
- ◆ Internet E-mail: huntron@huntron.com
- ◆ Internet Home Page: <http://www.huntron.com>

1-8. WEEE and RoHS Status



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



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

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



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

Notes:

SECTION 2 A QUICK TOUR

2-1. INTRODUCTION

The Huntron Tracker 4000, shown in figure 2-1, is a versatile troubleshooting tool having the following features:

- Backlit Graphic LCD with contrast control
- LED indicators for currently active functions
- Over 6,000 possible ranges ($V_S \times R_S \times F_S$)
- 100 storable user defined ranges
- 40 frequencies
- Dual channel capability for easy comparison
- Large CRT display
- Displays two signatures simultaneously on the CRT
- Non-volatile memory for storing user configurations
- Electronic circuit protection from overvoltage
- Encoder for quick access of user settable options

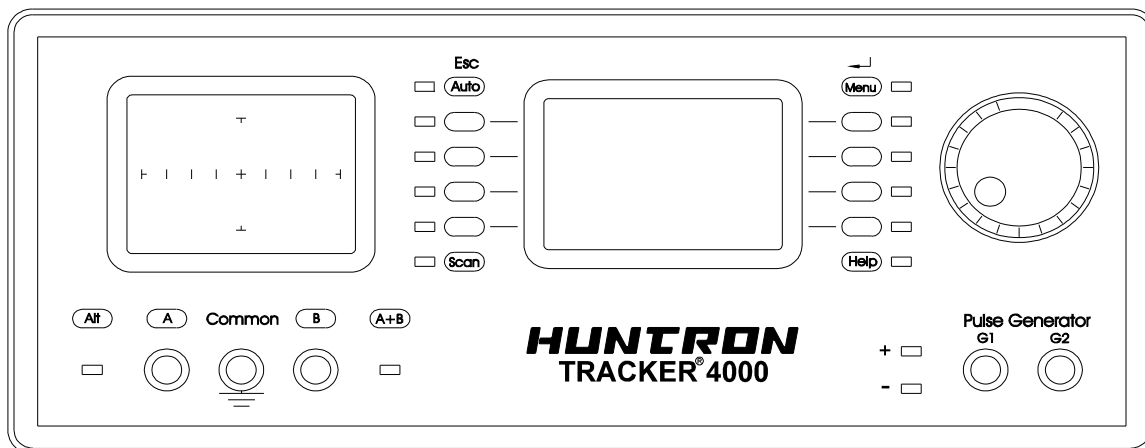


Figure 2-1. Tracker 4000 Front Panel.

The Tracker 4000 tests components using a two terminal system (three terminal system when the built-in pulse generator is used) where two leads are placed on the leads of the component under test. The Tracker 4000 tests' components in-circuit, even when there are several components in parallel.

All voltage sources in boards and systems must be in a power-off condition when using the Tracker 4000. Electronic protection is connected in series with the channel A and B test terminals. Accidental contact of the test leads to active voltage sources, for example, line voltage, powered-up boards or systems, charged high voltage capacitors, etc., may cause the circuit protection to trip. A tripped circuit protector is indicated by channel A or B or both indicator(s) LED flashing rapidly accompanied by an OVERVOLTAGE message on the LCD screen. When this condition occurs, remove the test probes from the component under test. Press the channel selection button that corresponds to the flashing LED. This action will reset the electronic circuit protection.

CAUTION

The device to be tested must have all power turned off, and have all high voltage capacitors discharged before connecting the Tracker 4000 to the device.

The AC line fuse (located in the power entry module on the rear panel) should only open when there is a failure inside the instrument. Therefore the problem should always be located and corrected before fuse replacement. Be sure to always replace the fuse with the identical type and rating as the original fuse. Refer to the electrical specifications for more information on the correct fuse type.

Before you begin to use the Tracker 4000, please take a few minutes to familiarize yourself with the instrument. All of the externally accessible features are discussed in the following sections.

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2-2. FRONT PANEL

The front panel of the Tracker 4000 is designed to ease access to its many features. All buttons are momentary action type and most have adjacent LED indicators to show which functions are active. Refer to figure 2-2 and table 2-1 for a detailed description of each item on the front panel.

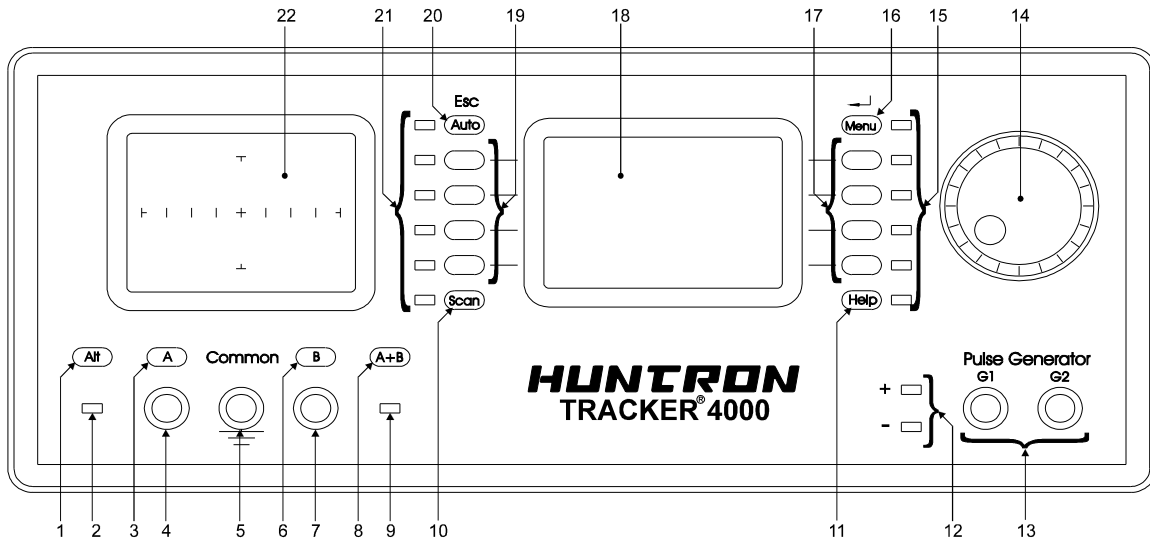


Figure 2-2. Tracker 4000 Front Panel With Callouts.

Table 2-1. Front Panel Controls And Connections.

Item	Name	Function
1	ALT Button	Causes the Tracker 4000 to alternately display channel A and channel B on the CRT. The alternation speed can be varied by the Rate button(LCD menu item).
2	Channel A LED	Channel A is being displayed on the CRT when on.
3	Channel A Button	Selects channel A for display on the CRT.
4	Channel A Test Terminal	Safety shrouded banana jack for channel A test signal.
5	Common Test Terminal	Safety shrouded banana jack that is the instrument common and the common reference point for both channel A and channel B.
6	Channel B Button	Selects channel B for display on the CRT.
7	Channel B Test Terminal	Safety shrouded banana jack for channel B test signal.
8	A+B Button	Displays both channel A and B on the CRT at the same time.
9	Channel B LED	Channel B is being displayed on the CRT when on.
10	Scan Button	Sequences the test signal through the four selected ranges at the Main menu.
11	Help Button	Provides context sensitive on-screen help.
12	Pulse Generator Polarity LEDs	Indicates the polarity settings for the Pulse Generator outputs.
13	G1 & G2 Terminals	Pulse Generator G1 & G2 dual outputs.
14	Encoder Knob	Knob used for scrolling through LCD menu items.
15	Active Item LEDs	LEDs used to indicate the active items.
16	Menu (↵) Button	Used to navigate between various menu screens.
17	Selection Buttons	Buttons used to select LCD menu items.
18	LCD Display	Displays the Tracker 4000 menus and Help.
19	Selection Buttons	Buttons used to select LCD menu items.
20	Esc/Auto Button	Used to exit a menu screen or discard changes.
21	Active Item LEDs	LEDs used to indicate the active item.
22	CRT Display	Displays the component's analog signature(s) produced by the Tracker 4000.

2-3. BACK PANEL

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

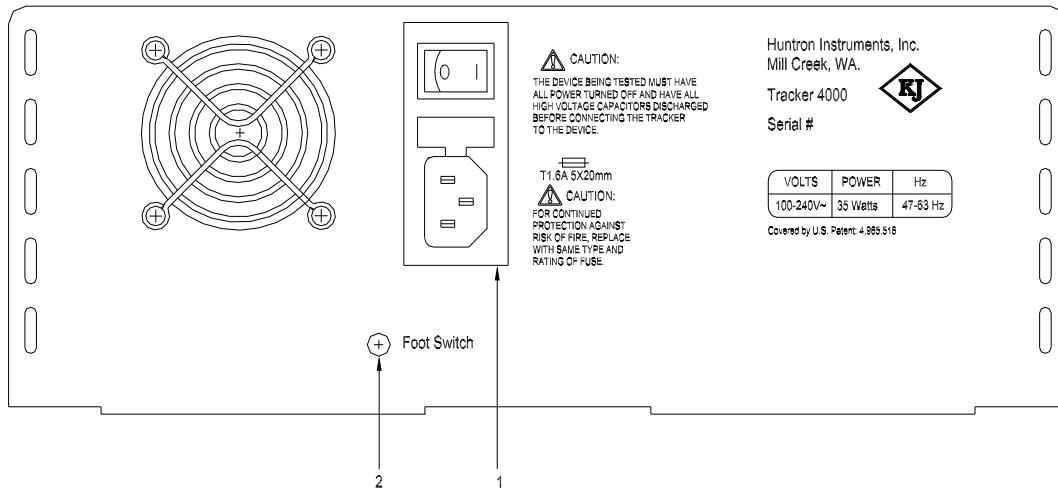


Figure 2-3. Tracker 4000 Panel.

Table 2-2. Back Panel Items.

Item	Name	Function
1	Power Entry Module	AC Mains power cord connection, power switch and AC mains line fuse
2	Switch Connector	Plug for foot switch accessory

2-4. CRT DISPLAY

The CRT displays the analog signature of the component being tested. The display has a graticule consisting of a horizontal axis which represents voltage, and a vertical axis which represents current. The axis divides the display into four quadrants. Each quadrant displays different portions of the signatures. Quadrant 1 displays positive voltage (+V) and positive current (+I), quadrant 2 displays negative voltage (-V) and positive current (+I), quadrant 3 displays negative voltage (-V) and negative current (-I), and quadrant 4 displays positive voltage (+V) and negative current (-I).

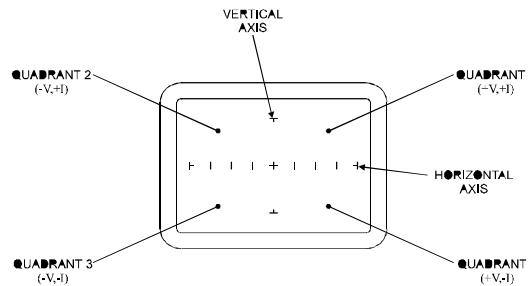


Figure 2-4. CRT Display.

The horizontal axis is divided into eight line segments. These segments serve as a visual aid in estimating the voltage at which changes in the analog signature occur. Each segment has an approximate value in volts per division units (also known as the horizontal sensitivity) that's a function of each Tracker 4000 range voltage. The horizontal sensitivity can be calculated by dividing the range voltage setting by 4. For example, if the range voltage is 10 volts, then each horizontal segment is 2.5 volts. This feature may be useful for advanced analog signature analysis users in determining the forward and reverse voltages of semiconductor junction of solid state components.

Table 2-3 lists the horizontal sensitivities for the Tracker 4000 Factory range group (default).

Table 2-3. Tracker 4000 Horizontal Sensitivities.

Factory Range	Volts / Division
HV20	5.0
MED2	5.0
MED1	3.75
LOW	2.5

2-5. LCD DISPLAY

The Tracker 4000 contains a graphic LCD to serve as a simple intuitive user interface. This LCD screen displays various menus, help information, labels for soft buttons and special annunciator symbols that access the multitude of features of the Tracker 4000.

There are a group of special graphic symbols that represent a specific action or state. Familiarize yourself with the following annunciators that are used by the Tracker 4000:

<u>SYMBOL</u>	<u>DESCRIPTION</u>
	Use the encoder to change.
	Feature is enabled as Default Power On.
	Right pointer.
	Left pointer.
	Text Editing Cursor.
	Button toggle.
	Enter button.
	MaxV feature is enabled.
	Test Frequency Wildcard Value.
	Wait indicator, Store operation in progress.



Use the encoder to change.



Feature is enabled as Default Power On.



Right pointer.



Left pointer.



Text Editing Cursor.



Button toggle.



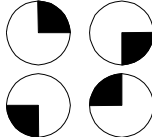
Enter button.



MaxV feature is enabled.



Test Frequency Wildcard Value.



Wait indicator, Store operation in progress.

2-6. INITIAL SETUPS

POWER ON

Turn the power on to your Tracker 4000 using the power switch located on the rear panel. The LCD screen will momentarily display the power on screen with information on the firmware version and the unit's internal serial number. Next the power on diagnostics and initialization will run and when finished, the Tracker 4000's LCD screen will display the Main menu. Also, Channel A will be selected, and the first range of the power-up default range group will be selected.

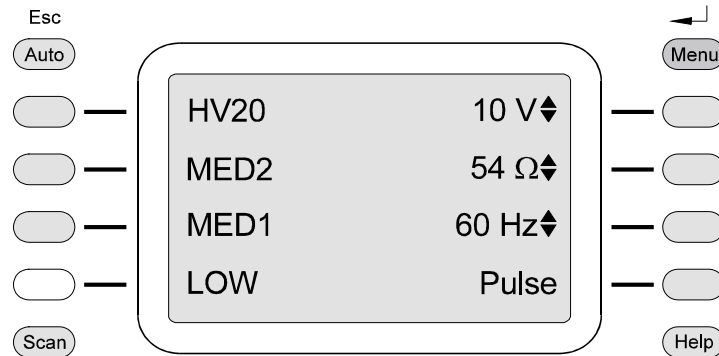


Figure 2-5. Tracker 4000 Main Menu Screen.

LCD ADJUSTMENT

If the LCD contrast requires adjustment, from the Main menu press the **Menu** button to get to the **Menu 1** screen and then press **Prefs**,

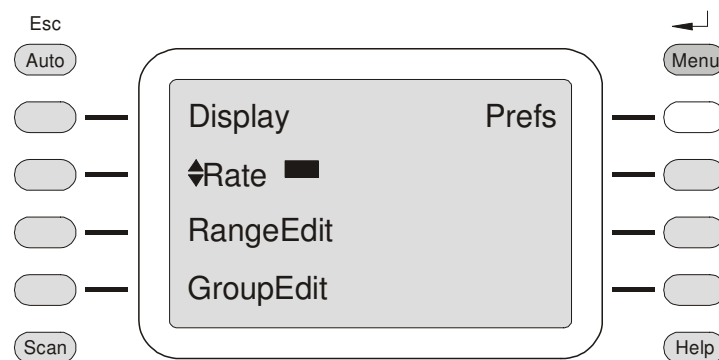


Figure 2-6. Tracker 4000 Menu1 Screen.

Next, press **LCDCOn** and rotate the encoder to adjust. Press **Store** and wait for the clock indicator to disappear.

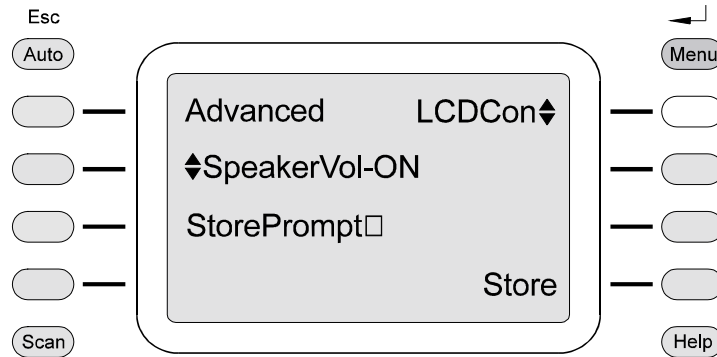


Figure 2-7. Tracker 4000 Prefs Screen.

Press the **Esc** button to return to Menu 1.

CRT ADJUSTMENT

When you're trying to analyze a signature it's important to make sure the CRT trace is positioned properly. Sometimes, ASA requires a close examination of which quadrants the portions of a signature are located. If the CRT trace requires adjustment, from the Main menu screen press the **Menu** button to get to the Menu 1 screen. Press **Display** to display the CRT adjustment menu screen.

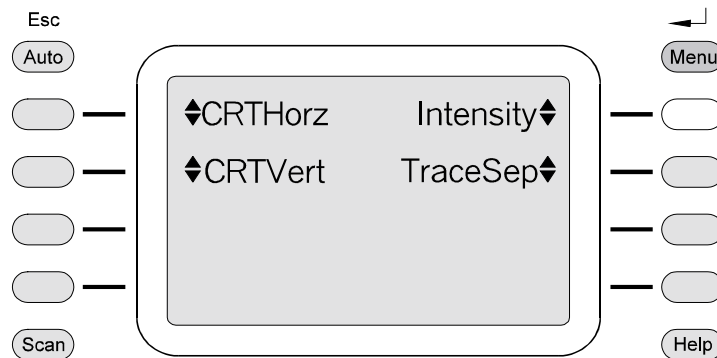


Figure 2-8. Tracker 4000 CRT Adjustment Menu Screen.

Press **Intensity** and rotate the encoder to adjust the CRT trace to a comfortable brightness level.

Press **CRTVert** and rotate the encoder to adjust until the trace is even within the vertical axis.

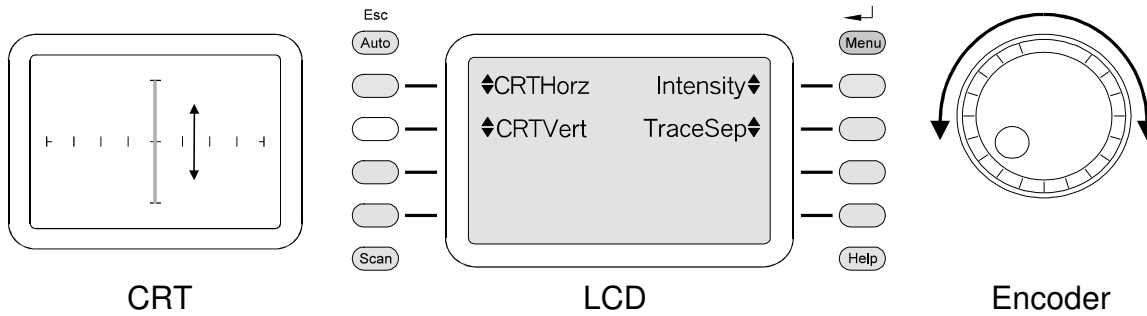


Figure 2-9. Tracker 4000 CRT Vertical Trace Adjustment.

Press **CRTHorz** and use the encoder to adjust until the trace is centered in between the horizontal end marks of the graticule.

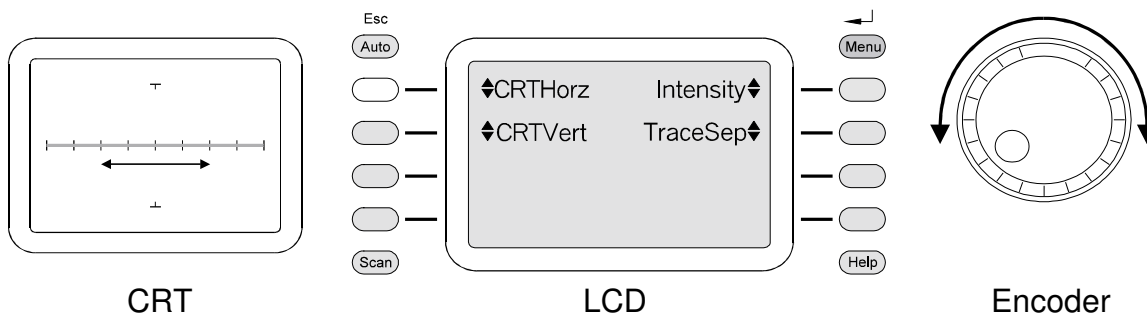


Figure 2-10. Tracker 4000 CRT Horizontal Trace Adjustment.

Press **TraceSep** and rotate the encoder to adjust the space between the two traces on the CRT approximately 1/16 inch is recommended.

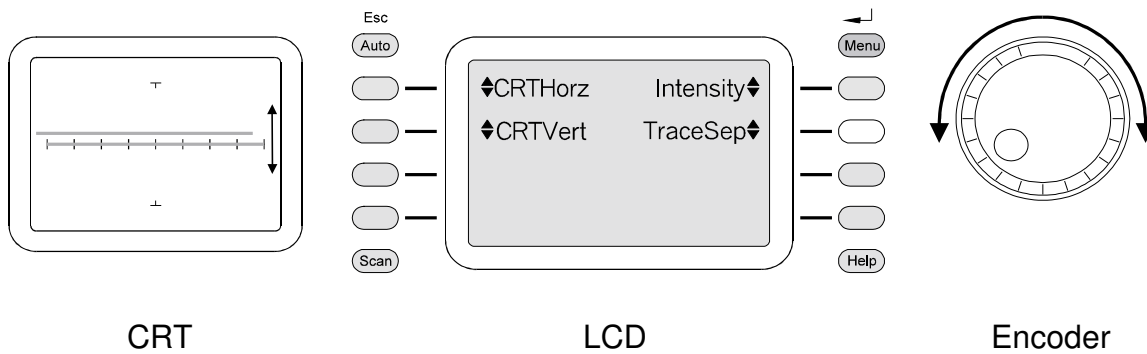


Figure 2-11. Tracker 4000 CRT Trace Separation Adjustment.

Press the **Esc** button to return to Menu 1 screen. Press the **Esc** button again to return to the Main menu screen. Press the **A** button to display channel A. After the CRT has been setup, you should not need to adjust it during normal use.

2-7. MENU SELECTION

The Tracker 4000 has two primary menu selection screens, Main and Menu 1. Press the **Menu** button to toggle between these two menu screens. From these two primary menu screens, you can have direct access to a wealth of Tracker 4000 capabilities.

The Main menu screen displays the ranges on the left side of the screen. Displayed on the right of this screen are the voltage, resistance and frequency components of a range and the access to the pulse generator menu screen.

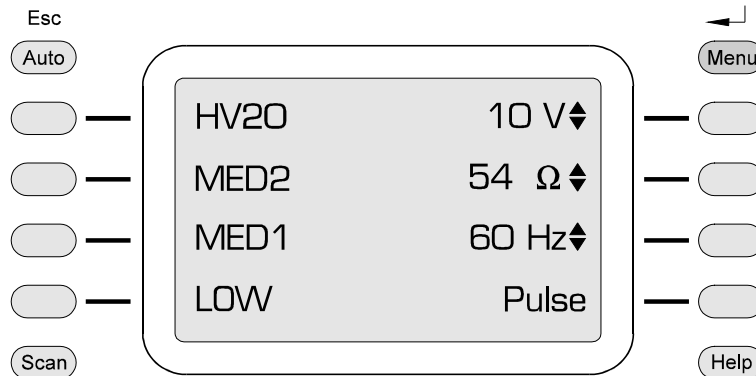


Figure 2-12. Main Menu Screen.

The left side of the Menu1 screen contains control features, Display and Rate, range management features: RangeEdit and GroupEdit. This screen's right side contains features: Prefs and LoopTrim.

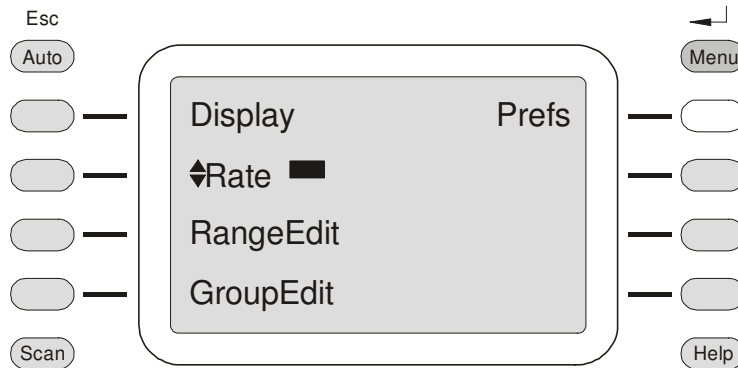


Figure 2-13. Menu1 Menu Screen.

2-8. RANGES

The Tracker 4000 produces various AC (alternating current) sine wave signals to the test probes. Each test signal or range is made up of a specific combination of electrical parameters. Ranges are accessed at the Main menu screen with the soft buttons.

Note:

Soft buttons are the 8 buttons (4 on each side) that are adjacent to the LCD display. These buttons have different actions that can change depending on the current menu screen.

WHAT'S ALL THIS RANGE STUFF ABOUT ANYWAY?

Each range generated by the Tracker 4000 is made up of three parameters, voltage, resistance and frequency. These parameters affect not only how a component's analog signature appears on the Tracker 4000's display but also how descriptive it is. The Tracker 4000 offers maximum adjustability of each range parameter. This enables you to be able to custom tailor a range for a specific component family (i.e., capacitors, TTL logic, CMOS, Low voltage logic, etc.). Also, with this custom tailoring you can screen out unwanted portions of a composite signature (i.e., caps across diodes in power supplies, semiconductor manufacturing differences). This is a very powerful feature of the Tracker 4000 and it is the first instrument of its kind to incorporate this kind of flexibility. Table 2-4 lists the Tracker 4000 ranges.

Table 2-4. Tracker 4000 Test Ranges.

V_s	$R_s (\Omega)$	F_s
200 mV to 800 mV in 200 mV steps 1 V to 20 V in 1 Volt steps	10, 20, 50, 100, 200, 500 1k, 2k, 5k, 10k, 20k, 50k, 100k, 54, 1.24 k, 27.6 k	20 to 190 Hz in 10 Hz steps 200 to 1.9 kHz in 100 Hz steps 2k Hz to 5 kHz in 1 kHz steps

When selecting a test range, the goal is to obtain the best or most descriptive display of the component's analog signature. The Tracker 4000 enables you to do this by allowing you to change any one of these parameters. The V_s source voltage of the test signal is used to either enhance or disregard semiconductor switching and avalanche characteristics. The R_s source resistance or Tracker 4000 internal resistance is used to enhance or disregard the impedance (resistance) of the device or fault to be viewed. The F_s source frequency or frequency of the Tracker 4000 sine wave is used to enhance or disregard the reactive factor (capacitance or inductance) of a component.

Press the soft button beside the range on the LCD Main menu screen to activate. The LED adjacent to it is lit when selected. The range LED will turn off if a range parameter, like Ω is activated. To return to the selected range defaults, press the original range button again.

2-9. RANGE GROUPS

Because the Tracker 4000 can produce a vast number of test ranges, the ranges are organized in groups of four in order to make this powerful feature quick and easy to use. When used properly, the range and group settings can be a powerful tool in quickly finding the good and faulty components from the wide range of electronics in use today. To select a range push a soft button next to a range from the current range group in the Main menu screen. The Tracker 4000 has preconfigured range groups and user range groups.

The preconfigured range groups are designed for use with different types of electronic components. There are six preconfigured groups in your Tracker 4000. They are Factory, Caps, TTL, MOS, SMT and Passive. For example, the Factory range group is general purpose and is intended for analog signature analysis on a wide variety of components. The TTL range group is used when performing ASA troubleshooting on primarily TTL digital logic components.

The Tracker 4000 has 20 user definable range groups. User range groups can have a unique name. You can arrange these user groups so that each group name is descriptive of ranges for a specific component type or an individual user preference. For example, you can assemble a group of ranges that work well when troubleshooting high frequency semiconductors and name it "HFSEMI".

At the Menu1 screen, press the soft button **GroupEdit** to select the GroupEdit menu.

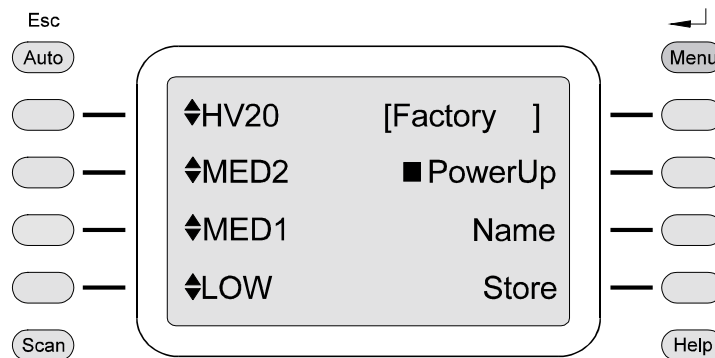


Figure 2-14. GroupEdit Menu Screen.

Press the soft button next to the bracketed [**Group name**] on this screen and rotate the encoder to scroll through the available range groups. The Tracker 4000 is preconfigured to the Factory range group as the default PowerUp group (LOW, MED1, MED2, HV20). These are shown in table 3-2. They are the same as the three lowest ranges available on the Tracker Model 2000. The LOW and MED2 are the same V_S as the LOW and MEDIUM on the Tracker Model 1000. The Tracker Model 1000/2000 HIGH range is not available on the Tracker 4000. The Tracker Model 1000/2000 HIGH range is simulated on the Tracker 4000 by the HV20 range ($V_S = 20\text{ V}$ and $R_S = 100\text{ k}\Omega$ in the Factory group).

Table 2-5. Tracker 4000 Factory Range Group.
(Tracker Model 2000 Equivalent.)

RANGE	SINE WAVE V_s	R_s
HV20	20 V	100 k Ω
MEDium 2	20 V	27.6 k Ω
MEDium 1	15 V	1.24 k Ω
LOW	10 V	54 Ω

2-10. RANGE VOLTAGE SELECTION

The Tracker 4000 has 24 discrete test signal voltages: 200 millivolt to 1 volt in 200 millivolt steps and 1 volt to 20 volt in 1 volt steps. To change the voltage press the **V** button and turn the encoder to select.

2-11. RANGE FREQUENCY SELECTION

The Tracker 4000 has 40 test signal frequencies: 20 Hz to 190 Hz in 10 Hz steps, 200 Hz to 1.9 kHz in 100 Hz steps, and 2 kHz to 5 kHz in 1 kHz steps. To change the frequency press the **Hz** button and turn the encoder to select.

2-12. RANGE RESISTANCE SELECTION

The Tracker 4000 has 13 discrete test signal resistances that are selectable. To change the resistance press the **Ω** button and turn the encoder to select.

2-13. CHANNEL SELECTION

There are two test signal channels in the Tracker 4000, Channel A and Channel B. Located directly below the Tracker 4000's CRT are four dedicated buttons, **Alt**, **A**, **B** and **A+B** to select what channel(s) will be displayed on the CRT.

Before you view an analog signature on the Tracker 4000, make sure that the analog signature is displayed in the correct quadrants on the CRT by following this procedure. When using a single channel, plug the red test probe into the corresponding channel test terminal and plug the black test probe into the common test terminal. When testing solid state or polarity sensitive components, place the red test probe to its positive terminal (i.e., anode, +V, etc.) and place the black probe to its negative terminal (i.e. cathode, -V, ground, etc.).

Push the corresponding channel button, **A** or **B** to view a single analog signature.

Push the **Alt** button below the CRT to enable the Alternate display mode of the Tracker 4000. This mode provides an automatic alternating display of channel A and channel B. It's easy to make a visual comparison of analog signatures for two of the same components or the same node points on two identical circuit boards when in Alt mode. Alternate CRT display mode is one of the most useful features for comparing a known good device with a unknown device of the same type. The alternation frequency is varied by the RATE button in the Menu 1 screen. Refer to figure 2-15 for an example on how to connect your test leads for comparison testing.

The Tracker 4000 also allows the user to view channel A and channel B at the same time by using the A+B mode. Push the **A+B** button (below the CRT) to view both channel A and channel B simultaneously on the CRT.

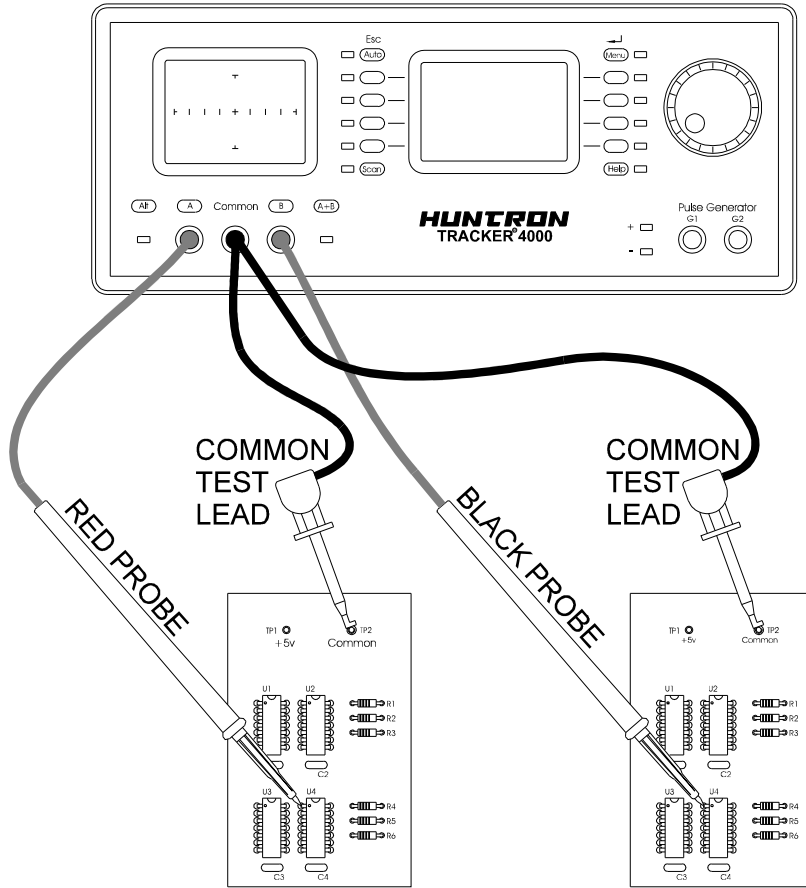


Figure 2-15. Comparison Testing With Alternate And A+B Display Mode.

2-14. PULSE GENERATOR

The built-in pulse generator of the Tracker 4000 allows dynamic, in-circuit testing of three terminal components in their active mode. You simply apply the pulse generator's output to the control input of the component you want to test while applying a test signal from one of Tracker 4000's channels to the component's other two terminals. The pulse generator has dual tracking outputs (G1 and G2) so that you can visually compare the analog signatures of two of these three terminal components by using the Alt or A+B mode. The following figure illustrates how to connect the Tracker 4000 when using the pulse generator. Refer to Section 5-2 and 5-3 for more detailed information on how to use this feature.

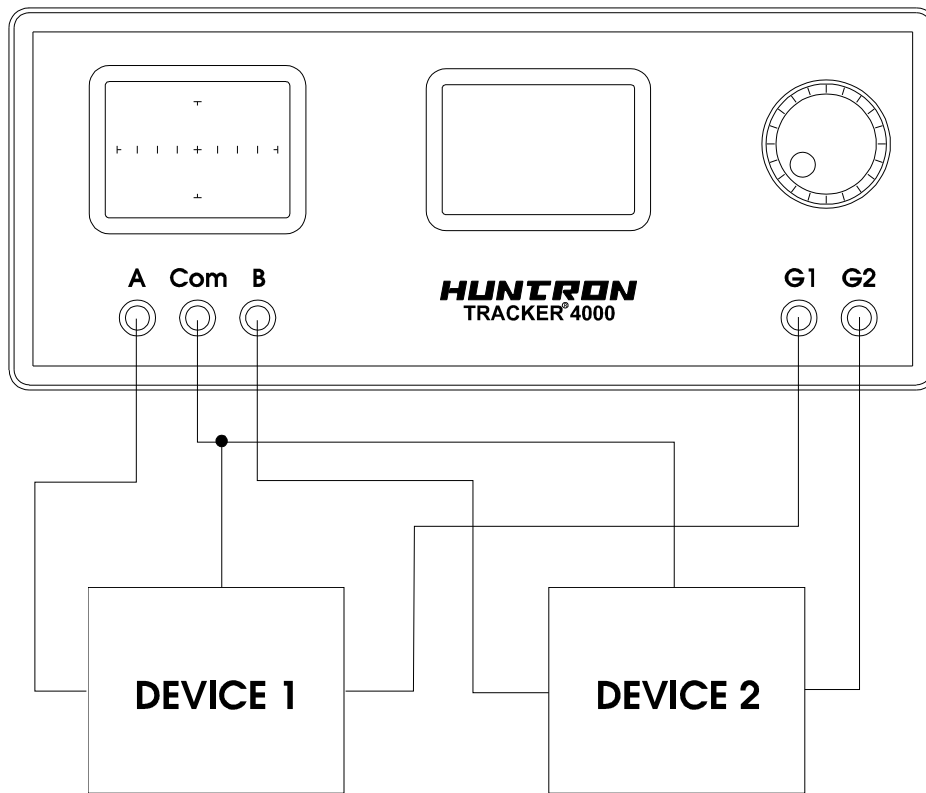


Figure 2-16. Comparison Test With The Pulse Generator.

Notes:

SECTION 3

USING YOUR TRACKER 4000

3-1. INTRODUCTION

Electronic troubleshooting is a skilled art, based largely on logical deduction, experience and intuition. The Huntron Tracker 4000 uses Analog Signature Analysis or ASA to take full advantage of a technician's skills. ASA is the examination of the current versus voltage characteristic of a component under power-off conditions for the purpose of troubleshooting. The component's analog signature is displayed for visual analysis and indicates its relative health and condition. For solid state components, ASA enables you to visualize component leakage and substrate damage that is difficult to find with conventional test methods.

With ASA, you can troubleshoot components without applying power, saving circuits from possible further damage. By comparing the signatures of a questionable component with those of a known-good component, you can quickly locate failed and marginal components in most cases. You can troubleshoot and quickly find problems on circuit boards even if there is no schematic.

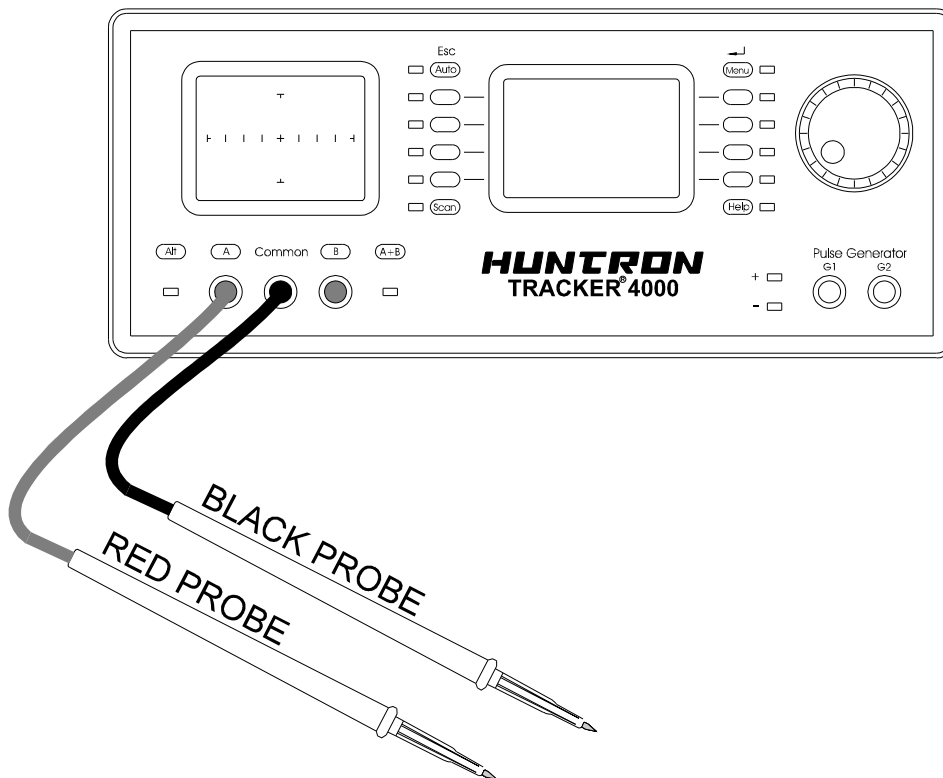


Figure 3-1. Tracker 4000 With Test Probes.

3-2. BASICS OF ASA - HOW IT WORKS

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

The Tracker 4000 outputs a precision current-limited AC sine wave signal to a component and displays the resulting current flow, voltage drop and any phase shift on its CRT. The current flow causes a vertical trace deflection on the CRT display, while the voltage across the component causes a horizontal trace deflection. This resultant trace on the CRT is called an analog signature.

Understanding the Tracker 4000's basic Tracker core circuit is the key to understanding how analog signatures respond to different types of components. Since the induced current is a function of the impedance of the circuit, the analog signature displayed can be thought of as a visual representation of Ohm's Law,

$$V = IR$$

where V = voltage, I = current and R = resistance

The next figure shows a simplified diagram of the Tracker core circuit. The sine wave generator is the test signal source and is connected to a resistor voltage divider made up of R_S and R_L . The load impedance, R_L , is the impedance of the component under test. R_L is in series with the Tracker 4000's internal or source impedance R_S . Because R_S is constant, both the voltage across the component under test and the current through it is a function solely of R_L .

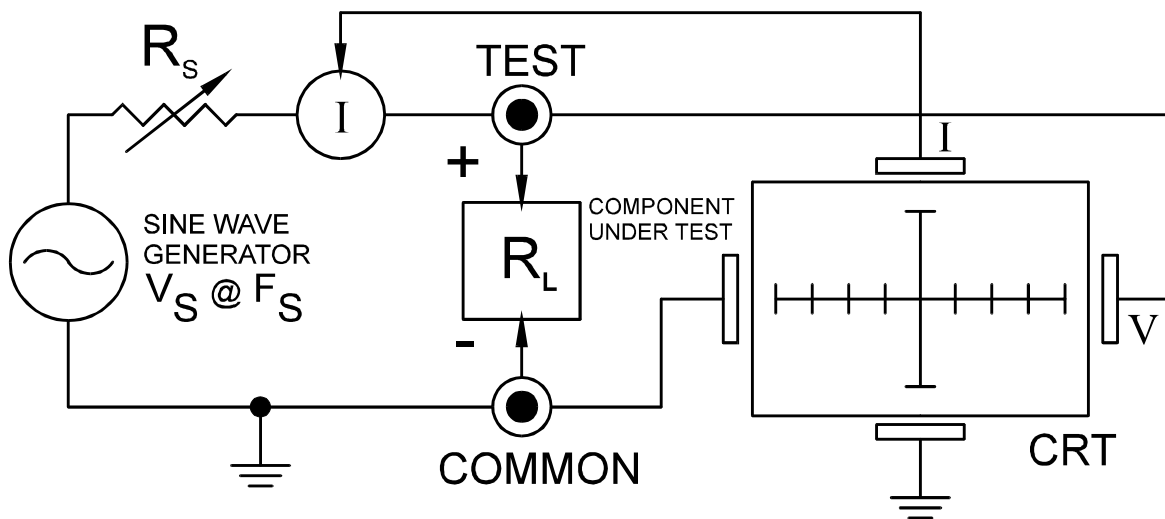


Figure 3-2. Tracker Core Circuit Block Diagram.

R_S = Source Resistance, V_S = Source Voltage, R_L = Load Resistance, F_S = Source Frequency.

Each test signal or range has three parameters: source voltage V_s , source resistance R_s , and source frequency F_s . When using ASA for troubleshooting, the objective is to select the range that will display the most descriptive analog signature information.

The Tracker 4000 can readily accomplish this by changing the proper range parameter. The V_s or source voltage of the test signal can be used to enhance or disregard semiconductor switching and avalanche characteristics. The R_s or internal test signal source resistance can be used to enhance or disregard the impedance (resistance) of the device or fault to be viewed. The F_s or frequency of the test signal source can be used to enhance or disregard the reactive factor (capacitance or inductance) of a component.

3-3. HORIZONTAL AXIS

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

The horizontal axis is divided up by small graticule lines similar to those on a conventional oscilloscope. Each mark is approximately 1/4 of the peak range voltage. In LOW range (Factory Group), for example, since $V_s = 10$ V peak, each division is approximately 2.5 V. You can use these graticule marks to get a rough estimate of the voltage drop across the component under test R_L .

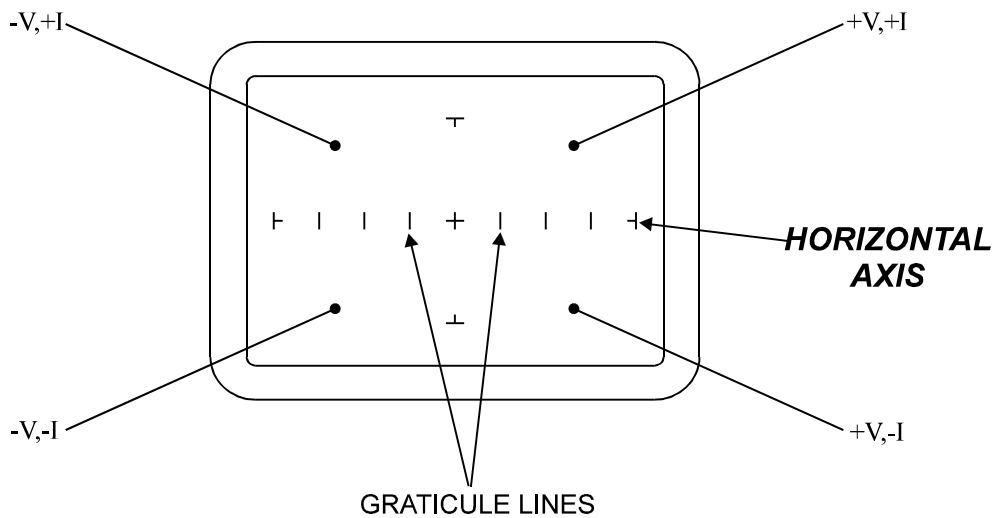


Figure 3-3. Tracker 4000 CRT Display Horizontal Axis And Graticule Lines.

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

Turn on the Tracker 4000 and observe the CRT display. With nothing connected to its test terminals, the CRT trace is a horizontal line (that is, $R_L = \infty$).

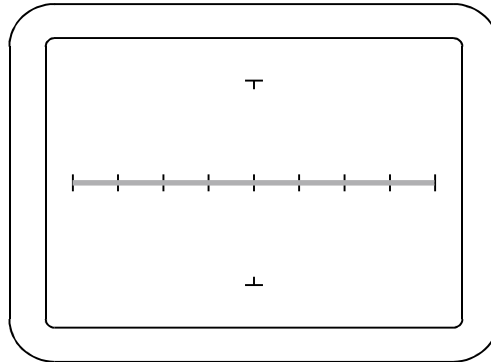


Figure 3-4. Tracker 4000 CRT Display With Open Test Terminals.

3-4. VERTICAL AXIS

The amount of vertical trace deflection on the CRT is controlled by the voltage dropped across the internal impedance R_s of the Tracker 4000. Because R_s is in series with the load R_L , this voltage will be proportional to the current flowing through R_L . This current that flows through the component under test is the vertical part of the analog signature.

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

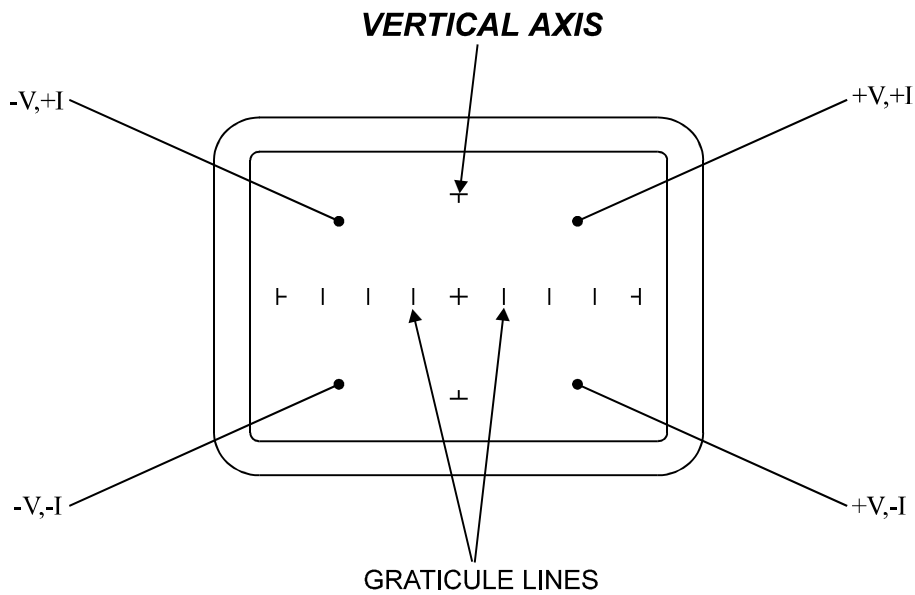


Figure 3-5. Tracker 4000 CRT Display With Vertical Axis And Graticule Lines.

Connect the red microprobe to the output channel A jack on the Tracker 4000 and the black microprobe to the Common jack.

Touch and hold the probes together and observe the analog signature on the CRT.

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

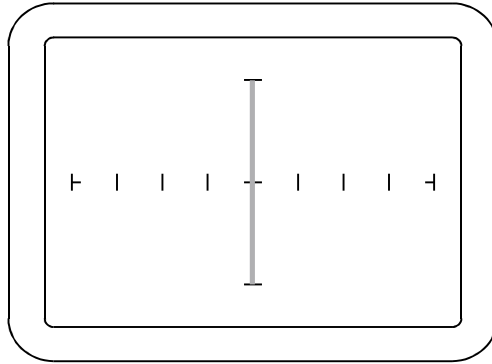


Figure 3-6. Tracker 4000 CRT Display With Short Circuit Signature.

3-5. BASIC ANALOG SIGNATURES - OPEN AND SHORT

In ASA, the two most basic analog signatures are the open and the short. The open signature occurs when an output terminal is not connected to anything. The short signature occurs when an output terminal is directed connected to the common terminal. In the following figures, the upper screen represents the Tracker 4000's CRT and the lower screen is a graphical plot of the sine wave test signal at the output terminal showing its current and voltage relationship. The current and voltage graphical plots are for illustration only and cannot be displayed on Tracker 4000's CRT.

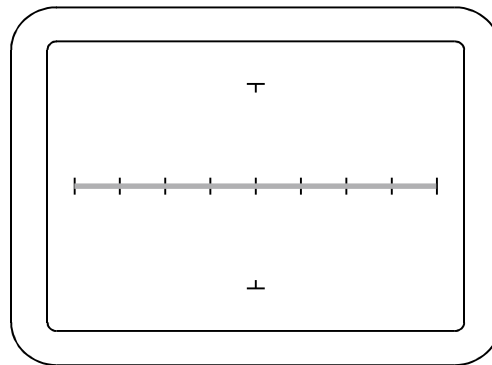


Figure 3-7. "OPEN" Analog Signature On CRT Display (Horizontal Line).

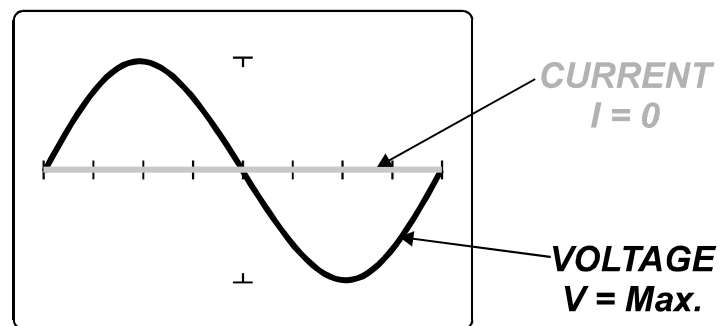


Figure 3-8. Test Signal (Open Circuit) With Current And Voltage Waveforms. Minimum Current And Maximum Voltage

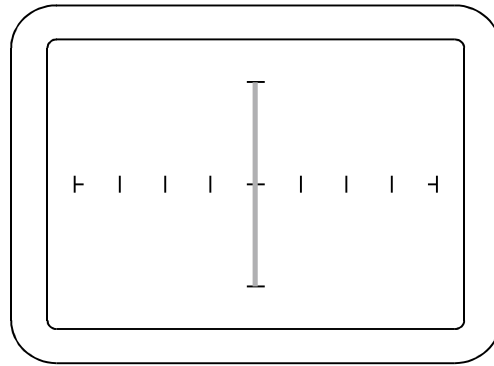


Figure 3-9. "SHORT" Analog Signature On CRT Display (Vertical Line).

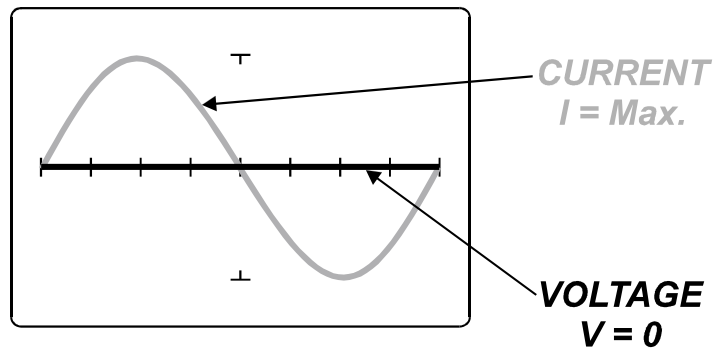


Figure 3-10. Test Signal (Short Circuit) With Current And Voltage Waveforms. Maximum Current And Minimum Voltage

3-6. FOUR BASIC COMPONENT ANALOG SIGNATURES

All analog signatures are a composite of one or more of the four basic component signatures which are: resistance, capacitance, inductance and semiconductor. Each one of these basic components responds differently to Tracker 4000's test signal, so recognizing these four basic unique signatures on the CRT display are one of the keys to successful ASA troubleshooting. When components are connected together to form a circuit, the signature at each circuit node is a composite of the basic component signatures in that circuit. For example, a circuit with both resistance and capacitance will have a signature that combines the analog signatures of a resistor and capacitor. The signature of a resistor is always indicated by a straight line at an angle from 0 to 90 degrees. The signature of a capacitor is always in the form of a circle or ellipse shape. The signature of an inductor is also a circle or ellipsoid shape, that may also have internal resistance. Finally, the semiconductor diode signature is always made up of two or more linear line segments that most of the time form an approximate right angle.

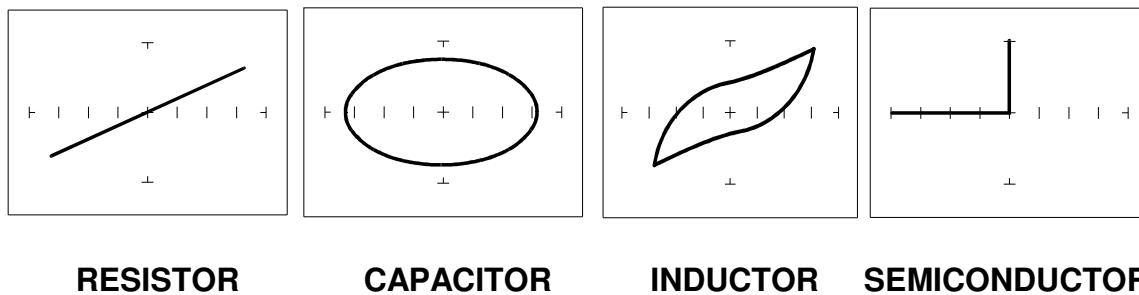


Figure 3-11. Analog Signatures Of 4 Basic Components.

3-7. TRACKER 4000 FACTORY RANGE GROUP

The Tracker 4000 is set up so that the ranges are organized in permanent and user selectable groups, with four ranges per group. The Tracker 4000 has four permanent preconfigured ranges called the Factory group. This range group is the power-on default group and is shown in table 3-1.

Note:

The test ranges are the same as the three base ranges of the Tracker Model 2000. The LOW and MED2 are the same V_S as the LOW and MEDIUM ranges on the Tracker Model 1000/2000. The Tracker Model 1000/2000 HIGH range is not present in the Tracker 4000. The HIGH range can be simulated at $V_S = 20$ V with $R_S = 100$ k Ω and is placed above the MED2 range in the Factory group.

Table 3-1. Tracker 4000 Factory Range Group (Default).

RANGE	V_S (PEAK)	R_S
HV20	20 V	100 k Ω
MEDium2	20 V	27.6 k Ω
MEDium1	15 V	1.24 k Ω
LOW	10 V	54 Ω

3-8. RANGE EDITING

Once an effective range setting is determined, the Tracker 4000 allows you to save it. The Tracker 4000 features include editing and storing of 100 user definable ranges. To customize a range, press the **Menu** button from the Main menu and go to the Menu1 screen. Press the **RangeEdit** button to select the RangeEdit screen.

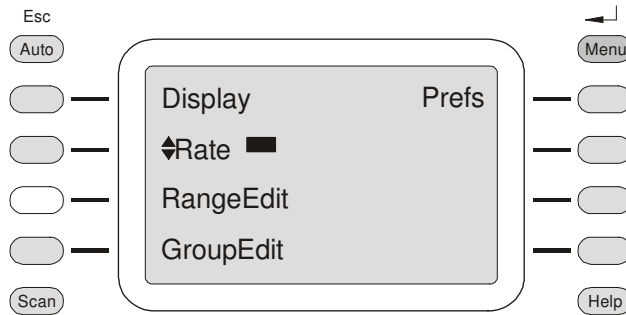


Figure 3-12. Menu1 Screen With RangeEdit Button Selected.

The RangeEdit screen shows the current range, voltage, resistance and frequency parameters. In addition, the RangeEdit screen also has **Name** which is used for changing the range name and **Store** which saves the range name and parameters in nonvolatile memory.

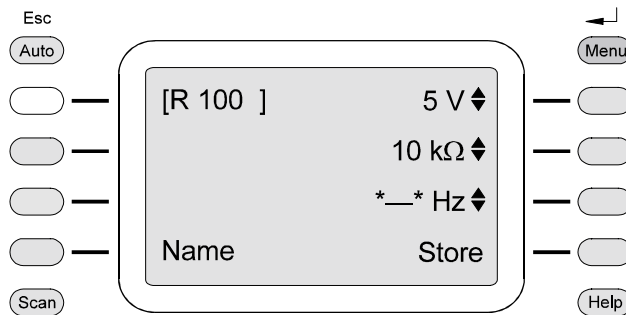


Figure 3-13. RangeEdit Screen.

Note:

You cannot edit or save any of the Factory preprogrammed ranges.

To create and save a new user range, push the **[range]** button and rotate the encoder to choose a user range location (R001 - R100). Change the range parameters by selecting each parameter (voltage, resistance, or frequency) and use the encoder to set a new value.

Note:

If the current range is a Factory preprogrammed range, then pressing the **[range]** button will display a user-defined range [R 100].

If you wish give this custom range a unique name, press the **Name** button to go to the RangeEdit Name screen.

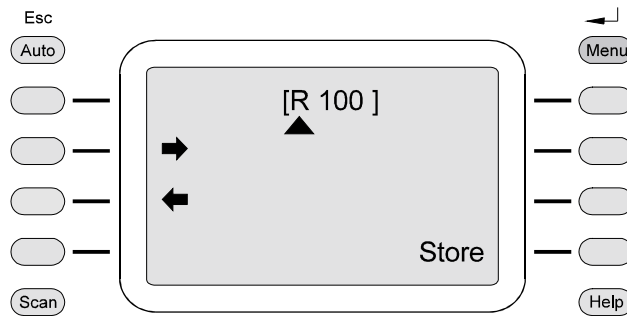


Figure 3-14. RangeEdit Name Screen.

Each range name can have up to five characters. Rotate the encoder to select a character and press the ← or → buttons to move to each character position. Press the **Store** button to save the range name and return to the RangeEdit screen. Next, press the **Store** button to save this custom range then press **Esc** to return to the Main menu screen.

For example, to save a custom range name "AMUX6" with parameters of 6 volts, 20 kΩ and 200 Hz, press the **RangeEdit** button in the Menu1 screen to enter the RangeEdit screen. Next, press the **[range]** button and rotate the encoder to choose a user range location. Press the **V** button (voltage parameter) and rotate the encoder to set the voltage to 6 volts. Press the **Ω** button (resistance parameter) and rotate the encoder to set the resistance to 20 kΩ. Press the **Hz** button (frequency parameter) and rotate the encoder to set the frequency to 200 Hz.

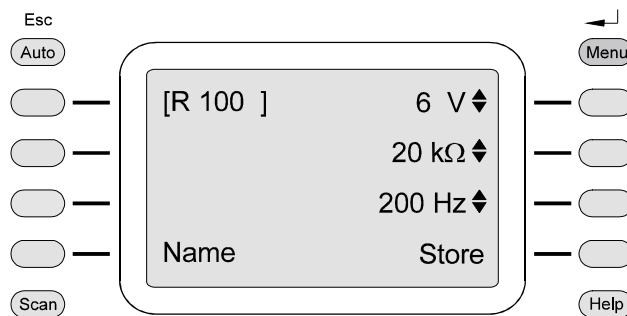


Figure 3-15. RangeEdit Custom "AMUX6" Range.

Press the **Name** button and using the encoder and the ← and → arrow buttons to enter "AMUX6" for the range name.

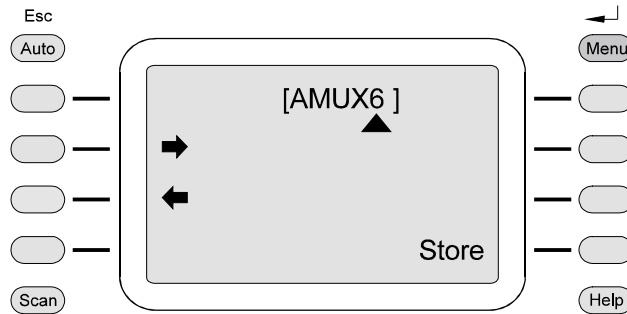


Figure 3-16. RangeEdit Name Screen Example.

Press **Store** to save the range name, and then to finish, press the **Store** button to store this custom range.

WHAT'S ALL THIS STUFF ABOUT "*"-" FREQUENCY ABOUT ANYWAY?

In the Tracker Model 2000 (Tracker 4000's predecessor), each test range by definition is a fixed voltage and resistance combination. Frequency is not in the Model 2000 range definition. The Model 2000 has a single range group of four voltage/resistance ranges and are selected by individual buttons. It also has separate buttons to select different test frequencies. Therefore, a Model 2000's range group is essentially frequency independent. For example, you can set the test frequency to 400 Hz and each time a range button is pressed to select a new voltage/resistance combination, it will use this test frequency for the entire range group.

In contrast, the Tracker 4000 allows a range to be defined by a fixed voltage, resistance and frequency combination, therefore a custom user range can involve all three parameters. A user range group could consist of four ranges that each has different test frequencies.

The Tracker 4000 also can operate like a Model 2000 so that a user range can be a fixed voltage and resistance combination without defining the frequency parameter. This Model 2000-like operation is the Tracker 4000's default mode. The Tracker 4000 uses the undefined frequency feature for all of its Factory ranges. So every test frequency change affects all ranges in the each of the Factory range groups.

A user range with an undefined frequency, "*"-" selection means that when this range is selected at the Main menu screen, it will use the current frequency selection. The current frequency is not changed by this user range selection.

For example, if the R100 user range's frequency = *-* and the current frequency = 60 Hz, then when R100 is selected, the Tracker 4000's frequency remains set to 60 Hz. If the current frequency is changed using the encoder in the Main menu, then R100 will follow the current frequency.

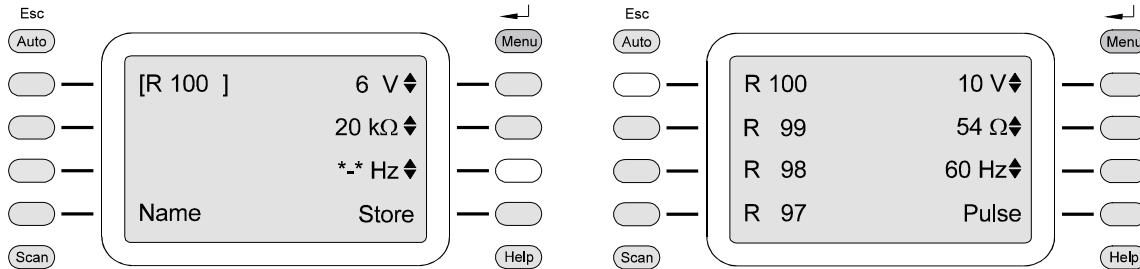


Figure 3-17. User Range With Frequency = *-* (Undefined).

On the other hand, if a user range has a defined frequency, then selecting this range will force the Tracker 4000 to change to the defined frequency. For example, the R100 user range frequency = 200 Hz and the current frequency = 60Hz.

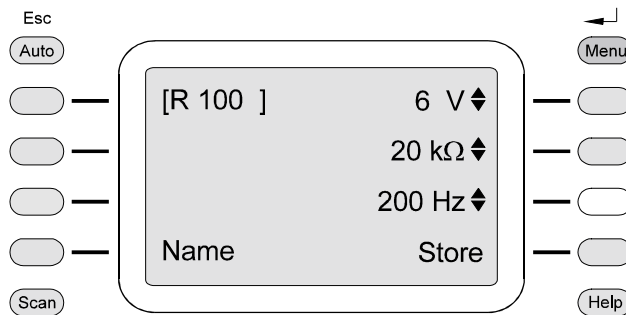


Figure 3-18. User Range With Frequency = 200 Hz (Defined).

When R100 is selected, the current test frequency will change from 60 Hz to 200 Hz.

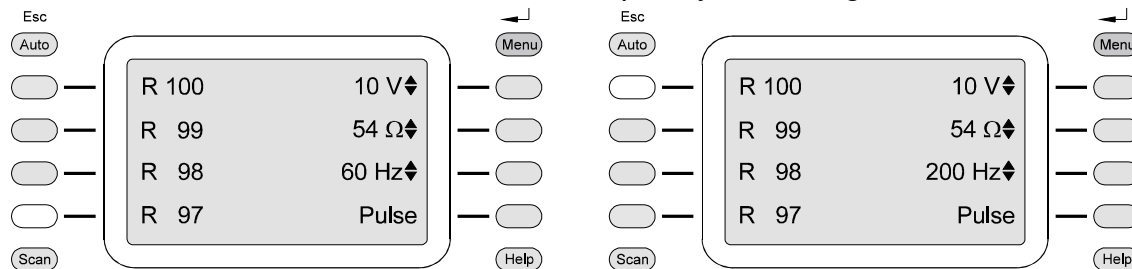


Figure 3-19. User Range With Frequency = 200 Hz (Selected).

If the current frequency = 200 Hz and is changed using the encoder in the Main menu, then the frequency will revert back to 200 Hz when R100 is selected.

3-9. RANGE GROUP EDITING

Tracker 4000's test ranges are organized in groups of four so this feature is quick and easy to use. When used properly, the range and group settings can be a powerful tool in quickly finding the good and faulty components from the wide range of electronics in use today. The Tracker 4000 has 20 User definable range groups. User range groups can have a unique name. You can arrange these user groups so that each group name is descriptive of ranges for a specific component type or an individual user preference.

For example, here's how to assemble a custom user group of test ranges. At the Menu1 screen, press the soft button **GroupEdit** to select the GroupEdit menu.

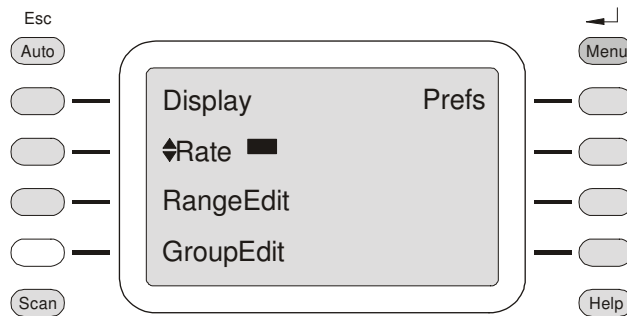


Figure 3-20. Menu1 With GroupEdit Selection.

Press the soft button [**Group name**] and use the encoder to scroll through the available user range groups. Choose [Group01] for this exercise and press the soft button adjacent to this selection.

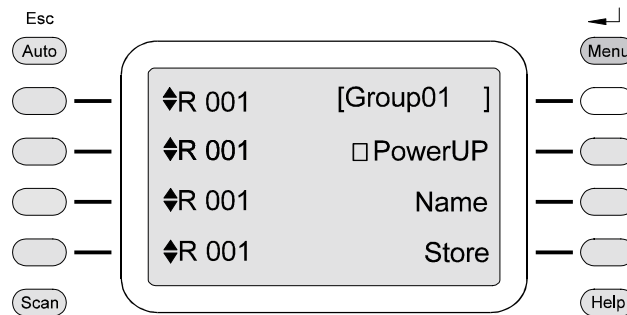


Figure 3-21. GroupEdit Screen With Group01 Example.

Press the **Name** button to get to the Group Name screen and edit "Group01" to "FastLogic" using the encoder to select each character and the arrow buttons ← and → to change character positions. Each Group Name can be up to 9 characters.

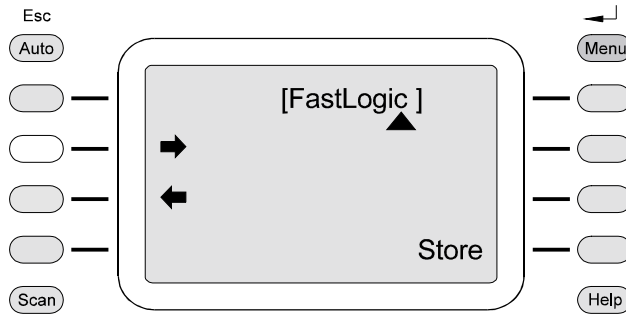


Figure 3-22. GroupEdit Name Screen With "FastLogic" Example.

When finished, press the **Store** button to save the new name and return back to the GroupEdit screen. Next, select the ranges you want to be included in the FastLogic group. Press a **[range]** button and use the encoder to select the desired range. Repeat this step for the rest of the ranges in the group. When all four ranges have been selected, press the **Store** button to save your custom range group.

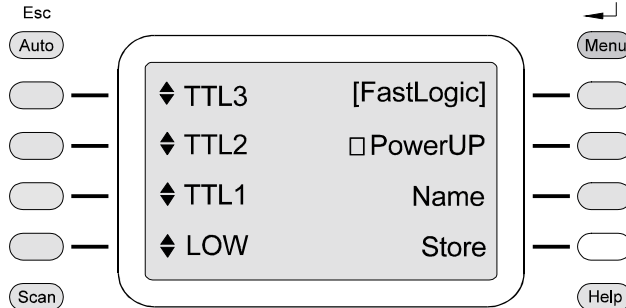


Figure 3-23. GroupEdit Screen Example.

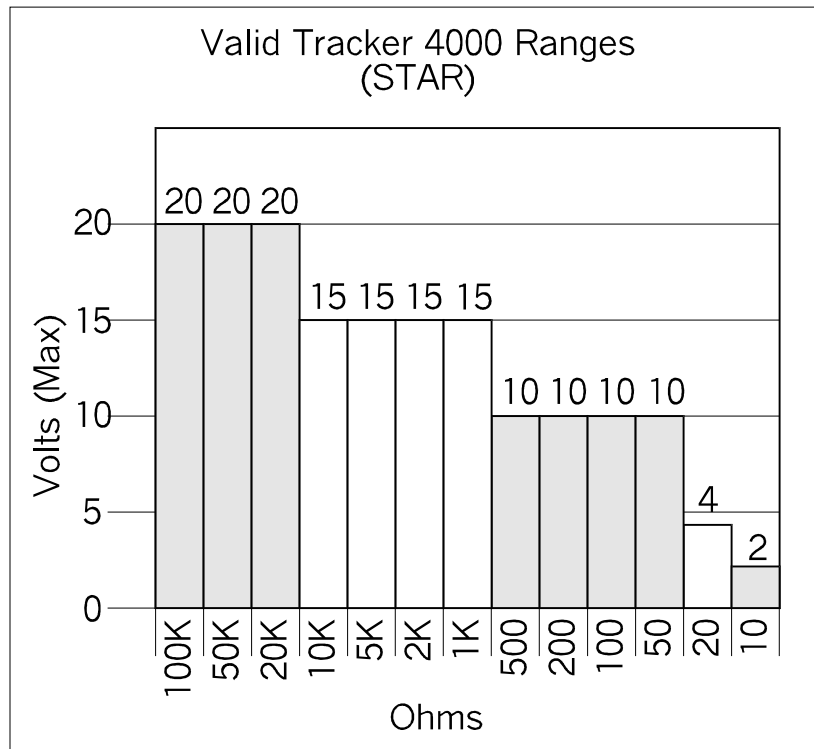
Press the **Menu** button to return to the Main screen.

3-10. RANGE FEATURE: STAR AND MAXV

Two advanced and exclusive features of the Tracker 4000's ASA are the Smart Tracker Active Range (**STAR**) and the **MaxV** (Maximum Voltage) feature. Both these features prevent components from being inadvertently exposed to possibly excessive test signals (for example, 20 Volts and 10 ohms). The STAR settings were derived from previous Tracker ranges that have proved to be dependable over the last two decades. The Tracker 4000's MaxV feature is an additional built-in test safeguard and is user definable.

The Tracker 4000's STAR feature is always enabled and cannot be disabled. The STAR feature is designed to limit the maximum power of any test range available at the Tracker 4000's output terminals. This feature ensures that especially for special types of power sensitive solid state components, the test range parameters cannot be set to any combination that might overpower the component under test.

Table 3-2. Tracker 4000's STAR Feature.



The MaxV feature is an additional ASA safeguard allows you to globally limit the Tracker 4000's test signal voltage. This feature is primarily intended for test applications that may have voltage sensitive components and will prevent unintentional overvoltage conditions. When MaxV is activated, a "limited" range will be displayed with a tilde "~" character in front of the range name. For example, a "~HV20" range, means that normal HV20 range is altered from it's default 20 Volt to MaxV 3 Volt setting.

To activate MaxV, press the **Prefs** button on the Menu1 screen.

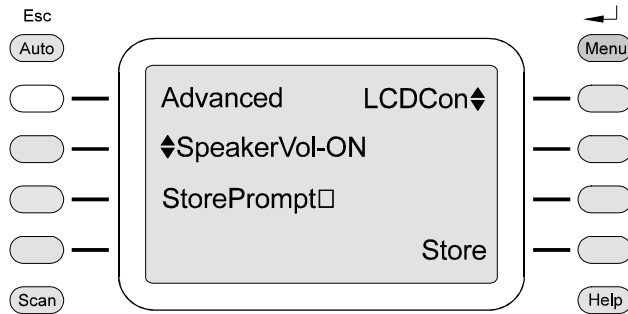


Figure 3-24. Prefs Screen With Advanced Selection.

Then, press the **Advanced** button to display the Advanced menu screen. At the Advanced menu screen, press the **MaxV** button and use the encoder to select the desired voltage.

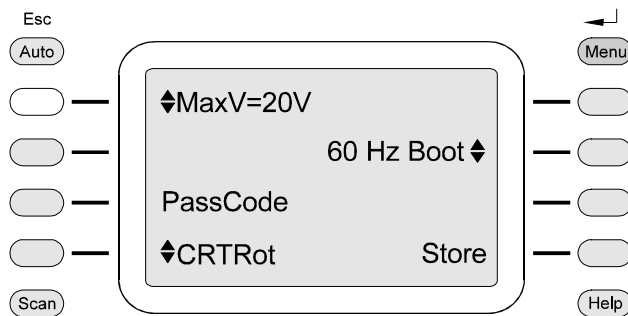


Figure 3-25. Advanced Screen With MaxV Selection.

Once you have selected the MaxV voltage, press the **Store** button in the same Advanced menu screen to save and then press the **Menu** button to return to the Main menu screen.

SECTION 4

TESTING PASSIVE COMPONENTS

4-1. RESISTORS

Exploring how the Tracker 4000 ranges interact with different resistance values is a good introduction on how basic ASA troubleshooting is applied. This section will briefly familiarize you with Tracker 4000 basic operation and teach you how resistor signatures relate to both test range and the resistance of the circuit under test. After completing this section, you will know how to:

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

As you go through the following section, make a mental note on the relationship between the Tracker 4000's test range parameters: voltage, resistance and frequency.

Turn power on to your Tracker 4000. Put the red test lead in the **A** jack, and the black test lead in the **Common** jack.

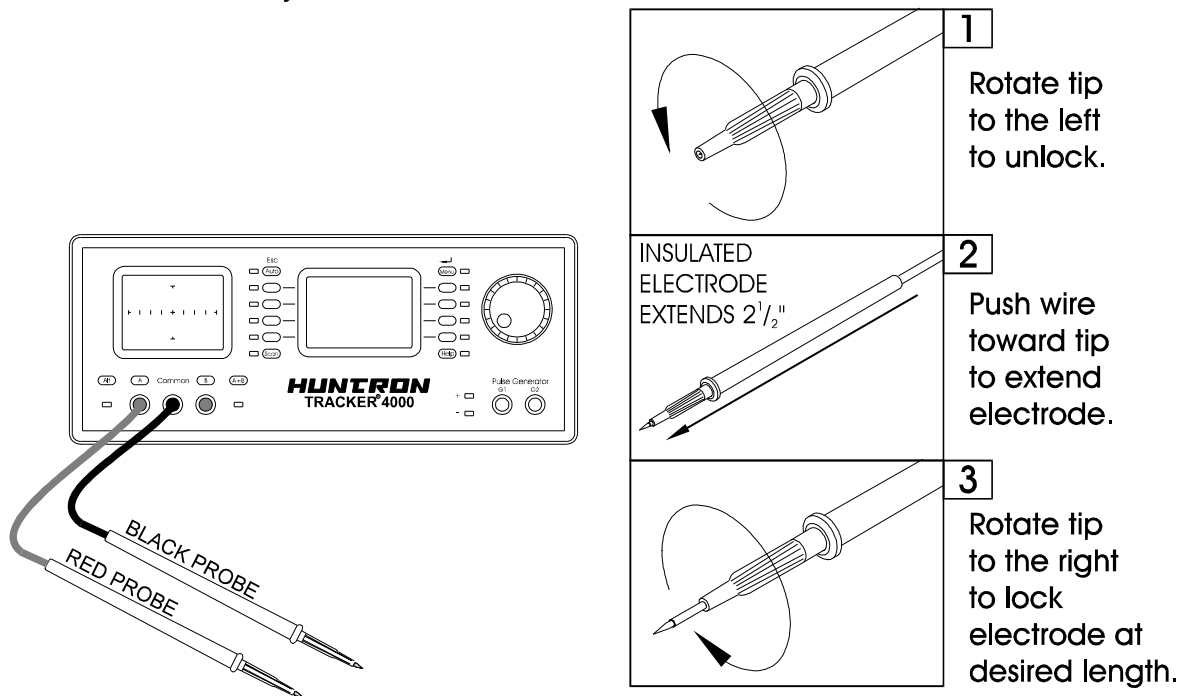


Figure 4-1. Tracker 4000 With Test Probe Leads And Probe Adjustment.

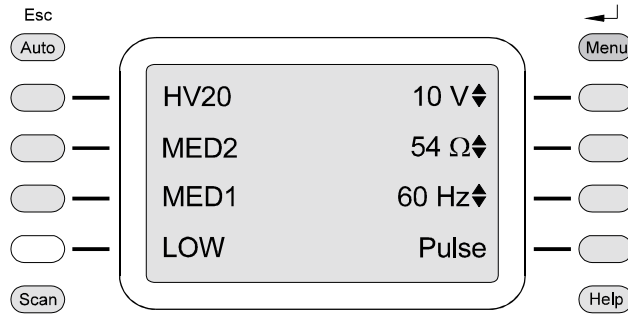


Figure 4-2. Tracker 4000 Main Menu Screen With Factory Defaults.

To display the analog signature of a resistor:

1. Press the **LOW** range button (Factory Group) in the Main Menu screen.
2. The yellow **LED** will be on next to the LOW range once activated.
3. Place or clip a test lead on the opposite ends of a resistor and observe the signature on the Tracker 4000 CRT display.

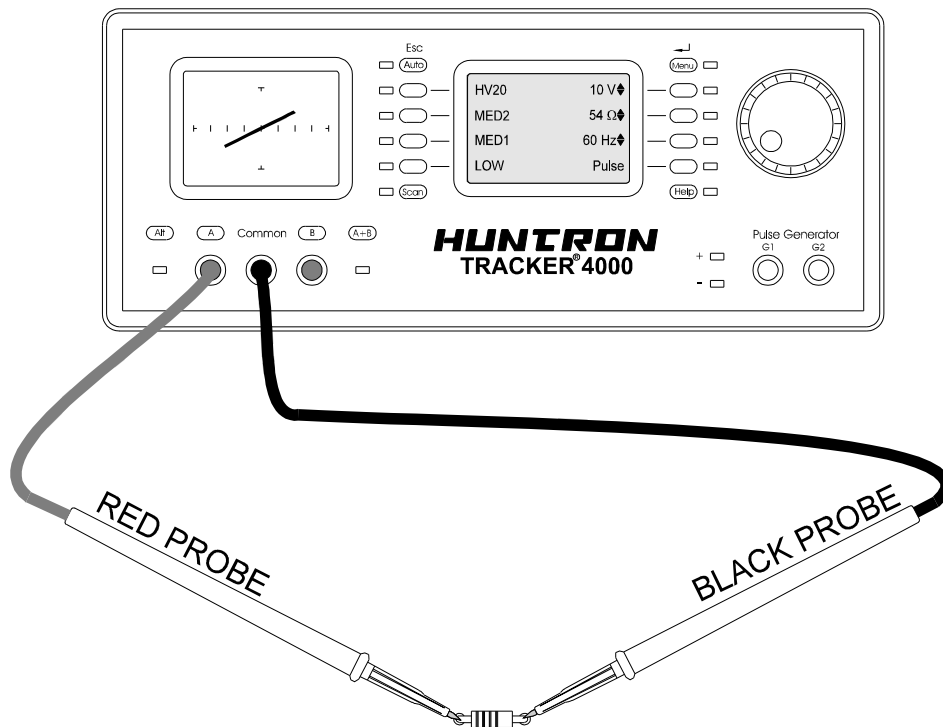
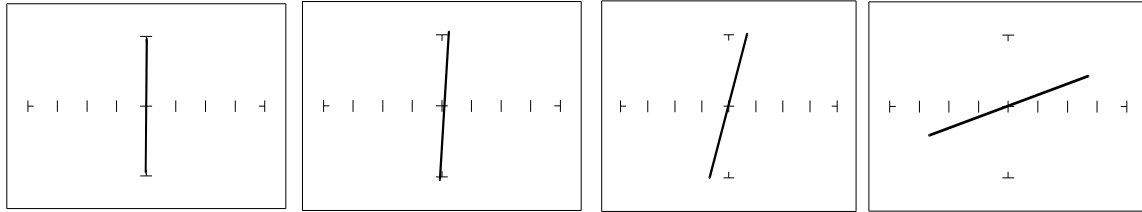


Figure 4-3. Tracker 4000 Connected To A Resistor.

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



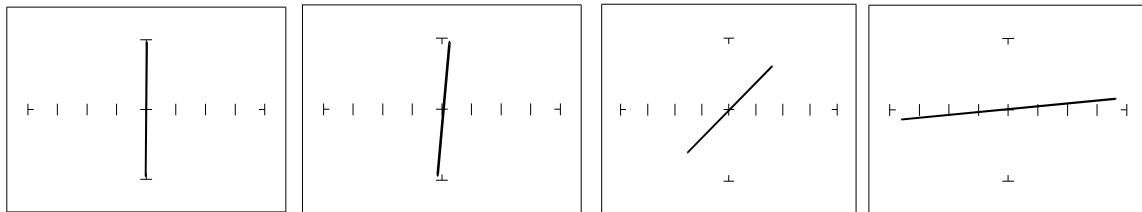
150 Ω

1.5 kΩ

15 kΩ

150 kΩ

HV20 Range (RS=100 kΩ)



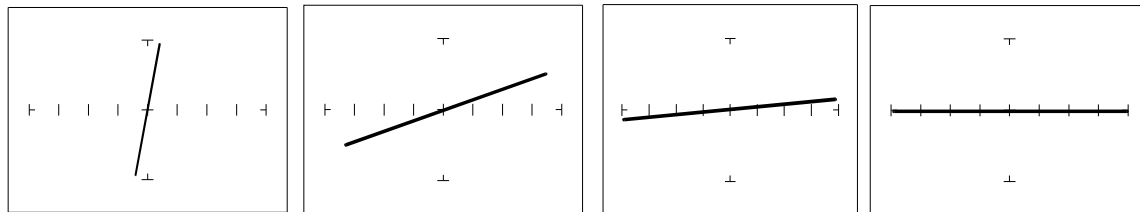
150 Ω

1.5 kΩ

15 kΩ

150 kΩ

MED2 Range (RS=27.6 kΩ)



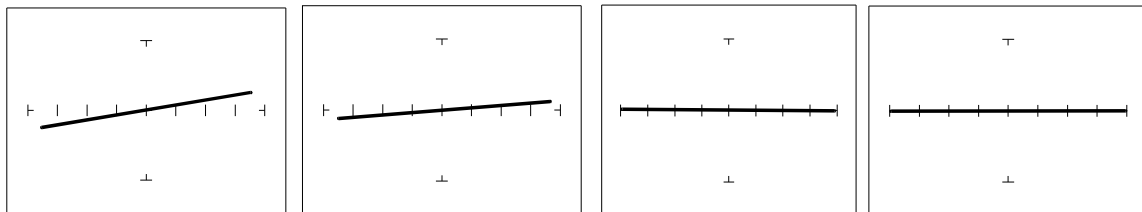
150 Ω

1.5 kΩ

15 kΩ

150 kΩ

MED1 Range (RS=1.24 kΩ)



150 Ω

1.5 kΩ

15 kΩ

150 kΩ

LOW Range (RS=54 Ω)

Figure 4-4. Signatures Of Different Resistors In Factory Range Group.

Now that you have an idea of what the signatures of different resistor values look like in different ranges, the next part will give you an idea of what happens when you vary R_S source resistance, V_S source voltage and F_S source frequency of the Tracker 4000 and how it affects the resistive analog signature.

The Affect of R_S on Resistor Analog Signatures.

Press the **LOW** range button in "Factory" group. To vary R_S press the **54 Ω** button. The resistance value will change to 50 Ω . Turn the encoder to change the value of R_S .

Observe the signatures for a 150 ohm resistor in the figure below as R_S varies. Note how these resistor signatures respond to changing Tracker 4000's internal resistance.

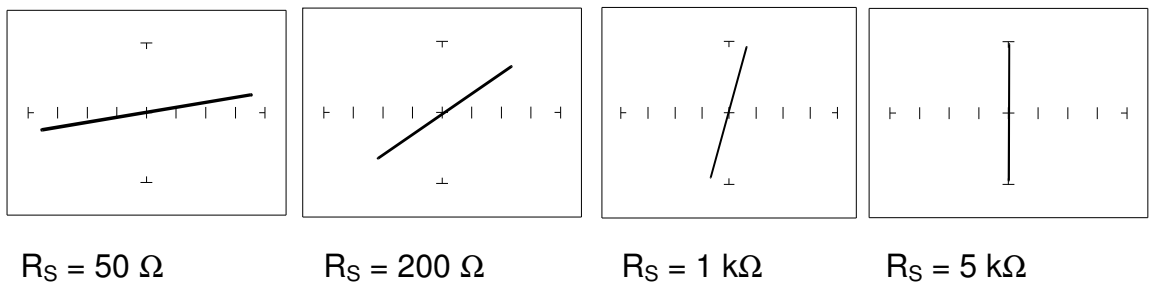


Figure 4-5. Affect Of Varying R_S On A Resistor Signature.
 LOW Range, $R_L = 150 \Omega$

Note that once you change the R_S , the active range's yellow range LED is turned off. This means that the LOW range fixed default parameters has changed and may no longer be current.

The Affect of V_S on Resistor Analog Signatures.

Press the **LOW** range button again to re-establish the Factory range LOW. Press the **10V** button and rotate the encoder to vary V_S the test range's output voltage. Note that once you press the (**10V** button) V_S the yellow range LED is extinguished. This tells you that this is not the LOW (factory group) fixed range any more. The Tracker 4000 also changes the R_S value from 54Ω to 50Ω .

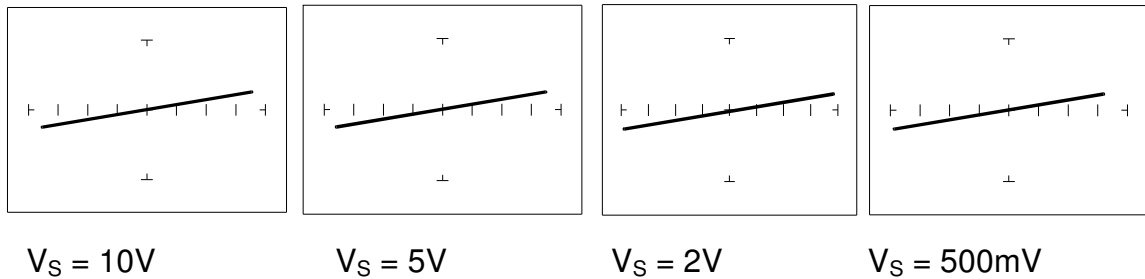


Figure 4-6. Affect Of Varying V_S On A Resistor Signature.
LOW Range, $R_L = 150 \Omega$

Observe that these signatures do not change with the changing voltage. Note that V_S cannot be set above 10V because R_S is set to a value of 50Ω . This limit on range parameter combinations is a result of the Tracker 4000's STAR feature, it protects components from possible excessive power (see section 3-11). 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.

Press **LOW** again to re-establish the “factory group” LOW. Press the **Hz** button and then use the encoder to vary the test range frequency F_S . Observe the resistor signatures in the following figures do not change as F_S changes. To re-establish the frequency, you have to manually return the setting with the encoder.

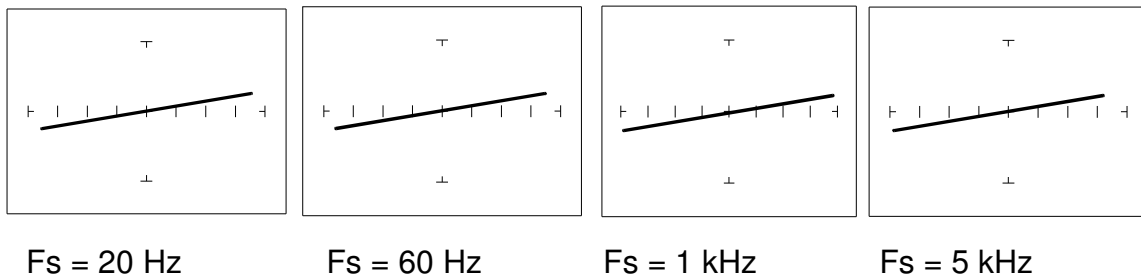


Figure 4-7. Affect Of Varying F_S On A Resistor Signature.
LOW Range, $R_L = 150 \Omega$

UNDERSTANDING RESISTIVE SIGNATURES

The Tracker 4000's signature is a visual representation of Ohm's Law in the circuit under test. The amount of voltage applied to the circuit is shown along the horizontal axis, and the resultant current is shown along the vertical axis. The signature is a straight line because the relationship between voltage and current in a purely resistive circuit is linear. The slope changes as we change the internal resistance of the Tracker 4000.

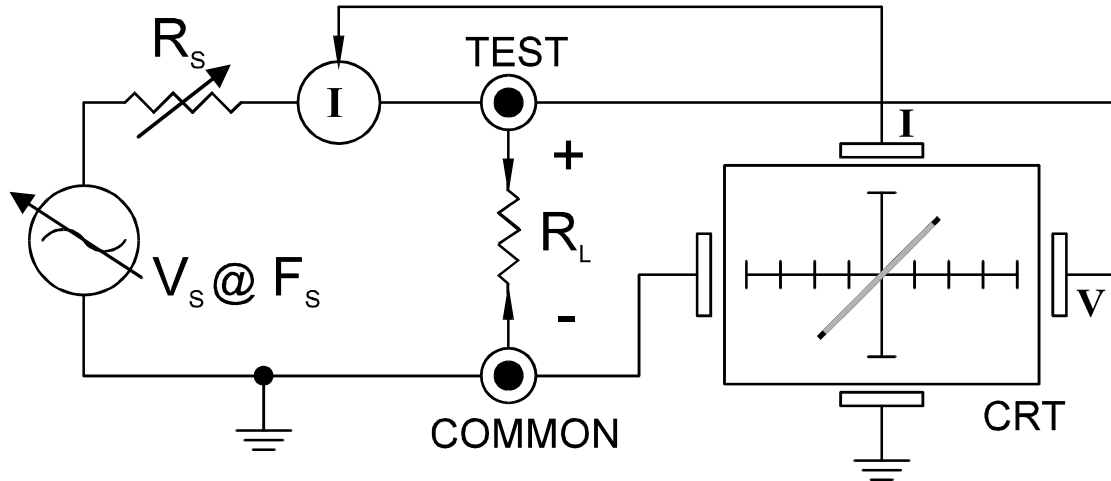
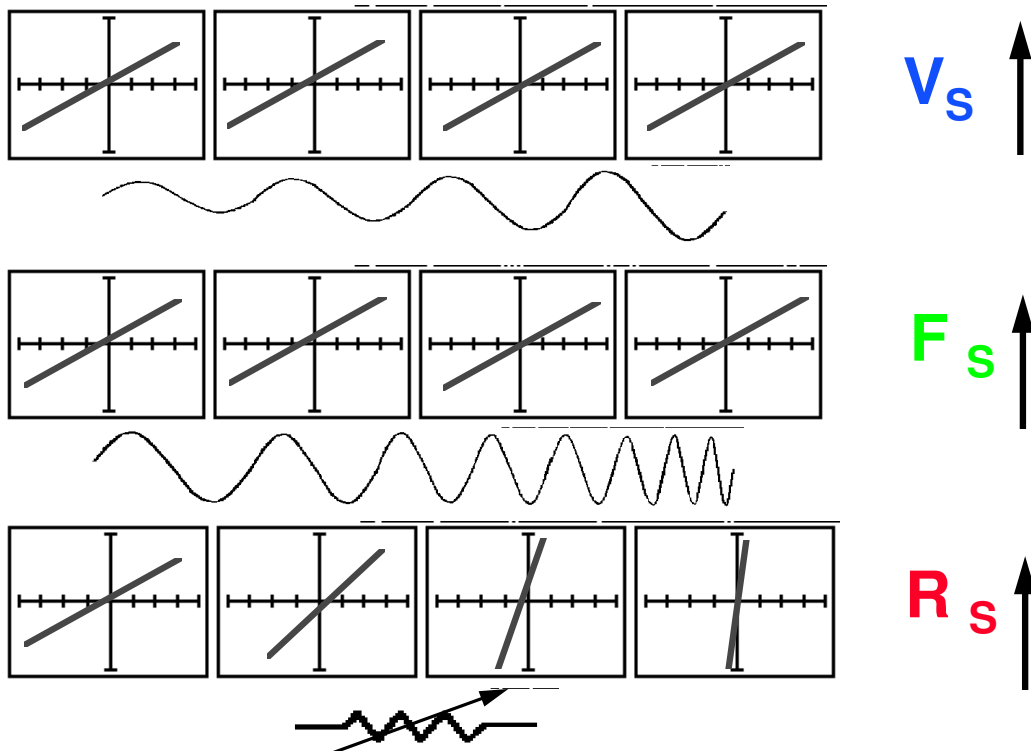


Figure 4-8. Tracker Core Circuit Block Diagram With A Resistor.

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

A pure resistance across the test terminals will cause the trace on the Tracker 4000 CRT to rotate in a counter clockwise direction around its center axis from horizontal open circuit position (high value resistance) to a vertical short circuit (low value resistance). The degree of rotation is a function of the resistance value.



How Tracker Parameter Changes Affect Resistive Signatures

Figure 4-9. Range Parameters Changes And Affects On Resistive Signatures.

SHORTS AND OPENS, RESISTOR FAULTS

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

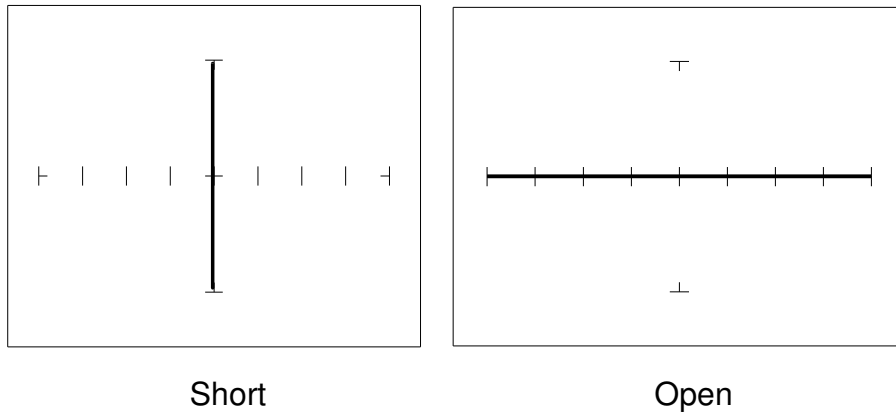


Figure 4-10. Short And Open Signature.

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 (factory group)
 - the volts per division of the horizontal axis increases
 - the internal resistance increases
 - the signature becomes more vertical

TROUBLESHOOTING APPLICATIONS

- The Tracker 4000 is a fast and efficient continuity tester, providing real time information.
- The Tracker 4000 will quickly locate resistor defects, shorts, opens and degradation that other testers cannot find.
- A majority of component failures are resistive in nature. This is important to remember; a component fault may only appear in one range because of the resistive nature of the fault.
- The Tracker 4000's ability to determine the approximate fault resistance value greatly enhances the troubleshooting capability if the correct value is known.
- The Tracker 4000's CRT is a real time display and using the Tracker 4000 for testing noisy or dirty potentiometer (variable resistors) is an excellent application. Connect Tracker 4000's test terminals to one fixed pot lead and the other to the pot's wiper lead. Simply monitor the wiper signature while rotating the pot back and forth. A flawed pot would have the telltale intermittent angular signature.

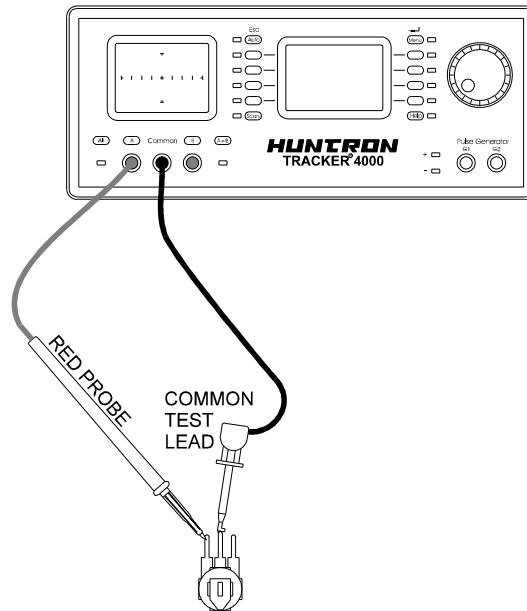


Figure 4-11. Using Tracker 4000 To Test A Potentiometer.

- The Tracker 4000 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.

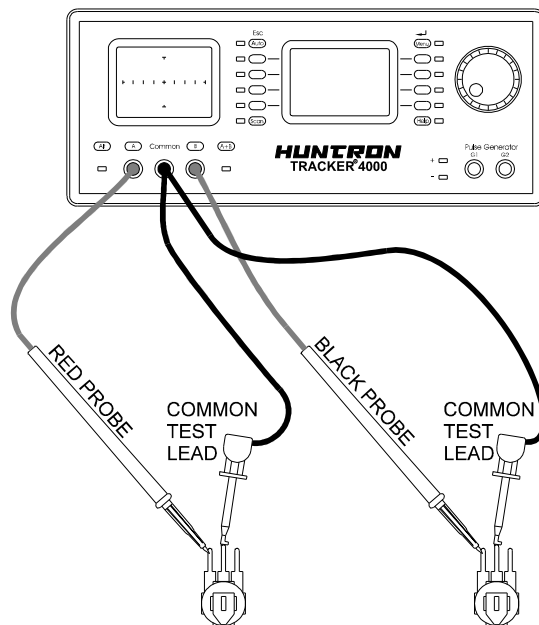


Figure 4-12. Using Tracker 4000 To Compare Two Potentiometers.

4-2. CAPACITORS

With a capacitor connected to the Tracker 4000, the test signal across it responds quite differently than a resistor. The typical analog signature of a capacitor is an elliptical circular pattern and this is 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.

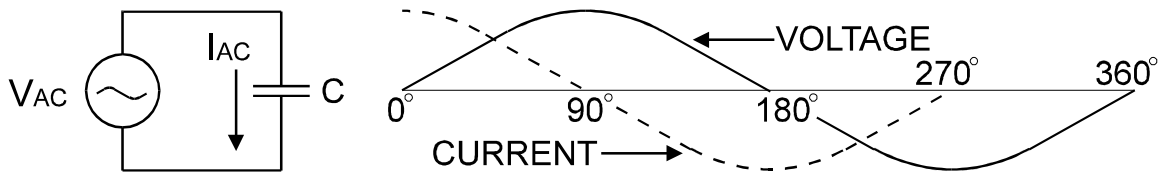


Figure 4-13. Capacitor Circuit With Test Signal's Current And Voltage Waveforms.

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

Because the current is at its maximum value when the voltage is at zero, the current leads the voltage. This is called phase shift and in a purely capacitive circuit, this phase shift equals 90°. On the Tracker 4000, this analog signature appears as a circular waveform. The actual shape and slope of the elliptical signature depends on the capacitance and impedance value of the component and the test signal's voltage, internal resistance and frequency.

CAPACITOR ANALOG SIGNATURES

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

- The capacitance (μf) of the circuit under test
- The frequency (F_s) of the test signal
- The voltage (V_s) of the test signal
- The internal resistance (R_s) of the Tracker 4000

Turn power on to your Tracker 4000. Plug the red test microprobe in the A jack, and the black test clip lead in the Common jack.

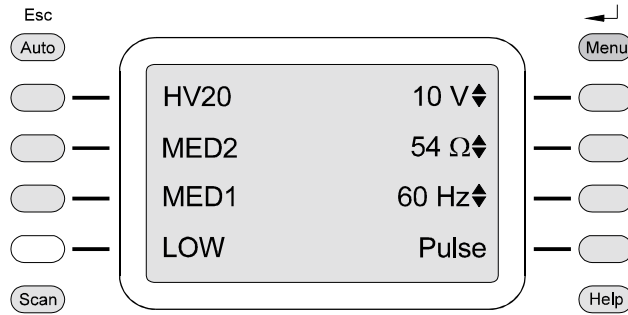


Figure 4-14. Tracker 4000 Main Menu Screen With Factory Defaults.

CAUTION

The device to be tested must have all power turned off, and have all high voltage capacitors discharged before connecting the Tracker 4000 to the device.

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

1. Press the **LOW** range button (Factory Group) in the Main Menu Screen.
2. The yellow **LED** will be on next to the LOW range once activated.
3. Place or clip a test lead on the opposite ends of a resistor and observe the signature on the Tracker 4000 CRT display.

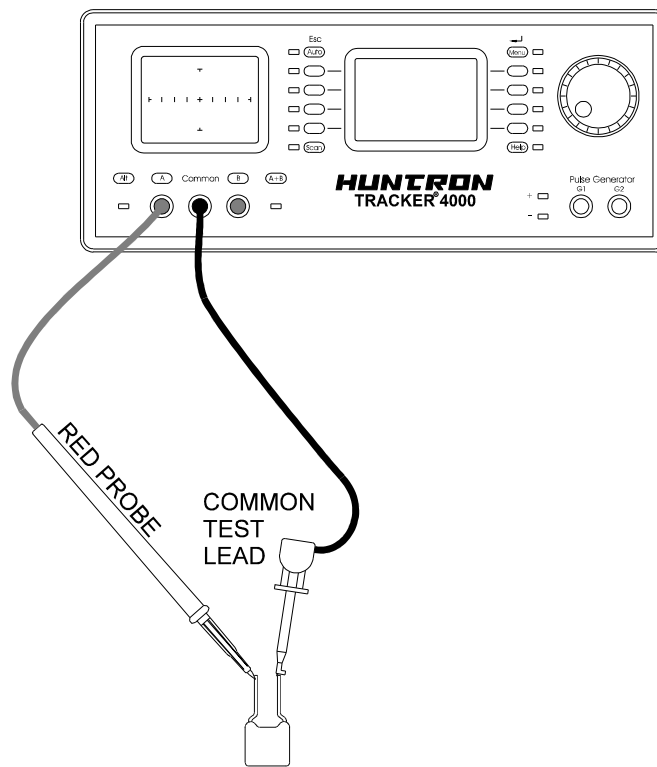


Figure 4-15. Tracker 4000 With Test Probes Connected To A Capacitor.

THE SIGNATURES OF DIFFERENT CAPACITORS IN LOW RANGE

The figure below shows analog signatures for four different value capacitors, 1000 μf , 100 μf , 10 μf and 1 μf . The Tracker 4000 LOW range is selected.

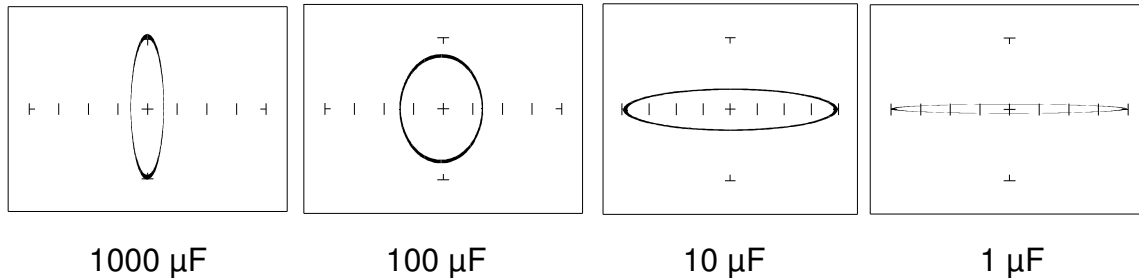


Figure 4-16. Signatures Of 4 Capacitors In Low Range.
LOW Range (Factory group)

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 μ F CAPACITOR

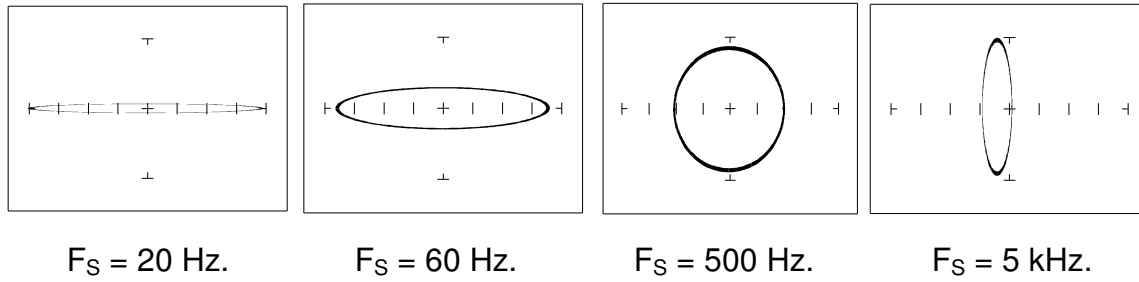


Figure 4-17. Signatures Of A 10 μ F Capacitor At Different Frequencies. LOW Range (Factory Group)

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

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

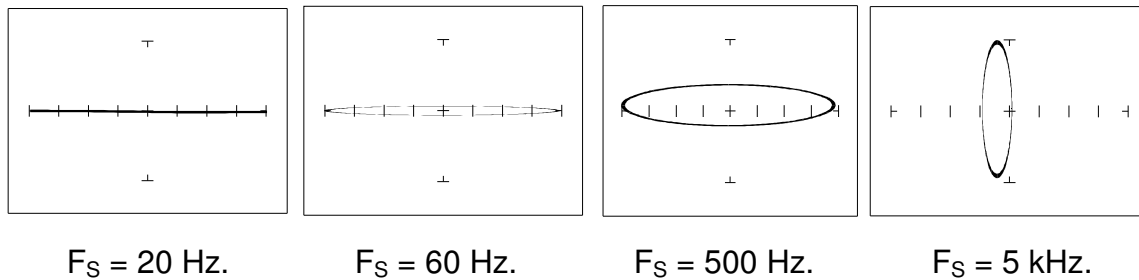


Figure 4-18. Signatures Of A 0.1 μ F Capacitor At Different Frequencies. MED1 Range (Factory Group)

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 μ F capacitor is similar to the 10 μ F 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 μ F CAPACITOR

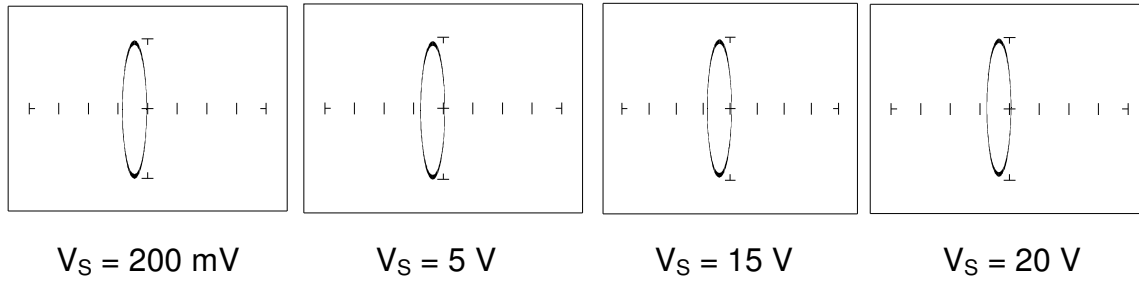


Figure 4-19. Signatures Of A 1 μ F Capacitor At Different Test Signal Voltages. MED2 Range (Factory group)

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 1 μ F CAPACITOR

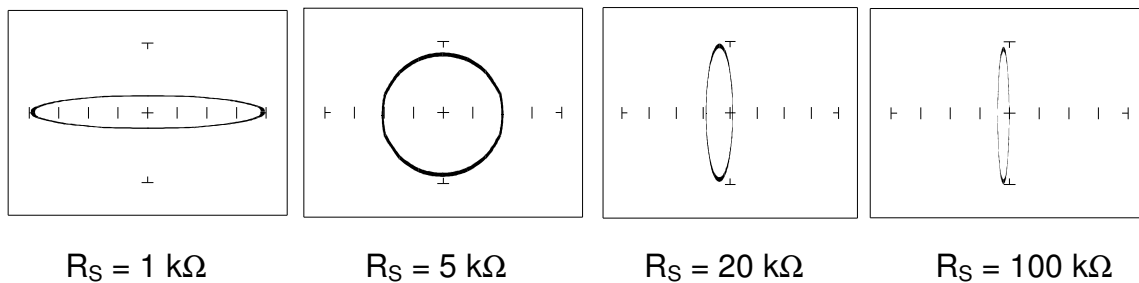


Figure 4-20. Signatures Of A 1 μ F Capacitor At Different Internal Resistances. MED1 Range (Factory Group)

As the Tracker 4000'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

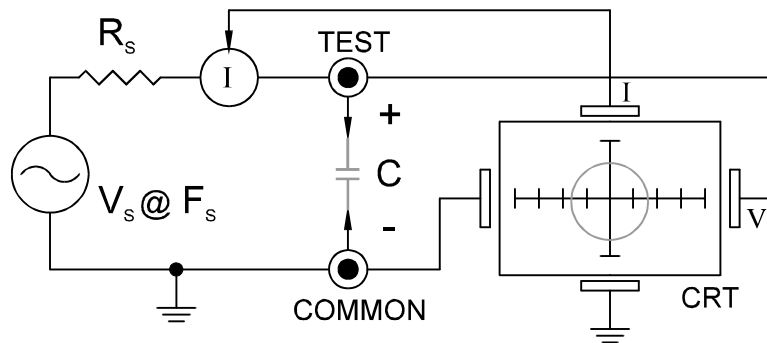


Figure 4-21. Tracker Core Circuit Block Diagram With A Capacitor.

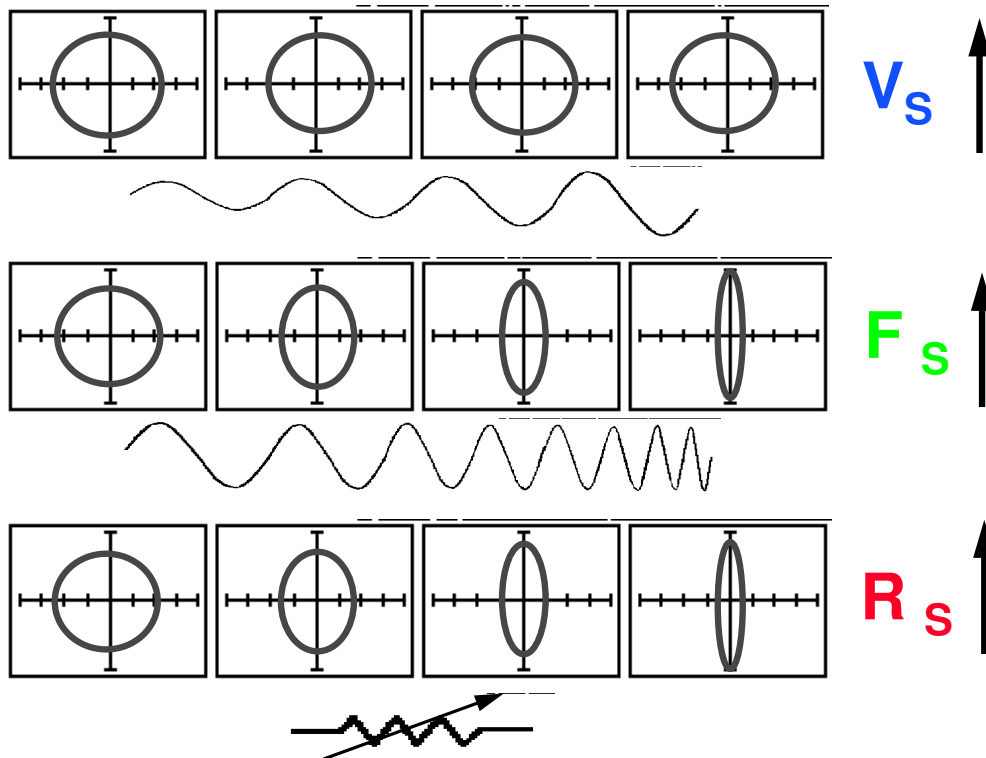
The Tracker 4000 CRT displays as a response to its test signal, an analog signature that represents the relationship between voltage, current and resistance of a component. For circuits that contain capacitors, the effective resistance is called capacitive reactance, X_C . The mathematical formula is:

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

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 Tracker 4000, the elliptical signature will become increasingly vertical that implies more current flow.
- Changing frequency F_s : As the frequency of the test signal increases, the capacitive reactance X_C will decrease and the amount of current in the circuit will increase. On the Tracker 4000, 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 $1\text{ k}\Omega$ to $100\text{ k}\Omega$, the following occurs:
 - X_C of the capacitor is not affected
 - V_S increases so current decreases proportionately
 - The elliptical signature becomes increasingly vertical



How Tracker Parameter Changes Affect Capacitive Signatures

Figure 4-22. 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 4-1 shows the Tracker 4000's limits for the minimum and maximum capacitance values it can handle.

Table 4-1. Tracker 4000 Minimum And Maximum Capacitor Values.

R_s	$F_s = 20 \text{ Hz.}$	$F_s = 5 \text{ kHz}$
100 k Ω	0.01 μF - 1 μF	10 pF - 0.01 μF
10 Ω	20,000 μF - 100 μF	0.1 μF - 100 μF

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 on the Tracker 4000 display.

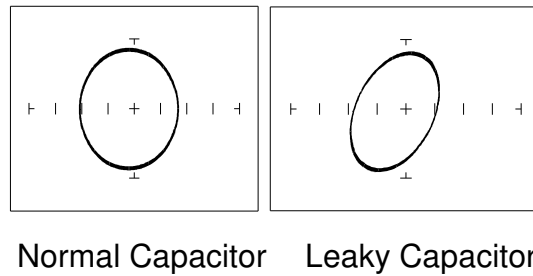


Figure 4-23. Signatures Of A 100 μF Capacitor With Dielectric Leakage. LOW range (Factory group), $F_S = 60 \text{ Hz}$

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.

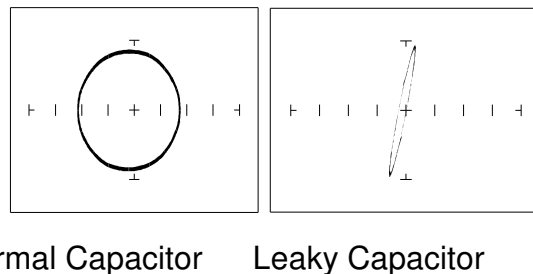


Figure 4-24. Signatures Of A 10 μF Capacitor With Dielectric Leakage. 10 μF Range (CAPS Group), $F_S = 60 \text{ Hz}$

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

As you can see from the two previous examples, adding resistance in parallel to a capacitor distorts the normal signature with a diagonal bend to it. This is our first look at a composite signature, the kind of signature the Tracker 4000 displays when there are several components connected together in a circuit.

REVIEW

- Capacitors have elliptical signatures due to the current and voltage phase shift.
- As the test signal's frequency increases, the capacitor's signature becomes more vertical due to decreasing X_C of the component.
- Capacitors with leakage flaws have their ellipses tilted diagonally due to an internal resistance in parallel with the capacitance.

APPLICATIONS

- The Tracker 4000 can locate defective capacitors in or out of circuit. The ranges cover 10 pF to 20,000 μ F.
- When analyzing a capacitor's signature, adjust the Tracker 4000'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 on the CRT display.

4-3. INDUCTORS

Inductors, like capacitors, have elliptical analog signatures and respond to Tracker 4000's test signal non-linearly. Also like capacitors, an inductor's reactance (resistance to an AC test signal) is dependent on the test signal's frequency. Because of the way they are constructed using wire which has some amount of resistance in it, it is hard to find a pure inductance. An inductor's analog signature will usually be an elliptical pattern with a some slope or tilt to it due to the resistance of the coil wire.

INDUCTOR ANALOG SIGNATURES

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

- The inductance (**L** μH) of the circuit under test
- The frequency (**F_S**) of the test signal
- The voltage (**V_S**) of the test signal
- The internal resistance (**R_S**) of the Tracker 4000

Turn power on to your Tracker 4000. Plug the red test microprobe in the **A** jack, and the black test clip lead in the **Common** jack.

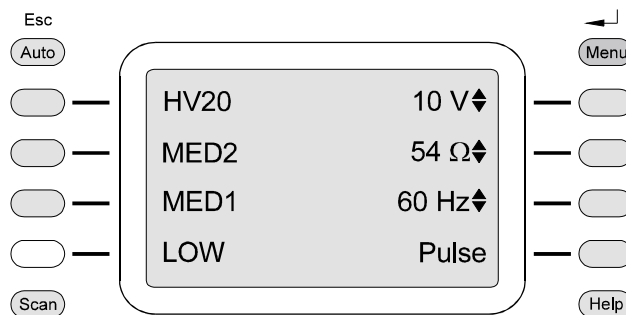


Figure 4-25. Main Menu Screen.

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

1. Press the **LOW** range button (Factory Group) in the Main Menu screen.
2. The yellow **LED** will be on next to the LOW range once activated.
3. Place or clip each test lead on the opposite ends of an inductor and observe the signature on the ProTrack CRT display.

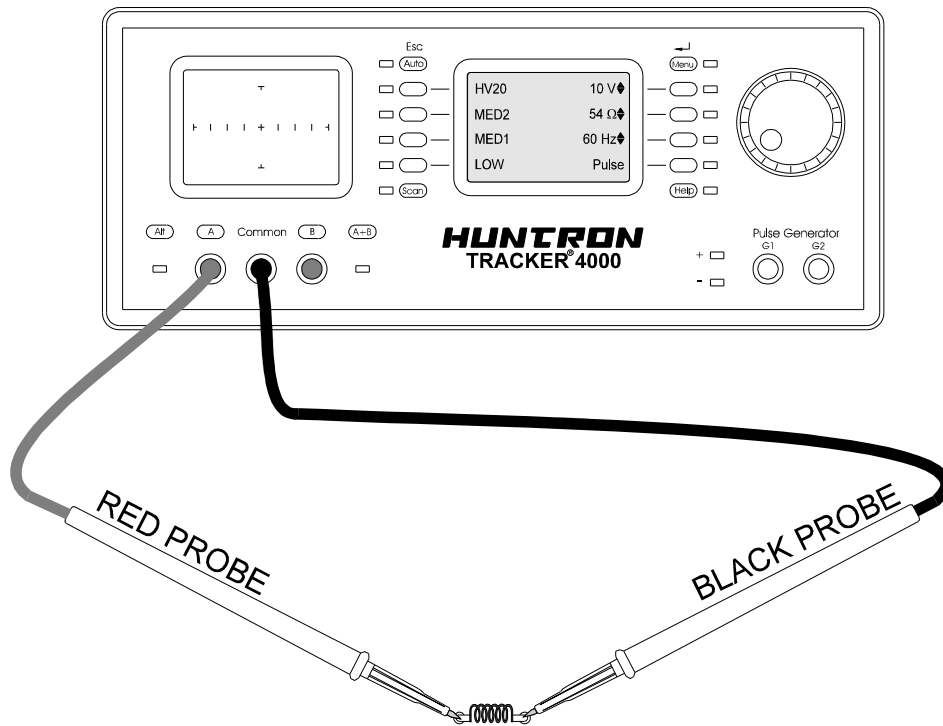


Figure 4-26. Tracker 4000 With Probes To An Inductor.

THE SIGNATURES OF DIFFERENT INDUCTORS IN LOW RANGE

The figure below shows analog signatures for four different value inductors, 12,000 μH , 1200 μH , 120 μH and 12 μH in LOW range.

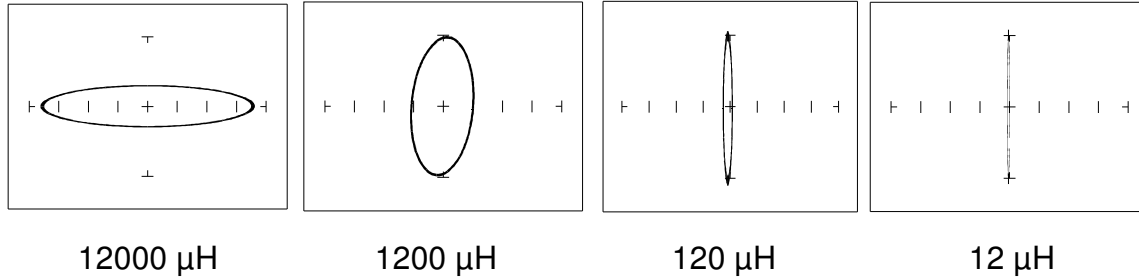


Figure 4-27. Signatures Of 4 Inductors In LOW Range.
 $V_S = 10 \text{ V}$, $R_S = 54 \Omega$, $F_S = 2 \text{ kHz}$

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

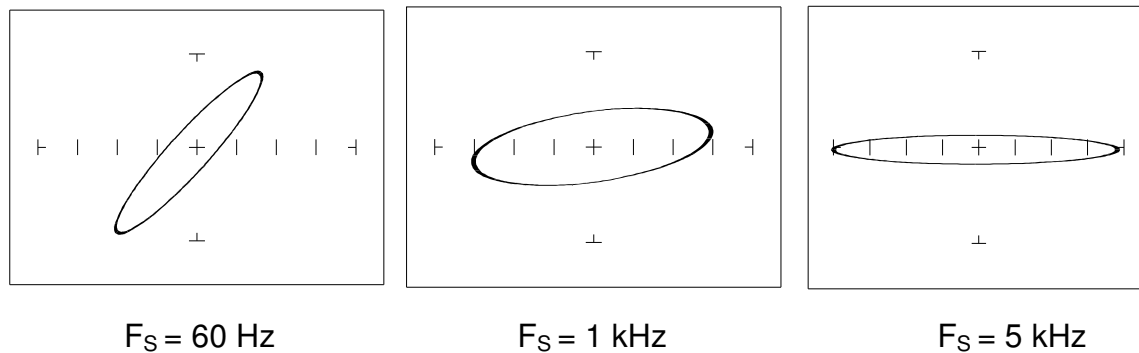


Figure 4-28. Affect of Varying F_S On Inductor Signatures.
 LOW Range (Factory Group), $L = 12,000 \mu\text{H}$

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

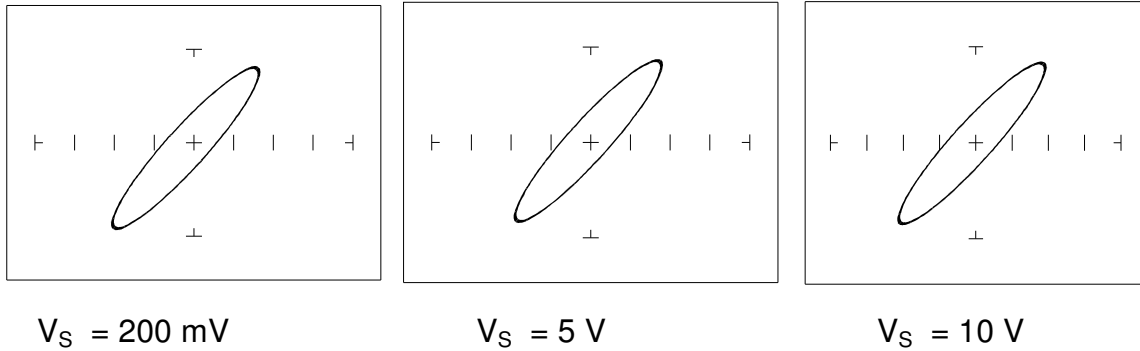


Figure 4-29. Affect Of Varying V_S On Inductor Signatures.
 LOW Range, $F_S = 60 \text{ Hz}$, $L = 12,000 \mu\text{H}$

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.

AFFECT OF INTERNAL RESISTANCE R_S ON INDUCTOR SIGNATURES

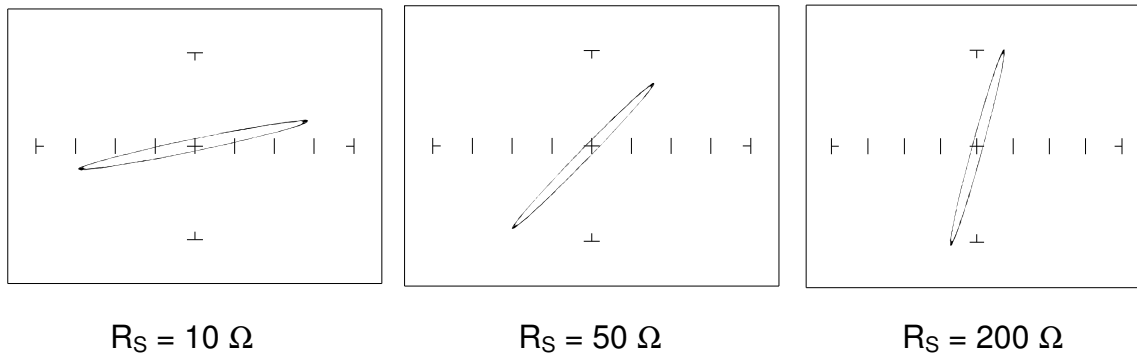


Figure 4-30. Affect Of Varying R_S On Inductor Signatures.
 LOW Range, $V_S = 2 \text{ V}$, $F_S = 60 \text{ Hz}$, $L = 12,000 \mu\text{H}$

Note that the signature changes from a horizontal to a vertical position as the Tracker 4000's internal resistance R_S increases. This means the inductor's resistance can be analyzed by matching it with the Tracker 4000's test signal resistance.

UNDERSTANDING INDUCTIVE SIGNATURES

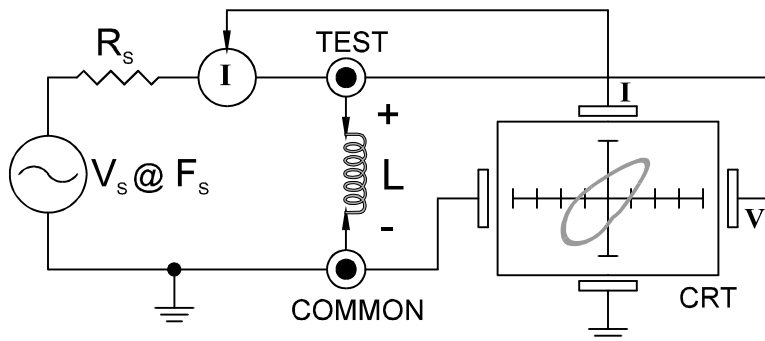


Figure 4-31. Tracker Core Circuit Block Diagram With An Inductor.

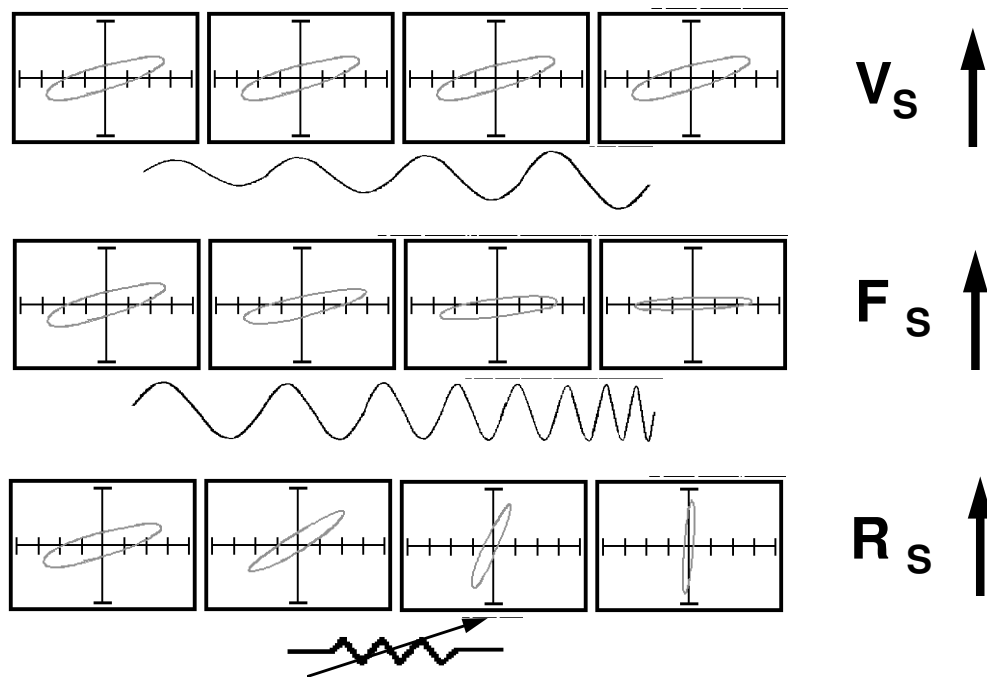
The Tracker 4000's block diagram shows an inductor between the test terminals. The current is represented by the vertical axis and is derived as a series current that flows through Tracker 4000's internal resistance, R_s . The voltage is represented by the horizontal axis and is derived as a voltage across the inductor.

The formula for the reactance X_L of an inductor is:

$$X_L = 2\pi fL$$

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

Since inductors in reality are not pure inductors, the elliptical signatures they form on the Tracker 4000 display usually is distorted. Inductors constructed with a ferrite core makes the inductive characteristics different from those constructed without. The Tracker 4000 responds with a unique analog signature for each inductor type.



How Tracker Parameter Changes affect Inductive Signatures

Figure 4-32. Range Parameters Changes And Affects On Inductive Signatures.

REVIEW

- Inductors display elliptical signatures similar to capacitors. Since the inductor also exhibits resistance, due to its construction, the ellipse may be distorted.
- As the Tracker 4000 test signal's frequency is increased, the ellipse signature becomes flatter. This response is opposite to that of a capacitor.
- As the Tracker 4000 internal resistance R_S increases, an inductor's signature becomes more vertical (like the capacitor signature).
- When an inductor has a ferrite core, its signature distorts from a non ferrite inductor's ellipse.

APPLICATIONS

- The Tracker 4000 is excellent for troubleshooting inductors. It can reveal shorted or open windings in large variety of inductive components.
- Components that are inductors or have inductive characteristics can be found in many real world applications. For example, some of these are power transformers, relays, solenoids, flybacks, speakers, magnetic sensors, stepping motors and motor windings.
- The best technique for testing inductors is the comparison of a known good component's signature to a suspect component. For example, a motor armature has typically numerous windings so every winding should have a similar analog signature. This fact is true whether it's from an elevator or a tape deck. The armature of a DC motor can be tested by simply connecting to the motor brush leads and then adjusting the test range for the most pronounced or descriptive signature. Slowly turn the armature. Observe the Tracker 4000's CRT display. This test will check continuity, the inductance, and the condition of each brush contact without disassembling the motor.
- A computer switching power supply contains inductors. For example, a computer is reported "dead." To make a quick diagnosis of the possible problem first make sure the computer is disconnected from AC power. Then connect the red and black test probes across the prongs on the AC line cord going to the computer. Turn the computer power switch to the On position. If there is a response on the Tracker 4000's display, adjust the test range for the most pronounced inductive signature. Flick the power switch off and on and watch for noisy switch contacts. If there is no response, start by checking each component up to the primary winding of the transformer. With this technique, we have just verified the AC cord, the AC noise filter, the fuse, the power switch and the primary winding of the transformer, without removing the cover of the computer.
- Another simple test for a speaker or microphone is to apply the Tracker 4000 signal in LOW 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.

4-4. ELECTROMECHANICAL SWITCHING COMPONENTS

Switches are electrical devices that either stop or allow current to flow in a circuit. They are either in an on or off state. Switching devices come in all types and sizes. There are simple mechanical switches, relays, optical switches, and many kinds of semiconductor switches. They are different because each uses a different kind of stimulus to turn them on or off. Because there are so many kinds of switching devices, there is no single testing procedure that will test them all completely. With the Tracker 4000, the test signal can be setup so that the switch's analog signature will verify its switching function. The goal of this section is to develop a test strategy using ASA to test the switching function. This is not a complete test, but it will be enough to determine whether or not the device is functioning as a switch.

MANUALLY OPERATED MECHANICAL SWITCHES

A mechanical switch has two states: it is either open or closed. When open, no current can flow; when closed, it acts as a short and allows current to flow. The Tracker 4000 can test the switching function of mechanically activated switches easily. Unlike the DVM that samples and gives a continuity measurement, the Tracker 4000 displays real time activity so if a switch has noisy, resistive or intermittent operation, its analog signature on Tracker 4000's display will reflect these conditions.

Turn power on to your Tracker 4000. Plug the red test microprobe in the A jack, and the black test clip lead in the Common jack.

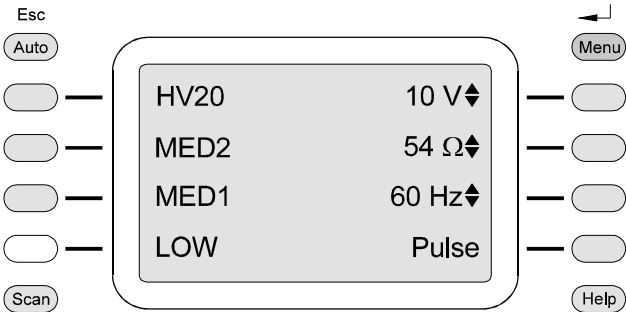


Figure 4-33. Main Menu Screen.

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

1. Press the **LOW** range button (Factory Group) in the Main Menu screen.
2. The yellow **LED** will be on next to the LOW range once activated.
3. Place or clip each test lead to the switch leads and observe its signature on the Tracker 4000 CRT display.
4. Turn the switch to its on or off position.

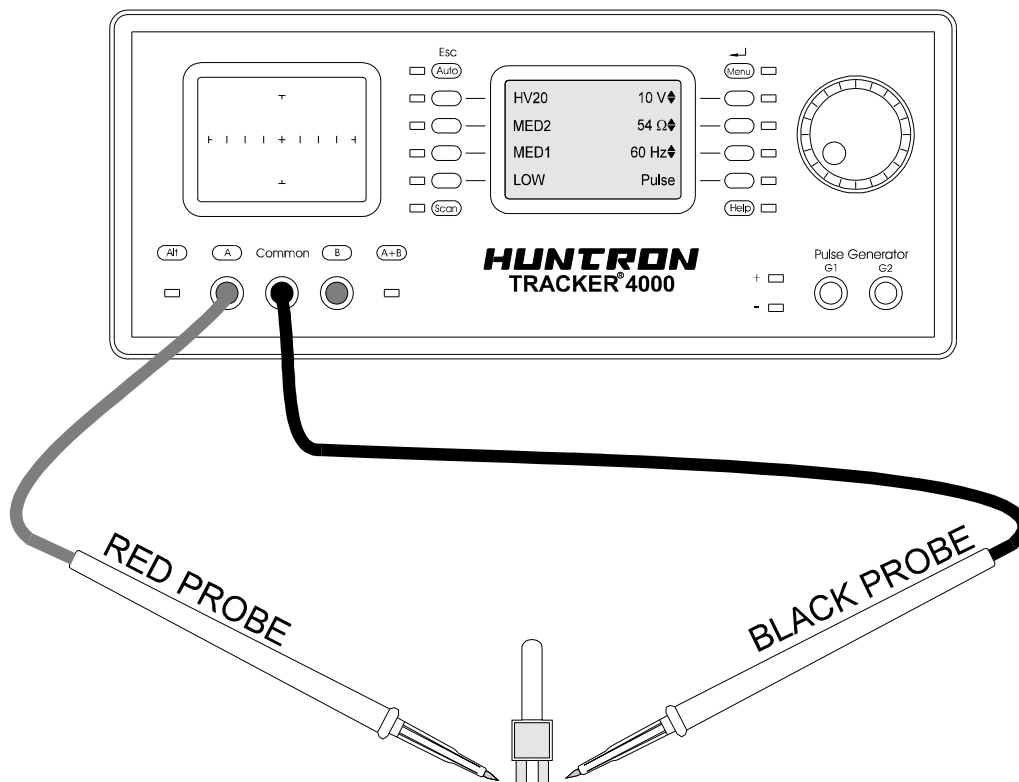


Figure 4-34. Tracker 4000 With Probes To A Mechanical Switch - SPST Type.

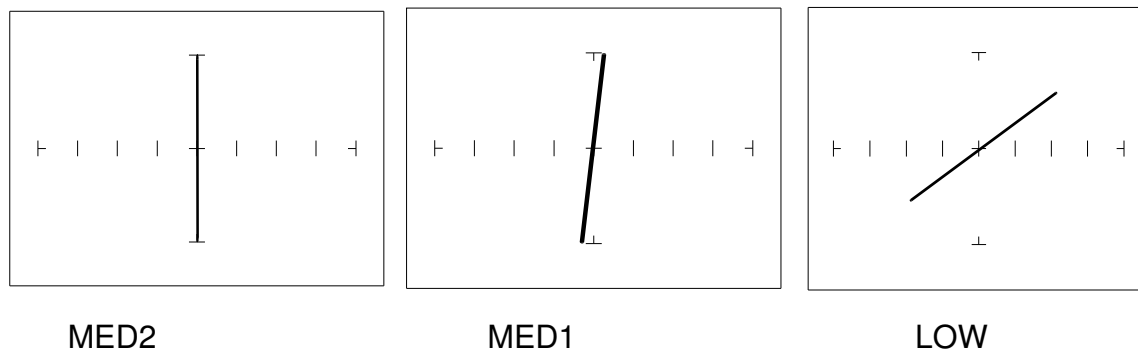


Figure 4-35. Signatures Of A Keyboard Pushbutton Conductive Elastomer Switch. SPST Type, "ON" position, Factory Range Group

Note that as the ranges change from MED2 to MED1 to LOW, 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 Tracker 4000 can test the coil part of the relay by looking at its inductive analog signature. You can also connect the Tracker 4000's pulse generator to the magnetic coil and while at the same time connecting the Tracker's test signal to the relay contacts to test the relay's switching action directly.

RELAY COIL TEST

Do the following:

1. Press the **LOW** button (Factory Group) in the Main Menu screen .
2. Press the **Hz** button.
3. Rotate the encoder to set the test frequency to 5 kHz.
4. Connect the black test lead from Tracker 4000's COMMON terminal to one side the relay coil (normally, the minus lead).
5. Connect the red test lead from Tracker 4000's TEST terminal to the other side of the relay coil (normally, the plus lead).

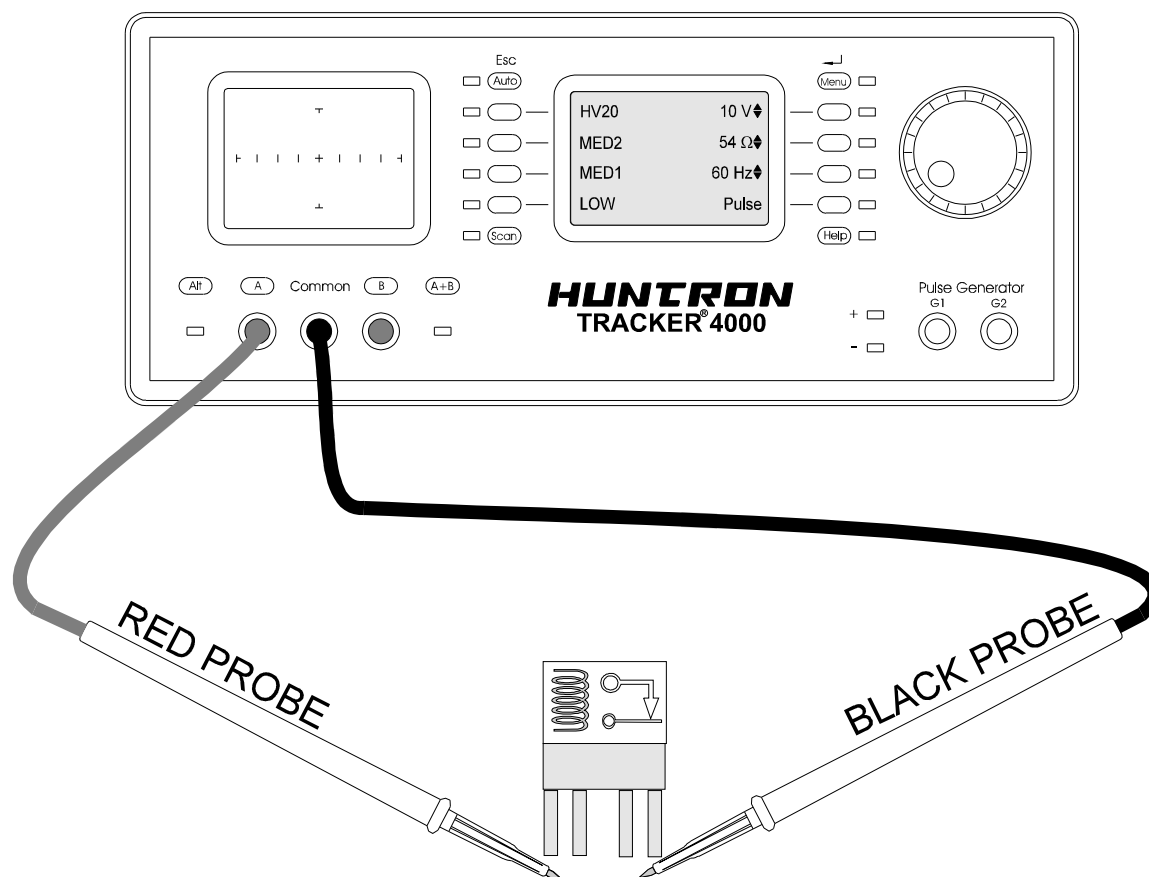


Figure 4-36. Tracker 4000 With Test Leads Connected To Relay's Coil.

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

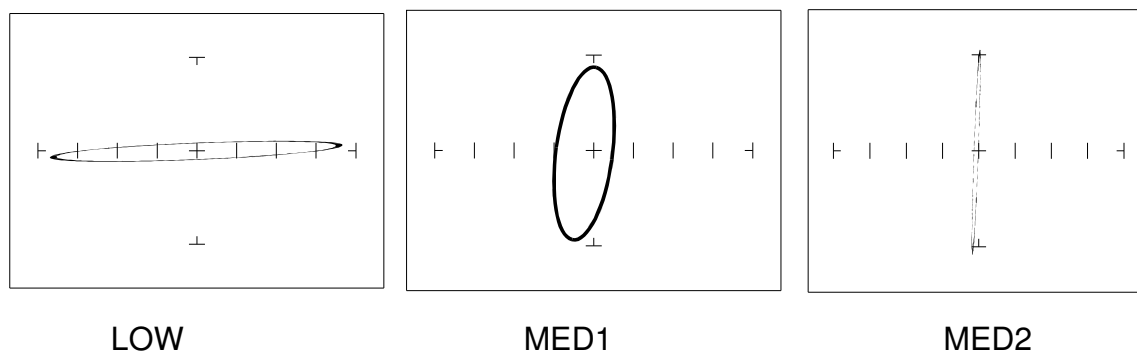


Figure 4-37. Signatures Of A Magnetic Reed Relay Coil.
Factory Group, $F_s = 1 \text{ kHz}$

Note the characteristic inductive oval in LOW and MED1 ranges. When applying Tracker 4000'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.

USING THE PULSE GENERATOR TO TEST A REED RELAY

Do the following:

1. Press the **LOW** in the Factory range group.
2. Connect the Tracker 4000 pulse generator output G1 to the positive (+) lead of the relay coil.
3. Connect the Tracker 4000 COMMON to the relay's negative (-) lead).
4. Connect the black test lead from Tracker 4000's COMMON terminal to one side of the relay switch contact.
5. Connect the red test lead from Tracker 4000's TEST terminal to the other side of the relay switch contact.
6. Press **Pulse** button on the Tracker 4000.
7. Press the **Mode** button to select $\overline{\text{DC}}$ Mode (DC) and press the +/- button, if needed to activate the positive DC output (+ blue LED should be on).
8. Press the **0.0 VDC** button and turn the encoder slowly. Watch the relay contacts' signature for a short circuit. At this point, turn the encoder back and forth and watch the relay relay's signature change between an open and a short.
9. When testing is complete, press the $\overline{\text{DC}}$ button (DC) twice to OFF Mode to turn off the pulse generator. Press **Esc** to return to the Main menu screen.

If the relay does not activate and you know that it is known good, then connect both pulse generator outputs G1 and G2 in parallel to the relay coil terminal for more output drive current. This will effectively double the drive current available to the device.

REVIEW

- The Tracker 4000 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 in LOW range.

Notes:

SECTION 5

TESTING DISCRETE SEMICONDUCTORS

5-1. 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 5-1. 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 a which is characteristic of a good semiconductor junction.

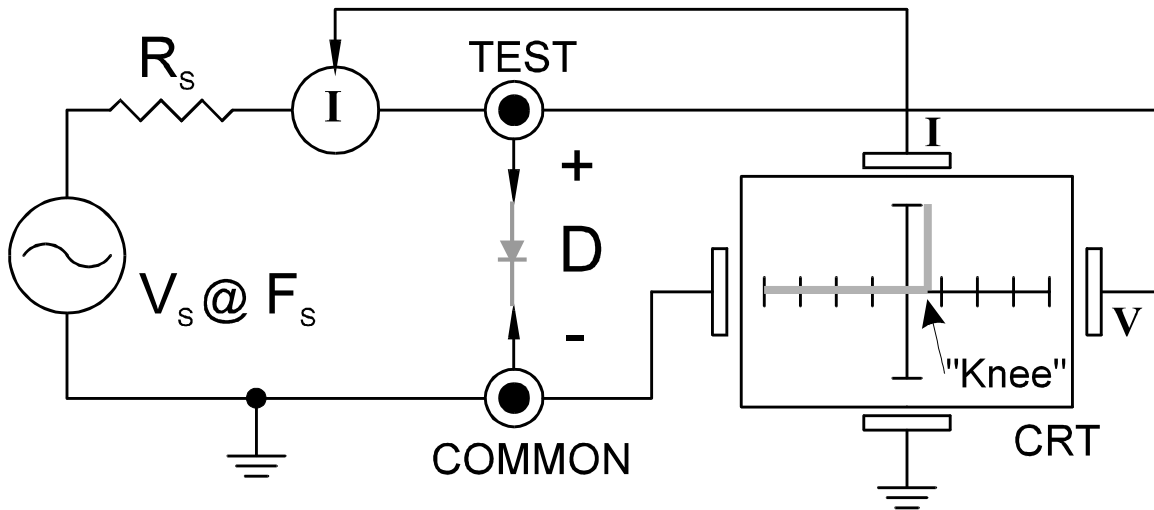


Figure 5-2. Tracker Core Circuit Block Diagram With A Diode.

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

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

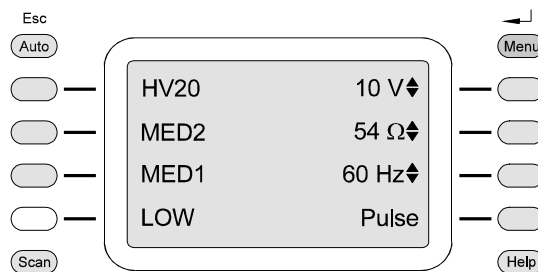


Figure 5-3. Main Menu Screen.

1. Turn power on to your Tracker 4000.
2. Press the **LOW** range button (Factory Group) in the Main Menu screen.
3. The yellow LED will be on next to the LOW range once activated.
4. Place or clip the red test lead from the Tracker 4000's A test terminal to anode lead of the diode.
5. Place or clip the black test lead from the Tracker 4000's Common terminal to anode lead of the diode.

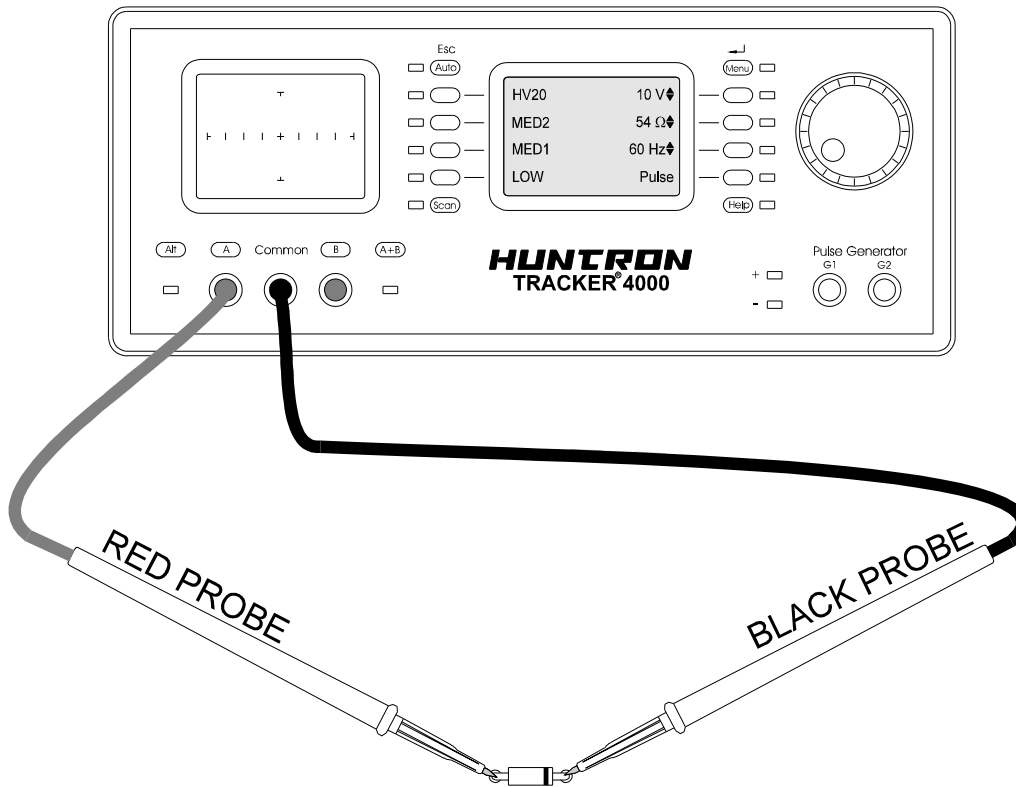


Figure 5-4. Tracker 4000 With Probes To A Diode.

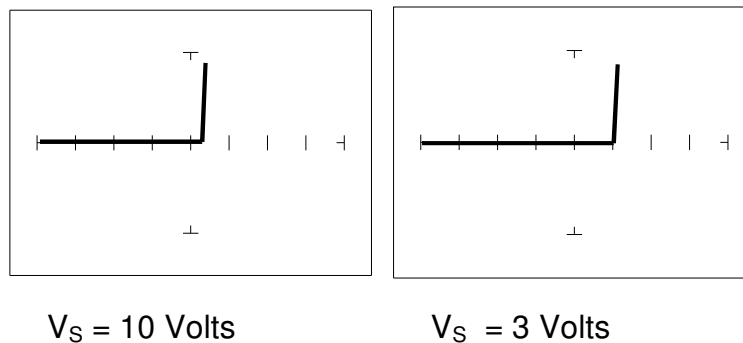


Figure 5-5. Signature Of A 1N914 Type Silicon Diode.
 LOW Range, $R_S = 54 \Omega$, $F_S = 60 \text{ Hz}$

The diode signatures are similar to each other. In LOW 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 LOW range (factory group) 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.

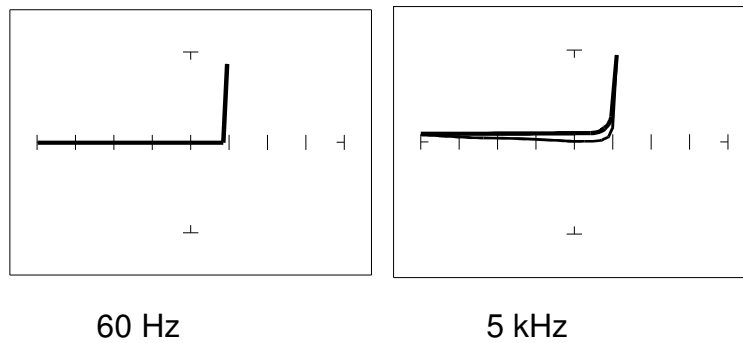


Figure 5-6. Signature Of A 1N914 Diode At Different Range Frequencies.
LOW Range, $V_S = 3$ V, $R_S = 54 \Omega$

AFFECTS OF INTERNAL RESISTANCE (R_S) ON THE DIODE SIGNATURE

Changing Tracker 4000's internal resistance R_S moves the vertical knee portion of the diode's analog signature. As R_S increases, the knee of the signature moves inward toward the origin. R_S controls the current that's flowing through the diode so the forward diode voltage changes in response to the current change.

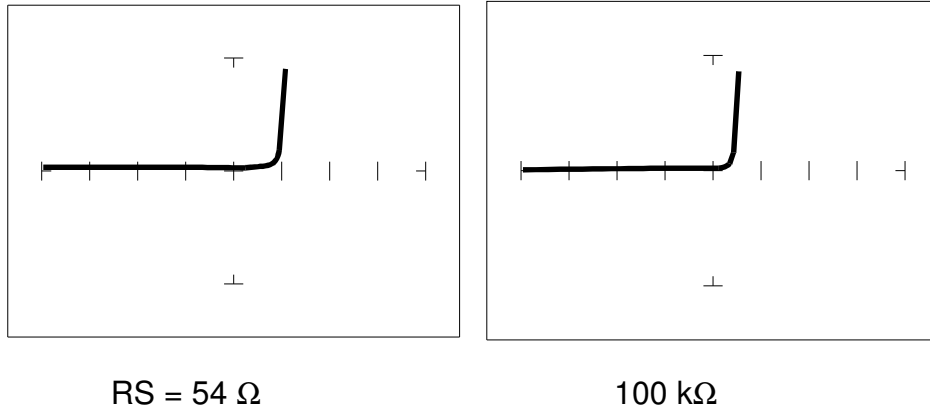
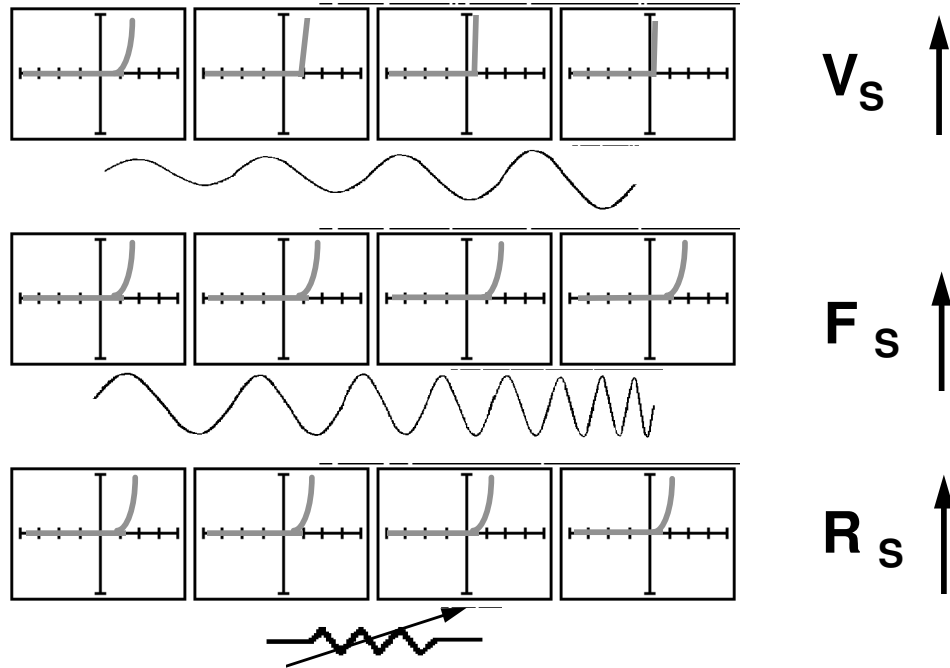


Figure 5-7. Signature Of A 1N914 Diode At Different Range Resistances.
LOW Range, $V_S = 3\text{ V}$, $F_S = 60\text{ Hz}$

UNDERSTANDING DIODE SIGNATURES

Figure 5-8 reviews the Tracker 4000's three range parameters and how they affect the diode signature.



How Tracker Parameter Changes affect Diode Signatures

Figure 5-8. 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.

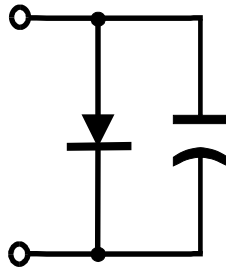


Figure 5-9. Composite Model Of A Diode And Capacitor In Parallel.

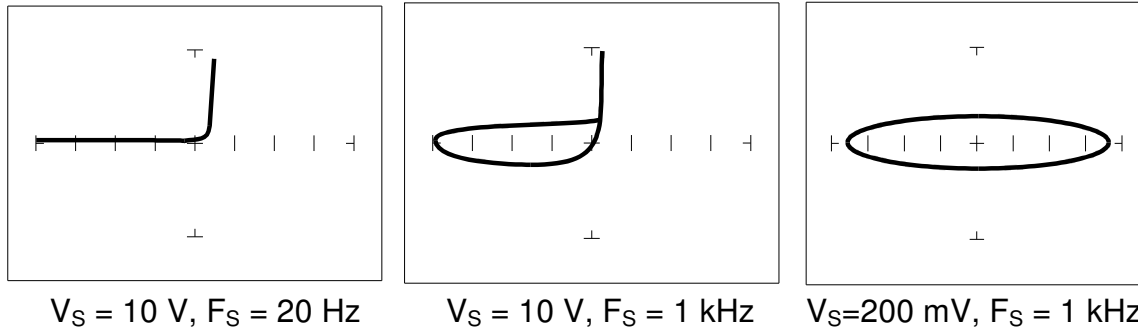


Figure 5-10. Composite Signature - 1N914 Diode And 1 μF Capacitor In Parallel.
LOW range, $R_S = 54\ \Omega$

The signature on the left shows only the diode signature because the test signal frequency is set below any visible contribution due the capacitive reactance. The composite signature in the center consists of the distinctive loop of the capacitor and the "knee" pattern of the diode. The signature on the right shows only the capacitor signature because the test signal voltage is below the diode's turn on level. When multiple components are connected together, it's important to realize that the Tracker 4000 has the ability to selectively display the signature of a single component.

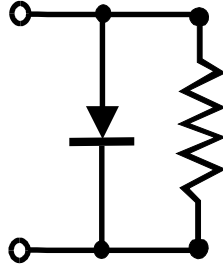
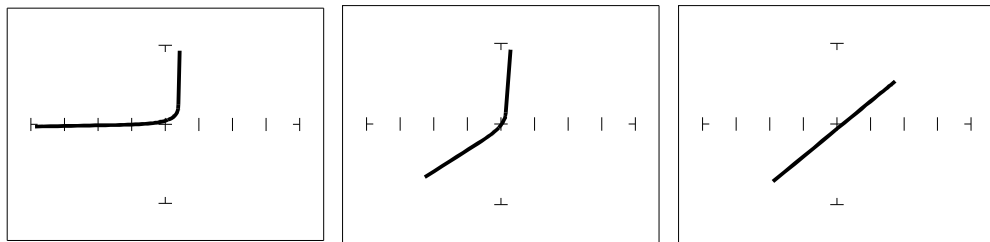


Figure 5-11. Composite Model Of A Diode And Resistor In Parallel.



$V_S = 10\text{ V}, R_S = 50\ \Omega$ $V_S = 10\text{ V}, R_S = 1\text{ k}\Omega$ $V_S = 200\text{ mV}, R_S = 1\text{ k}\Omega$

Figure 5-12. Composite Signature - 1N914 Diode And 1.5 k Ω Resistor In Parallel.
 LOW range, $F_S = 60\text{ Hz}$

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 k Ω resistor. The composite signature in the center consists of the distinctive slope of the resistor and the "knee" pattern of the diode. The signature on the right shows only the resistor signature because the test signal voltage is below the diode's turn on level. Again, when multiple components are connected together, it's important to realize that the Tracker 4000 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

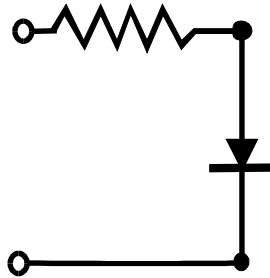


Figure 5-13. Defective Diode Model With A Small Series Resistor.

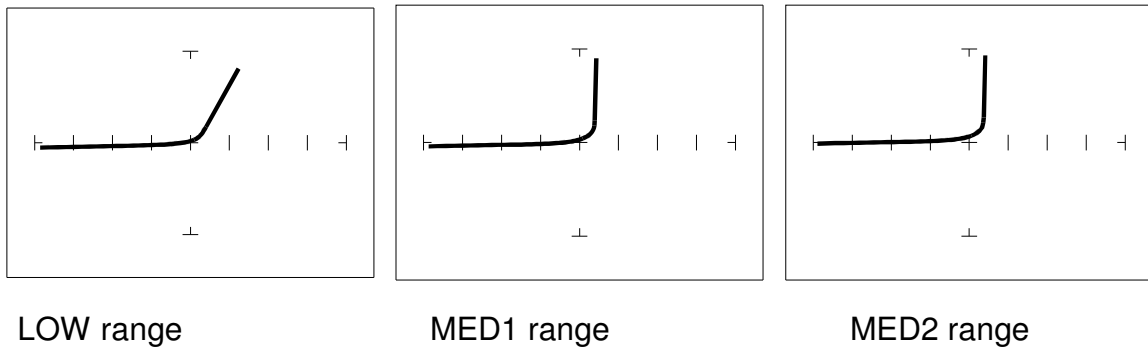


Figure 5-14. Defective Diode Signature With A 50 Ω Series Resistor.

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

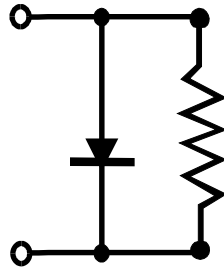


Figure 5-15. Defective Diode Model With An Internal Leakage Resistance.

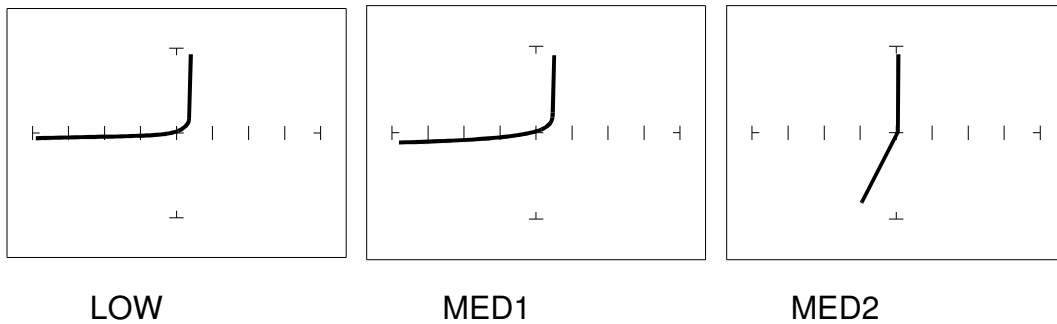


Figure 5-16. Signature Of A Diode With Internal Leakage Flaw.
1N914 Diode With A 10 kΩ Resistor In Parallel

Notice that in LOW range there does not seem to be any problem, but that 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.

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.

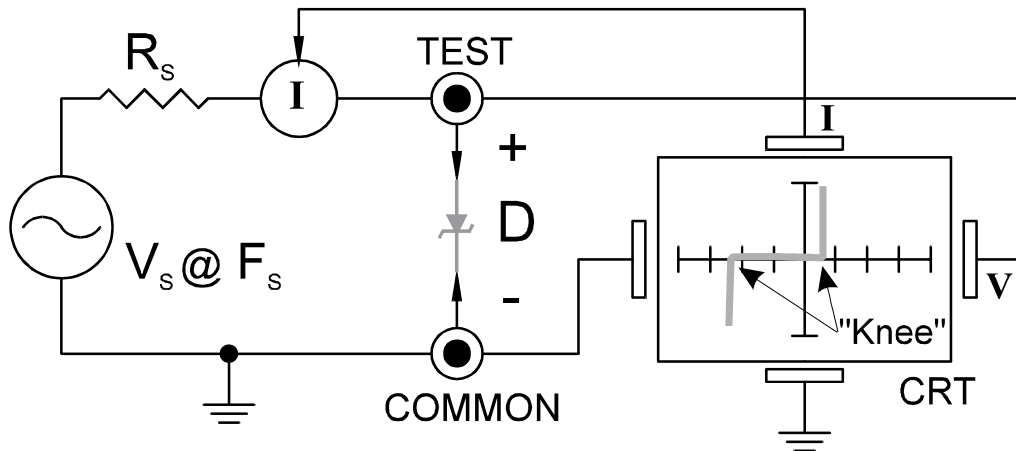


Figure 5-17. Tracker Core Circuit Block Diagram With A Zener Diode.

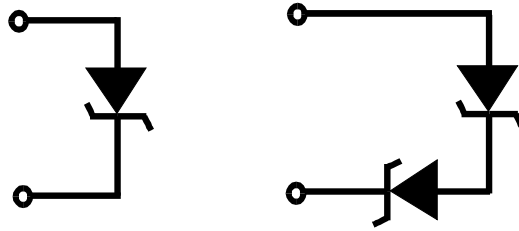
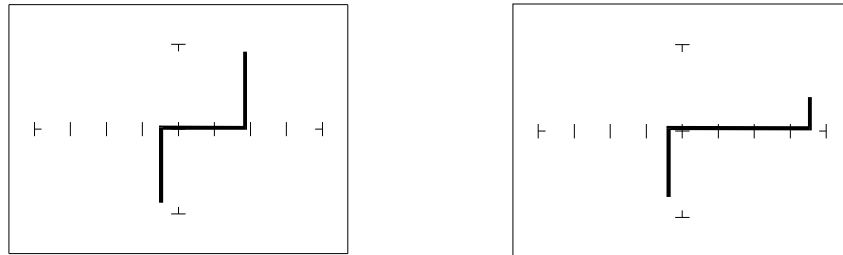


Figure 5-18. Single Zener Diode And 2 Zener Diodes In Series.



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

Figure 5-19. Signature Of A Single Zener Diode And 2 Zener Diodes In Series.
MED2 Range (Factory Group)

Since each horizontal division on the CRT graticule (in MED2 range) is approximately 5 Volts, from the signature on the left you can estimate that this is about a 9 volt zener diode. The signature at the right is the signature of two zener diodes connected in series. The Zener voltage (V_Z) of this circuit is the sum V_Z of each of the separate diodes. The signature shows this voltage to be approximately 18 Volts.

REVIEW

- Diodes conduct current in one direction (forward biased) and not the other. The diode's analog signature displays this characteristic as the “knee” effect or pattern.
- Diodes have polarity, an anode and a cathode.
- Diode defects, other than opens and shorts, are usually resistive.
- A diode in series or parallel with a resistor or capacitor will create a composite signature displaying both characteristics. The Tracker 4000 makes it easier to separate these characteristics from composite signatures using the three parameters F_S , R_S and V_S .
- Zener diodes are special diodes that conduct when reverse biased at a specific voltage.

APPLYING WHAT WE HAVE LEARNED

- Diode damage or degradation can appear as a loss of sharpness or rounding in the “knee”.
- While faulty diodes display resistive current and voltage legs, they are usually nonlinear or curved.
- The polarity of an unmarked diode can be determined by the orientation of the display with a known diode.
- The Tracker 4000 can be used to identify an unknown zener diode. If the zener diode is damaged, locate a good one, possibly on another board or in the same circuit and use the Tracker 4000 to approximate the voltage.
- Look for the zener effect when checking voltage regulators such as the 7805 type. This can help determine an unknown or faulty device.
- The Tracker 4000 can be used to test and determine the four pin connections on a bridge rectifier, (AC1, AC2, + and -).

5-2. 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 a NPN transistor.

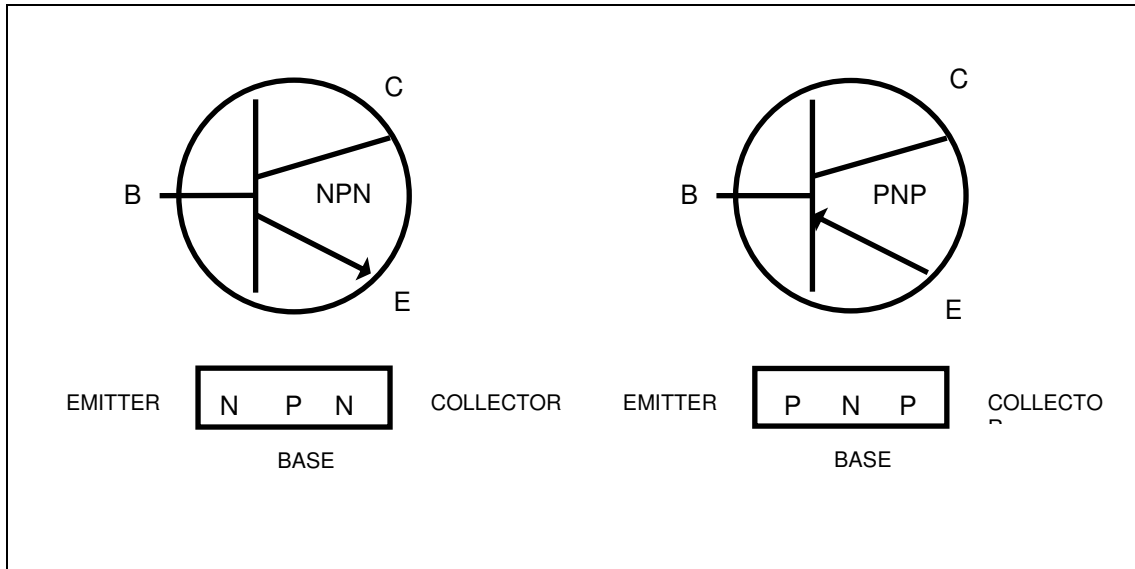


Figure 5-20. Diagram Of An NPN And PNP Bipolar Transistor.

IMPORTANT NOTE

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

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

Suggestions to minimize effects on bipolar transistors:

1. Use 5 Volts or less for testing the base-emitter or collector-emitter.
2. If using 6 Volts or greater, then keep the duration of the test as short as possible.
3. Identify the base, emitter and collector pins of the device and then test the collector-base junction to determine whether it is an NPN or PNP. Since the emitter is not tested there will be no effect on h_{FE} regardless of the selected voltage. Then use the three terminal test described in the "Using The Pulse Generator To Test Transistor Operation" later in this section.

BIPOLAR TRANSISTOR SIGNATURES

In order to better understand the signatures that transistors create on the Tracker 4000, 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.

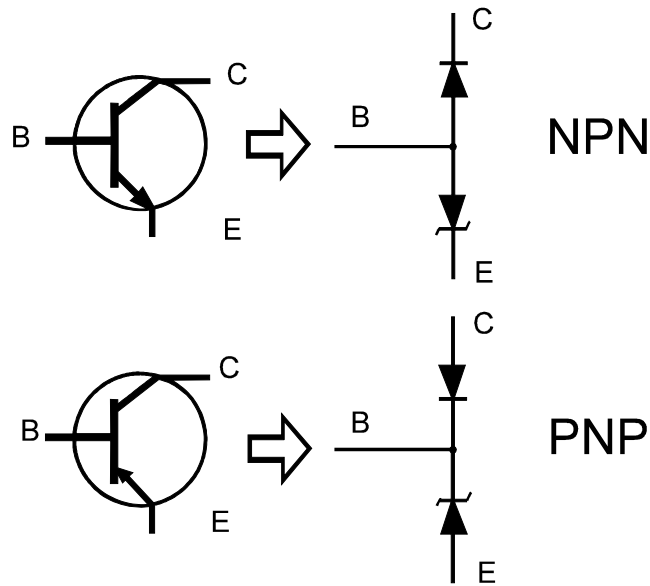


Figure 5-21. NPN And PNP Bipolar Transistors' Equivalent Circuits.

BIPOLAR TRANSISTOR BASE-COLLECTOR SIGNATURES

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

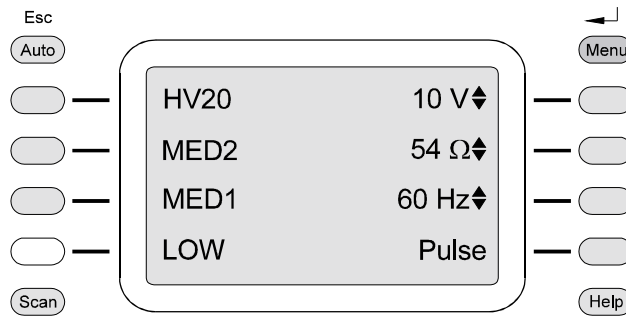


Figure 5-22. Main Menu Screen.

1. Turn power on to your Tracker 4000.
2. Press the **MED2** range button (Factory Group) in the Main Menu Screen.
3. The yellow LED will be on next to the MED2 range once activated.
4. Place or clip the red test lead from the Tracker 4000's A test terminal to collector lead of the transistor.
5. Place or clip the black test lead from the Tracker 4000's Common terminal to base lead of the transistor.

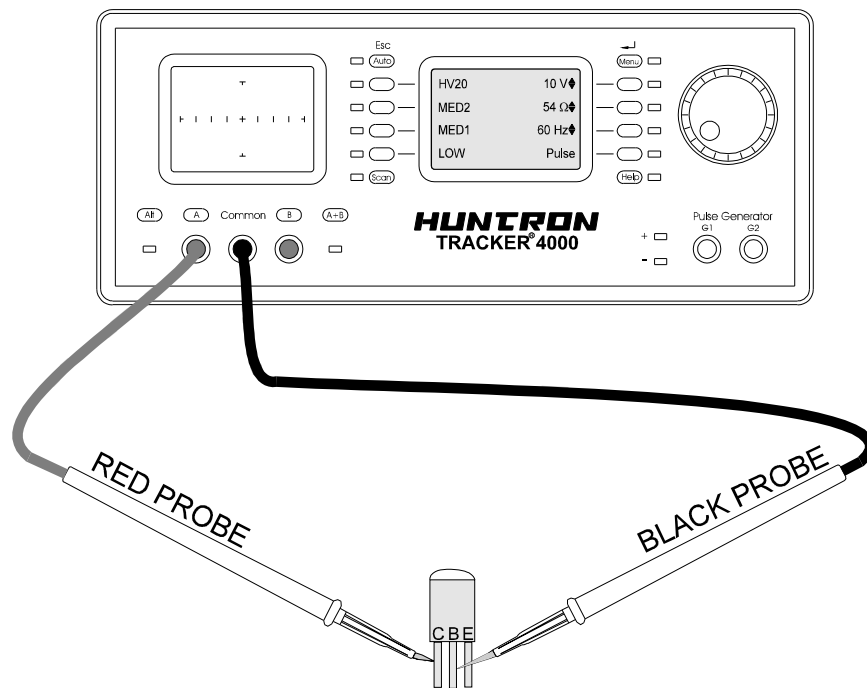
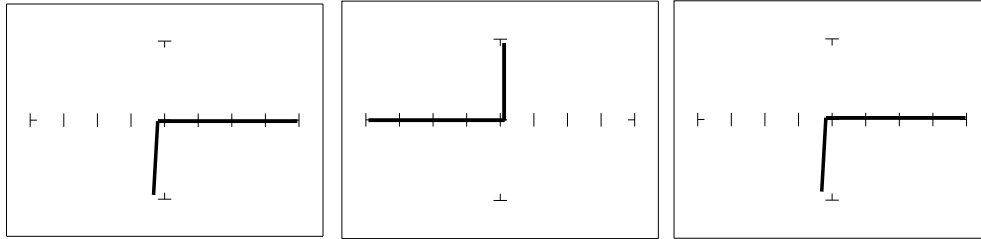


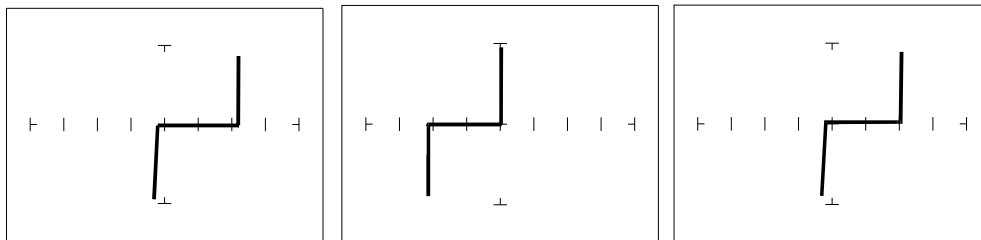
Figure 5-23. Tracker 4000 Connected To The Collector And Base Leads Of A Transistor



Diode 1N914 PNP Transistor 2N3906 NPN Transistor PN2222A

Figure 5-24. Signature Of A Diode And Collector-Base Of A Transistor.
MED1 Range (Factory Default)

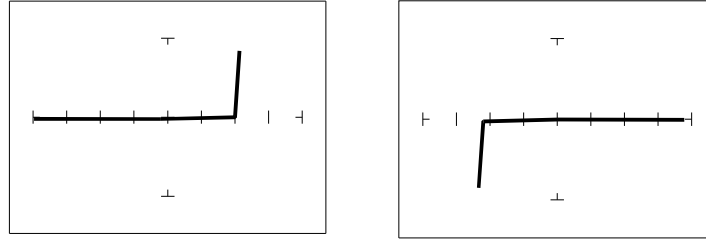
Notice that the collector-base signature of a NPN transistor is identical to the signature of diode. The collector-base signature of a PNP transistor, which has opposite polarity from a NPN, looks similar to a diode with its polarity reversed. These are the signatures we expected from our circuit modeling.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



Zener Diode 1N5239B PNP Transistor 2N3906 NPN Transistor PN2222A

Figure 5-25. Signature Of A Diode And Emitter-Base Of A Transistor.
MED1 Range (Factory Default)

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 5-26. Signature Of The Collector-Emitter Of A PNP And NPN Transistor.
MED1 Range (Factory Default), Emitter To Common

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

All bipolar junction transistors have essentially the same looking signatures.

IDENTIFYING UNKNOWN TRANSISTORS

Sometimes, we need to identify unknown transistors. We may need to replace one in a circuit for which we do not have a schematic. The Tracker 4000 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. Press the **MED2** range button (Factory Group) in the Main Menu Screen.
2. Set the frequency to 60 Hz.

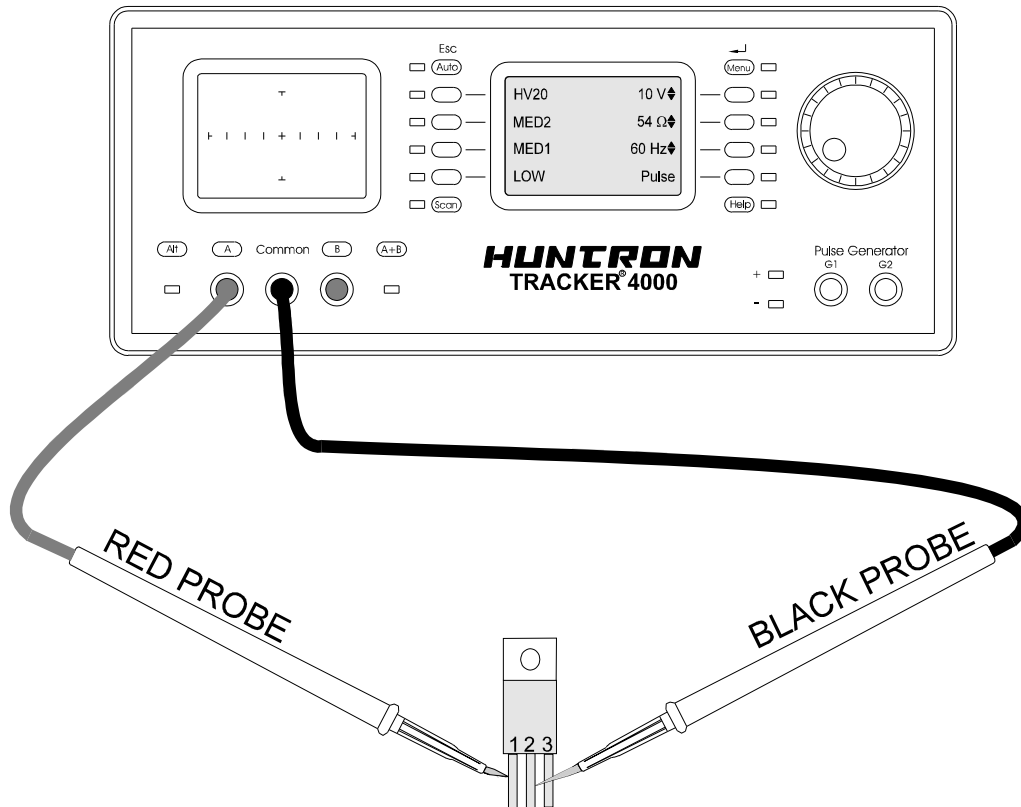


Figure 5-27. Tracker 4000 With Probes To An Unmarked Transistor.

Do the following:

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

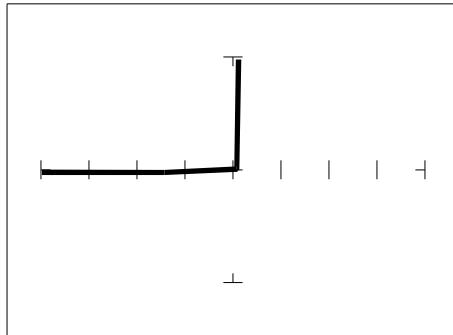


Figure 5-28. Signature Of Pins 1 And 2 Of An Unknown Transistor.

2. This looks like a collector-base signature. What you do not know yet is which pin is the collector and which pin is the base.
3. Probe pin 3 with the red probe and pin 2 with the black probe.
4. Identify the signature.
1. This looks like a collector-emitter signature.

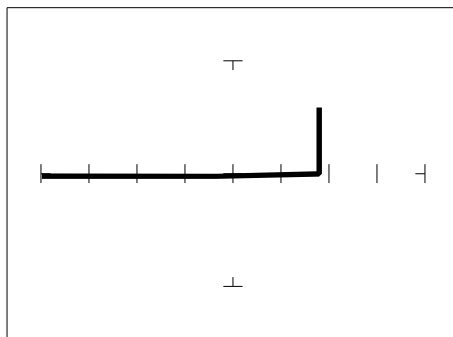


Figure 5-29. Signature Of Pins 3 And 2 Of An Unknown Transistor.

1. 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.

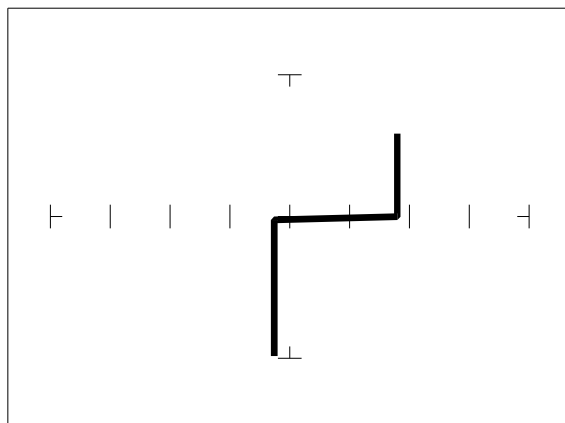


Figure 5-30. Signature Of Pins 1 And 3 Of An Unknown Transistor.

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.

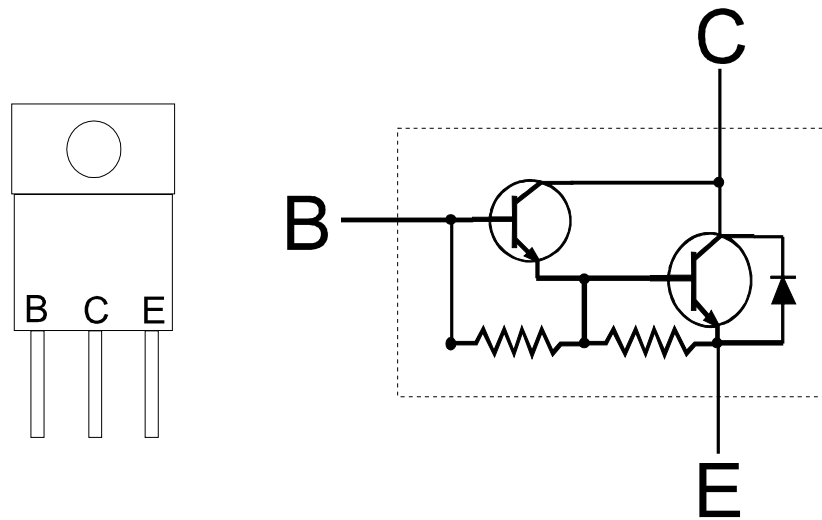


Figure 5-31. Diagram Of A Darlington Transistor.

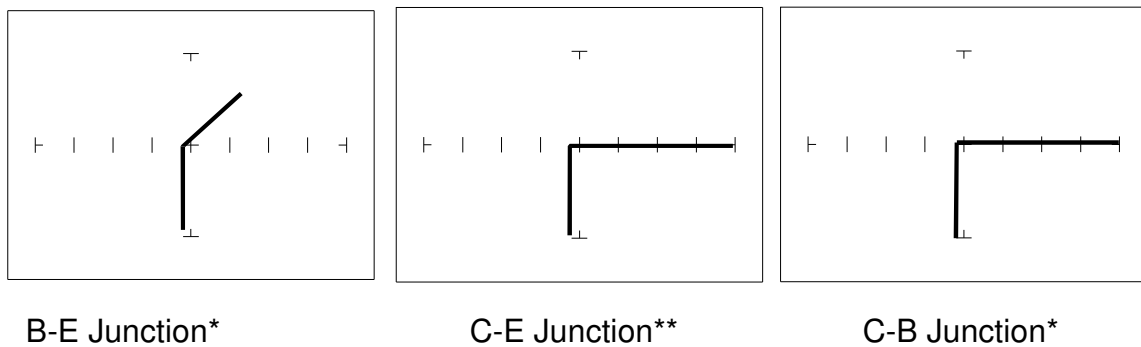


Figure 5-32. Signature Of A Darlington Transistor, TIP112 NPN Type.
 MED2 Range (Factory Default)
 Base To Common*, Emitter To Common**

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

USING THE PULSE GENERATOR TO TEST TRANSISTOR OPERATION

Figure 5-33 shows the test circuit for an NPN transistor using the pulse generator to drive the base. The constant current signature produced is similar to that produced by a transistor curve tracer except that only one curve is shown instead of a family of curves. This technique can be useful for functionally testing and matching transistor gain characteristics.

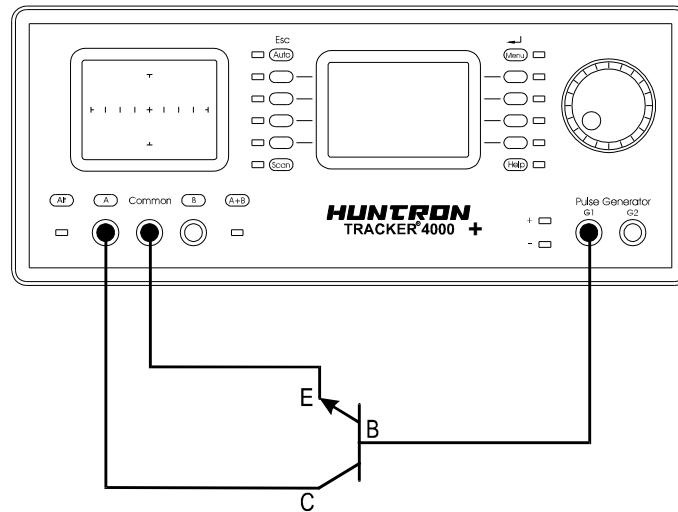


Figure 5-33. Pulse Generator Test Circuit For An NPN Transistor.

Figure 5-34 shows the test setup for a PNP transistor. As for the NPN transistor, this signature will be the result of the collector-base junction of the transistor.

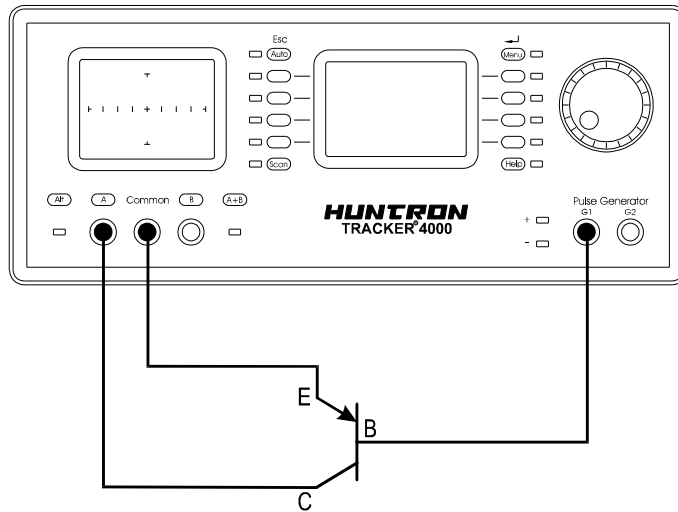



Figure 5-34. Pulse Generator Test Circuit For A PNP Transistor.

ANALYZING THE ACTIVE CHARACTERISTICS OF A TRANSISTOR

Setup:

1. Setup the test circuit shown in figure 5-33 or 5-34 depending on what type of bipolar transistor you wish to test.
2. Connect the blue grabber test lead from G1 on the Tracker 4000 to the transistor's base lead.
3. Press the **MED1** range button (Factory Group) in the Main Menu screen.
4. Set the frequency to 60 Hz.

Do the following:

1. Press the **Pulse** button to go to the Pulse Menu screen.
2. Press the **OFF Mode** button to  (DC) **Mode**.
3. Use **+** for PNP testing or **-** for NPN testing. Press the **+/-** button to set the correct polarity and observe that the blue "+" or "-" LED is lit.
4. Press the **V** button.
5. Rotate the encoder until the transistor switches on (short circuit signature) and note the turn-on voltage.

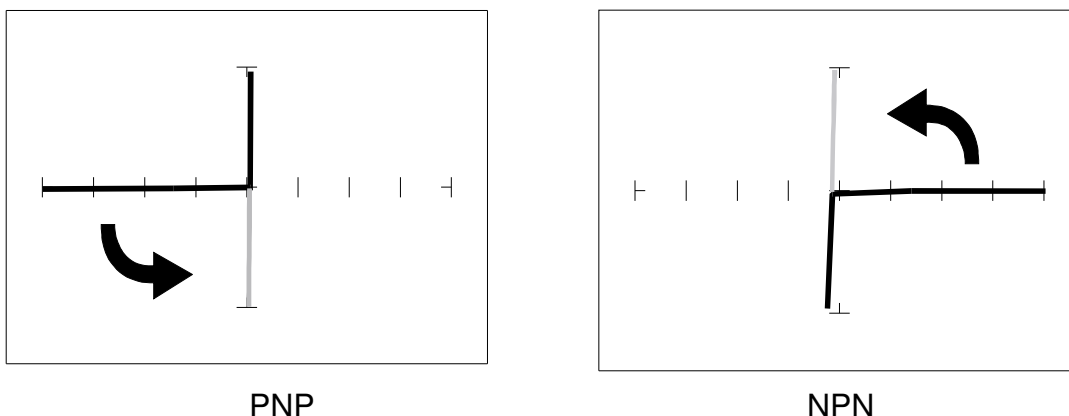


Figure 5-35. Testing Transistors With The Pulse Generator - DC Mode.

1. Press the **Mode** button to select either ┌ or ┐ pulse.
2. Press the **2%** button and use the encoder to adjust the pulse width of the pulse generator output.

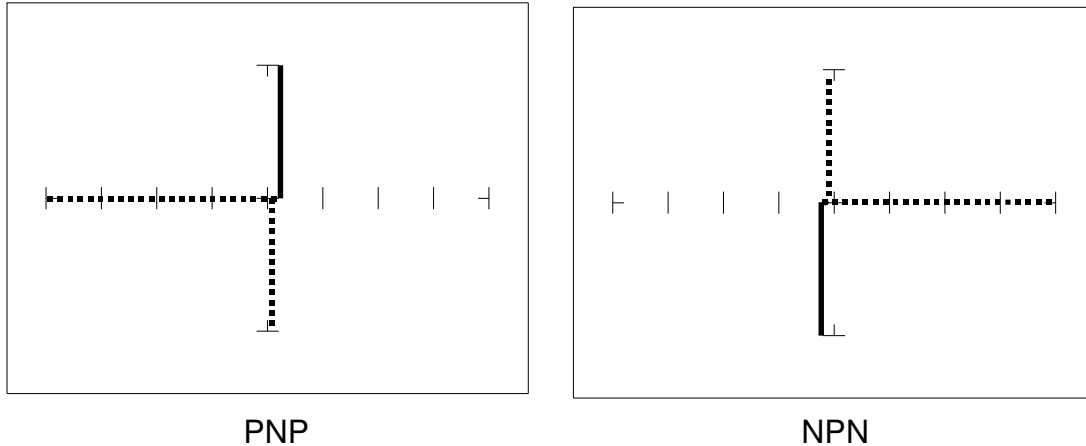


Figure 5-36. Testing Transistors With The Pulse Generator - Pulse Mode.

1. Look at the transistor's signature change as the duty cycle changes. The figure above shows these signatures as dotted lines. This composite signature shows multiple operating states as the base stimulus varies. The transistor is actually being switched on and off by the Tracker 4000.

REVIEW

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

APPLYING WHAT WE HAVE LEARNED

- Transistors will display the same type of faulty signature as diodes, with a rounded “knee” and non-linear or resistive current and voltage legs.
- The Tracker 4000 can be used to determine the type of transistor; bipolar, Darlington, FET, etc.
- The Tracker 4000 can be used to identify the polarity of a transistor (PNP or NPN).
- The Tracker 4000 can be used to determine the base, collector and emitter on an unknown transistor.
- The Tracker 4000 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.

5-3. SOLID STATE SWITCHING COMPONENTS

OPTICAL SWITCHES

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

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

PHOTOTRANSISTOR

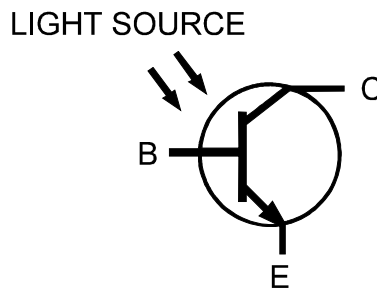


Figure 5-37. Phototransistor Schematic Diagram.

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

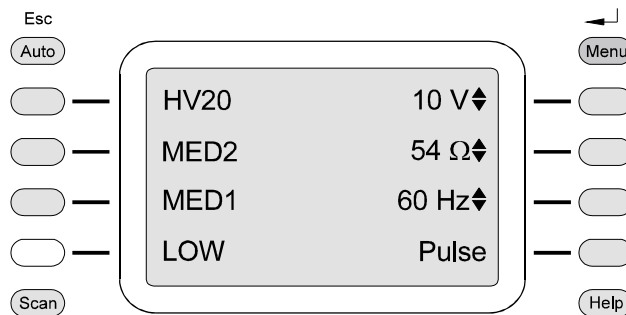


Figure 5-38. Main Menu Screen.

1. Press the **MED2** range button (Factory Group) in the Main Menu screen.
2. The yellow LED will be on next to the MED2 range once activated.
3. Place or clip the red test lead from the Tracker 4000's A test terminal to collector lead of the component.

- Place or clip the black test lead from the Tracker 4000's Common terminal to emitter lead of the component.

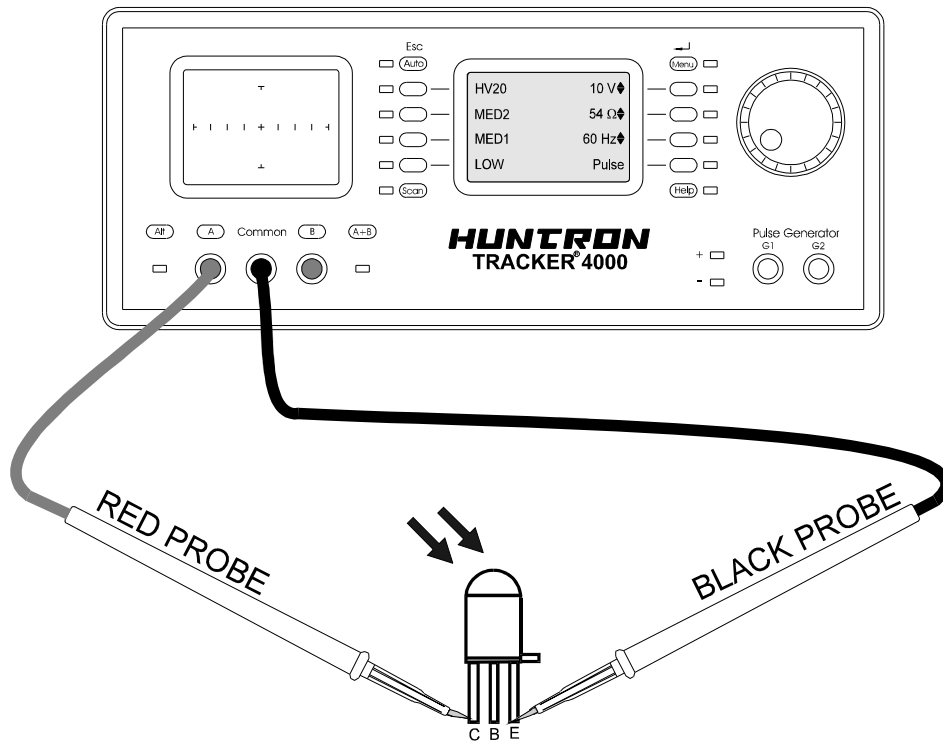


Figure 5-39. Tracker 4000 With Test Probes To A Phototransistor.

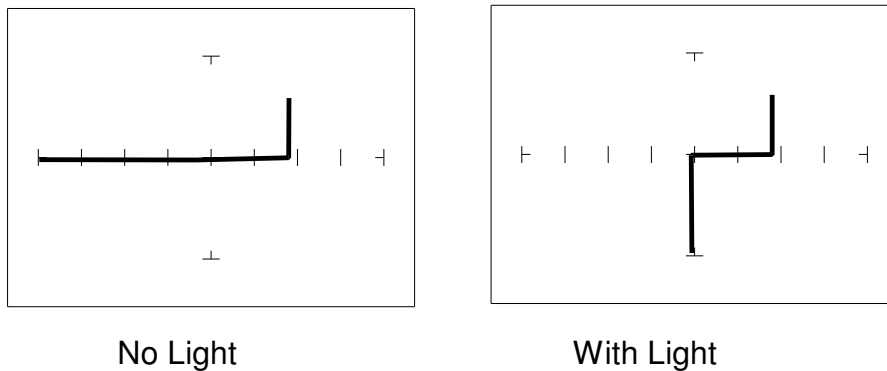


Figure 5-40. Signatures Of An NPN Phototransistor - MRD3056 Type. MED1 (Factory Group), C-E Junction

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.

OPTOCOUPLER DYNAMIC TESTING

The Tracker 4000's pulse generator can perform a dynamic test of optocouplers. Apply the pulse generator's output to the control input of a switching device and connect Tracker 4000's test leads across the component's switch terminals. Observe the optocoupler's signature for on and off states.

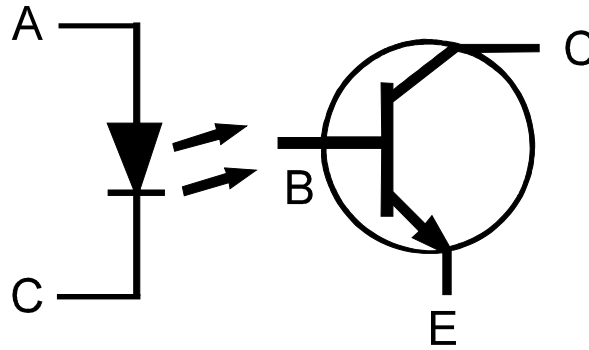


Figure 5-41. Diagram Of An Optocoupler.

OPTOCOUPLER SIGNATURES

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

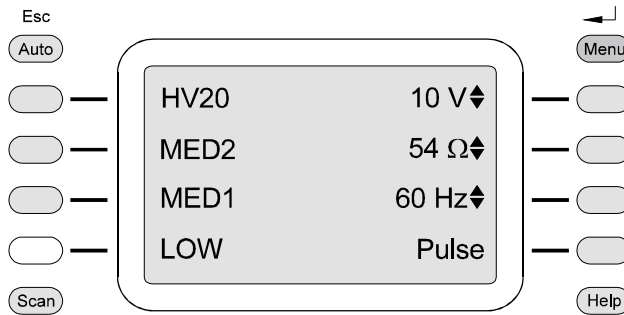


Figure 5-42. Main Menu Screen.

1. Press the **MED1** range button (Factory Group) in the Main Menu screen.

2. Connect the black test lead or easy grabber from Tracker 4000's Common test terminal to the transistor emitter lead and the diode cathode lead of the optocoupler.
3. Connect the red test lead or easy grabber from Tracker 4000's A test terminal to the transistor collector lead.
1. Connect the pulse generator G1 output with the blue easy grabber test clip to the diode anode lead.

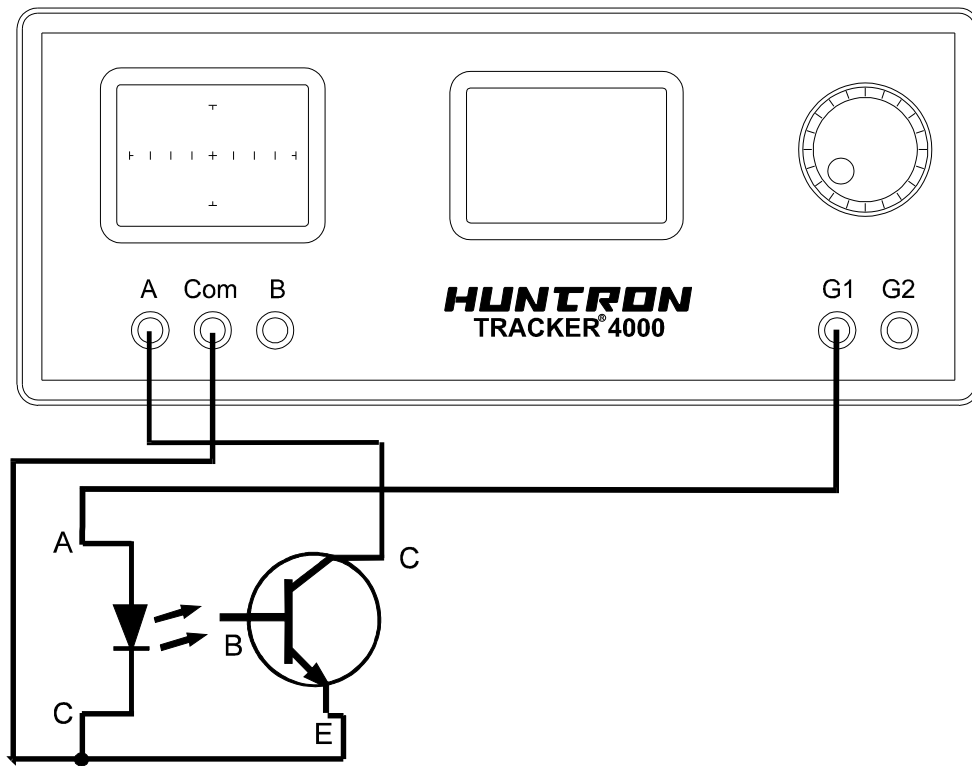



Figure 5-43. Pulse Generator Test Circuit For An Optocoupler.

1. Set the pulse generator controls to  (DC) Mode with the + LED illuminated.
2. Press the **VDC** button and rotate the encoder to 0.0 VDC.
3. Rotate the encoder clockwise to approximately 2.0 V.

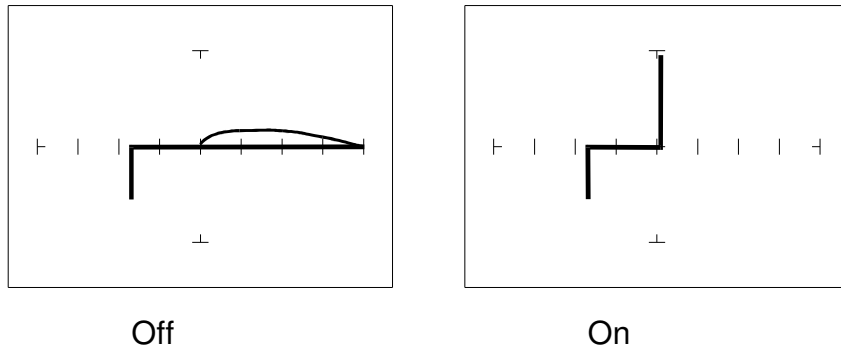


Figure 5-44. Signatures Of An Optocoupler - 4N33 Type MED1 (Factory Group)

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 as an open. When the gate is forced more positive than the cathode, positive current flows between the anode (A) and the cathode.

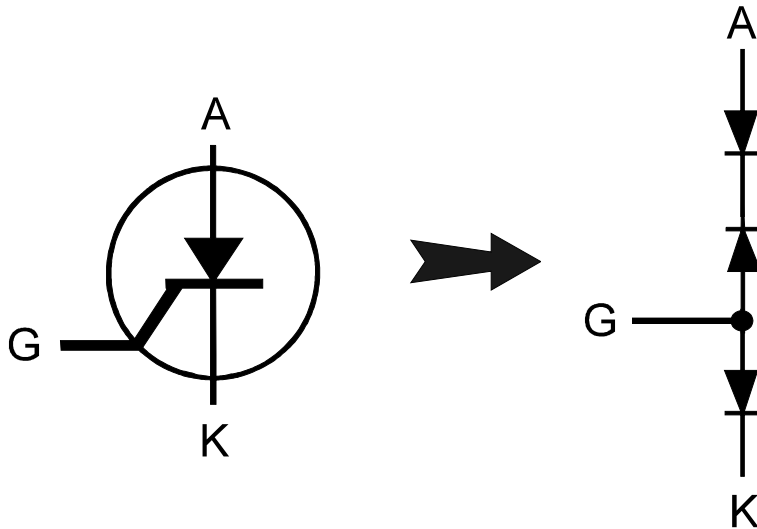


Figure 5-45. Diagram Of A Silicon Controlled Rectifier.

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

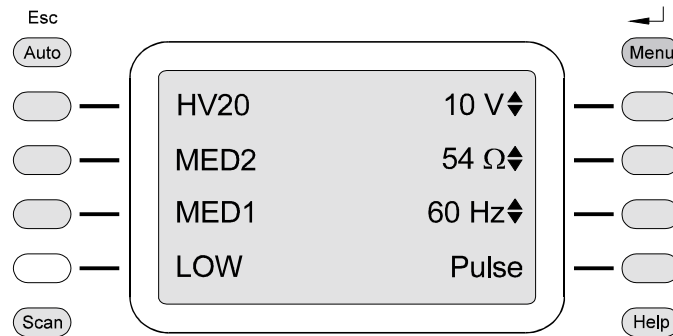


Figure 5-46. Main Menu Screen.

1. Press the **MED2** range button (Factory Group) in the Main Menu screen.
2. The yellow LED will be on next to the MED2 range once activated.
3. Place or clip the red test probe from the Tracker 4000's A test terminal to gate lead (G) of the component.
1. Place or clip the black test probe from the Tracker 4000's Common terminal to anode lead (A) of the component.

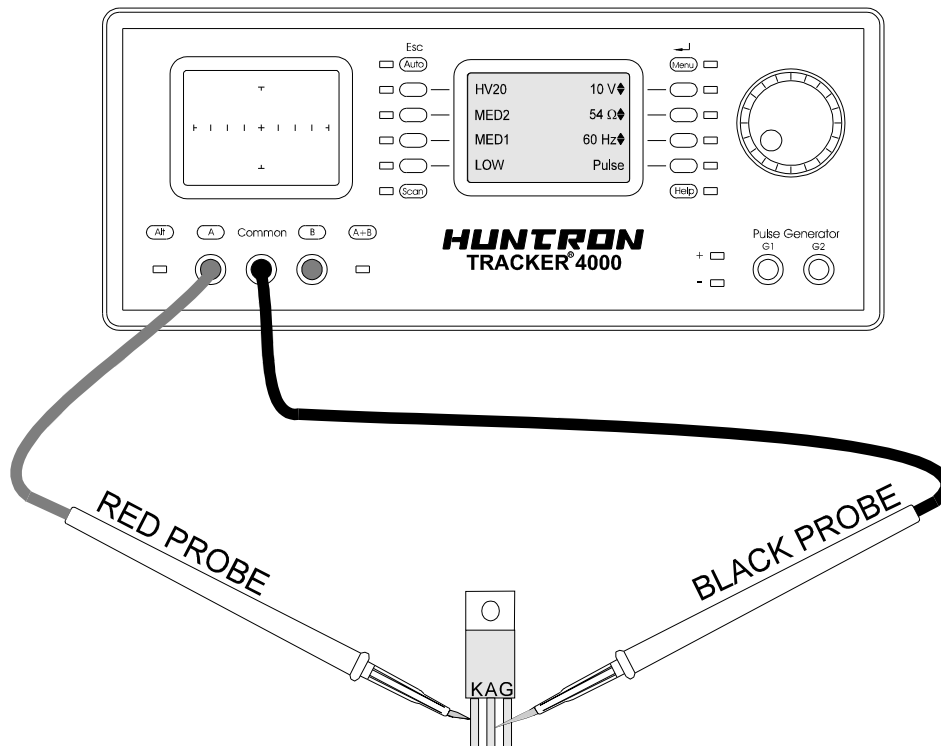


Figure 5-47. Tracker 4000 With Test Leads To A SCR.

2. Observe the gate-anode signature of the SCR.
3. Move the black test probe from the SCR's anode lead to cathode lead (K) of the component.
4. Observe the gate-cathode signature of the SCR.
5. Place the red test probe to the SCR's anode lead and the black test probe to the SCR's cathode lead.
6. Observe the SCR's anode-gate signature.

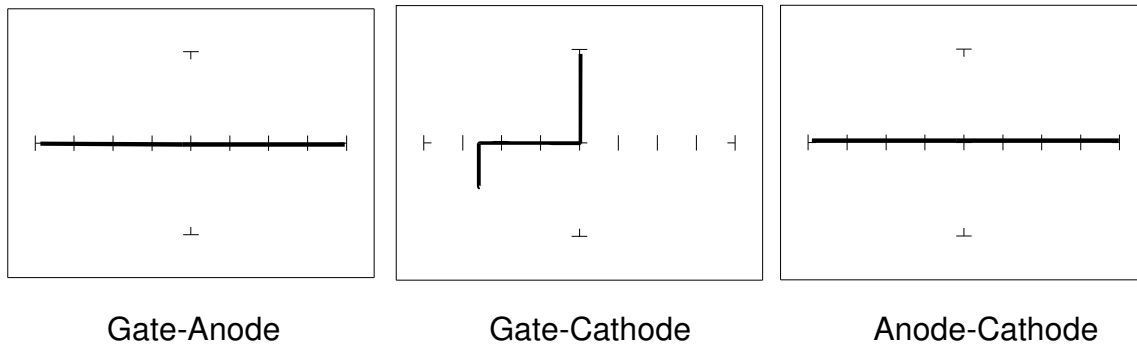


Figure 5-48. Signatures Of A SCR - C106B Type.
MED2 (Factory Default)

ACTIVE TESTING OF AN SCR

Connect the SCR to the Tracker 4000 as illustrated below:

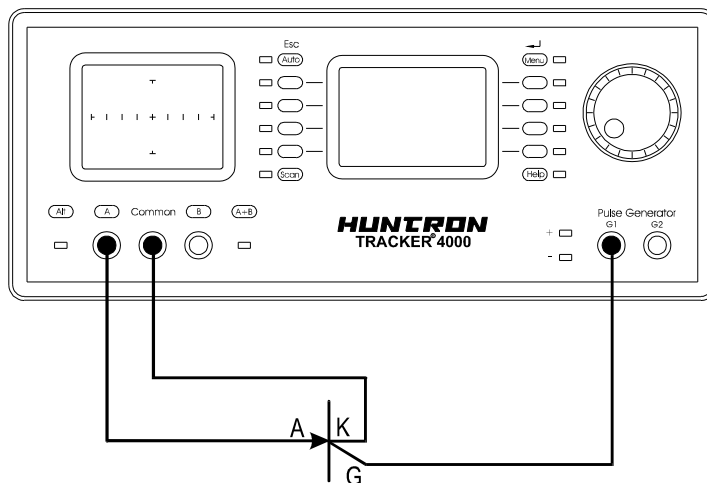


Figure 5-49. Pulse Generator Test Circuit For A SCR.

Do the following to dynamically test a SCR using the Tracker 4000:

1. Press the **MED1** range button (Factory Group) in the Main Menu screen.
2. Set the frequency to 60 Hz.
3. Press **Pulse**. Select **DC Mode** and **+** (the blue "+" LED will illuminate).
4. Connect the blue easy grabber from Tracker 4000's pulse generator G1 output terminal to the component's gate lead.
5. Connect the red test probe from Tracker 4000's A test terminal to the SCR's anode lead.
6. Connect the black test probe from Tracker 4000's Common test terminal to the SCR's cathode lead.
7. Turn the encoder clockwise to increase the voltage level from 0.0VDC.

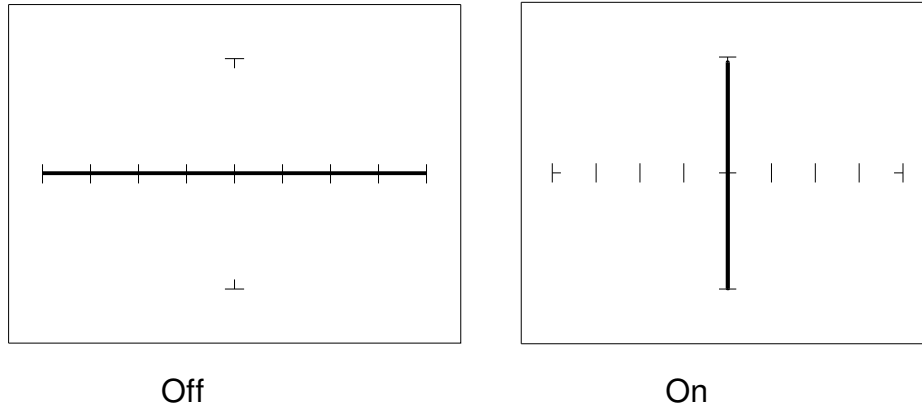


Figure 5-50. Signature Of A SCR (C106B Type) With The Pulse Generator Test. MED1 Range (Factory Group)

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

TRIAC

The TRIAC is a device designed to switch an AC current with either positive or negative gate control pulses.

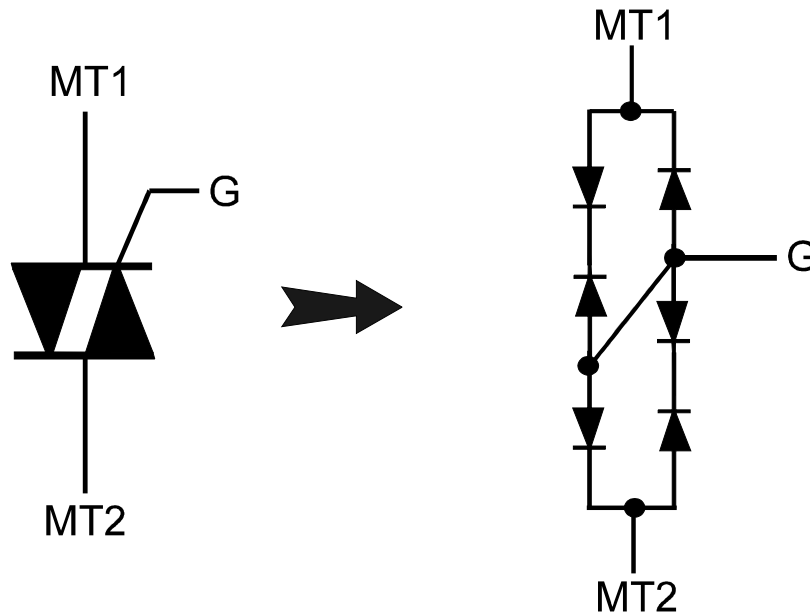


Figure 5-51. Diagram And Symbol Of A TRIAC.

The next section demonstrates how to dynamically test a triac with the Tracker 4000's pulse generator.

ACTIVE TESTING OF TRIACS

Connect the Tracker 4000 to the TRIAC as shown in figure 5-52.

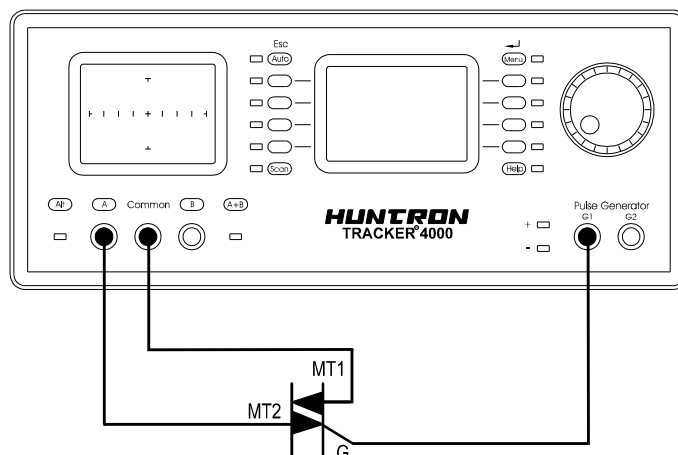


Figure 5-52. Pulse Generator Test Circuit For A TRIAC.

Do the following to dynamically test a TRIAC using the Tracker 4000:

1. Press the range to **MED2** (Factory Group) in the Main Menu screen.
2. Set the frequency to 60 Hz.
3. Press the **Pulse** button to go to the Pulse Menu screen. Select \square Mode and “+/-” (both blue LEDs illuminated).
4. Connect the blue easy grabber from Tracker 4000's pulse generator G1 output terminal to the gate lead on the component.
5. Connect the red test probe from Tracker 4000's A test terminal to the triac's MT2 lead.
6. Connect the black test probe from Tracker 4000's Common test terminal to the triac's MT1 lead.
7. Press **0.0 VDC** and turn the encoder clockwise to increase the voltage level.
8. Observe the TRIAC begin to conduct first in a forward direction and then in a reverse direction. You will see that the TRIAC is turned on by pulses of either polarity.

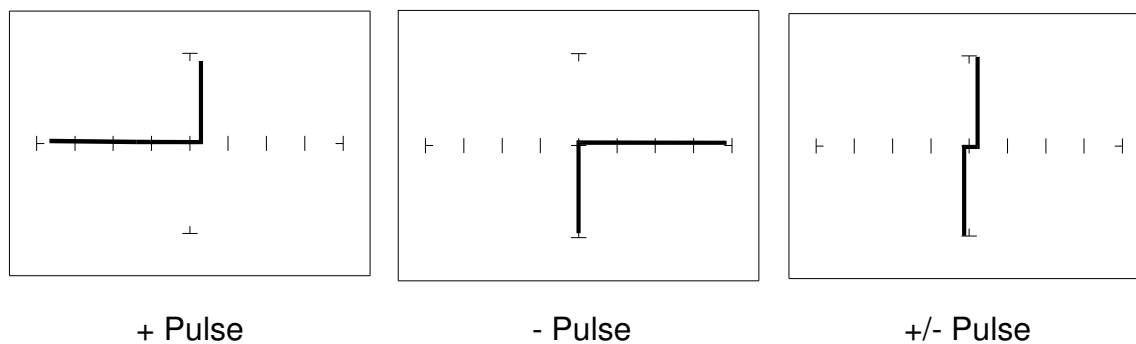


Figure 5-53. TRIAC Signatures With The Pulse Generator Test.
MED2 (Factory Group), PW (Pulse Width) = 50%

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.

APPLYING WHAT WE HAVE LEARNED

- The Tracker 4000 can also dynamically test optocouplers and phototransistors. These components are commonly found in isolation and switching circuits. Their operation can slowly deteriorate making them intermittent. This type of problem is extremely difficult to troubleshoot. With analog signature analysis, the Tracker 4000 will detect small amounts of degradation in an optocoupler's LED and the phototransistor's emitter-collector junction.
- The SCR and TRIAC can also be a problem to troubleshoot. They may be used to switch large currents. Quite often these components are susceptible to degradation and eventual failure. The Tracker 4000 can easily show these failures.

SECTION 6

TESTING INTEGRATED CIRCUITS

6-1. 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 on one chip. These chips can have pins from 14 to over 200, although quite often many pins share quite similar signatures. This can make troubleshooting easier by giving us an easy-to-find signature to use as a comparison. In this section, it is important to understand how the Tracker 4000 and ASA respond to these circuits.

INTEGRATED CIRCUIT FAILURES

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

- **EOS** Electrical Over Stress. The IC's maximum electrical specifications have been exceeded. This condition may result in the IC developing internal shorts and opens.
- **ESD** Electrostatic Discharge. Repeated exposure may cause internal resistance to develop in the IC junctions. This internal resistance may vary from 5 k Ω to 25 k Ω with a typical value of 20 k Ω . ESD exposure can cause internal flaws such as resistance, opens and shorts.
- **Dendrites** A process flaw that results in particles growing between conductors on a substrate causing shorts.
- **Ionic Contamination** Contamination introduced at the time of manufacturing that develops into leakage between substrate channels. This causes 5 k Ω to 25 k Ω 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 metalization 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.

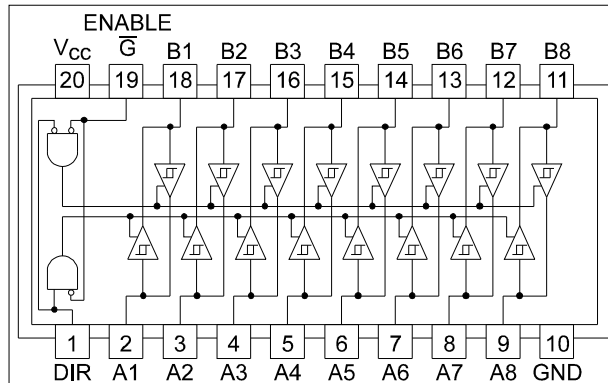


Figure 6-1. Digital IC 74LS245 Block Diagram.

- 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):

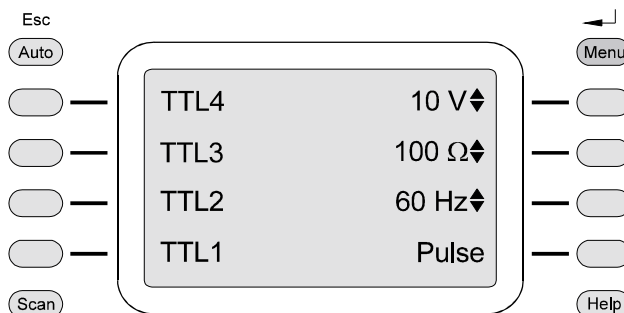


Figure 6-2. Main Menu Screen With TTL Range Group.

1. Turn power on to your Tracker 4000.
2. Press the **Menu** button followed by the **GroupEdit** button to display the GroupEdit Menu screen.
3. Press the group selection [**Factory**] button and use the encoder to select [TTL]. Press the **Enter** ↵ button to activate and return to the Main Menu screen.
4. Press the **TTL3** range button in the Main Menu screen.
5. The yellow **LED** will be on next to the **TTL3** range once activated.
6. If needed, set the test signal frequency to 60 Hz.
7. Place or clip the black test lead from the Tracker 4000's Common terminal to the IC's ground pin. For this example, the ground pin of the 74LS245 is pin 10.
8. Use the red test lead from the Tracker 4000's A test terminal. Probe each pin of the IC and view its signature on Tracker 4000's CRT 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.)
9. Use the red test lead from the Tracker 4000's A test terminal. Probe the enable input pins of the IC and view their signatures on the CRT 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.)
10. Set the range to **TTL1**. Use the red test lead from the Tracker 4000's A test terminal. Probe the power supply V_{CC} input pin and view its signature on the CRT display. For this example, the V_{CC} pin of the 74LS245 is pin 20.

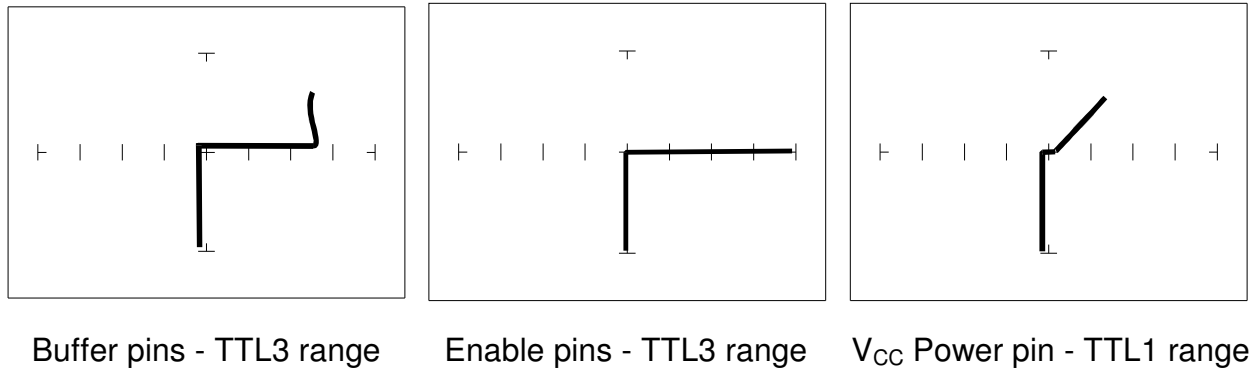


Figure 6-3. Signatures of A Digital IC, 74LS245.
TTL Group, Ground Pin To Test Common

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 Tracker 4000.

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

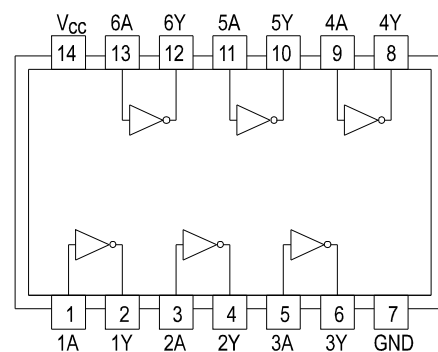
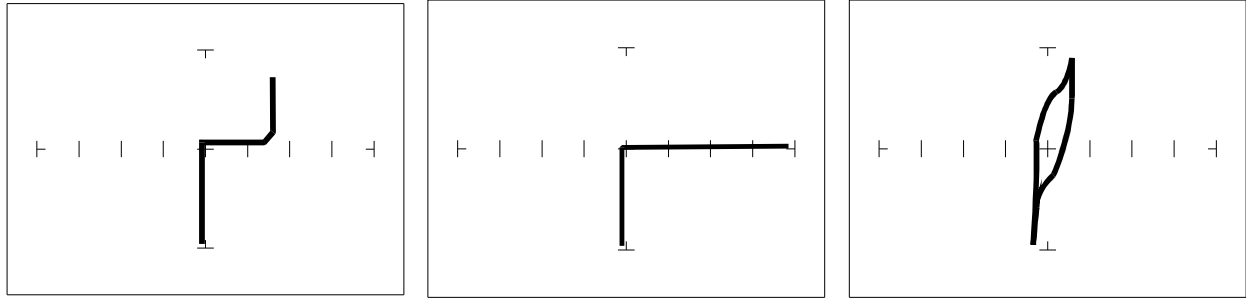
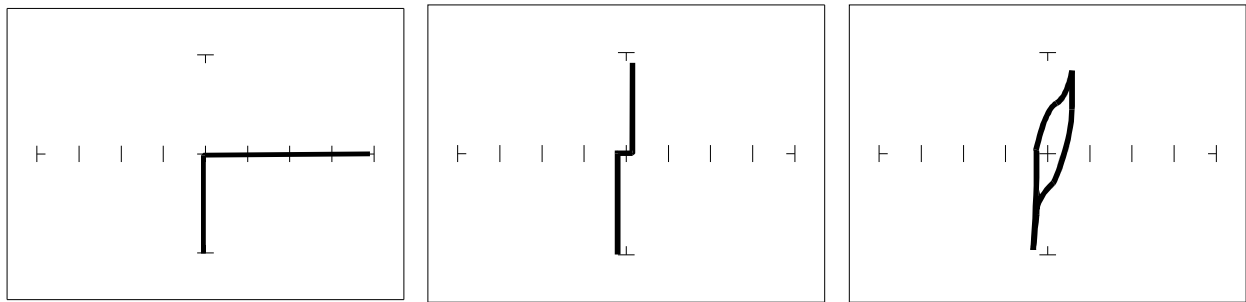


Figure 6-4. Diagram Of 7404 & 74LS04.



Pin 1 input - TTL3 range Pin 2 output - TTL3 range Pin 14 power - TTL1 range

Figure 6-5. Signatures Of A 7404 Hex Inverter.
TTL Group



Pin 1 input - TTL3 range Pin 2 output - TTL3 range Pin 14 power - TTL1 range

Figure 6-6. Signatures Of A 74LS04 Hex Inverter.
TTL Group

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.

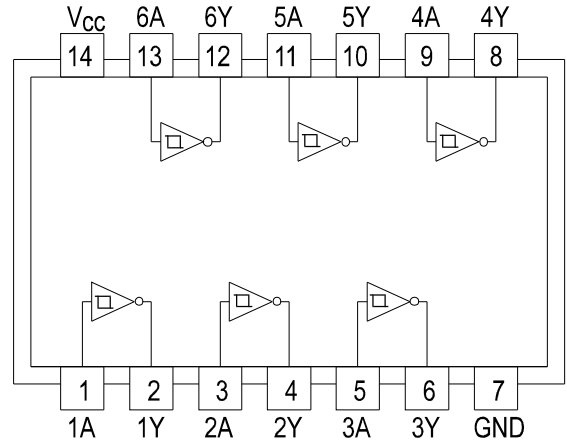


Figure 6-7. 74HC14 Block Diagram.

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

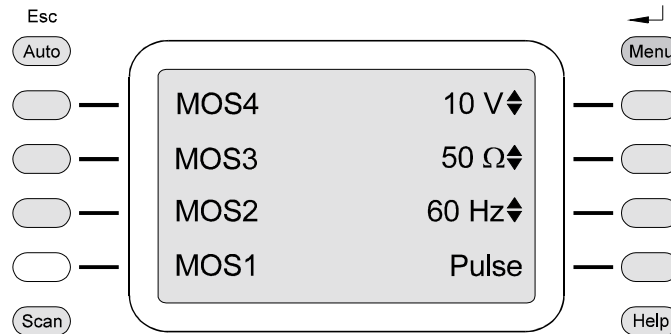
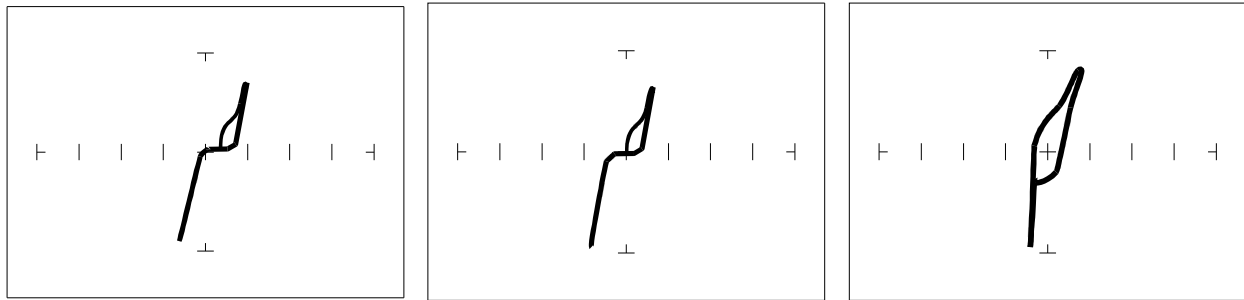


Figure 6-8. Main Menu Screen With MOS Range Group.

1. Turn power on to your Tracker 4000.
2. Press the **Menu** button followed by the **GroupEdit** button to display the GroupEdit Menu screen.
3. Press the group selection [**Factory**] button and use the encoder to select [**MOS**]. Press the **Enter** ↵ button to activate and return to the Main Menu screen.
4. Press the **MOS1** range button in the Main Menu screen.
5. The yellow **LED** will be on next to the **MOS1** range once activated.
6. Set the test signal frequency to 60 Hz, if needed.

7. Place or clip the black test lead from the Tracker 4000's Common terminal to the IC's ground pin. For this example, the ground pin of the 74HC14 is pin 7.
8. Use the red test lead from the Tracker 4000's A test terminal and probe each pin of the IC. For this example, pins 1, 3, 5, 9, 11, and 13 are all input buffer circuits so they will have identical signatures. (Note: This is only for ICs out of circuit.)
9. 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.)
10. Use the red test lead from the Tracker 4000's A test terminal and probe the power supply V_{CC} input pin. For this example, the V_{CC} pin of the 74HC14 is pin 14.



Pin 1 Input - MOS1 range

Pin 2 Output - MOS1 range

Pin 14 V_{CC} - MOS1 range

Figure 6-9. Signatures Of A 74HC14 CMOS Hex Inverter.
MOS Group

CMOS COMPONENTS AND TEST SIGNAL FREQUENCY F_S

CMOS logic circuits inherently have a significant amount of internal capacitance. This junction capacitance is visible in the CMOS signatures when using the Tracker 4000. Capacitance in CMOS circuitry may be emphasized or de-emphasized by changing the frequency of the test signal.

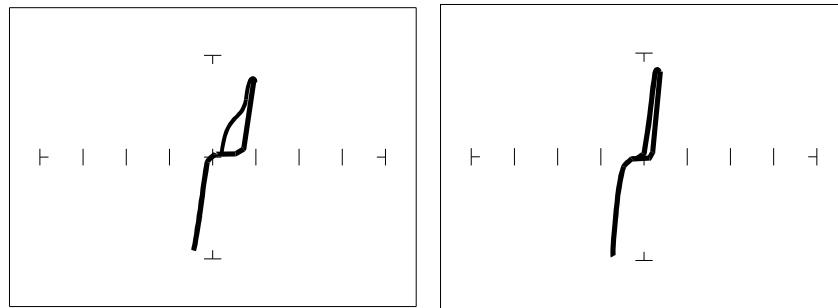
 $F_S = 20 \text{ Hz}$ $F_S = 400 \text{ Hz}$

Figure 6-10. Signatures Of A 74HC14 Input Pin At Different Frequencies.
MOS2 Range

TROUBLESHOOTING DIGITAL LOGIC ICS

Comparison testing is a very powerful and effective test strategy when troubleshooting digital logic using ASA. The Tracker 4000's Alt and Both features makes this technique quick and simple. Instead of having to remember the specific signatures of a good component, all that's needed is to have a reference component or board along side the one that's suspect. This section gave many examples of signatures from TTL, Schottky TTL and CMOS logic families. Although from first inspection, these signatures appear to be complex, remember that each of the ICs in the examples had really only four unique signatures (buffer input, buffer output, power supply VCC and power supply ground). We can use this characteristic to develop an effective model for troubleshooting digital logic chips.

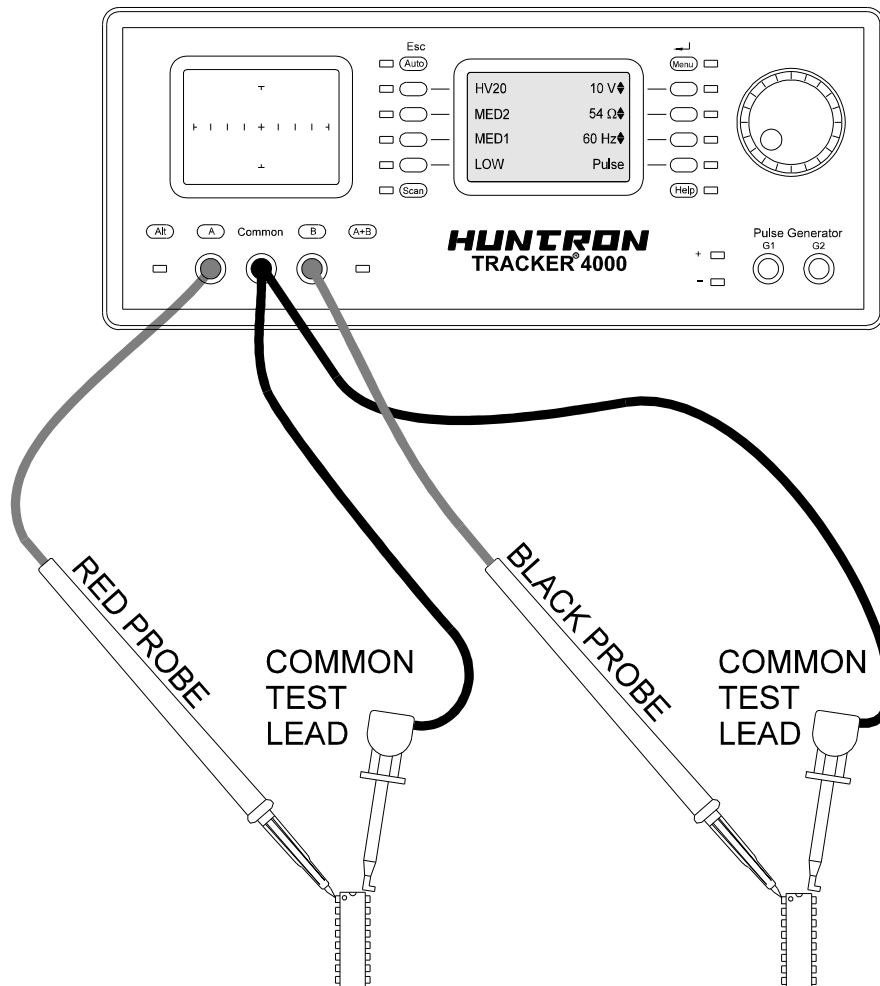


Figure 6-11. Tracker 4000 With Test Leads Setup For Comparing 2 ICs.

COMPARISON TESTING FOR DIGITAL ICs

Do the following to setup comparison testing and display the analog signatures of a digital IC:

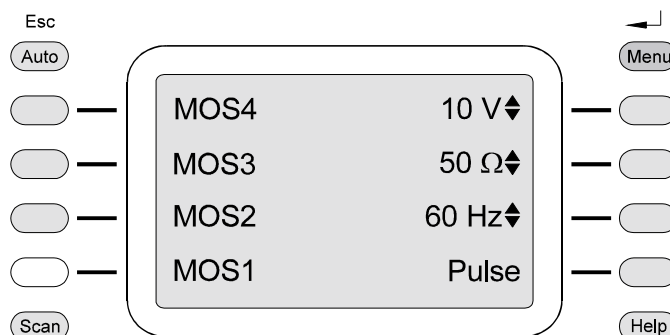


Figure 6-12. Main Menu With MOS Range Group.

1. Turn power on to your Tracker 4000.
2. Press the **Menu** button followed by the **GroupEdit** button to display the GroupEdit Menu screen.
3. Press the group selection [**Factory**] button and use the encoder to select [MOS]. Press the **Enter** ↵ button to activate and return to the Main Menu screen.
4. Press the **MOS1** range button in the Main Menu screen.
5. The yellow **LED** will be on next to the **MOS1** range once activated.
6. Set the test signal frequency to 60 Hz.
7. Place or connect the black or blue ground clip lead from the Tracker 4000's Common terminal to both reference and suspect IC or boards ground pin.
8. Place or clip the black test lead from the Tracker 4000's B test terminal to the suspect IC's pin. For this example, start with pin 1 of the suspect IC.
9. Place or clip the red test lead from the Tracker 4000's A test terminal to the reference or known good IC's pin. For this example, start with pin 1 of the known good IC.
10. Push the Channel **A** button. Observe the signature. This is the signature of the pin of the known good component.
11. Push the Channel **B** button. Observe the signature. This is the signature of the pin of the suspect component.
12. Press the **A+B** button on Tracker 4000's front panel to display both channels A and B simultaneously.

13. Or press the **Alt** button to display the A and B channels on the CRT alternately. If needed, press the **Rate** button (accessible from the **Menu** button) and use the encoder to adjust the display speed.
14. Visually compare the reference signature (channel A) with the suspect signature (channel B).
15. 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**.
16. Move the red probe on pin **2**, an output pin. Probe all the other output pins of the suspect component with the black probe until you have identified all the pins that have signatures that are the same as pin **2**.

REVIEW

- Integrated circuits are complex devices that are built using basic electronic components.
- The IC signatures resemble zener diodes.
- There are many causes for IC failures and the Tracker 4000 can display its "health" as resistive leakage, an open or a short.
- Functionally identical pins on a single IC out-of-circuit will display the same signature.
- The most common point for reference is ground, but V_{CC} or another point might give a more informative signature.
- Different logic families exhibit different characteristic signatures.
- To simplify the large number of signature variations, use the comparison test strategy with the Tracker 4000. The Tracker 4000 features either alternately switching or simultaneous display of the A and B channels to allow comparison of two individual signatures. The channel switching has two operating modes A+B and Alt.

APPLYING WHAT WE HAVE LEARNED

- Testing for faulty IC's is one of the more common uses for the Tracker 4000. A technician can compare IC's in or out of circuit.

6-2. ANALOG CIRCUITS

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

OP AMPS

Frequently, each pin of an op amp creates a different signature on the Tracker 4000. 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.

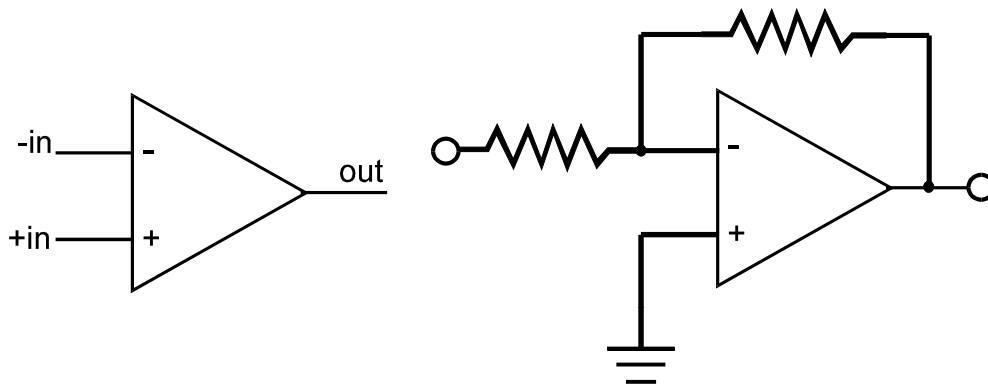


Figure 6-13. Op Amp Symbol And Schematic Diagram Of An Inverter Circuit.

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

OP AMP SIGNATURES

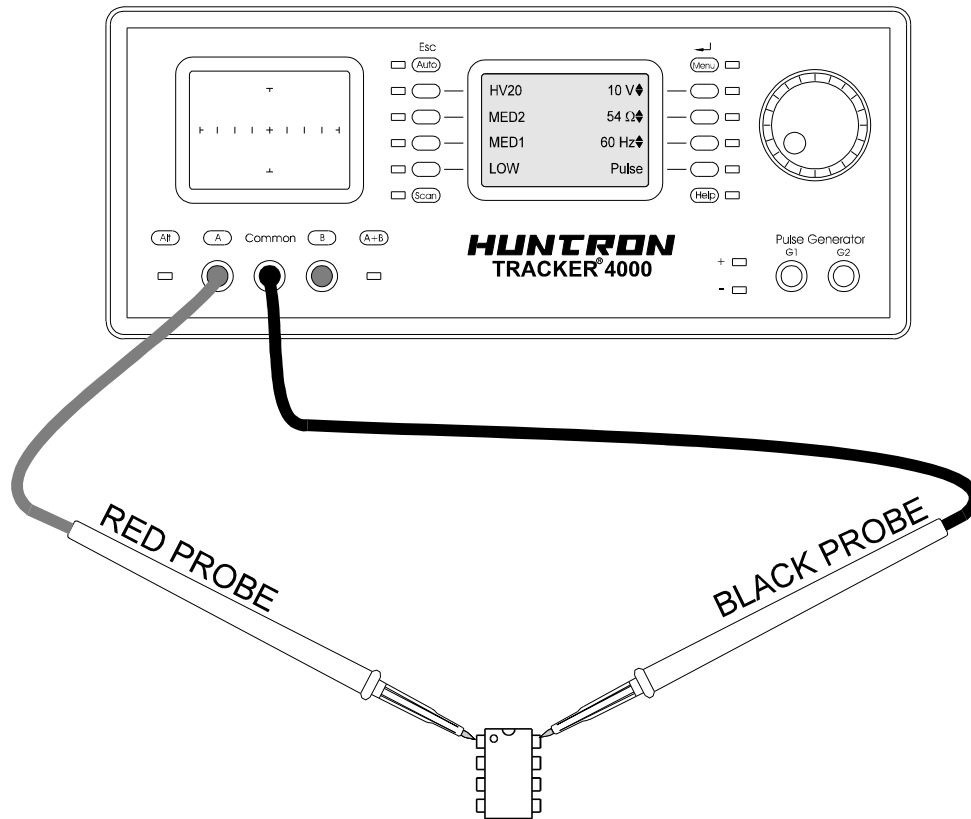


Figure 6-14. Tracker 4000 With Test Leads To An Op Amp.

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

1. Turn power on to your Tracker 4000.
2. Press the **MED1** range button (Factory Group) in the Main Menu screen.
3. The yellow LED will be on next to the MED1 range once activated.
4. Set the test signal frequency to 60 Hz.
5. Place or clip the black test lead from the Tracker 4000's Common terminal to the IC's ground or a power supply pin. For this example, the negative power supply pin of the 741 is pin 4 and the positive power supply is pin 8.
6. Use the red test lead from the Tracker 4000's A test terminal and probe each pin of the IC.

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

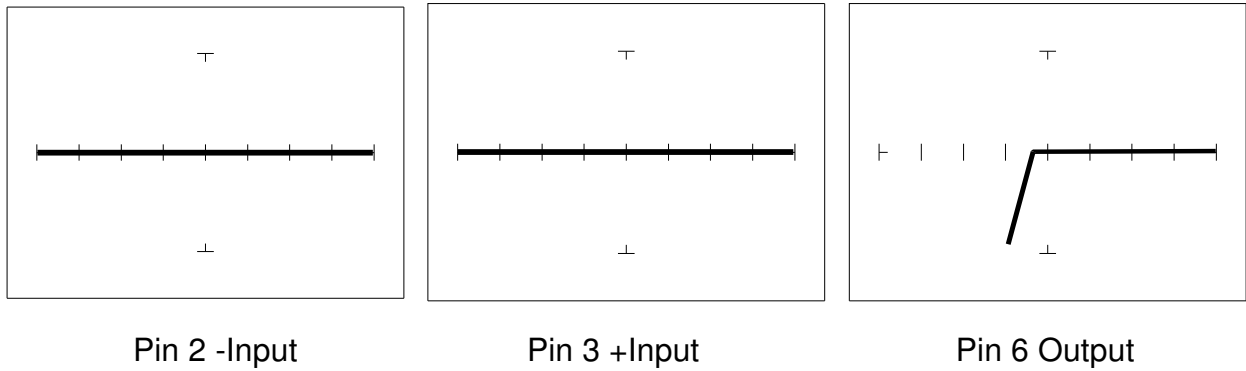


Figure 6-15. Signatures Of An Op Amp (741 Type) In LOW Range.
Factory Group, Common to Pin 4

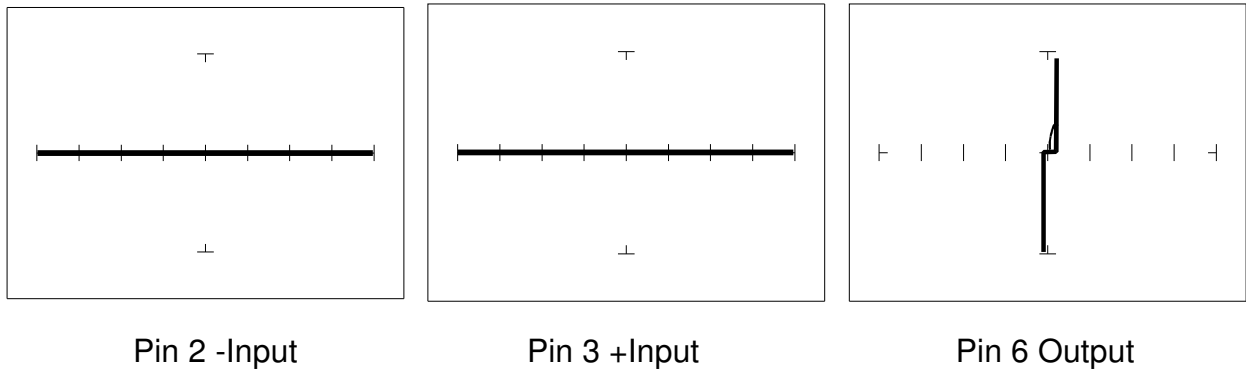


Figure 6-16. Signatures Of An Op Amp (741 Type) In MED2 Range.
Factory Group, Common to Pin 4

TROUBLESHOOTING OP AMP CIRCUITS

Troubleshooting an op amp in-circuit may be very challenging. These circuits usually have numerous connections that act as feedback or compensation loops. This results in almost an infinite number of possible analog signatures. Use the comparison test method when troubleshooting op amps in-circuit. In this case, components on a suspect board is compared to those on a known good board. The Tracker 4000 can help locate the defective component quickly.

The op amp has three main terminals; + input, - input and output. An alternative way to perform ASA on the op amp is to connect Tracker 4000's Common terminal to the op amp's output while making a comparison with the red test probe to the “ + ” and then the “ - ” leg. This eliminates problems encountered when probing op-amps that are isolated from power and common. When there is more than one op amp in a package, compare one with the other. The dual op amp and quad op amps are very common. This technique also works with comparators.

LINEAR VOLTAGE REGULATORS

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

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

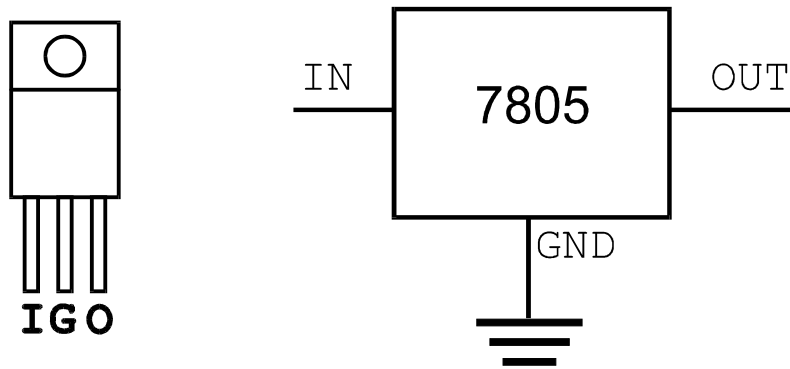
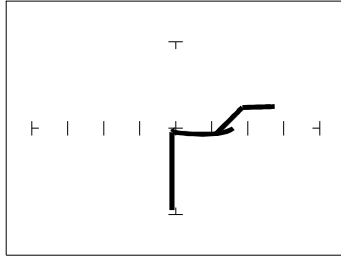
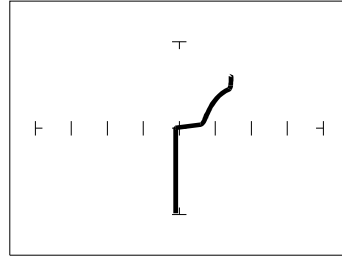


Figure 6-17. Diagram And Symbol Of A Linear Voltage Regulator, 7805 Type.

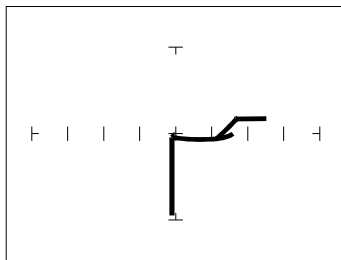


Input - TTL2 range

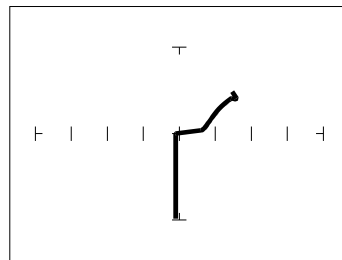


Output pin - TTL2 range

Figure 6-18. Signatures Of A 7805 Voltage Regulator By SGS Thomson.
Factory Group, Ground Pin To Common



Input - TTL2 range



Output pin - TTL2 range

Figure 6-19. Signatures Of A 7805 Voltage Regulator By Motorola.
Factory Group, Ground Pin To Common

REVIEW

- Integrated circuits are complex devices that are built using basic electronic components.
- The IC signatures resemble zener diodes.
- There are many causes for IC failures and the Tracker 4000 can display its "health" as resistive leakage, an open or a short.
- Functionally identical pins on a single IC out-of-circuit will display the same signature.
- The most common point for reference is ground, but V_{CC} or another point might give a more informative signature.
- Different analog IC families exhibit different characteristic signatures.
- To simplify the large number of signature variations, use the comparison test strategy with the Tracker 4000. The Tracker 4000 features either alternately switching or simultaneous display of the A and B channels to allow comparison of two individual signatures. The channel switching has two operating modes A+B and Alt.

APPLYING WHAT WE HAVE LEARNED

- Testing for faulty IC's is one of the more common uses for the Tracker 4000. A technician can compare IC's in or out of circuit.

6-3. LOW VOLTAGE

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

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

The Tracker 4000 has the built-in "SMT" test range group which has been optimized for this LV logic. SMT is an abbreviation for surface mount technology and refers to the physical IC package type in which the LV logic family is commonly available.

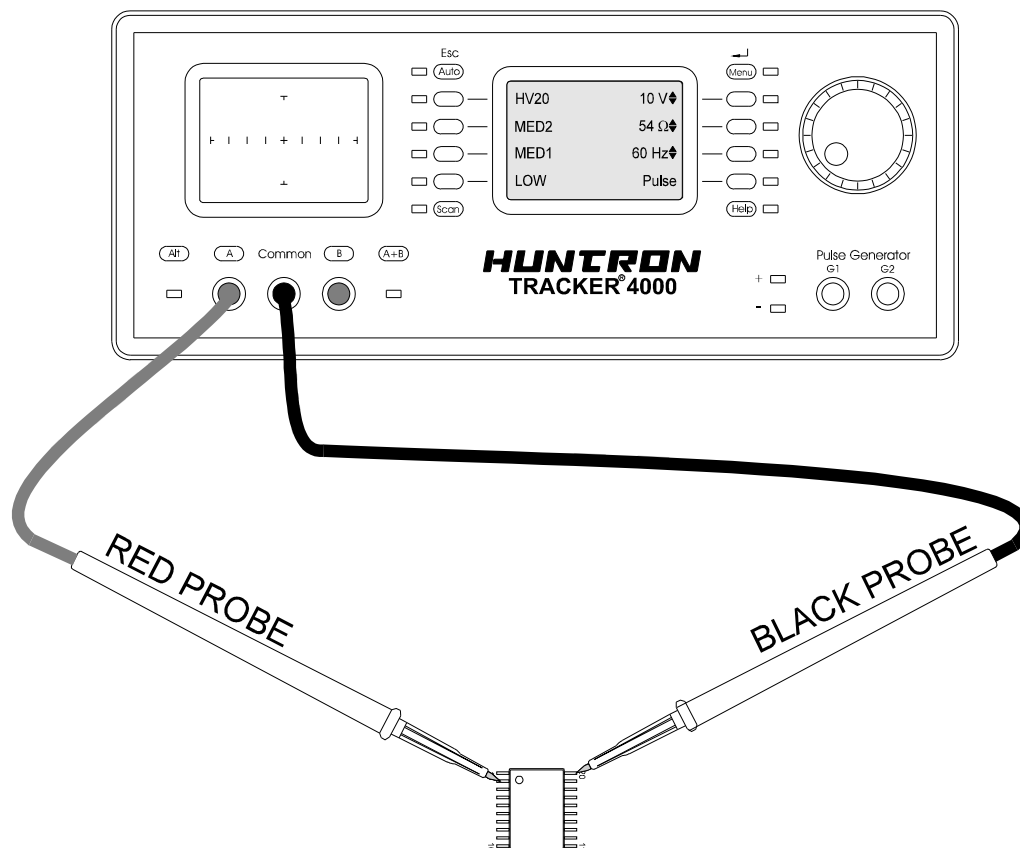


Figure 6-20. Tracker 4000 With Test Probes To A 20 Pin Surface Mount IC.

Use Tracker 4000's SMT ranges as a starting point when troubleshooting this type of component.

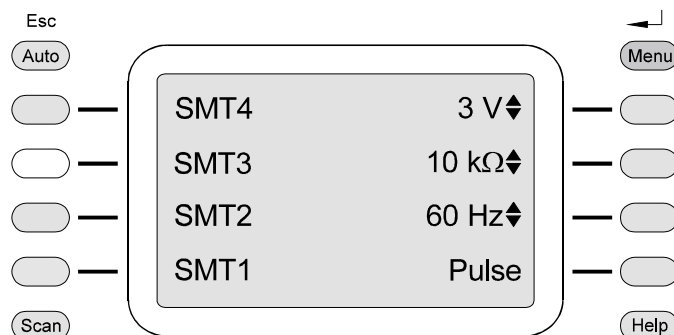
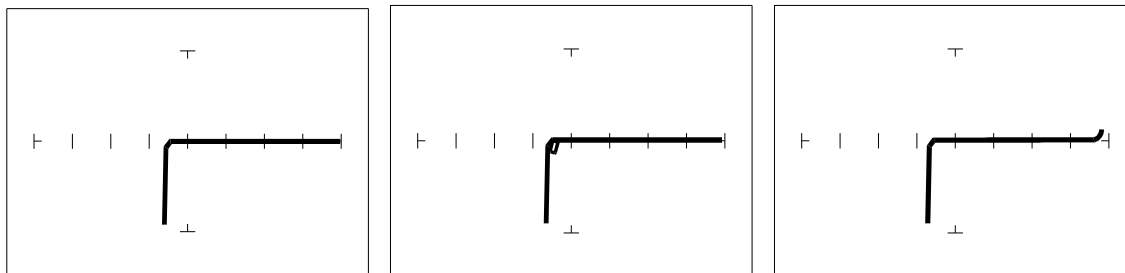


Figure 6-21. Main Menu Screen With SMT Range Group.

Do the following to view signatures of low voltage logic:

1. Turn power on to your Tracker 4000.
2. Press the **Menu** button followed by the **GroupEdit** button to display the GroupEdit Menu screen.
3. Press the group selection [**Factory**] button and use the encoder to select [SMT]. Press the **Enter** ↵ button to activate and return to the Main Menu screen.
4. Press the **SMT3** range button in the Main Menu screen.
5. The yellow **LED** will be on next to the **SMT3** range once activated.
6. Set the test signal frequency to 60 Hz.
7. Place or clip the black test lead from the Tracker 4000's Common terminal to the IC's ground pin. For this example, the ground pin of the 74LVQ245 is pin 10.
8. Use the red test lead from the Tracker 4000's A test terminal and probe each pin of the IC. For this example, pins 2 to 9 and 11 to 18 are all buffer circuits so they will have identical signatures. (Note: This is only for ICs out of circuit.)
9. Use the red test lead from the Tracker 4000's A test terminal and probe the enable input pins. For this example, the enable pins of the 74LVQ245 are pin 1 and 19 and will have the same signatures. (Note: This is only for ICs out of circuit.)
10. Use the red test lead from the Tracker 4000's A test terminal and probe the power supply V_{CC} input pin. For this example, the V_{CC} pin of the 74LVQ245 is pin 20.



Buffer pins - SMT3 range Enable pins - SMT3 range V_{CC} Power pin - SMT3 range

Figure 6-22. Signatures Of A Low Voltage IC (74LVQ45 Type).
SMT Range Group, Ground Pin To Test Common

The SMT test ranges have been developed to enhance the resistive fault signatures that are commonly found when troubleshooting this logic family. The test signal voltage V_S is lower than the Factory or the TTL range groups to ensure that most descriptive signature is displayed. A higher V_S may result in a signature going toward a short which would mask out flaws. The short signature can be attributed by the LV family's lower voltage characteristics.

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

REVIEW

- Integrated circuits are complex devices that are built using basic electronic components.
- The IC signatures resemble regular and zener diode signatures.
- There are many causes for IC failures and the Tracker 4000 can display its "health" as resistive leakage, an open or a short.
- Functionally identical pins on a single IC out-of-circuit will display the same signature.
- The most common point for reference is ground, but V_{CC} or another point might give a more informative signature.

- To simplify the large number of signature variations, use the comparison test strategy with the Tracker 4000. The Tracker 4000 features either alternately switching or simultaneous display of the A and B channels to allow comparison of two individual signatures. The channel switching has two operating modes A+B and Alt.

APPLYING WHAT WE HAVE LEARNED

- Testing for faulty IC's is one of the more common uses for the Tracker 4000. A technician can compare IC's in or out of circuit.

SECTION 7

THEORY OF OPERATION

7-1. INTRODUCTION

This section describes the basic operation of Tracker 4000. First a general overview of operation is provided, followed by descriptions of the major sections of the unit's circuitry and functions. The information in this section is not intended to be used as a repair guide or servicing instructions. Contact Huntron for service and repair assistance.

7-2. GENERAL OVERVIEW

The figure below is a functional block diagram of the Tracker 4000 design.

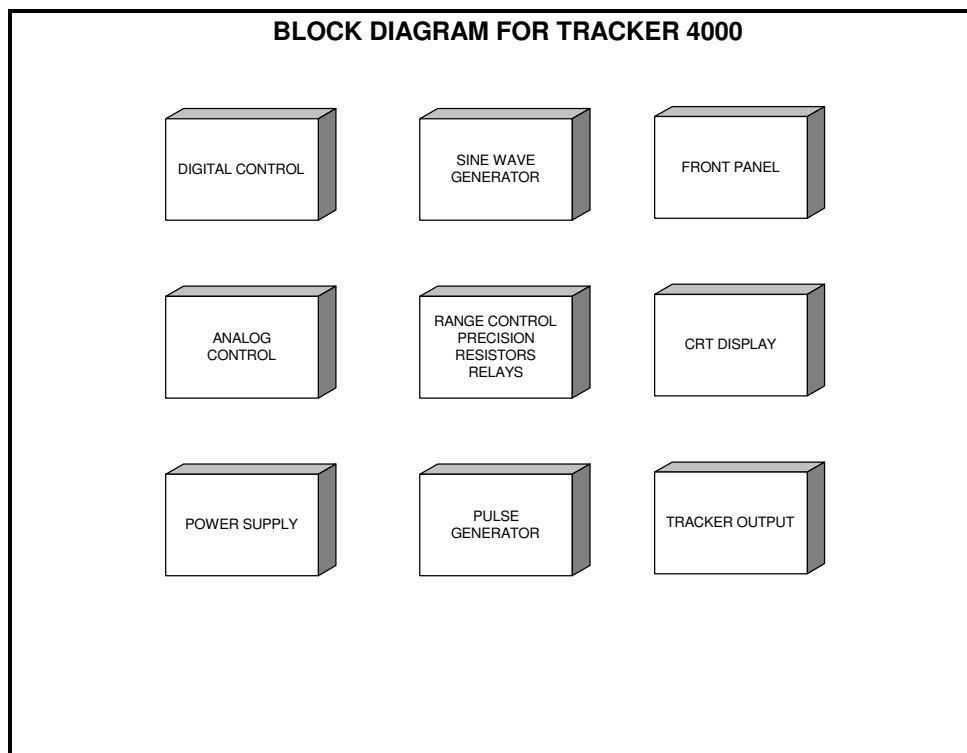


Figure 7-1. Tracker 4000 Operational Block Diagram.

- The Front Panel block consists of buttons, rotary encoder, LCD, and LEDs.
- The CRT Display block consists of CRT display, CRT drive and control circuits, and CRT power supply.
-

- The Tracker Output block consists of a relay switch matrix, buffer and output amplifiers.
- The Pulse Generator block consists of control logic, timing circuits and output amplifiers.
- The Range Control block consists of control logic, precision resistors and relay switching matrix.
- The Sine Wave Generator block consists of programmable crystal controlled dual sine wave oscillators, control logic and buffer amplifiers.
- The Power Supply block consists of a primary unit that's a universal AC line input switching supply for internal operation and a secondary regulated high voltage power supply for the CRT display.
- The Analog Control block consists of control logic, multiplexers and voltage references.
- The Digital Control block consists of microcontroller, memory, input/output circuitry and control logic.

7-3. FRONT PANEL BLOCK

The buttons on the Tracker 4000's front panel are of the conductive rubber type. They are scanned and multiplexed by the digital control logic. The encoder is a precision electro-opto unit with 128 steps and it's also connected to the digital control logic. The LCD is a 128 by 64 dot graphic STN panel with a LED backlight. The digital control logic interfaces to the LCD panel. The CRT is a monochrome electrostatic deflection type cathode ray tube. The digital control logic interfaces to the CRT control circuit which in turn connects directly to the CRT itself.

7-4. CRT DISPLAY BLOCK

The Tracker 4000 uses an electrostatic type CRT to display analog signatures. The voltage and current elements of the signature are applied to the X horizontal and Y vertical CRT deflection driver circuit. The CRT power supply has multiple outputs for the CRT's filament, deflection drivers and control grids and acceleration voltage source. The CRT high voltage circuits control the focus, intensity, astigmatism and trace rotation functions.

7-5. TRACKER OUTPUT BLOCK

The buffer and output amplifier circuits take the channel A and B test signals and routes them to the range resistors control block. From there, the test signals are routed through a relay switch matrix to the front panel output jacks.

7-6. PULSE GENERATOR BLOCK

The Pulse Generator uses the zero crossings of the test signal to trigger the start of a pulse. The control logic determines when positive (+) pulse out mode is enabled and a positive going zero crossing triggers a positive pulse. When a negative (-) pulse out mode is enabled, a negative going zero crossing triggers a negative pulse at the output. If both polarities (bipolar mode) are enabled, then both positive and negative output pulses are produced on alternate zero crossings (composite pulses). Once triggered, the duration of a pulse is set by the width button in 2% increments. The output amplifiers and drivers are dual output channels, G1 and G2. They have the ability to drive up to 20 volts peak to peak in bipolar pulse output mode and source up to 100 milliamps of current.

7-7. RANGE CONTROL BLOCK

The range control has dual identical circuits for channel A and channel B. A test signal is routed to a resistor and relay matrix where control logic sets the programmed path. The path sets the selected resistance and then the test signal is made available at Tracker 4000's output terminals. The matrix consists of 16 precision resistors and 16 reed type relays for each test signal channel A and channel B.

7-8. SINE WAVE GENERATOR BLOCK

The Tracker 4000 has dual sine wave generators to implement to channel A and channel B test signals. Each sine wave source consists of a digitally programmable IC for precisely setting the frequency for each channel's test signal. Programmed logic and firmware control this generator block.

7-9. POWER SUPPLY BLOCK

The Tracker 4000 uses a universal input switching power supply for operation. The switching power supply connects to the external AC line (mains) through an input module containing an on/off switch and line fuse. This switching power supply has triple output voltages that are connected to internal assemblies. On-card IC voltage regulators and DC-DC converters are used to meet additional circuit requirements.

7-10. ANALOG CONTROL BLOCK

The control logic for the analog circuitry is implemented in hardware with several complex programmable logic devices (CPLD) and in firmware. This digital interface design extends to digital potentiometers, analog multiplexors and voltage references resulting in almost all adjustments and calibrations front panel accessible.

7-11. DIGITAL CONTROL BLOCK

The main microcontroller is the core of this system. It is supported by static RAM (random access memory) and non-volatile reprogrammable Flash type program memory. The program memory contains the operating firmware code as well as the unit's calibration and user preferences. The slave microcontroller interfaces to Tracker 4000's front panel and communicates front panel functions bi-directionally to the main microcontroller. CPLDs add chip address selection and interrupt vector and priority processing support for this block.

SECTION 8 MAINTENANCE

8-1. INTRODUCTION

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

8-2. EXTERNAL CLEANING AND LUBRICATION



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

Should the Tracker 4000 case require cleaning, wipe the instrument with a cloth that is lightly dampened with water or mild detergent solution. The instrument requires no lubrication.

8-3. STORAGE INSTRUCTIONS

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

8-4. SERVICE INFORMATION

The conditions of the Tracker 4000 Warranty are given at the front of this manual. Malfunctions that occur within the limits of the warranty will be corrected at no cost to the purchaser exclusive of one-way shipping costs to Huntron Inc. Huntron service is also available for repair of instruments that are beyond the warranty period. In either case, please describe clearly the problems encountered with the instrument.

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

Huntron is also accessible by Fax at 425-743-1360, by Internet E-mail at huntron@huntron.com, and on our Internet Home Page at <http://www.huntron.com>

Notes: