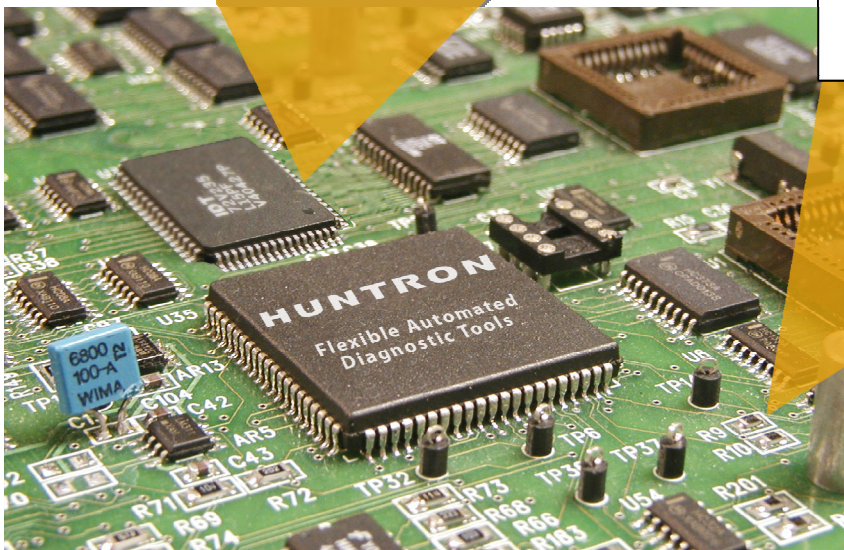
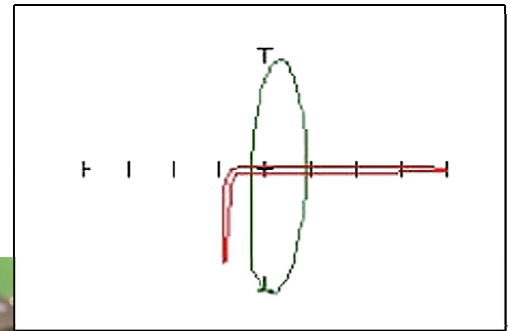
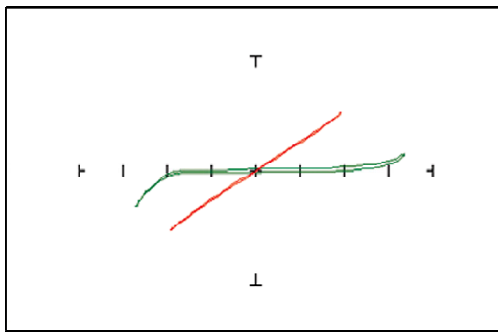


Fundamentals of Signature Analysis

An In-depth Overview of Power-off Testing
Using Analog Signature Analysis



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Table of Contents

<u>SECTION 1. INTRODUCTION.....</u>	<u>7</u>
PURPOSE.....	7
ANALOG SIGNATURE ANALYSIS (ASA) BASICS.....	8
FOUR BASIC COMPONENT ANALOG SIGNATURES.....	11
HOW ANALOG SIGNATURES ARE OBTAINED.....	11
GOOD VERSUS SUSPECT COMPARISON.....	12
RESISTANCE SELECTION.....	13
FREQUENCY SELECTION.....	14
VOLTAGE SELECTION.....	15
PULSE GENERATOR AND DC VOLTAGE SOURCE.....	15
<u>SECTION 2 TESTING RESISTORS.....</u>	<u>17</u>
TESTING RESISTORS - INTRODUCTION.....	17
CHANGING COMPONENT RESISTANCE VALUE.....	17
RESISTIVE SIGNATURES - CHANGING VOLTAGE AND FREQUENCY.....	19
REVIEW FOR RESISTIVE SIGNATURES.....	19
<u>SECTION 3 TESTING CAPACITORS.....</u>	<u>20</u>
INTRODUCTION.....	20
CHANGING COMPONENT CAPACITANCE VALUE.....	20
REVIEW FOR CAPACITIVE SIGNATURES.....	23
<u>SECTION 4 TESTING INDUCTORS.....</u>	<u>24</u>
INTRODUCTION.....	24
CHANGING COMPONENT INDUCTANCE VALUE.....	24
REVIEW FOR INDUCTIVE SIGNATURES.....	26
<u>SECTION 5 TESTING DIODES.....</u>	<u>27</u>

INTRODUCTION	27
DIODE SIGNATURES AND BREAKDOWN VOLTAGE (VBD)	28
EFFECTS OF CHANGING TRACKER SETTINGS ON DIODE SIGNATURES	29
DIODE FAILURES.....	30
COMPOSITE DIODE SIGNATURES.....	31
ZENER DIODES	32
REVIEW FOR DIODE SIGNATURES	33
<u>SECTION 6 TESTING TRANSISTORS.....</u>	34
INTRODUCTION	34
PNP AND NPN TRANSISTOR SIGNATURES	35
USING THE PULSE GENERATOR OR DC VOLTAGE SOURCE TO TEST TRANSISTOR OPERATION	35
REVIEW FOR TRANSISTOR SIGNATURES	36
<u>SECTION 7 TESTING THE OPERATION OF SWITCHING DEVICES.....</u>	38
INTRODUCTION	38
TESTING SWITCH DEVICES WITH THE DC VOLTAGE SOURCE OR PULSE GENERATOR.....	38
REVIEW FOR SWITCHING DEVICES	40
<u>SECTION 8 TESTING INTEGRATED CIRCUITS.....</u>	42
INTRODUCTION	42
WHY AN INTEGRATED CIRCUIT (IC) FAILS	42
DIGITAL INTEGRATED CIRCUIT SIGNATURES	42
SIGNATURES OF DIFFERENT IC FAMILIES.....	44
TESTING ANALOG ICs.....	45
REVIEW OF TESTING INTEGRATED CIRCUITS	47
<u>SECTION 9 ANALOG SIGNATURE ANALYSIS FAILURE EXAMPLES</u>	48
EXAMPLE 1	48
EXAMPLE 2	49

Section 1. Introduction

Purpose

This document is for the purpose of providing a comprehensive explanation of the concept, use and application of Analog Signature Analysis commonly known by the acronym “ASA”.

The information presented here is intended to be general in nature and not necessarily product or manufacturer specific. However, it may be necessary to reference instrument or software products produced by Huntron, Inc. Huntron is the recognized leader in ASA troubleshooting instruments and systems and this document will draw on that experience and expertise.

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Analog Signature Analysis (ASA) Basics

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

Understanding the ASA core circuit is the key to understanding how analog signatures respond to different types of components. ASA is sometimes referred to as “V/I Test” and 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 ASA 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’s internal or source impedance R_s . Because R_s is constant, both the voltage across the component under test and the current through it is a sole function of R_L .

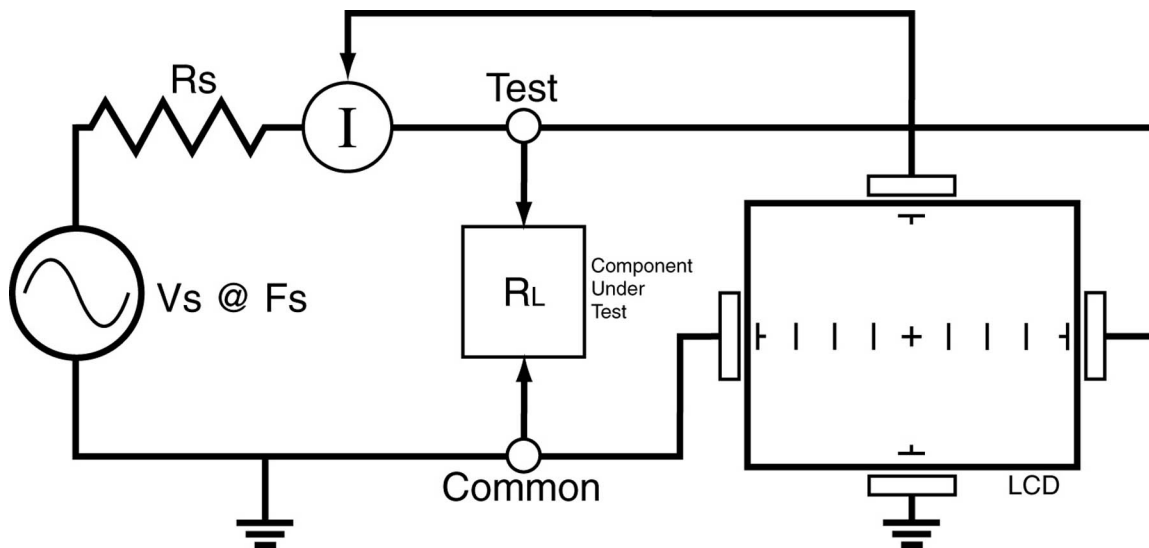


Figure 1-1: ASA Core Circuit Block Diagram

R_s = Source Resistance, V_s = Source Voltage, R_L = Load Resistance, F_s = Source Frequency

Each test signal or range has three parameters: source voltage V_s , resistance R_s and source frequency F_s . When using ASA for troubleshooting, the objective is to select the range that will display the most descriptive analog signature information. A Huntron Tracker can readily accomplish this by changing the proper range parameter. The source voltage V_s of the test signal can be used to enhance or disregard semiconductor switching and avalanche characteristics. The F_s or frequency of the test signal

source can be used to enhance or disregard the reactive factor (capacitance or inductance) of a component or circuit node. The R_s or source resistance is used to match the impedance load under test and provide the most descriptive signature possible.

Horizontal Axis

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

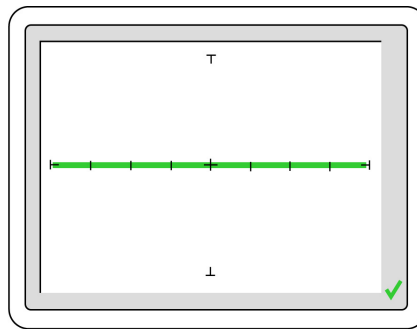


Figure 1-2 Display with Open Test Terminals

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

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

Table 1-1 Horizontal Scale per Voltage Range

The signature viewing area of the instrument display can also be set up in quadrants to show positive and negative current and voltage characteristics. Refer to figure 1-3.

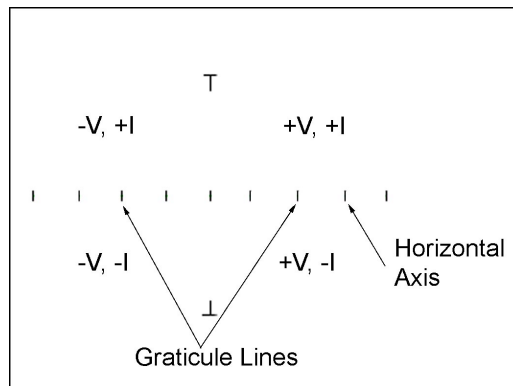


Figure 1-3. Display Horizontal Axis and Graticule Lines.

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 instrument 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.

Vertical Axis

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

When the R_L is zero ohms (0Ω) by shorting the output terminal to the common terminal, there is no voltage dropped across R_L causing no horizontal component displayed in the analog signature. This short circuit signature is a vertical line trace on the instrument display as shown in Figure 1-4.

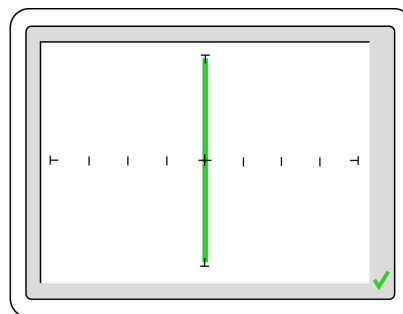


Figure 1-4 Display with Vertical Axis, Graticule Lines displaying a short circuit

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 semi-conductance. Refer to Fig 1-5. Each one of these basic components responds differently to the instrument's test signal. Recognizing these four basic unique signatures on the instrument display is one of the keys to successful ASA troubleshooting. When components are connected together to form a circuit, the signature at each circuit node is a composite of the basic component signatures in that circuit. For example, a circuit with both resistance and capacitance will have a signature that combines the analog signatures of a resistor and capacitor. The signature of a resistor is always indicated by a straight line at an angle from 0 to 90 degrees. The signature of a capacitor is always in the form of a circle or ellipse shape. The signature of an inductor is also a circle or ellipsoid shape that may also have internal resistance. Finally, the semiconductor diode signature is always made up of two or more linear line segments that generally form an approximate right angle. Semi-conductance signatures can show conduction in both forward and reverse-bias. This will form a zener semiconductor pattern which will show both junctions.

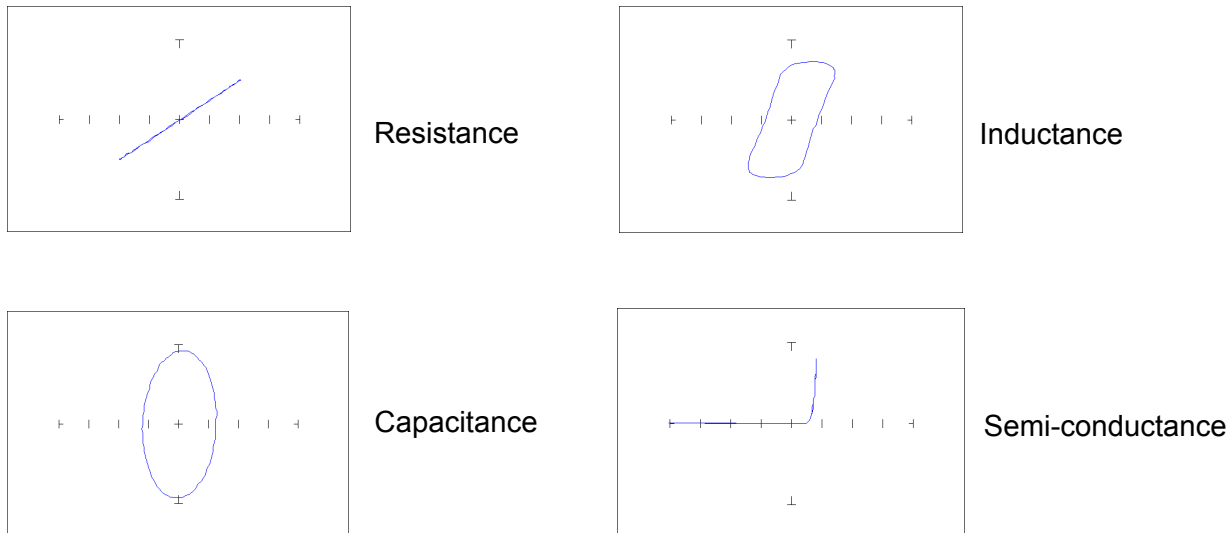


Figure 1-5 Analog Signatures of the Four Basic Components

How Analog Signatures are Obtained

The signatures shown in this document were obtained using ASA instruments manufactured by Huntron, Inc.

For most of the signatures shown in this document, a simple two probe approach is used. Probes are held either directly across a component or from between a component pin and a common reference such as ground or Vcc on the circuit board.

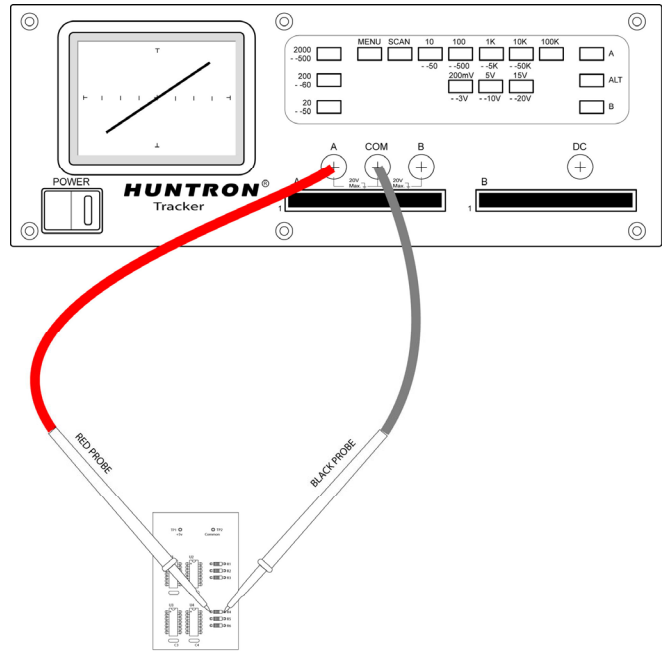


Figure 1-6 Typical two probe application testing a component such as a resistor. One probe (red) is connected to channel A and the other probe (black) is connected to Common.

The Channel A and Channel B connections are the “test” or signal connections. The actual test signal is applied through these connections.

The Common connection is the common signal reference or “signal return”. This is sometimes referred to as “ground” although Common can be attached to any point on the circuit board.

Good versus Suspect Comparison

In most cases, analog signature analysis is used for comparison troubleshooting. This means that the signatures of a good printed circuit assembly (PCA) are compared to those of a suspect PCA. Signature differences can indicate a potential problem. In general practice, Channel A is used for the good PCA and the B Channel is used for the suspect PCA.

There are two channels on a Huntron Tracker, channel **A** and channel **B**. These are selected by pressing the appropriate front panel button or select the desired channel in Huntron Workstation software.

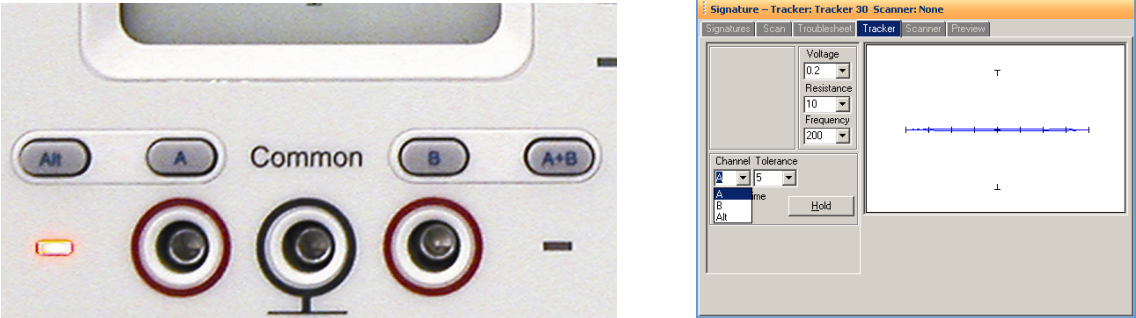


Figure 1-7 Channel A and Channel B shown on a Huntron ProTrack and in Workstation software

When using a single channel, the red probe should be plugged into the corresponding channel test terminal and the black probe or common test lead should be plugged into the common test terminal. When testing, the red probe should be connected to the positive terminal of a device (i.e. anode, +V, etc.) and the black probe should be connected to the negative terminal of a device or a common reference (i.e. cathode, ground). Following this procedure should assure that the signature appears in proper quadrant of the display.

Typical comparison signatures are displayed in figures 1-8 and 1-9. The green is the good “reference” signature and the red in the suspect signature.

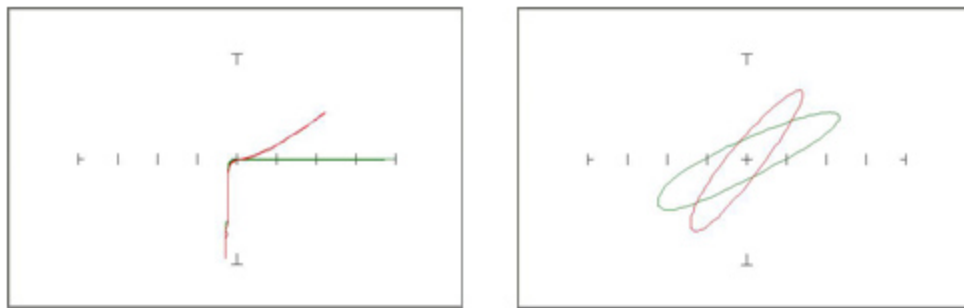


Figure 1-8 Good versus bad signatures

These images show good versus bad signatures (good is green and bad is red). The signatures on the left show a damaged transistor (leakage) compared to a working device. The signatures on the right show a good inductor and one with shorted windings.

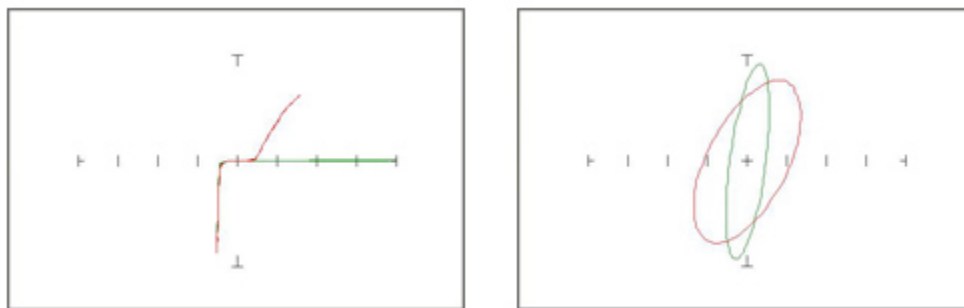


Figure 1-9 Good versus bad signatures

These images show good versus bad signatures (good is green and bad is red). The signatures on the left show a good output 74S04 IC pin and an output pin with a damaged junction. The signatures on the right show a good capacitor and one with internal leakage.

Resistance Selection

A ASA test instrument is typically designed with multiple resistance ranges varying from **10Ω** to **100kΩ**. A resistance range is selected by pressing the appropriate button on the instrument front

panel, turning a encoder knob (Huntron ProTrack and Huntron Tracker 4000) or by selecting a resistance setting from the Resistance drop menu in the Huntron Workstation Tracker window (figure 1-10).

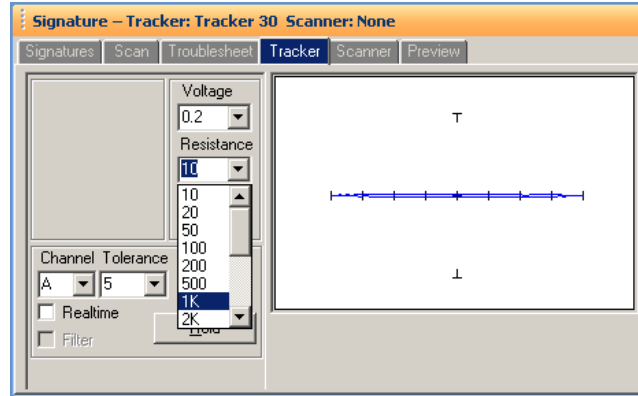


Figure 1-10 Selecting Resistance in the Workstation Tracker Tab

It is best to start with one of the middle resistance values (i.e. **100Ω or 1kΩ**). If the signature on the display is close to an open (horizontal trace), set the Tracker to the next higher resistance for a more descriptive signature. If the signature is close to a short (vertical trace), go the next lower resistance. An optimum resistive signature is approximately at a 45° angle to the horizontal and vertical lines of the graticule.

Frequency Selection

The instrument test signal frequencies will vary from **20Hz to 5000Hz** and can be selected by pressing the appropriate button on the front panel, turning a encoder knob or by selecting a setting from the Frequency drop menu in the Workstation Tracker window (figure 1-11).

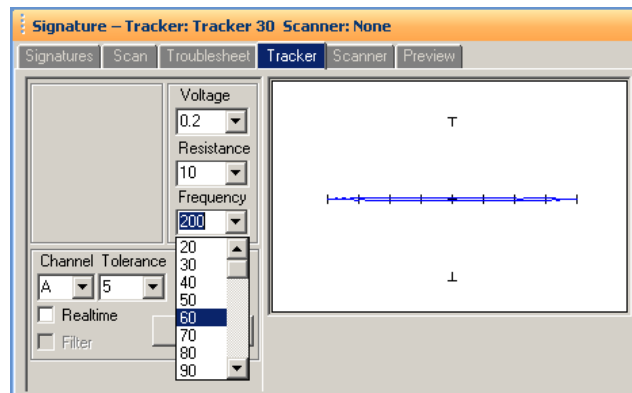


Figure 1-11 Selecting Frequency in the Huntron Workstation Tracker tab

Frequency is typically changed when testing reactive components such as capacitors or inductors. Changing frequency will affect the elliptical shape of the signatures displayed.

Voltage Selection

The test instrument voltage selection varies from **200mV** to **20V**. This controls the peak applied sine-wave voltage. The voltage setting can be selected by pressing the appropriate button on the front panel, turning a encoder knob or by selecting a setting from the Voltage drop menu in the Workstation Tracker window (figure 1-12).

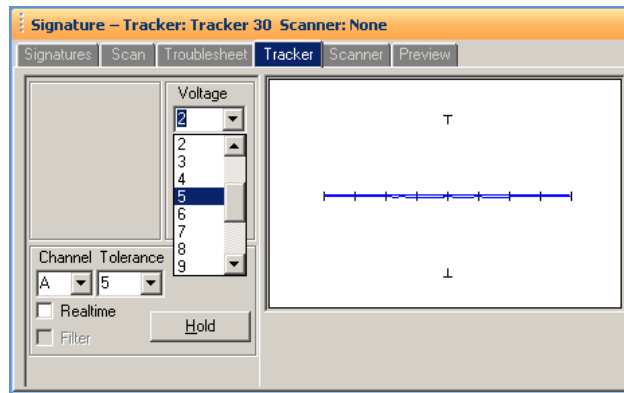


Figure 1-12 Selecting Voltage in the Workstation Tracker tab

Pulse Generator and DC Voltage Source

Some models of ASA test instruments have a built-in DC (direct current) voltage source or Pulse Generator that allows for in-circuit testing of certain devices in their active mode. In addition to using the red and black probes, the output of the DC voltage source or Pulse Generator is connected to the control input of the device to be tested with the clip lead provided with your instrument. In general use, a DC level from the DC voltage source or Pulse Generator is used. Figure 1-13 shows how to connect a Huntron Tracker to the device under test, using the DC voltage source.

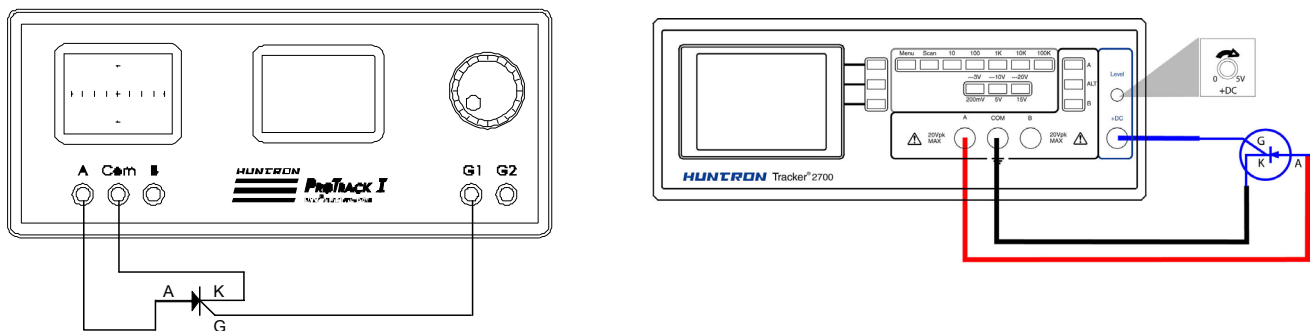


Figure 1-13 Typical Tracker Pulse Generator or DC Source Setup using a SCR

The DC Voltage Source or Pulse Generator output is set using a Level control on the instrument front panel, using front panel encoder or using the Pulse Level setting in the Workstation Tracker tab. The level control varies the magnitude of output voltage from zero to 10 volts.

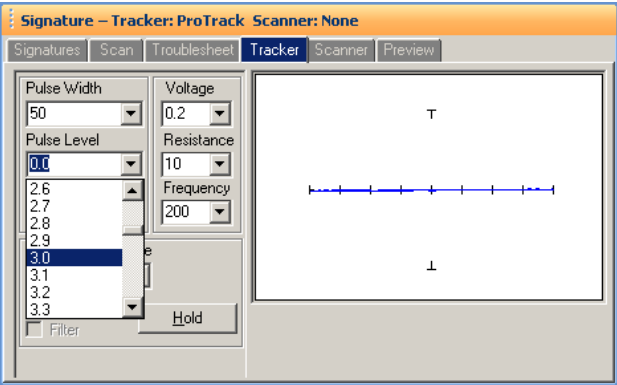


Figure 1-14 Selecting Voltage Level in Huntron Workstation Signature Pane/Tracker tab

SECTION 2 TESTING RESISTORS

Testing Resistors - Introduction

The signatures displayed on an ASA test instrument are a visual representation of Ohm's Law as it relates to the circuit under test. The amount of voltage applied to the circuit is shown along the horizontal axis and the induced current is shown along the vertical axis. Resistors will display a straight line signature because the relationship between voltage and current is linear. The slope of the signature changes as the ASA test instrument resistance range changes or if the amount of resistance across the test leads changes.

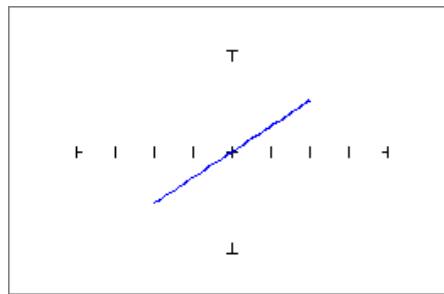


Figure 2-1 Typical Resistive Signature

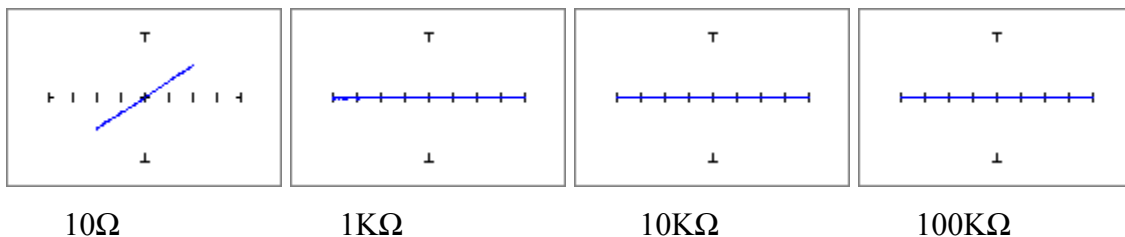
This section will explore how different ASA ranges interact with different resistance values. The following examples are designed to show how resistive signatures relate to changes in test range voltage, resistance and frequency.

Changing Component Resistance Value

The following examples illustrate how changing the resistor value under test affects the signatures shown on the instrument display.

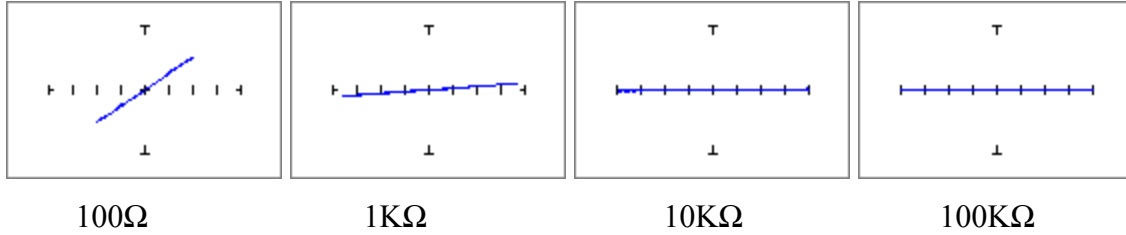
Testing at the 10 Ω resistance range

10 Ω Resistance range setting



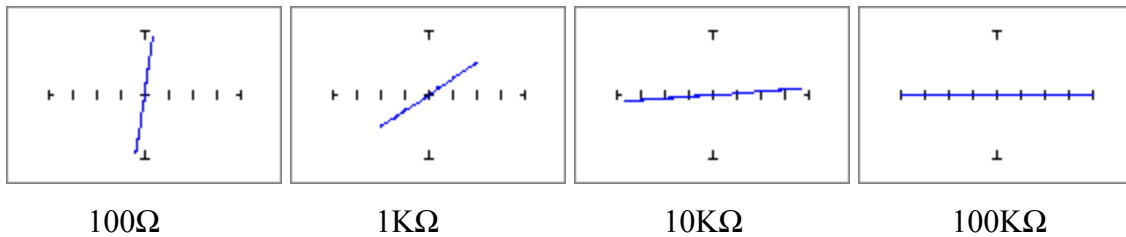
In the signatures above note that as the value of the resistance being tested increases, the signature displayed becomes more horizontal.

100Ω Resistance range



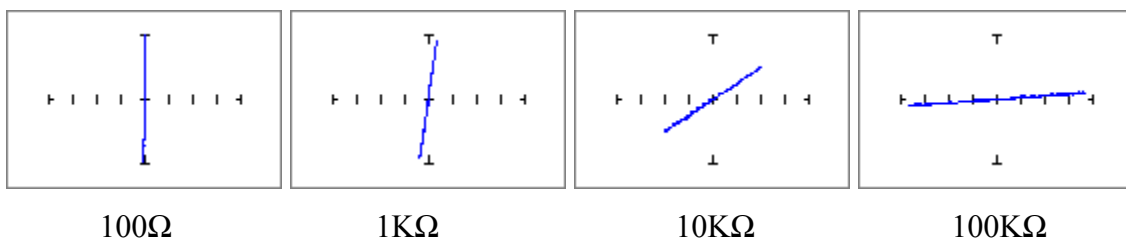
Note that the signature of the 100Ω resistor is showing a typical angled, straight line resistive signature but the other resistor signatures are still relatively flat.

1KΩ Resistance range



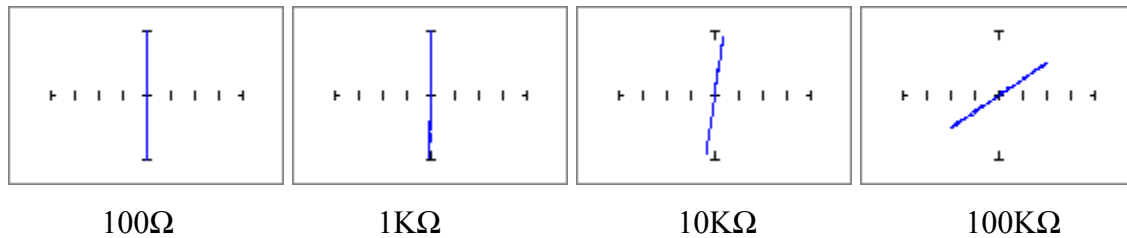
Note that the signature of the 100Ω is now more vertical. The 1KΩ resistor is showing typical angled, straight line resistive signature but the other resistor signatures are still relatively flat.

10KΩ Resistance range



Note that the signatures of the 100Ω and 1KΩ resistors are showing almost vertical, straight line resistive signatures. The 10KΩ resistor is showing a typical straight line angled signature and the 100KΩ resistor is relatively flat.

100KΩ Resistance range



Note that the signatures of the 10KΩ and 100KΩ resistors are showing typical angled, straight line resistive signatures but the 100Ω and 1KΩ resistor signatures are almost vertical. You may also see slight capacitance (loop signature) as the resistance value is increases. This happens as the internal capacitance of the instrument begins to show in the signature.

Resistive Signatures - Changing Voltage and Frequency

The analog signature of a resistor does not change when voltage is varied. The resistive load across the test leads remains unchanged compared to the internal source resistance of the instrument.

The analog signature of a resistor does not change when frequency is varied. Resistors are not a reactive device and the resistive load across the test leads remains unchanged compared to the internal source resistance of the instrument.

Review for resistive signatures

- The signature of a purely resistive circuit will display a straight line signature because the relationship between voltage and current in a purely resistive circuit is linear.
- This straight line signature can vary from a completely horizontal (open circuit) to completely vertical (short circuit).
- As resistance across the test leads increases, the current decreases and the signature will become more horizontal.
- As the ASA test instrument range resistance increases, a resistive signature becomes more vertical.

To download the complete 51 page version of the Fundamentals of ASA, go to the Huntron web site and register at <http://www.huntron.com/asp/register.htm>