User’s Guide

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1152A 2.5-GHz Active Probe

1152A 2.5-GHz Active Probe

The 1152A 2.5-GHz Active Probe is a probe solution for high-frequency applications. This probe is compatible with the AutoProbe Interface which completely configures the Infiniium series of oscilloscopes for the probe. See chapter 1 for full specifications and characteristics.

- A bandwidth of 2.5 GHz
- Input resistance of 100 kΩ
- Input capacitance of approximately 0.6 pF
- Dynamic range of ±5 V dc + peak ac
- Variable dc offset of ±20 V
- Excellent immunity to ESD and over-voltages
- Probe-tip ground connection not necessary for "browsing"

Accessories Supplied

The following accessories are supplied. See "Accessories supplied" in chapter 1 for a complete list.

- "Walking-stick" ground
- Box of small accessories
- Carrying case

Accessories Available

The following accessories can be ordered.

- 11880A Type N(m) to probe tip adapter and 50-Ω termination
- 10218A BNC(m) to probe tip adapter
- 10229A Hook tip adapter

In This Book

This guide provides user and service information for the 1152A 2.5-GHz Active Probe.

Chapter 1 gives you general information such as inspection, cleaning, accessories supplied, and specifications and characteristics of the probe.

Chapter 2 shows you how to operate the probe.

Chapter 3 gives you information about some important aspects of probing and how to get the best results with your probe.

Chapter 4 provides service information.

Contents

1

General Information

Introduction

This chapter covers the following information:

- Inspection
- Cleaning
- Accessories supplied
- Probe operating range
- Performance specifications
- Performance characteristics
- General characteristics

To inspect the probe

- ❑ Inspect the shipping container for damage.

  Keep a damaged shipping container or cushioning material until the contents of the shipment have been checked for completeness and the instrument has been checked mechanically and electrically.

- ❑ Check the accessories.

  Accessories supplied with the instrument are listed in "Accessories Supplied" in table 1-1 later in this chapter.

  - If the contents are incomplete or damaged notify your Agilent Technologies Sales Office.

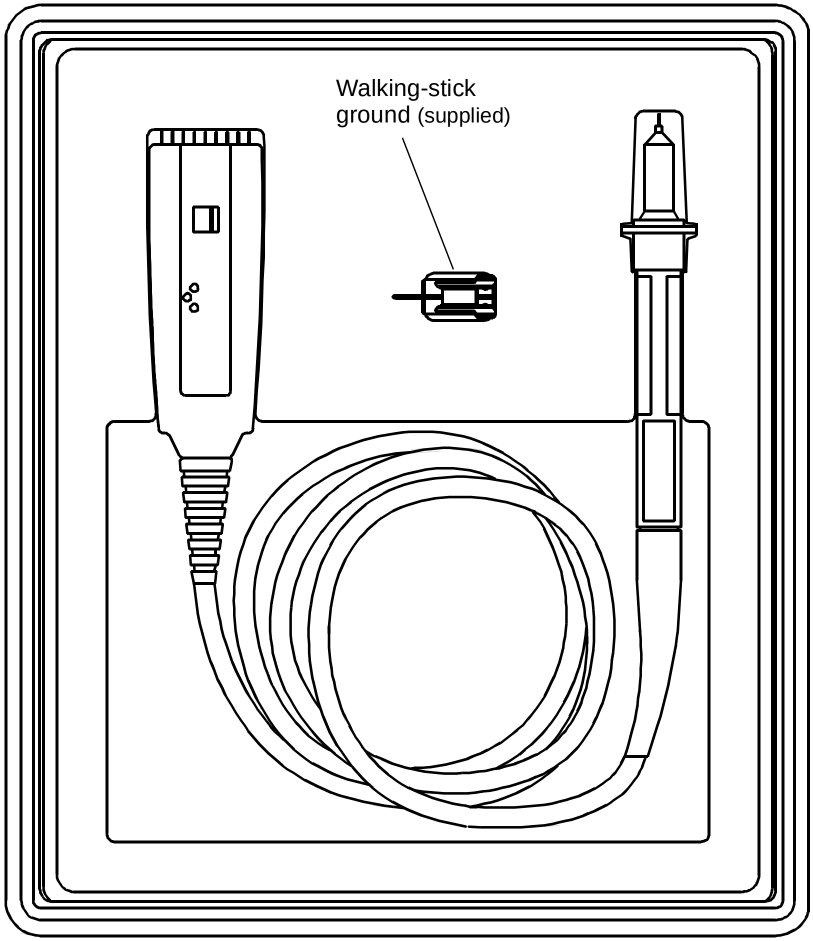
- ❑ Inspect the instrument.

  - If there is mechanical damage or defect, or if the instrument does not operate properly or pass performance tests, notify your Agilent Technologies Sales Office.
  - If the shipping container is damaged, or the cushioning materials show signs of stress, notify the carrier as well as your Agilent Technologies Sales Office. Keep the shipping materials for the carrier's inspection. The Agilent Technologies Office will arrange for repair or replacement at Agilent Technologies' option without waiting for claim settlement.

To clean the probe

If this probe requires cleaning, disconnect it from the oscilloscope and clean it with a mild detergent and water. Make sure the instrument is completely dry before reconnecting it to the oscilloscope.

Figure 1-1



Included with the probe is a box of small accessories. See table 1-1, *Accessories Supplied* later in the chapter for a complete list of accessories.

152A Active Probe

Accessories supplied

The following figure and table illustrate the accessories supplied with the 1152A Active Probe.

Figure 1-2

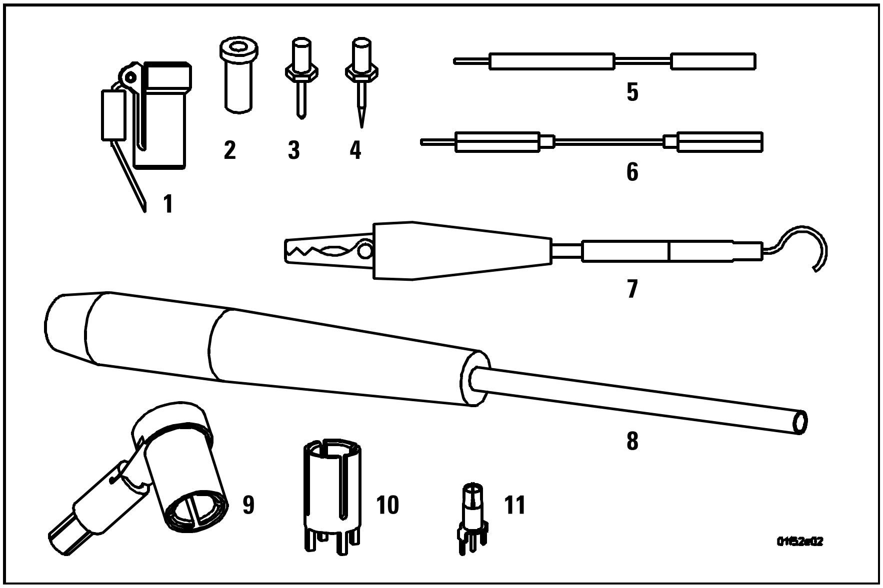


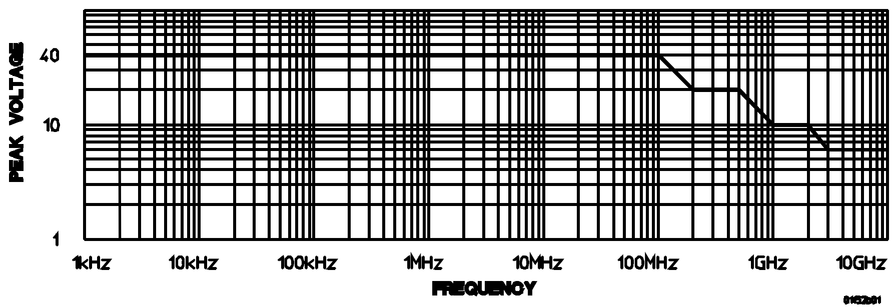
Table 1-1 **Accessories Supplied**

Item	Description	Qty	Agilent Part Number
1	Walking-stick ground	1	5960-2491
2	Single-contact socket	5	1251-5185
3	Standard probe replacement tip	5	54701-26101
4	Sharp probe tip	2	5081-7734
5	200-Ω signal lead	1	54701-81301
6	2-inch ground extension lead, attachable to walking-stick ground	1	01650-82103
7	4-inch alligator ground lead, attachable to probe tip ground	1	01123-61302
8	Nut Driver 3/32-in	1	8710-1806
9	Flexible Probe Adapter	1	54701-63201
10	Probe Socket	1	5041-9466
11	Coaxial Socket	3	1250-2428

Probe operating range

⚠ Figure 1-3 shows the maximum input voltage for the active probe as a function of frequency. This is the maximum input voltage that can be applied without risking damage to the probe.

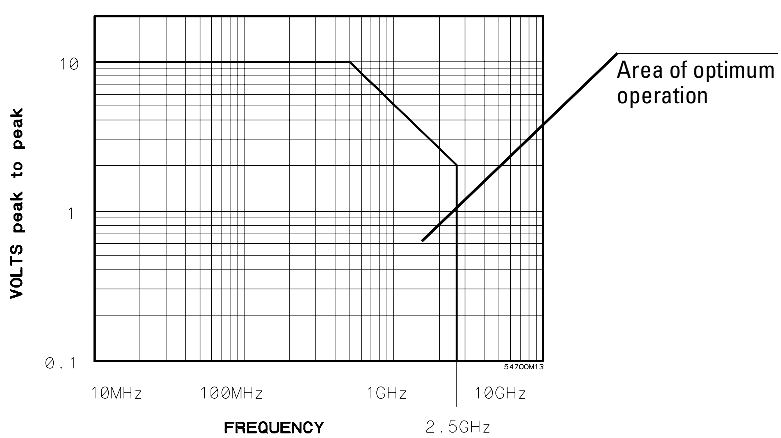
Figure 1-3



Maximum Input Voltage vs Frequency

Figure 1-4 shows the operating range of the probe. For the most accurate measurements and safety for the probe, signals should be within the indicated operating region.

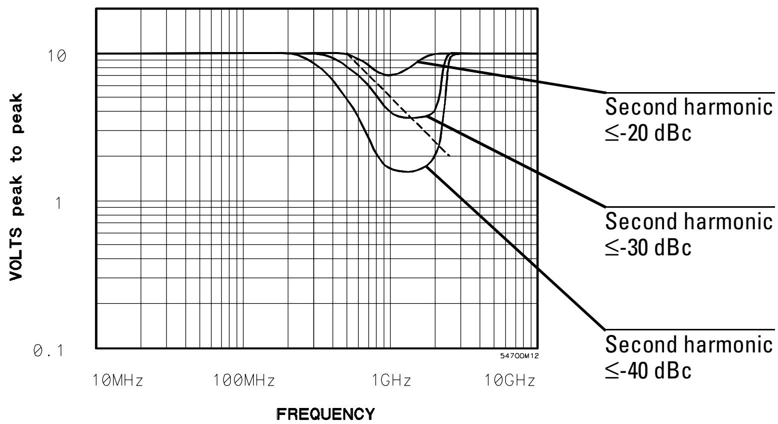
Figure 1-4



Probe Operating Range

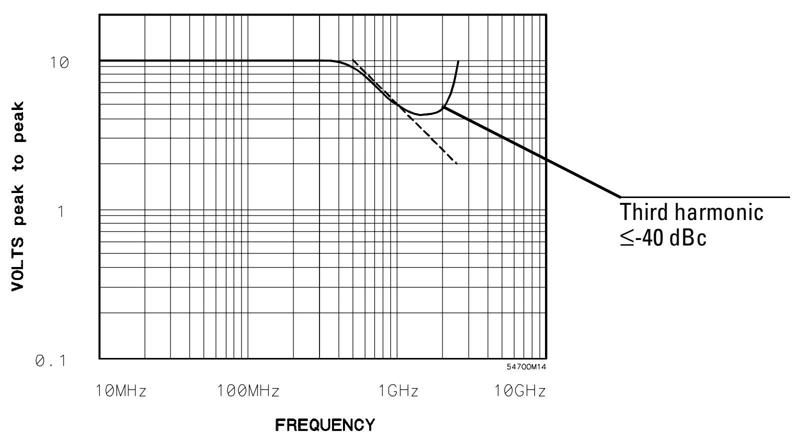
The curves in Figure 1-5 and Figure 1-6 represent the typical input signal limits for several levels of second and third harmonic distortion in the output signal. For input signals below a given curve, the level of harmonic distortion in the output is equal to or below that represented by the curve. The dashed straight line in each figure represents the operating range limit as shown in Figure 1-4 on the previous page.

Figure 1-5



Second Harmonic Distortion, Input Voltage vs Frequency

Figure 1-6



Third Harmonic Distortion, Input Voltage vs Frequency

Performance Specifications

Table 1-2 gives performance specifications for the active probe.

Table 1-2

Table 1–2 Performance Specifications

Bandwidth (–3dB)	>2.5 GHz
Attenuation Factor	10:1
dc Input Resistance	100 kΩ ±1%
dc Gain Accuracy	±0.5% with 50Ω ±0.5Ω load

Characteristics

The following characteristics are typical for the active probe.

Table 1-3

Characteristics	
System bandwith	
with 54845A and 54835A	1.3 GHz
with 54810A/15A/20A/25A	500 MHz
Rise time (10% to 90%)	<140 ps calculated from t_r = (0.35/Bandwidth)
Input Capacitance	0.6 pF (typical)
Flatness	
<3 ns from rising edge	±6% with input edge ≥170 ps
≥3 ns from rising edge	±1% with input edge ≥170 ps
Dynamic Range (<1.5% gain compression)	±5 V dc + peak ac
dc Offset Accuracy	±1% of offset ±1 mV
Offset Adjustment Range	±20 V at the probe tip
Offset Gain	4.6 V/mA
RMS Output Noise (dc to 2.5 GHz, input loaded in 50 Ω)	<300 µV
Propagation Delay	7.5 ns (approximately)
Maximum Input Voltage[1]	±40 V [dc + peak ac(<20 MHz)], CAT I
ESD Tolerance	(150 Ω/150 pF)

[1]This is not the voltage measurement range. See Dynamic Range characteristic for measurement range.

General Characteristics

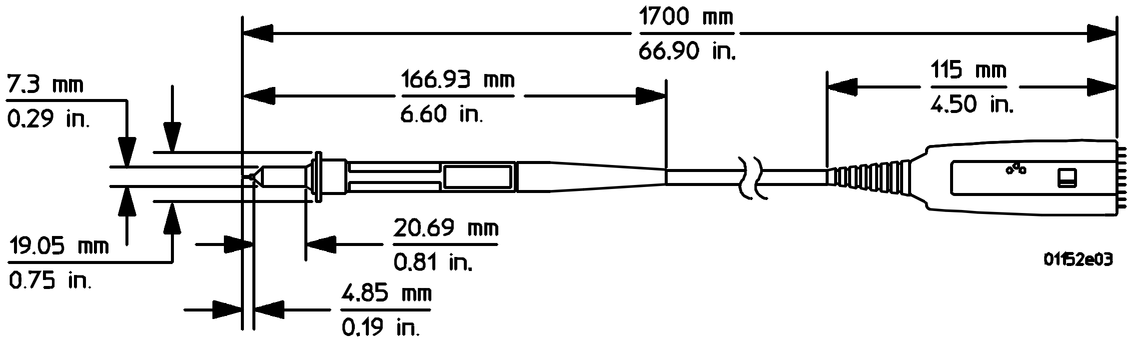
The following general characteristics apply to the active probe.

Table 1-4 **General Characteristics**

Environmental Conditions

	Operating	**Non-operating**
Temperature	0 °C to +55 °C (32 °F to +131 °F)	–40 °C to +70 °C (–40 °F to +158 °F)
Humidity	up to 95% relative humidity (non-condensing) at +40 °C (+104 °F)	up to 90% relative humidity at +65 °C (+149 °F)
Altitude	up to 4,600 meters (15,000 ft)	up to 15,300 meters (50,000 ft)
Vibration	Random vibration 5 to 500 Hz, 10 minutes per axis, 0.3 g_{rms}.	Random vibration 5 to 500 Hz, 10 min. per axis, 2.41 g_{rms}. Resonant search 5 to 500 Hz swept sine, 1 octave/min. sweep rate, (0.75g), 5 min. resonant dwell at 4 resonances per axis.
Power Requirements	+12 Vdc @ 5 mA max –12 Vdc @ 95 mA max +4 Vdc @ 90 mA max.	(voltages supplied from AutoProbe Interface)
Weight	approximately 0.69 kg (1.52 lb)	
Dimensions	Refer to the outline drawing below.	

Figure 1-7



1152A Active Probe Dimensions

2

Operating the Probe

To use the probe

The 1152A Active Probe requires a dc voltage source for power, and a dc bias voltage to offset any dc component in the target signal. The probe must be properly biased to offset any dc component in the target system or clipping occurs on the output.

The Infiniium family oscilloscopes provide both the power and the dc bias through the front panel connector. The dc bias is directly proportional to the vertical offset setting selected on the oscilloscope.

Probe handling considerations

This probe has been designed to withstand a moderate amount of physical and electrical stress. However, with an active probe, the technologies necessary to achieve high performance do not allow the probe to be unbreakable. Treat the probe with care. It can be damaged if it is dropped onto a hard surface. This damage is considered to be abuse and will void the warranty when verified by Agilent Technologies service professionals.

- Exercise care to prevent the probe end from receiving mechanical shock.
- Store the probe in a shock-resistant case such as the foam-lined shipping case which came with the probe.

To bias the probe

The probe has limiting designed to avoid excessive power dissipation. The input operating range of the probe is ±5 V, and up to ±20 Vdc can be biased out using the oscilloscope or power module dc offset function. The dc offset function sends a dc offset bias voltage to the probe. If the input plus the non-compensated dc voltage exceeds +14 V relative to the probe tip, the output of the probe will limit at +1.4 V. As the input plus the non-compensated dc voltage reaches –14 V, the output will limit at –1.4 V; then, it will fold back to approximately –0.8V as the input plus non-compensated DC voltage exceeds –14 V. The output of the probe will remain at the limit voltage until the input plus non-compensated DC voltage falls below approximately –8 Vdc.

To ensure that the output is in the active region of the probe, and not in one of the two saturated limit regions, always set the oscilloscope vertical sensitivity to ≥1.25 V/div, for a maximum fullscale reading of 10 V. If the waveform goes offscale top or bottom, use the DC offset knob to position the waveform back onto the screen. This places the probe back within its dynamic range.

To connect the probe

1 Connect the probe output to the instrument input.

2 Calibrate the oscilloscope and probe combination with the instrument calibration routines.

When the probe has been calibrated, the dc gain, offset zero, and offset gain will be calibrated. The degree of accuracy specified at the probe tip is dependent on the oscilloscope system specifications.

System bandwidth

Since the 1152A is an active probe, the bandwidth of the oscilloscope and probe combination is a mathematical combination of their individual specifications.

Equation 2-1

$$\text{System Bandwidth} = \frac{0.35}{\sqrt{(t_{r1})^2 + (t_{r2})^2}}$$

where

t_{r1} is the rise time of the oscilloscope
t_{r2} is the rise time of the probe

The probe has limiting designed to avoid excessive power dissipation. The input operating range of the probe is ±5 V. If the input and offset exceeds +14 V relative to the probe tip, the output of the probe will limit at +1.4 V. As the input plus offset reaches –14 V, the output will limit at –1.4 V; then, it will fold back to approximately –0.8 V as the input plus offset exceeds –14 V. The output of the probe will remain at the limit voltage until the input plus offset falls below approximately –8 Vdc.

Using probe accessories

The following figure and table illustrate the accessories supplied with the 1152A Active Probe.

Figure 2-1

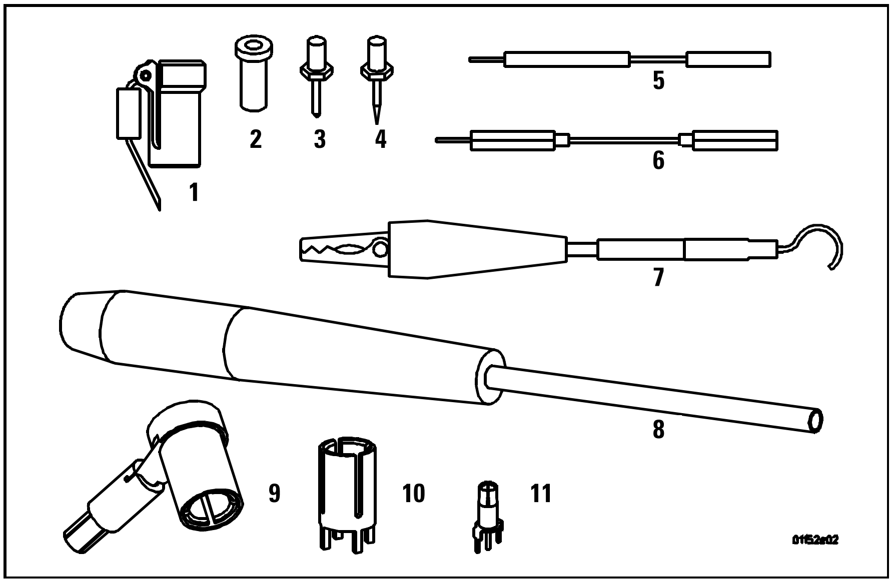


Table 2-1 **Accessories Supplied**

Item	Description	Qty	Agilent Part Number
1	Walking-stick ground	1	5960-2491
2	Single-contact socket	5	1251-5185
3	Standard probe replacement tip	5	54701-26101
4	Sharp probe tip	2	5081-7734
5	200-Ω signal lead	1	54701-81301
6	2-inch ground extension lead, attachable to walking-stick ground	1	01650-82103
7	4-inch alligator ground lead, attachable to probe tip ground	1	01123-61302
8	Nut Driver 3/32-in	1	8710-1806
9	Flexible Probe Adapter	1	54701-63201
10	Probe Socket	1	5041-9466
11	Coaxial Socket	3	1250-2428

Walking-stick Ground

The walking-stick ground is the best ground for general probing. It is short, and the ground wire includes a bead for damping probe resonance. This provides a well maintained probe response for frequencies to 2.5 GHz.

Single-contact Socket

The single-contact sockets can be soldered into a circuit to provide a probe point to hold the probe tip or ground. The socket accepts 0.018-inch to 0.040-inch pins. The sockets accept the probe tips, the walking-stick ground, the 200-Ω signal lead, and the ground extension lead.

Probe Tips

There are two types of replaceable probe tips furnished with the probe. The 0.030-inch round standard probe tip is for general applications. It is made of a material that will generally bend before breaking. The 0.025-inch round sharp probe tip has a narrower point and is a harder material. It can be used to probe constricted areas or penetrate hard coatings.

CAUTION

Do not solder the probe tip into circuitry. Excessive heat may damage the tip or circuitry inside the probe. If you need to solder something into your circuitry, use the single contact sockets, ground extension lead, or 200-Ω signal lead. They are less easily damaged and less expensive to replace.

- To remove and replace probe tips, use the nut driver to unscrew the tip from the end of the probe.
- Be sure to screw the replacement tip all the way in or the probe may be intermittent or appear ac coupled.

Nut Driver

The 3/32-in nut driver is provided for easier replacement of the probe tips.

200-Ω Signal Lead

This 2-inch orange extension lead includes a molded-in resistor to dampen resonance caused by the lead inductance. Use this lead and the ground extension lead to provide a flexible connection to the circuit under test.

There is a trade-off when using the extension leads. To maintain a clean pulse response, the probing system bandwidth is limited to 1.5 GHz. Probe resonance is damped by the walking-stick bead and the resistor in the signal lead.

Ground Extension Lead

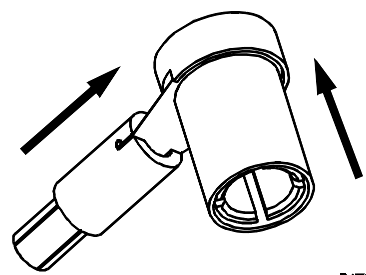
This 2.25-inch black ground lead can be used to extend ground from the walking-stick to the circuit under test. When used with the walking-stick ground the probe resonance is damped by the bead on the walking-stick.

Alligator Ground Lead

The alligator ground lead can be used in general applications when the bandwidth of the signal is 350 MHz or lower. With no signal lead extension the probe resonant frequency is about 650 MHz.

Flexible Probe Adapter

The flexible probe adapter provides a high-quality connection between a coaxial socket and the 1152A probe. The right-angle connection allows the probe to remain parallel to a PC board and the flexibility prevents the leverage of the probe and cable from damaging PC board circuitry.

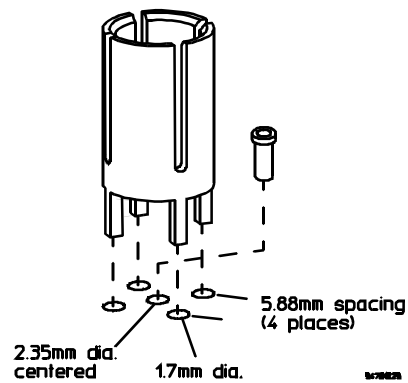


54701E27

As with any cable-type interconnection, always apply insertion and removal forces to the connectors directly, and not through the cable itself (see the illustration).

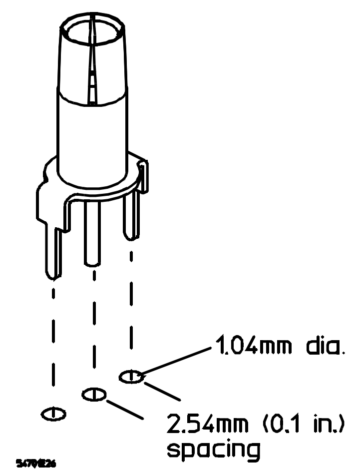
Probe Socket

The probe socket is a direct fit to the shield surface of the 1152A probe. Use this socket and the single contact socket to design the highest quality probing of a PC board. The illustration shows the socket and the PC board layout needed to mount the parts.



Coaxial Socket

The coaxial socket is designed to fit the standard mini-probe. When used with the flexible probe adapter, it can be installed in a circuit so you can probe with the 1152A. The illustration shows the socket and the PC board layout needed to mount the socket to the board.



See Also

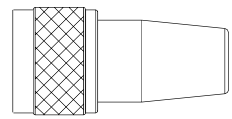
Chapter 3, "Probing Considerations," for a more complete discussion about the effects of probe connection techniques on signal fidelity.

Additional accessories

The following accessories enhance use of the active probe. For ordering information, see "Replaceable Parts" in chapter 3.

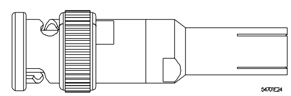
Type-N to Probe Tip Adapter

The 11880-60001 Type-N(m) to probe tip adapter is available to connect the input of the active probe to Type-N connectors. It has an internal 50-Ω load. It can be used for general testing and is specifically recommended for testing the probe bandwidth. This adapter must be ordered separately.



BNC to Probe Tip Adapter

The 10218A BNC(m) to probe tip adapter is available to connect the input of the active probe to BNC type connectors. It does not have an internal load so it is not recommended for testing where the full bandwidth of the probe is needed. This adapter must be ordered separately.



Probing Considerations

Introduction

This chapter gives you some guidance about the effects of probing and how to get the best measurement results. The effect of the following parameters are covered in this chapter:

- Resistive Loading
- Capacitive Loading
- Ground Inductance
- Bandwidth

Two important issues while measuring signals with probes are how the probe/oscilloscope combination represents the signal at the probe tip and how the probe affects the circuit during the measurement. When a probe is connected to a circuit to measure a signal it becomes part of the circuit. Probing a signal can be easy and successful if some forethought is given to the nature of the circuit under test and what type of probe best solves the measurement problem. Because of the wide variety of signals that may be encountered, ranging from high bandwidth (fast rise times) to high impedance, in a given situation one probe may do a better job than another. Therefore, it is helpful to understand the different effects caused by the interaction between the probed circuit and the probe.

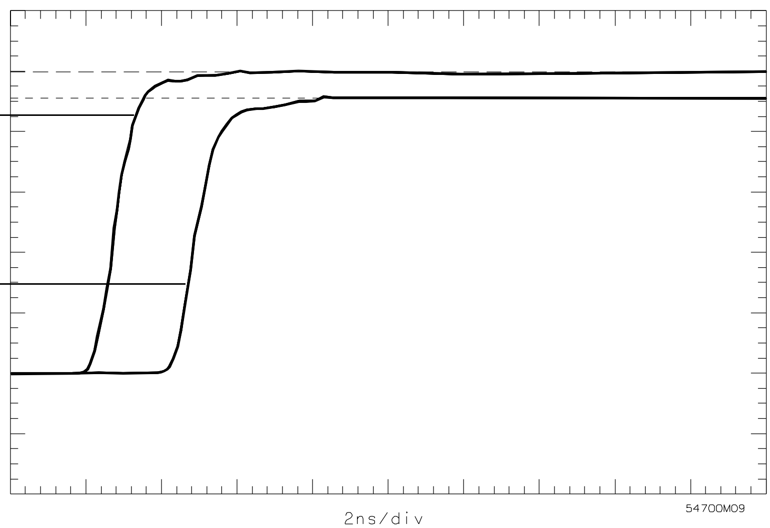
Resistive Loading Effects

The two major effects caused by resistive loading are amplitude distortion and changes in dc bias conditions in the circuit under test.

Amplitude Distortion

Amplitude distortion is depicted in Figure 3-1, where waveform 1 is the signal before probing and waveform 2 is the signal while probing. (The baselines of these signals have been overlaid to show the amplitude change. If the baseline of a signal is not at zero volts it will shift when the signal is probed.)

Figure 3-1



Oscilloscope Display Showing Amplitude Distortion

The cause of the error is the voltage divider developed between the source resistance of the device under test and the input resistance of the probe being used. Equation 3-1 calculates the error caused by the voltage divider.

Equation 3-1

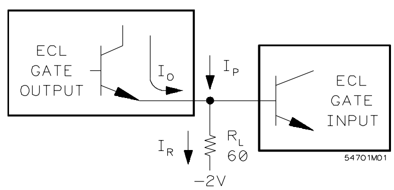
$$\text{Error}(\%) = \frac{R_{source}}{R_{source} + R_{probe}} \times 100$$

A probe with an input resistance ten times that of the source resistance of the device under test causes a 9.09% error in the measurement. It is best to use a probe with an input resistance at least ten times that of the source resistance.

Bias Changes

Probes with low input resistance can cause bias changes in the device under test. A good example of this effect can be seen when probing ECL circuits. Figure 3-2 represents a typical ECL node with a 60-Ω bias resistor to –2 V. Ip represents current that flows from ground into the circuit when the probe is connected. The table shows the current that flows in each device at both the high (–0.8 V) and low (–1.75 V) states, with and without a 500-Ω probe connected.

Figure 3-2



	High (-0.8 V)		Low(-1.75 V)	
	Without Probe	With Probe	Without Probe	With Probe
I_O	20 mA	18.4 mA	4.2 mA	0.7 mA
I_R	20 mA	20 mA	4.2 mA	4.2 mA
I_P		1.6 mA		3.5 mA

Probing ECL Circuits

Note that in the high state there is little difference in current flow with or without the probe connected. However, in the low state the output stage is closer to cutoff. Connecting the probe sources current into the output node, which reduces the current sourced from the gate output. The output current drops from 4.2 mA to 0.7 mA. The low output current can cause problems with switching noise margins. The output gate will have difficulty reaching the low threshold, so ac performance will suffer because the falling edge degrades. If a larger bias resistor had been used to keep the current levels lower, when a 500-Ω probe is attached the output gate could go into cutoff before it reaches the low threshold.

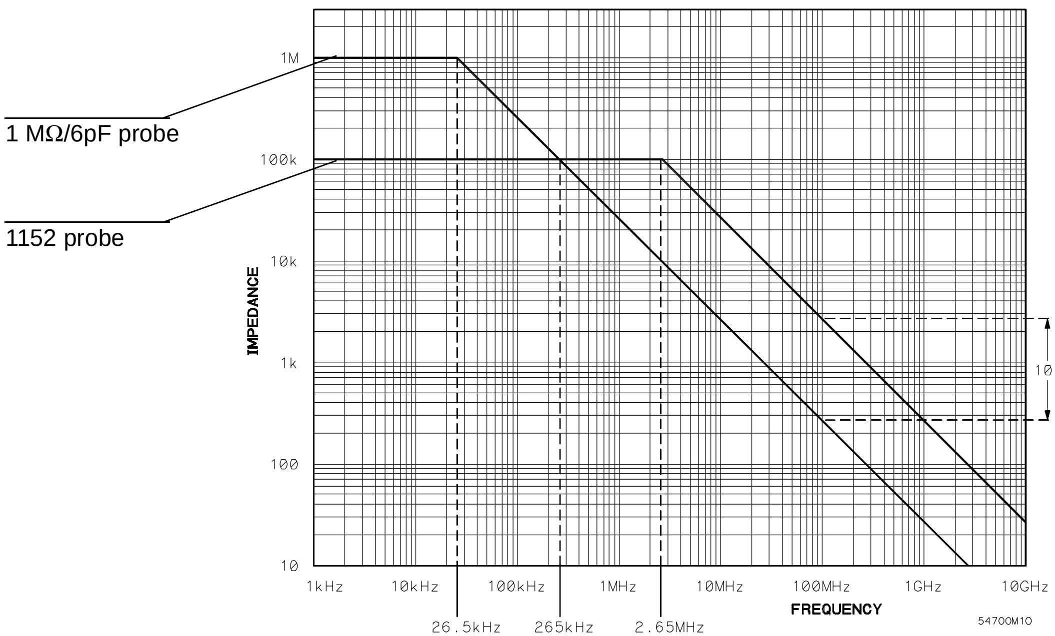
Recommendation

Be careful not to use a probe just because it has the highest input resistance available. High-resistance probes usually come with trade-offs in other important parameters, such as higher capacitance, which also affect measurement accuracy.

Capacitive Loading Effects

The input capacitance of a probe causes the overall input impedance to decrease as a function of frequency. For this reason, input capacitance becomes one of the most important parameters that affect high frequency measurements. Figure 3-3 plots the probe impedance vs frequency for two probes: a 1-MΩ, 6-pF probe and the 1152A probe (100 kΩ, 0.6 pF). It shows that because of the lower input capacitance, the 1152A probe actually has a higher input impedance for frequencies above 240 kHz. At frequencies above 2.65 MHz, it has as much as 10 times the impedance of the 1-MΩ probe.

Figure 3-3

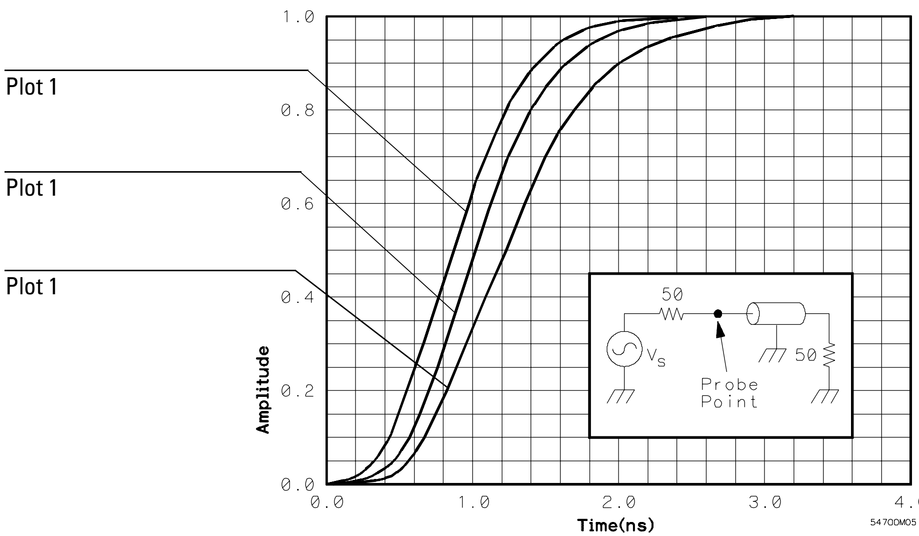


Probe Impedance vs Frequency

The input capacitance of a probe forms an RC time constant with the parallel combination of source impedance and probe input resistance. This can cause an increase in the circuit rise time and a time delay in a pulse edge.

Figure 3-4 represents plots from three spice simulations showing this loading effect. Plot 1 shows the signal edge before probing. Plot 2 shows the edge after probing with a 6-pF probe and plot 3 after probing with a 15-pF probe.

Figure 3-4



Spice Simulation Of Probe Capacitance Loading Effects

Table 3-1 summarizes the data. It shows that the 6-pF probe didn't significantly increase the rise time of the signal, but delayed it (referenced at the 50% point) approximately 150 ps. The 15-pF probe not only slowed the rise time approximately 33% but also delayed the edge 340 ps.

Table 3-1 **Probe Capacitance Loading Effects**

Plot	Rise Time	Delay
1	1 ns	0.0 ps
2	1.067 ns	150 ps
3	1.33 ns	340 ps

The circuit used in the simulation is modeled after a 50-Ω system with a 1-ns source and terminated transmission line with 500-ps delay. The inset shows the spice model, with the probe point where the probe was connected. As signals achieve faster rise times, probes with lower input capacitance are required to make accurate timing and rise time measurements.

Ground Inductance Effects

Probe grounding techniques are an important factor in making accurate high frequency measurements. The main limitation, probe resonance, is a function of the input capacitance of the probe and the inductance of the ground return. These two parameters in series form an LC resonant circuit that, when connected to the circuit under test, becomes part of the circuit's response.

The probe resonance can cause overshoot and ringing on pulse edges that contain energy in the same frequency band as the resonance. The true response is masked, the false response gets transferred to the oscilloscope, and the oscilloscope display shows an incorrect result. If overshoot and ringing added by a probe during troubleshooting changes how the circuit functions, it can produce an incorrect judgment about circuit operation. To minimize the problem of ground ringing, use the shortest possible ground with a probe that has the lowest possible input capacitance. Equation 3-2 can be used to calculate the frequency where a certain probe and grounding technique resonates.

Equation 3-2

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

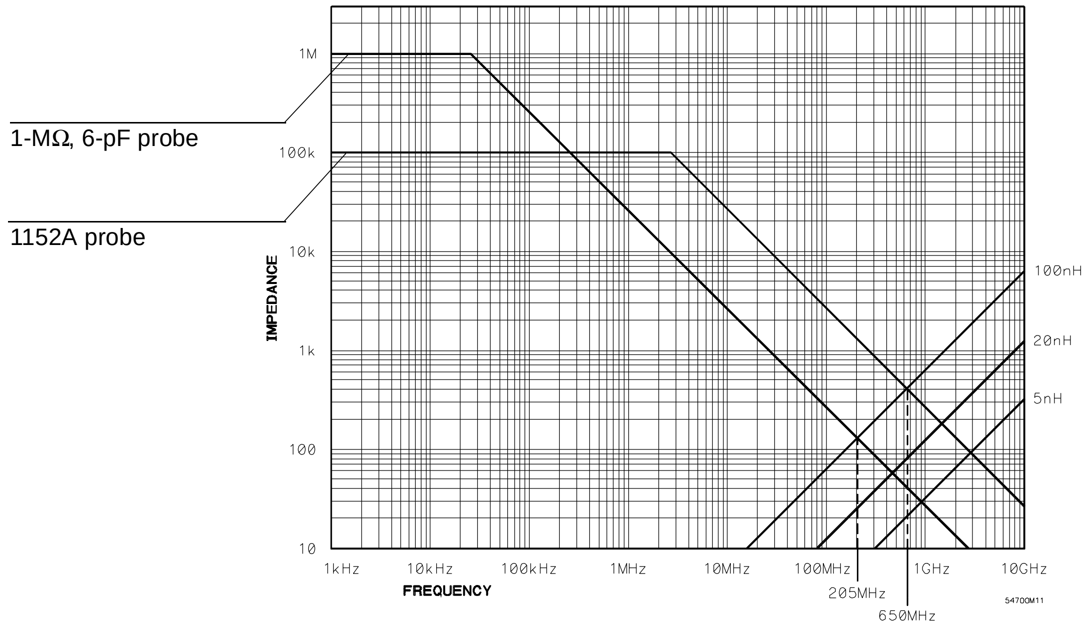
where

C is the probe input capacitance. (It is usually found in the probe data sheet.)

L is the inductance of the ground return. (It can be approximated using the constant of 25 nH per inch.)

Figure 3-5 plots the probe impedance vs frequency for two probes: a 1-MΩ, 6-pF probe and the 1152A probe (100 kΩ, 0.6 pF). It also plots the inductive reactance vs frequency for three different values of ground inductance. The 5-nH inductance represents a PC board socket, the 20-nH inductance a spanner ground, and the 100-nH inductance a 4-inch ground wire. Where the probe plots cross the inductance plots gives the resonant frequency of the probe and ground combination. You can see from the graphs that in all three cases the 6-pF probe resonates at approximately one-third the frequency of the 1152A (0.6 pF). The lower resonance means that the effect of the resonance is more likely to influence the representation of the signal.

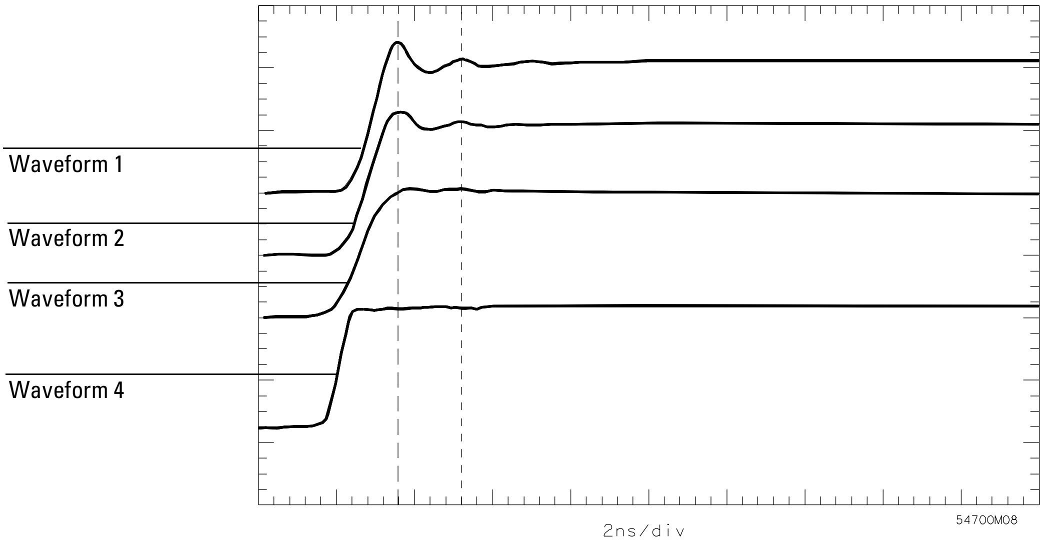
Figure 3-5



Probe Impedance and Resonance

Figure 3-6 shows waveforms measured by the 1152A (100 kΩ, 0.6 pf) and the 1-MΩ, 6-pF probe; both probes are connected to a 1-GHz oscilloscope.

Figure 3-6



Probe Resonance Effects

Waveform 1 shows the pulse response of a 6-pF probe measuring a 400-ps step. The ringing on the pulse is caused by the input capacitance of the probe and by the inductance of the ground return. The period of the ringing measures 1.72 ns, representing a frequency of 581 MHz. The circuit had a ground return of 1/2 inch. Using Equation 3-2 to calculate the resonant frequency (12.5 nH and 6 pF) results in 580 MHz. The measurement and the calculation yield the same result, showing how probe resonance causes problems when probing high speed signals.

Waveform 2 shows the pulse response when the same 6-pF probe measures an 800-ps edge. Notice that the overshoot and ringing are still present, but are significantly reduced. This is because the slower signal edge has less energy at the resonant frequency of the probe.

Waveform 3 shows the pulse response when the 6-pF probe measures a 1.25-ns edge. The ringing is nearly subdued and doesn't play a significant role in the measurement.

Waveform 4 shows the 1152A 0.6-pF probe, with a one-inch ground lead, measuring the 400-ps edge. Because of its much lower capacitance, and even with a longer ground lead, its resonant frequency is much higher and it shows no ringing in the response.

The measurements from the first three waveforms lead to a rule of thumb:

To minimize signal distortion due to probe resonance, provide a two-to-one, or greater, difference between the resonant frequency of the probe and the bandwidth of the signal being measured.

For pulsed data applications, the rise time of a signal can be related to the bandwidth by using a constant of 0.35 as shown in Equation 3-3. This equation is derived from a first order RC response.

Equation 3-3

$$\text{Bandwidth} = \frac{0.35}{t_r}$$

Example

The 1.25-ns edge (waveform 3 in Figure 3-6) equates to a 280-MHz bandwidth.

$$\text{Bandwidth} = \frac{0.35}{t_r} = \frac{0.35}{1.25\times10^{-9}} = 280\text{ MHz}$$

This is approximately half the resonant frequency calculated for the 6-pF probe with 1/2-inch ground, 580 MHz. Therefore the subdued ringing on waveform 3 validates the rule of thumb.

As noted before, waveform 4 shows the effect when a low-capacitance probe measures a high-frequency signal. Because of the low capacitance the resonant frequency is high. Therefore, there is less chance of the probing system affecting the measurement of the signal.

Probe Bandwidth

The bandwidth of the probe is often given much consideration during purchase, then forgotten while making measurements. Error in measurements occur when the frequency content (at the –3 dB point) of the signal being measured approaches or exceeds the bandwidth of the probe. The probe can be modeled as a low-pass filter for the signal.

If a 700-MHz probe is used to measure a 1-ns signal, the rise time error can be calculated using equations 3-3 and 3-4. For this exercise assume that the oscilloscope bandwidth is great enough not to contribute any errors.

Equation 3-4

$$t_r = \sqrt{(t_{r1})^2 + (t_{r2})^2}$$

where

t_{r1} is the rise time of the probe,

t_{r2} is the rise time of the signal.

1 Calculate the rise time of the 700-MHz probe (Equation 3-3).

$$t_r = \frac{0.35}{\text{Bandwidth}} = \frac{0.35}{700\text{ MHz}} = 0.5\text{ ns}$$

2 Calculate the rise time of the 1-ns signal as measured by the 700-MHz probe (Equation 3-4).

$$t_r = \sqrt{(0.5)^2 + (1.0)^2} = \sqrt{1.25} = 1.12\text{ ns}$$

The measurement error between the actual signal and what was measured is 12%. To keep measurement errors less than 6%, use a probe with a bandwidth three or more times that of the signal.

3 Calculate the bandwidth of the 1-ns signal (Equation 3-3).

$$\text{Bandwidth} = \frac{0.35}{1\text{ ns}} = 350\text{ MHz}$$

Use a probe with a bandwidth of 1.05 GHz (the rise time is 0.333 ns, Equation 3-3).

4 Calculate the rise time of the 1-ns signal measured by the 1.05-GHz probe (Equation 3-4).

$$t_r = \sqrt{(0.333)^2 + (1.0)^2} = \sqrt{1.11} = 1.054\text{ ns}$$

Now, the measurement error is less than 6%.

Conclusion

In conclusion we can review the issues by using the effect the 1152A Active Probe (100 kΩ, 0.6 pF) has while measuring a fast CMOS gate.

Resistive Loading

Resistive loading is caused by the input resistance of the probe. When the CMOS output is high (5 V) the 100 kΩ input resistance of the probe draws 50 A. A CMOS gate can drive many times this current, so the load is insignificant. In addition, the output impedance of a CMOS gate is the on resistance of the output FET. Whether high or low, this is typically less than 100 Ω. The voltage divider of 100 Ω and 100 kΩ is also insignificant and will not change the value of either state of the gate.

Capacitive Loading

CMOS gates typically have an input capacitance between 5 and 10 pF. The traces between gates will contribute another 5 to 10 pF, which gives a total of 10 to 20 pF. The 0.6-pF input capacitance of the 1152A probe is about 3% to 6% that of the circuit capacitance. It will not significantly change the time constant in the node being probed.

Ground Inductance

The CMOS gate has a rise time approaching 1 ns. This equates to a bandwidth of 350 MHz (Equation 3-3). If we use the walking-stick ground (about 20 nH) provided with the 1152A probe, the probe resonance will be about 1.45 GHz (Equation 3-2). We can see that the CMOS equivalent bandwidth (350 MHz) is at less than half the resonant frequency of the probe. This fits within the rule of thumb given previously, that to avoid ringing in the response, the resonance of the probe should be at least twice the frequency of the energy in the signal.

Bandwidth

Although it was specifically not covered in this chapter, the bandwidth of the probe and oscilloscope combination is also very important. As previously noted, with CMOS signals of 1 ns rise times the signal bandwidth is 350 MHz. This means for an accurate representation the probe and oscilloscope combination should have at least a 3-to-1 margin in bandwidth, at least 1.05 GHz.

4

Service

Introduction

This chapter provides service information for the 1152A Active Probe. The following sections are included in this chapter:

- Service strategy
- Returning to Agilent Technologies for service
- Troubleshooting and failure symptoms

Service Strategy

The 1152A Active Probe is a high-frequency instrument with many critical relationships between parts. For example, the frequency response of the amplifier on the hybrid is trimmed to match the output coaxial cable. As a result, to return the probe to optimum performance requires factory repair. All probes must be returned to the factory for repair and calibration until January 1998. After that time, if the probe is under warranty, normal warranty services apply. If the probe is not under warranty, a failed probe can be exchanged for a reconditioned one at a nominal cost.

To return the probe to Agilent Technologies for service

Before shipping the instrument to Agilent Technologies, contact your nearest Agilent Technologies Sales Office for additional details.

1 Write the following information on a tag and attach it to the instrument.

- Name and address of owner
- Instrument model number
- Instrument serial number
- Description of the service required or failure indications

2 Remove all accessories from the instrument.

Accessories include all cables. Do not include accessories unless they are associated with the failure symptoms.

3 Protect the instrument by wrapping it in plastic or heavy paper.

4 Pack the instrument in foam or other shock absorbing material and place it in a strong shipping container.

You can use the original shipping materials or order materials from an Agilent Technologies Sales Office. If neither are available, place 3 to 4 inches of shock-absorbing material around the instrument and place it in a box that does not allow movement during shipping.

5 Seal the shipping container securely.

6 Mark the shipping container as FRAGILE.

In any correspondence, refer to instrument by model number and full serial number.

Troubleshooting

- If your probe is under warranty and requires repair, return it to Agilent Technologies. Contact your nearest Agilent Technologies Service Center.
- If the failed probe is not under warranty, you may exchange it for a reconditioned probe. See "To Prepare the Probe for Exchange" in this chapter.

Failure Symptoms

The following symptoms may indicate a problem with the probe or the way it is used. Possible remedies and repair strategies are included.

The most important troubleshooting technique is to try different combinations of equipment so you can isolate the problem to a specific instrument.

Probe Calibration Fails

Probe calibration failure with an oscilloscope is usually caused by improper setup. If the calibration will not pass, check the following:

- Be sure the instrument passes calibration without the probe.
- Check that the probe passes a signal with the correct amplitude.
- If the probe is powered by the oscilloscope, check that the offset is approximately correct. The probe calibration cannot correct major failures.

Incorrect Frequency Response

Incorrect frequency response may be caused by a defective probe, plug-in or oscilloscope mainframe, or an improper application such as poor connections or grounding. Read chapter 2, "Probing Considerations," in this guide. If the application is correct, try the probe with another oscilloscope.

If the probe appears ac coupled at a high frequency, check for a loose probe tip.

The frequency response of the probe is determined by the amplifier hybrid in the probe and the probe cable. If the probe fails the bandwidth test, factory repair is necessary. Also read "Incorrect Pulse Response" below.

Incorrect Pulse Response (flatness)

If the probe's pulse response shows a top that is not flat (incorrect ac gain), it is most likely caused by an inaccurate 50-Ω load on the probe. The probe is designed to work into a 50-Ω load that is accurate within 1.0% (±0.5 Ω). Check the value of the load you are using before you suspect the probe. If the load is accurate, the gain problem with the probe will have to be repaired by the factory.

If the probe appears ac coupled at a high frequency, check for a loose probe tip.

Incorrect dc Gain

The dc gain is a function of the values of internal parts. It is independent of the load on the probe. Any failure of the accuracy of the dc gain requires factory repair.

Incorrect Input Resistance

First, check that the probe tip is not loose. The input resistance is determined in the amplifier hybrid in the probe and cannot be repaired in the field. The probe must be returned to the factory for repair.

Incorrect Offset

Incorrect offset can be caused by a misadjusted offset zero (see "Offset Will Not Zero" below) or lack of probe calibration with the oscilloscope.

Offset Will Not Zero

With no signal input and no offset setting, the dc output of the probe should be within ±1 mV.

If the probe is connected to an Infiniium oscilloscope, the oscilloscope will calibrate out an offset zero error during a probe calibration. If the offset error can not be calibrated out, return it to Agilent Technologies for repair.

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DECLARATION OF CONFORMITY

according to ISO/IEC Guide 22 and EN 45014

Manufacturer's Name: Agilent Technologies

Manufacturer's Address: Colorado Springs Division
1900 Garden of the Gods Road
Colorado Springs, CO 80907, U.S.A.

declares, that the product

Product Name: Oscilloscope probe

Model Number(s): 1152A

Product Option(s): All

conforms to the following Product Specifications:

Safety: IEC 1010-1:1990+A1 / EN 61010-1:1993
UL 3111
CSA-C22.2 No. 1010.1:1993

EMC: CISPR 11:1990 / EN 55011:1991 Group 1, Class A
IEC 555-2:1982 + A1:1985 / EN60555-2:1987
IEC 555-3:1982 + A1:1990 / EN 60555-2:1987 + A1:1991
IEC 801-2:1991 / EN 50082-1:1992 4 kV CD, 8 kV AD
IEC 801-3:1984 / EN 50082-1:1992 3 V/m, {1kHz 80% AM, 27-1000 MHz}
IEC 801-4:1988 / EN 50082-1:1992 0.5 kV Sig. Lines, 1 kV Power Lines

Supplementary Information:

The product herewith complies with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC, and carries the CE-marking accordingly.

This product was tested in a typical configuration with Hewlett-Packard test systems.

Colorado Springs, 04/22/1997

Ken Wyatt

Ken Wyatt, Quality Manager

European Contact: Your local Agilent Technologies Sales and Service Office or Agilent Technologies GmbH, Department ZQ / Standards Europe, Herrenberger Strasse 130, D-71034 Böblingen Germany (FAX: +49-7031-14-3143)

Product Regulations

Safety

IEC 1010-1: 1990+A1 / EN 61010-1: 1993
UL 3111
CSA-C22.2 No. 1010.1:1993

EMC

This product meeets the requirements of the European Communities (EC) EMC Directive 89/336/EEC.

CE
ISM 1-A

Emissions EN55011/CISPR 11 (ISM, Group 1, Class A equipment)

N279

Immunity

EN50082-1	Code[1]	Notes[2]
IEC 555-2	1	
IEC 555-3	1	
IEC801-2 (ESD) 4kV CD, 8 kV AD	2	
IEC 801-3 (Rad.) 3 V/m	2	
IEC 801-4 (EFT) 0.5 kV, 1 kV	2	

[1] Performance Codes:
1 Pass - Normal operation, no effect.
2 Pass - Temporary degradation, self recoverable.
3 Pass - Temporary degradation, operator intervention required.
4 Fail - Not recoverable, component damage.

[2] Notes: (none)

Sound Pressure Level N/A

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Agilent Technologies shall not be liable for errors contained herein or for damages in connection with the furnishing, performance, or use of this material.

Safety

This apparatus has been designed and tested in accordance with IEC Publication 1010, Safety Requirements for Measuring Apparatus, and has been supplied in a safe condition. This is a Safety Class I instrument (provided with terminal for protective earthing). Before applying power, verify that the correct safety precautions are taken (see the following warnings). In addition, note the external markings on the instrument that are described under "Safety Symbols."

Warning

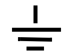
Before turning on the instrument, you must connect the protective earth terminal of the instrument to the protective conductor of the (mains) power cord. The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. You must not negate the protective action by using an extension cord (power cable) without a protective conductor (grounding). Grounding one conductor of a two-conductor outlet is not sufficient protection.

- Only fuses with the required rated current, voltage, and specified type (normal blow, time delay, etc.) should be used. Do not use repaired fuses or short-circuited fuseholders. To do so could cause a shock of fire hazard.
- Service instructions are for trained service personnel. To avoid dangerous electric shock, do not perform any service unless qualified to do so. Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.
- If you energize this instrument by an auto transformer (for voltage reduction), make sure the common terminal is connected to the earth terminal of the power source.
- Whenever it is likely that the ground protection is impaired, you must make the instrument inoperative and secure it against any unintended operation.
- Do not operate the instrument in the presence of flammable gasses or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.
- Do not install substitute parts or perform any unauthorized modification to the instrument.
- Capacitors inside the instrument may retain a charge even if the instrument is disconnected from its source of supply.
- Use caution when exposing or handling the CRT. Handling or replacing the CRT shall be done only by qualified maintenance personnel.

Safety Symbols

Instruction manual symbol: the product is marked with this symbol when it is necessary for you to refer to the instruction manual in order to protect against damage to the product.

Hazardous voltage symbol.



Earth terminal symbol: Used to indicate a circuit common connected to grounded chassis.

WARNING

The Warning sign denotes a hazard. It calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a Warning sign until the indicated conditions are fully understood and met.

CAUTION

The Caution sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product. Do not proceed beyond a Caution symbol until the indicated conditions are fully understood or met.

Agilent Technologies
P.O. Box 2197
1900 Garden of the Gods Road
Colorado Springs, CO 80901

Product Warranty

This Agilent Technologies product has a warranty against defects in material and workmanship for a period of three years from date of shipment. During the warranty period, Agilent Technologies will, at its option, either repair or replace products that prove to be defective. For warranty service or repair, this product must be returned to a service facility designated by Agilent Technologies. For products returned to Agilent Technologies for warranty service, the Buyer shall prepay shipping charges to Agilent Technologies and Agilent Technologies shall pay shipping charges to return the product to the Buyer. However, the Buyer shall pay all shipping charges, duties, and taxes for products returned to Agilent Technologies from another country. Agilent Technologies warrants that its software and firmware designated by Agilent Technologies for use with an instrument will execute its programming instructions when properly installed on that instrument. Agilent Technologies does not warrant that the operation of the instrument software, or firmware will be uninterrupted or error free.

Limitation of Warranty

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by the Buyer, Buyer- supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

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The remedies provided herein are the buyer's sole and exclusive remedies. Agilent Technologies shall not be liable for any direct, indirect, special, incidental, or consequential damages, whether based on contract, tort, or any other legal theory.

Assistance

Product maintenance agreements and other customer assistance agreements are available for Agilent Technologies products. For any assistance, contact your nearest Agilent Technologies Sales Office.

Certification

Agilent Technologies certifies that this product met its published specifications at the time of shipment from the factory. Agilent Technologies further certifies that its calibration measurements are traceable to the United States National Institute of Standards and Technology, to the extent allowed by the Institute's calibration facility, and to the calibration facilities of other International Standards Organization members.

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New editions are complete revisions of the manual. Many product updates do not require manual changes; and, conversely, manual corrections may be done without accompanying product changes. Therefore, do not expect a one-to-one correspondence between product updates and manual updates.