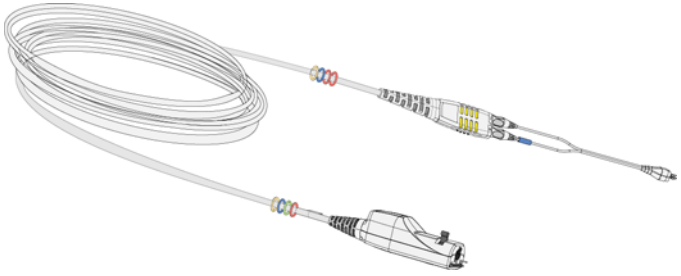
Keysight N2830A-Series Differential InfiniiMax III+ Probes

User's Guide



KEYSIGHT TECHNOLOGIES

Notices

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Contents

1 Using InfiniiMax III+ Series Probes

Use the N2830/1/2A differential probes to perform differential, common mode, and single-ended measurements using InfiniiMax III and N2848A QuickTip probe heads. The probes are compatible with the Infiniium AutoProbe Interface which completely configures the Infiniium series of oscilloscopes for the probes.

WARNING **Before using the probe, refer to "Safety Information" on page 34.**

KEYSIGHT TECHNOLOGIES

Introduction

The N2830/1/2A probes are shipped in the case that is shown in Figure 1. When you receive the probe, inspect it as described in "Inspecting the Probe" on page 33. When opening the case, lift out the foam cutout and flip the cutout over to reveal the ground lead as shown in the following figure.

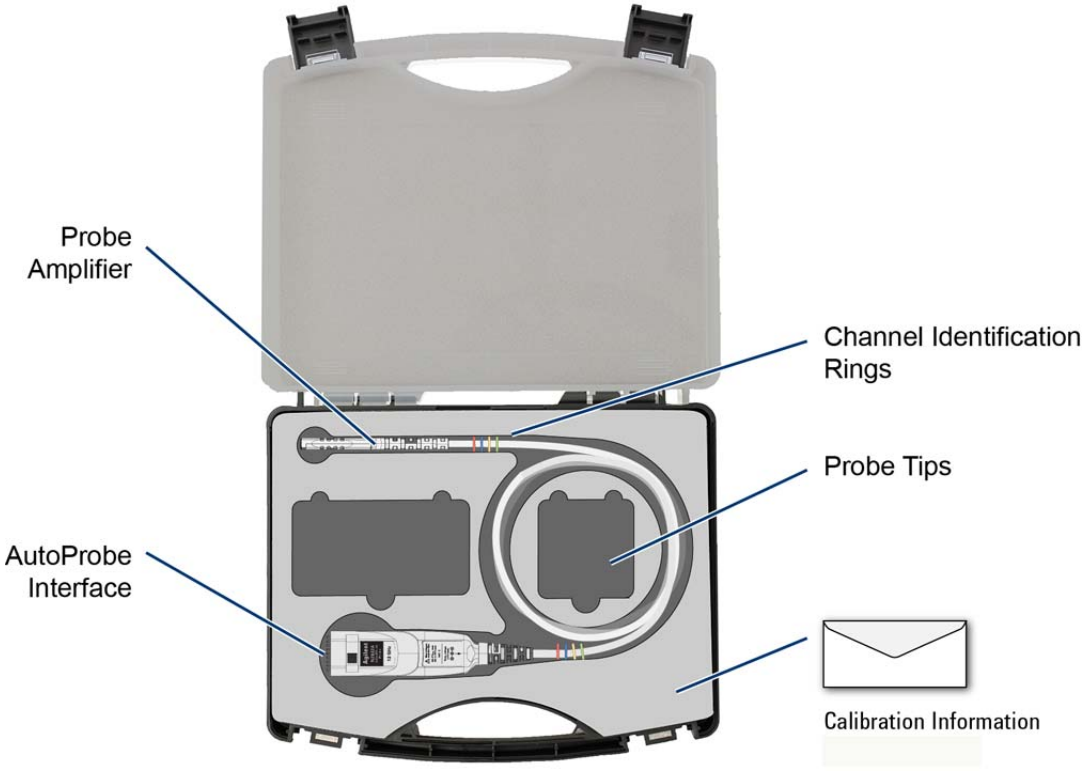


Figure 1 Probe in Supplied Case

The probes have the following bandwidths:

N2830A: . . . . . 4 GHz
N2831A: . . . . . 8 GHz
N2832A: . . . . . 13 GHz

Compatible Oscilloscopes

Table 1 lists the oscilloscopes that are compatible with the N2830/1/2A probes. Because these probes use a precision BNC AutoProbe 1 connection, an N5442A adapter is required to connect the probe to series 90000 Q, X, and Z-series Infiniium oscilloscopes. For use with the InfiniiMax III+ N2830/1/2A probes, Infiniium oscilloscopes require software version 5.0 or higher. These probes are *not* compatible with 9000 series or InfiniiVision oscilloscopes.

Table 1 Compatible Infiniium Oscilloscopes

Oscilloscope	Adapter Required
90000 Q, X, and Z-Series	N5442A
90000A Series	none
S-Series	none
86100C/D Series	N1022A/B

Is Your Oscilloscope Software Up-to-Date?

Keysight periodically releases software updates to support your probe, fix known defects, and incorporate product enhancements. To download the latest firmware, go to www.keysight.com and search for your oscilloscope's topic. Click on the "Drivers, Firmware & Software" tab.

Probe Heads

Before you can use the probe, you must connect one of the available probe heads to an N2830/1/2A probe amplifier. The available probe heads are documented in Chapter 2, "Using InfiniiMax III+ Probe Heads".

CAUTION

Before using the probes, refer to "To Avoid Damaging the Probe" on page 13.

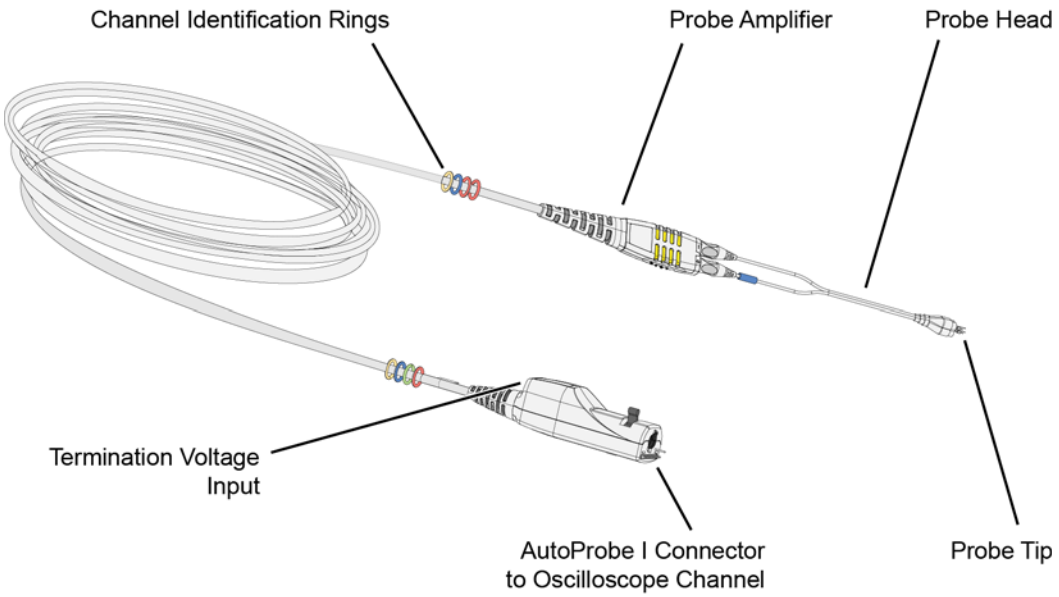


Figure 2 Probe with Attached Head

Figure 5 on page 12 shows the available probe heads and accessories. The N2830/1/2A probes are designed to use the InfiniiMax III probe heads. InfiniiMax III probe heads are also compatible with InfiniiMax III N2800A-series probes. Each available InfiniiMax III probe head is documented in Chapter 2, “Using InfiniiMax III+ Probe Heads”.

Differential probe heads offer easy measurement of differential signals and greatly improve the measurement of single-ended signals. Single-ended probe heads offer extremely small size for probing single-ended signals in confined spaces.

WARNING **Always observe the ESD, temperature, maximum voltage, and maximum terminal voltages listed on the probe labels as shown in Figure 3.**

The N2830/1/2A probes are designed for Measurement Category I (CAT I). Measurement Category I is for measurements performed on circuits not directly connected to a mains supply. Observe the following voltage limits:

Maximum AC at probe tips:. . . . . $5V_{rms}$
Maximum DC at probe tips:. . . . . ±18V
Maximum terminal voltage:. . . . . ±4V

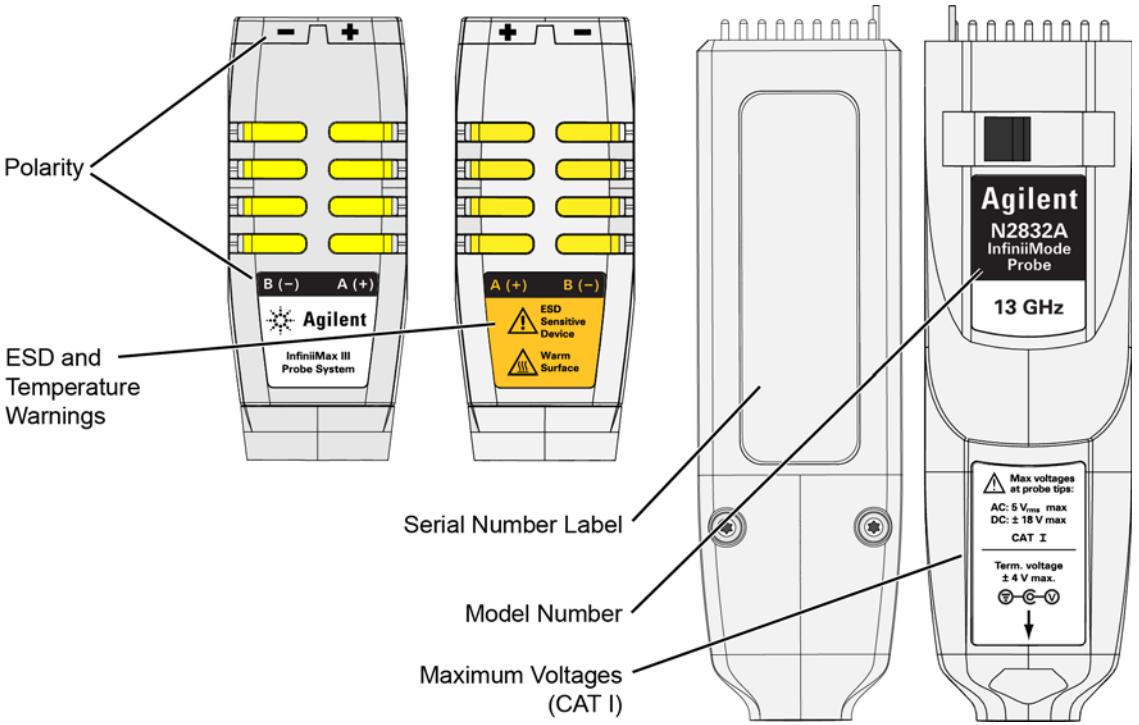


Figure 3 Probe Labels

Supplied Accessories

Figure 4 shows the accessories that are shipped with the N2830/1/2A probe amplifiers. Any head shown in Figure 5 on page 12 can be ordered at any time for any N2830/1/2A probes.

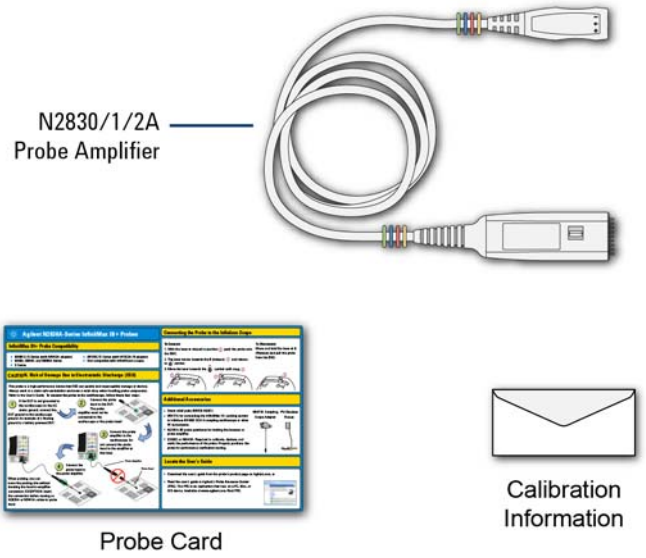


Figure 4 Accessories Supplied With the Probe Amplifier

Cleaning the probe

If the probe requires cleaning, disconnect it from the oscilloscope and clean it with a soft cloth dampened with a mild soap and water solution. Make sure the probe is completely dry before reconnecting it to the oscilloscope.

Channel Identification Rings

When multiple probes are connected to the oscilloscope, use the channel identification rings to associate the channel inputs with each probe. Place one colored ring near the probe's channel connector and place an identical color ring near the probe head.

InfiniiMax III and III+ Probing System Family Diagram

Figure 5 on page 12 shows the InfiniiMax III / III+ probes and compatible probe head accessories.

For extreme temperature testing, use the N5450B InfiniiMax extreme temperature extension cable with the N5441A solder-in head. The N5441A can withstand temperatures from –55°C to +150°C for up to 250 test cycles.

CAUTION

None of the N2830/1/2A probe amplifiers can withstand the extreme temperatures (–55°C to +150°C) that the N5450B can withstand. When using the N5450B extension cable, do not subject the InfiniiMax III+ probe amplifier to extreme temperatures.

CAUTION

None of the other probe heads are designed for extreme temperature testing.

The N5449A includes one N2873A 10:1 passive probe. The adapter is specifically tuned for the N2873A probe. Similar probes (1 MΩ input) can be used. Other probes may not meet the bandwidth specification.

An E2655C or N5443A Performance Verification (PV) accessory fixture can be used to properly position the probe for PV testing.

For the N5444A probe head, optional N5448A 2.92 mm extension cables can be purchased. Use these cables in place of the supplied semi-rigid cable set.

The N2830/1/2/3A probes can be used with the 86100D sampling scope with degraded performance, depending on the probe head used. Use only in differential 1x mode (10:1 attenuation).

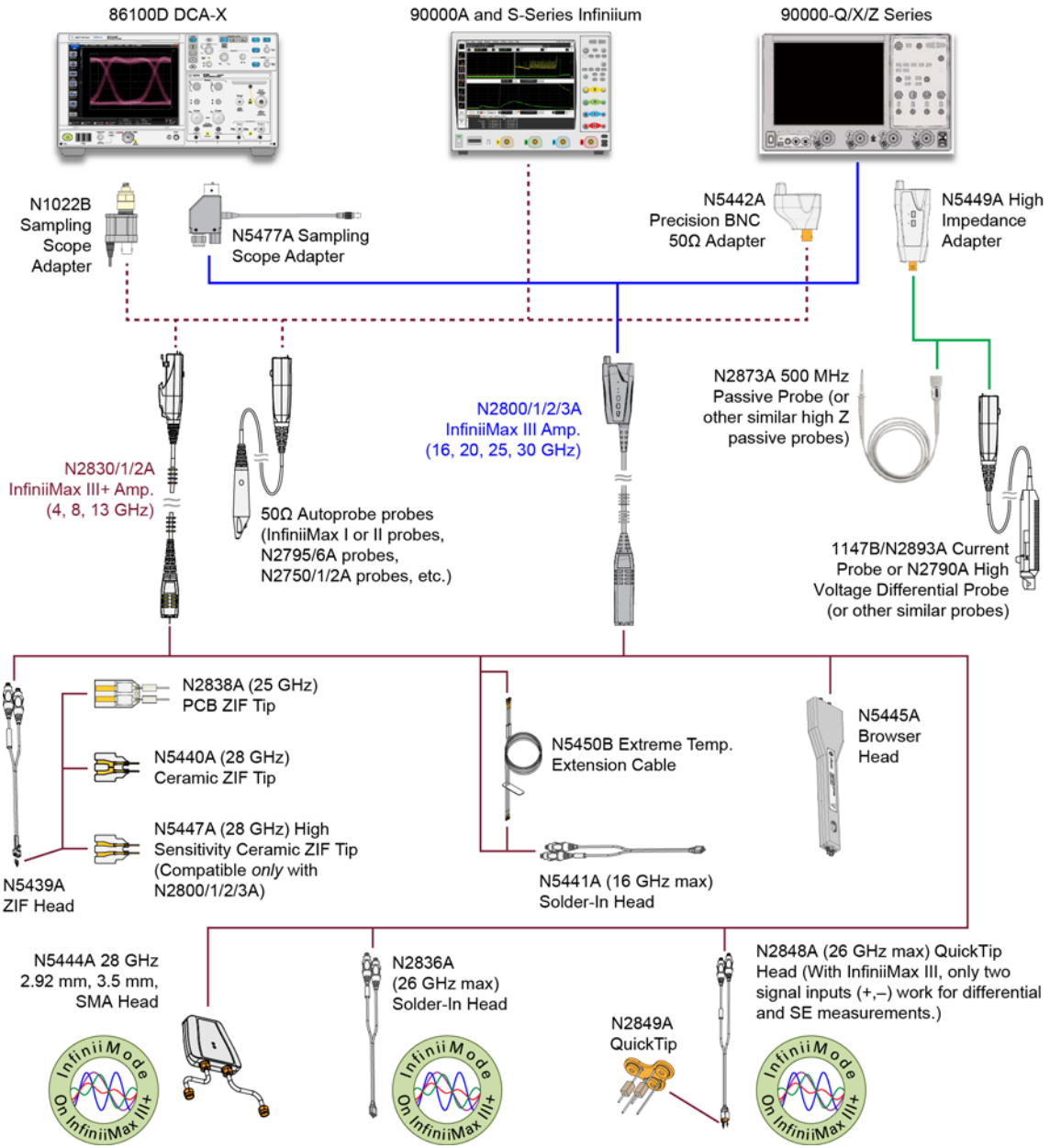


Figure 5 InfiniiMax III and III+ Family Diagram

To Avoid Damaging the Probe

In this section, you'll learn to properly handle your probes to prevent damage and maintain high performance. For more safe-handling information, go to **www.keysight.com** and search for *InfiniiMax III ESD Best Practices demo video*.

CAUTION Electrostatic discharge (ESD) can quickly and imperceptibly damage or destroy high-performance probes, resulting in costly repairs. Always wear a wrist strap when handling probe components.

CAUTION Probes are sensitive devices and should be treated with care. Do not bend or kink the probe amplifier cable. Do not drop heavy objects on the probe, drop the probe from large heights, spill liquids on the probe, etc. Any of these examples can significantly degrade the performance of the probe.

CAUTION When storing the probe, it is best to coil the cable in a large radius and avoid a net twist in the cable during the process. This can be done in a similar manner to how garden hoses or extension cords are typically coiled.

CAUTION InfiniiMax I and II probe heads cannot be used with Infiniimax III+ probe amplifiers and InfiniiMax III+ probe heads cannot be used with InfiniiMax I and II amplifiers.

CAUTION Never allow the probe head to be connected to the probe amplifer, if the probe amplifier is *not* connected to the oscilloscope channel.

CAUTION Always disconnect an N2836A or N5441A solder-in probe head from the probe amplifier before unsoldering, moving to a new position, and resoldering the head.

Using a Static-Safe Work Station

InfiniiMax probes and accessories are ESD sensitive devices and should be treated with care. Before using or handling the probe or accessories, always wear a grounded ESD wrist strap and ensure that cables and probe heads are discharged before being connected.

All work, including connecting probe amplifiers to the oscilloscope, should be performed at a static-safe work station as shown in Figure 6.

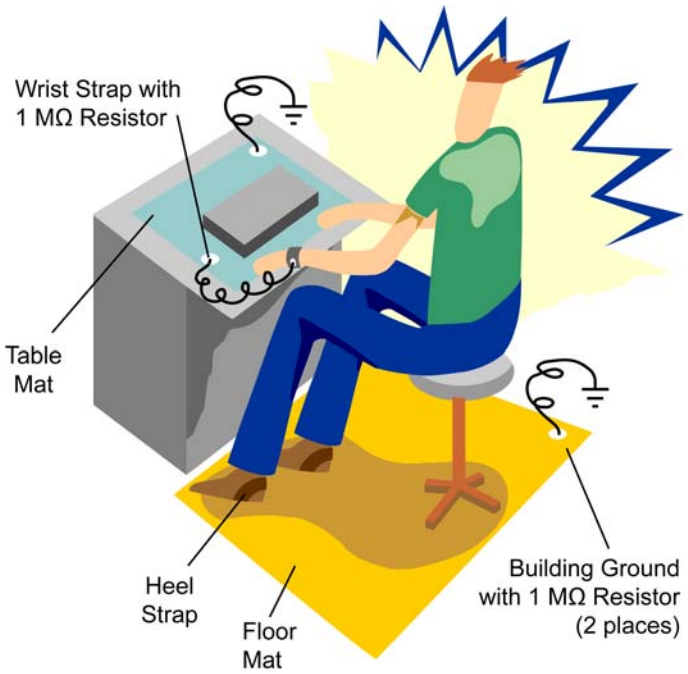


Figure 6 Static-Safe Work Station

Many scopes including Keysight's 90000X series have a front-panel ground socket. You can plug the wrist strap into the ground socket as seen in the following picture.

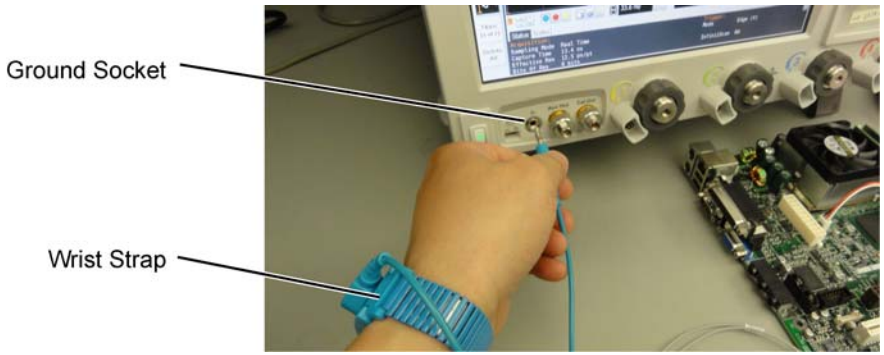


Figure 7 Wrist Strap Connected to Oscilloscope Ground Socket

The static-safe work station shown in Figure 6 uses two types of ESD protection:

- Conductive table-mat and wrist-strap combination.
- Conductive floor-mat and heel-strap combination.

Both types, when used together, provide a significant level of ESD protection. Of the two, only the table-mat and wrist-strap combination provides adequate ESD protection when used alone. To ensure user safety, the static-safe accessories must provide at least 1 MΩ of isolation from ground. Purchase acceptable ESD accessories from your local supplier.

WARNING **These techniques for a static-safe work station should not be used when working on circuitry with a voltage potential greater than 500 volts.**

Safely Connecting the Probe to an Oscilloscope

To protect against ESD damage, always use the four steps shown in Figure 8 on page 17 when connecting your probe to the oscilloscope.

CAUTION

When connecting a probe head to a probe amplifier, push straight in. When disconnecting a probe head from an amplifier, pull the probe head connectors straight out of the sockets. Never bend the probe head in order to pry it loose from the amplifier. Also, do not wiggle the probe head up and down or twist it to remove the connectors from the sockets. This can damage the pins in the amplifier or the probe head itself.

Probing the DUT

When making your measurements, you'll often need to probe different locations on the DUT. You can safely move any of the following three probe heads *without* having to first break the amplifier-to-head connection:

- N5445A differential browser head
- N5439A ZIF head,
- N5444A 2.92 mm/3.5 mm/SMA head.
- N2848A QuickTip InfiniiMode head.

The only exception is when the DUT is *not* grounded to the oscilloscope via the AC mains ground. In this case, connect the DUT ground to the oscilloscope ground *before* moving the probe. An example of a device having a floating ground would be a battery-powered DUT.

CAUTION

When probing with an N2836A and N5441A, always disconnect the probe head from the amplifier *before* unsoldering, moving to a new position, and resoldering the head. This is because some soldering-iron tips can hold a charge which can damage the probe amplifier.

CAUTION

When probing with an N2848A, always disconnect the probe head from probe tip *before* unsoldering, moving to a new position, and resoldering the tip. This is because some soldering-iron tips can hold a charge which can damage the probe amplifier.

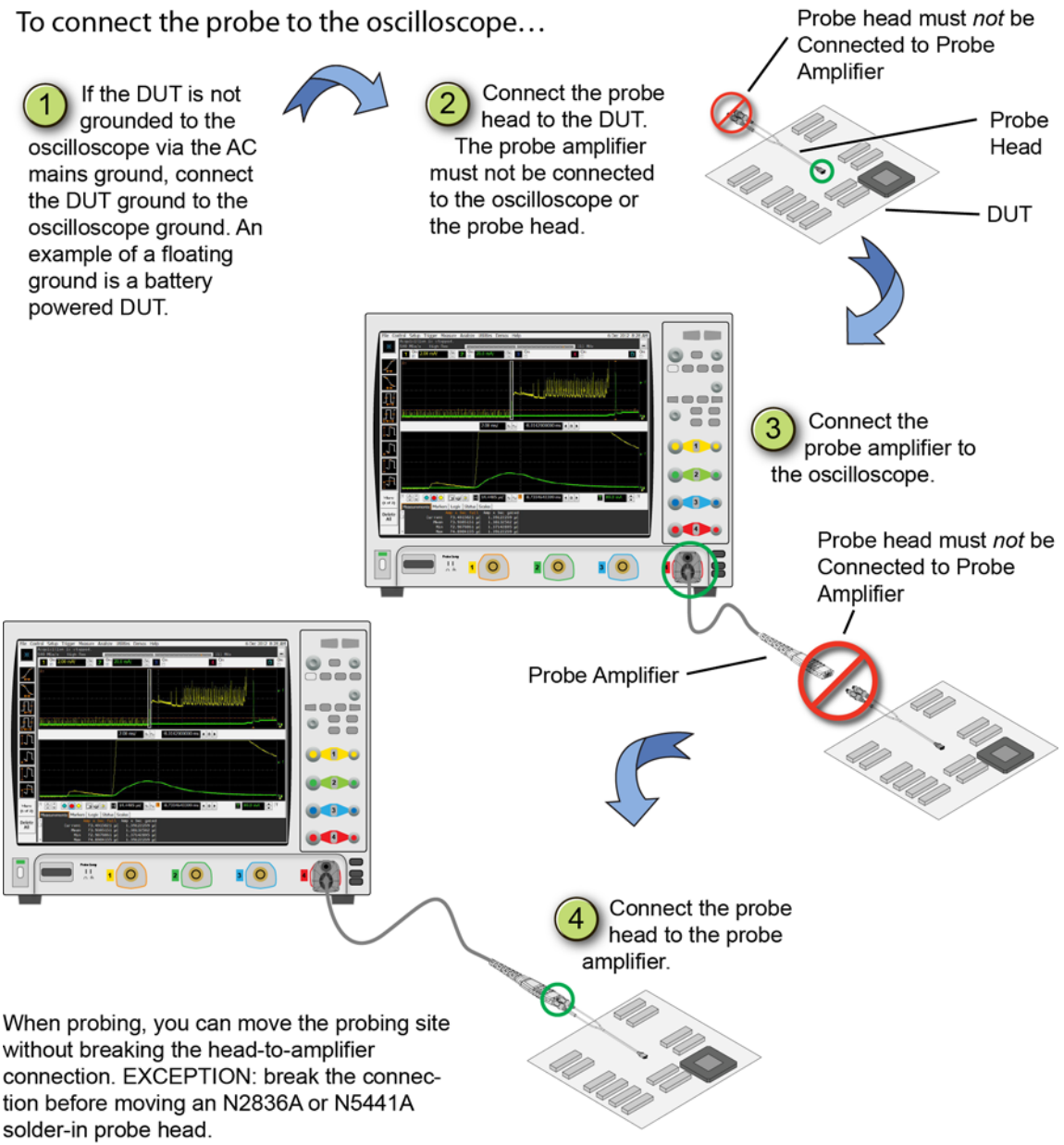


Figure 8 Connecting the Probe to the Oscilloscope

Safely Disconnecting the Probe from an Oscilloscope

Always disconnect the probe head from the probe amplifier *before*:

- disconnecting the probe amplifier from the oscilloscope.
- switching the probe amplifier from one oscilloscope channel to another.

CAUTION

Never allow the probe head to be connected to the probe amplifier, if the probe amplifier is *not* connected to the oscilloscope channel.

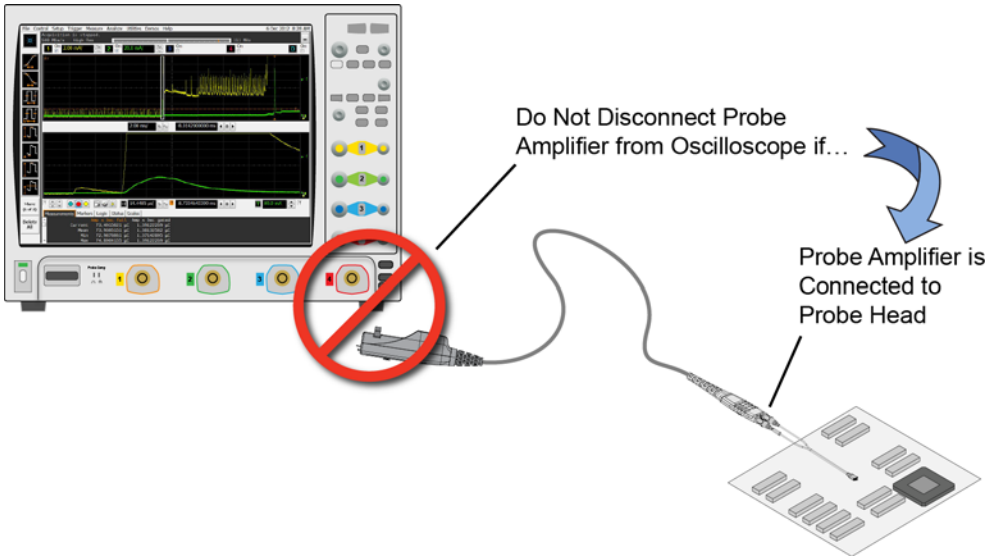


Figure 9 Probe Improperly Disconnected from Oscilloscope while Probe Head is Connected to the Probe Amplifier

To Ensure Maximum Measurement Accuracy

To increase measurement accuracy, use the oscilloscope's **Select Probe Head** dialog box to indicate the type of probe head that is attached to the probe amplifier. Making this selection allows the oscilloscope to apply the proper type of correction filter (S parameter) for your measurement case. The correction filter increases accuracy by flattening the magnitude and phase response of the probe. The following two sources of S parameters are automatically used for the filter:

- S parameters of the InfiniiMax III+ probe amplifier. These S parameters are unique to and stored on the probe amplifier.
- S parameters of the specific probe-head model. For example, the **N2836A: DF Solder-In (Vertical)** selection applies S parameters for the N2836A head held in a vertical position (perpendicular to the surface of the DUT).

To display the dialog box, click **Probes** > **Channel Setup Menu**.

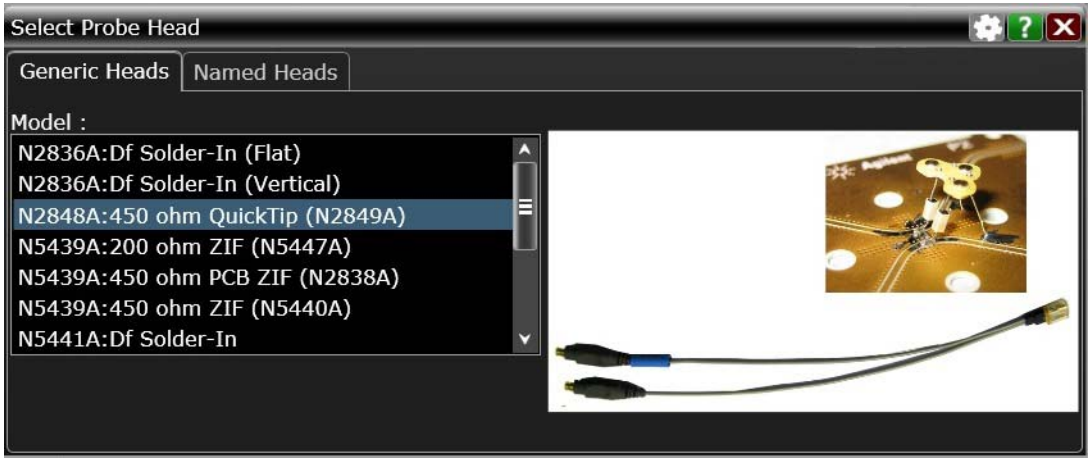


Figure 10 Select Probe Head Dialog Box

To Use InfiniiMode

InfiniiMode allows you to switch between differential, single-ended, and common mode measurements without needing to change or reconnect the probe or probe leads. Switching measurements is accomplished using the oscilloscope's probe configuration dialog box.

The N2848A QuickTip, N2836A Solder-In head, and N5444A SMA head are InfiniiMode compatible.

The following table shows, depending on the probe tip and InfiniiMode setting, which signal types can be measured.

Table 2 Supported InfiniiMode Measurements by Probe Tip

InfiniiMode Setting	**Signal Being Measured**	
	Single-Ended	**Differential**
Differential	Browser *(full BW)* [a]	Browser *(full BW)*
	Solder-In *(lower BW)*	Solder-In *(lower BW)*
	QuickTip *(lower BW)*	QuickTip *(lower BW)*
Single-Ended	Browser *(not supported)*	Browser *(not supported)*
	Solder-In	Solder-In
	QuickTip	QuickTip
Common-Mode	Browser *(not supported)*	Browser *(not supported)*
	Solder-In	Solder-In
	QuickTip	QuickTip

a Full bandwidth obtained by touching one tip to ground.

NOTE Because the N5445A browser tip has two leads instead of three, it is not InfiniiMode compatible. However, you can still use the browser tip to measure single-ended signals by selecting differential mode and touching one tip to ground.

Making InfiniiMode Connections

When probing a differential or common mode signal, connect the probe tips as shown in Figure 11. The positive (+) and negative (–) leads can be reversed by swapping the connections at the probe amplifier.

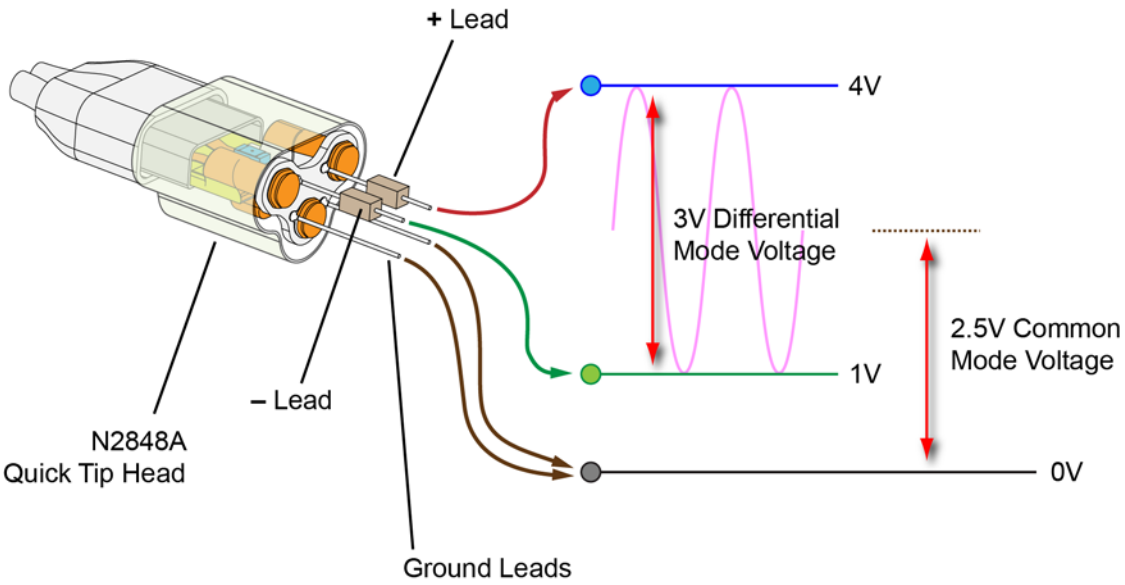


Figure 11 Example InfiniiMode Probe Circuit Connections

NOTE

Soldering the ground wires is not required when making differential or single-ended (+ or – leads) measurements.

The following measurements can be made *without* reconnecting the probe tips. These equations use the voltages shown in Figure 11.

Differential Measurement

$$V_{+lead} - V_{-lead} = 4V - 1V = 3V$$

Common Mode Measurement

$$\frac{V_{+lead} + V_{-lead}}{2} = \frac{4V + 1V}{2} = 2.5V$$

Single-Ended Measurement with +Lead

$$V_{+lead} - gnd = 4V - 0V = 4V$$

Single-Ended Measurement with –Lead

$$V_{-lead} - gnd = 1V - 0V = 1V$$

Probe Configuration Dialog Box

When the probe is connected to an Infiniium oscilloscope (S-series, 90000 series, or 90000 X, Q, and Z-series), open the probe's **Channel** menu and then **Probe** menu to set up the probe configuration and select the InfiniiMode measurment mode.

In the Probe Amplifier dialog box, select the InfiniiMode measurement mode: **Differential**, **Single-Ended A**, **Single-Ended B**, or **Common Mode**. The default setting is **Differential**. See Figure 12.

Figure 12 Probe Configuration Dialog Box

To Probe Ungrounded Devices

If the DUT is not grounded to the oscilloscope via the AC mains ground, connect the DUT ground to the oscilloscope ground. An example of a floating ground is a battery-powered device.

Without the ground connection, the common mode voltage is not guaranteed to be within the common mode range of the probe amplifiers.

NOTE **Failure to connect the ground may result in the display of inaccurate waveforms.**

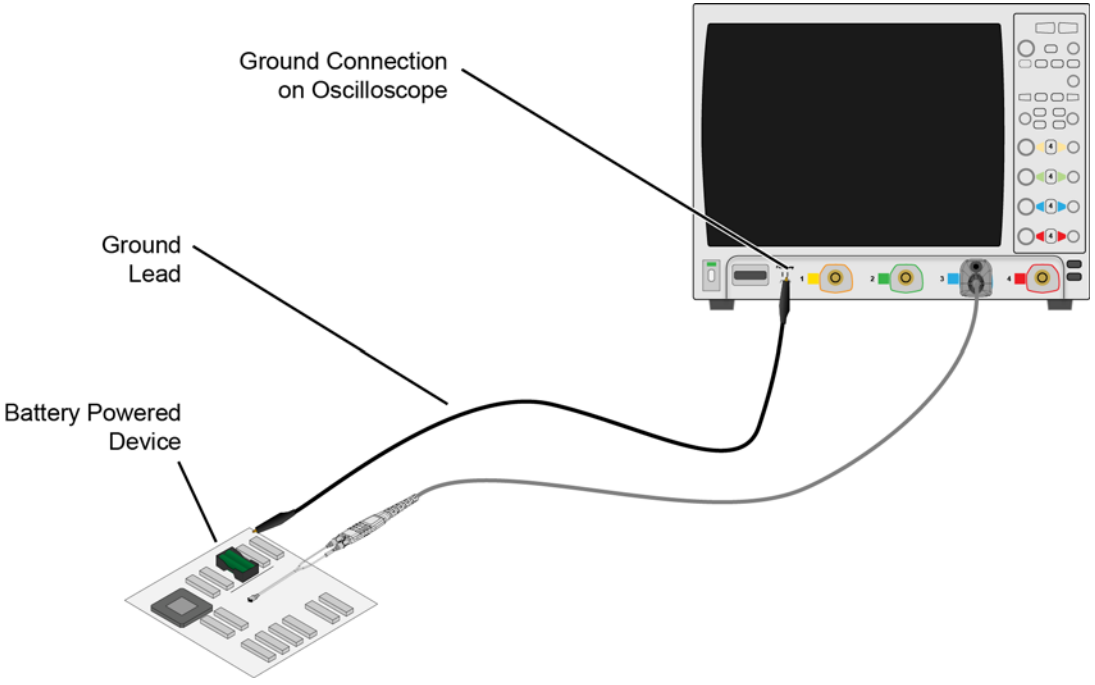


Figure 13 Grounding the DUT to an S-Series Oscilloscope

To Probe Single-Ended Signals with a Differential Head

Using a differential probe head rather than a single-ended probe head to probe single-ended signals results in the advantages of higher bandwidth and increased accuracy. Also no offset range is sacrificed when using a differential probe head, as any supplied offset is applied only to the probe head's plus side. To learn more about applying a DC offset when probing, refer to "To Measure Small Signals on a Large DC Level" on page 26.

If possible, orient the probe head vertically as shown in Figure 14. Laying the probe head flat over a single-ended signal will cause coupling to the tip that can degrade the performance. Notice that the head's "–" lead is connected to ground.

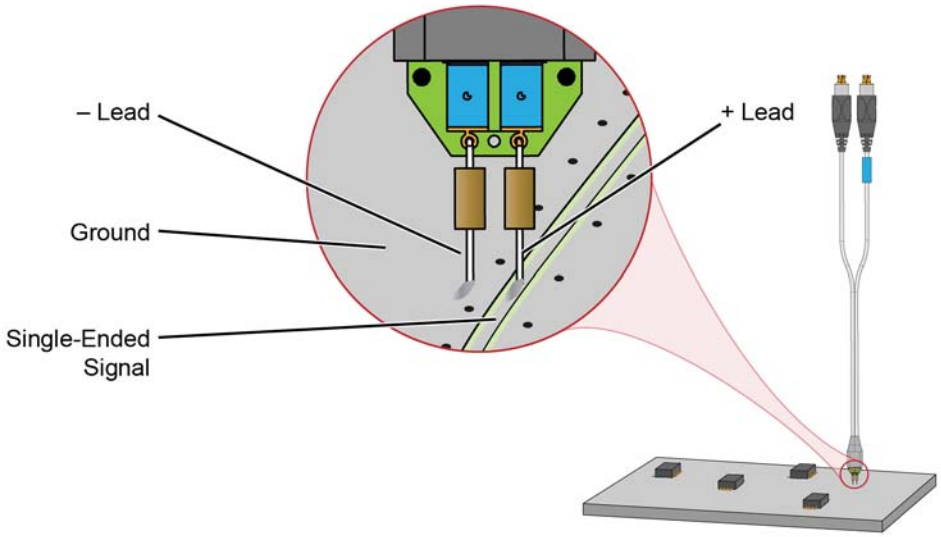


Figure 14 Connecting a Differential Head to a Single-Ended Signal

To Measure Small Signals on a Large DC Level

Measuring small AC signals riding on top of a large DC can be challenging. By subtracting out most or all of the DC component, the signal can be positioned to better utilize the input's available dynamic range. This is accomplished by applying an offset by either the probe or oscilloscope channel. Probe offset is applied when viewing single-ended signals and *scope* channel offset is applied when viewing differential signals.

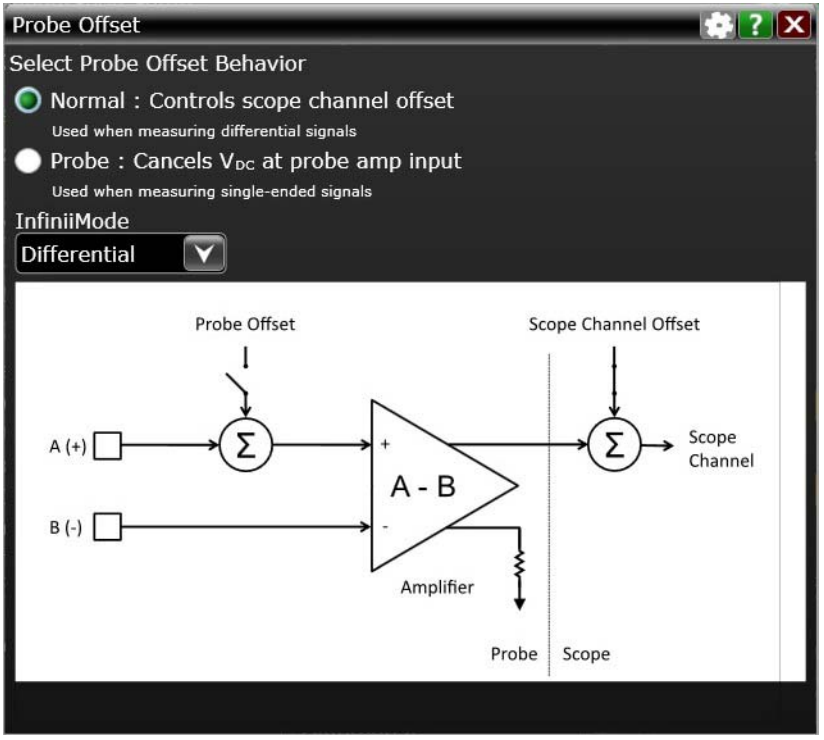


Figure 15 Probe Offset Dialog Box (Normal Setting)

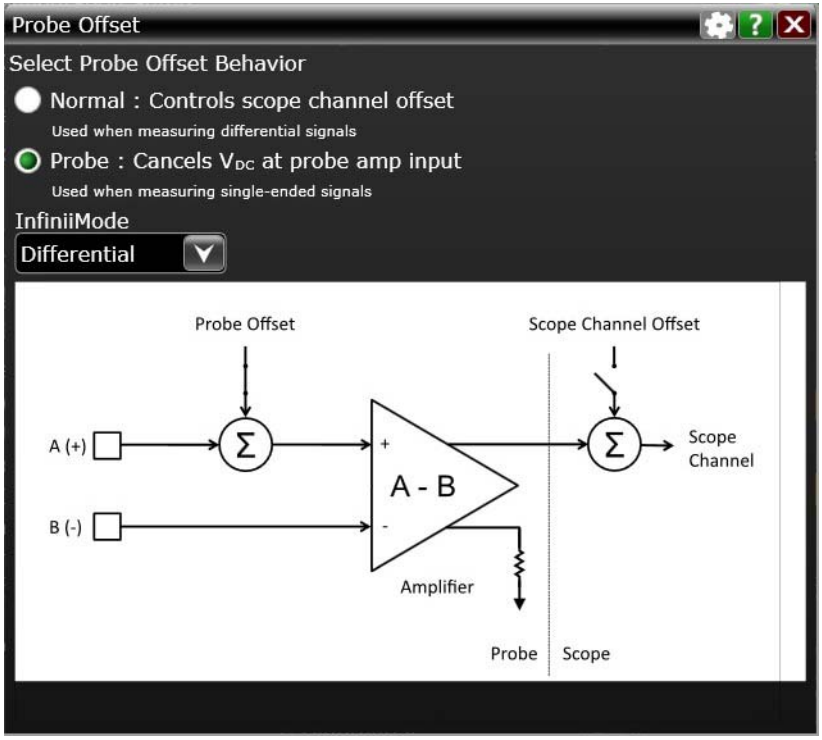


Figure 16 Probe Offset Dialog Box (Probe Setting)

As shown in the figure, when probing single-ended signals you can apply probe offset using the oscilloscope's front-panel vertical offset controls.

InfiniiMax III/III+ probe provides a very large offset range (up to ±16V) for probing single-ended signals and a large common-mode range for probing differential signals. Use this offset range to subtract most or all of the DC component of the input signal so that the signal can better utilize the dynamic range of the input. This is possible due to the designs having summing nodes at the amplifier input. For information on properly using probe offset to ensure that you can get the maximum performance and dynamic range from the InfiniiMax probe, refer to Keysight application note 5988-9264EN.

Understanding how to properly use offset for your application can ensure that you get the maximum performance and dynamic range from your probes. The unique method of applying probe offset in InfiniiMax differential probes allows the full benefits of differential probing for single-ended signals without sacrificing offset range. Table 3 lists the interactions between the signal type and the different offsets.

Table 3 Signal Type and Available Offset Range

	Signal Being Probed	
	Single Ended	**Differential**
Probe Head Type	Differential or Single Ended Head	Differential Head
Offset Applied To	Probe (channel offset is set to 0V)	Oscilloscope Channel (probe offset is set to 0V)
Offset Range	±16V (with 450 ohm probe head)	±2.5V
Description	The offset voltage is subtracted from the input signal before the probe's differential amplifier. Since this subtraction is done *before* any active circuits, the offset range is large. **Differential Probe Head**. A differential probe can make higher bandwidth and more accurate measurements on single-ended signals than a single-ended probe and this method of applying offset to only the plus side of a differential probe means that there is no sacrificing of offset range. All of the InfiniiMax III+ heads are differential. **Single-Ended Probe Head**. Single-ended probe tips do not have a minus lead so nothing is plugged into the probe amplifier's "–" input. This is normal and does not cause any problems.	Since the plus and minus sides of differential signals have the same dc component, the dc component is subtracted out and the probe's output by definition is centered around ground. The channel offset allows the waveform seen on screen to be moved as desired. The allowable dc component in the plus and minus signals is determined by the common mode range of the probe. Any voltage applied to the probe's offset input jack is not used and has no effect on the signal.

Slew Rate Requirements for Different Technologies

The following table shows the slew rates for several different technologies. The maximum allowed input slew rate is 18 V/ns for single-ended signals and 30 V/ns for differential signals. Table 4 shows that the maximum required slew rate for the different technologies is much less that of the probe.

Table 4 Slew Rate Requirements

Name of Technology	Differential Signal	Max Single-Ended Slew Rate[a] (V/ns)	Max Differential Slew Rate[b] (V/ns)	Driver Min Edge Rate (20%-80% ps)	Max Transmitter Level (Diff V)
PCI Express (3GIO)	YES	9.6	19.2	50	1.6
RapidIO Serial 3.125Gb	YES	8.0	16.0	60	1.6
10GbE XAUI (4x3.125Gb)	YES	8.0	16.0	60	1.6
1394b	YES	8.0	16.0	60	1.6
Fibre Channel 2125	YES	8.0	16.0	75	1
Gigabit Ethernet 1000Base-CX	YES	7.8	15.5	85	2.2
RapidIO 8/16 2Gb	YES	7.2	14.4	50	1.2
Infiniband 2.5Gb	YES	4.8	9.6	100	1.6
HyperTransport 1.6Gb	YES	4.0	8.0	113	1.5
SATA (1.5Gb)	YES	1.3	2.7	134	0.6
USB 2.0	YES	0.9	1.8	375	1.1
DDR 200/266/333	NO	7.2	n/a	300	3.6
PCI	NO	4.3	n/a	500	3.6
AGP-8X	NO	3.1	n/a	137	0.7

a The probe specification is 18 V/ns
b The probe specification is 30 V/ns

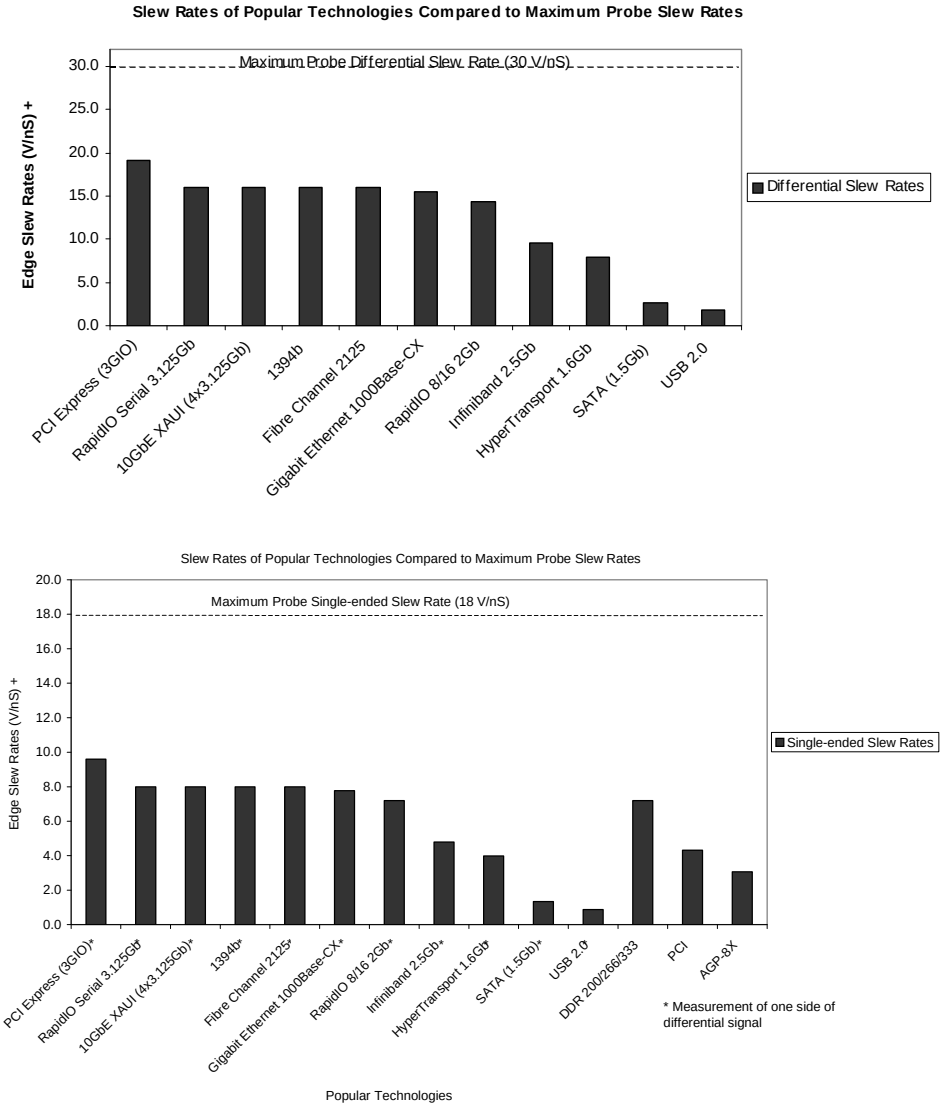


Figure 17 Slew Rates of Popular Technologies Compared to Maximum Probe Slew Rates

Available Accessories

N1022B Sampling Scope Adapter

The N1022B Sampling Scope Adapter allows you to connect the InfiniiMax III+ probing system to the Infiniium 86100D DCA-X sampling oscilloscope or other RF instruments.

N5450B Extreme Temp Cable Extension Kit

The extreme temperature cable extension kit is an accessory that allows an oscilloscope probe to be used to monitor a device in a temperature chamber. Keysight's Infiniimax probe amplifiers have a specified operating temperature range from 5^{o} C to 40^{o} C, but the probe heads can be operated over a much larger range of temperatures. Use the extension cables to physically separate the amplifier from the probe head which allows you to operate the probe head inside a temperature chamber while the probe amplifier remains outside the chamber.

To ensure a high-quality measurement, the N5450B cable set have been phase-matched at the factory. A coupling tag is included with the cables to ensure the cables stay as a matched pair. To install the coupling tag, slip the small end of each cable through the holes in the tag. The tag can be positioned anywhere along the length of the cable and can withstand the temperature ranges specified.

CAUTION Avoid rapid changes in temperature that can lead to moisture accumulating in the form of condensation on the probe components, as well as the DUT. If this occurs, wait until the moisture has evaporated before making any measurements.

CAUTION Additional care must be taken when handling probe heads used during extreme temperature cycling because this process makes the probe heads less robust.

CAUTION Secure the ends of the extension cable near the probe head in the temperature chamber such that the probe head legs are not tugged or moved around significantly.

CAUTION Prevent abrasion and tears in the cable's jacket, do not rest the extension cables on any metal objects or objects with sharp edges.

CAUTION Do not kink the cables. The cables are designed to be flexible, but are not designed to be bent sharply.

NOTE Keep your extreme temperature testing probes separate from the probes that you use under milder conditions. This is because cycling probe heads through extreme temperature ranges has a marked affect on their lifetimes. Only the lifetime of the probe head is affected by temperature cycling. The extension cables and probe amplifier should not need to be replaced with extended temperature cycling.

NOTE Discoloration or texture changes are possible with the extension cables. These changes do not, however, affect the performance or the quality of a measurement.

Inspecting the Probe

- Inspect the shipping container for damage.

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

- Check the accessories.
- If the contents are incomplete or damaged, notify your Keysight Technologies Sales Office.
- Inspect the probe. If there is mechanical damage or defect, or if the probe does not operate properly or pass calibration tests, notify your Keysight Technologies Sales Office.

If the shipping container is damaged, or the cushioning materials show signs of stress, notify the carrier as well as your Keysight Technologies Sales Office. Keep the shipping materials for the carrier's inspection. The Keysight Technologies office will arrange for repair or replacement at Keysight Technologies' option without waiting for claim settlement.

Safety Information

This manual provides information and warnings essential for operating this probe in a safe manner and for maintaining it in safe operating condition. Before using this equipment and to ensure safe operation and to obtain maximum performance from the probe, carefully read and observe the following warnings, cautions, and notes.

This product has been designed and tested in accordance with accepted industry standards, and has been supplied in a safe condition. The documentation contains information and warnings that must be followed by the user to ensure safe operation and to maintain the product in a safe condition.

Note the external markings on the probe that are described in this document.

To avoid personal injury and to prevent fire or damage to this product or products connected to it, review and comply with the following safety precautions. Be aware that if you use this probe assembly in a manner not specified, the protection this product provides may be impaired.

WARNING **Use Only Grounded Instruments.**
Do not connect the probe's ground lead to a potential other than earth ground. Always make sure the probe and the oscilloscope are grounded properly.

WARNING **Connect and Disconnect Properly.**
Connect the probe to the oscilloscope and connect the ground lead to earth ground before connecting the probe to the circuit under test. Disconnect the probe input and the probe ground lead from the circuit under test before disconnecting the probe from the oscilloscope.

WARNING **Observe Probe Ratings.**
Do not apply any electrical potential to the probe input which exceeds the maximum rating of the probe. Make sure to comply with the voltage versus frequency derating curve found in this manual.

WARNING **Indoor Use Only.**
Do not operate in wet/damp environments. Keep product surfaces dry and clean.

WARNING **Do Not Operate With Suspected Failures. Refer to qualified service personnel.**

WARNING **Never leave the probe connected to a conductor while it is not connected to an oscilloscope or voltage measuring instrument.**

WARNING **Do not use a probe which is cracked, damaged or has defective leads.**

WARNING **Do not install substitute parts or perform any unauthorized modification to the probe.**

WARNING **Do not operate the probe or oscilloscope in the presence of flammable gasses or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.**

WARNING **Do not use the probe or oscilloscope in a manner not specified by the manufacturer.**

WARNING **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.**

CAUTION The probe cable is a sensitive part of the probe and, therefore, you should be careful not to damage it through excessive bending or pulling. Avoid any mechanical shocks to this product in order to guarantee accurate performance and protection.

Concerning the Oscilloscope or Voltage Measuring Instrument to Which the Probe is Connected

WARNING **Whenever it is likely that the ground protection is impaired, you must make the instrument inoperative and secure it against any unintended operation.**

WARNING **If you energize the instrument by an auto transformer (for voltage reduction or mains isolation), the ground pin of the input connector terminal must be connected to the earth terminal of the power source.**

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.**

WARNING **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 fuse holders. To do so could cause a shock or fire hazard.**

WARNING **Capacitors inside the instrument may retain a charge even if the instrument is disconnected from its source of supply.**

Service

The following symptoms may indicate a problem with the probe or the way it is used. The probe is a high frequency device 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. If the probe is under warranty, normal warranty services apply.

Probe Calibration Fails

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

- Check that the probe passes a waveform 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.
- Be sure the oscilloscope passes calibration without the probe.

Incorrect Pulse Response (flatness)

If the probe's pulse response shows a top that is not flat, check for the following:

- Output of probe must be terminated into a proper 50 Ω termination. If you are using the probe with an Infiniium oscilloscope, this should not be a problem. If you are using the probe with other test gear, insure the probe is terminated into a low reflectivity 50Ω load (~ ±2%).
- If the coax or coaxes of the probe head in use has excessive damage, then reflections may be seen within ~ 1 ns of the input edge. If you suspect a probe head, swap it with another probe head and see if the non-flatness problem is fixed.
- If the one of the components in the tip have been damaged there may be a frequency gain non-flatness at around 40 MHz. If you suspect a probe head, swap it with another probe head and see if the non-flatness problem is fixed.

Incorrect Input Resistance

The input resistance is determined by the probe head in use. If the probe head is defective, damaged, or has been exposed to excessive voltage, the input resistor may be damaged. If this is the case, the probe head is no longer useful. A new probe head will need to be obtained either through purchase or warranty return.

Incorrect Offset

Assuming the probe head in use is properly functioning, incorrect offset may be caused by defect or damage to the probe amplifier or by lack of probe calibration with the oscilloscope.

Returning the Probe for Service

If the probe is found to be defective we recommend sending it to an authorized service center for all repair and calibration needs. Perform the following steps before shipping the probe back to Keysight Technologies for service.

1. Contact your nearest Keysight sales office for information on obtaining an RMA number and return address.
2. Write the following information on a tag and attach it to the malfunctioning equipment.
   - Name and address of owner
   - Product model number (for example, N2830A)
   - Product Serial Number (for example, MYXXXXXXXX)
   - Description of failure or service required

NOTE **Include probing and browsing heads if you feel the probe is not meeting performance specifications or a yearly calibration is requested.**

3. Protect the probe by wrapping in plastic or heavy paper.
4. Pack the probe in the original carrying case or if not available use bubble wrap or packing peanuts.
5. Place securely in sealed shipping container and mark container as "FRAGILE".

NOTE **If any correspondence is required, refer to the product by serial number and model number.**

Contacting Keysight Technologies

For technical assistance, contact your local Keysight Call Center.

- In the Americas, call 1 (800) 829-4444
- In other regions, visit http://www.keysight.com/find/assist

Before returning an instrument for service, you must first call the Call Center at 1 (800) 829-4444.

2
Using InfiniiMax III+ Probe Heads

Performance Graphs

Graphs showing the performance of the heads for each probe amplifier are shown in Chapter 6,

This chapter describes the various probe heads. The probe configurations are listed in the order of the best performance to the least performance in terms of bandwidth and input loading characteristics. The recommended configurations are designed to give the best probe performance for different probing situations. This allows you to quickly make the measurements you need with confidence in the performance and signal fidelity. Using the recommended connection configurations is your key to making accurate oscilloscope measurements with known performance levels.

Recommended Configurations at a Glance

Table 5 Configurations at a Glance (Sheet 1 of 2)

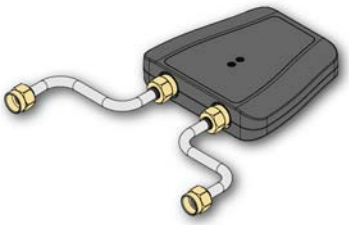
Recommended Order of Use	BW (GHz)	Cdiff [a] (pF)	Cse [b] (pF)	Usage
N5444A InfiniiMax III 2.92 mm Head (Refer to page 44.)				
1	N2830A: 4 N2831A: 8 N2832A: 13	–	–	Differential and Single-ended signals InfiniiMode compatible For cabled measurements. Can terminate to a non-ground voltage.
N5439A InfiniiMax III ZIF Head (Refer to page 46.)				
2	N2830A: 4 N2831A: 8 N2832A: 13	32 fF	44 fF	Single-ended signals only Solder-in hands free connection when physical size is critical Extremely low loading measurement with N5440A/47A ZIF tips Hard to reach targets Very small fine pitch targets
N5445A InfiniiMax III Browser (Refer to page 53.)				
3	N2830A: 4 N2831A: 8 N2832A: 13	35 fF	50 fF	Differential and Single-ended signals General purpose troubleshooting of signals Handheld browing Variable pitch spacing from 20 mil to 125 mil
N5441A InfiniiMax III Solder-In Head (Refer to page 61.)				
4	N2830A: 4 N2831A: 8 N2832A: 13	77 fF	105 fF	Differential and Single-ended signals Economical semi-permanent connection Extreme Temperature
N2836A InfiniiMode Solder-In Head (Refer to page 64.)				
5	N2830A: 4 N2831A: 8 N2832A: 13	108 fF	140 fF	Differential and Single-ended signals InfiniiMode Compatible Solder-in hands free connection

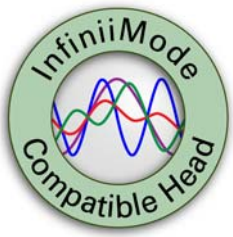
Table 5 Configurations at a Glance (Sheet 2 of 2)

Recommended Order of Use	BW (GHz)	Cdiff [a] (pF)	Cse [b] (pF)	Usage
N2848A QuickTip Head (Refer to page 70.)				
6	N2830A: 4 N2831A: 8 N2832A: >12	340 fF	200 fF	Differential and Single-ended signals InfiniiMode Compatible Easy head-to-tip connection in tight space Solder-in hands free connection

a Capacitance seen by differential signals
b Capacitance seen by single-ended signals

1 N5444A InfiniiMax III 2.92 mm/3.5 mm/ SMA Probe Head





The N5444A InfiniiMax III 2.92mm/3.5mm/SMA probe head provides 28 GHz bandwidth and allows you to connect two 2.92mm, 3.5mm, or SMA cables to make a differential measurement on a single oscilloscope channel.

The N5444A provides for a termination to a common DC voltage rather than to ground, which is required for many signal standards. It is implemented such that from DC to approximately 1 kHz, the termination is 55 Ohms to the termination voltage, and above approximately 10 kHz, the termination is 50 Ohms to 0.9 times the termination voltage. The termination voltage range is ±4V with a minimum step of 5 mV and a maximum current of 80 mA. The termination voltage can be controlled internally by the oscilloscope or applied externally using the supplied DC jack.

Table 6 Bandwidth

Probe Amplifier	BW
N2830A	4 GHz
N2831A	8 GHz
N2832A	13 GHz

PERFORMANCE PLOTS. Refer to Chapter 6, “Performance Plots”.

Figure 18 N5444A InfiniiMax III 2.92mm/3.5mm/SMA Probe Head

Order N5448A 2.92 mm head flex cables (10” or 25 cm long) to extend the cable length and add convenience. Figure 19 shows the N5448A cables attached to the N5444A probe head. You must first remove the supplied rigid cables before connecting the N5448A cables.

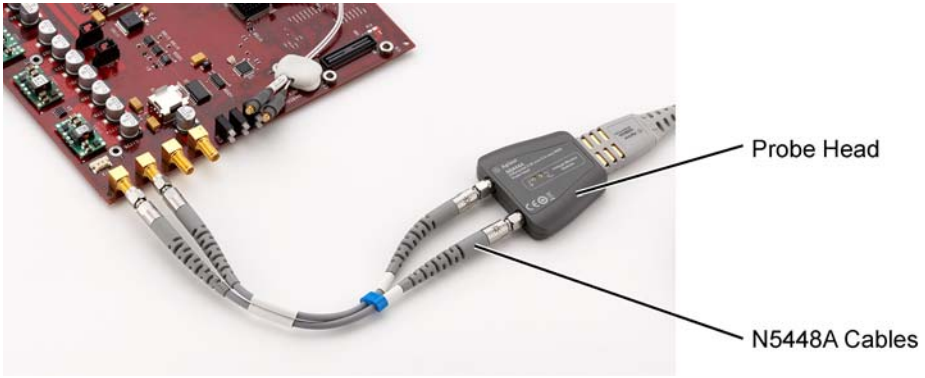
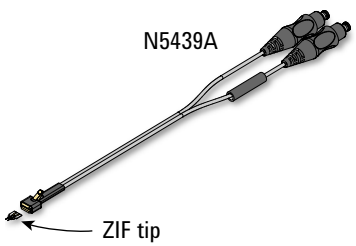


Figure 19 N5444A with N5448A Head Flex Cables Attached

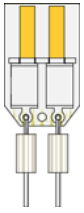
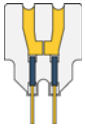
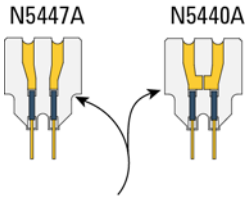
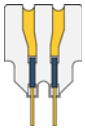
2 N5439A InfiniiMax III ZIF Probe Head

Replaceable Economical ZIF Tip



The N5439A Zero Insertion Force (ZIF) probe head supports the three types of economical replaceable tips that are shown in Table 7. Solder as many tips onto your DUT as needed. Because of the ZIF tip's extremely low loading, the tips can remain on the DUT as you easily move the probe head from one probing site to the next.

Table 7 Available ZIF Tips

ZIF Tip	Description		Variable Tip Spacing	Qty
N2838A 	25 GHz 450Ω PC board tip provides robust design with high bandwidth.		5 mil to 250 mil (0.127 mm to 6.35 mm).	5
N5440A 	28 GHz 450Ω ceramic (normal sensitivity) for extremely low probe loading.		5 mil to 80 mil (0.127 mm to 2 mm).	5
N5447A 	The N5447A ZIF tip is *not* compatible with the N2830/1/2A probes. Compatible only with InfiniiMax III N2800/1/2/3A probes.		—	—

NOTE The N5439A does not include any ZIF tips. You must order either the N2838A or N5440A in addition to N5439A.

NOTE The N5447A ZIF tip is *not* compatible with N2830/1/2A probes.

TO INSTALL OR REPAIR N2838A RESISTOR LEADS. Refer to "Replacing Axial Resistor Tips" on page 80.

PERFORMANCE PLOTS. Refer to Chapter 6, "Performance Plots".

Table 8 Bandwidth

Probe Amplifier	BW
N2830A	4 GHz
N2831A	8 GHz
N2832A	13 GHz

Ensuring Maximum N2838A Tip Performance

The specifications and performance plots of the N2838A ZIF tip were measured with a nominal spacing of 40 mil (1 mm). In order to achieve the proper response as shown in the performance plots, keep the mini-axial lead resistors roughly parallel as shown in Figure 43, and use the tip wires on the mini-axial leads to get the desired span.

If you need to position the resistors different than shown in this figure (that is, resistor bodies close together or spread apart), use N2807A and N2808A PrecisionProbe products to perform an AC calibration of the probe, which properly captures the response. Increasing the spacing to 250 mil degrades the performance some, but PrecisionProbe can be used to compensate or qualify the effect.

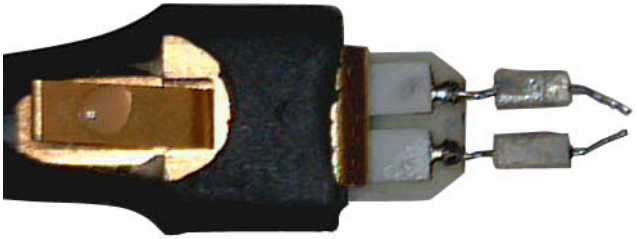


Figure 20 Proper Position of Resistors

Soldering a ZIF Tip to the DUT

CAUTION

The ZIF tips are very fragile. They must be manufactured in this way in order to meet the high-performance, high bandwidth applications they are intended for. Be extremely careful when handling.

1 Break off a ZIF tip/handle combination from the packaging holder at the point shown in the figure.

Figure 21 Five ZIF Tips on Packaging

2 Flux and tin the leads on the target DUT.

Figure 22 Preparing the DUT Leads

3 While holding the plastic form, form the ZIF tip wires to match the DUT's pitch and angle.

4 Flux the ZIF tip wires and DUT leads.

5 Position the ZIF tip with the gold traces facing up as shown in Figure 23 and carefully re-flow the solder. This orients the tip so that it will properly mate with the probe head.

NOTE When soldering the tip to your DUT, use the tip handle to hold the tip. This allows you to position these small tips without damaging them.

CAUTION Do not dwell on this solder joint.

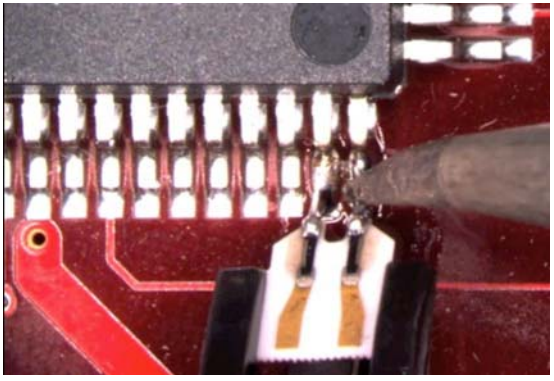


Figure 23 Soldering the ZIF Tip

6 Pull the ZIF handle from the ZIF tip in the direction shown in Figure 24. ZIF tips can be carefully handled with your fingertips and reinserted into a plastic handle if necessary.

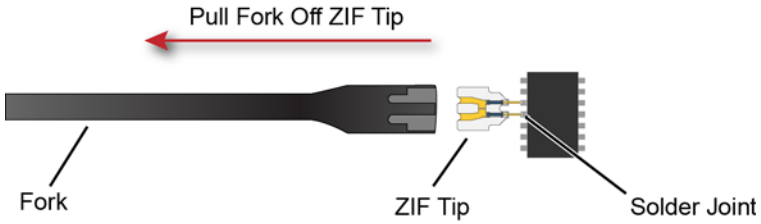


Figure 24 Removing the Handle from the ZIF Tip

7 You can connect ZIF tips to any of the locations on a DUT that you need to probe. The probe head can be quickly moved between the tips.

CAUTION Always mechanically strain-relieve the ZIF head *before* using to protect both your probe accessories and DUT from damage. Refer to "Strain Relieving the Probe Heads" on page 75.

CAUTION Be careful not to damage the tip wires when handling the ZIF tips. Wires can be carefully reshaped with tweezers or fingers if necessary.

Connecting the Probe Head to the ZIF Tip

1 Add strain relieve for the ZIF probe head as described in "Strain Relieving the Probe Heads" on page 75.

2 Form the coaxial cables to bring the probe head near the tip. Press the lever down on the ZIF probe head (see Figure 25) and slide the probe head onto the tip. Pressing on this lever removes the clamping force of the connector and enables you to insert or remove ZIF tips.

CAUTION

Stop if you encounter any resistance at all when sliding the probe head over the ZIF tip. Check your alignment, make sure the lever is pressed, and try again. Inserting the ZIF tip should require “zero” insertion force.

CAUTION

Always use the lever when inserting or removing ZIF tips.

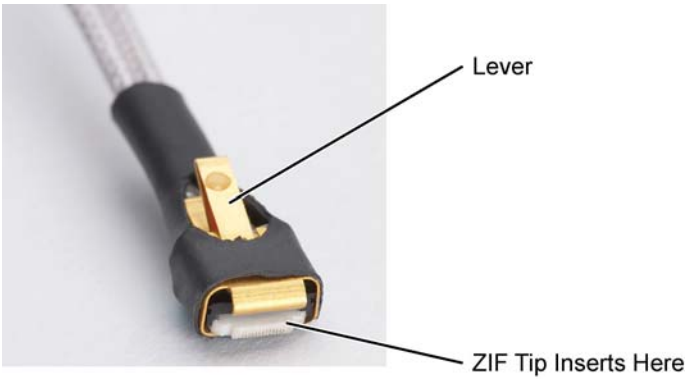


Figure 25 Probe Head with Location of the Lever

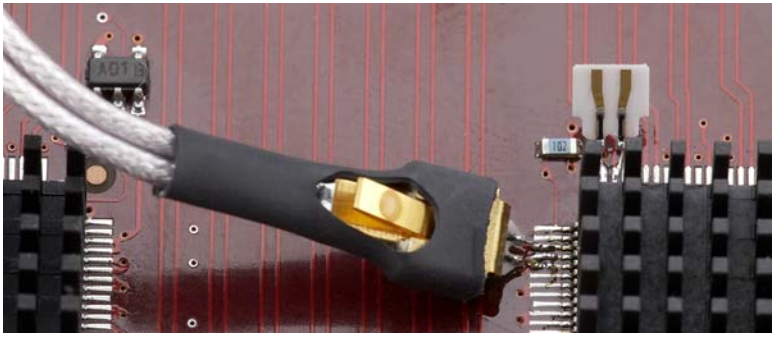


Figure 26 Probe Head Connected to a Soldered ZIF Tip

NOTE

For more repeatable results, orient the probe connection perpendicular to the device as shown in Figure 27.

Figure 27 Probe Oriented Perpendicular to Device

3 To move the probe head to a different tip, press the lever and remove the probe head from the ZIF tip. The ZIF tip remains soldered to the DUT. Then, simply connect the ZIF head to another ZIF tip at a different location on the DUT.

3 N5445A InfiniiMax III Differential Browser Probe Head

Full BW Browsing

The N5445A browser head (30 GHz) is the best choice for the general-purpose trouble shooting of differential signals with spring-loaded tips and variable spacing from 20 mil to 125 mil (or 0.5 mm to 3.1 mm). The span between the signal tips is easily adjusted with a thumb wheel on the browser (see Figure 28).

Table 9 Bandwidth

Probe Amplifier	BW
N2830A	4 GHz
N2831A	8 GHz
N2832A	13 GHz

PERFORMANCE PLOTS. Refer to Chapter 6, “Performance Plots”.

Figure 28 N5445A InfiniiMax III Differential Browser Head

Using the LED Headlights

A pair of LED headlights are integrated into the tip of the browser to illuminate the probing area for better visibility. The headlight intensity is controlled from the oscilloscope's **Probe Amplifier** dialog box.

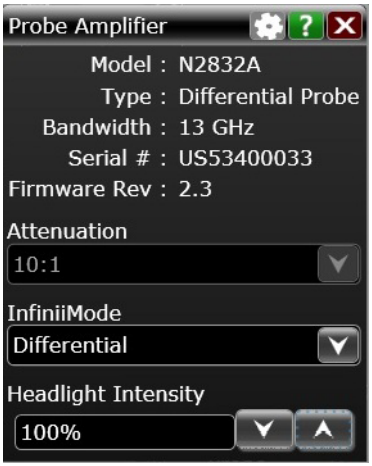


Figure 29 The Probe Amplifier Dialog Box

Adjusting the Tip Span

Turn the browser's thumb wheel (see Figure 30) to adjust the tip spacing from 20 to 125 mil (0.5 mm to 3.1 mm). Do not force the adjustment near the end of its range.

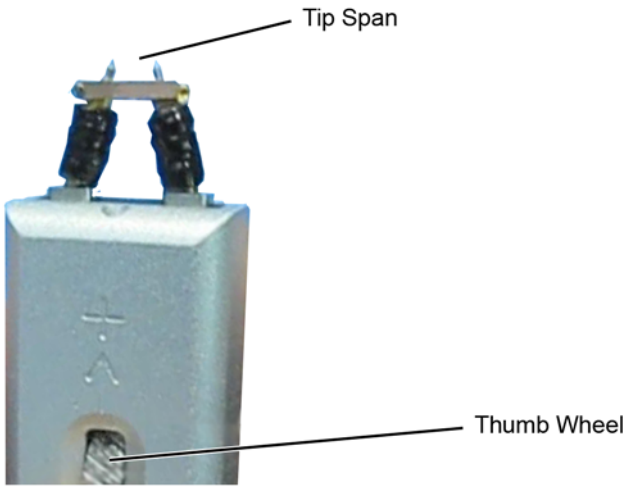


Figure 30 Adjusting the Tip Span

Tip-Span Entry for Probe Calibration

When calibrating the probe, you will be prompted to enter the span setting on the oscilloscope's Probe Calibration dialog box. To determine the tip span, do the following steps:

1. Adjust the browser's tip span for your measurement.
2. Locate the tip-span gauge on the browser's protective cap as shown in Figure 31.
3. Determine which of the three possible tip-span settings most closely matches the browser's tip span.

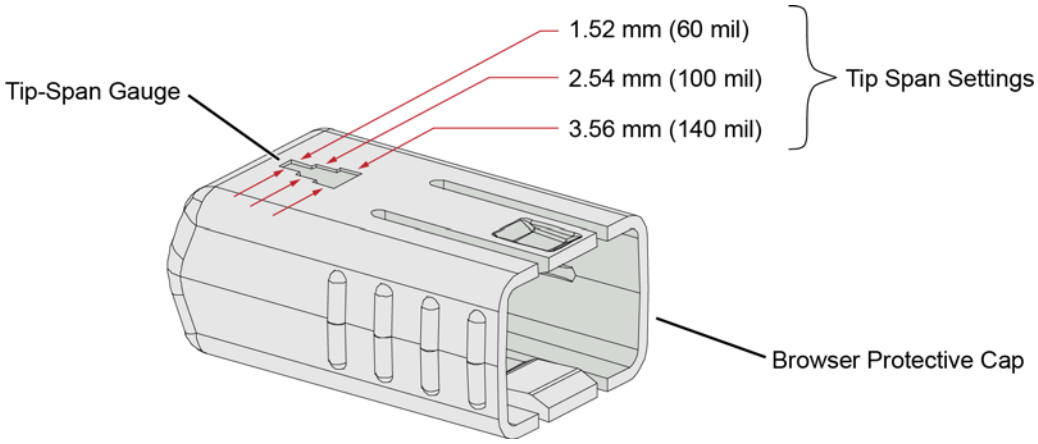


Figure 31 Tip Span Gauge on Browser Protective Cap

Mounting the Browser

There are two holes on the back side of the browser. Use these holes to mount the browser to a customer designed holder. Figure 32 below shows the dimensions of these mounting holes.

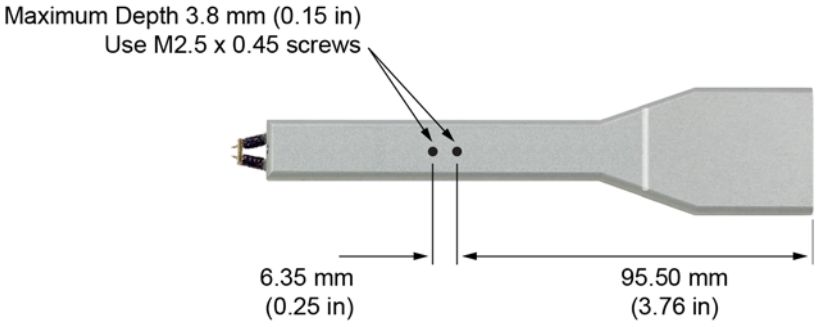


Figure 32 Dimensions of Mounting Holes

Probe Along the Browser's Axis

To prevent tip damage, probe along the browser's axis as shown in Figure 33. Hold the probe vertical and perpendicular to the circuit board.

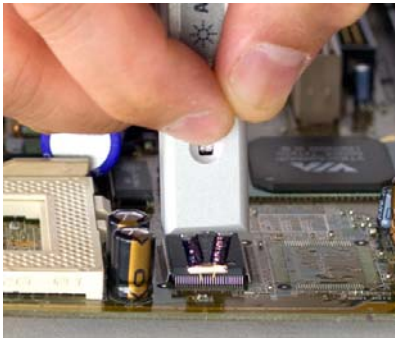


Figure 33 Proper Probe Handling

CAUTION To avoid damaging the browser's tips, do not apply a side load to the browser.

Figure 34 Improper Probe Handling

CAUTION Do not apply too much force when browsing. The weight of the probe in your hand should be sufficient. The axial travel of the probe is about 15 mils (0.4 mm).

CAUTION The browser's protective cap should be kept on the browser at all times except when probing.

CAUTION Always remove the browser from the device under test (DUT) before disconnecting the probe amp from the oscilloscope.

Replaceable Parts

Figure 35 shows the replaceable parts for th N5445A.

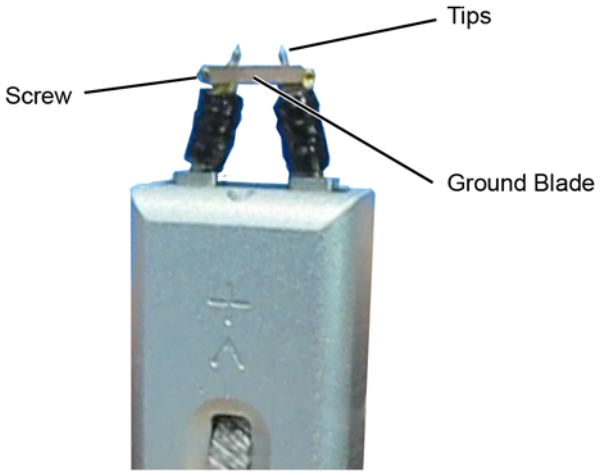


Figure 35 Browser Tips and Ground Blade

Table 10 N5445A Replaceable Parts

Description	Qty	Part Number
Browser tips	4	N5476A
Ground Blade	1	N4855A
Ground Blade Screws	1	N4856A

N2787A 3D Probe Positioner

Using the N2787A 3D probe positioner with the N5445A browser probe head reduces the chance of breaking the browser tips and ensures that the tips maintain solid contact. Use the following steps to position the probe using the N2787A:

1. Lock the vertical compliance of the probe positioner.
2. Clamp the browser into the positioner, aligning the browser's slot with the positioner's gripping pad.
3. While holding the browser, loosen the main knob and position the probe.
4. Use the browser's own weight to depress the tips, and tighten the main knob to lock the probe's position.

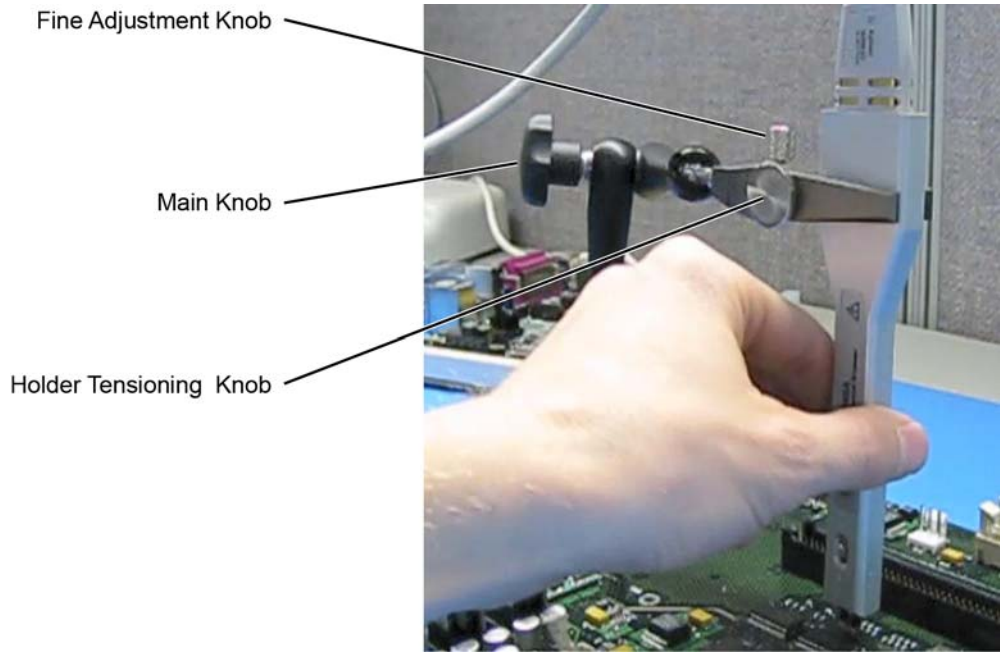


Figure 36 Using the Browser with the N2787A 3D Probe Positioner

4 N5441A InfiniiMax III Solder-In Head

Solder-In Extreme Temp.

The N5441A InfiniiMax III solder-in probe head is an economical semi-permanent connection that provides up to 16 GHz of system bandwidth. Variable span of the leads ranges from 5 mil to 80 mil (0.127 mm to 2 mm).

The N5441A probe head can be used with the N5450B InfiniiMax extreme temperature extension cable. This is the *only* InfiniiMax III probe head that can withstand the –55°C to +150°C extreme temperature range (for up to 250 test cycles).

Table 11 Bandwidth

Probe Amplifier	BW
N2830A	4 GHz
N2831A	8 GHz
N2832A	13 GHz

CAUTION

When using the N5450B extension cable, do not subject the InfiniiMax III probe amplifier or probe head (other than the N5441A solder-in probe head) to extreme temperatures.

Replaceable Parts

Extra wire (for solder-in probe head only). 01169-81301 (7 mil), 01169-21306 (5 mil)

TO INSTALL OR REPAIR WIRE LEADS. Refer to "Replacing N5441A Probe Head Wires" on page 85.

PERFORMANCE PLOTS. Refer to Chapter 6, "Performance Plots".

CAUTION

The wires on the N5441A are fragile. They must be manufactured in this way in order to meet the high-performance, high bandwidth applications they are intended for. Be careful when handling.

Soldering the Probe Head to the DUT

To solder the probe head to your DUT, complete the following steps. The procedure is very similar to that for the ZIF probe tips used with the N5439A probe head.

1. Position the probe head near the location on the DUT where you want to solder the probe.
2. Add strain relieve for the probe head as described in "Strain Relieving the Probe Heads" on page 75.
3. Apply flux to your target leads as shown in Figure 37.

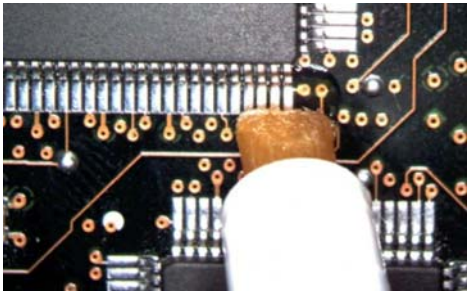


Figure 37 Applying Flux

4. Tin the leads with a small amount of solder.

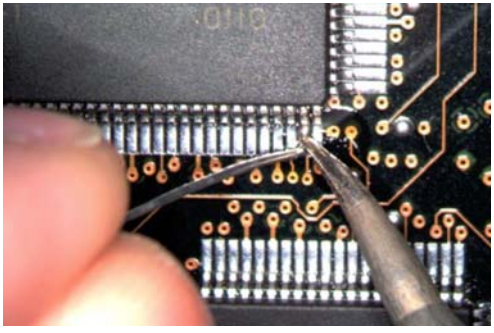


Figure 38 Tin the Leads

5. Use tweezers to form the probe head wires to fit your DUT's geometry.

6 Flux the DUT leads and your probe head wires.

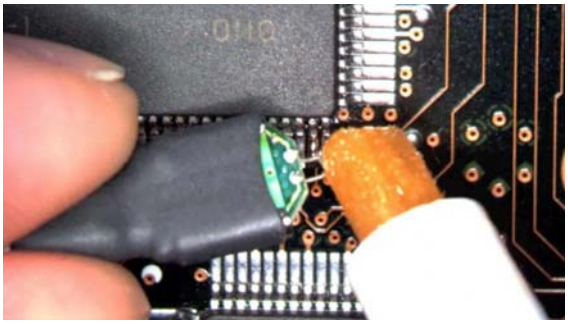


Figure 39 Applying Flux to Leads and Wires

7 Position the probe head wires on the DUT leads and quickly re-flow the solder as shown in Figure 40.

CAUTION **Do not leave the iron in contact with the probe head for more than a few seconds at a time.**

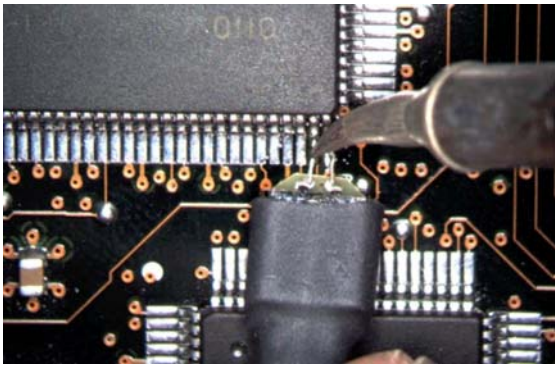
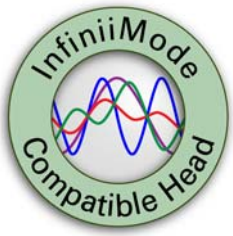


Figure 40 Positioning Wires

5 N2836A InfiniiMode Solder-In Head

Economical Solder-In Tip



The N2836A InfiniiMax III solder-in probe head (26 GHz) is an economical semi-permanent connection. This is an InfiniiMode probe head (like the N2848A) which allows you to make differential, common mode, and single ended measurements without having to re-solder the tip leads. Because this is an InfiniiMode compatible head, the tip has two signal leads and two ground leads. To learn about InfiniiMode, refer to "To Use InfiniiMode" on page 20.

The ground leads have minimal effect on differential measurements. However, if you are making only differential measurements you can optionally cut off the ground leads or fold them out of the way. If you have older N2836A probe heads, you can easily add ground leads.

The variable span of the tip leads ranges from 5 mil to 250 mil (0.127 mm to 6.35 mm).

Table 12 Bandwidth

Probe Amplifier	BW
N2830A	4 GHz
N2831A	8 GHz
N2832A	13 GHz

TO INSTALL OR REPAIR RESISTOR LEADS. Refer to "Replacing Axial Resistor Tips" on page 80.

PERFORMANCE PLOTS. Refer to Chapter 6, "Performance Plots".

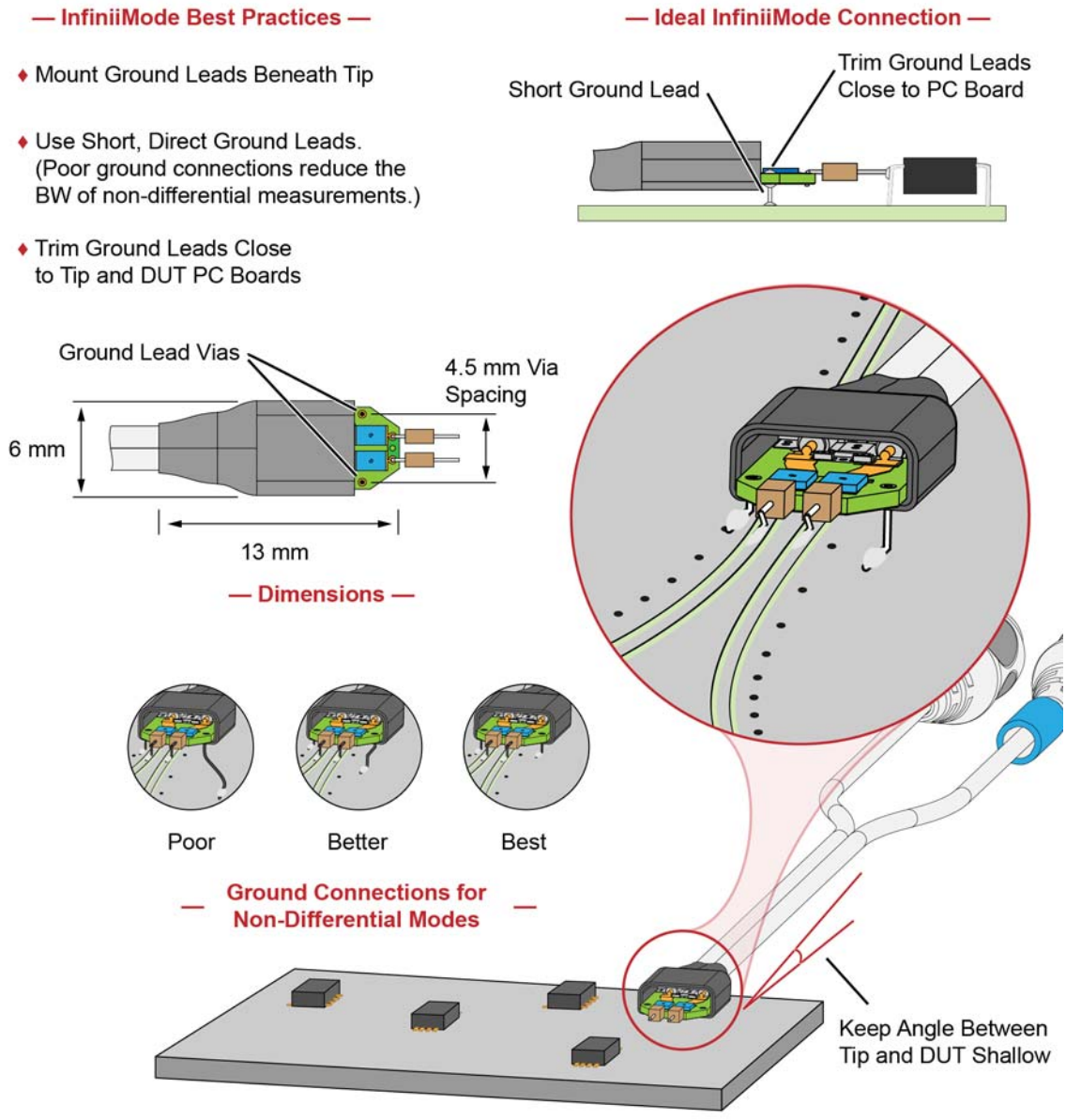


Figure 41 Probe Head Connection to DUT (*InfiniiMode*)

— Non-InfiniiMode Best Practices —

- Probe single-ended and differential signals. Do not solder ground leads to ground lead vias as is done with IniniiMode probing.
- For single-ended signals, orient the probe head vertically. Laying the probe head flat causes coupling to the tip that can degrade the performance.
- For single-ended signals, connect the "–" lead to ground.

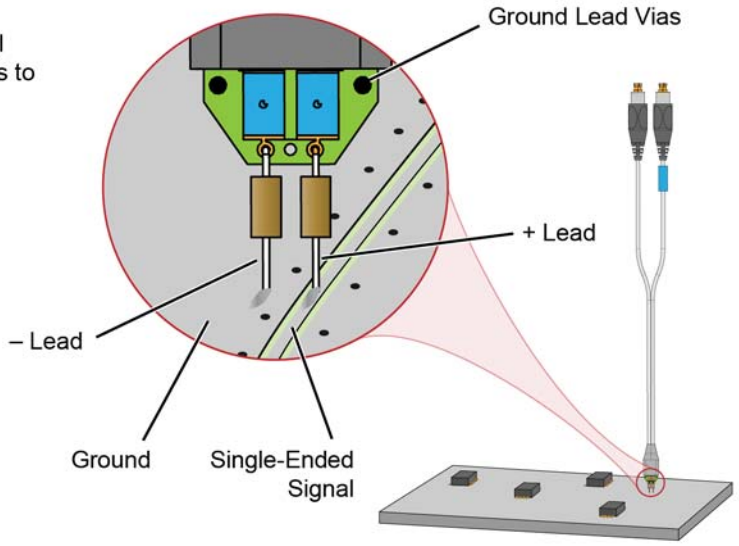


Figure 42 Probe Head Connection to DUT (*Non-InfiniiMode*)

Ensuring Maximum Performance

The specifications and performance plots of the N2836A probe head were measured with a nominal spacing of 40 mil (1 mm). In order to achieve the proper response as shown in the performance plots, keep the mini-axial lead *resistors* roughly parallel as shown in Figure 43, and use the tip wires on the mini-axial leads to get the desired span.

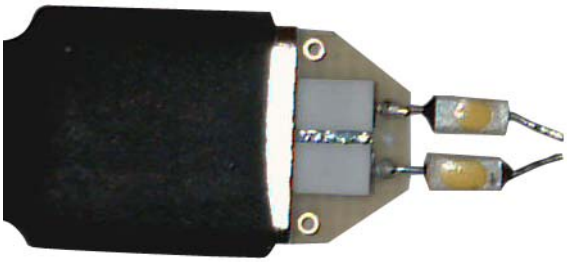


Figure 43 Proper Position of Resistors

If you need to position the mini-axial lead resistors different than shown in this figure (that is, resistor bodies close together or spread way apart), use N2807A and N2808A PrecisionProbe products to perform an AC calibration of the probe. The AC calibration will properly capture the response. Increasing the spacing to 250 mil will degrade the performance some, but Precision Probe can be used to compensate or qualify the effect.

CAUTION

The axial resistors on the N2836A solder-in probe head are fragile. They must be manufactured in this way in order to meet the high-performance, high bandwidth applications they are intended for. Be careful when handling.

Soldering the Probe Head to the DUT

To solder the probe head to your DUT, complete the following steps. The procedure is very similar to that for the ZIF probe tips used with the N5439A probe head. This procedure does not show soldering the ground leads, but the same techniques are used.

1 Apply flux to your target leads as shown in Figure 37.

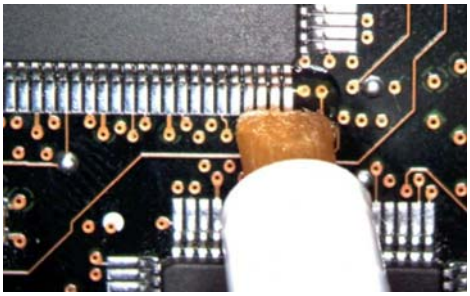


Figure 44 Applying Flux

2 Tin the leads with a small amount of solder.

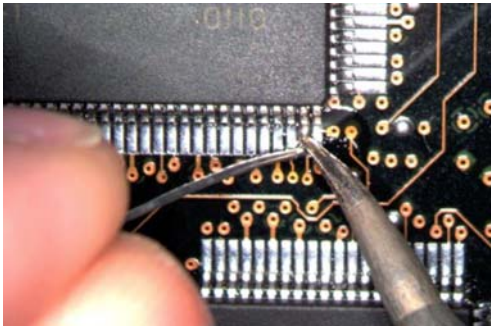


Figure 45 Tin the Leads

3 Use tweezers to form the probe head wires to fit your DUT's geometry.

4 Flux the DUT leads and your probe head wires.

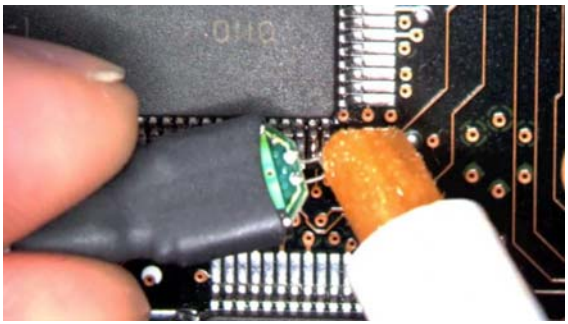


Figure 46 Applying Flux to Leads and Wires

5 Position the probe head wires on the DUT leads and quickly re-flow the solder as shown in Figure 40.

CAUTION Do not leave the iron in contact with the probe head for more than a few seconds at a time.

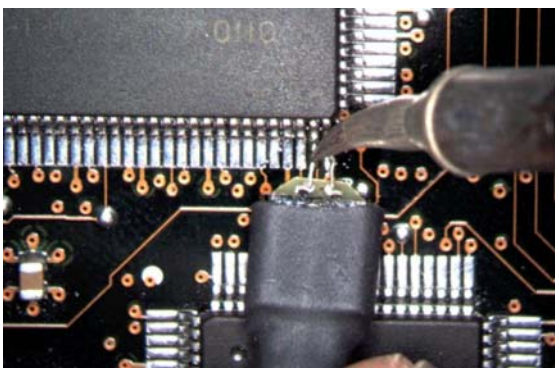
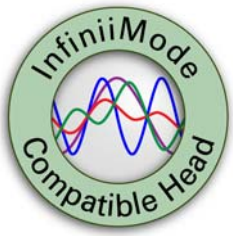


Figure 47 Positioning Wires

6 N2848A QuickTip InfiniiMode Probe Head

Easy, Quick Measure-ments



The N2848A QuickTip probe head is used with an N2849A QuickTip and together they provide the following advantages:

- InfiniiMode allows you to make differential, common mode, and single ended measurements without having to re-solder the tip leads.
- Easy-to-make secure magnetic mechanical connection between the probe head and QuickTip. Three magnets in the head connect the two sides of a differential signal and a ground. No latch lever is used!

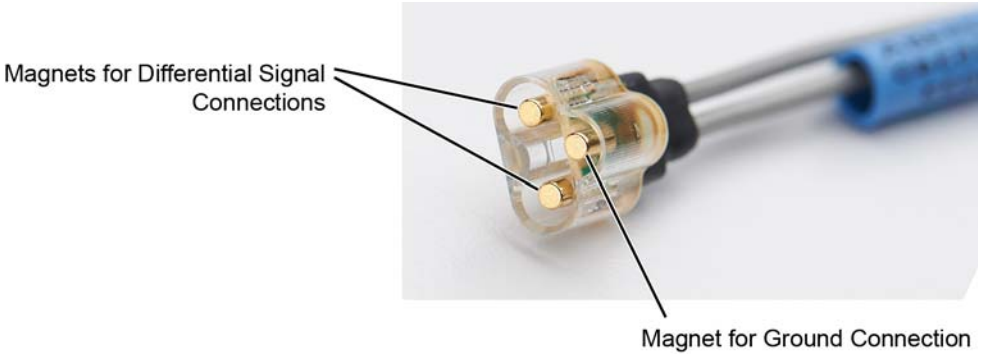


Figure 48 Magnet Connections in Probe Head

- Extreme temperature environments such as temperature chambers.

Table 13 Bandwidth

Probe Amplifier	BW
N2830A	4 GHz
N2831A	8 GHz
N2832A	>12 GHz

Permanently solder any number of QuickTips to your DUT as shown in Figure 49 on page 72. Because the probe head is magnetically connected (instead of mechanically connected) to the QuickTip, you can effortlessly connect and disconnect to each QuickTip. For best performance, position the QuickTip vertically on the DUT. Because this is an InfiniiMode compatible head, the tip has two signal leads and two ground leads. To learn about InfiniiMode, refer to "To Use InfiniiMode" on page 20. The ground leads have minimal effect on your differential measurements. However, if you are making only differential measurements you can optionally cut off the ground leads or fold them out of the way. Be aware that without the ground leads, the mechanical stability of the QuickTip will be reduced and you will need to stabilize the probe head.

CAUTION Do not replace or repair the N2849A QuickTip's resistor or ground leads. Attempting to do so will damage the ability of the tip to mate with the N2848A probe head.

NOTE The N2848A does not include any N2849A QuickTips. The N2849A must be ordered separately.

NOTE Before connecting the QuickTip head to the tip, use the tack-putty (N5439-65201) included with the N2848A QuickTip probe head or the N2787A 3D probe positioner for securing the probe amplifier to a rigid body near the DUT.

PERFORMANCE PLOTS. Refer to Chapter 6, "Performance Plots".

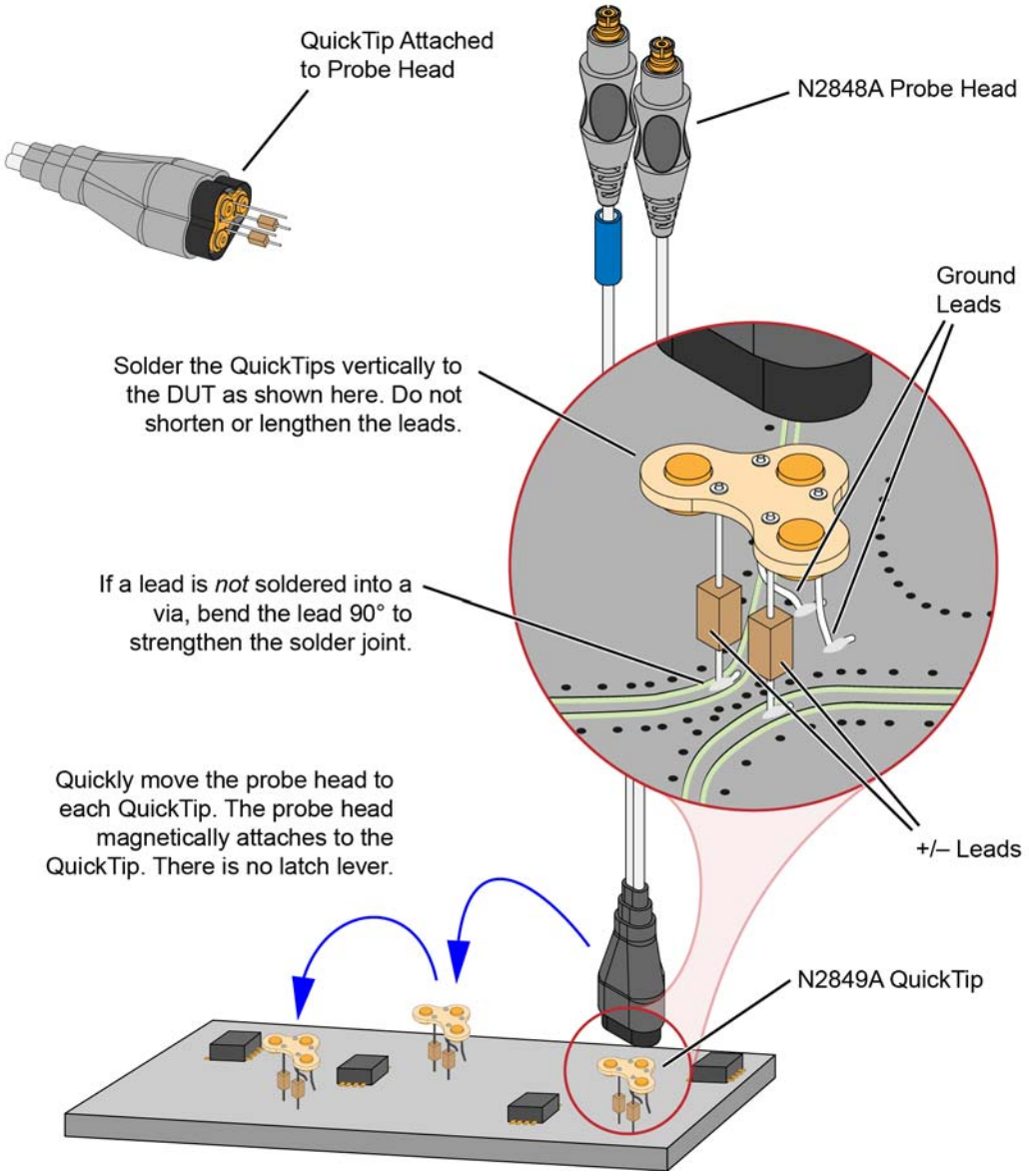


Figure 49 Probing with the N2848A Probe Head and QuickTip

Connecting a QuickTip to the DUT

Use the following tips when soldering the QuickTips to your DUT:

- Orient the QuickTip vertically as shown in Figure 49 on page 72.
- Solder the four leads to vias or surfaces.

CAUTION

Always mechanically strain-relieve the QuickTip head *before* using to protect both your probe accessories and DUT from damage. Refer to "Strain Relieving the Probe Heads" on page 75.

NOTE

Resistor and wire leads on the QuickTip are factory trimmed to the proper length for use. Adding wire length to the tip of the mini-axial lead resistors or to the ground leads will degrade the performance of the probe.

NOTE

Soldering the ground wires is not required when making differential or single-ended (+ or – leads) measurements.

- When soldering to a via, always trim the lead close to the via's underside.
- If a lead is to be soldered to a surface and *not* a via, make a stronger solder joint by bending the end of the lead 90°. For signal leads, bend the wire approximately half way between the resistor and the end of the wire. Bend the ground leads at about the same distance.

CAUTION

Be careful not to damage the tip wires when handling the QuickTips. Wires can be carefully reshaped with tweezers or fingers if necessary.

CAUTION

The QuickTips are very fragile. They must be manufactured in this way in order to meet the high-performance, high bandwidth applications they are intended for. Be extremely careful when handling.

Cleaning the Magnetic Connections

If the three magnetic connections in the head become dirty, clean the connections using the following steps:

1. Use compressed air or a cloth to remove any loose dirt.
2. Gently rub a small piece of tack putty (supplied with the probe) against the magnetic connections to clean off any remaining surface grime.

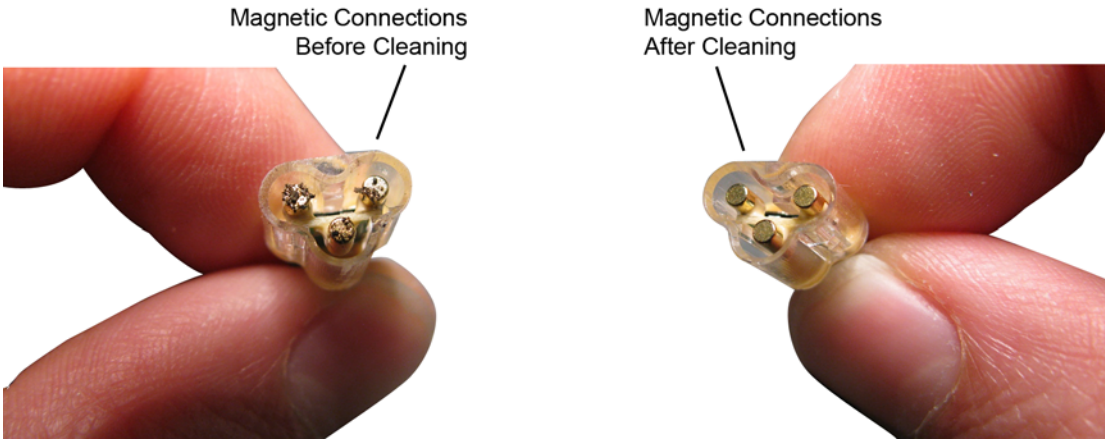


Figure 50 N2848A Head Before and After Cleaning

Strain Relieving the Probe Heads

High-performance probes have small physical geometries to ensure the lowest possible loading and best electrical response. Because of their small size, probing accessories are often delicate. It is important to mechanically secure your probes to protect both your equipment and designs from damage. Although tack putty and low-temperature hot glue are recommended, you can also use other methods such as tape or hook-and-loop strain relief. Keep in mind that different accessories have different cable stiffness. You should choose a strain relief method appropriate for the cable stiffness. For instance, it is best to secure the stiffer N5439A near the SMP connectors and form the cable to the optimal location.

CAUTION **Do not kink cables. Do not crush cables. Do not use aggressive adhesives or high temperatures**

Tack-Putty

Keysight recommends the use of tack putty for securing both probe heads and amplifiers. Tack putty can be ordered using part number N5439-65201. Wrap a small amount of tack-putty around your probe head cables, taking care to not pinch them. The mass can then be secured to a rigid body neat your DUT.

Similar techniques can be used to secure probe amplifiers where you apply some tack-putty to the underside of the probe amplifier body and attach it to a rigid body near your DUT.

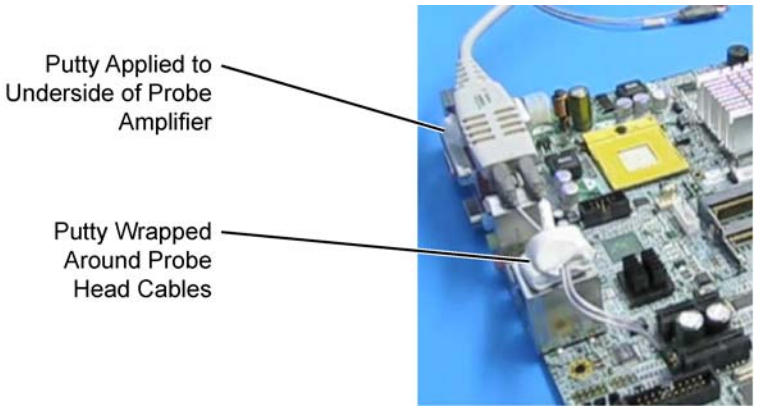


Figure 51 Probe Secured Using Tack Putty

You can also use putty with a positioner, such as the N2787A as shown in Figure 52.

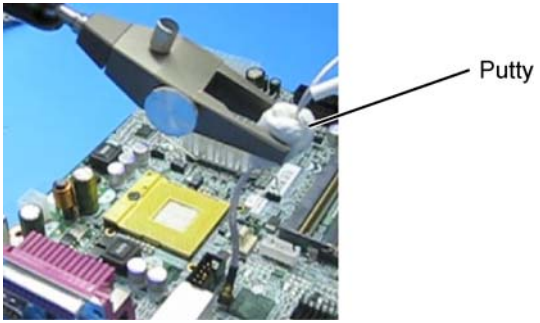


Figure 52 Using Putty With the N2787A 3D Probe Positioner

The same positioner can also be used to support your probe amplifier as shown in Figure 36 on page 60.

Low-temperature Hot Glue

You can also use low-temperature hot glue to secure cables.

CAUTION

Only use *low-temperature* hot glue. To remove the hot glue, warm it with a heat gun set on low. Only heat the hot glue enough to remove it.

Figure 53 Probe Secured Using Low-Temperature Hot Glue

3
Maintaining Probe Heads

Many probe heads come equipped with replaceable resistor or wire tips which can be replaced or repaired. Using the procedures in this chapter, you can extend the life of the following items:

- N2836A probe heads
- N5441A probe heads
- N2838A ZIF tips

CAUTION

Do not replace or repair the N2849A QuickTip's resistor or ground leads. Attempting to do so will damage the ability of the tip to mate with the N2848A probe head.

Replacing Axial Resistor Tips

The procedure in this sections shows you how to replace the 130 ohm axial resistors that are located at the tip of the

- N2836A solder-in probe head and
- N2838A ZIF tip.

These resistors can become worn or damaged with use. Order the replacement axial resistor kit (N2836-68701) which provides 10 resistors.

NOTE **The pictures in the following procedure show the N2836A solder-in probe head, but the same procedure applies to the N2838A ZIF tip.**

Recommended Equipment

- Vise or clamp for holding tip.
- Metcal STTC-022 (600 °C) or STTC-122(700 °C) tip soldering iron or equivalent. The 600 °C tip will help limit burning of the FR4 tip PC board.
- 0.381 mm (0.015 in) diameter RMA flux standard tin/lead solder wire.
- Fine stainless steel tweezers.
- Rosin flux pencil, RMA type (Kester #186 or equivalent).
- Diagonal cutters.
- Magnifier or low power microscope.
- Ruler.

CAUTION **As the probe heads and tips are easily damaged, only experienced soldering technicians should attempt this repair.**

Procedure

1 As shown in Figure 54, clamp the probe head or ZIF tip in a vise. Tweezers can be used to hold the probe head or ZIF tip away from

the vise. When using tweezers, grip the tip either on the sides or top and bottom.

CAUTION **When tightening the vise, use light force to avoid damaging the solder-in probe head.**

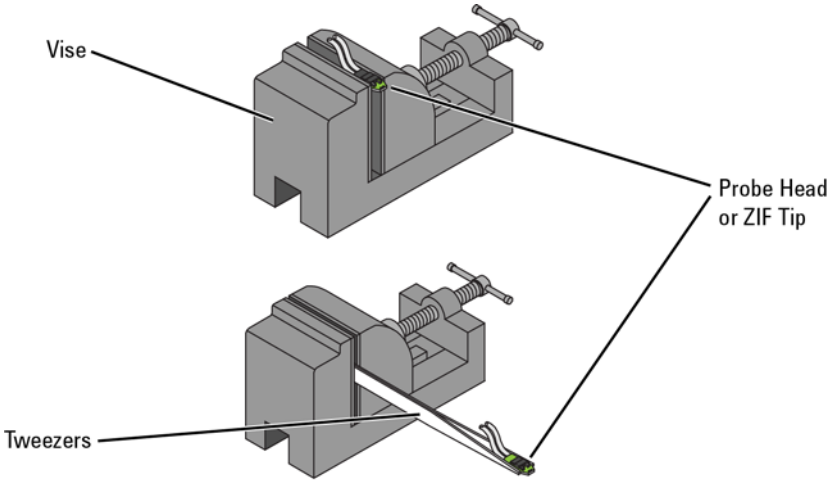


Figure 54 Clamping the Part

2 Grab each resistor lead or wire with tweezers and pull very gently up. Touch the soldering iron to solder joint just long enough for the resistor to come free of the probe head tip.

Figure 55 Removing the Resistor

NOTE Clean the soldering iron tip of any excess solder before using.

NOTE The solder joint has very low thermal mass so the joint will quickly melt and release.

CAUTION To limit burning and damage to the PC board, do not keep the soldering iron in contact with the tip any longer than is necessary.

CAUTION Excessive dwell time with the iron will permanently damage the flip-chip resistor.

3 Use the soldering iron and solder to fill the holes in preparation for mounting the new resistors (or wires).

CAUTION Do not leave the iron in contact with the tip any longer than necessary.

4 Use the flux pencil to coat the solder joint area with flux.

5 Locate the trim gauge which is supplied with the N2836-68701 replacement axial resistor kit.

a Place a resistor over the lead length gauge shown in Figure 56. Trim the leads to match the drawing. The orientation of the lead is not important.

b Place a resistor over the bend gauge and bend the leads to match the drawing. This bend fits in the hole in the tip's PC board.

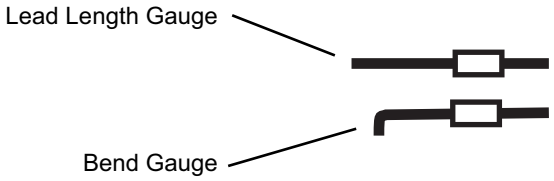


Figure 56 Trim Gauge

6 Holding the resistor lead or wire in one hand and soldering iron in the other, position the end of the resistor lead (after the 90 degree bend) over the solder filled hole.

Figure 57 Soldering in a new axial resistor

7 Touch the soldering iron to the side of the hole. When the solder in the hole melts, the resistor lead will fall into the hole.

CAUTION **Remove the soldering iron as soon as the lead falls into the hole.**

NOTE **Because the thermal mass of the joint is very small, extra dwell time with the soldering iron is not needed to ensure a good joint.**

8 Using a digital volt meter, measure the resistance from the coax center conductor to the resistor tip. The DC resistance should measure 450 ohms.

Replacing N5441A Probe Head Wires

Use the following procedure to install or replace the wire leads on the N5441A solder-in probe head. Depending on your probing application, you can order either 5 mil or 7 mil wire as listed in the following table. For example, use the 5 mil wire for attaching to small vias.

Table 14 Required Wire Type

Wire Diameter	Part Number
0.007 inch (tin-plated nickel wires)	01169-81301
0.005 inch (tin-plated nickel wires)	01169-21306

Table 15 Recommended Equipment

Equipment
Vise or clamp for holding tip
Metcal STTC-022 (600 °C) or STTC-122 (700 °C) tip soldering iron or equivalent. The 600 °C tip will help limit burning of the FR4 tip PC board.
0.381 mm (0.015 in) diameter RMA flux standard tin/lead solder wire
Fine stainless steel tweezers
Rosin flux pencil, RMA type (Kester #186 or equivalent)
Flush cutting wire cutters
Magnifier or low power microscope
Keysight supplied trim gauge (01169-23801)

Procedure

1 Use the vise or clamp to position the tip an inch or so off the work surface for easy access.

CAUTION If using a vise, grip the tip on the sides with light force. When tightening the vise, use light force to avoid damaging the solder-in probe head If using a tweezers clamp, grip the tip either on the sides or at the top and bottom.

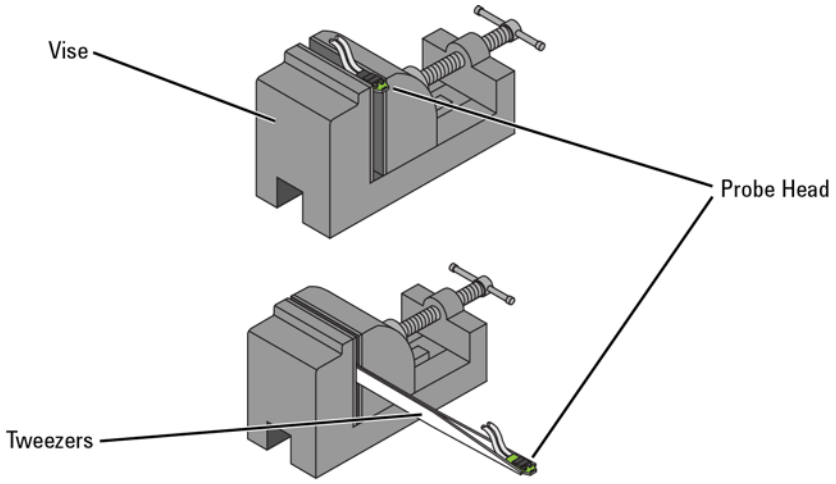


Figure 58 Clamping the Probe Head

2 As shown in Figure 59, remove the old wires with tweezers while re-flowing the solder from the underside of the probe.

CAUTION Apply heat quickly to avoid damaging your probe.

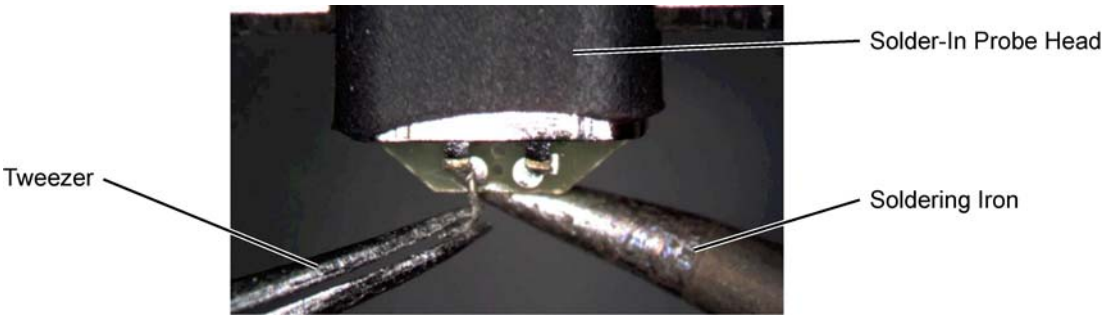


Figure 59 Removing the Old Wire

3 If necessary, add a small amount of solder to the holes and apply flux.

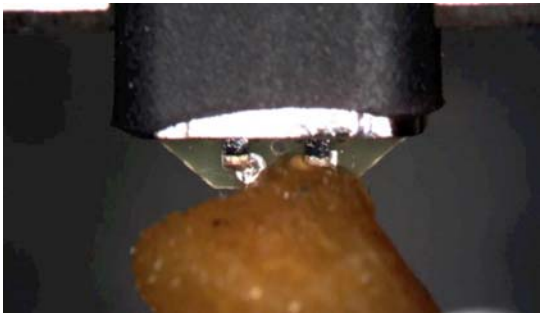


Figure 60 Adding Solder and Flux

4 Re-flow the solder from the underside and insert a new piece of wire. It is best to shape the wire into an “L” before attempting to insert.

CAUTION Do not dwell with the iron in contact with the probe head.

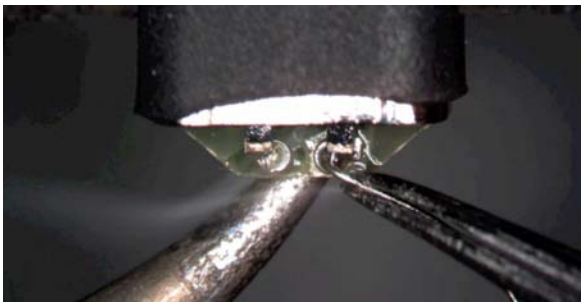


Figure 61 Adding a New Wire

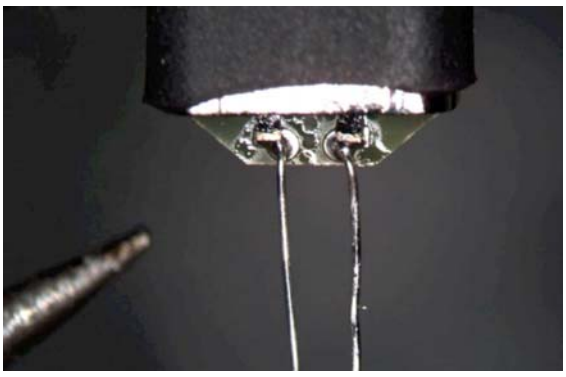


Figure 62 New Wires Properly Attached

5 Trim any wire stubs on the probe head underside.

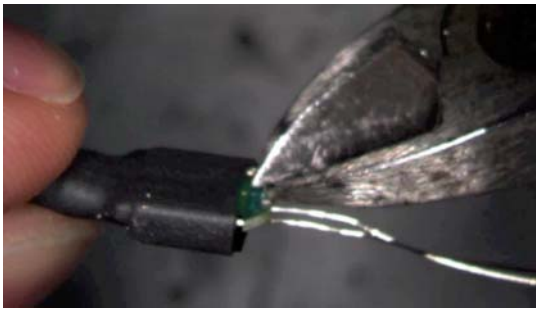


Figure 63 Trim Wire Stubs

6 Use the included trim gauge to cut the wire lengths. Doing so ensures the best performance from your probe head.

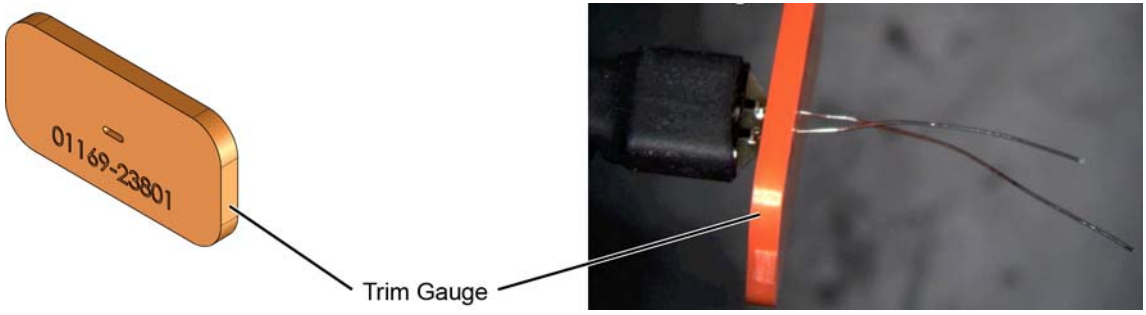


Figure 64 Trim Gauge Placed on Wires

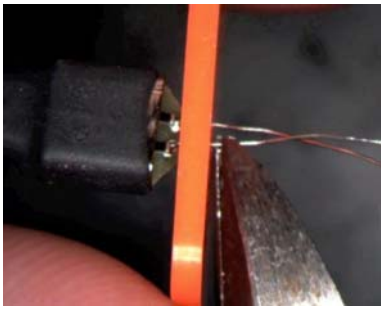


Figure 65 Removing Excess Wire

7 Check the DC resistance of each probe leg when you have replaced the wires. The correct resistance should be 450 ohms.

4
Calibrating Probes

Calibrating the is done using the E2655C Deskew and Calibration Kit. The kit contains the following parts:

- SMA (male) to SMA (male) adaptor
- SMA (male) to BNC (female) adaptor
- BNC (male) to SMA (male) adaptor
- 50Ω SMA Terminator
- De-skew Fixture

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.

This document contains procedures showing vertical and skew calibration solder-in differential probe head and the differential browser probe head. The procedures can also applied to all of the different InfiniiMax probe configurations.

Calibration for Solder-In Probe Heads

Calibration of the solder-in probe head consists of a vertical calibration and a skew calibration. The vertical calibration should be performed before the skew calibration. Both calibrations should be performed for best probe measurement performance.

NOTE **Before calibrating the probe, verify that the Infiniium oscilloscope has been calibrated recently and that the calibration D temperature is within ±5°C. If this is not the case, calibrate the oscilloscope before calibrating the probe. This information is found in the Infiniium Calibration dialog box.**

Step 1. Connecting the Probe for Calibration

The calibration procedure requires the following parts.

- BNC (male) to SMA (male) adaptor
- Deskew fixture
- 50Ω SMA terminator

1. As shown in Figure 66 on page 94, connect BNC (male) to SMA (male) adaptor to the deskew fixture on the connector closest to the yellow pincher.
2. Connect the 50Ω SMA terminator to the connector farthest from the yellow pincher.
3. Connect the BNC side of the deskew fixture to the Aux Out BNC of the Infiniium oscilloscope.
4. Connect the probe to an oscilloscope channel.
5. To minimize the wear and tear on the probe head, the probe head should be placed on a support to relieve the strain on the probe head cables.
6. Push down on the back side of the yellow pincher. Insert the probe head resistor lead underneath the center of the yellow pincher and over the center conductor of the deskew fixture. The negative probe head resistor lead or ground lead must be underneath the yellow pincher and over one of the outside copper conductors

(ground) of the deskew fixture. Make sure that the probe head is approximately perpendicular to the deskew fixture.

NOTE **For the socketed probe head, insert two properly trimmed 82 Ω resistors into the sockets.**

7 Release the yellow pincher.

NOTE **To insure contact, pull up on the back side of the yellow pincher to insure good contact between resistor leads and the deskew fixture.**

Step 2. Verifying the Connection

1 On the Infiniium oscilloscope, press the autoscale button on the front panel.

2 Set the volts per division to 100 mV/div.

3 Set the horizontal scale to 1.00 ns/div.

4 Set the horizontal position to approximately 3 ns. You should see a waveform similar to that in Figure 67.
If you see a waveform similar to that of Figure 68, then you have a bad connection and should check all of your probe connections.

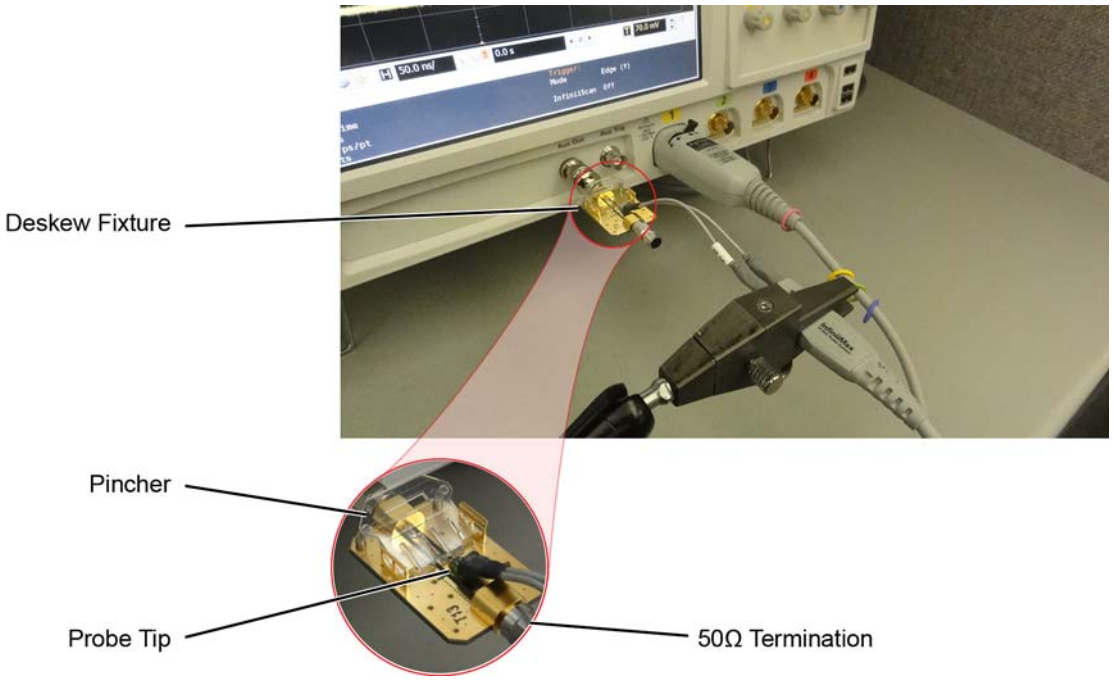


Figure 66 Connecting the Probe and Deskew Fixture

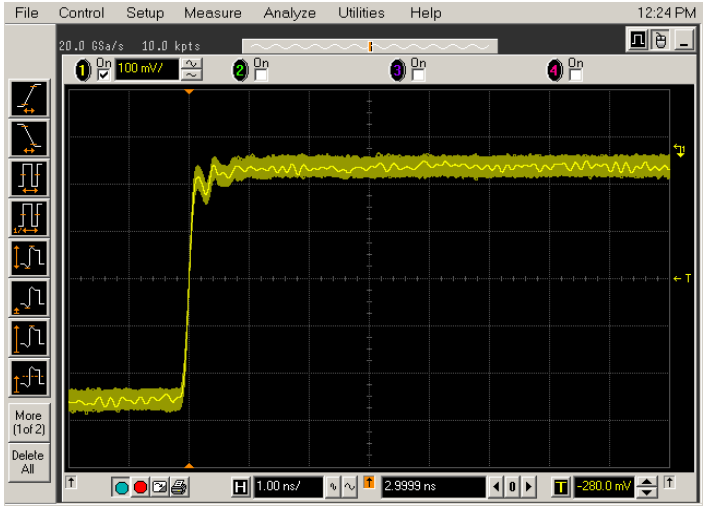


Figure 67 Good Connection

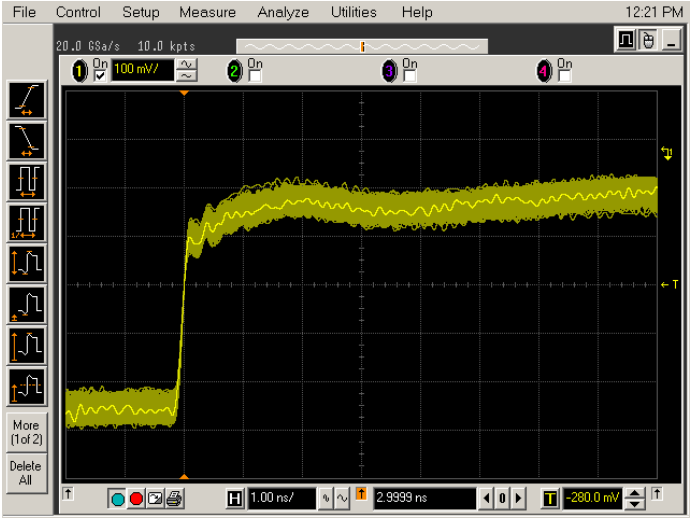


Figure 68 Bad Connection

Step 3. Running the Probe Calibration and Deskew

1. On the Infiniium oscilloscope in the Setup menu, select the channel connected to the probe.
2. In the Channel Setup dialog box select the Probes... button.
3. In the Probe Setup dialog box select the Calibrate Probe... button.
4. In the Probe Cal dialog box select the Calibrated Atten/Offset radio button.
5. Select the Start Atten/Offset Calibration... button and follow the on-screen instructions for the vertical calibration procedure.
6. Once the vertical calibration has successfully completed, select the Calibrated Skew... button.
7. Select the Start Skew Calibration... button and follow the on-screen instructions for the skew calibration. At the end of each calibration the oscilloscope will inform you if the calibration was or was not successful.

Verifying the Probe Calibration

If you have just successfully calibrated the probe, it is not necessary to perform this verification. However, if want to verify the probe was properly calibrated, the following procedure will help you verify the calibration.

The calibration procedure requires the following parts.

- BNC (male) to SMA (male) adaptor
- SMA (male) to BNC (female) adaptor
- BNC (male) to BNC (male) 12 inch cable such as the Keysight 8120-1838 (not included in this kit)
- Keysight 54855-61620 calibration cable (Infiniium oscilloscopes with bandwidths of 6 GHz and greater only)
- Keysight 54855-67604 precision 3.5 mm adaptors (Infiniium oscilloscopes with bandwidths of 6 GHz and greater only)
- Deskew fixture

For the following procedure, refer to Figure 66 on page 94.

1 As shown in Figure 69 on page 98, connect BNC (male) to SMA (male) adapter to the deskew fixture on the connector closest to the yellow pincher.

2 Connect the SMA (male) to BNC (female) to the connector farthest from the yellow pincher.

3 Connect the BNC (male) to BNC (male) cable to the BNC connector on the deskew fixture to one of the unused oscilloscope channels. For Infiniium oscilloscopes with bandwidths of 6 GHz and greater, use the 54855-61620 calibration cable and the two 54855-67604 precision 3.5 mm adapters.

4 Connect the BNC side of the deskew fixture to the Aux Out BNC of the Infiniium oscilloscope.

5 Connect the probe to an oscilloscope channel.

6 To minimize the wear and tear on the probe head, the probe head should be placed on a support to relieve the strain on the probe head cables.

7 Push down on the back side of the yellow pincher. Insert the probe head resistor lead underneath the center of the yellow pincher and over the center conductor of the deskew fixture. The negative probe head resistor lead or ground lead must be underneath the yellow pincher and over one of the outside copper conductors (ground) of the deskew fixture. Make sure that the probe head is approximately perpendicular to the deskew fixture.

NOTE **For the socketed probe head, insert two properly trimmed 82 Ω resistors into the sockets.**

8 Release the yellow pincher.

NOTE **To ensure contact, pull up on the back side of the yellow pincher to insure good contact between resistor leads and the deskew fixture.**

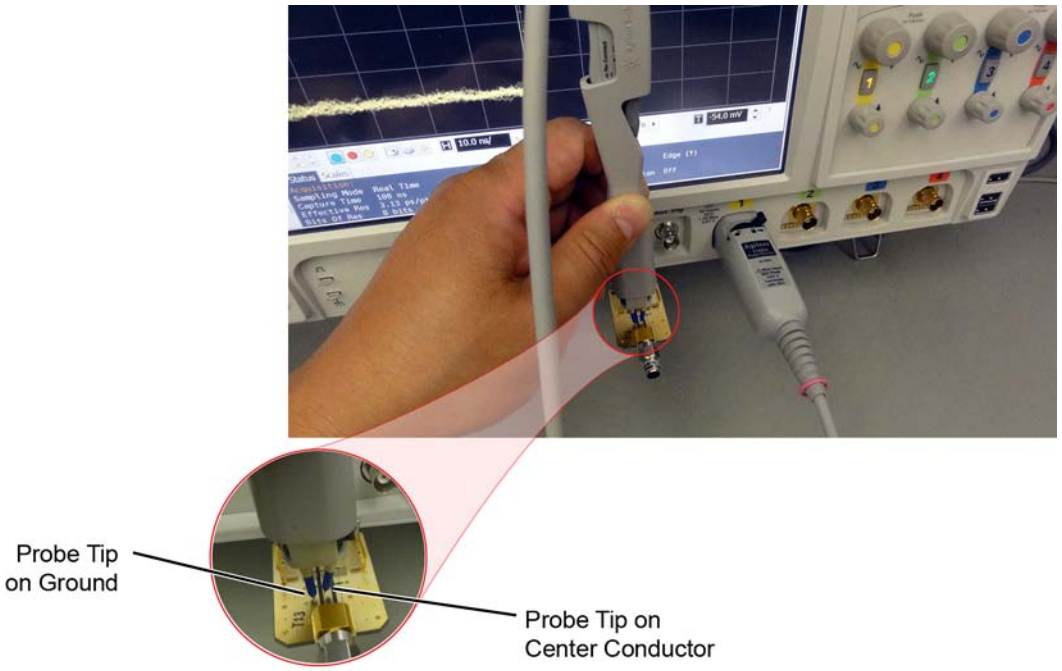


Figure 69 Connecting the Probe

9 On the oscilloscope, press the autoscale button on the front panel.

10 Select Setup menu and choose the channel connected to the BNC cable from the pull-down menu.

11 Select the Probes... button.

12 Select the Configure Probe System button.

13 Select User Defined Probe from the pull-down menu.

14 Select the Calibrate Probe... button.

15 Select the Calibrated Skew radio button.

16 Once the skew calibration is completed, close all dialog boxes.

17 Select the Start Skew Calibration... button and follow the on-screen instructions.

18 Set the vertical scale for the displayed channels to 100 mV/div.

19 Set the horizontal range to 1.00 ns/div.

20 Set the horizontal position to approximately 3 ns.

21 Change the vertical position knobs of both channels until the waveforms overlap each other.

22 Select the Setup menu choose Acquisition... from the pull-down menu.

23 In the Acquisition Setup dialog box enable averaging. When you close the dialog box, you should see waveforms similar to that in Figure 70.

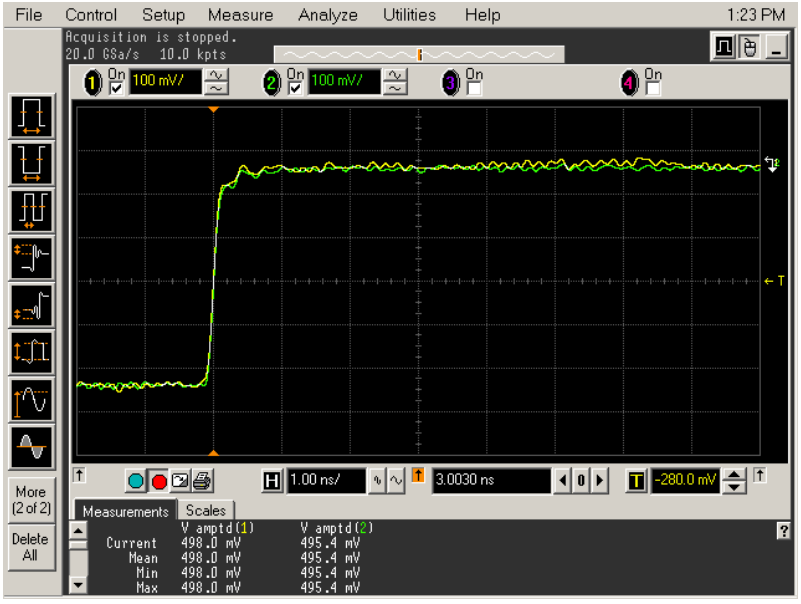


Figure 70 Overlapping Waveforms

Calibration for Hand-held Browser Probe Heads

Calibration of the hand-held browser probe heads consists of a vertical calibration and a skew calibration. The vertical calibration should be performed before the skew calibration. Both calibrations should be performed for best probe measurement performance.

NOTE **Before calibrating the probe, verify that the Infiniium oscilloscope has been calibrated recently and that the calibration Δ temperature is within ±5 °C. If this is not the case, calibrate the oscilloscope before calibrating the probe. This information is found in Infiniium Calibration dialog box.**

Calibration Setup

The calibration procedure requires the following parts.

- BNC (male) to SMA (male) adaptor
- Deskew fixture
- 50 Ω SMA terminator

1. As shown in Figure 71 on page 101, connect BNC (male) to SMA (male) adaptor to the deskew fixture on the connector closest to the yellow pincher.
2. Connect the 50Ω SMA terminator to the connector farthest from the yellow pincher.
3. Connect the BNC side of the deskew fixture to the Aux Out of the Infiniium oscilloscope.
4. Connect the probe to an oscilloscope channel.
5. Place the positive resistor tip of the browser on the center conductor of the deskew fixture between the green line and front end of the yellow pincher. The negative resistor tip or ground pin of the browser must be on either of the two outside conductors (ground) of the deskew fixture.
6. On the Infiniium oscilloscope in the Setup menu, select the channel connected to the probe.
7. In the Channel Setup dialog box select the Probes... button.

8 In the Probe Setup dialog box select the Calibrate Probe... button.

9 In the Probe Cal dialog box select the Calibrated Atten/Offset radio button.

10 Select the Start Atten/Offset Calibration... button and follow the on-screen instructions for the vertical calibration procedure.

11 Once the vertical calibration has successfully completed, select the Calibrated Skew... button.

12 Select the Start Skew Calibration... button and follow the on-screen instructions for the skew calibration.

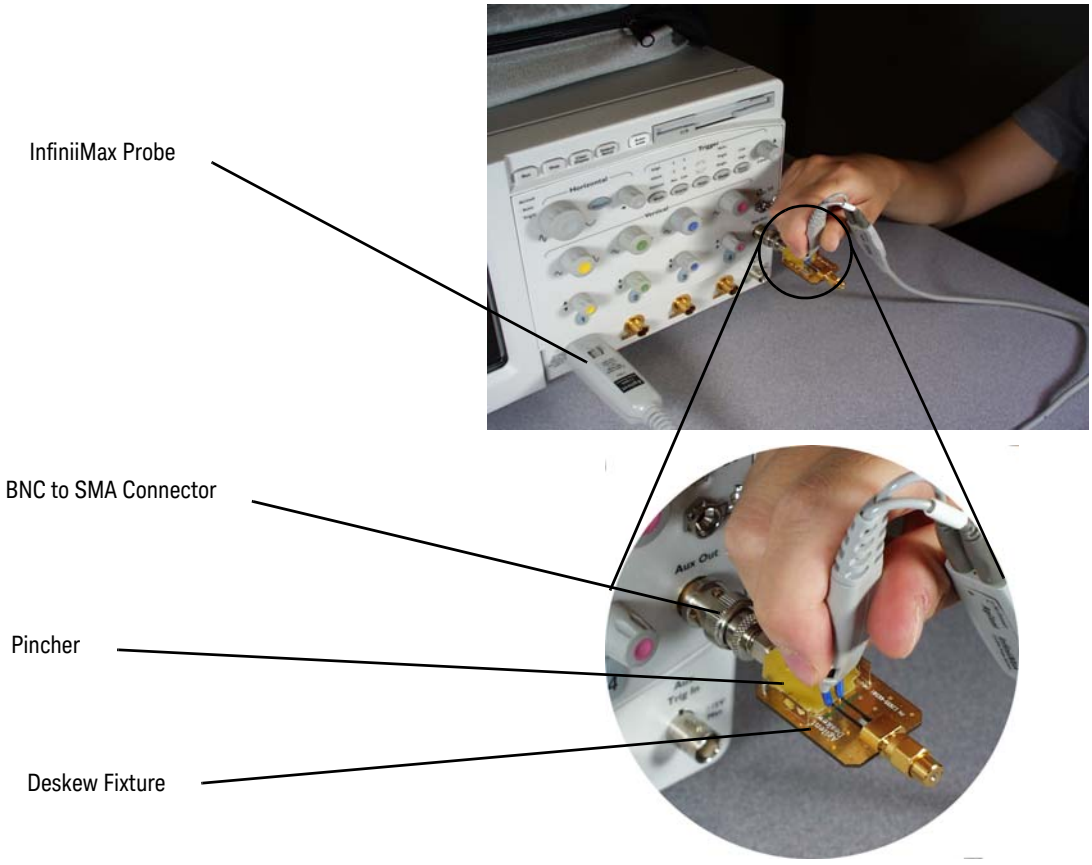


Figure 71 Placing the Probe on the Fixture

5 Specifications and Characteristics

All characteristics are the typical performance values of the InfiniiMax probes using the InfiniiMax III+ probe amplifiers and each different probe head except otherwise specified.

KEYSIGHT TECHNOLOGIES

Warranted Specifications

Table 16 Warranted Specifications

Probe Amplifier	Probe Head	Bandwidth	DC Input Resistance	
			R_{diff}	R_{se}
N2832A	N2836A 450Ω Solder-In Head. Head vertically oriented with no ground wires.	13 GHz	100 kΩ ± 2%	50 kΩ ± 2%

Probe Head Characteristics

The characteristics listed in the Table 17 are for the N2832A InfiniiMax III+ probe amplifier using different probe heads. The characteristics are mainly determined by the probe head. Performance with the lower bandwidth amplifiers (N2830A and N2831A) is the *lower* of the following values:

- Amplifier bandwidth
- Bandwidth measured with the highest bandwidth amplifier (N2832A).

Table 17 Characteristics for Probe Heads Using N2832A

Probe Head	Tip	Input Capacitance C_{diff}	Input Capacitance C_{se}	Mode	Bandwidth (–3 dB)	10 – 90% Transition Time	20 – 80% Transition Time
N5439A ZIF	N5440A 450Ω ZIF	32 fF	44 fF	Differential:	13 GHz	33.4 ps	23.7 ps
				Single Ended:	–	–	–
				Common:	–	–	–
	N2838A 450Ω ZIF	95 fF	130 fF	Differential:	13 GHz	33.4 ps	23.7 ps
				Single Ended:	–	–	–
				Common:	–	–	–
N5445A 450Ω Browser		35 fF	50 fF	Differential:	13 GHz	33.4 ps	23.7 ps
				Single Ended:	–	–	–
				Common:	–	–	–
N5441A 450Ω Solder-In		77 fF	105 fF	Differential:	13 GHz	33.4 ps	23.7 ps
				Single Ended:	–	–	–
				Common:	–	–	–
N2836A 450Ω Solder-In Head vertically oriented with no ground wires		108 fF	140 fF	Differential:	13 GHz	33.4 ps	23.7 ps
				Single Ended:	–	–	–
				Common:	–	–	–
N2836A 450Ω Solder-In Head oriented flat with minimum length ground wires		108 fF	140 fF	Differential:	13 GHz	33.4 ps	23.7 ps
				Single Ended:	13 GHz	33.4 ps	23.7 ps
				Common:	13 GHz	33.4 ps	23.7 ps
N2848A QuickTip	N2849A 450Ω QuickTip	340 fF	200 fF	Differential:	13 GHz	33.4 ps	23.7 ps
				Single Ended:	13 GHz	33.4 ps	23.7 ps
				Common:	13 GHz	33.4 ps	23.7 ps
N5444A 2.92, 3.5 mm, SMA		–	–	Differential:	13 GHz	33.4 ps	23.7 ps
				Single Ended:	13 GHz	33.4 ps	23.7 ps
				Common:	13 GHz	33.4 ps	23.7 ps

Probe Amplifier Characteristics

The characteristics listed in the Table 18 are mainly determined by the N2830/1/2A probe amplifiers.

Table 18 Characteristics for N2830/1/2A Probe Amplifiers (Sheet 1 of 2)

Item	N5439A, N5441A, N2836A, N2848A	With N5444A Probe Head (2.92 mm, SMA, 3.5 mm)
DC Input Resistance	R_{se} = 50 kΩ ± 2% each input to ground R_{diff} = 100 kΩ ± 2% R_{cm} = 25 kΩ ± 2%	55Ω to V_{term}
Input Resistance (> 10 KHz)	R_{se} = 500Ω ± 2% each input to ground R_{diff} = 1 kΩ R_{cm} = 250Ω	50Ω to 0.901 * V_{term}
Input Voltage Range (Differential or Single Ended)	2.5 Vpp or ±1.25V @ 5:1 attenuation 5.0 Vpp or ±2.50V @ 10:1 attenuation	2.5 Vpp or ±1.25V @ 5:1 attenuation 5.0 Vpp or ±2.50V @ 10:1 attenuation without violating maximum input power
Maximum Input Power	N/A	125 mW calculated with the following equation for each input: $P_{max} = \frac{(\mathrm{rms}_{(V_{in} - V_{term})})^2}{55}$
Input Common Mode Range	±7 V_{DC} to 100 Hz, ±1.25V > 100 Hz at 5:1 attenuation ±2.5V > 100 Hz at 10:1 attenuation	±6 V_{DC} to 100 Hz, ±1.25V > 100 Hz at 5:1 attenuation ±2.5V > 100 Hz at 10:1 attenuation without violating maximum input power
DC Attenuation Ratio	5:1 or 10:1. Automatically selected based on volts-per-division (all modes)	5:1 or 10:1. Automatically selected based on volts-per-division (all modes)
Offset Range (for probing a single-ended signal)	±16V	±6V without violating maximum input power
Input Referred Noise Spectral Density	Diff 5:1 attenuation 33.5 nV/rt(Hz), Diff 10:1 attenuation 53.9 nV/rt(Hz), SE A or B 5:1 attenuation 27.8 nV/rt(Hz), SE A or B 10:1 attenuation 47.7 nV/rt(Hz), CM 5:1 attenuation 21.8 nV/rt(Hz), CM 10:1 attenuation 38.4 nV/rt(Hz)	

Table 18 Characteristics for N2830/1/2A Probe Amplifiers (Sheet 2 of 2)

Item	N5439A, N5441A, N2836A, N2848A	With N5444A Probe Head (2.92 mm, SMA, 3.5 mm)
Input Referred Noise Example	4.5 mV_{rms} in diff mode 5:1 attenuation with ≥18 GHz probe head and N2832A 13 GHz probe amplifier	4.5 mV_{rms} in diff mode 5:1 attenuation with 28 GHz N5444A probe head and N2832A 13 GHz probe amplifier
Maximum Input Voltage	18 V_{peak} CAT 1	8 V_{peak} without violating maximum input power

Environmental

The following general characteristics apply to the active probe.

Table 19 Environmental Characteristics

Environmental Conditions	Operating	Non-Operating
Temperature	5 °C to +40 °C	–40 °C to +70 °C
Humidity	up to 95% relative humidity (non-condensing) at +40 °C	up to 90% relative humidity at +65 °C
Altitude	Up to 4,600 meters	Up to 15,300 meters
Power Requirements	Voltages supplied by Keysight oscilloscope AutoProbe Interface.	
Weight	approximately 0.69 kg	
Dimensions	Refer to "Probe Dimensions" on page 109.	
Pollution degree 2	Normally only non-conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation must be expected.	
Use	Indoor Only	

Probe Dimensions

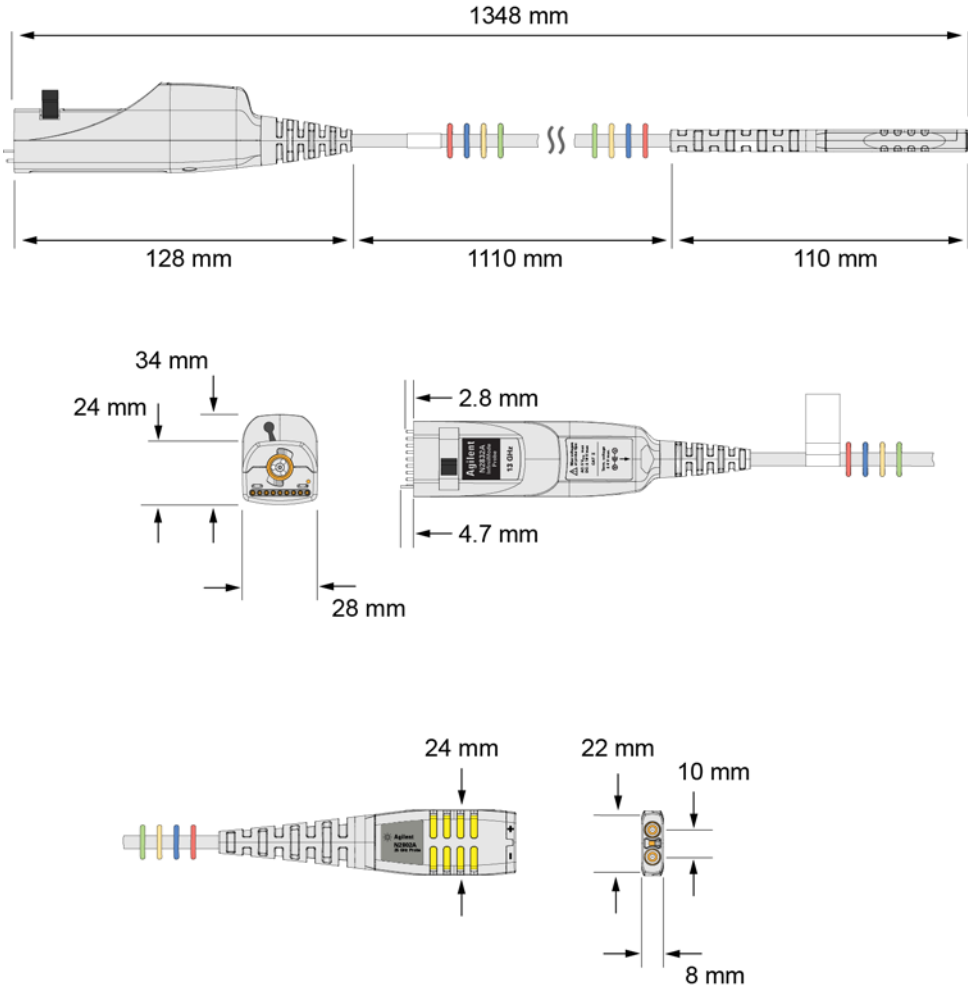


Figure 72 Probe Dimensions

6
Performance Plots

InfiniiMax Probe System Responses

InfiniiMax high bandwidth active probes for use with Infiniium realtime oscilloscopes utilize DSP correction filters to enhance the accuracy of measurements. InfiniiMax III and III+ probe amplifiers store their unique s parameters in on board memory for the scope to readout when needed. Probe heads are simple passive devices and with careful manufacture their s parameters don't vary significantly so they are stored as nominal s parameters in the oscilloscope.

When a probe is connected to an oscilloscope channel and the proper probe head is selected, the oscilloscope calculates a DSP correction filter that includes the probe head, probe amp, and oscilloscope channel. This provides the maximum measurement accuracy for the complete probe and scope channel system.

Since there are so many different probe amplifiers and probe head combinations, it is not reasonable to show the responses of all these combinations and the responses would all be very much the same because they are all corrected to same target system response. The target system response is a flat magnitude, flat phase response high order low pass filter that maximizes measurement accuracy.

Figure 73 on page 113 shows an example of corrected system frequency response of an N2836A solder-In probe head used with an N2832A 13 GHz InfiniiMax III+ probe amplifier. Figure 74 shows the step response of the corrected system.

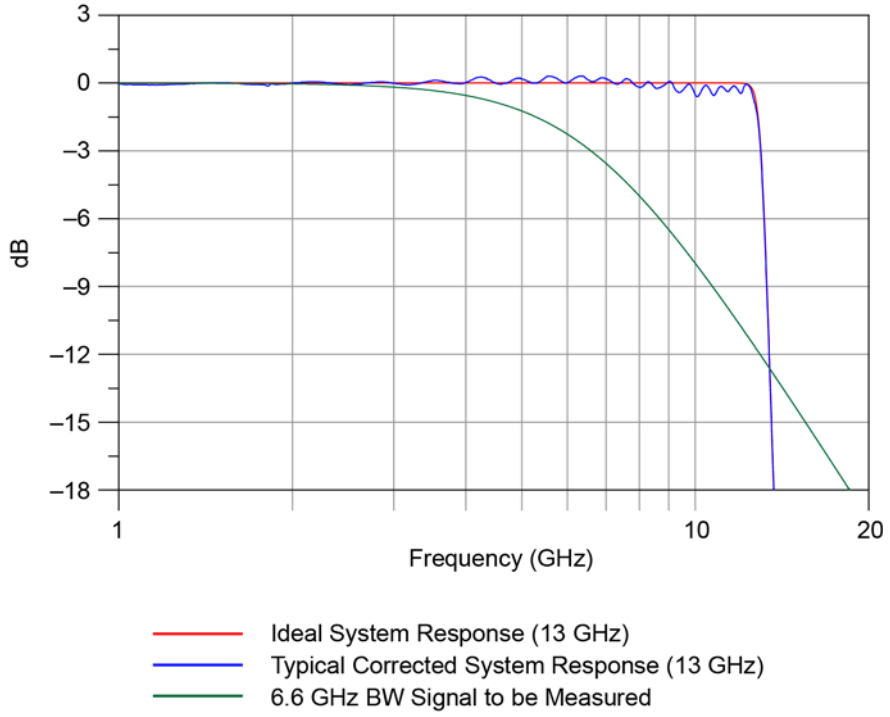


Figure 73 Corrected System Frequency Response (N2836A Solder-In Head and N2832A Amplifier)

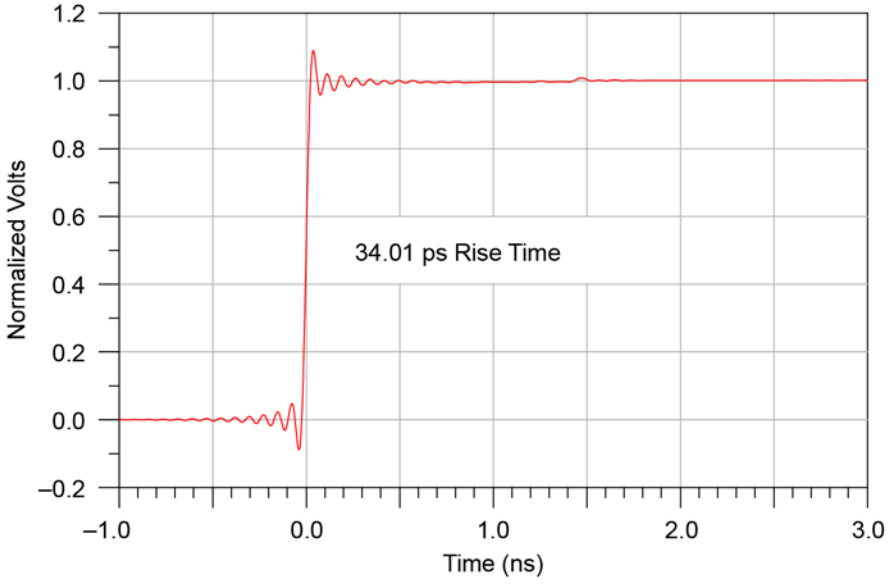


Figure 74 Step Response of Corrected System

Since the corrected system response has flat magnitude and phase, the step response is very flat and has equal pre-shoot and over-shoot. The flat phase will not distort the phase of the signal under test and therefore provides the truest reproduction of the signal. The reflection at 1.5 ns (twice the electrical length of the probe head) is very small indicating that the probe amplifier input termination is good.

The measure of the quality of a probe system is how well it reproduces the signal at the probe tip on the oscilloscope screen. Figure 75 on page 115 shows the step response of the 6.6 GHz BW signal in red, and blue shows how well the probe system reproduces that step. The BW of the signal being measured is as high as it can be while limiting the measured rise time error to about 3%.

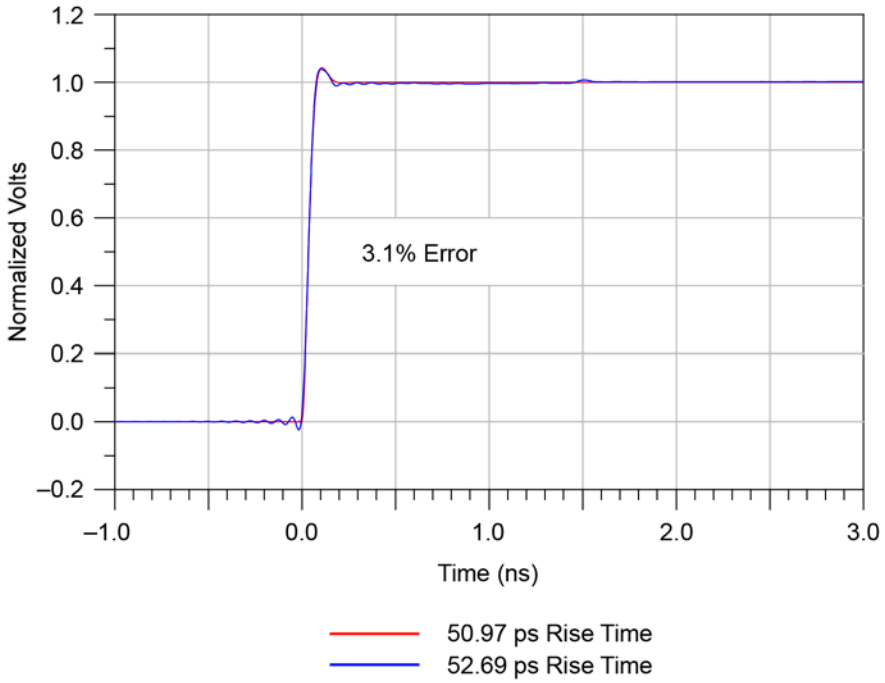


Figure 75 Fidelity of Step Response (Probe System Versus Input Signal)

This example was for a 13 GHz system measuring a 6.6 GHz signal. This ratio can be used to determine the measurement bandwidth needed for other bandwidth signals (for a 3% rise time measurement error):

$$BW_{\text{probe-scope system}} \cong \frac{13\ \text{GHz} \times BW_{\text{signal}}}{6.6\ \text{GHz}}$$

$$\cong 1.97 \times BW_{\text{signal}}$$

N2848A QuickTip Head with N2849A QuickTip Tip

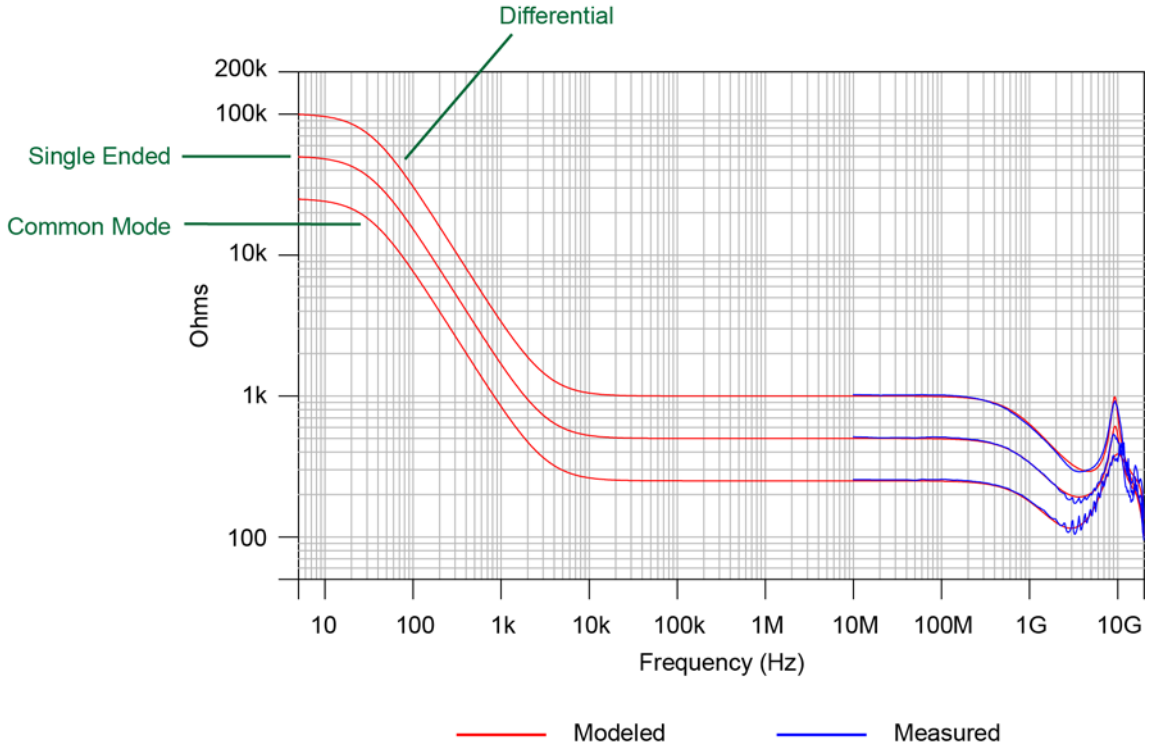


Figure 76 Input Impedances (Modeled and Measured)

N2836A Solder-In Probe Head (Flat Orientation)

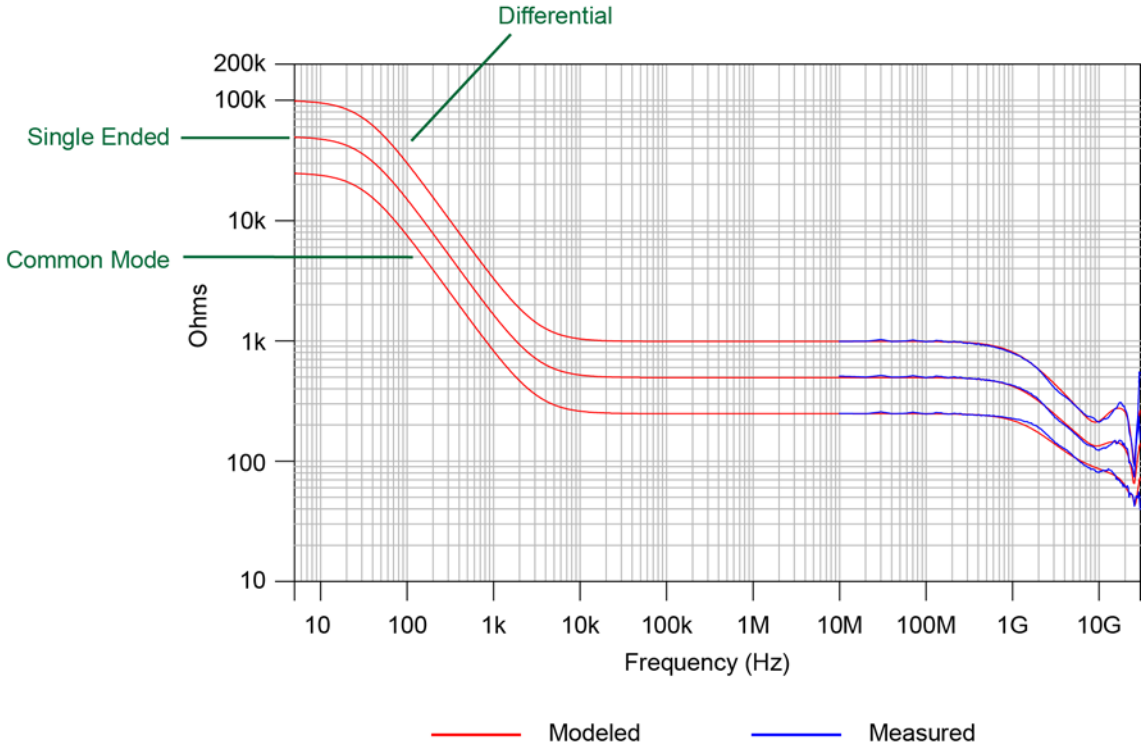


Figure 77 Input Impedances (Modeled and Measured)

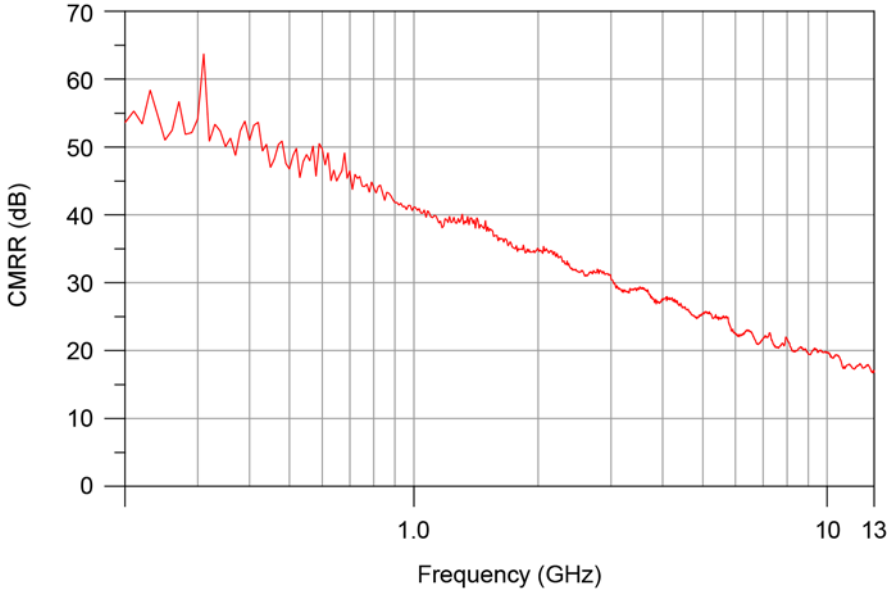


Figure 78 Common Mode Rejection Ratio (CMRR) of N2836A Solder-In Probe Head with N2832A Probe Amplifier

7
Performance Verification

This chapter describes the equipment and procedures needed to verify the performance of InfiniiMax III+ probes. Due to the very high frequency of the InfiniiMax III+ probing system, it is important to carefully adhere to the techniques and procedures described in this chapter to accurately measure the performance.

It is also important to note that the performance measured here is of the probe by itself. Keysight high performance real-time scopes (and sampling scopes under certain conditions) will apply probe correction that will further enhance the performance of the probes.

CAUTION

Electrostatic discharge (ESD) can quickly and imperceptibly damage or destroy high performance probes, resulting in costly repairs. Always wear a wrist strap when handling probe components and insure that cables are discharged before being connected.

Bandwidth Performance Verification

This section documents the bandwidth performance of the N2832A InfiniiMax III+ probe amplifier with the N2836A solder-in probe head.

NOTE **The recommended test interval is one year/2000 hours.**

Equipment Needed

- InfiniiMax III+ N2836A solder-in probe head.
- Keysight 2 port E8361A/C Vector Network Analyzer or equivalent VNA that covers at least a 50 MHz to 13 GHz range. The VNA must have the following capability:
  - ❏ Ability to use a Touchstone file to de-embed at a port.
  - ❏ A bias port for port 1 of the VNA. That is it must have an internal bias T's and a BNC port that allows bias to be applied to port 1).

NOTE **This procedure is written assuming the E8361A/C PNA. If a different VNA is used, references that are specific to the PNA will need to be modified.**

- Proper test port cables and/or adapters to provide male 2.92 mm connectors at reference planes. If test port cables are 2.4 mm or 1.85 mm cables, then Keysight 11904A and 11904D adapters can be used to convert to 2.92 mm male connectors.
- Keysight N5443A Performance Verification Fixture.
- Maury Microwave 8775B2 2.92 mm male broadband load. Or other 2.92 mm male load with similar or better return loss. A high quality 2.92 mm adapter to a 2.4 mm or 1.85 mm VNA calibration load with required return loss could be used.
- Keysight N5477A Autoprobe II/3.5 mm Adapter.
- Keysight 1143A Power supply.
- Keysight 5062-1247 outside thread 3.5 mm (male) to 3.5 mm (female) adapter.
- Keysight N4692A-00F 2.92 mm (female/female) ECal module. Or, other 2.92 mm calibration kit that can calibrate to the 2.92 mm male connectors at the test ports.

- BNC 50 ohm male terminator. Or equivalent; not a critical part. For example, a Pomona number 3840-50 or 4119-50.

VNA Setup

Power level: . . . . . –6 dBm
Sweep: . . . . . Log
Frequency: . . . . . 50 MHz to 34 GHz
Points: . . . . . 284 (100 pts/decade)
IF BW: . . . . . 1 kHz

1 Connect Test port cables and adapters (if needed) to provide male 2.92 mm connectors at the measurement planes. Install the BNC 50 ohm terminator to the bias input for port 1 of the VNA (on the rear panel of E8361 PNA). This provides a DC 50 ohm termination for the probe amplifier output.

2 Clear all traces from display, then select S12 to display. Configure the following settings for S12:

Scale: . . . . . 3 dB/div
Reference Level: . . . . . 0 dB
Reference Position: . . . . . 5 divisions

Procedure

1 Calibrate the PNA to the two male 2.92 mm connectors as shown in Figure 80 on page 123 using the N4692A-00F ECal module (or equivalent 2.92 mm cal kit).

CAUTION **As with all precision connector interfaces, make sure to torque all connections using the proper torque wrench!**

2 Prepare the N2836A solder-in probe head for connection to the PV fixture as shown in Figure 79 on page 122. Shape the leads as shown. If needed, slightly spread the tips wires to better match the spacing needed for the PV fixture.

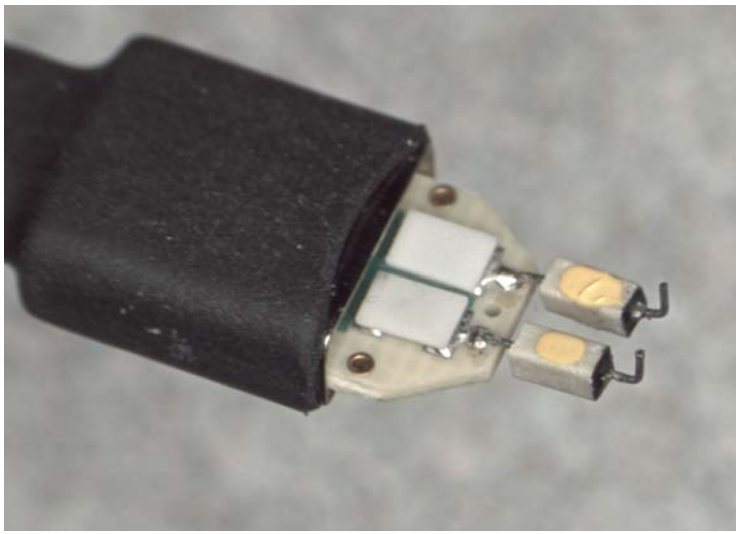


Figure 79 N2836A ZIF Probe Head

3 Connect the 1250-1749 adapter and N5443A PV fixture assembly to the calibrated ports of the PNA as shown in Figure 80 on page 123. A small bench vise is useful to hold PV fixture steady.

4 Connect the N5477A AutoProbe II adapter to the 1143A power supply and turn on the power supply.

   a Make sure the probe offset control button on the 1143A is set to "Zero" so no probe offset is applied.

   b The 5062-1247 adapter should be attached to the N5477A and properly torqued.

5 Connect the probe amp pod end to the N5477A and torque connector.

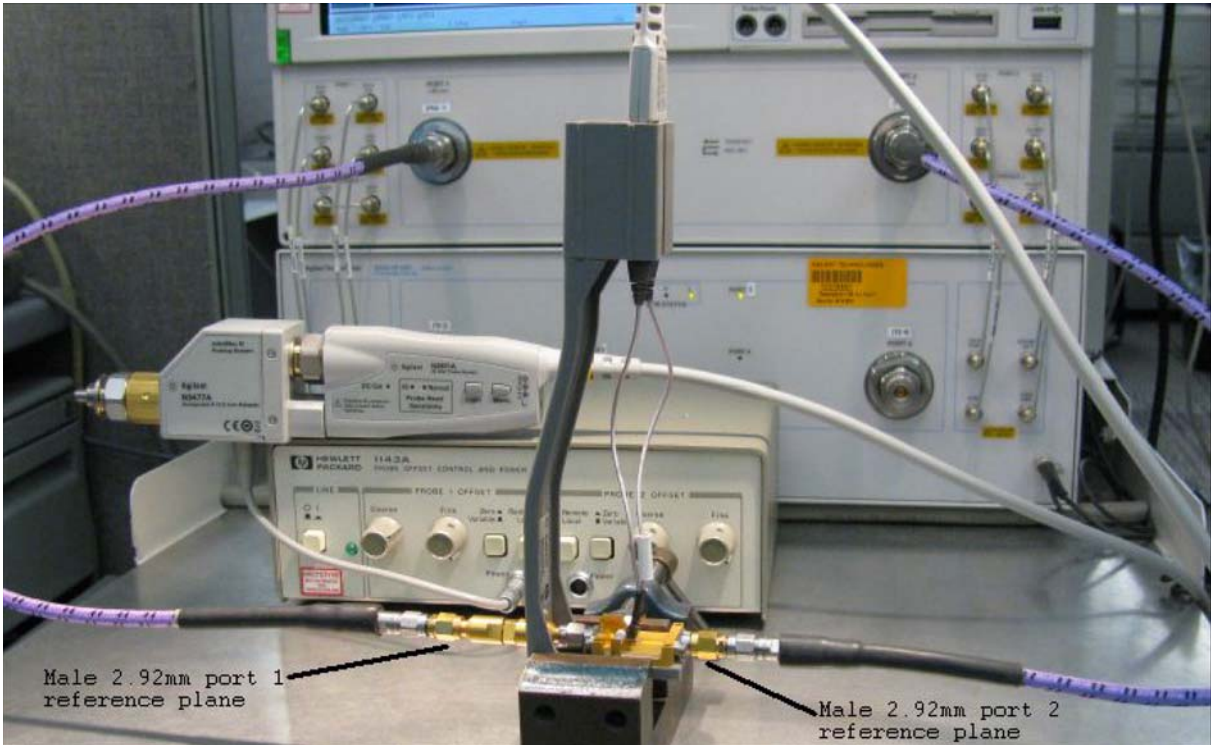


Figure 80 Setup for Measuring V_{in} of Probe

6 Connect the probe to the N5443A PV fixture:

a Probe amp with ZIF probe head is inserted into the PV holder far enough that the tip wires can easily reach the pinches on the PV fixture.

b Form the coax cables so that the tip wires are close to the pincher points before trying to connect the tip wires. The connectors between the probe head and the probe amp can be rotated to align the probe tip properly to the punchers. Since the center trace of the PV fixture is above the ground plane, the

probe head should be tipped slightly so the tip wires touch the center trace and ground plane at the same time.

c Depress the actuators on the pincher and carefully insert one wire under the center pincher and the other wire under one of the side pincher. Either polarity of the probe can be tested and will yield the same results (but opposite phase) if the probe is working properly. Figure 81 on page 125 shows a close up of the tip wires positioned under the pincher.

d Ideally the probe head should not be angled toward the port 2 side of the PV fixture, but a slight angle of 5 degrees is acceptable. If angled too much, the measured BW of the probe will be degraded due to coupling from the trace to the probe tip.

7 Install the proper file to de-embed the 1250-1749 adapter and the output side of the N5443A. This is the path from the male 2.92 mm connector to the probe point of the N5443A) from port 1 of the VNA.

a Create a Touchstone file for the 1250-1749 and N5443A PV fixture by cutting and pasting the text in "Touchstone File (1250-1749 & N5443A)" on page 131. Name the file **Adaptor_1250_1749__OutputSideOfFixture_N5443A.s2p**.

b On the VNA, go to menu "Calibration/Fixturing Selections/2 Port De-embedding" and select Port 1.

c Set S2P file selection to the file saved in step a.

d Check the "Enable De-embedding".

e Under "Calibration" menu, select "Fixturing ON/off" to turn on de-embedding.

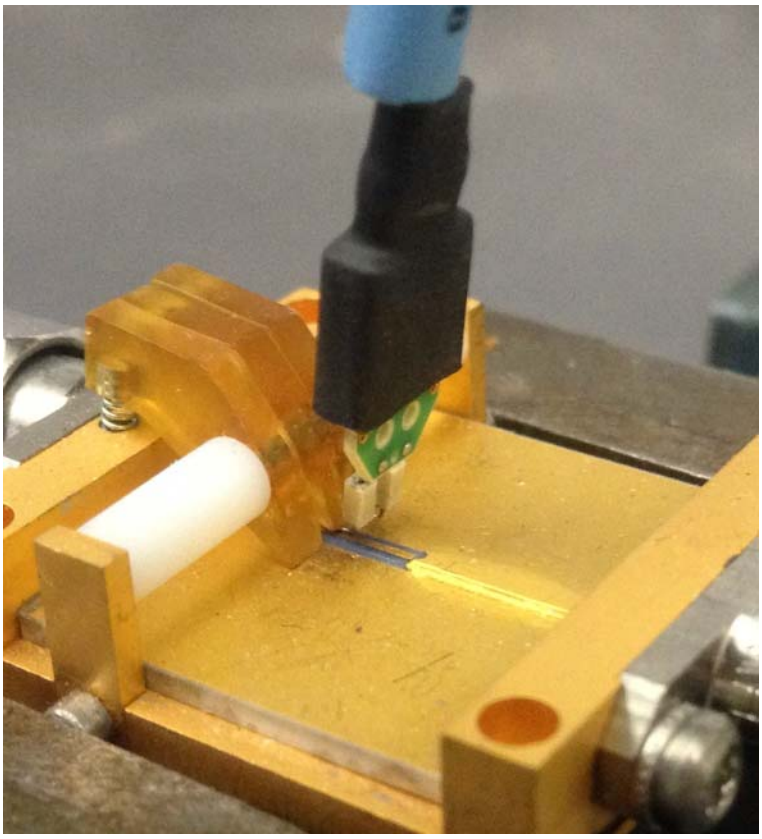


Figure 81 Close-Up of Tip Wires Positioned Under Pincher

8 Trigger the VNA to perform a single sweep. Press “Trigger” under Channel Setup, and then the green soft-key for “Single”. Display should look like Figure 82 on page 126. If it looks noticeably different, the probe tip wires may not be making contact under the pincher.

9 Under “Trace/Math/Memory” select “Data->Memory”. This will save the de-embedded input voltage trace into the memory.

Figure 82 De-Embedded V_{in} Trace

10 Now move the 2.92 mm male test port 1 connector to the 5062-1247 adapter and N5477A Autoprobe II adapter assembly. Connect the Maury Microwave 8775B2 2.92 mm male broadband load to the 1250-1749 adapter and N5443A PV fixture assembly. This new setup is shown in Figure 83 on page 128. Torque all connections.

11 Install the proper file to de-embed the 5062-1247 adapter and N5477A adapter from port 1 of the VNA.

   a Create a Touchstone file for the 5062-1247 and N5477A by cutting and pasting the text in "Touchstone File (5062-1247 & N5477A)" on page 136. Name the file **Adapter_5062_1247__Adapter_N5477A.s2p**.

   b Go to menu "Calibration/Fixturing Selections/2 Port De-embedding" and select Port 1.

   c Set S2P file selection to the file saved in step a.

   d Make sure the "Enable De-embedding" box is still checked.

   e Under "Calibration" menu, make sure "Fixturing ON/off" is still checked so file is being used for de-embedding.

12 Trigger VNA to perform a single sweep.

   a Press "Trigger" under Channel Setup, and then the green soft-key for "Single".

   b Under "Scale" menu, adjust the reference level until the 50 MHz point (left side of the screen) is at center screen. Reference level should be approximately –15.3 dB, but can vary a few tenths of a dB either way.

   c Display should look like Figure 84 on page 129. If it looks noticeably different, the probe tip wires may not be making contact under the pincher.

13 Under menu "Trace/Math/Memory" select "Data/Memory" in the "Data Math" box.

   a This will divide the current trace (de-embedded vout trace) by the memory trace (de-embedded vin trace) and therefore show the voltage transfer function of the probe or "vout/vin".

   b Again, adjust the "Reference Level" in the scale menu so the 50 MHz point is at center screen. The display should look like Figure 85 on page 130.

   c Turn on a marker and adjust it to where the trace crosses 3 dB below the 50 MHz point (which is one division below center screen since screen is set to 3 dB/div).

   d Verify that the BW is ≥ 13 GHz for the N2836A solder-in probe head and N2832A 13 GHz probe amp combination.

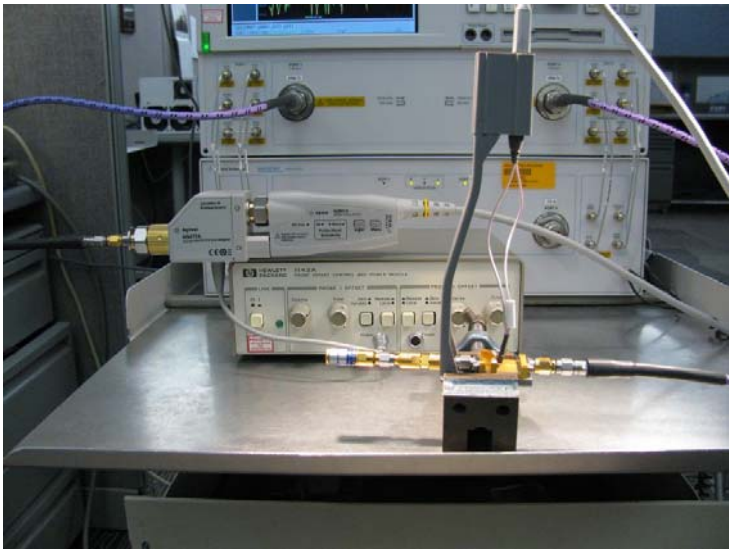


Figure 83 Setup to Measure V_{out} of Probe

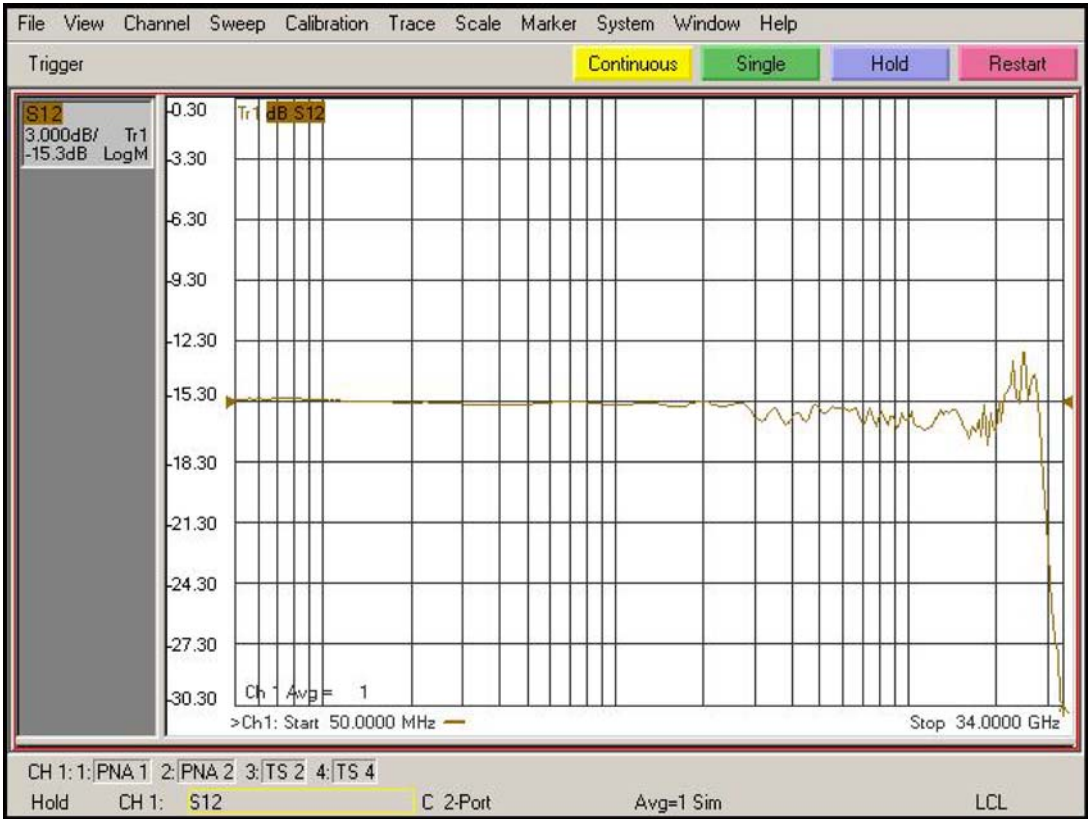


Figure 84 De-Embedded V_{out} Trace

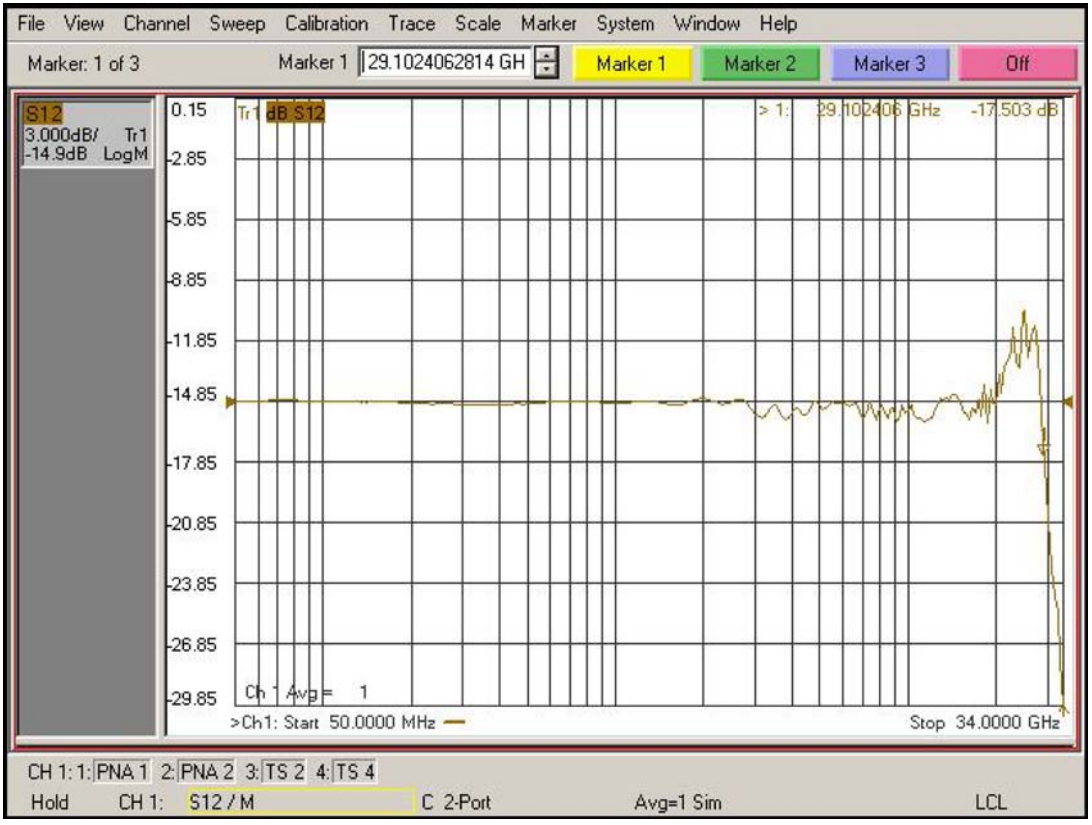


Figure 85 De-Embedded V_{out}/V_{in} Response of the Probe

Touchstone File (1250-1749 & N5443A)

Cut and paste the following text and save in a text file named **Adapter_1250_1749___OutputSideOfFixture_N5443A.s2p**. This file is used in Step 8 on page 125.

NOTE

You'll find the following data on the Adobe AIR version of the Probe Resource Center (PRC). Copying this data from the PRC is the simplest most reliable method to get the data. To download the PRC, visit http://www.keysight.com/find/PRC.

```
! freq S11 S21 S12 S22
!Port 1=female 3.5mm connector of 1250-1749 adaptor, Port 2=probe point on N5443A fixture
# Hz S DB R 50
50000000.000000 -49.528411 110.869328 -0.026318 -4.180881 -0.025870 -4.223772 -67.754661 -176.153454
51165694.067857 -49.988587 91.181375 -0.025517 -4.280433 -0.024720 -4.324675 -68.880923 -164.662475
52358564.988911 -50.522661 71.165730 -0.024697 -4.382306 -0.023543 -4.427929 -70.190588 -152.193533
53579246.361093 -51.148132 50.755093 -0.023858 -4.486555 -0.022339 -4.533591 -71.710672 -138.296498
54828386.553961 -51.883012 29.852775 -0.023000 -4.593234 -0.021107 -4.641716 -73.455393 -122.229302
56106649.053084 -52.745137 8.328609 -0.022122 -4.702400 -0.019846 -4.752362 -75.383422 -102.800368
57414712.812455 -53.751090 -13.985221 -0.021223 -4.814111 -0.018557 -4.865588 -77.285484 -78.453735
58753272.615119 -54.914477 -37.296089 -0.020304 -4.928426 -0.017237 -4.981454 -78.641246 -48.710849
60123039.442212 -56.136285 -60.059373 -0.019410 -5.044783 -0.015920 -5.098670 -78.505514 -17.996645
61524740.850598 -56.339746 -65.253403 -0.018972 -5.157375 -0.014907 -5.204612 -74.600997 0.238726
62959121.359318 -56.549712 -70.614809 -0.018523 -5.272593 -0.013871 -5.313024 -71.786638 16.619539
64426942.845040 -56.765722 -76.151300 -0.018064 -5.390497 -0.012811 -5.423964 -69.665881 32.555062
65928984.946733 -56.987159 -81.870529 -0.017595 -5.511150 -0.011726 -5.537491 -68.056466 48.587163
67466045.479778 -57.213226 -87.779882 -0.017115 -5.634616 -0.010616 -5.653665 -66.866526 65.023732
69038940.859729 -57.442930 -93.886209 -0.016623 -5.760962 -0.009481 -5.772548 -66.050126 82.119449
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72295597.435395 -57.551220 -142.499775 -0.015869 -6.038769 -0.011116 -6.029813 -62.891316 82.809542
73981088.416647 -57.272309 -174.184620 -0.015537 -6.186061 -0.012827 -6.165369 -61.314332 74.543748
75705874.734666 -56.913609 155.103108 -0.015196 -6.336786 -0.014577 -6.304085 -59.987656 65.638030
77470872.516269 -56.615036 125.361237 -0.014847 -6.491025 -0.016368 -6.446035 -58.847549 56.200571
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```

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Touchstone File (5062-1247 & N5477A)

Cut and paste the following text and save in an text file named **Adapter_5062_1247___Adapter_N5477A.s2p**. This file is used in Step 11 on page 127.

NOTE

You'll find the following data on the Adobe AIR version of the Probe Resource Center (PRC). Copying this data from the PRC is the simplest most reliable method to get the data. To download the PRC, visit http://www.keysight.com/find/PRC.

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! freq S11 S21 S12 S22
!Port 1=female side of 5062_1247 adaptor, Port 2=male side of N5477A
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28275350278.367512 -17.914343 -10.269666 -0.535415 -144.847239 -0.495666 -144.767531 -18.500405 -94.926037
28934558440.089119 -25.403265 -145.855952 -0.458652 85.819950 -0.471521 86.027882 -25.033409 132.887622
29609135302.682766 -21.411602 -123.245956 -0.500273 -47.265432 -0.509761 -47.235075 -21.254847 -153.392821
30299439170.217197 -27.014691 72.673095 -0.489298 176.678655 -0.474972 177.031191 -25.338474 101.072054
31005836700.219704 -26.316760 -92.472631 -0.452905 37.601195 -0.500821 37.724078 -24.884493 -3.740226
31728703098.427670 -24.576379 -122.274522 -0.482050 -105.277061 -0.496607 -105.184253 -22.985629 83.341478
32468422318.080524 -18.473439 97.257414 -0.522336 109.131590 -0.552294 109.178004 -17.832689 -62.528240
33225387263.857967 -35.956091 36.668777 -0.453368 -40.549604 -0.433040 -40.351388 -38.607656 -59.673550
34000000000.000000 -18.584633 -83.525655 -0.518071 166.056015 -0.538472 166.289380 -18.908405 -121.618048

DC Input Resistance Performance Verification

NOTE The recommended test interval is one year/2000 hours.

Equipment Needed

- InfiniiMax III+ N2836A solder-in probe head. An N5441A solder-in probe head may be substituted.

NOTE You only need to perform the performance verification test on one of these probe heads, not both of them. If it passes for one of them, then it will pass for all of them.

- Keysight N5443A Performance Verification Fixture. No substitute.
- BNC(m) to SMA(m) Adapter. Pomona 4288 or equivalent.
- Banana Plug to BNC(f). Pomona 1269 or equivalent.
- Digital Multimeter:
  - Keysight 33401A or equivalent
  - Critical specification: 2 wire resistance accuracy
  - Power Supply for Probe
  - DSO/DSA 90000 X-series oscilloscope or 1134A power supply with N5477A Autoprobe adapter (see the "Bandwidth Performance Verification" on page 120 procedure)
  - No substitute
- Probe Positioner
  - Keysight N2787A 3D Probe Positioner
  - Critical specification: stable/accurate positioning
- Small Bench Vise

Measuring Input Resistance of N2836A Probe Head

Figure 86 shows the correct setup for measuring the differential input resistance for the solder-in probe head.

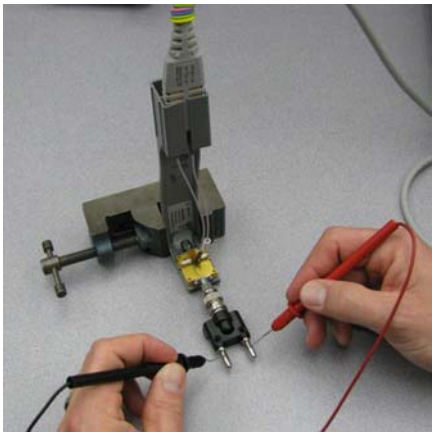

Figure 86 Measuring the Differential Input Resistance of Solder-In Probe Head

1. Connect the BNC to SMA adapter and BNC to Banana Plug adapters as shown in Figure 86.
2. Position the PV fixture on a table top and clamp it with a small bench vise to steady it. Ensure that the PV fixture is flush with the table top so that when the banana plugs are probed, it does not rock the PV fixture.
3. Connect the probe amplifier to the oscilloscope or power supply so it is powered.
4. Connect the ZIF or solder-in probe head to the probe amp and insert it into the PV fixture as shown Figure 86.
5. Depress the pincher fingers on the PV fixture so they open and carefully insert the tip wires under the pincher. Release the pincher once the tips are inserted.
6. As shown in Figure 86, measure the DC input resistance between the banana plugs. Since one tip wire is connected to the signal line and the other tip is connected to the PV fixture ground, this is a measurement of the differential input resistance. It should be 100 kΩ ±2% (98 to 102 kΩ).

7 To measure the single-ended input resistance, measure the resistance between the signal plug of the banana adapter and the probe amplifier ground, which can be accessed as shown in Figure 87 (through the vent window of the probe amplifier).

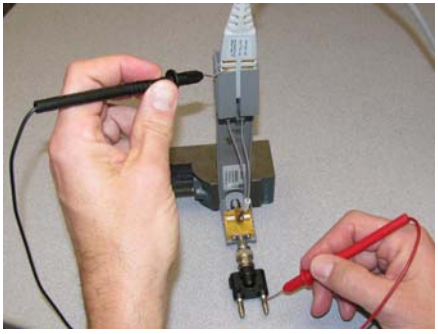

Figure 87 Measuring the Single-Ended Input Resistance the Solder-In Probe Head

Performance Test Record

NOTE The recommended test interval is one year/2000 hours.

Keysight Technologies	**Keysight InfiniiMax III Series Probe**
Model Number:	**Tested by:**
Serial Number:	**Work Order Number:**
Recommended next test date:	**Date:**

Probe Head (only required to test one)	**Test Limits**	**Result**	**Pass/Fail**
Bandwidth Performance Test			
N2836A	≥ 13 GHz		
DC Input Resistance Performance Test			
N2836A	98 to 102 kΩ (differential mode) 49 to 51 kΩ (single-ended mode)		
N5441A	98 to 102 kΩ (differential mode) 49 to 51 kΩ (single-ended mode)		

8
SPICE Models

The SPICE models in this chapter are for the input impedances of the various Infiniimax III+ probes heads. The input impedance is only a function of the probe head, as the amplifier input does not significantly affect the input impedance.

Chapter 6, “Performance Plots” shows the matching between the measured input impedance and these modeled input impedances for the various probe heads.

N2848A QuickTip Head with N2849A QuickTip Tip

The following input-impedance SPICE subcircuit data is for the N2848A QuickTip probe head with N2848A QuickTip tip. The data models all modes of input impedance: differential, common, and A or B. The probe is vertical orientated with both ground wires connected to the DUT ground.

SPICE Subcircuit Data

```
.subckt N2849A_N2848A 1 2
r1 1 3 1e8
r2 2 3 1e8
r9 3 0 .5e8
r_srlc2 5 7 242.9
l_srlc2 7 8 5.370n
c_srlc2 8 6 52.43f
r_srlc3 4 9 68.66
l_srlc3 9 10 7.669n
c_srlc3 10 6 7.102f
r_srlc1 4 11 245.5
l_srlc1 11 12 1.550n
c_srlc1 12 6 197.9f
r3 4 13 1000
c1 13 6 50n
r5 13 6 100k
r8 6 0 1e-6
r4 14 16 500
r_srlc4 14 18 353.9
l_srlc4 18 19 10.98n
c_srlc4 19 17 230.6f
r_srlc5 14 20 110.7
l_srlc5 20 21 5.880n
c_srlc5 21 17 8.244f
r_srlc6 15 22 611.8
l_srlc6 22 23 8.632n
c_srlc6 23 17 49.18f
r6 16 17 50k
c2 16 17 100n
r7 17 0 1e-6
e1 5 0 4 0 -1
e2 4 0 1 2 1
```

```
e3 14 0 3 0 2
e4 15 0 14 0 -1
g1 1 2 6 0 1e6
g2 1 0 17 0 1e6
g3 2 0 17 0 1e6
.ends
```

N5439A ZIF Probe Head with N5440A ZIF Tip

The following SPICE subcircuit data is for the N5440A 28 GHz ceramic ZIF Tips on an N5439A ZIF probe head.

SPICE Subcircuit Data

```
.subckt N5440A_N5439A_450ohmZIF 1 2
c1 1 10 20f
l1 10 11 1.5n
r1 11 2 180
rp1 1 3 180
lp1 3 4 1.5n
cp1 4 5 24f
cp2 5 6 100n
rp2 6 1 500
rp3 5 1 50k
cm1 2 7 24f
lm1 7 8 1.5n
rm1 8 5 180
cm2 2 9 100n
rm2 9 5 500
rm3 2 5 50k
rom 5 0 180
lom 5 0 30u
.ends
```

N5439A ZIF Probe Head with N2838A ZIF Tip

The following SPICE subcircuit data is for the N2838A 25 GHz printed-circuit board ZIF Tip on an N5439A ZIF probe head.

SPICE Subcircuit Data

```
.subckt N2838A_N5439A_PcbZif 1 2
Cblkp 6 13 100n
Cblkn 2 14 100n
Cg1p 1 4 26.1f
Cg1n 5 6 26.1f
Cg2p 1 10 128.4f
Cg2n 12 6 128.4f
Cm2 2 8 3.04f
Cm3 2 3 7.05f
Rg1p 4 6 67.8
Rg1n 2 5 67.8
Rg2p 9 6 126.2
Rg2n 2 11 126.2
Rm2 1 7 225.9
Rm3 1 15 71.5
Rmbp 1 13 500
Rmbn 14 6 500
Rdcp 1 6 50k
Rdcn 2 6 50k
Rom 6 0 110
Lom 6 0 30u
Lg2p 9 10 1.21n
Lg2n 11 12 1.21n
Lm2 7 8 15.3n
Lm3 3 15 5.76n
.ends
```

N2836A 26 GHz Solder-In Probe Heads

SPICE Subcircuit Data

```
.subckt N2836A_SldrIn 1 2
Cblkp 6 13 100n
Cblkn 2 14 100n
Cg1p 1 4 20.7f
Cg1n 5 6 20.7f
Cg2p 1 10 152.2f
Cg2n 12 6 152.2f
Cm2 2 8 4.12f
Cm3 2 3 6.46f
Rg1p 4 6 52.4
Rg1n 2 5 52.4
Rg2p 9 6 142
Rg2n 2 11 142
Rm2 1 7 172.4
Rm3 1 15 67.9
Rmbp 1 13 500
Rmbn 14 6 500
Rdcp 1 6 50k
Rdcn 2 6 50k
Rom 6 0 110
Lom 6 0 30u
Lg2p 9 10 1.12n
Lg2n 11 12 1.12n
Lm2 7 8 11.2n
Lm3 3 15 5.90n
.ends
```

N5441A 16 GHz Solder-In Probe Head

SPICE Subcircuit Data

```
.subckt N5441A_SldrIn 1 2
c1 1 10 50f
l1 10 11 2.1n
r1 11 2 65
rp1 1 3 65
lp1 3 4 2.5n
cp1 4 5 55f
cp2 5 6 100n
rp2 6 1 500
rp3 5 1 50k
cm1 2 7 55f
lm1 7 8 2.5n
rm1 8 5 65
cm2 2 9 100n
rm2 9 5 500
rm3 2 5 50k
rom 5 0 130
lom 5 0 30u
.ends
```

N5445A Browser Probe Head

This section includes N5445A SPICE models for the probe tips adjusted to a 1 mm, 2 mm, and 3 mm span.

SPICE Subcircuit Data (1 mm span)

```
.subckt N5445A_Brwsr1mmSpn 1 2
c1 1 10 20f
l1 10 11 2.3n
r1 11 2 150
rp1 1 3 150
lp1 3 4 2.3n
cp1 4 5 30f
cp2 5 6 100n
rp2 6 1 500
rp3 5 1 50k
cm1 2 7 30f
lm1 7 8 2.3n
rm1 8 5 150
cm2 2 9 100n
rm2 9 5 500
rm3 2 5 50k
rom 5 0 40
lom 5 0 30u
.ends
```

SPICE Subcircuit Data (2 mm span)

```
.subckt N5445A_Brwsr2mmSpn 1 2
c1 1 10 20f
l1 10 11 2.3n
r1 11 2 250
rp1 1 3 250
lp1 3 4 2.3n
cp1 4 5 30f
cp2 5 6 100n
rp2 6 1 500
rp3 5 1 50k
cm1 2 7 30f
lm1 7 8 2.3n
rm1 8 5 250
cm2 2 9 100n
rm2 9 5 500
rm3 2 5 50k
rom 5 0 40
lom 5 0 30u
.ends
```

SPICE Subcircuit Data (3 mm span)

```
.subckt N5445A_Brwsr3mmSpn 1 2
c1 1 10 20f
l1 10 11 2.3n
r1 11 2 300
rp1 1 3 300
lp1 3 4 2.3n
cp1 4 5 30f
cp2 5 6 100n
rp2 6 1 500
rp3 5 1 50k
cm1 2 7 30f
lm1 7 8 2.3n
rm1 8 5 300
cm2 2 9 100n
rm2 9 5 500
rm3 2 5 50k
rom 5 0 40
lom 5 0 30u
.ends
```

N5444A SMA Probe Head

The N5444A 2.92 mm/3.5 mm/SMA probe head is modeled by 40 short transmission lines of varying impedance. This accurately models the temporal nature of this probe head.

SPICE Subcircuit Data

```
.subckt N5444A_2p92mm 01
t01 01 0 02 0 z0=50.1226 td=4.5p
t02 02 0 03 0 z0=48.6767 td=4.5p
t03 03 0 04 0 z0=50.0690 td=4.5p
t04 04 0 05 0 z0=50.1226 td=4.5p
t05 05 0 06 0 z0=47.8189 td=4.5p
t06 06 0 07 0 z0=48.4842 td=4.5p
t07 07 0 08 0 z0=51.5636 td=4.5p
t08 08 0 09 0 z0=51.3432 td=4.5p
t09 09 0 10 0 z0=50.1231 td=4.5p
t10 10 0 11 0 z0=50.9715 td=4.5p
t11 11 0 12 0 z0=51.2048 td=4.5p
t12 12 0 13 0 z0=49.3079 td=4.5p
t13 13 0 14 0 z0=48.3903 td=4.5p
t14 14 0 15 0 z0=50.1144 td=4.5p
t15 15 0 16 0 z0=51.9126 td=4.5p
t16 16 0 17 0 z0=51.1671 td=4.5p
t17 17 0 18 0 z0=48.7858 td=4.5p
t18 18 0 19 0 z0=49.7704 td=4.5p
t19 19 0 20 0 z0=54.9662 td=4.5p
t20 20 0 21 0 z0=55.6338 td=4.5p
t21 21 0 22 0 z0=50.6714 td=4.5p
t22 22 0 23 0 z0=47.9673 td=4.5p
t23 23 0 24 0 z0=48.6942 td=4.5p
t24 24 0 25 0 z0=51.3949 td=4.5p
t25 25 0 26 0 z0=52.4910 td=4.5p
t26 26 0 27 0 z0=50.3990 td=4.5p
t27 27 0 28 0 z0=49.9508 td=4.5p
t28 28 0 29 0 z0=50.5692 td=4.5p
t29 29 0 30 0 z0=49.8539 td=4.5p
t30 30 0 31 0 z0=51.6006 td=4.5p
t31 31 0 32 0 z0=49.4657 td=4.5p
t32 32 0 33 0 z0=51.3932 td=4.5p
t33 33 0 34 0 z0=50.6702 td=4.5p
t34 34 0 35 0 z0=50.1108 td=4.5p
```

```
t35 35 0 36 0 z0=50.9072 td=4.5p
t36 36 0 37 0 z0=50.6940 td=4.5p
t37 37 0 38 0 z0=50.1733 td=4.5p
t38 38 0 39 0 z0=50.2609 td=4.5p
t39 39 0 40 0 z0=50.1355 td=4.5p
t40 40 0 41 0 z0=51.2333 td=4.5p
rterm 41 0 50.3
.ends
```

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