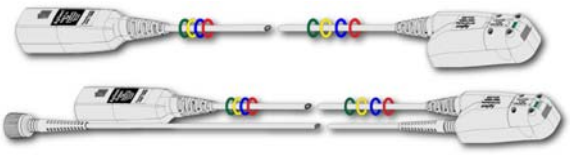
Agilent N2820/1A High-Sensitivity Current Probes



User's Guide

Agilent Technologies

Notices

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Oscilloscope Products Division

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CAUTION. A **CAUTION** notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in damage to the product or loss of important data. Do not proceed beyond a **CAUTION** notice until the indicated conditions are fully understood and met.

WARNING. **A WARNING notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in personal injury or death. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.**

Contents

1 General Information

The N2820A and N2821A high-sensitivity current probes allow you to measure AC and DC currents from 50 µA to 5A. These high dynamic-range probes are designed to be used on devices that have very tight geometry constraints. Since these probes do not need to be degaussed and do not require frequent calibration, you can focus on making your measurements. The probes accurately construct the current waveform by measuring the voltage across an R_{SENSE} resistor, which results in highly repeatable measurements.

CAUTION Before using the probe, refer to "Safety Information" on page 28.

Introduction

The N2820A and N2821A 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 26. When opening the case, lift out the foam cutout and flip the cutout over to reveal the ground lead and secondary cable as shown in the following figure. The secondary cable is only provided with N2820A probes.

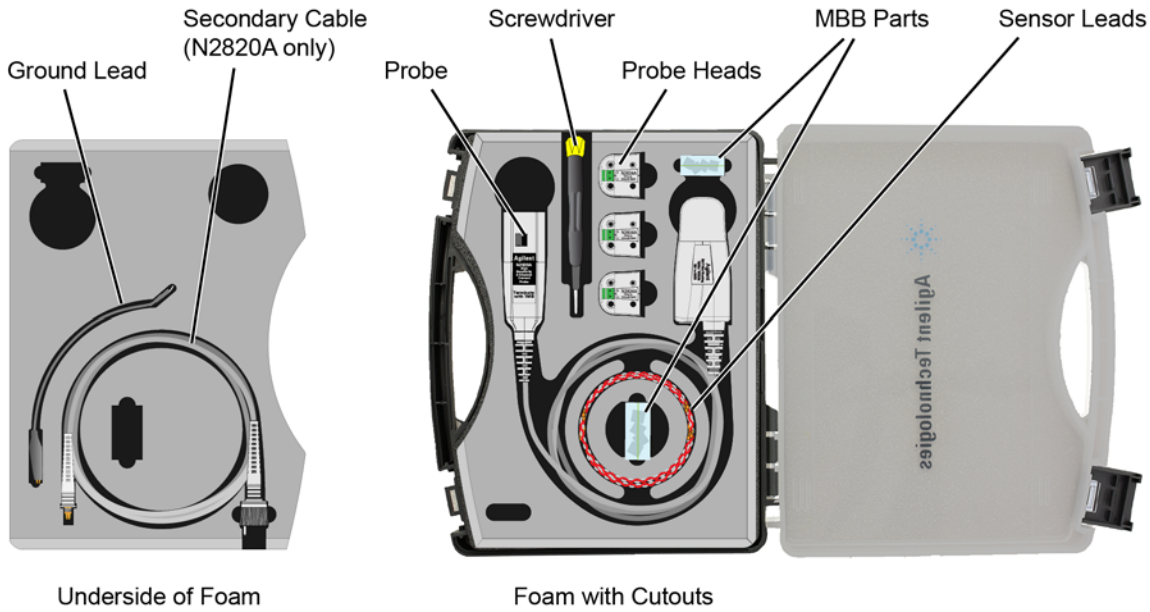


Figure 1 Probe in Supplied Case

Figure 2 shows the different components of the N2820A and N2821A probes. The N2820A two-channel probe, with its two internal, parallel differential amplifiers, provides simultaneous low and high gain views. The N2821A also

includes two amplifiers and its main output can be switched between these two views. Before using an N2820A probe, connect the secondary cable as described in "Connecting the Probe to The Oscilloscope" on page 13. The N2821A single-channel probe looks identical to the N2820A but *does not* include the secondary cable. The accessories provided with the probes are shown in Figure 3 on page 10.

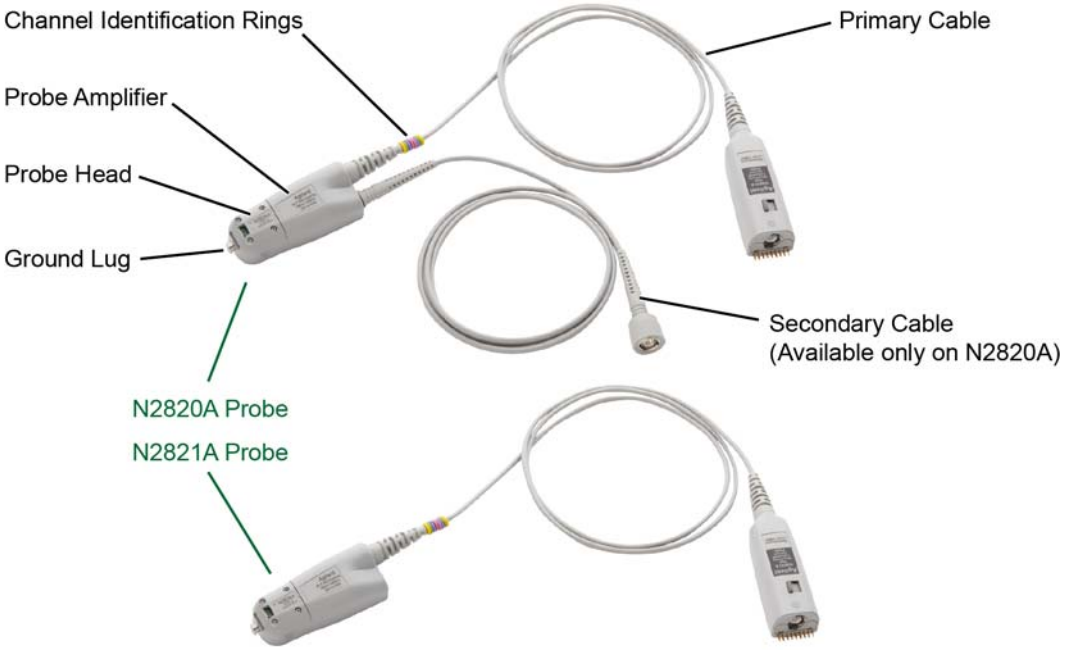


Figure 2 Probe Parts Identification

CAUTION Probes are ESD sensitive devices, particularly at the probe heads. Follow standard ESD precautions when handling. Remove head accessories when storing the probe.

Oscilloscope Compatibility

The N2820A and N2821A probes are compatible with the Agilent oscilloscopes shown in Table 1. The table also lists the minimum required firmware version for the oscilloscope.

NOTE The N2820A and N2821A probes are designed for oscilloscopes with 1 MΩ AutoProbe-interface channel inputs.

Is Your Oscilloscope Software Up-to-Date?

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

Table 1 Compatible Oscilloscopes and Support

Oscilloscope	Probe	
	N2820A 2 Channel Probe	**N2821A 1 Channel Probe**
Infiniium Oscilloscopes *(firmware version 4.2 or above)*		
90000A, X-, and Q-Series	not supported	not supported
9000 H-Series	✓[a]	✓
9000A-Series	✓[a]	✓
InfiniiVision Oscilloscopes *(4000 X firmware version 3.10 or above, 3000 X firmware version 2.30 or above)*		
4000 X-Series	✓	✓
3000 X-Series	*Supported Spring of 2013*	
2000 X-Series	not supported	not supported

a Dual-Grid View available

NOTE Infiniium and InfiniiVision 4000 X-Series oscilloscopes support up to two N2820A probes or up to four N2821A probes on a 4-channel oscilloscope. InfiniiVision 3000 X-Series oscilloscopes support up to two N2820/1A probes on a 4-channel oscilloscope.

Infiniium Dual-Grid View

The N2820A probe provides two channel-input cables which allow two simultaneous views of the current waveform: a high-gain zoomed-in and a low-gain zoomed-out view. On Infiniium oscilloscopes, both zoomed-in and zoomed-out waveforms can be simultaneously displayed in *dual-grid view*, where each waveform can be viewed in a different time span. To learn more about dual-grid view, refer to "N2820A Probes and Dual-Grid View" on page 18. InfiniiVision oscilloscopes do not support dual-grid views. The zoomed-in channel has 500 kHz bandwidth and the zoomed-out channel has 3 MHz bandwidth. N2821A probes, having only one channel-input cable, do not support the simultaneous display of zoomed-out and zoomed-in views.

NOTE There is *no* upgrade available to convert an N2821A (1 channel) probe to an N2820A (2 channel) probe.

Probe Heads

The probe is supplied with the N2822A, N2824A, and N2825A interchangeable R_{SENSE} probe heads. The N2822A and N2824A heads include different R_{SENSE} resistor values. The N2825A user-defined head does *not* include an R_{SENSE} resistor and is selected in situations when you want to use your own R_{SENSE} resistor that you have mounted on your DUT. To learn about configuring and using the heads, refer to Chapter 2, "Probing".

Make-Before-Break (MBB) Connectors

Five Make-Before-Break (MBB) connectors are provided with the probes. The MBB connectors allow you to quickly probe multiple locations on your DUT without interrupting the circuit under test. Refer to "Make-Before-Break Connectors" on page 40 for more information.

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.

Accessories

Supplied Accessories

The N2820A and N2821A probes come with the accessories shown in Figure 3. To learn how to use these accessories, refer to Chapter 2, “Probing”.

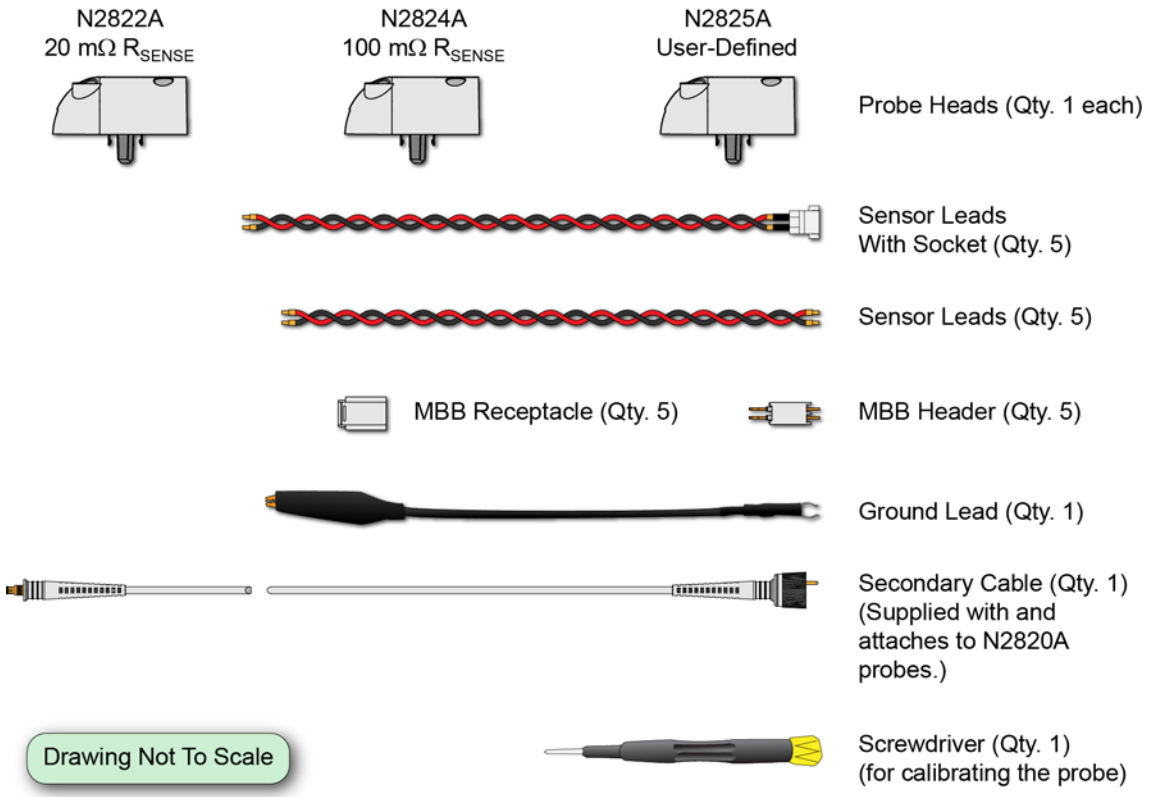


Figure 3 Supplied Accessories

NOTE To ensure the display of accurate waveforms, *always* connect the supplied ground lead when probing battery-powered devices, such as mobile phones. Refer to "Measurements on Battery Powered Devices" on page 12.

Replacement Accessories

Table 2 shows the available replacement accessories and parts.

Table 2 Replacement Accessories

Model Number	Description	Quantity
N2822A	20 mΩ R_{SENSE} Head	1
N2824A	100 mΩ R_{SENSE} Head	1
N2825A	User-defined R_{SENSE} Head	1
N2826A	Replacement unsocketed sensor leads (22 AWG)	5
N2827A	Secondary Cable for use with N2820A probe	1
N2828A	Replacement MBB Headers	5
N2829A	Replacement MBB Receptacles and socketed sensor leads (22 AWG)	5

Measurements on Battery Powered Devices

When making measurements on a battery-powered (floating) device, such as a mobile phone, *always* connect the supplied ground lead between ground on your device and the probe's ground connector as shown in Figure 4. Simply snap the end of the ground lead onto the probe's connector. Without the ground connection, the common mode voltage is not guaranteed to be within the common mode range of the amplifiers.

NOTE Failure to connect the ground lead may result in inaccurate waveforms.

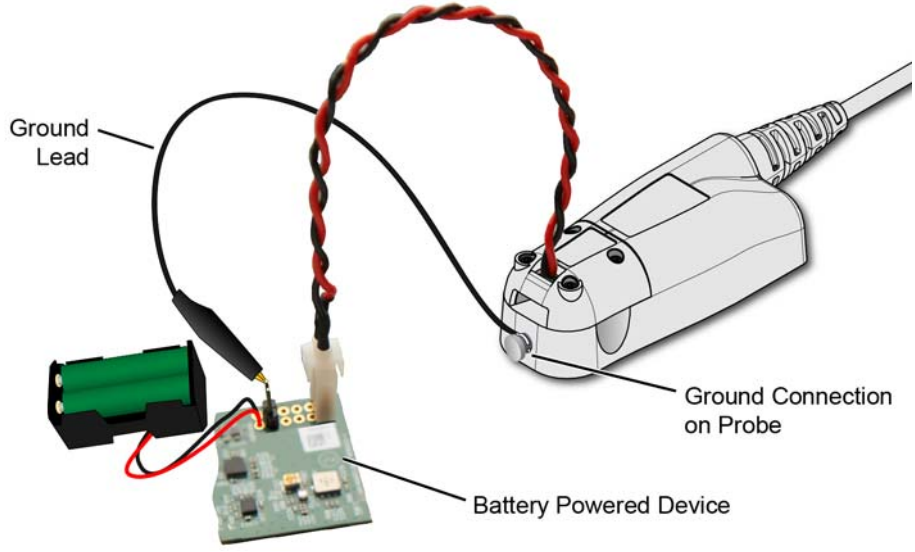


Figure 4 Supplied Ground Lead on Device

Connecting the Probe to The Oscilloscope

If you have an N2820A two-channel probe, locate the secondary cable and gently snap the cable into the probe amplifier as shown in Figure 5. The N2821A probes are not designed for use with the secondary cable and cannot be upgraded.

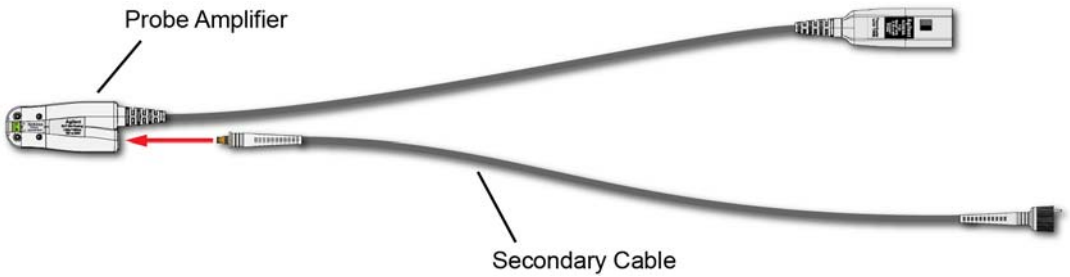


Figure 5 Connecting the N2820A's Secondary Cable

To Clean the Probe

Disconnect the probe from the oscilloscope and clean the probe with a soft cloth dampened with a mild soap and water solution. Make sure that the probe is completely dry before reconnecting it to an oscilloscope.

On N2820A probes, you can connect the primary and secondary probe cables to any available oscilloscope channel. Although connecting the cables to adjacent channels may reduce clutter, this is not a requirement. For example, you could connect an N2820A's primary cable to channel 2 and its secondary cable to channel 4. Connecting an N2820A probe *does require* connecting the primary cable first *promptly* followed by the secondary cable. This enables the oscilloscope to automatically associate the two inputs to the same probe. Figure 6 on page 14 is an example of connecting two N2820A probes to non-adjacent channel inputs.

NOTE

To ensure the display of accurate waveforms, *always* connect the supplied ground lead when probing battery-powered devices. Refer to "Measurements on Battery Powered Devices" on page 12.

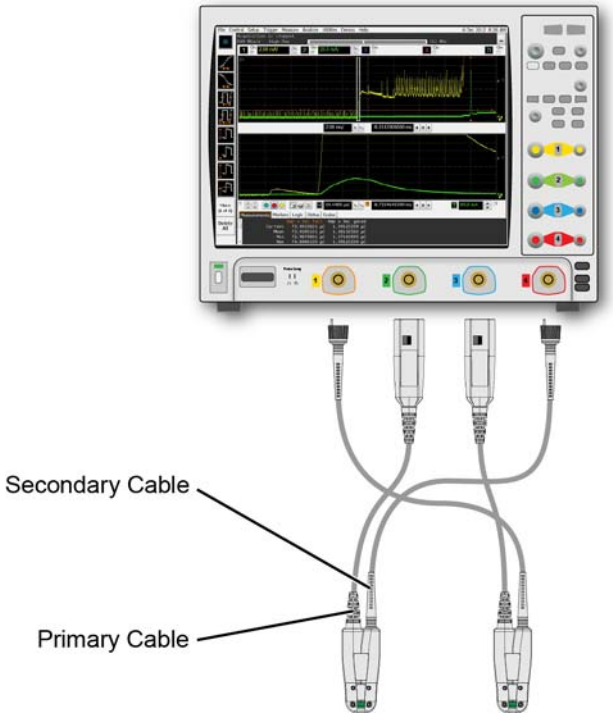


Figure 6 Two N2820A Probes Connected to the Oscilloscope

Probe Configuration (Infiniium Oscilloscopes)

Use the Probe Configuration dialog box to setup your probe. For N2820A probes, the probe's primary channel tab in the Probe Configuration dialog box configures both the primary and secondary channel. The secondary channel is listed on another tab but is not controlled from that tab.

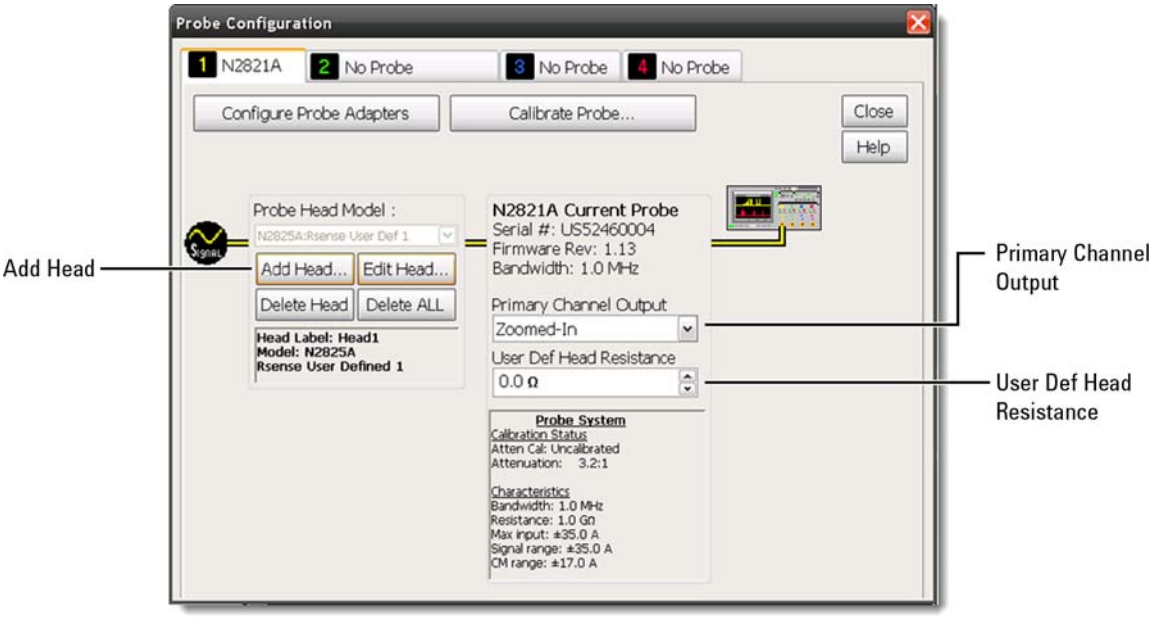


Figure 7 Infiniium's Probe Configuration Dialog Box (N2821A Probe)

To configure the probe

1. Connect the probe to the oscilloscope. On N2820A probes, connect the primary channel first followed by the secondary channel.
2. Click the **Setup** > **Probe Configuration** menu command.
3. In the Probe Configuration dialog box, click the tab that represents the primary channel for the probe.

4 If you are using an N2821A probe, use the **Primary Channel Output** field to configure the input channel as a zoomed-in or zoomed-out channel.

5 If you are using an N2825A user-defined head, in the dialog box click **Add Head** to assign a unique name to the head and enter the resistance of the external R_{SENSE} resistor in the **User Def Head Resistance** field. For more information, refer to "N2825A User-Defined Head" on page 37.

Probe Configuration (InfiniiVision Oscilloscopes)

For N2820A probes, softkeys for the probe's primary channel configure *both* the primary and secondary channel. Unlike Infiniium oscilloscopes, InfiniiVision oscilloscopes do *not* support the assigning of names to identify N2825A/R_{SENSE} combinations.

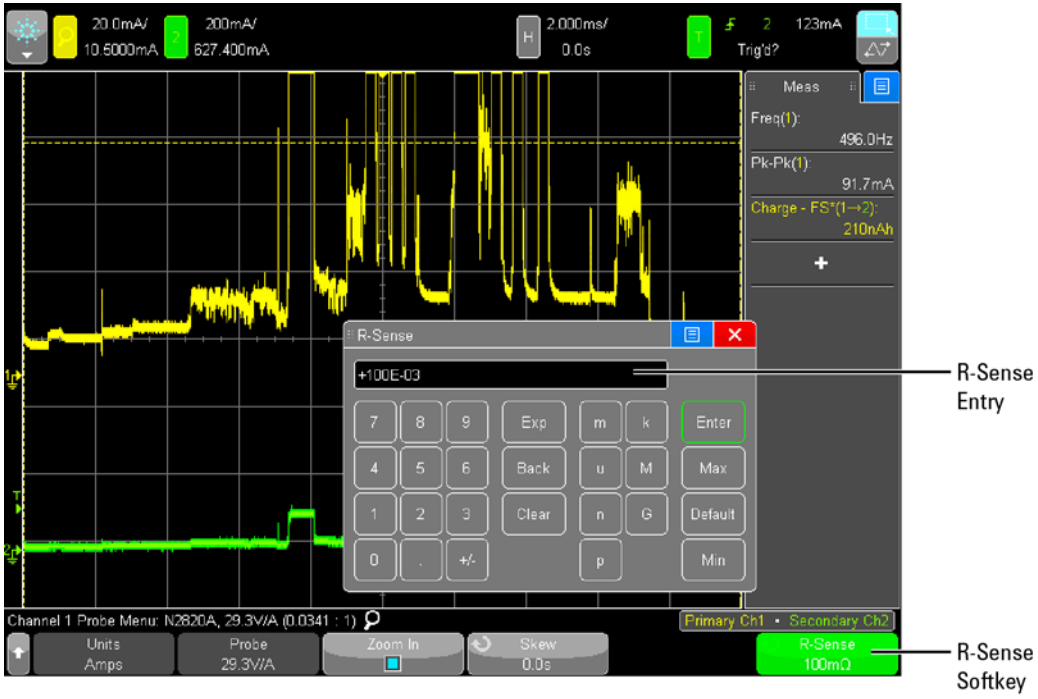


Figure 8 InfiniiVision's R-Sense Entry Box

To configure the probe

1. Connect the probe to the oscilloscope. On N2820A probes, connect the primary channel first followed by the secondary channel.
2. Press the front-panel channel key that is associated with the probe's primary input.
3. Press the **Probe** softkey.
4. If you are using an N2821A probe, press the **Zoom-In** softkey to toggle between zoomed-in (blue selection box on softkey) or zoomed-out (clear selection box) for the channel.
5. If you are using an N2825A user-defined head, press the **R-Sense** softkey, shown in Figure 8 on page 16, and enter the resistance of the R_{SENSE} resistor that you are using.

N2820A Probes and Dual-Grid View

When using an N2820A probe on a 9000 H-Series or 9000A Infiniium oscilloscope, the zoomed-in and zoomed-out waveforms can be simultaneously viewed in dual-grid view, as shown in Figure 9. In dual-grid view, the zoomed-out waveform originates from the probe's low-gain amplifier, and the zoomed-in waveform originates from the probe's high-gain amplifier. The zoomed-in waveform has less noise and dynamic range than the zoomed-out waveform.

NOTE Dual-Grid View is not supported in InfiniiVision oscilloscopes.

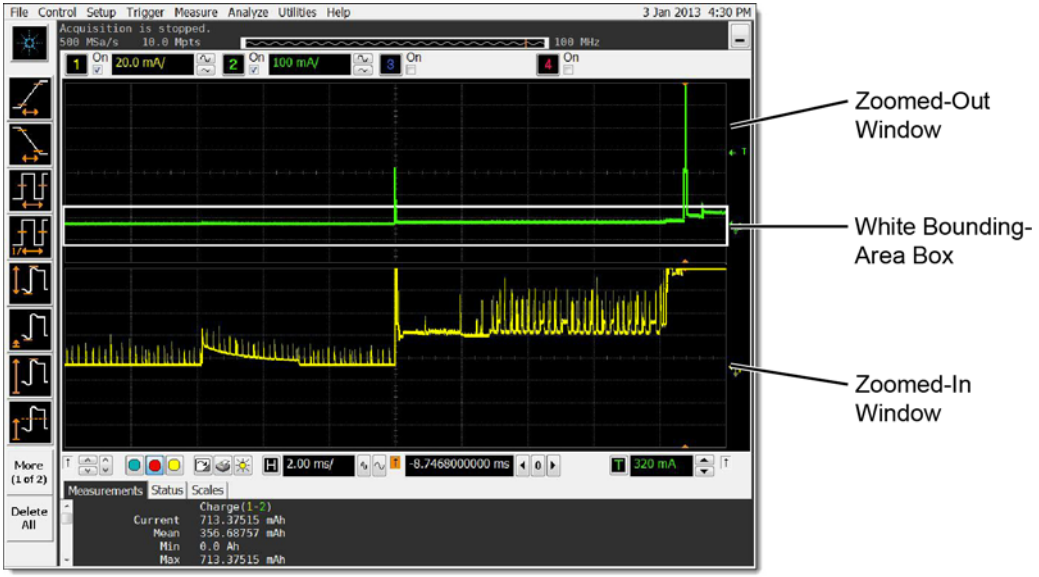


Figure 9 Displayed Zoom Windows

If you're familiar with the oscilloscope's Zoom Mode, you may be interested to know that while Zoom Mode uses software to expand the zoomed-in waveform, dual-grid view uses hardware amplification applied by the probe's high-gain amplifier.

On the display, the white bounding-area box identifies the portion of the zoomed-out waveform that is displayed in the zoomed-in window. This box does not indicate waveform clipping.

Dual-grid view allows simultaneous viewing of high sensitivity and high dynamic-range inputs. One example of using dual-grid view is to quickly identify and view a specific pulse and perform a DC power measurement on that pulse.

To view only one window, click **Setup** > **Display** to open the Display Setup dialog box and, in the **Quantity** field, select **1**.

NOTE For best measurement results, on the oscilloscope click **Setup** > **Acquisition** and select one of the **High Resolution** settings.

Charge—A New Measurement

For the N2820A and N2821A probes, the oscilloscopes include a new measurement, **Charge**. This measurement determines the total current consumption over time with the results listed in ampere-hours (**Ah**). For N2820A probes, the measurement includes the area under the curve across both zoomed-in and zoomed-out waveforms.

Figure 10 shows a **Charge** measurement on an Infiniium oscilloscope's with Zoom Mode applied and zoom window gating enabled. Figure 11 on page 21 shows the measurement on an InfiniiVision oscilloscope.

NOTE Always connect the ground lead when probing mobile phones, as explained in "Measurements on Battery Powered Devices" on page 12.

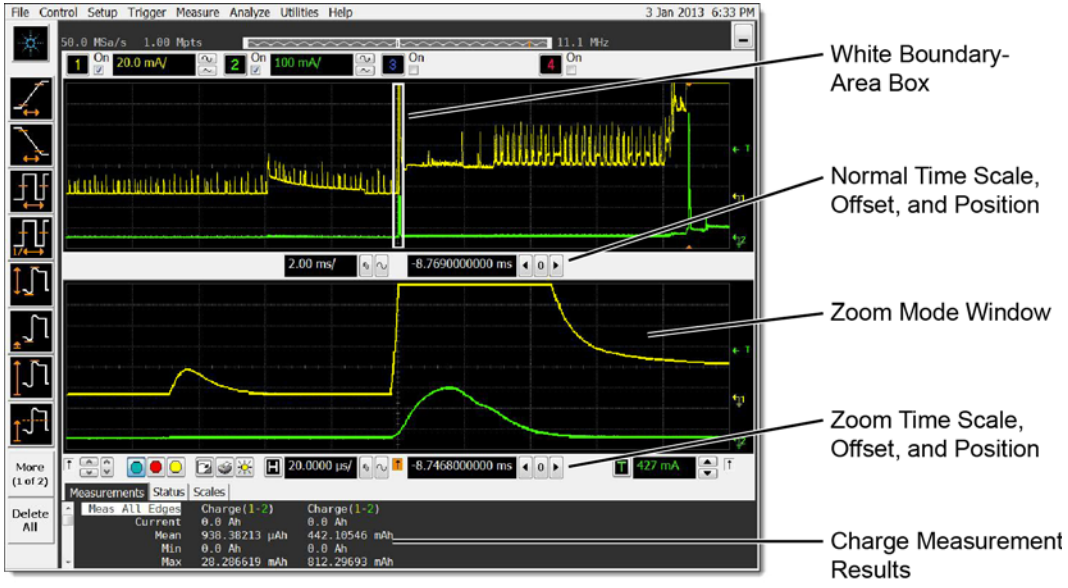


Figure 10 Charge Measurement of Mobile Phone Current in Standby State with Zoom Mode (Infiniium Oscilloscope)

Zoom Mode Buttons	
	9000 H-Series and 9000A Oscilloscopes
	3000 X and 4000 X-Series Oscilloscopes

With the oscilloscope's Zoom Mode turned on, gating can be used to show a reduced zoom-window time span compared to the normal window. This is indicated on the non-zoomed waveform by a white boundary-area box (Infiniium scopes) or a non-shaded boundary-area box (InfiniiVision scopes). Click the oscilloscope's **Zoom** button to turn on Zoom Mode. For Infiniium oscilloscopes you must additionaly select **Gate to Zoom Window** in the **Charge** measurement's Enter Measurement Info dialog box. Zoom mode is a software only expansion and results in the same vertical resolution and accuracy between the zoom and non-zoom waveforms.

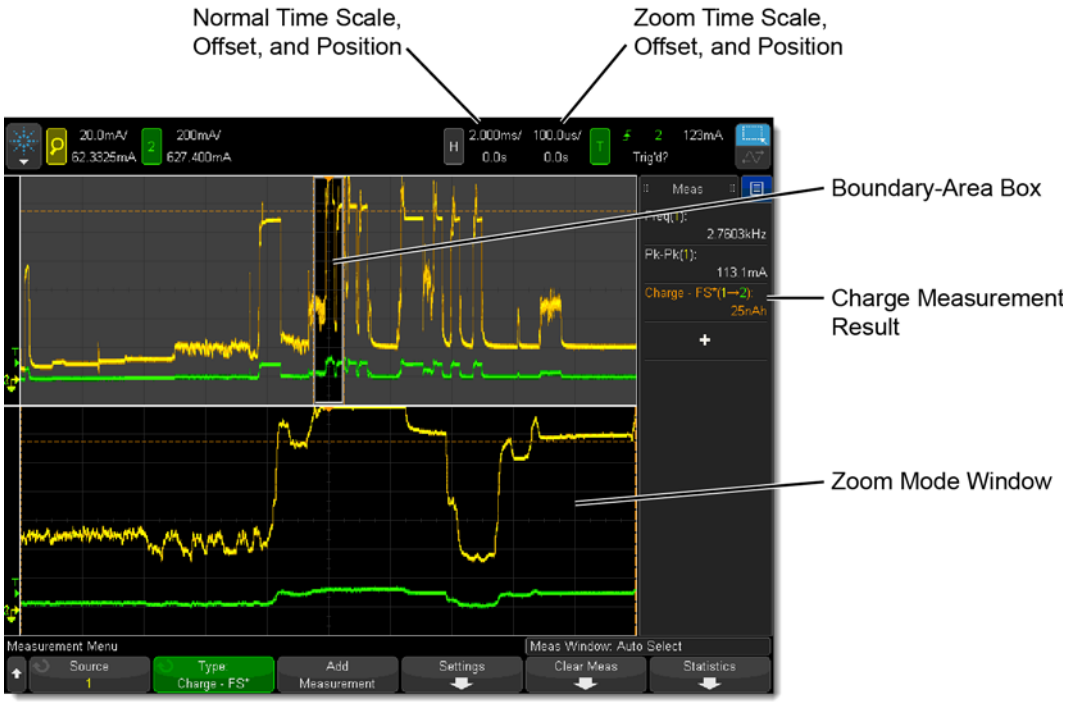


Figure 11 Full Screen Charge Measurement with Zoom Mode (InfiniiVision Oscilloscope)

On Infiniium Oscilloscopes

To make a Charge measurement:

1. Connect the probe. If an N2825A user-defined head is used, enter the R_{SENSE} resistance as explained in "Probe Configuration (Infiniium Oscilloscopes)" on page 15.
2. Click **Measure** > **Mixed** > **Charge (N282XA)**.
3. In the Enter Measurement Info dialog box:
   a. If Zoom Mode is turned on, select **Gate to Zoom Window** to enable a reduced zoom-window time span. If Zoom Mode is turned off, the **Gate to Zoom Window** field is not selectable (grayed out).
   b. If more than one N2820/1A probe is connected in the oscilloscope, the dialog box allows you to select the probe used for the measurement.

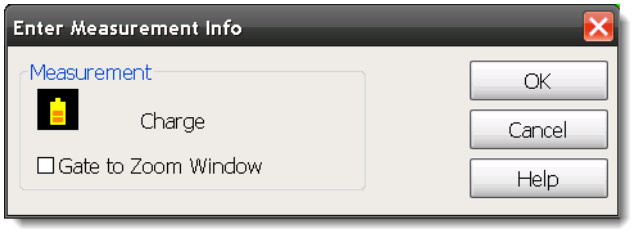


Figure 12 Enter Measurement Info Dialog Box

On InfiniiVision Oscilloscopes

To make a Charge measurement:

1. Connect the probe. If an N2825A user-defined head is used, enter the R_{SENSE} resistance as explained in "Probe Configuration (InfiniiVision Oscilloscopes)" on page 16.
2. Press the front-panel **Meas** key.
3. Press the **Type:** softkey.
4. Select one of two measurements:

   Charge - Full Screen. The Full Screen measurement interval variation measures the value on all displayed data points. For more information, refer to the oscilloscope's Help system.

   Charge - N Cycles. The N Cycles measurement interval variation measures the value on an integral numer of periods of the displyed signal. If less than three edges are present, the measurement shows "No edges". For more information, refer to the oscilloscope's Help system.
5. If more than one N2820/1A probe is connected to the oscilloscope, softkeys appear that allow you to specify the channel on which to perform the measurement.

Dynamic Range

The N2820A and N2821A probes provide a large dynamic measurement range (>20,000:1 or 86 dB on the zoomed-in channel) that allows you to observe both the entire current waveform and extremely small current fluctuations. As shown in Figure 13, you could simultaneously view a mobile phone's 135 mA receive current pulses and 2 mA idle current in the presence of 2A transmit current pulses, with a single acquisition. When using N2820A probes on Infiniium oscilloscopes, use the powerful new dual-grid view as explained in "N2820A Probes and Dual-Grid View" on page 18.

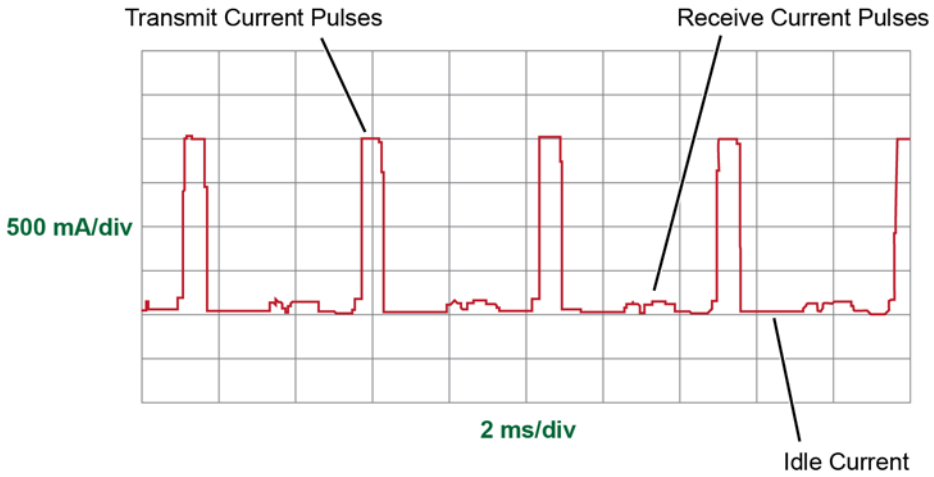


Figure 13 Small Pulses in the Presence of Large Pulses

R_{SENSE} Value and Dynamic Range

Since the N2820A probe has two outputs, each with a different gain, dynamic range encompasses both channels while using a single R_{SENSE} value. For example, with a 100 mΩ R_{SENSE} resistor, the zoomed-in waveform can display

about 50 µA and the zoomed-out channel can display about 2.2A for a dynamic range of approximately 93 dB:

$$93\,dB = 20\log\frac{2.2A}{50\,\mu A}$$

The value of the R_{SENSE} resistor can range from 1 mΩ to 1 MΩ as shown in Figure 29, "Maximum Current Range," on page 54. Using these two R_{SENSE} values in different measurements, the dynamic range could be increased to 100 dB.

Effects Other Than Dynamic Range

Selecting the proper R_{SENSE} resistance is often a compromise between a value that is large enough to obtain accurate measurements while small enough to avoid negatively affecting the circuit under test. Increasing the resistance

- *decreases* the noise,
- *increases* sensitivity, and
- *increases* the burden voltage across the R_{SENSE} resistor (I^2R).

Decreasing the resistance will have the opposite effect.

Channel Position on the Screen

This probe does not have voltage offset. Use the oscilloscope's position controls to adjust the location of the waveform on the screen. Vertical scaling occurs about zero amperes.

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 Agilent 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 Agilent Technologies Sales Office.

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

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 Agilent Technologies for service.

1. Contact your nearest Agilent 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, N2820A)
   - 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 Agilent Technologies

For technical assistance, contact your local Agilent Call Center.

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

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

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 **Keep Away From Live Circuits.**
Avoid open circuitry. Do not touch connections or components when power is present.

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.

NOTE Avoid, if possible, the proximity of other conductors which may create noise.

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.

2
Probing

In this chapter, you'll learn how to configure and connect the probe to your Device Under Test (DUT). The probe accessories are very flexible and can be configured to match your unique probing requirements regarding convenience versus accuracy. Some of these connection options are compared in Figure 14 on page 33.

Introduction

As mentioned in chapter 1, there are three interchangeable R_{SENSE} probe heads: N2822A, N2824A, and N2825A. The N2822A and N2824A heads include different internal R_{SENSE} resistor values. The N2825A user-defined head does *not* include an R_{SENSE} resistor and is selected in situations when you want to use your own external R_{SENSE} resistor that is mounted on your DUT. For instructions on how to attach a probe head to the probe, refer to "Attaching a Probe Head" on page 34. Figure 14 on page 33 illustrates the relative merits of using the three different heads and the method used to connect them to your DUT.

CAUTION Always wear an ESD wrist strap when working with active probes. Not doing so can result in the probe becoming permanently damaged.

Probe Leads

The probe heads do not come with the leads soldered on them. Instead, you must solder on the appropriate leads as described in "To Attach the Sensor Leads" on page 44. You can use any of the following leads:

- Accessory un-socketed leads (22 AWG).
- Accessory socketed leads (22 AWG).
- Your own leads.

The socketed leads are designed to plug directly onto the following items:

- Standard PC board headers with 2.54 mm (0.1") contact-pitch spacing.
- MBB accessory headers mounted on the PC board. You can quickly snap the socketed lead on and off the MBB header.

Dynamic Range

Refer to "Dynamic Range" on page 24 to learn how the selection of the R_{SENSE} resistor affects dynamic range.

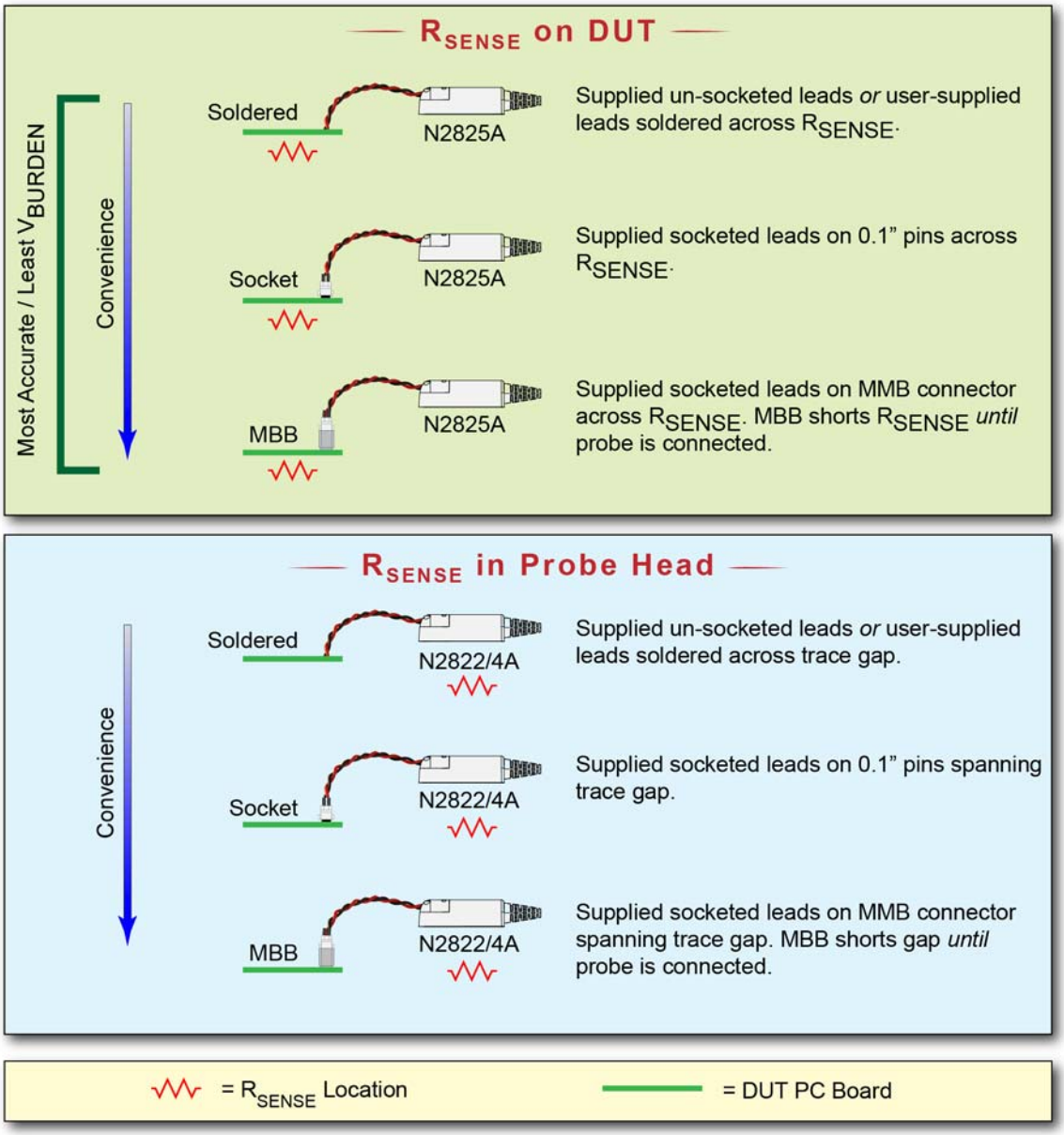


Figure 14 Different Probing Connections With Relative Merit

Attaching a Probe Head

You do not need any tools to attach or remove a probe head. To attach a head to the probe, gently press the head into position on the probe amplifier while carefully mating the connector as shown in Figure 15. Never apply excessive force when attaching the head. To remove a head, pull the head straight off the probe in the direction shown.

NOTE Do not remove the four head screws when removing the head.

NOTE You can safely change a probe head while the probe is connected to an oscilloscope that is powered on.

CAUTION If lead wires are attached, do not pull on the wires as this could damage the head.

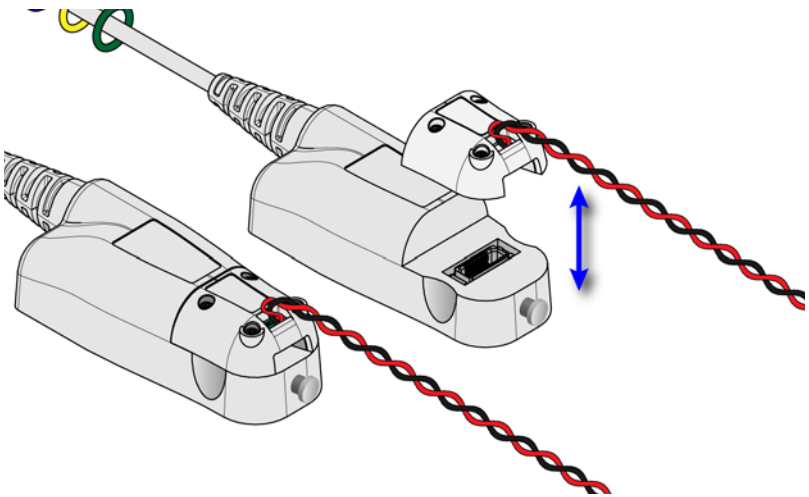


Figure 15 Attaching and Removing a Head from the Probe

N2822/4A Probe Heads

The N2822/4A heads include an R_{SENSE} resistor. Because the oscilloscope recognizes when these probes are connected, the oscilloscope automatically knows the value of the R_{SENSE} resistor when calculating measurements.

Table 3 Description of Heads

Description	N2822A	N2824A
R_{SENSE} Resistor	20 mΩ	100 mΩ
R_{SENSE} Tolerance	±1%	±1%
Maximum Power Dissipation[a]	500 mW	500 mW
Current Range	250 µA to 5A	50 µA to 2.2A
Added Benefit	Smaller voltage drop (lower burden voltage).	For higher sensitivity (ie. lower noise).

a Temperature coefficient is 20 ppm / °C

CAUTION The maximum sensor resistor power rating is 500 mW. The maximum acceptable average current for the N2822A is 5 A_{rms} and N2824A is 2.2 A_{rms}.

Burden Voltage

When an N2822/4A head is used, the resistance of the head's connectors, sensor leads, and internal R_{SENSE} resistor is connected in series with the DUT's circuit and current is flowing through the probe head, as shown in Figure 16 on page 36. Therefore, a burden voltage (I^2R) is introduced into your circuit. Burden voltages may affect the circuit and will tend to increase the noise. Burden voltages do *not* affect the measurement. Table 4 on page 36 lists the resistances added by various probing components.

NOTE N2825A heads do not contribute a burden voltage as the current is *not* flowing through the head.

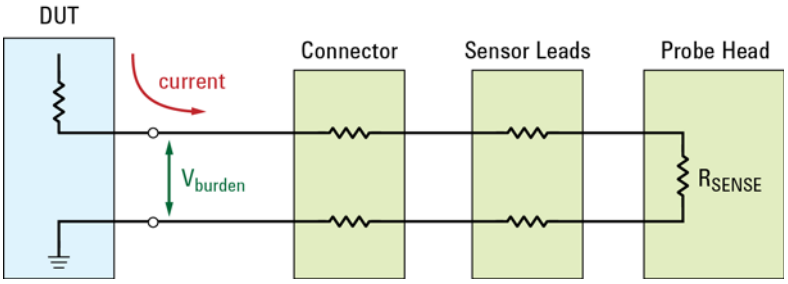


Figure 16 V_{burden} Developed Across Probing Components

Table 4 Resistance Added by Head Components

Component	Resistance Contribution (Round Trip)
Sensor Leads Without Socket	20 mΩ
Sensor Leads With Socket	40 mΩ
MBB Header Only (Not Connected)	20 mΩ
MBB Header/Receptacle/Socket	40 mΩ
R_{SENSE} (N2822A Head)	20 mΩ
R_{SENSE} (N2824A Head)	100 mΩ

Need a Different R_{SENSE} Resistor Value?

If you need to use a different R_{SENSE} resistance than provided by the N2822A and N2824A heads, you can convert an N2825A head to an internal R_{SENSE} head. Refer to "Converting an N2825A to Internal RSENSE Head" on page 39.

NOTE Do not change the R_{SENSE} resistor in N2822A or N2824A heads.

N2825A User-Defined Head

Use the N2825A user-defined head in situations where you want to use your own R_{SENSE} resistor that you have mounted on your DUT. As shown in Figure 14 on page 33, the N2825A head has the lowest burden voltage. But, in some situations, the N2825A head may be less convenient to use than the N2822A and N2824A heads.

Associating a Head with an R_{SENSE} Resistance

On Infiniium oscilloscopes, use the Probe Configuration dialog box, shown in Figure 17, to associate an N2825A head with a specific R_{SENSE} resistance on your DUT. This enables the oscilloscope to make accurate measurements. The dialog box fields are explained in the following sections.

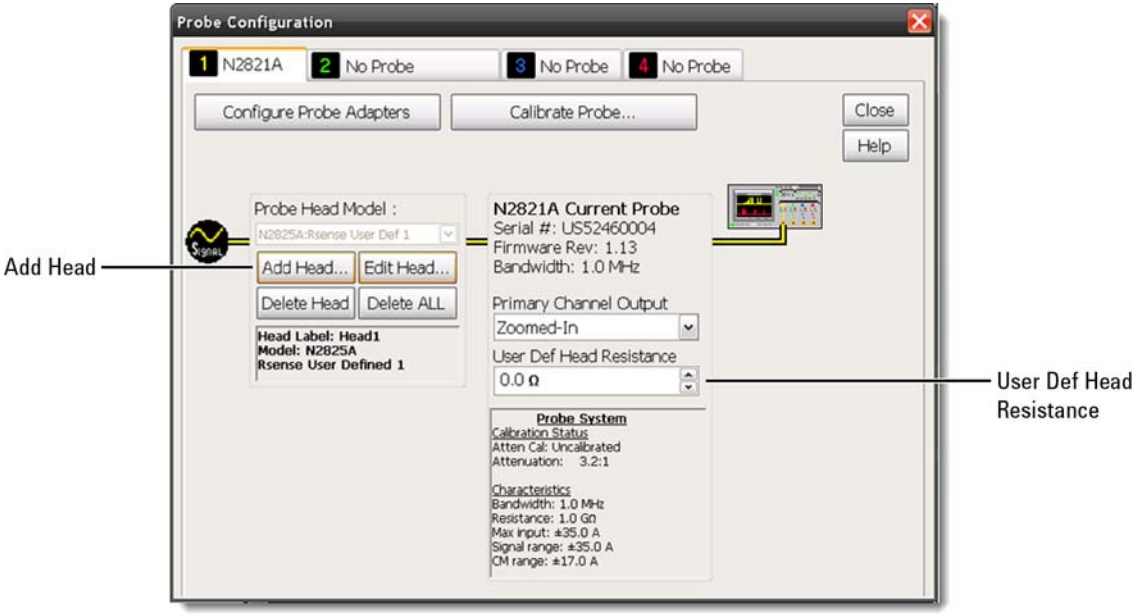


Figure 17 Infiniium Dialog Box With N2825A Heads

In the dialog box, use the **User Def Head Resistance** field to enter the R_{SENSE} resistance. Because the oscilloscope associates this resistance with the N2825A head, you only need to enter the value of your R_{SENSE} resistor the first time that you use the N2825A head.

On InfiniiVision oscilloscopes, associate an N2825A head with a specific R_{SENSE} resistance by pressing the front-panel channel key that is associated with the probe's primary input. Then, click the **Probe** softkey followed by the **R-Sense** softkey.

Using Multiple R_{SENSE} Resistances in Your DUTs?

In this situation you can do one of the following actions:

- Enter the **User Def Head Resistance** each time that you use the N2825A head, or
- On Infiniium oscilloscopes, open the Probe Configuration dialog box, and use the **Add Head** field to assign a unique name for each of your N2825A/R_{SENSE} resistance associations. Each time that you connect the probe, select the appropriate name in the dialog box.
- If you use less than six different R_{SENSE} resistances in your DUTs, you can avoid entering the resistance or selecting a name (Infiniium only) each time that you use the N2825A. This is accomplished by changing the N2825A's internal ID resistor as explained in "To Change an N2825A Head's ID Resistor" on page 45. After changing the ID resistor, the first time that you use the N2825A you must enter the associated R_{SENSE} resistance. However, for subsequent uses, the oscilloscope automatically associates this resistance with the specific N2825A head. You can order additional N2825A heads from Agilent.

NOTE Remember to mark your different N2825A heads, using a marker pen or tape, so that you can distinguish between them.

Converting an N2825A to Internal R_{SENSE} Head

Although the N2825A is intended to be used with an external R_{SENSE} resistor mounted on your DUT, you can add an R_{SENSE} resistor internal to the N2825A head. This converts the N2825A head so that it is similar to the N2822/4A heads. The value of the precision resistor can range from 1 mΩ to 1 MΩ in 1 mΩ increments. You must still enter the R_{SENSE} resistance the first time that you connect the converted N2825A to the oscilloscope. Refer to "To Add an RSENSE Resistor to an N2825A Head" on page 49. You could also change the head's internal ID resistor as explained "Associating a Head with an RSENSE Resistance" on page 37.

Make-Before-Break Connectors

The supplied Make-Before-Break (MBB) connectors allow you to quickly probe multiple locations on your DUT without having to solder or unsolder the leads. You can easily connect and disconnect them without interrupting the circuit-under-test as shown in Figure 18. The MBB can be used with all R_{SENSE} probe heads including the N2825A user-defined probe head.

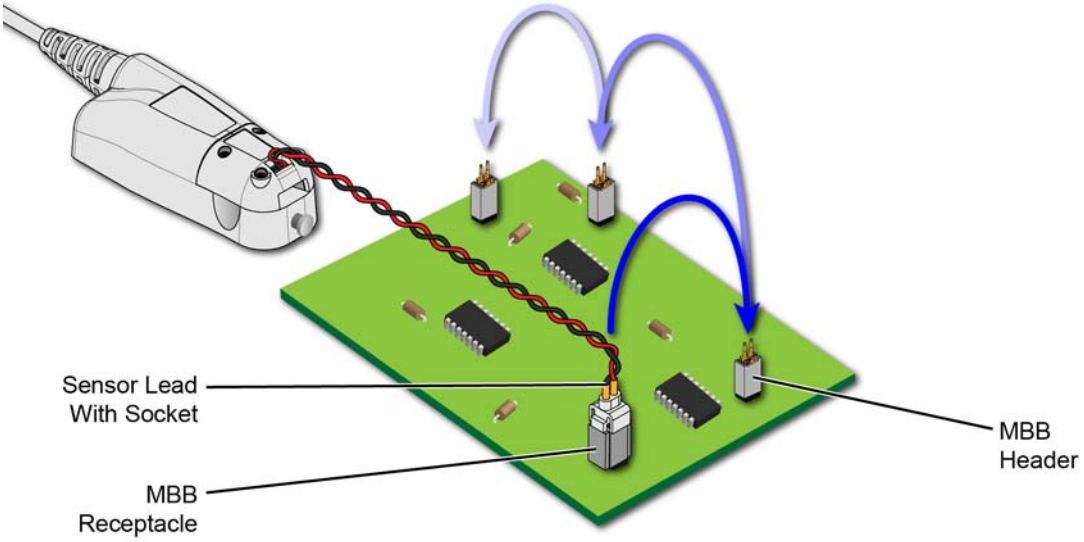


Figure 18 Probing with MBB Connector on DUT

MBB connectors consist of a receptacle and header. A sensor lead with socket snaps onto the receptacle as shown in Figure 19 on page 41.

The header has two 0.025" square pins that are soldered onto pads with 2.54 mm (0.1") contact-pitch spacing.

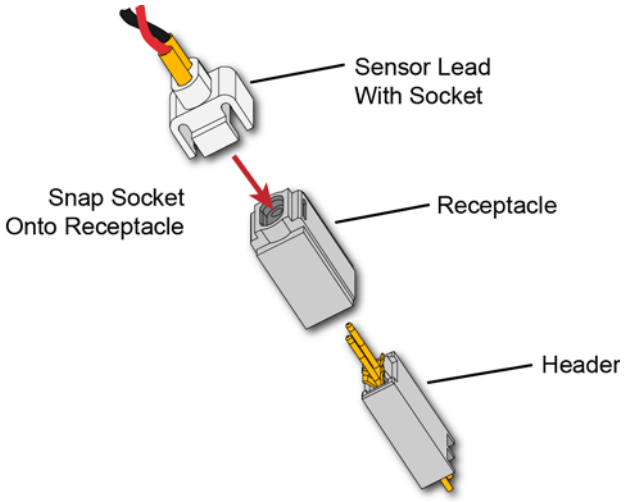


Figure 19 Socketed Lead Snaps Onto the MBB Receptacle

To Use the MBB Connector

1. Solder one or more headers onto your DUT.
2. Snap the sensor lead's socket onto the receptacle.

NOTE Once attached to the receptacle, the socket cannot easily be removed without deforming the receptacle. For information on ordering additional socketed sensor leads, receptacles, and headers, refer to Table 2 on page 11.

3. Repeatedly plug the lead with MBB receptacle onto different headers as you probe your DUT.

Figure 20 illustrates how the MBB connection changes as you gently push the socket/receptacle onto the header while using an N2822/4A head. Figure 21 on page 43 shows the schematic when using the MBB with an N2825A user-defined head.

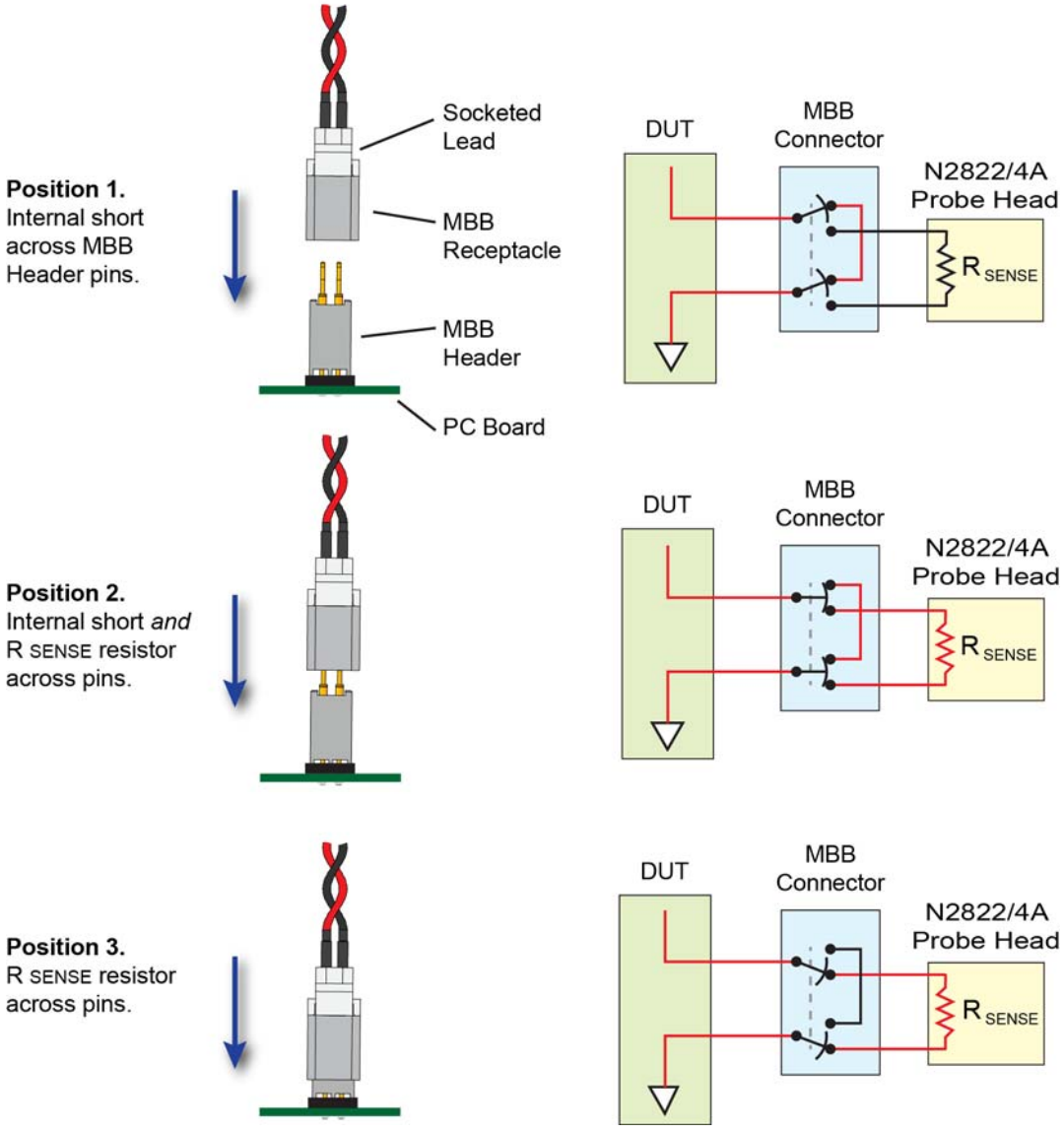


Figure 20 Connecting the MBB Connector with N2822/4A Head

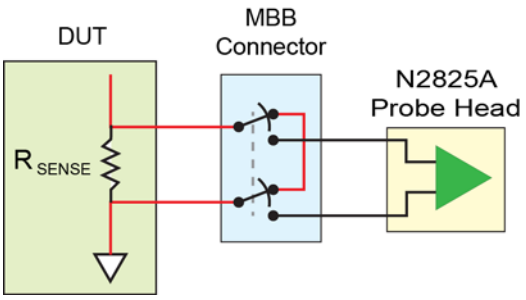


Figure 21 MBB Connector With N2825A User-Defined Head

To Download the Header Gerber File

You can download a Gerber file from Agilent that defines many of the parameters needed to design the PC board connection for the MBB header. Gerber files can be imported into many PC board layout applications. You can download this file using the following URL:

www.agilent.com/find/N2828A

For information on the physical dimensions of the MBB header and MBB socket/receptacle, refer to Figure 34 on page 59.

To Attach the Sensor Leads

1. Detach the head from the probe amplifier as explained in "Attaching a Probe Head" on page 34.
2. Position the sensor leads into the head's access hole as shown in Figure 22.

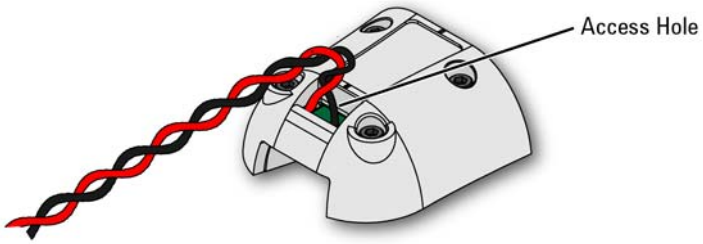


Figure 22 Placing the Leads into the Tip's Access Hole

3. Flip the head as shown in Figure 23 and insert the leads up through the PC board's solder holes **TP1** and **TP2**. Insert the **RED** (+) lead at TP2 and the **BLACK** lead at TP1. Solder the leads in place.

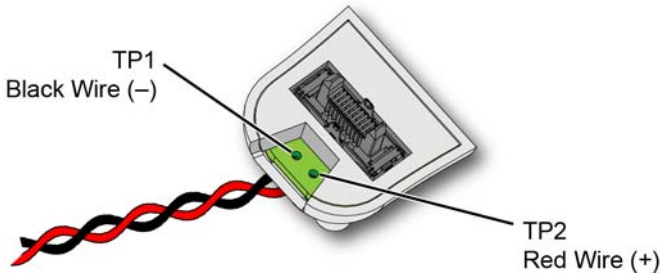


Figure 23 Lead Positions on PC Board

To Change an N2825A Head's ID Resistor

1 Detach the head from the probe amplifier as explained in "Attaching a Probe Head" on page 34.

2 Remove the four hex screws that secure the cover of the N2825A R_{SENSE} head and remove the cover.

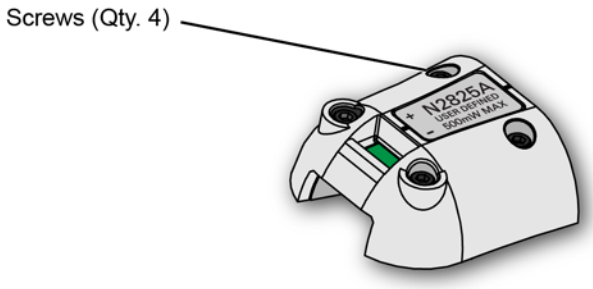


Figure 24 Removing the N2825A Cover

3 Remove the PC board from the head.

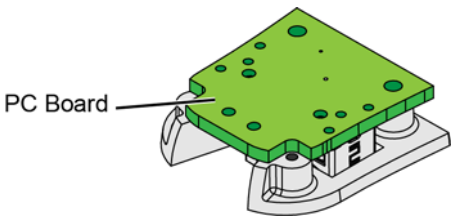


Figure 25 Remove PC Board

4 On the reverse side of the PC board, locate ID resistor, R2, as shown in Figure 26.

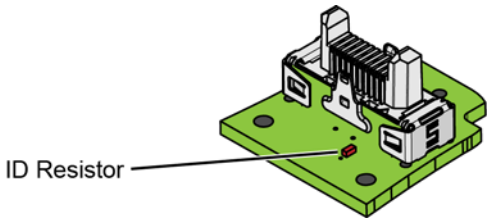


Figure 26 Location of ID Resistor (R2)

5 Replace the ID resistor with one of the values listed in Table 5. The default value loaded on the board is 16.2 kΩ. You can purchase a resistor from a supplier such as Digi-Key corporation.

CAUTION If you are *not* skilled in soldering, ask a trained assembler to change the resistor.

Table 5 Valid N2825A ID Resistors

Resistor Value	Description
16.2 kΩ	Default value. Resistor, ±1%, 0.063W, TC±100 thick film 0402 SMT
19.6 kΩ	Resistor, ±1%, 0.063W, TC±100 thick film 0402 SMT
26.1 kΩ	Resistor, ±1%, 0.063W, TC±100 thick film 0402 SMT
42.4 kΩ	Resistor, ±1%, 0.063W, TC±100 thick film 0402 SMT
61.9 kΩ	Resistor, ±1%, 0.063W, TC±100 thick film 0402 SMT

6 Replace the N2825A's cover using the four screws. (M1.6 x 0.35, 5 mm long, Agilent part number 0515-5210)

CAUTION To avoid damaging the aluminum casting, do not over tighten the screws.

7 Connect the N2825A to an N2820/1A probe and connect the probe to the oscilloscope.

8 On Infiniium oscilloscopes,

a Click the **Setup** > **Probe Configuration** menu command.

b Select the tab for the probe's primary channel. N2821A probes only have a primary channel.

c In the **User Def Head Resistance** field, enter the resistance of the DUT's R_{SENSE} resistor in ohms.

d In the dialog box, click **Add Head** to give your head with associated external R_{SENSE} resistor a unique name.

9 On InfiniiVision oscilloscopes,

a Press the front-panel channel key that is associated with the probe's primary input.

b Click the **Probe** softkey.

c Press the **R-Sense** softkey and enter the resistance of the R_{SENSE} resistor that you are using.

10 For future reference, mark your different N2825A heads using a marker pen or tape and record the information in Table 6 on page 48. In the table's fourth column, record the name that you entered in the Probe Configuration dialog box.

Table 6 N2825A Identification

N2825A Marking	Associated DUT R_{SENSE} Resistor Value	ID Resistor Value	Probe Name Registered on the Oscilloscope

To Add an R_{SENSE} Resistor to an N2825A Head

You can add your own R_{SENSE} resistor to N2825A heads. Use a resistor of type ±1%, 0.5W, TC ±600, thick film 2010 SMT. The value of the precision resistor can range from 1 mΩ to 1 MΩ in 1 mΩ increments. When selecting the resistance value, you must observe the 500 mW maximum power rating of the head.

1 Detach the head from the probe amplifier as explained in "Attaching a Probe Head" on page 34.

2 Remove the four hex screws that secure the head's cover and remove the cover.

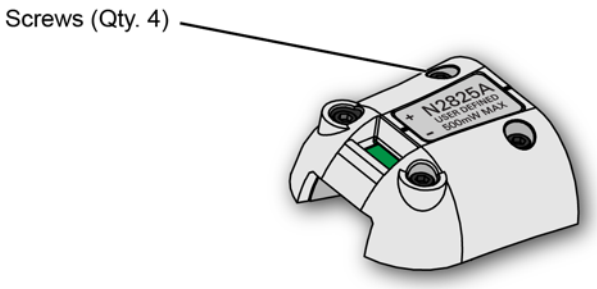


Figure 27 Removing the Cover

3 Change or add the R_{SENSE} resistor (R1) as shown in Figure 28.

CAUTION If you are *not* skilled in soldering, ask a trained assembler to change the resistor.

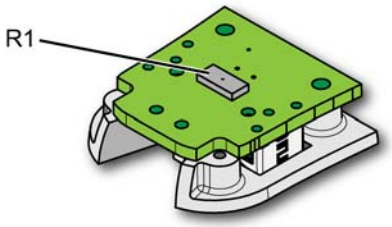


Figure 28 Location of R_{SENSE} Resistor (R1)

4 Replace the head's cover using the four screws. (M1.6 x 0.35, 5 mm long, Agilent part number 0515-5210)

CAUTION To avoid damaging the aluminum casting, do not over tighten the screws.

5 Connect the N2825A to an N2820/1A probe and connect the probe to the oscilloscope.

6 On Infiniium oscilloscopes,

- a Click the **Setup** > **Probe Configuration** menu command.
- b Select the tab for the probe's primary channel. N2821A probes only have a primary channel.
- c In the **User Def Head Resistance** field, enter the resistance of the DUT's R_{SENSE} resistor in ohms.
- d In the dialog box, click **Add Head** to give your head with associated external R_{SENSE} resistor a unique name.

7 On InfiniiVision oscilloscopes,

- a Press the front-panel channel key that is associated with the probe's primary input.
- b Click the **Probe** softkey.
- c Press the **R-Sense** softkey and enter the resistance of the R_{SENSE} resistor that you are using.

3 Characteristics and Specifications

This chapter provides the characteristics and specifications for the N2820A and N2821A probes. The probe should be warmed up for at least 20 minutes before any testing and the environmental conditions should not exceed the probe's specified limits.

Table 7 Characteristics and Specifications

Item	Characteristic
Bandwidth (–3 dB)	Zoom-Out Channel: DC to 3 MHz Zoom-In Channel: DC to 500 kHz
Risetime (Tr = 0.35/BW, 10% – 90%)	Zoom-Out Channel: < 0.116 µs Zoom-In Channel: < 0.7 µs
Minimum Measurable Current[a]	250 µA (with N2822A 20 mΩ,) 50 µA (with N2824A 100 mΩ,) 5 mA (with N2825A user defined 1 mΩ,) 500 nA (with N2825A user defined 1 kΩ,)
Maximum Measurable Current	5A (with N2822A 20 mΩ, 500 mW) 2.2A (with N2824A 100 mΩ, 500 mW) 5A (with N2825A, 1 mΩ installed) 1.2 mA (with N2825A user defined 1 kΩ,)
Output Voltage Rate	Zoom-In Channel: 6 V/A (with N2822A 20 mΩ) 30 V/A (with N2824A 100 mΩ) Zoom-Out Channel: 0.04 V/A (with N2822A 20 mΩ) 0.6 V/A (with N2824A 100 mΩ)
Amplitude Accuracy[b] (specification)	±3% or 10 µA (whichever is greater)
Maximum Input Voltage	±12V
Burden Voltage (voltage drop on R_{SENSE})	Measured current * R_{SENSE}
Dynamic Range	20,000:1, 86 dB (N2820A) 1,000:1, 60 dB (N2821A)
Output Impedance	1 MΩ
Gain (warranted specification)	Zoom-In: 300 ±3% Zoom-Out: 1.95 ±3%
Noise, AC_{rms}	150 µA (with N2822A 20 mΩ, (hi res mode on) [c] 240 µA (with N2822A 20 mΩ, (hi res mode off) 30 µA (with N2824A 100 mΩ, (hi res mode on) [b] 50 µA (with N2824A 100 mΩ, (hi res mode off)
Sensor Resistor Accuracy	±1% (N2822A, N2824A)
Sensor Resistor Power Rating	500 mW (N2822A, N2824A)
Temperature Coefficient of Sensor Resistor	< 20 ppm/°C
Cable Lengths	Sensor leads: 16 cm Probe cable: 1.2m

a V_{supply} is equal to 5V, solder attached.

b Denotes warranted spec after 20 minute warm up. All others entries in the table are characteristics.

c With scope with high resolution mode on, sampling rate < 2.5 MSa/s, 20 MHz low-pass filter on.

Table 8 Environmental Characteristics

Item	Characteristic
Temperature (operating)	Operating: 0° C to 40° C Non-Operating: –40° C to 70° C
Humidity (operating)	Operating: tested at 95% RH @ +40° C Non-Operating: tested at 90% RH, +65° C
ESD	8 kV HBM
Indoor Use	This probe is rated for indoor use only

Table 9 Compatible Oscilloscopes

InfiniiVision Oscilloscopes
3000 X-Series (with software version 2.30 or higher)
4000 X-Series (with software version 3.10 or higher)
Infiniium[a] Oscilloscopes
9000A and 9000 H-Series (with software version 4.20 or higher)

a Infiniium 90000A and 90000 X/Q-Series oscilloscopes are not compatible with N2820/1A current probes.

Current Range Graphs

The following graphs show the minimum and maximum current ranges versus R_{SENSE} resistance.

NOTE These graphs represent a condition where the sensor leads are solder attached to the R_{SENSE} resistor, the maximum probe-head power rating of 500 mW is observed, and the oscilloscope is set to high-resolution.

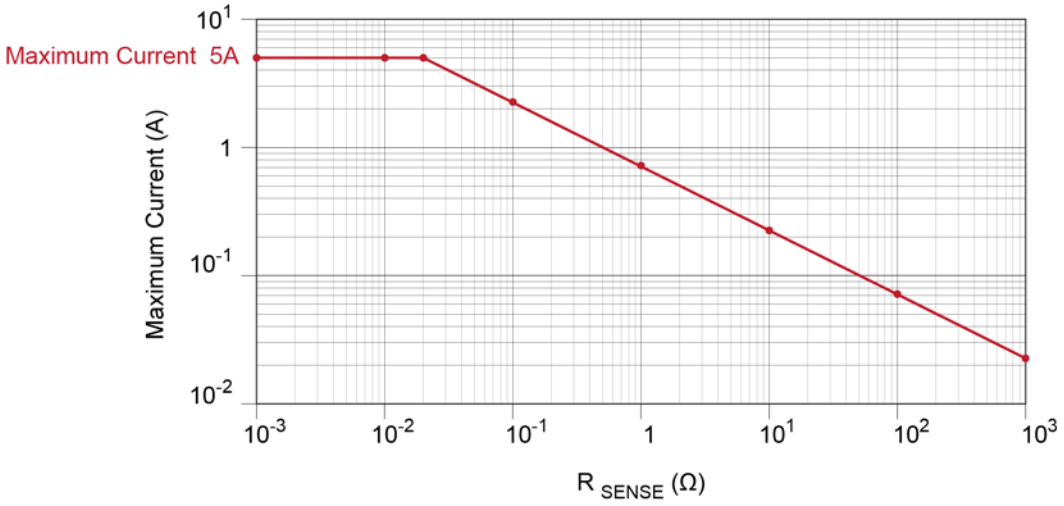


Figure 29 Maximum Current Range

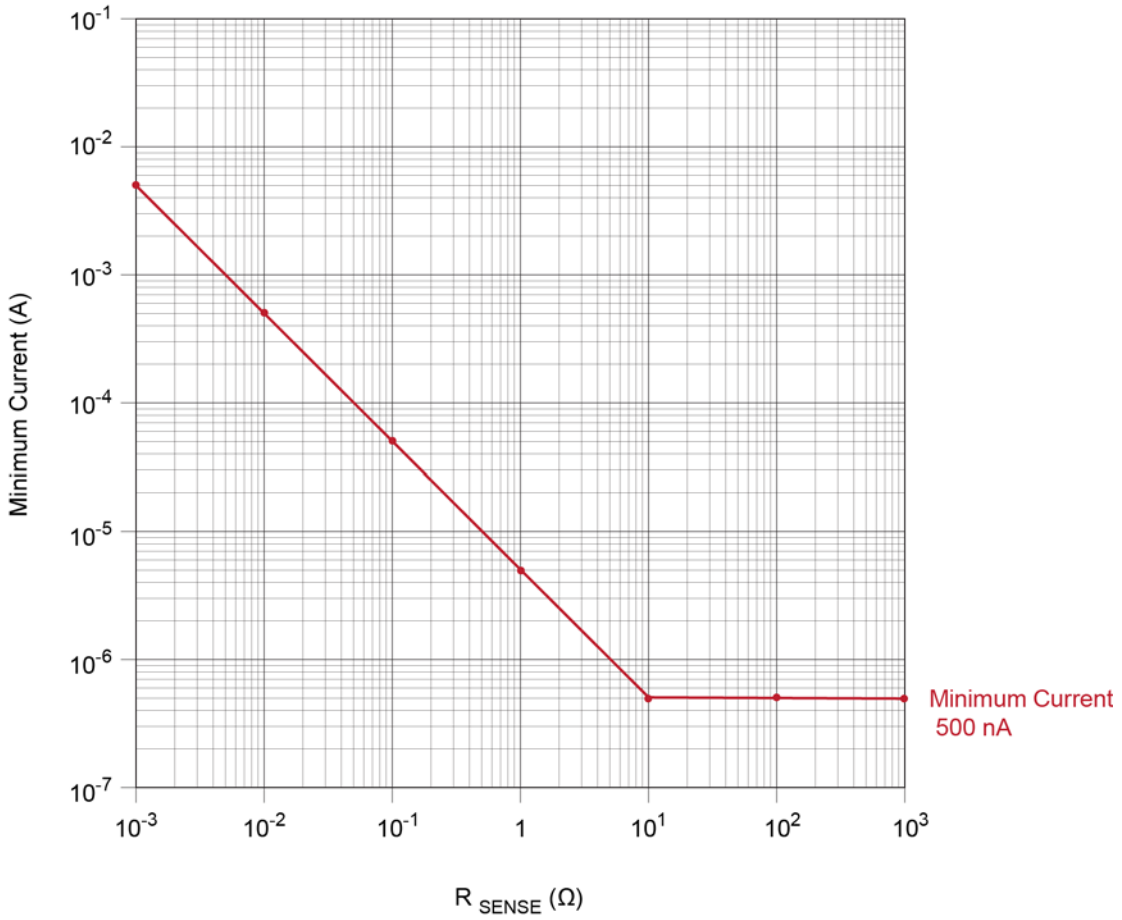


Figure 30 Minimum Current Range

Zoomed-In Input Voltage Range Versus Supply Voltage

For the zoomed-in probe input, the following graph shows the *typical* input voltage range allowed based on the supply voltage that you are measuring. For example, when measuring a 5V input, the input voltage range is ±45 mV.

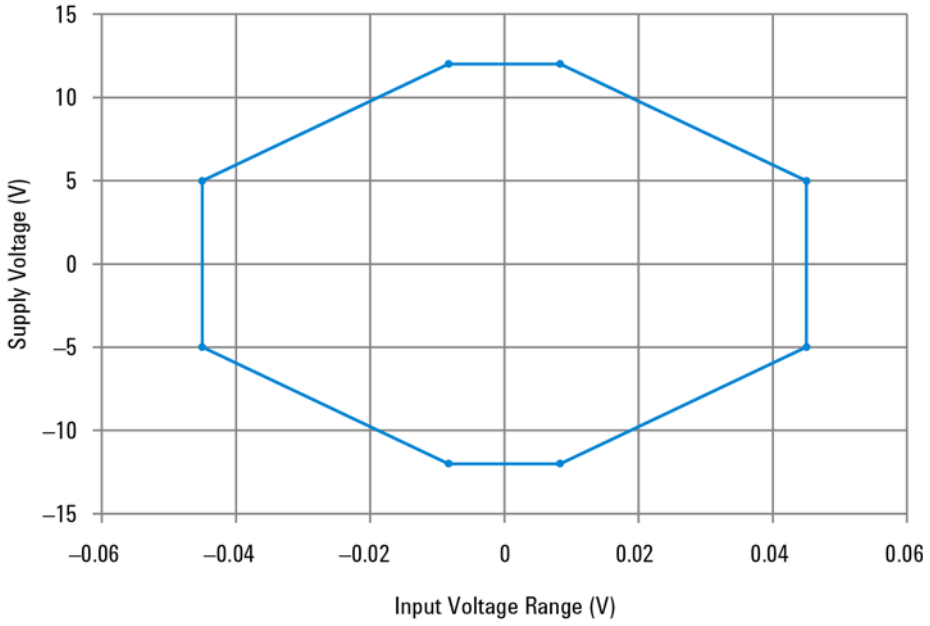


Figure 31 Zoomed-In Input Voltage Range Versus Supply Voltage

NOTE This plot can be used with N2825A heads (user-defined R_{SENSE}) to verify current range versus supply voltage.

Zoomed-In Input Current Range Versus Supply Voltage

For the zoomed-in probe input, the following two graphs show the *typical* input current range allowed based on the supply voltage that you are measuring. For example, when using an N2824A head and measuring a 5V input, the current range is ±0.54A. When using an N2822A head and measuring a 5V input, the current range is ±1.0A.

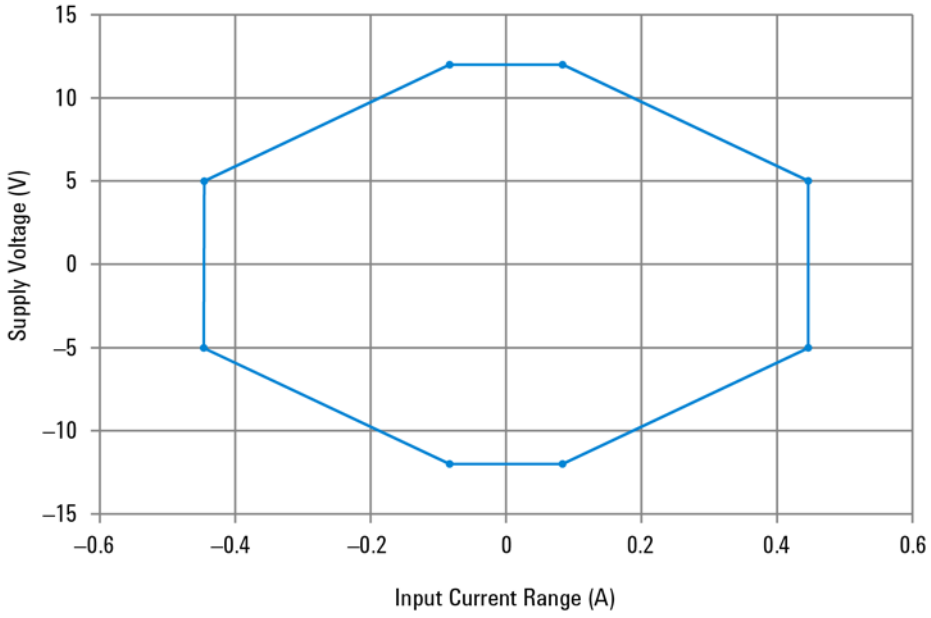


Figure 32 Zoomed-In Input Current Range Versus Supply Voltage (N2824A 100 mΩ Head)

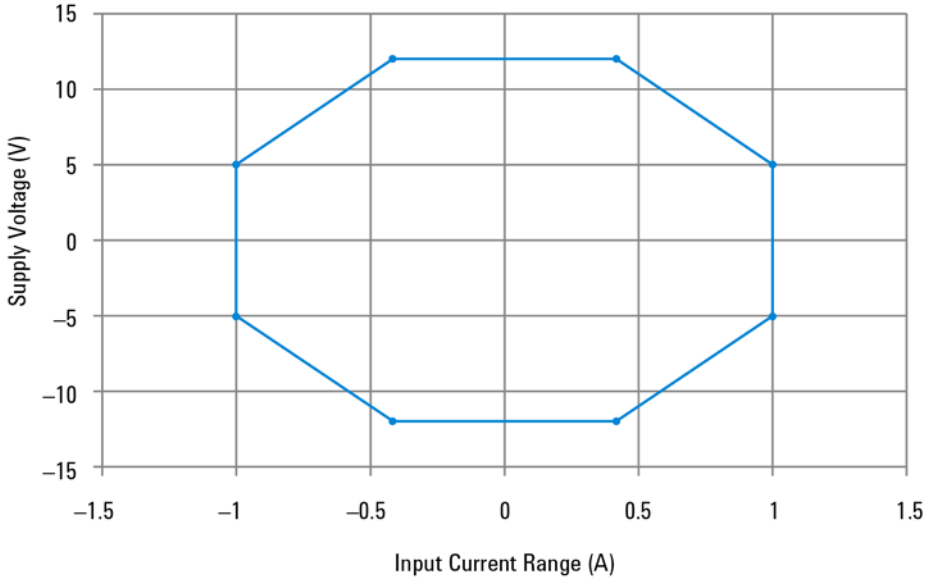


Figure 33 Zoomed-In Input Current Range Versus Supply Voltage (N2822A 20 mΩ Head)

Dimensions

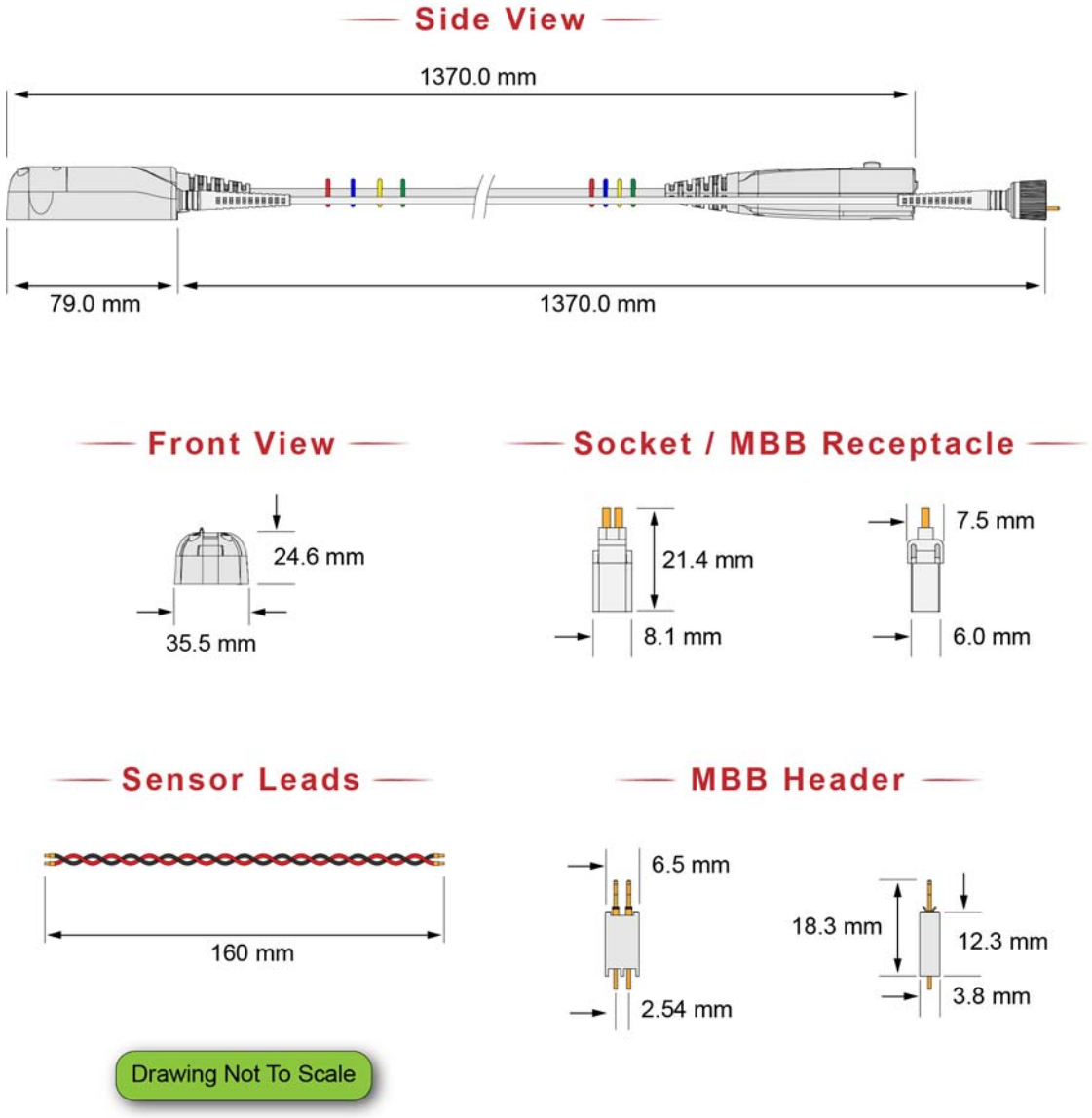
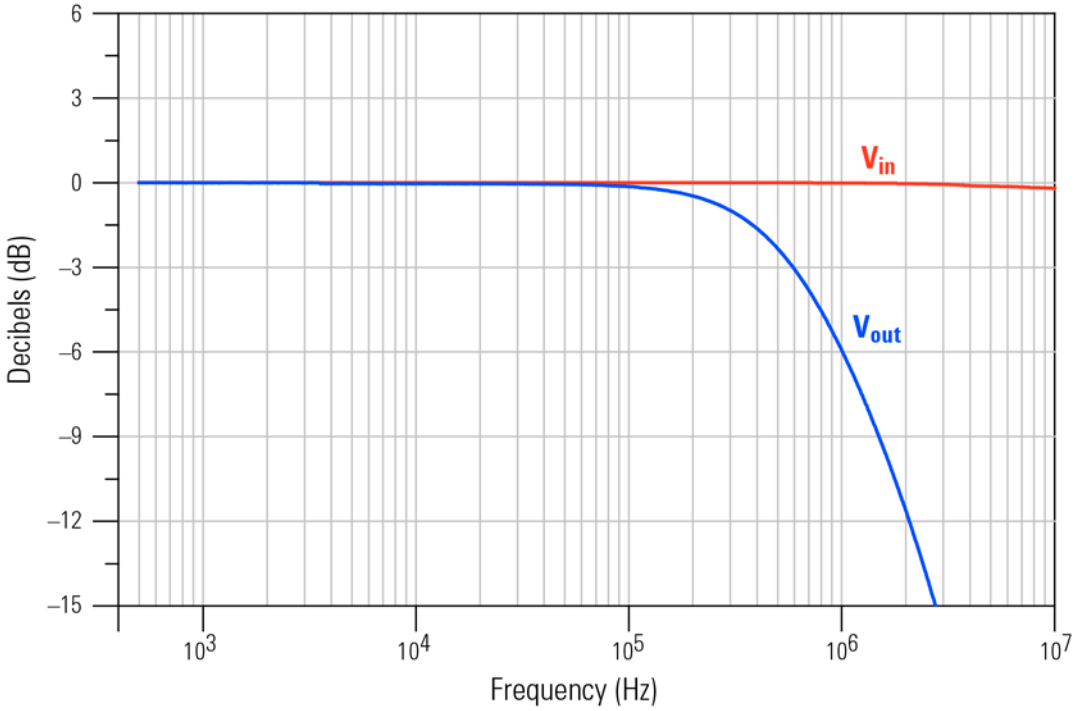


Figure 34 Probe and Tip Dimensions

4
Performance Data Plots

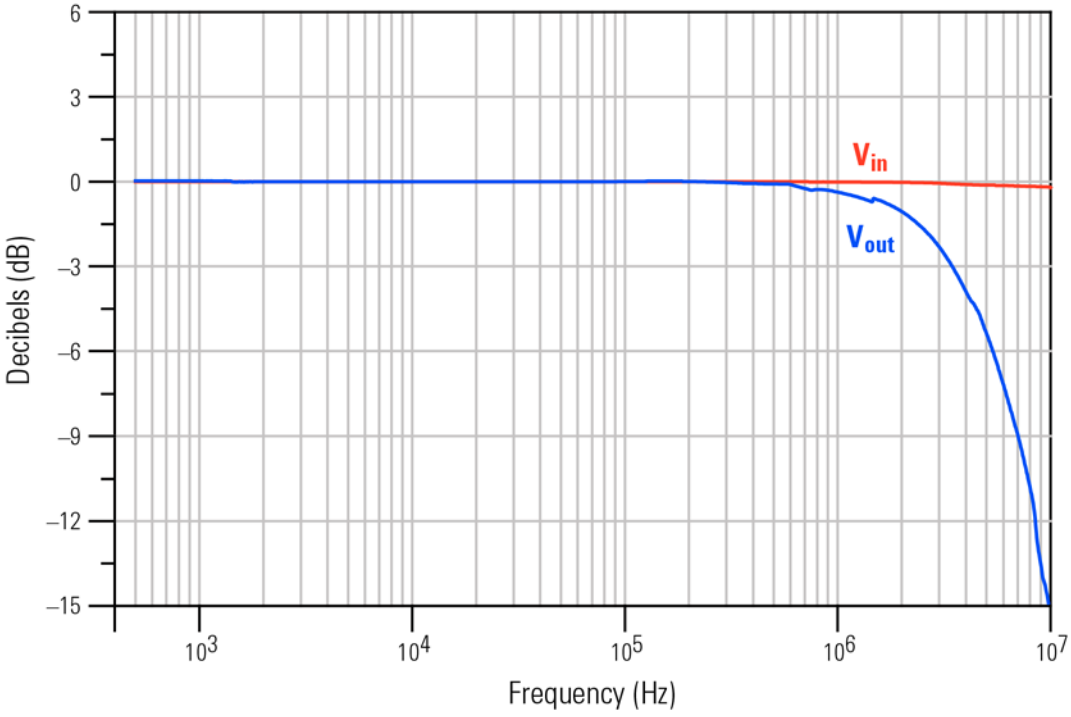
This chapter provides the performance plots for the N2820A.

N2820A Frequency Response



BW: . . . . . 590 kHz

Figure 35 Frequency Response, Zoomed-In Channel



BW: . . . . . 3.5 MHz

Figure 36 Frequency Response, Zoomed-Out Channel

N2820A Common Mode Rejection Ratio

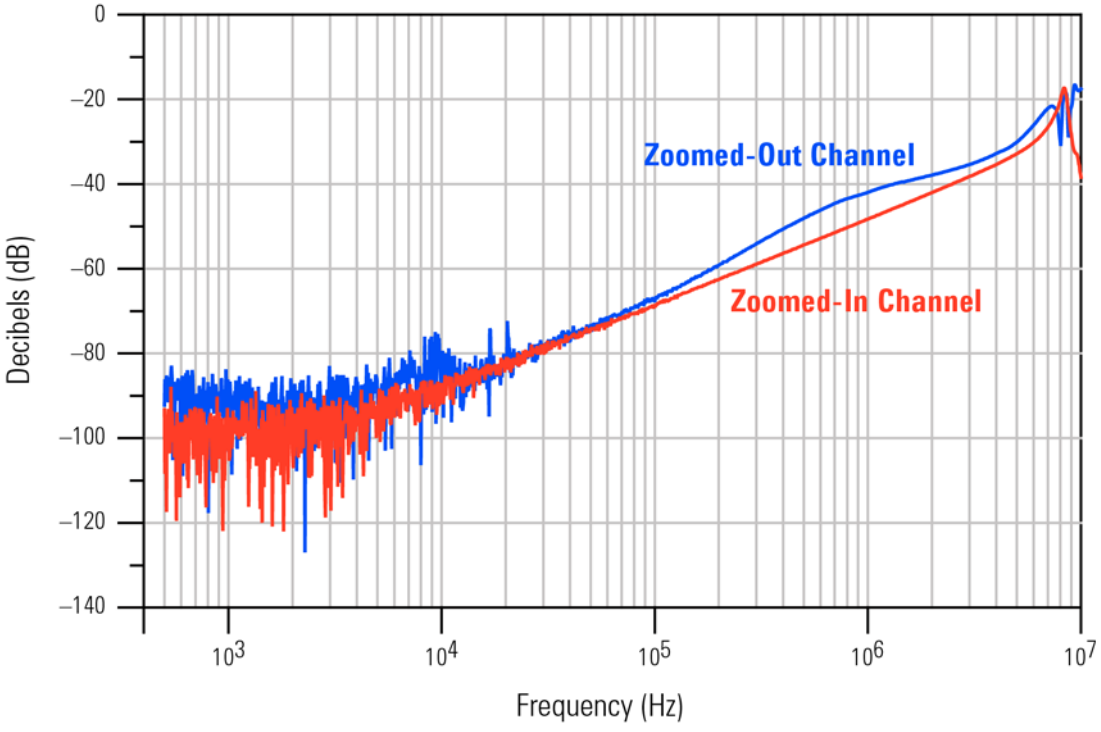
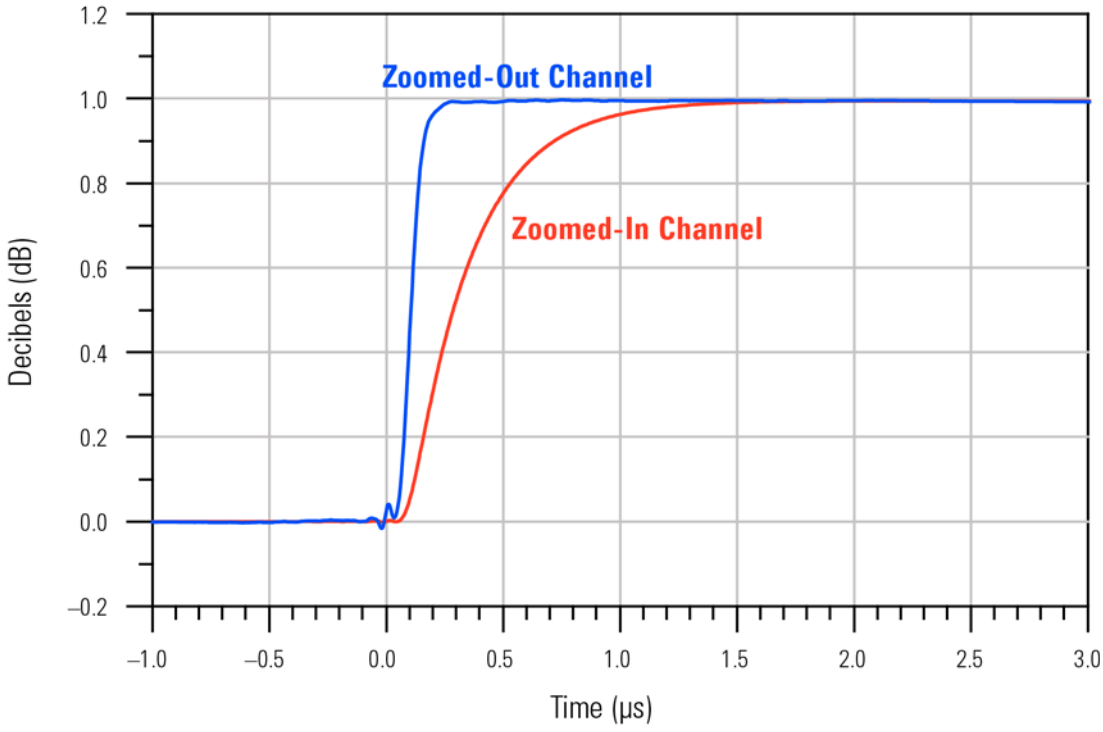


Figure 37 Common Mode Rejection Ratio (CMRR)

N2820A Step Response



Zoomed-In Channel

10–90% rising edge step: . . . . . 584.2 ns

20–80% rising edge step: . . . . . 365.8 ns

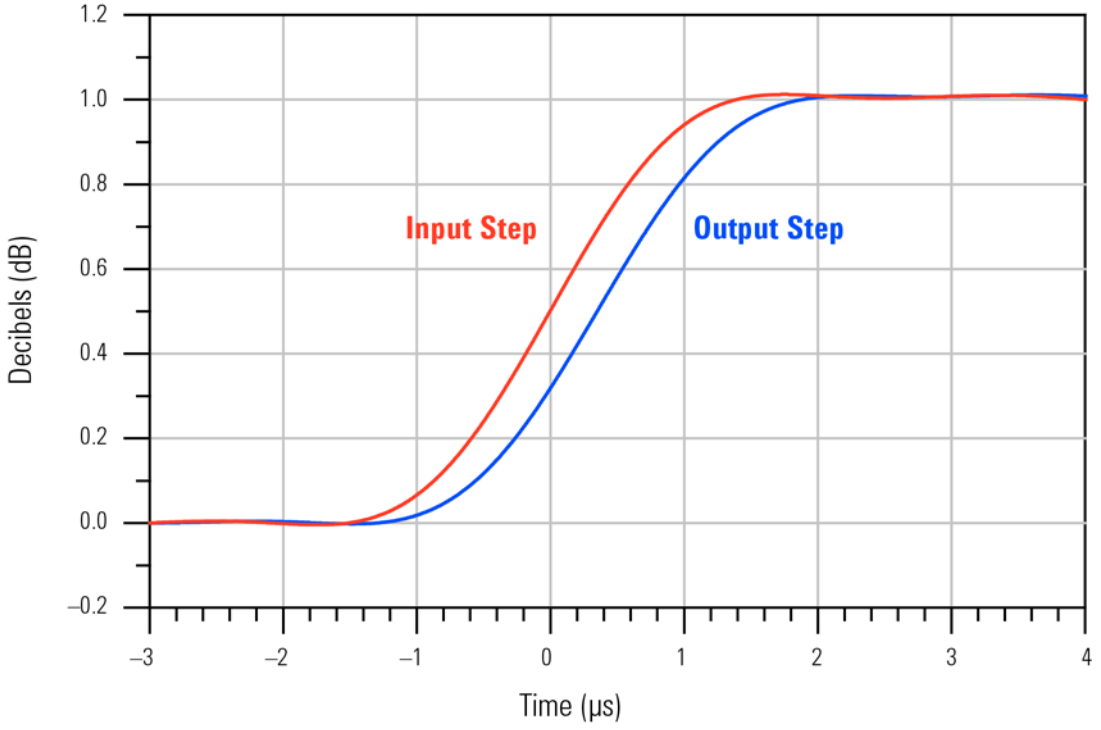
Zoomed-Out Channel

10–90% rising edge step: . . . . . 96.76 ns

20–80% rising edge step: . . . . . 63.33 ns

Figure 38 Step Response

N2820A Step Tracking



Input Step

10–90% Rise Time: . . . . . 1.688 µs

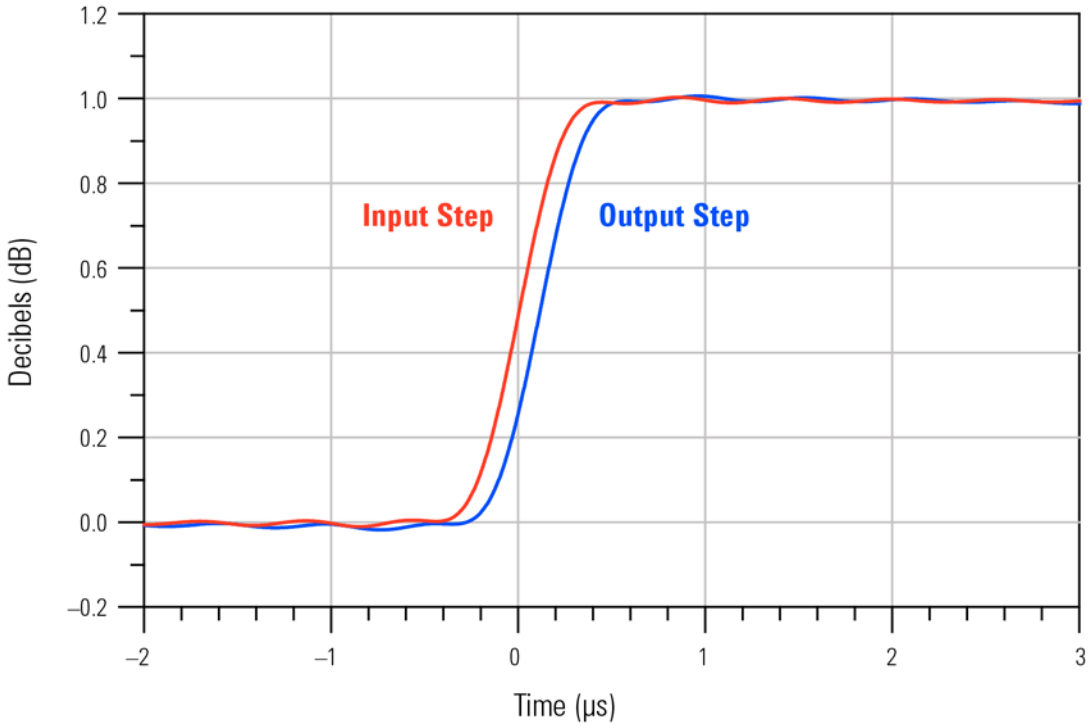
20–80% Rise Time: . . . . . 1.153 µs

Output Step

10–90% Rise Time: . . . . . 1.769 µs

20–80% Rise Time: . . . . . 1.204 µs

Figure 39 Zoomed-In Channel Step Tracking



Input Step

10–90% Rise Time: . . . . . 446.9 ns

20–80% Rise Time: . . . . . 299.8 ns

Output Step

10–90% Rise Time: . . . . . 450.0 ns

20–80% Rise Time: . . . . . 302.6 ns

Figure 40 Zoomed-Out Channel Step Tracking

N2820A Input Impedance

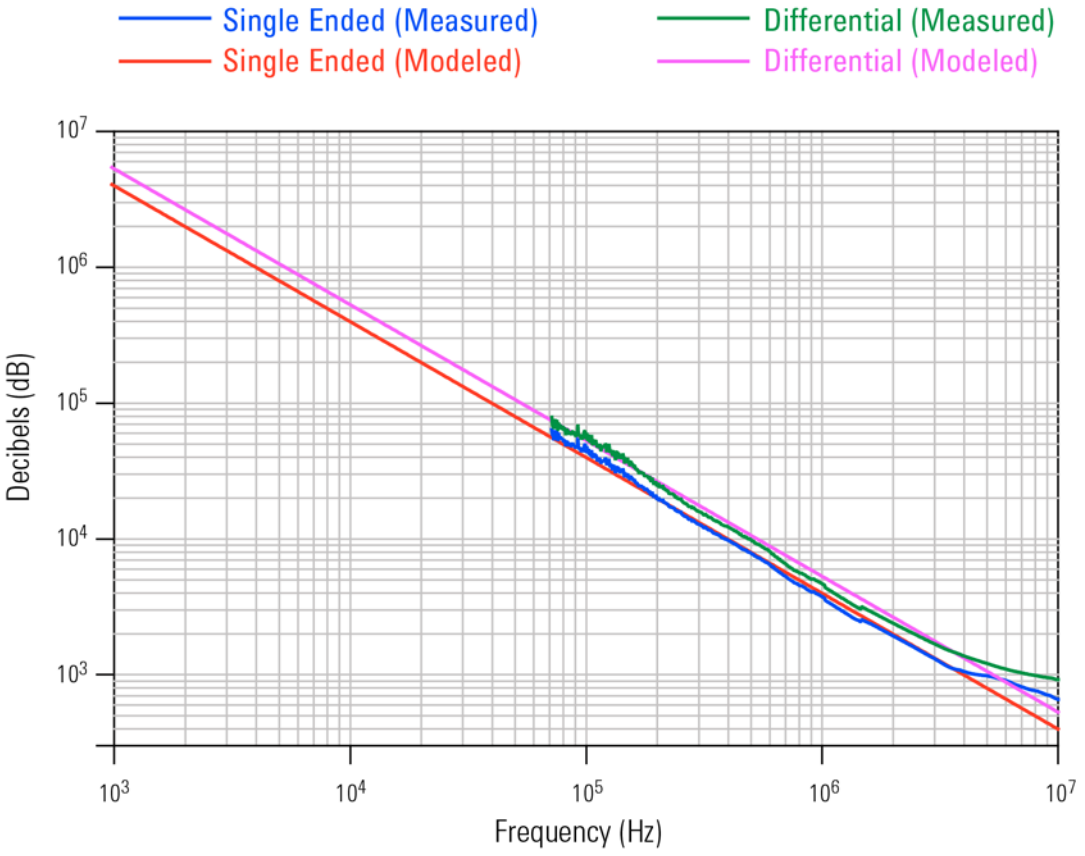


Figure 41 Input Impedance

Input Load Model

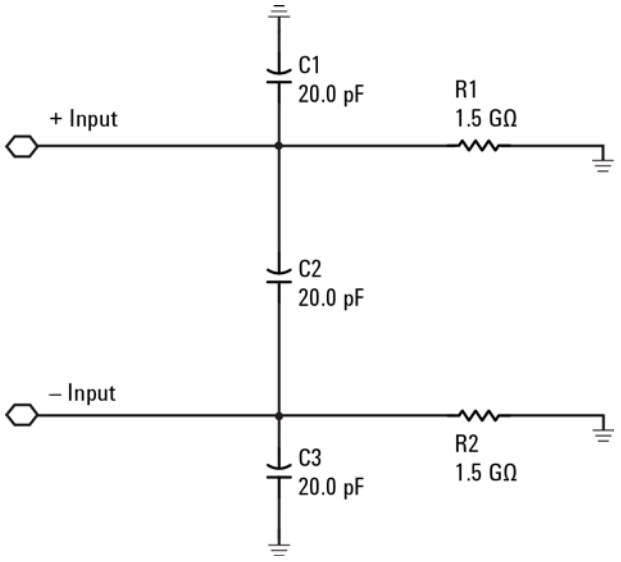


Figure 42 Input Load Model

5 Performance Verification

This chapter describes how to verify the performance of the N2820A and N2821A probes. The performance verification requires an N2825A probe head and consists of verifying the probe's DC gain.

NOTE The performance measured in this procedure is for the probe by itself. Agilent high performance real-time scopes apply probe correction that will further enhance the performance of the probes.

NOTE Agilent recommends a test interval of one year or 2000 hours of operation.

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.

Table 10 Required Test Equipment

Test Equipment	Recommended Model
Digital Multimeter	General purpose instrument for DC voltage measurement.
DC Power Supply	Recommended: ±20V Maximum: ≤ ±35V
Probe Power Supply	Agilent 1143A Probe Offset Control and Power Module 
Probe Adapter	Agilent N1022A/B Probe Adapter. 
Adapters	3.5 mm-to-BNC BNC-to-banana

Average Gain of Zoomed-In Channel

This procedure applies to both N2820A and N2821A probes.

NOTE Allow the probe to warm up for at least 20 minutes.

1 Snap an N2825A head onto the N2820/1A probe and connect the test equipment as shown in Figure 43. Be sure to connect the positive side of the DC supply to the red lead on the N2825A head.

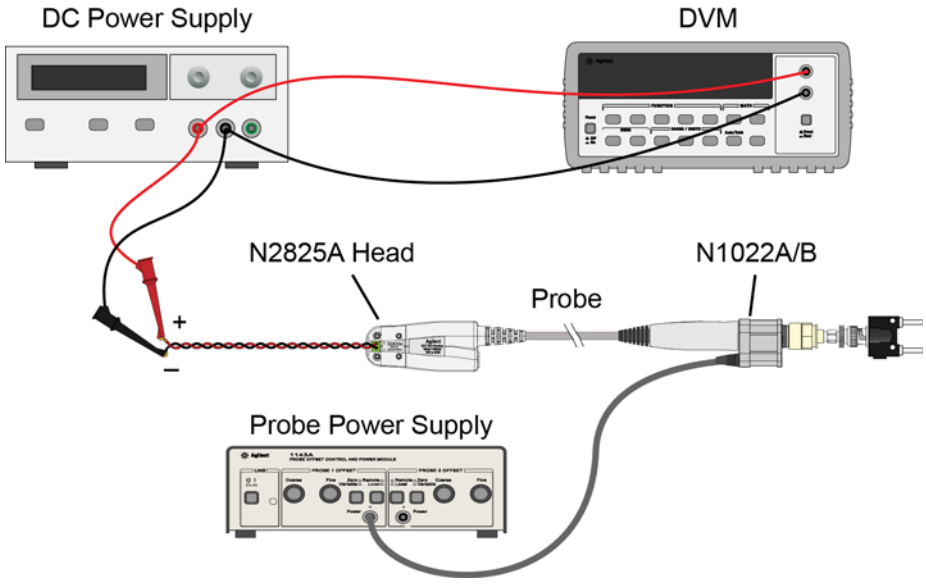


Figure 43 Test Setup for Measuring V_{in}

2 Set the DC power supply to +20 mV.

NOTE Although this is the recommended setting, you can use any voltages up to +35 mV.

3 Record the value of $+V_{in}$ measured on the multimeter:

$+V_{in}$: _____

4 Move the multimeter's leads to the banana plug on the output of the N1022A/B as shown in Figure 44.

5 Record the value of $+V_{out}$ measured on the multimeter:

$+V_{out}$: _____

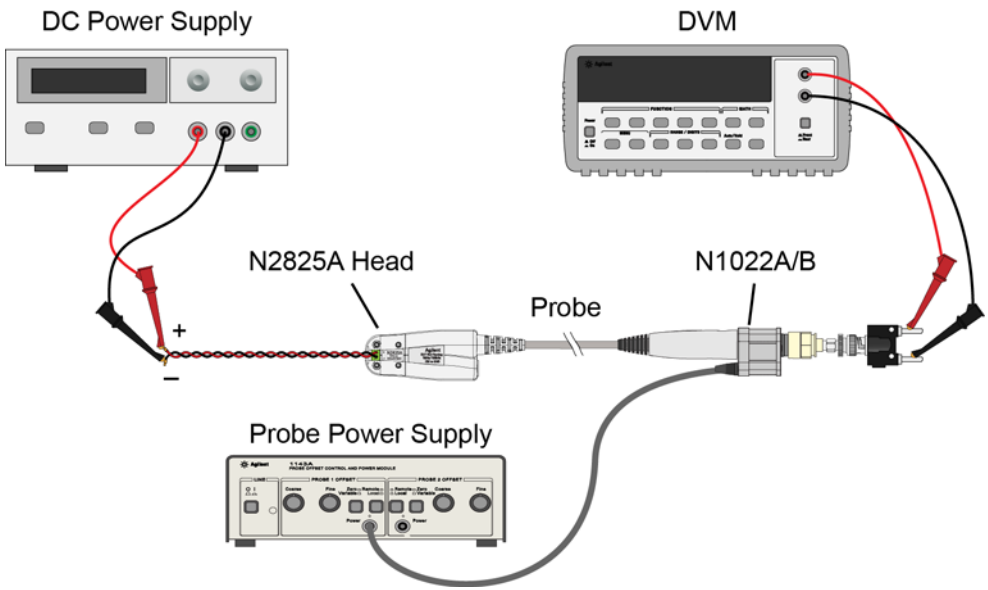


Figure 44 Test Setup for Measuring V_{out}

6 Calculate the positive gain of the zoomed-in (primary) channel and record the result in the following line:

$$\text{positive gain} = \frac{+V_{out}}{+V_{in}}$$

positive gain: _____

7 Set the DC power supply to –20 mV.

NOTE Although this is the recommended setting, you can use any negative voltage less than –35 mV.

8 Connect the multimeter on the DC power supply as shown in Figure 43 on page 73.

9 Record the value of $-V_{in}$ measured on the multimeter:

$-V_{in}$: _____

10 Connect the multimeter's leads to the banana plug on the output of the N1022A/B as shown in Figure 44 on page 74.

11 Record the value of $-V_{out}$ measured on the multimeter:

$-V_{out}$: _____

12 Calculate the negative gain of the zoomed-in (primary) channel and record the result in the following line:

$$\text{negative gain} = \frac{-V_{out}}{-V_{in}}$$

negative gain: _____

13 Calculate the average of the two gains:

$$\text{average gain} = \frac{\text{positive gain} + \text{negative gain}}{2}$$

average gain (zoomed-in): _____

14 The average gain (zoomed-in) should be 300 ±3%. Enter the value in Table 11 on page 80.

Average Gain of Zoomed-Out Channel

Perform this procedure *only* for N2820A probes.

NOTE Allow the probe to warm up for at least 20 minutes.

1 Snap an N2825A head onto the N2820/1A probe and connect the test equipment as shown in Figure 45. Be sure to connect the positive side of the DC supply to the red lead on the N2825A head.

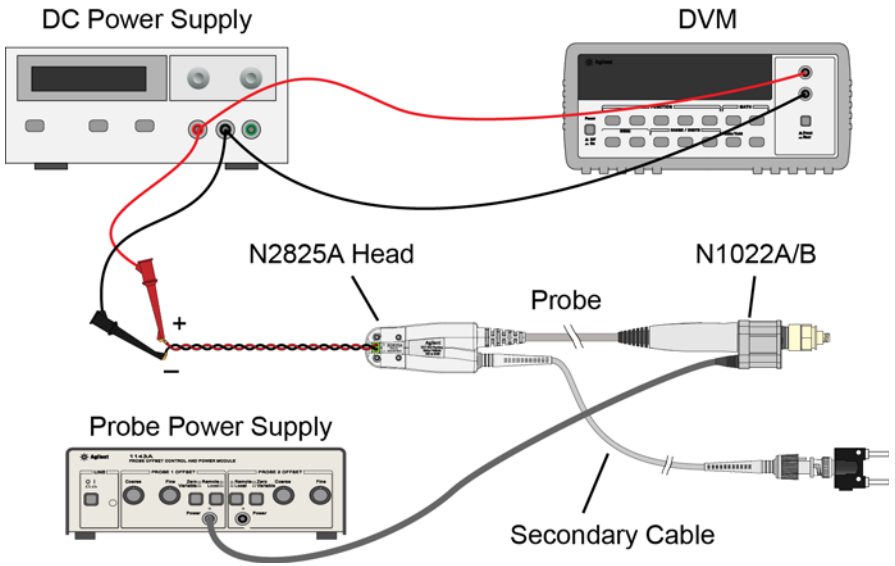


Figure 45 Test Setup for Measuring V_{in}

2 Set the DC power supply to +500 mV.

NOTE Although this is the recommended setting, you can use any voltage up to +700 mV.

3 Record the value of $+V_{in}$ measured on the multimeter:

$+V_{in}$: _____

4 Move the multimeter's leads to the banana plug on the output of the N1022A/B as shown in Figure 46.

5 Record the value of $+V_{out}$ measured on the multimeter:

$+V_{out}$: _____

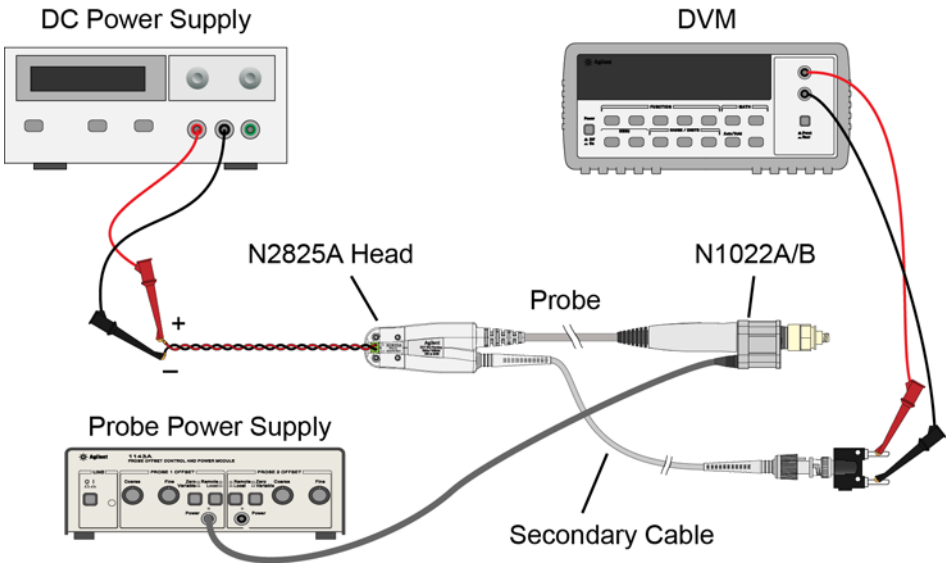


Figure 46 Test Setup for Measuring V_{out}

6 Calculate the positive gain of the zoomed-out (secondary) channel and record the result in the following line:

$$\text{positive gain} = \frac{+V_{out}}{+V_{in}}$$

positive gain: _____

7 Set the DC power supply to –500 mV.

NOTE Although this is the recommended setting, you can use any negative voltage less than –700 mV.

8 Connect the multimeter on the DC power supply as shown in Figure 45 on page 77.

9 Record the value of $-V_{in}$ measured on the multimeter:

$-V_{in}$: _____

10 Connect the multimeter's leads to the banana plug on the output of the N1022A/B as shown in Figure 46 on page 78.

11 Record the value of $-V_{out}$ measured on the multimeter:

$-V_{out}$: _____

12 Calculate the negative gain of the zoomed-out (secondary) channel and record the result in the following line:

$$\text{negative gain} = \frac{-V_{out}}{-V_{in}}$$

negative gain: _____

13 Calculate the average of the two gains:

$$\text{average gain} = \frac{\text{positive gain} + \text{negative gain}}{2}$$

average gain (zoomed-out): _____

14 The average gain (zoomed-out) should be 1.95 ±3%. Enter the value gain in Table 11 on page 80.

Performance Test Record

Table 11 N2820/1A Performance Test Record

Model #:	**Date:**	**Tested by:**	
Recommended next test date:			
Recommended Test Interval: 1 year / 2000 hours			
Probe Amplifier	**Test Limits**	**Result**	**Pass/Fail**
Average Gain of Zoomed-In Channel *(N2820/1A)*			
Average Gain (zoomed-in)	300 ±3%		
Average Gain of Zoomed-Out Channel *(N2820A only)*			
Average Gain (zoomed-out)	1.95 ±3%		

Index

R

S

T

U

V

W

Z