

Keysight N2790A Differential Voltage Probe

User Guide

Notices

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Manual Part Number

N2790-97005

Edition 6, August 2021

Available in electronic format only

Published by

Keysight Technologies, Inc.

1900 Garden of the Gods Road

Colorado Springs, CO 80907 USA

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Safety Notices

CAUTION

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WARNING

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Contents

| | |
|---------------------------------------------------------------------|----|
| Introduction | 5 |
| Compatibility | 5 |
| Inspecting the Probe | 5 |
| Supplied Accessories | 6 |
| Optional Accessories | 7 |
| Cleaning the Probe | 8 |
| Safety Information | 9 |
| Instrument Markings and Symbols | 9 |
| Safety Warnings and Cautions | 10 |
| Using the Probe | 13 |
| Using the Supplied Accessories | 13 |
| Using the Optional Accessories | 13 |
| Selecting the Correct Attenuation on the Probe and the Oscilloscope | 17 |
| Adjusting the Probe Offset Level | 17 |
| Characteristics and Specifications | 18 |
| Characterization Plots | 21 |
| Performance Verification Procedures | 23 |
| DC Differential Gain Accuracy | 24 |
| Bandwidth | 25 |
| Performance Verification Test Record | 25 |
| Service | 26 |

Keysight N2790A Differential Voltage Probe

User Guide

Introduction

The N2790A differential probe allows you to safely measure high-voltage floating circuits with the oscilloscope grounded. It is ideal for many applications such as motor speed controls, power supply designs, and electronic high-power converters. The N2790A offers sufficient dynamic range and bandwidth for your application to make the floating measurements found in high-speed power electronic circuits safely and accurately.

With 100 MHz bandwidth, switchable attenuation of 50:1 and 500:1, and a maximum differential voltage input of 1400V (DC + peak AC), it provides the versatility for a broad range of applications including high-voltage circuits. The probe is powered by the auto-probe interface.

Compatibility

The N2790A differential probe is compatible with the following Keysight oscilloscopes:

- InfiniiVision Series 5000, 6000 (except 100 MHz), and 7000 with version 5.2 software or later
- Infiniium 9000 (with version 2.00 software or later), 8000 (with version 5.61 software or later), and 54830 Series (with version 5.61 software or later)

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 instrument.
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 option at Keysight Technologies without waiting for claim settlement.

Supplied Accessories

Figure 1 shows the parts supplied with the N2790A Probe. The probe tips you receive may look slightly different than the ones shown in this picture. A Probe Tip Accessory Kit (consisting of 2 browser tips, 2 pincher clips, and 2 alligator plunger tips), can be ordered as part number N2790-68700. Replacement probe tips are not orderable separately.

The supplied accessories are for use only with the N2790A differential voltage probe.

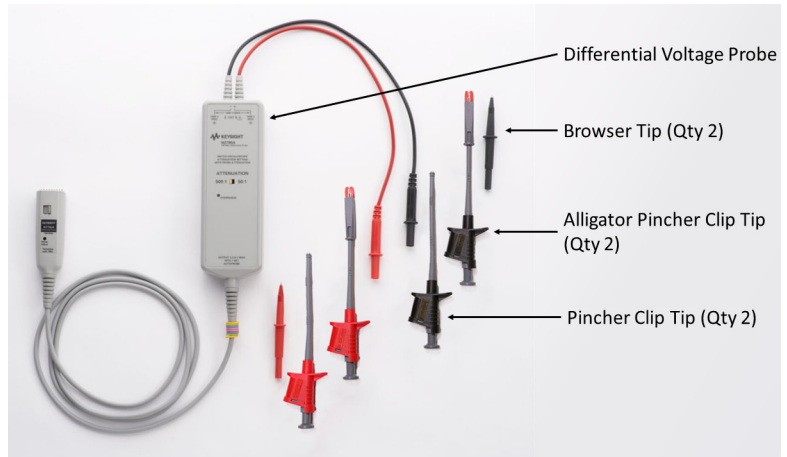


Figure 1 Probe with Supplied Accessories

Optional Accessories

Figure 2 shows the parts you can order separately with the N2790A Probe. For extreme temperature probing, you can order the N7013/14A Extreme Temperature Probing kit. This extreme temperature probing kit is compatible only with the N2790A differential voltage probe. The quantity for each accessory in the kit is the same as listed in Table 1.

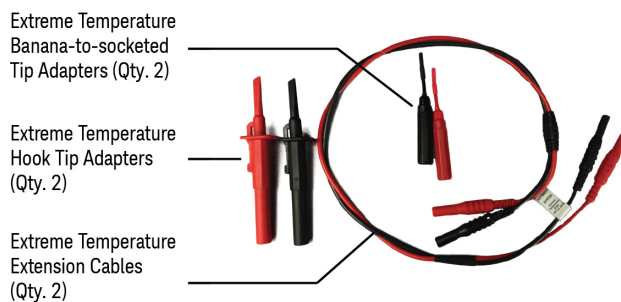


Figure 2 Optional Accessories (Extreme Temperature Probing Kit)

Table 1 Optional Accessories

| Accessory | Qty |
|--------------------------------------------------------------------------------------------------|-----|
| Extreme Temperature Hook Tip Adapters (Black) | 1 |
| Extreme Temperature Hook Tip Adapters (Red) | 1 |
| Extreme Temperature Differential Extension Cables (Black) | 1 |
| Extreme Temperature Differential Extension Cables (Red) | 1 |
| Extreme Temperature Banana-to-Socketed Tip Adapters for connecting to 0.025" square pins (Black) | 1 |
| Extreme Temperature Banana-to-Socketed Tip Adapters for connecting to 0.025" square pins (Red) | 1 |

WARNING

The applicable measurement category of the probe assembly and the optional accessories is the lower of the measurement categories of the probe assembly and the optional accessories. The optional accessories should only be used for measurements on mains isolated circuits.

Cleaning the Probe

Disconnect the probe from all power sources and clean it with a soft cloth dampened with a mild soap and water solution. Be careful not to get water in the attenuation switch. Make sure the probe is completely dry before reconnecting it to any other equipment.

Safety Information

This apparatus has been designed and tested in accordance with UL 61010-031 and CSA 22.2 No. 61010-031, and has been supplied in a safe condition. This is a Safety Class I instrument (provided with terminal for protective earthing). Before applying power, verify that the correct safety precautions are taken (see the warnings and cautions included in this topic and throughout the manual).

Instrument Markings and Symbols

The probe may have these markings and symbols.

WARNING



Risk of Danger symbol. Refer to the manual for more information.

CAUTION



The product is marked with this symbol when it is necessary for the user to refer to the instructions in the documentation.

WARNING



Risk of Electric Shock symbol. Refer to the manual for more information.

NOTE



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

Safety Warnings and Cautions

WARNING



The probe inputs are safety rated to a maximum of 1000 Vrms CAT II and 600 Vrms CAT III between either input and earth ground. These maximum ratings apply regardless of the attenuation setting of the probe. Do not apply voltages greater than 1000 Vrms CAT II or 600 Vrms CAT III between either input and ground.

WARNING



Observe probe accessory ratings.
The measurement category of a combination of a PROBE ASSEMBLY and an accessory is the lower of the measurement categories of the PROBE ASSEMBLY and of the accessory.
The probe tips that are provided are rated for 1000 Vrms CAT II and 600 Vrms CAT III usage.

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

If you energize this instrument by an auto transformer (for voltage reduction or mains isolation), the common terminal must be connected to the earth terminal of the power source.

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

Do not install substitute parts or perform any unauthorized modification or internal service to the product. For all repair or service needs, we recommend sending the probe to a Keysight authorized service center. Visit <http://www.keysight.com/find/assist> to find a service location near you.

WARNING

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

WARNING

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

WARNING

Do not use the instrument in a manner not specified by the manufacturer, the protection provided by the PROBE ASSEMBLY may be impaired.

WARNING

To clean the instrument. If the instrument requires cleaning: (1) Remove power from the instrument. (2) Clean the external surfaces of the instrument with a soft cloth dampened with a mixture of mild detergent and water. (3) Make sure that the instrument is completely dry before reconnecting it to any other equipment.

CAUTION

The probe cable and the extreme temperature extension cables are sensitive parts and, therefore, you should be careful not to damage them through excessive bending or pulling. Avoid any mechanical shocks to this product in order to guarantee accurate performance and protection.

WARNING



SHOCK HAZARD! These probes are designed for use with oscilloscopes that have a common terminal at **GROUND POTENTIAL** (in accordance with OSHA requirements and the National Electric Code). Exposed metallic surfaces of the probe and the oscilloscope **MUST BE GROUNDED**. Failure to ground the common terminal during certain applications, such as those requiring the oscilloscope to be powered from an external battery, might expose the operator to an electrical shock hazard that could be lethal (depending on voltage and current conditions.)

Using the Probe

WARNING

Inspect the probe cables regularly to check for any damage. Do Not Operate With Suspected Failures. If you suspect there is damage to this probe, have it inspected by a Keysight authorized service personnel.

WARNING

This probe has a cable with a built-in wear indicator. When the insulation of the cable deteriorates, the wear indicator becomes visible. Do not use the probe, when the contrasting color (Black) is visible through the cable jacket. Using a product with a worn cable may result in electric shock, fire, or equipment failure.

WARNING

Avoid contact of the probe cable with hazardous live voltages. The rated voltage of the probe tip is higher than the rated voltage of the probe cable. If the cable contacts hazardous live voltages, it will not provide adequate protection. Contact of the cable with hazardous live voltages may result in electric shock, fire, or equipment failure.

The N2790A probe is powered by the auto-probe interface found on Keysight InfiniiVision and Infiniium Series oscilloscopes.

Using the Supplied Accessories

- Use the supplied sharp browser probe tips for use on small components and in tight places.
- Use the alligator clips for connecting to larger cables and pincher clips.

Using the Optional Accessories

For extreme temperature probing, connect the N7013/14A extreme temperature probing kit to this probe.

NOTE

The N7013/14A extreme temperature probing kit is not supplied with the probe. You can order this kit separately.

The N7013A extreme temperature probing kit includes:

- One pair of extreme temperature differential extension cables (black and red)
- One pair of extreme temperature hook tip adapters (black and red)
- One pair of extreme temperature banana-to-socketed tip adapters for connecting to 0.025" square pins (black and red)

The N7014A extreme temperature probing kit includes:

- One pair of extreme temperature banana-to-socketed tip adapters for connecting to 0.025" square pins (black and red)

CAUTION

Only the extension cables and the tip adapters provided with the cables are rated to extreme temperatures. The differential probe, original cables, and original accessories should not be exposed to extreme temperatures. When probing with the extension cables the bandwidth performance will be reduced, see [Table 2](#) on page 18.

Connecting the Extreme Temperature Probing Kit to the Probe

Perform the following steps to connect the N7013/14A extreme temperature kit to the N2790A probe:

- 1 Connect the red and black extreme temperature differential extension cables to the existing probe cables.

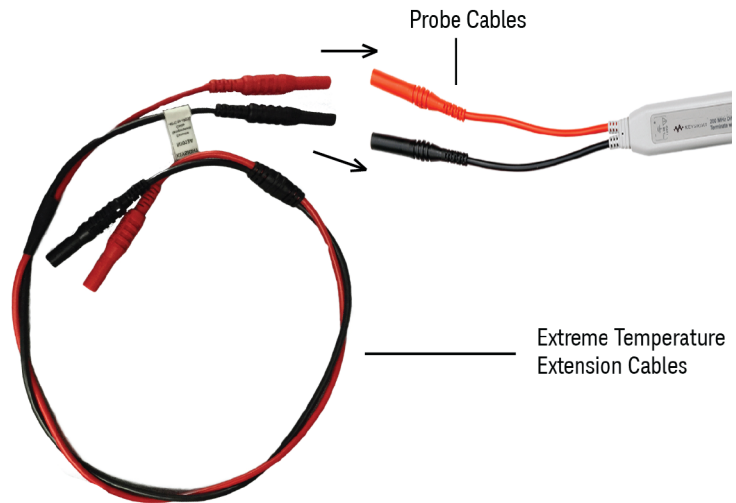


Figure 3 Connecting the Extreme Temperature Differential Extension Cables

- 2 Connect the red and black extreme temperature hook tip adapters to the extreme temperature differential extension cables which are already connected to the existing probe cables.

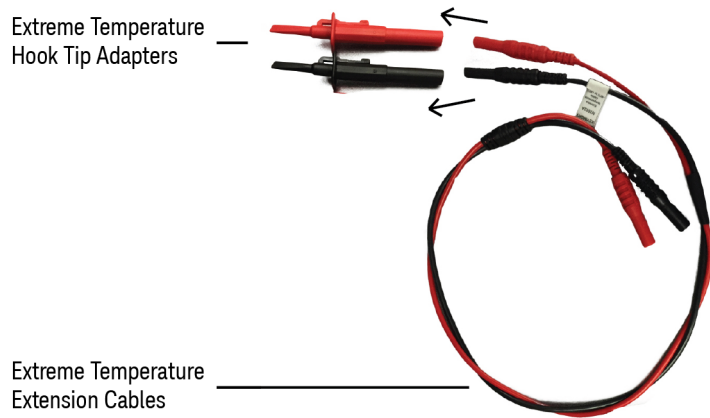


Figure 4 Connecting the Extreme Temperature Hook Tip Adapters

Or,

Connect the red and black extreme temperature banana-to-socketed tip adapters to the extreme temperature differential extension cables which are already connected to the existing probe cables.

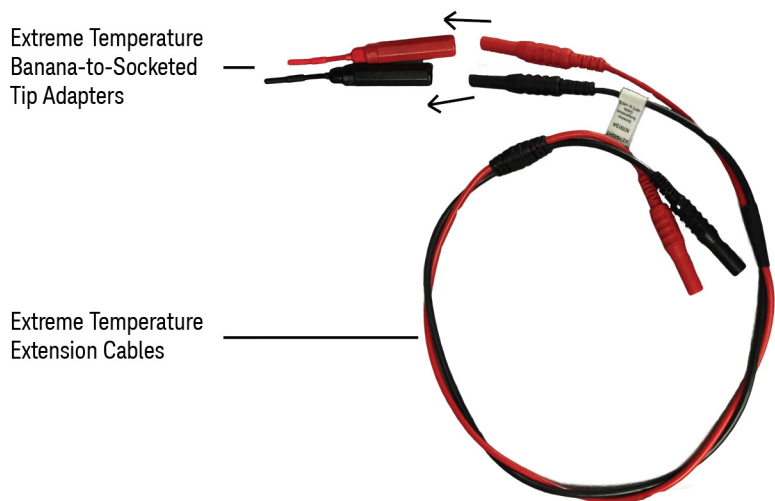


Figure 5 Connecting the Extreme Temperature Banana-to-Socketed Tip Adapters

There is an over-range LED on the probe to indicate when you have exceeded the maximum voltage of the probe.

Selecting the Correct Attenuation on the Probe and the Oscilloscope

The probe has two modes of operation, 50:1 and 500:1 attenuation. Use the 50:1 range on the differential voltage probe for smaller signals, such as ripple on a high voltage reference lead. To select the desired attenuation use the switch that is on the probe and set the correct probe attenuation setting on the oscilloscope. This ensures that accurate voltage readings can be made directly from the oscilloscope.

Adjusting the Probe Offset Level

The probe offset level is adjusted using the tool provided with the N2790A probe. Adjust the offset level by turning the potentiometer adjustment located on the auto-probe pod.



Characteristics and Specifications

Characteristics and specifications for the N2790A Differential Voltage Probe are shown below.

Table 2 Electrical Characteristics and Specifications

| Description | Characteristic/Specification without the N7013/14A Extreme Temperature Probing Kit | Characteristic/Specification with the N7013/14A Extreme Temperature Probing Kit |
|---------------------------|------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|
| Attenuation Ratios | 50:1 and 500:1 (Selectable via switch on probe.) | 50:1 and 500:1 (Selectable via switch on probe.) |
| Bandwidth (-3 dB)* | 100 MHz | 70 MHz |
| Gain Accuracy* | ±4% @ 0 - 20 °C, ±2% @ 20 - 30 °C, ±4% @ 30 - 55 °C | ±4% @ 0 - 20 °C, ±2% @ 20 - 30 °C, ±4% @ 30 - 55 °C |
| DC CMRR | -70 dB @ 500VDC | -70 dB @ 500VDC |
| AC CMRR | -80 dB @ 50/60 Hz -50 dB @ 100 kHz -50 dB @ 1 MHz | -80 dB @ 50/60 Hz -50 dB @ 100 kHz -50 dB @ 1 MHz |
| Input Impedance | Between inputs: 8 MΩ, 3.5 pF | Between inputs: 8 MΩ, 3.5 pF |
| Noise Referenced to Input | < 300 mVrms @ 500:1 < 50 mVrms @ 50:1 | < 300 mVrms @ 500:1 < 50 mVrms @ 50:1 |
| Propagation Delay | 14.0 ns @ 50:1, 12.8 ns @ 500:1 | 14.0 ns @ 50:1, 12.8 ns @ 500:1 |
| Switch Positions | 500:1, 50:1 | 500:1, 50:1 |
| Internal Power | Autoprobe interface | Autoprobe interface |

* Denotes warranted specification after 20 minute warm-up

Table 3 Input Characteristics

| Description | Characteristic |
|--------------------------------------------------------------|-----------------------------------------------|
| Cable Length | 170 cm (66.9 inches) |
| Length of Extreme Temperature Extension Cables | 70 cm (27.5 inches) |
| Length of Input Leads | 40 cm (15.7 inches) |
| Maximum Common Mode Operating Voltage (rms or DC + peak AC)* | 600V CAT III 1000V CAT II |
| Maximum Common Mode Operating Voltage Derating Frequency† | 2 MHz |
| Maximum Differential Mode Operating Voltage (DC + peak AC) | 1400V @ 500:1, CAT II 140V @ 50:1, CAT III |

* Refer to **“Safety Information”** on page 9 for further details on the input voltage safety rating.

† Refer to the derating plot in **Figure 8** on page 22.

Table 4 Output Characteristics

| Description | Characteristic |
|------------------------------|---------------------------|
| Output Cable | Safety designed BNC cable |
| Maximum Output Voltage Range | ±2.8 V into 1 MΩ at 500:1 |

Table 5 Environmental Specifications

| Description | Specification |
|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Temperature | Operating: +5 °C to +40 °C (Probe without the N7013/14A extreme temperature probing kit) Operating: -40 °C to +85 °C (Probe with the N7013/14A extreme temperature probing kit) Non-operating: -51 °C to +71 °C |
| Altitude | Operating: 2,000 m (6,561 feet) Non-operating: 15,300 m (50,200 feet) |
| Humidity | Operating: 80% RH for temperatures up to 31 °C (non-condensing), decreasing linearly to 50% RH @ 40 °C (non-condensing) Non-operating: 90% RH @ 65 °C (non-condensing) |
| Pollution Degree | Pollution Degree 2 |

Table 6 **Safety Specifications**

| Description |
|-------------------------------------------------------------------------------------------|
| UL Listed: File No. E332318 (<i>For N2790A probe and its supplied accessories only</i>) |
| Compliant with: UL 61010-031, CSA 22.2 No. 61010-031 |

Characterization Plots

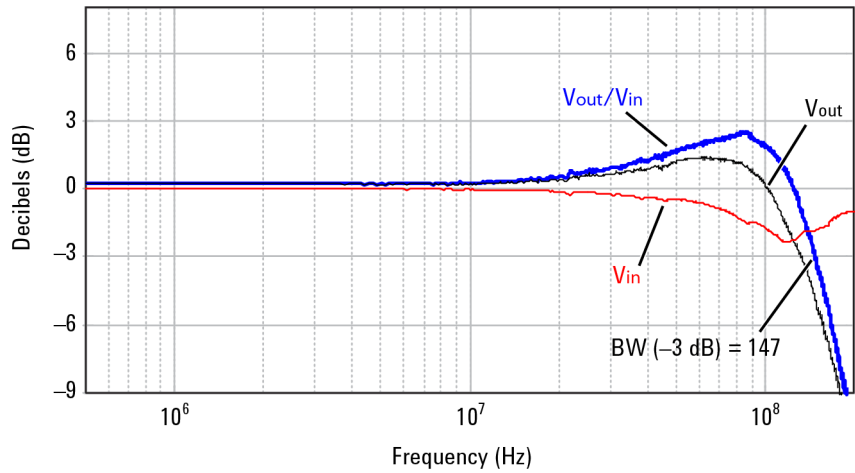
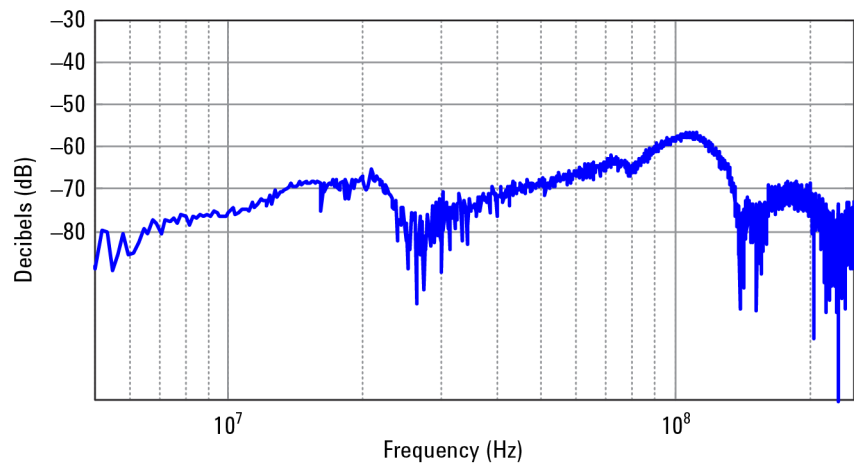
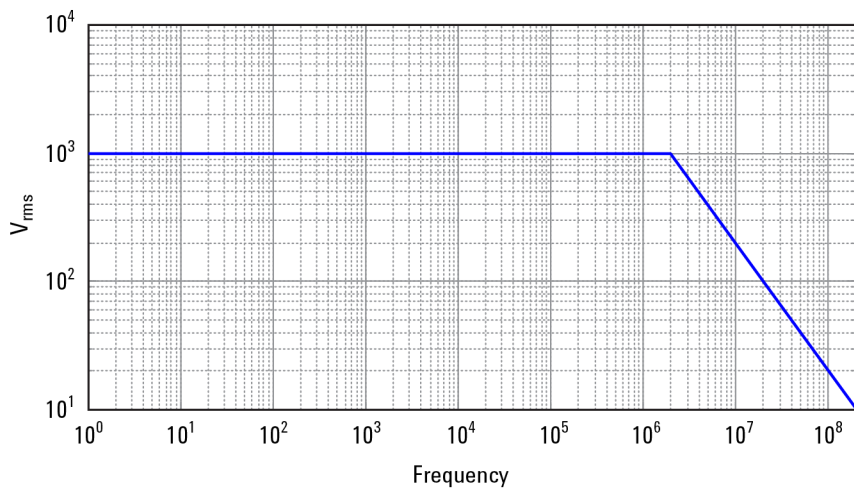


Figure 6 Frequency Response. Graph of $\text{dB}(V_{in})$, $\text{dB}(V_{out})$, and $\text{dB}(V_{out}/V_{in})$



Graph of $\text{dB}(V_{out}/V_{in})$ frequency response when inputs are driven in common (common mode rejection).

Figure 7 Common Mode Rejection Ratio



Above 2 MHz, the maximum input operating voltage decreases as the frequency increases.

Figure 8 Derating Plot

Performance Verification Procedures

The following procedures can be used to test and verify the DC differential gain accuracy and bandwidth of the N2790A high voltage differential probe.

Table 7 Required Test Equipment

| Description | Critical Specifications | Recommended Model Part Number | Functions |
|----------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|---------------------------------------------------------------------|
| Digitizing Oscilloscope | Bandwidth: >100 MHz 1 M Ω /50 Ω selectable input | Keysight MS09254A | Display probe output |
| Signal Generator Precision DC voltage source | Amplitude accuracy: less than or equal to 0.25% 1 M Ω / 50 Ω selectable load Sine wave greater than or equal to 25 MHz | Fluke 9500B or Fluke 5520A for DC source. | Signal source for DC gain and bandwidth |
| BNC Adapter | BNC (f) to Dual Banana (m) Adapter | Keysight 1251-2277 | Interconnection between probe and generator |
| 50 Ω BNC Feed Through Adapter | 50 Ω precision feed through | HP 11048C | Termination between probe and calibrator for bandwidth verification |

WARNING

These procedures require the application of high voltage to the inputs of the N2790A probe. Because the adapter used in this procedure has exposed metal surfaces, only qualified personnel should perform any testing with voltage levels exceeding 30V rms. All pertinent safety rules and guidelines for elevated voltage measurements should be followed and adhered to.

WARNING

Generator produces hazardous voltages. To avoid risk of shock, do not touch exposed metal parts after the generator output is enabled.

DC Differential Gain Accuracy

- 1 Set the volts/division on channel 1 of the oscilloscope to 20 mV/div. Set the seconds/div to 200 μ s and the acquisition mode to average 32.
- 2 Set the volts/division on channel 2 of the oscilloscope to 50 mV/div. Trigger on channel 2, select 50 Ω impedance.
- 3 Set the calibrator 9500B's channel 2 as the trigger channel (50 Ω load). Connect the calibrator's channel 2 active head to channel 2 of the oscilloscope.
- 4 Connect the active head channel 1 from the Fluke 9500B to channel 1 of the oscilloscope. Set the calibrator channel 1 to 0.1V peak-to-peak amplitude and 1 kHz (square wave, 1 M Ω load), enable the output.
- 5 Select the amplitude measurement on the oscilloscope and record the DC amplitude (approximately 100 mV) of the square wave. This measurement is only the oscilloscope.
- 6 Disable the Fluke calibrator output, disconnect the channel 1 active head from channel 1 of the oscilloscope.
- 7 Connect the output of the N2790A probe to channel 1 of the oscilloscope.
- 8 Attach the BNC adapter to the Fluke channel 1 active head.
- 9 Attach the differential probe input leads by clipping the alligator clamp to the BNC adapter banana post.
- 10 Set the probe to 50:1. Set the Fluke calibrator to 10V and 1 kHz standard amplitude output (channel 1, square wave, 1 M Ω load).
- 11 Enable the output of the calibrator.
- 12 Record the DC amplitude of the square wave and divide 50 into just the amplitude of the oscilloscope. Verify that the probe gain accuracy is $\pm 2\%$ + scope gain accuracy.
- 13 Set the calibrator to 100V output and set the attenuation button on the probe to 500:1.
- 14 Record the DC amplitude of the square wave and divide 500 into just the amplitude of the oscilloscope. Verify that the probe gain accuracy is $\pm 2\%$ + scope gain accuracy.
- 15 Disable the calibrator output and leave the setup connected for the next procedure.

Bandwidth

- 1 Connect the 50 Ω BNC feed through adapter to the calibrator's active head channel 1.
- 2 Attach the BNC (f)-to-banana post adapter to the BNC feed through adapter.
- 3 Attach the differential probe input leads by clipping the alligator clamp to the BNC adapter banana post.
- 4 Set the probe to 50:1 attenuation.
- 5 Set the volts/division on channel 1 of the oscilloscope to 1V/div and seconds/division to 20 ns/div. Set the trace to the center of the oscilloscope. Input impedance should be set to 1 M Ω . Disable average mode.
- 6 Set the calibrator to sine wave, 5V peak-to-peak amplitude. Set the frequency to 100 MHz, 50 Ω load.
- 7 Record the measured Vpp on the scope and divide it by 50. Write down the peak-to-peak amplitude measured by the oscilloscope. It should be greater than or equal to 71 mV + scope error.
- 8 Disable the generator output and disconnect the probe input.

Performance Verification Test Record

The recommended test interval is 1 year.

Table 8 N2790A Performance Test Record

| Certification Details | | | |
|----------------------------|---------------|-----------------------------------------|--------------|
| Serial Number: | | Tested By: | |
| Certification Date: | | Recommended Date of Next Certification: | |
| Certification Temperature: | | | |
| Test | Probe Setting | Test Limits | Test Results |
| Gain | 50:1 | 196 mV to 204 mV | |
| Gain | 500:1 | 196 mV to 204 mV | |
| Bandwidth | 50:1 | ≥ 71 mV | |

Service

For repair, calibration, and to ensure the N2790A performs to its warranted specifications, send the probe to an Keysight Service Center for calibration testing procedures. The probe should be tested once a year or as required by other standards. If repair is needed and the N2790A is under warranty, normal warranty services will apply. If the N2790A is not under warranty, repair costs will be applied.

To return the probe to Keysight Technologies for service, call (877) 477-7278 for further details and the location of your nearest Keysight Technologies Service Office.

- 1 Write the following information on a tag and attach it to the probe.
 - Name and address of the owner
 - Probe model number
 - Description of service required or failure indication
- 2 Retain all accessories.
- 3 Return the probe in its case or pack the probe in foam or other shock-absorbing material and place it in a strong shipping container. You can use the original shipping materials or order materials from an Keysight Technologies Sales Office. If neither are available, place 3 to 4 inches of shock-absorbing material around the instrument and place it in a box that does not allow movement during shipping.
- 4 Seal the shipment container securely.
- 5 Mark the shipping container as FRAGILE. In all correspondence, refer to the instrument by model number and full serial number.

