Tektronix®

TPR1000 and TPR4000 Active Power Rail Probes

User Manual

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077-1542-01 April 2025

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P.O. Box 500
Beaverton, OR 97077
US

For product information, sales, service, and technical support visit *tek.com* to find contacts in your area. For warranty information visit *tek.com/warranty*.

Contents

Important safety information

This manual contains information and warnings that must be followed by the user for safe operation and to keep the product in a safe condition.

General safety summary

Use the product only as specified. Review the following safety precautions to avoid injury and prevent damage to this product or any products connected to it. Carefully read all instructions. Retain these instructions for future reference.

This product shall be used in accordance with local and national codes.

For correct and safe operation of the product, it is essential that you follow generally accepted safety procedures in addition to the safety precautions specified in this manual.

The product is designed to be used by trained personnel only.

Only qualified personnel who are aware of the hazards involved should remove the cover for repair, maintenance, or adjustment.

Before use, always check the product with a known source to be sure it is operating correctly.

This product is not intended for detection of hazardous voltages.

Use personal protective equipment to prevent shock and arc blast injury where hazardous live conductors are exposed.

While using this product, you may need to access other parts of a larger system. Read the safety sections of the other component manuals for warnings and cautions related to operating the system.

When incorporating this equipment into a system, the safety of that system is the responsibility of the assembler of the system.

To avoid fire or personal injury

High temperature probe tips

WARNING: To prevent a burn injury, when using a solder micro-coax or flex tip in a high temperature application, be sure to allow the tip to cool down before handling the tip.

Observe all terminal ratings

To avoid fire or shock hazard, observe all rating and markings on the product. Consult the product manual for further ratings information before making connections to the product.

Do not exceed the Measurement Category (CAT) rating and voltage or current rating of the lowest rated individual component of a product, probe, or accessory. Use caution when using 1:1 test leads because the probe tip voltage is directly transmitted to the product.

Do not apply a potential to any terminal, including the common terminal, that exceeds the maximum rating of that terminal.

Do not float the common terminal above the rated voltage for that terminal.

The measuring terminals on this product are not rated for connection to mains or Category II, III, or IV circuits.

Do not connect a current probe to any wire that carries voltages above the current probe voltage rating.

Do not operate without covers

Do not operate this product with covers or panels removed, or with the case open. Hazardous voltage exposure is possible.

Avoid exposed circuitry

Do not touch exposed connections and components when power is present.

Do not operate with suspected failures

If you suspect that there is damage to this product, have it inspected by qualified service personnel.

Disable the product if it is damaged. Do not use the product if it is damaged or operates incorrectly. If in doubt about safety of the product, turn it off and disconnect the power cord. Clearly mark the product to prevent its further operation.

Before use, inspect voltage probes, test leads, and accessories for mechanical damage and replace when damaged. Do not use probes or test leads if they are damaged, if there is exposed metal, or if a wear indicator shows.

Examine the exterior of the product before you use it. Look for cracks or missing pieces.

Use only specified replacement parts.

Wear eye protection

Wear eye protection if exposure to high-intensity rays or laser radiation exists.

Do not operate in wet/damp conditions

Be aware that condensation may occur if a unit is moved from a cold to a warm environment.

Do not operate in an explosive atmosphere

Keep product surfaces clean and dry

Remove the input signals before you clean the product.

Provide proper ventilation

Refer to the installation instructions in the manual for details on installing the product so it has proper ventilation.

Slots and openings are provided for ventilation and should never be covered or otherwise obstructed. Do not push objects into any of the openings.

Provide a safe working environment

Always place the product in a location convenient for viewing the display and indicators.

Avoid improper or prolonged use of keyboards, pointers, and button pads. Improper or prolonged keyboard or pointer use may result in serious injury.

Be sure your work area meets applicable ergonomic standards. Consult with an ergonomics professional to avoid stress injuries.

Probes and test leads

Before connecting probes or test leads, connect the power cord from the power connector to a properly grounded power outlet.

Keep fingers behind the protective barrier, protective finger guard, or tactile indicator on the probes. Remove all probes, test leads and accessories that are not in use.

Use only correct Measurement Category (CAT), voltage, temperature, altitude, and amperage rated probes, test leads, and adapters for any measurement.

WARNING: To avoid electric shock, keep the probe wire as far from the tip and high voltage circuits as possible. The probe wire voltage rating is less than the probe tip voltage rating. Therefore the probe wire may not provide adequate protection.

WARNING: To avoid electric shock, do not use the probe if the wear indicator on the cable becomes visible. Contact Tektronix at *tek.com* for a replacement.

Beware of high voltages

Understand the voltage ratings for the probe you are using and do not exceed those ratings. Two ratings are important to know and understand:

- The maximum measurement voltage from the probe tip to the probe reference lead.
- The maximum floating voltage from the probe reference lead to earth ground.

These two voltage ratings depend on the probe and your application. Refer to the Specifications section of the manual for more information.

WARNING: To prevent electrical shock, do not exceed the maximum measurement or maximum floating voltage for the oscilloscope input BNC connector, probe tip, or probe reference lead.

Connect and disconnect properly.

Connect the probe output to the measurement product before connecting the probe to the circuit under test. Connect the probe reference lead to the circuit under test before connecting the probe input. Disconnect the probe input and the probe reference lead from the circuit under test before disconnecting the probe from the measurement product.

De-energize the circuit under test before connecting or disconnecting the current probe.

Connect the probe reference lead to earth ground only.

Do not connect a current probe to any wire that carries voltages or frequencies above the current probe voltage rating.

Do not connect or disconnect probes or test leads while they are connected to a voltage source.

Use only insulated voltage probes, test leads, and adapters supplied with the product, or indicated by Tektronix to be suitable for the product.

Inspect the probe and accessories

Before each use, inspect probe and accessories for damage (cuts, tears, or defects in the probe body, accessories, or cable jacket). Do not use if damaged.

Ground-referenced oscilloscope use

Do not float the reference lead of this probe when using with ground-referenced oscilloscopes. The reference lead must be connected to earth potential (0 V).

Floating measurement use

Do not float the reference lead of this probe above the rated float voltage.

Service the probe and accessories

Go to *tek.com/support* to find information on contacting Tektronix Service Support.

Terms in this manual and on the product

These terms may appear in this manual:

WARNING: Warning statements identify conditions or practices that could result in injury or loss of life.

CAUTION: Caution statements identify conditions or practices that could result in damage to this product or other property.

These terms may appear on the product:

- DANGER indicates an injury hazard immediately accessible as you read the marking.
- WARNING indicates an injury hazard not immediately accessible as you read the marking.
- CAUTION indicates a hazard to property including the product.

Symbols on the product

When this symbol is marked on the product, be sure to consult the manual to find out the nature of the potential hazards and any actions which have to be taken to avoid them. (This symbol may also be used to refer the user to ratings in the manual.)

The following symbols(s) may appear on the product.

CAUTION: Refer to Manual

Compliance information

This section lists the safety and environmental standards with which the instrument complies. This product is intended for use by professionals and trained personnel only; it is not designed for use in households or by children.

Compliance questions may be directed to the following address:

Tektronix, Inc.
PO Box 500, MS 19-045
Beaverton, OR 97077, US
tek.com

Safety compliance

This section lists the safety standards with which the product complies and other safety compliance information.

Equipment type

Test and measuring equipment.

Pollution degree description

A measure of the contaminants that could occur in the environment around and within a product. Typically the internal environment inside a product is considered to be the same as the external. Products should be used only in the environment for which they are rated.

- Pollution Degree 1. No pollution or only dry, nonconductive pollution occurs. Products in this category are generally encapsulated, hermetically sealed, or located in clean rooms.
- Pollution Degree 2. Normally only dry, nonconductive pollution occurs. Occasionally a temporary conductivity that is caused by condensation must be expected. This location is a typical office/home environment. Temporary condensation occurs only when the product is out of service.
- Pollution Degree 3. Conductive pollution, or dry, nonconductive pollution that becomes conductive due to condensation. These are sheltered locations where neither temperature nor humidity is controlled. The area is protected from direct sunshine, rain, or direct wind.
- Pollution Degree 4. Pollution that generates persistent conductivity through conductive dust, rain, or snow. Typical outdoor locations.

Pollution degree rating

Pollution Degree 2

IP rating

IPX0

Environmental compliance

This section provides information about the environmental impact of the product.

Product end-of-life handling

Observe the following guidelines when recycling an instrument or component:

Equipment recycling	Production of this equipment required the extraction and use of natural resources. The equipment may contain substances that could be harmful to the environment or human health if improperly handled at the product's end of life. To avoid release of such substances into the environment and to reduce the use of

natural resources, we encourage you to recycle this product in an appropriate system that will ensure that most of the materials are reused or recycled appropriately.

This symbol indicates that this product complies with the applicable European Union requirements according to Directives 2012/19/EU and 2006/66/EC on waste electrical and electronic equipment (WEEE) and batteries. For information about recycling options, check the Tektronix Web site (*www.tek.com/productrecycling*).

Preface

This manual describes the installation and operation of the TPR1000 and TPR4000 active power rail probes. Basic probe operations and concepts are presented in this manual. Access this document and other related information from *tek.com*.

The TPR1000 and TPR4000 probes provide a low noise, large offset range solution for measurement of ripple on DC power rails ranging from –60 to +60 VDC. Tektronix's power rail probes offer industry leading low noise and high offset range required to measure AC ripple between 200 μV_{p-p} and 800 mV_{p-p} at up to 4 GHz.

Compatible with the 6 series MSO, 5 series MSO, 4 Series MSO, 3 Series MDO, MDO3000 , MDO4000C, MSO/DPO5000B, DPO7000C, and DPO70000C/DX/SX oscilloscopes. Due to software incompatibilities between the TPR1000 and TPR4000 probes and the MDO3000 and MDO4000C oscilloscopes, the accuracy of probe measurements is reduced when these oscilloscopes are used in vertical scale settings less than 2 mV/division. For all other vertical scale settings, the specified accuracy of the probe is maintained. DPO70000 oscilloscopes require the optional TCA-VPI50 adapter.

Why use a power-rail probe?

The added functionality, higher density, and faster switching speeds of modern electronic products drive the need for lower supply voltages. Designers need to zoom-in on power rails to look for high-frequency intruder signals, measure ripple and analyze coupling effects with tighter tolerances. Oscilloscopes often don't have enough offset to shift the noise and ripple on DC rails to the center of the screen to make the needed measurements.

The TPR1000 and TPR4000 probes provide a low-noise measurement solution (oscilloscope and probe), which is critical to not confuse the noise of the oscilloscope and probe with the noise and ripple of the DC supply being measured. The higher input impedance in the probes minimize the oscilloscope loading effect on DC rails (50 kΩ at DC). The probes provide higher bandwidth to see more signal content (harmonics, faster ripples, etc.) on DC rails that could affect data signals, clocks, etc.

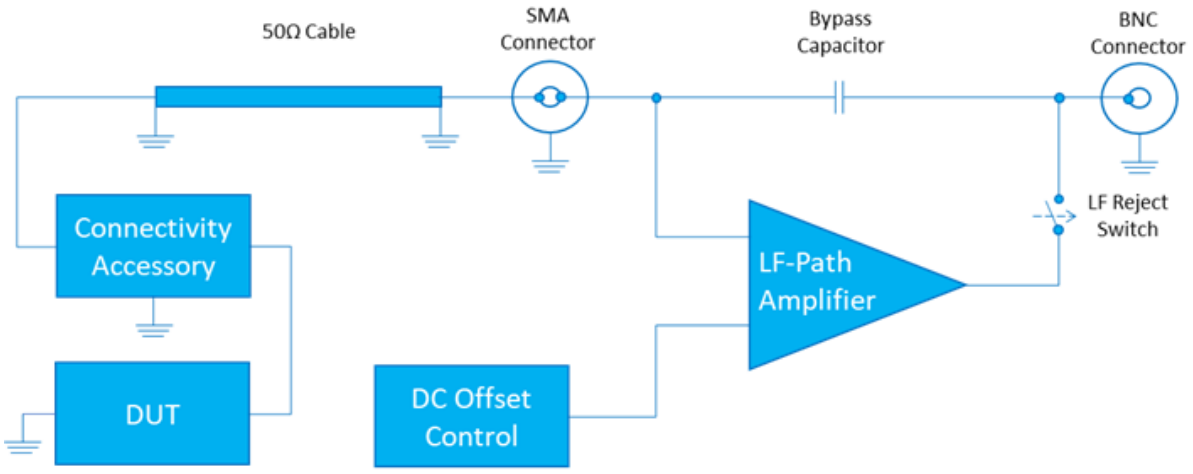
The TPR1000 and TPR4000 provide a best-in-class integrity solution for power integrity and validation engineers in the high speed (µP), low power (mobile) and switched-mode power supply markets. The probes are designed to offer the lowest noise with high bandwidth at 60 V offset, flexible connectivity options to cover customers challenges, and software packages to cover the digital power management market.

Operating information

Use this section to help you use the probe safely and effectively. Read all safety information before installing your measurement system to be aware of the operating and clearance requirements, including possible hazardous areas when the measurement system is connected to the device under test (DUT).

Theory of operation

The block diagram shows the major circuit blocks or modules in the TPR1000 and TPR4000 probes.



The TPR1000 and TPR4000 function by extending the oscilloscopes offset capability while maintaining a low noise signal path into the instrument. The linear dynamic range can be moved around the offset voltage operating window using the DC offset control into the LF amplifier. The LF amplifier can be disconnected when DC offset is not needed by setting the coupling mode to DC reject in the instrument vertical menu. The bypass capacitor acts as a low impedance path for high frequency components while blocking low frequency components. Because the TPR1000 and TPR4000 are designed for measuring the low source impedances of power distribution planes it is not recommended to measure devices with source impedances >1 Ω as it may cause distortion of the waveform.

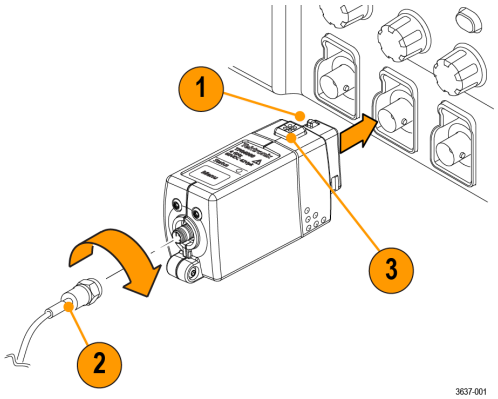
Environmental requirements

Characteristic	Description
Temperature	Probe body: 0 to +50 °C
	Standard accessories: -40 to +125 °C
	High temp accessories: -55 to +155 °C
Humidity	5 to 95% up to +40 °C, derate to 85% above +40 °C
Altitude	Up to 3,000 meters (9,842 feet)
Dynamics (random vibration)	Operating: 5 to 500 Hz, 2.66 gRMS
	Nonoperating: 5 to 500 Hz, 3.48 gRMS

Connecting to the instrument

The following steps describe the process for connecting the TPR1000 and TPR4000 probes.

Procedure



1. Slide the probe body into the FlexChannel or VPI receptacle.

   The probe clicks into place when fully engaged. When the probe is connected, the instrument reads information from the probe and identifies the device. Allow the probe to warm up for at least 20 minutes to achieve guaranteed specifications.
2. Attach one of the following probe cables to the SMA connector on the probe body.

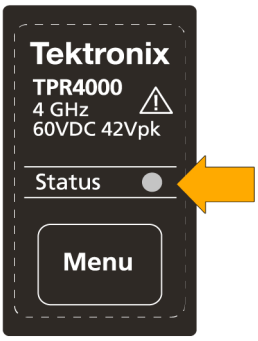
   Limit SMA nut torque to 8 in-lbs for either attachment or removal.

   - SMA-to-SMA standard cable (standard accessory)
   - SMA-to-MMCX standard cable (standard accessory)
   - SMA-to-MMCX high-temperature cable (optional accessory)
   - 1 GHz browser probe cable (optional accessory)
3. To disconnect, press the latch release button and pull away from the instrument.

Probe controls and indicators

A description of the controls and indicators on the compensation box.

When the probe is powered on, the multicolor Status LED indicates the status of the probe.

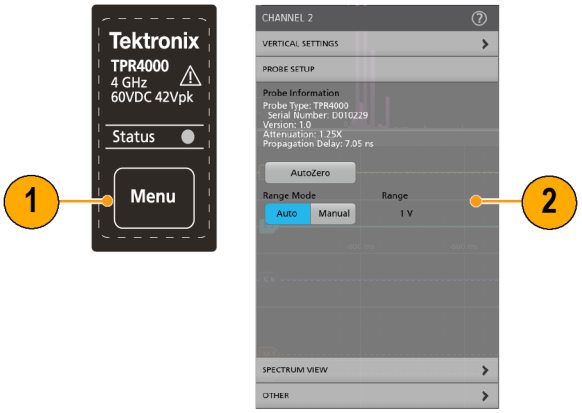


LED	Status	Action
Green (solid)	The probe has initialized and is in the normal operating mode.	-
Green (blinking)	The probe is connected, but has not initialized.	-
Red (any state)	An internal probe diagnostic fault exists.	Disconnect and reconnect the probe to restart the power-on diagnostic sequence. If the Status LED continues to be red or flashing for more than 30 seconds when the instrument application is running, the probe is defective and must be returned to Tektronix for repair.

Note: The TPR1000 and TPR4000 power rail probes are designed to work with all TekVPI-interface oscilloscopes and adapters. However, there may be some cases where all of the probe features may not work properly.

Menu button

Procedure

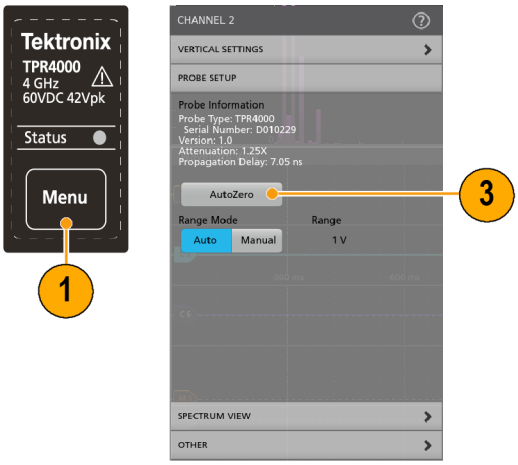


1. Press the probe Menu button to display the **Probe Setup** menu on the instrument.
2. Use the touch-screen buttons on the instrument to set the probe parameters.
   Press the probe Menu button again to close the **Probe Setup** menu.

AutoZero

It is recommend to run AutoZero after the 20 minute warm-up period or when the operating temperature of the probe changes by ±5 °C.

Procedure



1. Press the Menu button to display the Probe Setup menu on the instrument.
2. Short the probe tip to ground.
3. Press the **AutoZero** button on the instrument to run AutoZero.

Functional check

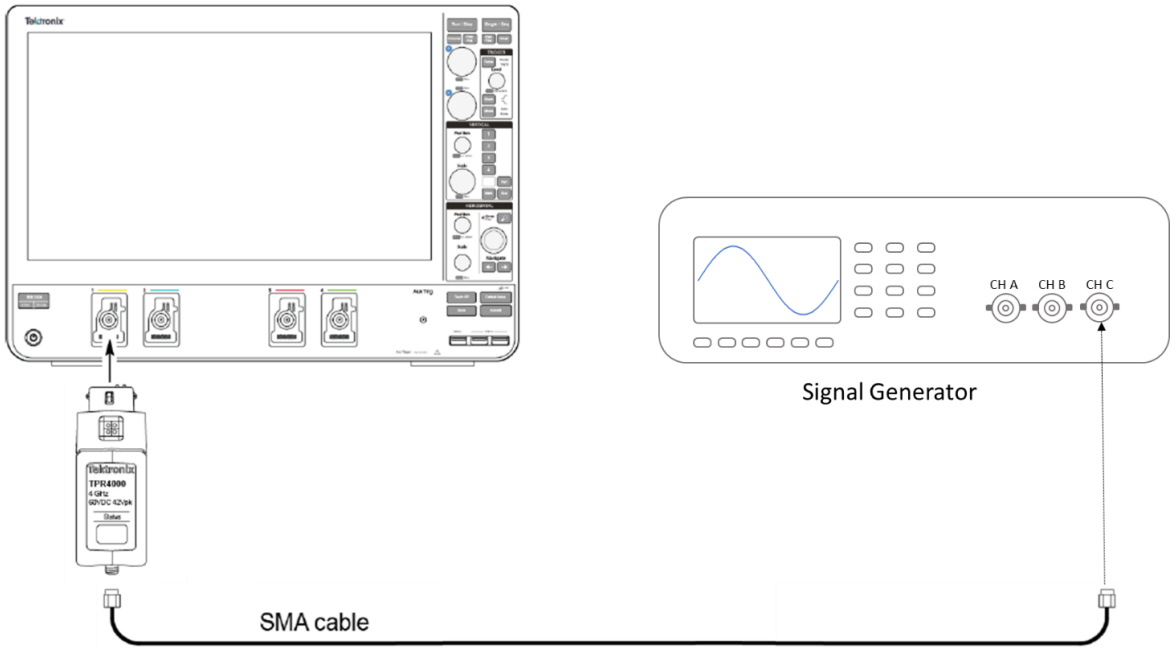
Use the following procedure to check that your probe is functioning properly. To verify that your probe meets the warranted specifications, refer to the Performance Verification procedures.

Before you begin

Table 1: Required equipment

Description	Performance requirement	Recommended equipment
Oscilloscope	TekVPI Interface	DPO7000 Series, 3 Series MDO, 4 Series MSO, 5 Series MSO, 6 Series MSO
SMA cable	1.3 m cable, SMA male-to-SMA male, 50 Ω	Cable included in standard accessory kit (TPR4KIT)
Sine wave generator	Frequency: 10 Mhz	-
	Amplitude: 1 Vpp, Offset 1 Vpp	

Procedure



1. Connect the probe to the oscilloscope and a function generator as detailed in the connection diagram.
2. If the function generator allows load impedance scaling, set the load impedance to high-Z.
   Otherwise, place a 50 Ω feed through terminator between the SMA cable and the probe.
3. Set the probes offset to 1 V and the vertical scale to 200 mV/div.
4. Set the function generator to 1 Vpp amplitude 1 V offset and the function to a 10 MHz sine wave.
5. The instrument should show a 1 Vpp sine wave on the screen centered around 1 V.
6. Open the vertical channel menu and change the coupling mode to DC reject.
7. Set the vertical offset to 0 V.
8. Confirm that the signal is centered around 0 V.

Required instrument software versions

The probe may operate with older versions of instrument software. However, older software versions than those listed are not guaranteed to provide full probe functionality.

Instrument	Required software version
5 and 6 Series MSO	1.12.5
MDO3000	1.27462
MDO4000C	1.09354
MSO/DPO5000B	10.8.3.3
DPO7000C	10.8.3.3
DPO70000C/DX/SX	10.9.1

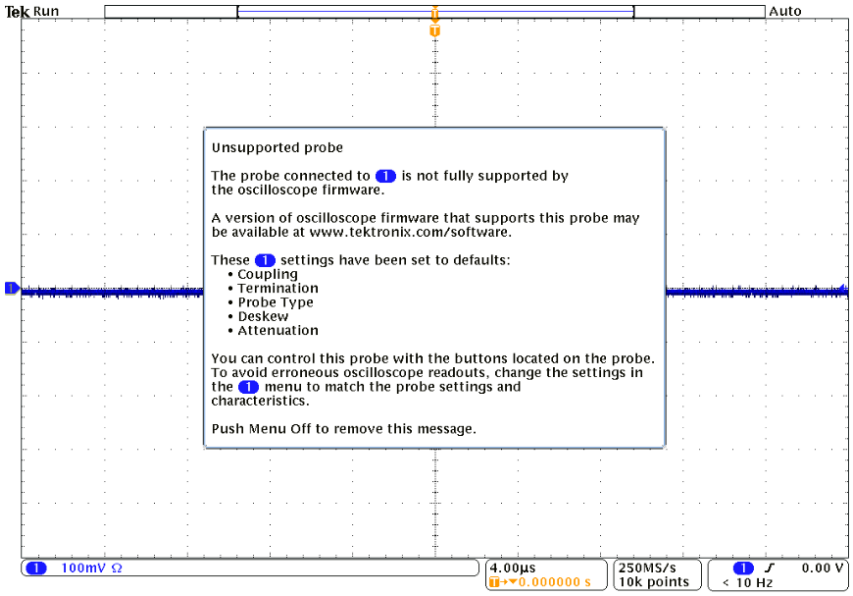
Probe compatibility

Due to software incompatibilities between the TPR1000 and TPR4000 probes and some instrument models, the accuracy of probe measurements is reduced when the oscilloscope is used in vertical scale settings less than 2 mV/division. For all other vertical scale settings, the specified accuracy of the probe is maintained.

To take accurate measurements when using a TPR1000 or TPR4000 probe with the oscilloscope models below, it is recommended to use vertical scale settings greater than 2 mV/division.

- MDO4000C
- MDO4000B
- MDO4000
- MDO3000

When you connect a TPR1000 or TPR4000 probe to one of the oscilloscopes listed above, the warning message shown below appears. If you want to proceed with using the probe with one of these oscilloscopes, press the Menu Off button on the oscilloscope to dismiss the message.



The oscilloscope will allow you to change the vertical scale setting below 2 mV/div without generating a warning message.

Probe input

The probe is electrically protected against static voltage. However, applying voltages above its design limits may damage the probe tip amplifier.

The probe head amplifier used by the probe has a limited linear operating range. To keep the input linearity error within specification, you must limit the signal input voltage to ±1 V.

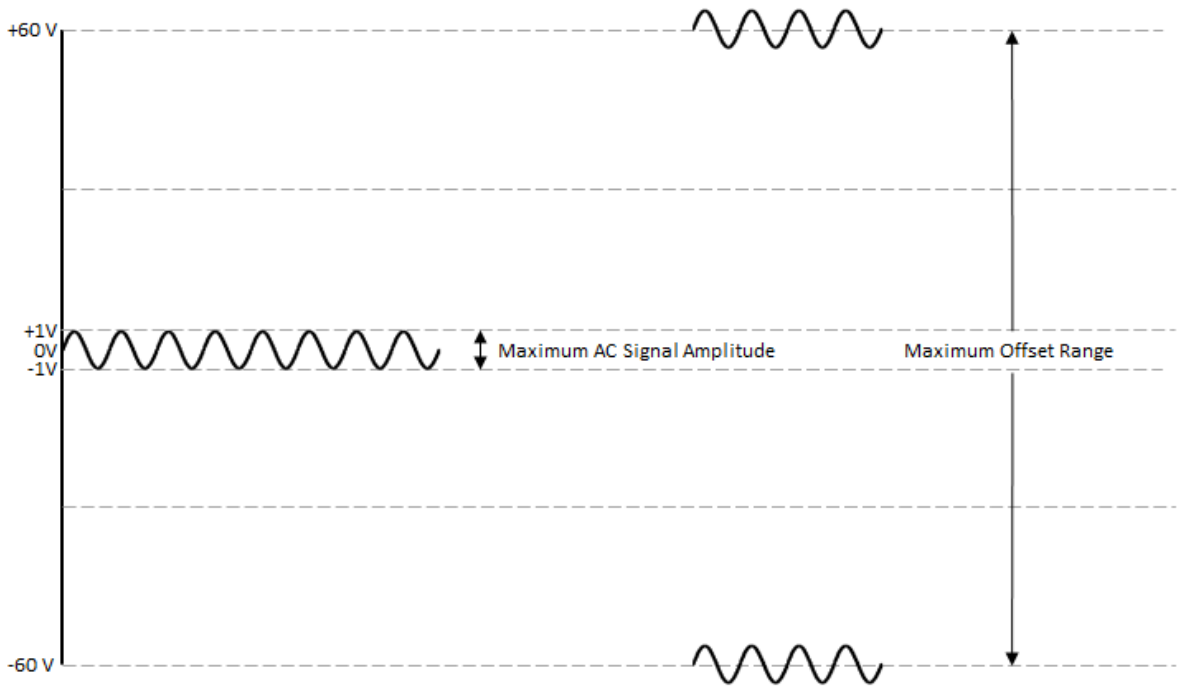


Figure 1: Dynamic and offset limitations

Probe offset

Use the following instructions for setting the probe offset.

Before you begin

See your oscilloscope user manual for specific instructions on using the offset control.

About this task

The probe offset is adjustable for operation within the linear range of the probe, and to increase the sensitivity of the probe at higher DC measurement voltages. Using the offset to cancel DC signal components enables optimal probe performance.

Procedure

1. Set the probe offset equal to the expected nominal DC value of the source you are connecting to.
2. Set the vertical scale to 500 mV/div.
3. Connect the probe to the circuit.
4. Change the volts/div setting to the desired range, adjusting the offset as needed to keep the signal in the center of the screen.

Results

The probe has a ±60 V offset range. The linear operating range is ±1 V. When you adjust the probe offset with no signal applied to the probe input, the output range is ±1 V, (the linear operating range of the probe), not the ±60 V offset range of the probe. However, when you apply up to ±60 V to the probe input, the probe offset control can zero this offset.

If the signal on the screen displays an offset that is either 1 Volt higher or lower than expected, check to make sure the DUT is connected and operating. This is a result of the input to the LF amplifier being clamped at one extreme of the dynamic range when no input is present.

Connect MMCX accessories

The following describes how to connect to MMCX accessories.

Gently insert the MMCX end of the cable into one of the following accessories: micro-coax tip, solder flex tip, u.fl adapter, or MMCX to square pin Y-lead adapter, until you feel the connector engage. To remove an accessory, gently pull from the MMCX connection point, being careful to only grip the knurled metal area of the connector.

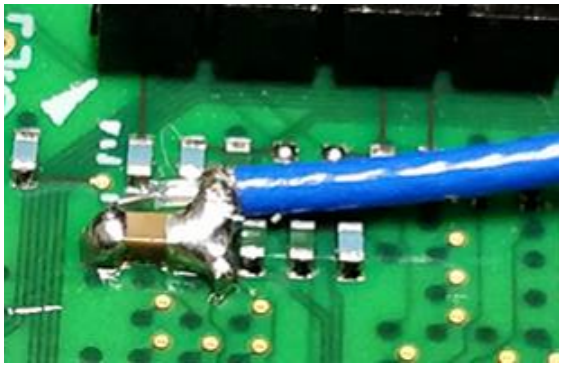
Connect solder-in accessories

The following describes how to connect to solder-in accessories.

There are two types of solder-in accessories, micro-coax and flex tips.

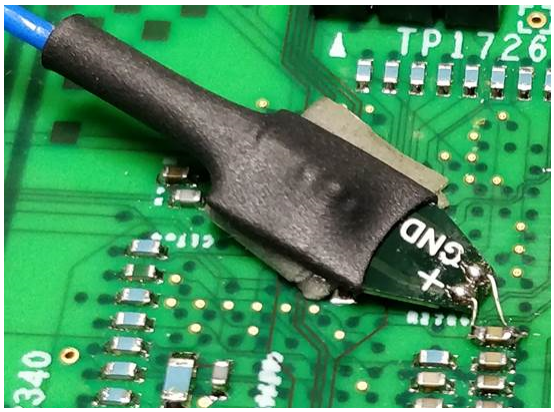
Micro-coax tip

For convenient first-time use, the solder micro-coax tips are shipped pre-trimmed and ready to be soldered to the test point. You can reuse a tip by removing the tip from the solder joint and then trimming the wire insulation back to expose the center pin and ground shield on the tip cable.



Flex tip

To attach the solder flex tip, first solder the enameled self-fluxing copper wire (standard accessory) to the test point. Feed the wire through the vias on the end of the flex tip, and then apply a small amount of solder to the vias to attach the wire to the tip.



Using the solder-pin installation tool

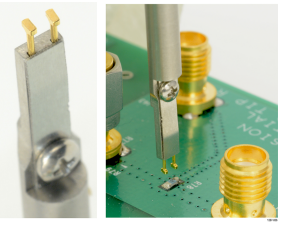
The following describes how to install the solder pins using the supplied soldering-aide tool.

Before you begin

The supplied set of solder pins are intended to be installed on DUT circuit boards and used with the supplied MMCX to square-pin adapter.

The solder pins are extremely small and can be challenging to handle. It is recommended to use tweezers and a magnifying tool when installing pins on a circuit board.

Procedure



1. Carefully insert the solder pins into the soldering aide tool as shown in the image.
2. Use the soldering aide tool to hold the solder pins in place while soldering the pins to the circuit board.
3. If necessary, apply a small amount of adhesive to further strengthen the connection to the circuit board.
   Keep the height of the adhesive to a minimum to provide good electrical contact for the adapter.

Using the tripod

The tripod probe support adds stability to square-pin mounted test points.

For more stability, use glue to attach the tripod legs to the DUT circuit board.

Using the optional browser

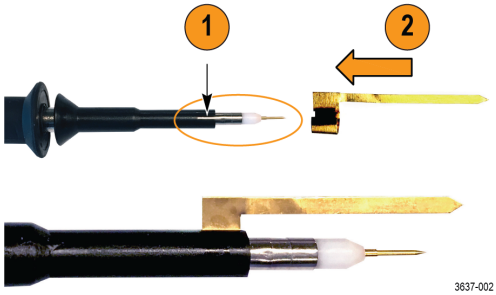
The optional browser kit contains the following parts: up to 1 GHz browser probe, square pin Y-lead adapter, micro-SMD clip, three ground leads, and four replacement probe-tip pins.

WARNING: To prevent injury to the operator or damage to the probe, oscilloscope, and DUT, do not touch the probe ground to any point that is not at the same potential as the chassis ground of the oscilloscope. The probe ground must be connected to the same potential as the chassis ground of the oscilloscope.

Installing ground leads

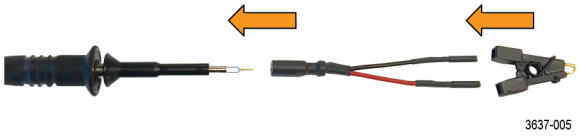
To obtain accurate measurements, always attach a ground lead to the probe tip before making measurements. It is recommended that you use the shortest ground lead that will function in your electrical application. The following illustration shows the browser probe tip, the tip cover, and the three types of grounds leads supplied with the browser.

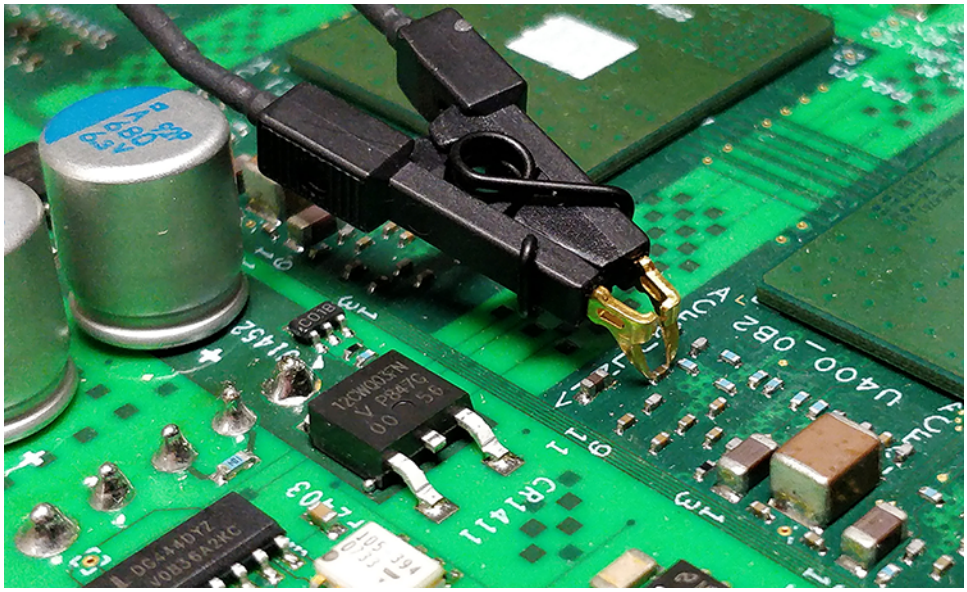
- To install the spring ground lead, slide the ground lead over the probe tip until it seats around the metal part of the probe-tip housing.
- To install the alligator ground lead, slide the ground lead prongs over the exposed metal between the plastic probe-tip sections.
- To install the blade ground lead, locate the slot in the probe-tip housing as shown below. Slide the ground lead over the probe tip until the blade slides into the slot.



Connecting the Y-lead adapter and micro-SMD clip

The browser kit includes a Y-lead adapter and a micro-SMD clip that connect as shown below. The Y-lead adapter can also connect to square pins.





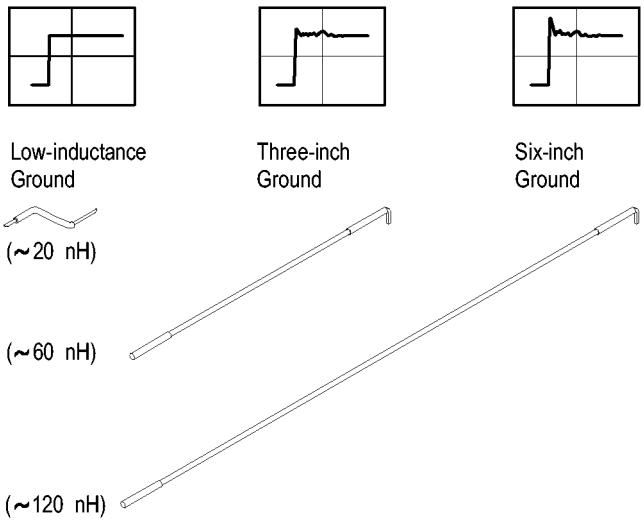
Replacing browser-tip pins

To remove the browser-tip pin, use pliers to grasp the pin and gently pull it out of the tip housing. To install a new browser-tip pin, select between a solid (silver colored) or spring-loaded (gold colored) pin, and then use pliers to gently insert the pin into the browser-tip housing until you feel the pin press against the bottom of the housing.

Ground lead length

When you are probing a circuit, you should always use as short a ground lead as possible between the probe head and circuit ground.

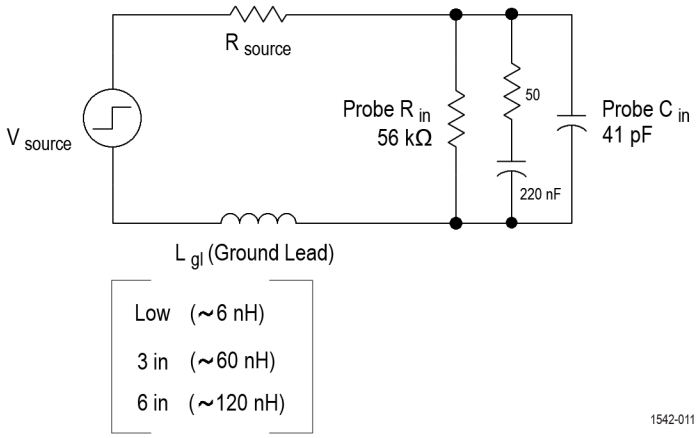
The following illustration shows the effects of lead length on waveform distortion.



The series inductance added by the probe tip and ground lead can result in a resonant circuit; this circuit may cause parasitic ringing within the bandwidth of your oscilloscope.

Ground lead inductance

When you touch your probe tip to a circuit element, you are introducing a new resistance, capacitance, and inductance into the circuit.



You can determine if ground lead effects may be a problem in your application if you know the self-inductance (L) and capacitance (C) of your probe and ground lead. Calculate the approximate resonant frequency (f_0) at which this parasitic circuit will resonate with the following formula.

$$f_0 = \frac{1}{2\pi\sqrt{L_{gl}\ Probe\, C_{in}}}$$

The equation shows that reducing the ground lead inductance will raise the resonant frequency. If your measurements are affected by ringing, your goal is to lower the inductance of your ground path until the resulting resonant frequency is well above the frequency of your measurements.

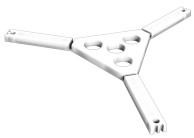
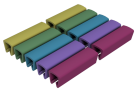
The low-inductance ground contacts described in Accessories can help you reduce the effects of ground lead inductance on your measurements.

Accessories

Each probe is shipped with one TPR4KIT accessory kit containing the following items.

Item	Image
1.3 m cable, SMA male-to-MMCX male, 50 Ω	
1.3 m cable, SMA male-to-SMA male, 50 Ω	

Table continued…

Item	Image
Y-lead adapter, MMCX female-to-0.8 mm sockets	
Adapter cable, MMCX female-to-U.FL female, 50 Ω	
Adapter, MMCX female-to-square pin (0.062 centers)	
DUT interface solder pins, set of 20	
Soldering aide tool, 0.062 solder pins over SMT	
Solder-in cable adapter, MMCX female-to-solder micro-coax tip, 50 Ω, set of 3	
Solder-in cable adapter, MMCX female-to-solder flex-paddle tip, 50 Ω, set of 3	
Wire card, solderable enameled self-fluxing copper wire (for use with the solder-in tips)	
Probe tip tripod support (with living hinge)	
Marker bands, set of 5 (for probe identification)	

Optional high-temperature accessory kit

The optional TPR4KITHT high-temperature accessory kit contains the following items.

Item	Image
2 m high-temperature cable, SMA male-to-MMCX male, 50 Ω	
Solder-in cable adapter, MMCX female-to-solder micro-coax tip, 50 Ω, set of 3	
Solder-in cable adapter, MMCX female-to-solder flex-paddle tip, 50 Ω, set of 3	

Optional 1 GHz browser accessory kit

The optional TPRBRWSR1G accessory kit contains the following items.

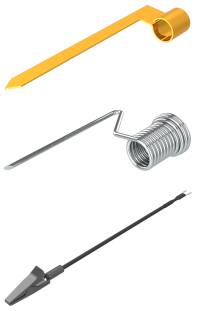
Item	Image
Browser	
Ground leads (blade, 0.5 mm spring, 15 cm alligator)	
Y-lead adapter, browser tip-to-0.8 mm sockets	
Micro-SMD clip	

Table continued…

Item	Image
Replacement 0.5 mm browser tips (2 solid tips, 2 spring tips)	

Optional solder-in micro-coax tip accessory kit

The optional TPR4SIACOAX accessory kit contains the following items.

Item	Image
Solder-in cable adapter, MMCX female-to-solder micro-coax tip, 50 Ω, set of 3	

Optional solder-in flex-paddle tip accessory kit

The optional TPR4SIAFLEX accessory kit contains the following items.

Item	Image
Solder-in cable adapter, MMCX female-to-solder flex-paddle tip, 50 Ω, set of 3	

Specifications

The specifications apply to both the TPR1000 and TPR4000 probes unless noted otherwise.

The specifications are valid under the following conditions:

- The probe has been calibrated at an ambient temperature of 23 °C ±5 °C.
- The probe is connected to a host instrument with an input impedance of 50 Ω.
- The probe and oscilloscope must have a warm-up period of at least 20 minutes and be in an environment that does not exceed the limits described.
- The Signal Path Compensation (SPC) has been run on the oscilloscope before testing the probe specifications.

Warranted characteristics

Warranted characteristics describe guaranteed performance within tolerance limits or certain type-tested requirements.

Warranted characteristics that have checks in the *Performance Verification* section are marked with the ✔ symbol.

Characteristic	Description
DC attenuation	1.25x
✔ DC attenuation accuracy	<±1% within 80% of DC dynamic range
✔ Analog bandwidth (SMA configuration)	1 GHz (TPR1000)
	4 GHz (TPR4000)
DC input dynamic range	>±1 V
✔ Offset scale accuracy	(2% of setting value + 2.5 mV max)
	Typical value is ±(0.1% + 2.5 mV) after SPC and Probe Zero

Typical characteristics

Typical characteristics describe typical, but not guaranteed performance.

Table 2: Electrical characteristics

Characteristic	Description
DC input resistance	50 kΩ
Return loss (50 Ω reference impedance)	Maximum: -12 dB between 10 MHz and 1 GHz (TPR1000)
	Maximum: -12 dB between 10 MHz and 4 GHz (TPR4000)
DC to AC impedance crossover frequency	300 Hz
DC to AC gain matching	±1%
Risetime (small signal, 20% to 80%)	282 pS (TPR1000)
	88 pS (TPR4000)
Risetime (small signal, 10% to 90%)	408 pS (TPR1000)
	128 pS (TPR4000)
Step Response Long Term Aberrations	<1% of final value after 50 µS
Delay time (compensation box only)	565 ps ±20% (TPR1000)
	475 ps ±20% (TPR4000)
Delay time for each accessory	6.19 ns ±10% (1.3 m MMCX cable)
	9.47 ns ±10% (2 m MMCX cable)
	494 pS ±20% (10 cm blue coax solder-in)
	500 pS ±20% (10 cm Flex Paddle Adapter)
	484 pS ±20% (U.FL to MMCX Adapter)
	5.2 nS ±10% (Browser)
Delay time (base configuration consists of 1.3 m SMA to MMCX cable + MMCX micro coax tip, TRPSIACOAX)	7.12 nS
Noise	Typical: <25% RMS additive to oscilloscope at full bandwidth
Noise (probe only, DC to 20 MHz)	Maximum: 220 µV p-p
	Typical: 165 µV p-p into 6 series MSO
Input common mode rejection	-20 dB 20 Hz up to probe bandwidth

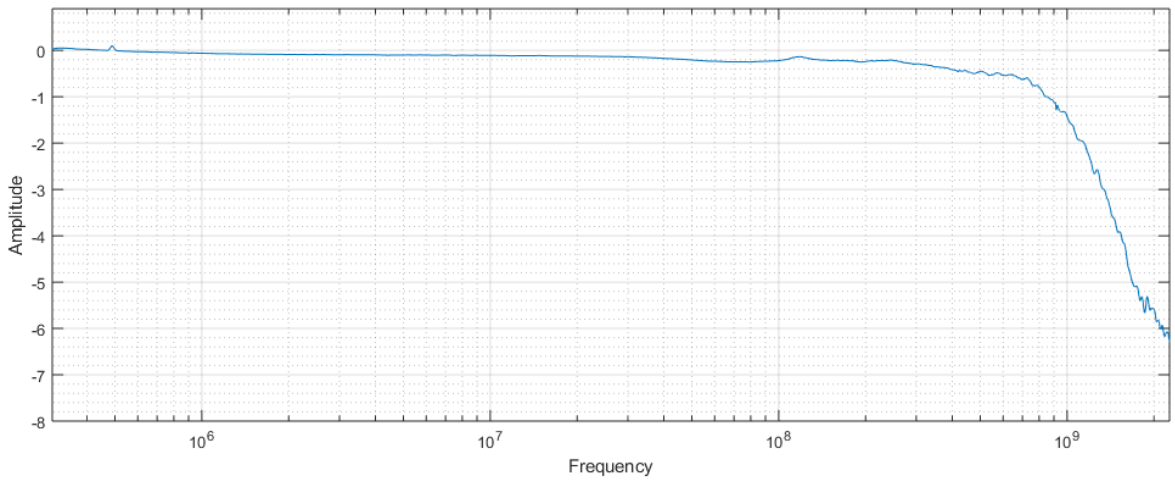


Figure 2: TPR1000 frequency response

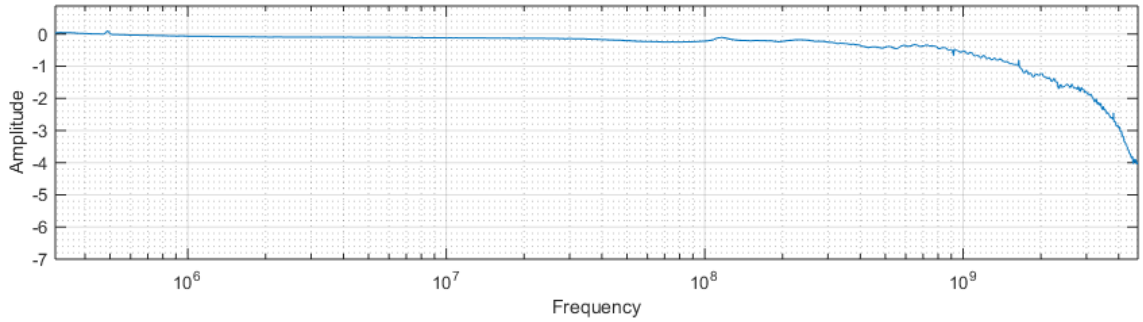


Figure 3: TPR4000 frequency response

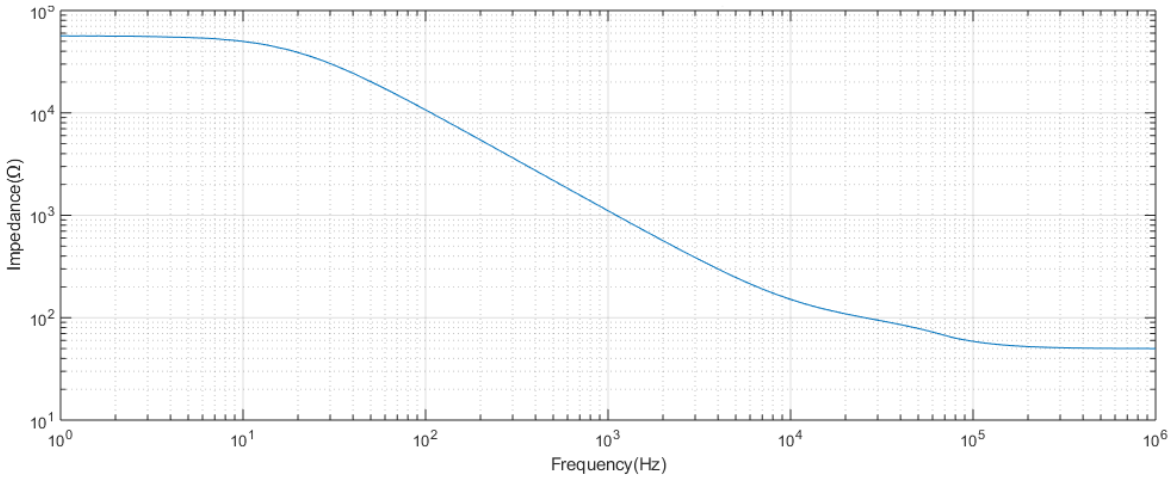


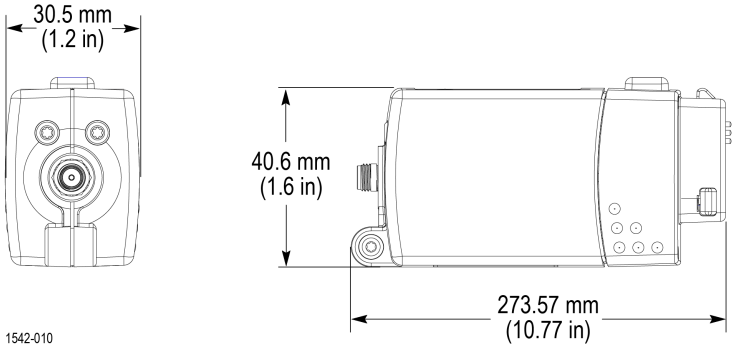
Figure 4: TPR1000 and TPR4000 input impedance versus frequency

Table 3: Mechanical characteristics

Characteristic	Description
Dimensions (compensation box)	85.1 mm × 40.6 mm × 30.5 mm (3.4 in × 1.6 in × 1.2 in)

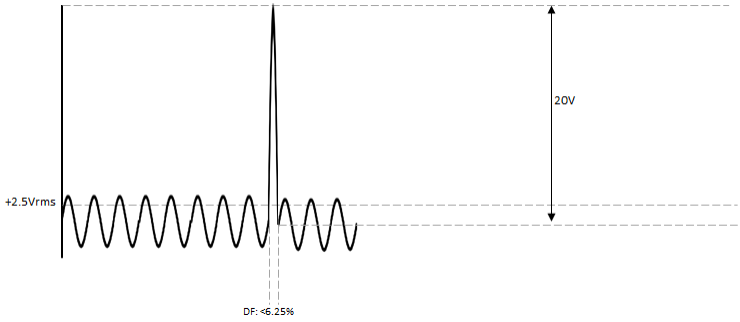
Table continued…

Characteristic	Description
Packaged weight	1.24 kg (2.7 lbs)



Nominal characteristics

Nominal characteristics describe guaranteed traits, but the traits do not have tolerance limits.

Characteristic	Description
Compatibility	Oscilloscopes equipped with the TekVPI interface
Instrument coupling	DC, LF-Reject
Input offset requestable range	±60 V
Non-destructive input voltage range (AC frequency above 10 kHz)	2.5 VRMS, with peaks ≤±20 V (DF 6.25%) 
Input connector on compensation box	SMA-female jack
Output connector on cable	SMA-male plug
DUT connector on standard cable	MMCX-male plug
DUT connector on optional cable	SMA-male plug
	SMP-female jack
Insulation voltage rating	±30 V RMS (AC)
	±42 V Peak (pk-pk)
	±60 V DC (DC)

Accessory characteristics

Specifications for the TPR1000 and TPR4000 accessories are either warranted and typical characteristics.

Table 4: Electrical characteristics

Characteristic	Description
TPR4SIAFLEX and TPRSIACOAX (typical)	1 GHz (TPR1000)
	>3.5 GHz (TPR4000)
SMA to SMA cable (warranted)	1 GHz (TPR1000)
	4 GHz (TPR4000)
MMCX to U.FL adapter (typical)	1 GHz (TPR1000)
	>2 GHz (TPR4000)
MMCX to square pin adapter (typical)	1 GHz (TPR1000)
	1 GHz (TPR4000)
2 M high temperature SMA to MMCX cable (typical)	1 GHz (TPR1000)
	>2 GHz (TPR4000)

Table 5: Typical mechanical characteristics

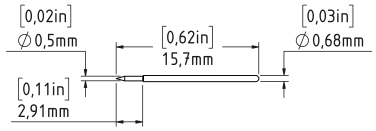
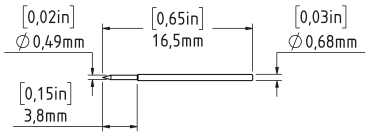
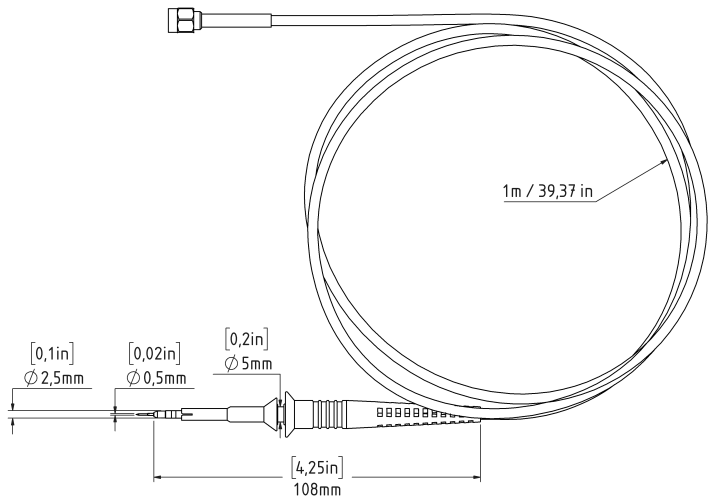
Item number	Dimensions
Rigid Browser Tip	
Pogo Browser Tip	
Browser	

Table continued…

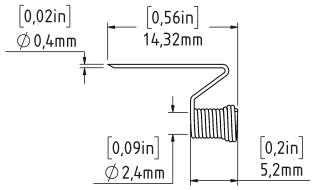
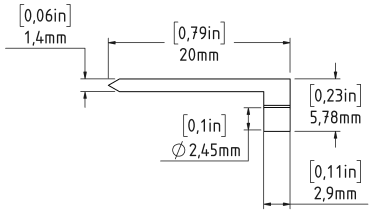
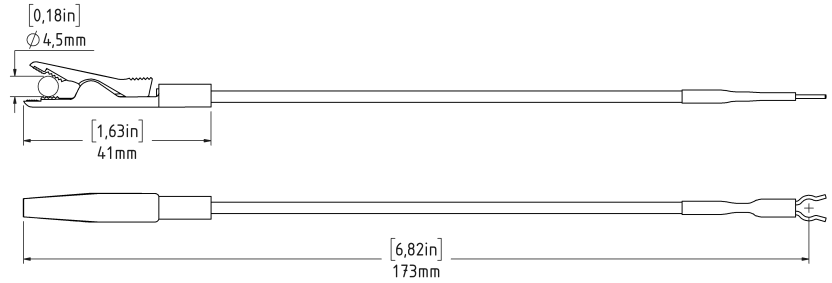
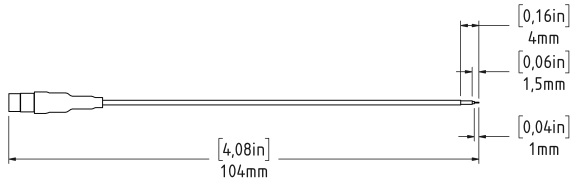
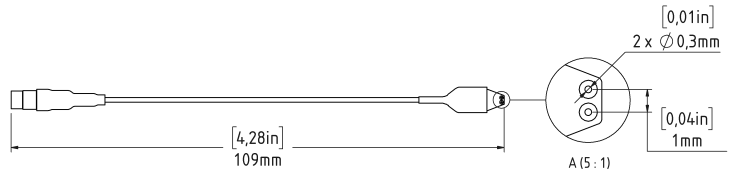
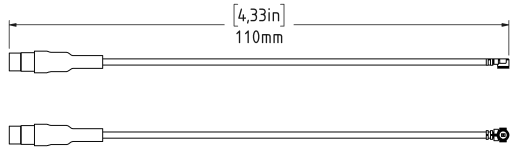
Item number	Dimensions
Browser Spring Ground	
Browser Blade Ground	
Browser Alligator Ground	
TPRSIACOAX	
TPRSIAFLEX	
MMCX to U.FL adapter	

Table continued…

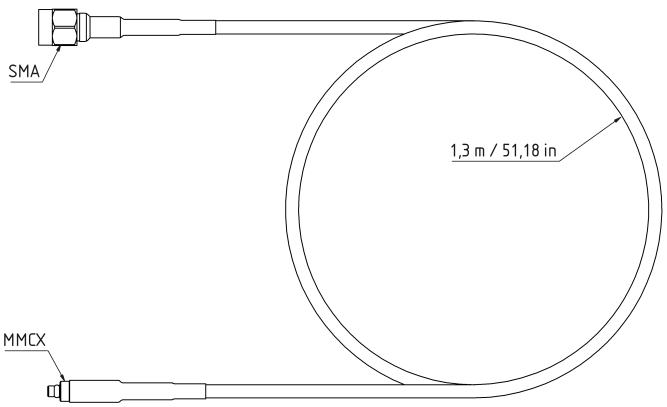
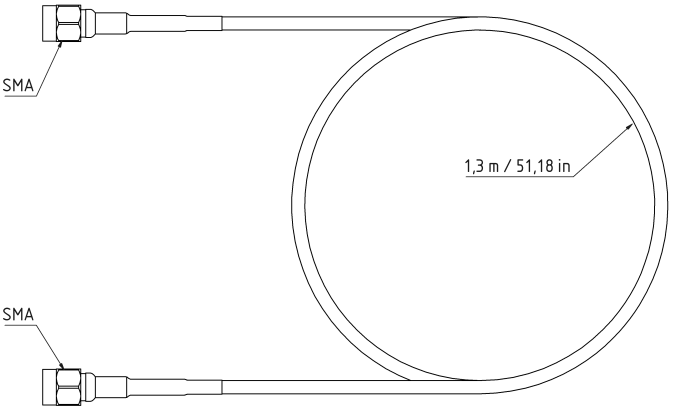
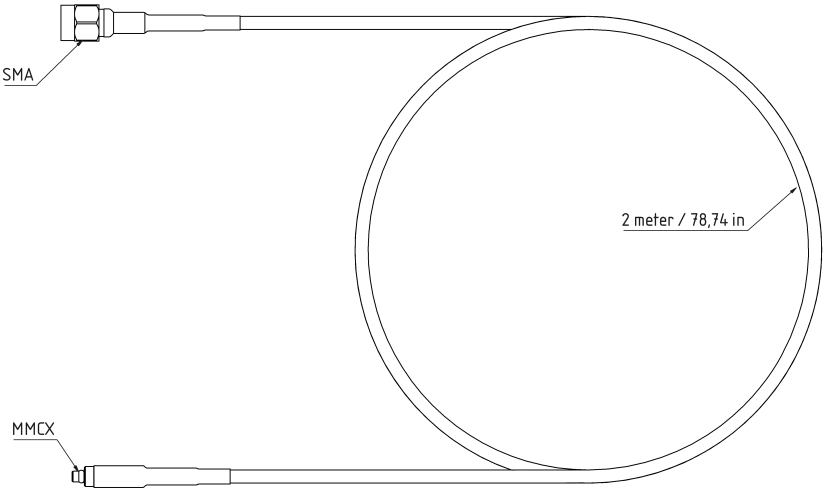
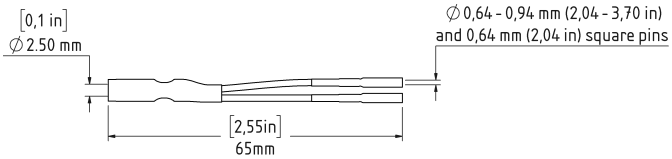
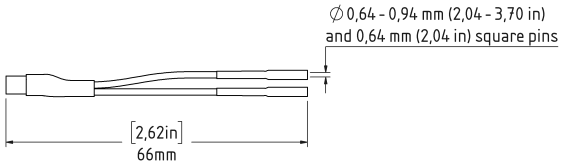
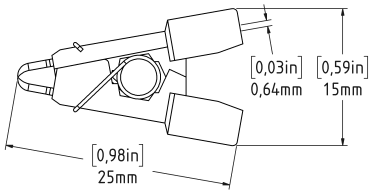
Item number	Dimensions
1.3 m SMA to MMCX Cable	
1.3 m SMA to SMA Cable	
2 m SMA to MMCX Cable	
Browser to Square-pin adapter	

Table continued…

Item number	Dimensions
MMCX to Square-pin adapter	
SMT Component Clip	

Performance verification

The procedures that follow verify the warranted specifications of the probe. The recommended calibration interval is one year. Perform the verification procedures in the order listed.

The following equipment is required for the performance verification procedures. The nine-digit part numbers (xxx-xxxx-xx) are Tektronix part numbers.

Table 6: Required test equipment

Description and quantity	Performance requirement	Recommended example
Oscilloscope	TekVPI Interface	Tektronix 6 Series MSO, 8 GHz bandwidth option
DC calibration source	-	Keithley 2400 SMU
Digital multimeter (DMM)	Resistance, 0.1% accuracy	Keithley 2700 DMM
Network Analyzer	-	Tektronix VNA TTR506, 067-1701-XX with Calibration kit BN533828
TekVPI Calibration Verification adapter	TekVPI Interface	-
SMA to BNC adapter	SMA male to BNC female	015-0554-XX
SMA to BNC adapter	SMA female to BNC male	015-0572-XX
SMA to SMA adapter	SMA male to SMA male	015-0551-XX
BNC-to-dual banana adapter (2)	-	103-0090-XX
BNC cable (2)	50 Ω, 0.76 m (30 in) length	012-0117-XX
Feed-thru termination	50 Ω, 1 GHz, ±0.5 Ù	011-0049-XX
SMA cable for network analyzer	N to SMA-M 5 foot cable	012-1774-XX
SMA adapter for network analyzer	Type-N male to Type-SMA female	013-0406-XX
SMA torque wrench	5/16-in, 7 in-lb.	-
SMA adapter wrench	7/32-in	-

Equipment setup

Use the following procedures to set up and warm up the equipment to test the probe.

Use the DC setup diagram for the following performance checks.

- DC gain accuracy
- DC input dynamic range
- Input offset range and scale accuracy

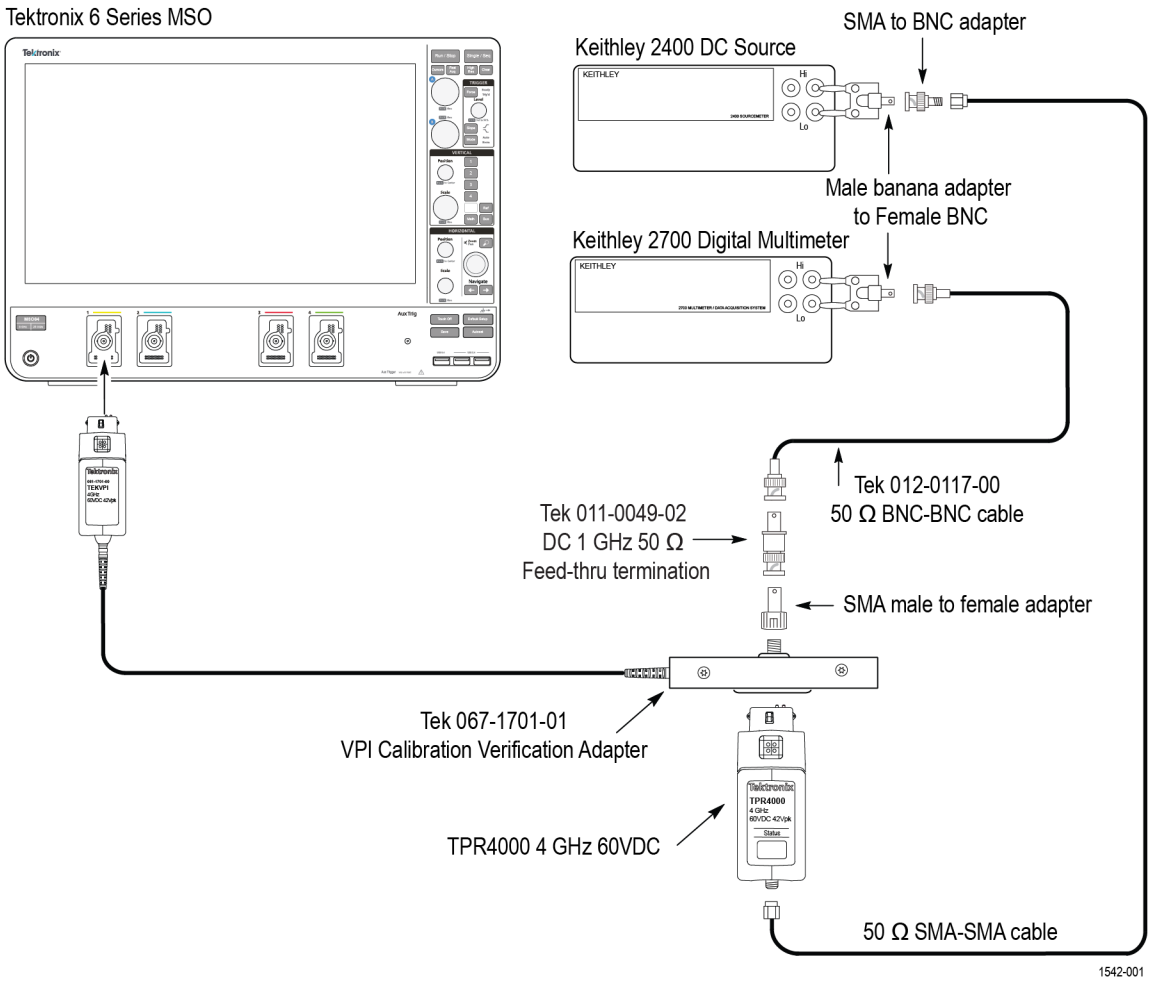


Figure 5: DC setup connection diagram

Use the analyzer setup diagram for the analog bandwidth performance check.

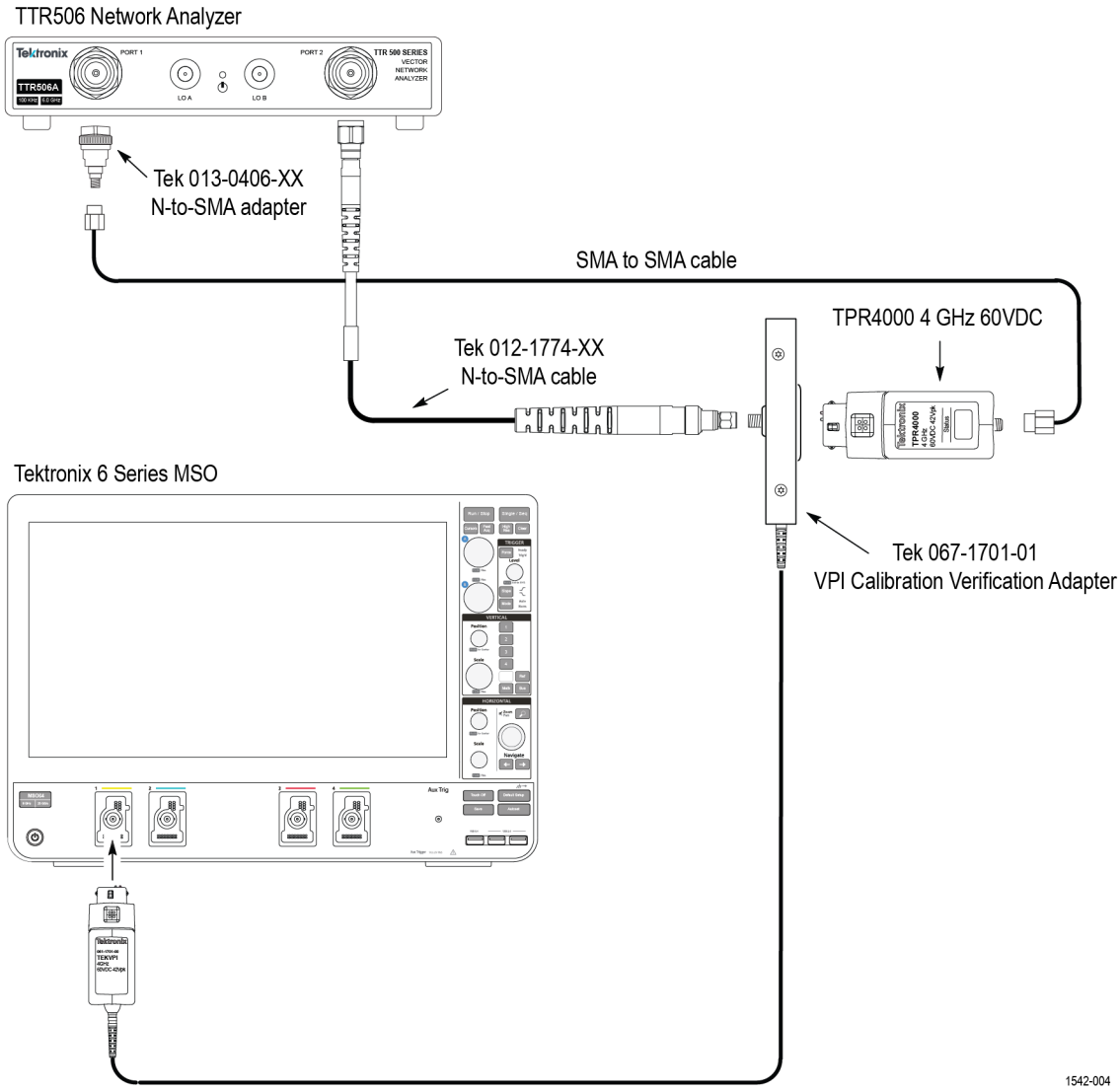


Figure 6: Analyzer setup connection diagram

Warm up the test equipment

1. Turn on the TekVPI oscilloscope.
2. Connect the TekVPI Calibration/Verification adapter to the oscilloscope.
3. Connect the probe to the TekVPI Calibration Verification adapter and verify that the Status LED on the probe turns green.
4. Turn on the remaining test equipment.
5. Allow 20 minutes for the equipment to warm up.
6. Use the test record template to record the test results.

Test record

Use the test record to record the values of the performance verification checks.

Probe Model/Serial Number:	
Certificate Number:	
Temperature:	
RH %:	
Date of Calibration:	
Technician:	

Performance test		**Minimum**	**Measured / calculated**	**Maximum**
DC gain accuracy		0.792		0.808
DC input dynamic range		–1 V		NA
		NA		+1 V
DC reject function		Pass/Fail		-
Input offset range and scale accuracy	+12 V offset	-194 mV		194 mV
	+1 V offset	-18 mV		18 mV
	–1 V offset	-194 mV		194 mV
	–12 V offset	-18 mV		18 mV
Analog bandwidth	TPR1000	-3 dB		NA
	TPR4000	-3 dB		NA

Check the DC gain accuracy

Use the following test to check the DC gain accuracy of the probe.

Before you begin

When using the DMM function in a Keithley SMU, turn on **FILTER** to reduce transient output values.

Procedure

1. Connect the test equipment as shown in the *DC setup diagram*.
2. Before attaching the probe to the TekVPI Calibration Verification adapter, measure the resistance of the feed-thru termination with the DMM.
3. Record its value.

   If it is out of specification, replace the precision terminator before continuing the test.
4. Attach the probe to the TekVPI Calibration Verification adapter.
5. Ensure the probe offset is set to 0 V.
6. Set the digital multimeter (DMM) to the following settings.
   a) DC Volts auto ranging
   b) Filter mode on
   c) Measurement rate slow
7. Set the DC source current limit to 3 mA.
8. Set the DC source to the first voltage level listed below.

Table 7: DC source voltage levels

Index	DC source voltage	Vout (measured)	Vout (linear fit)
–2	–640 mV		–512 mV
–1	–320 mV		–256 mV
0	0 mV		0 mV
1	320 mV		256 mV
2	640 mV		512 mV

9. On the DMM measure the probe response and record the level in the Vout (measured) column in the table.
10. Repeat steps *8* on page 39 and *9* on page 39 for each voltage level listed in the table.
11. Perform a linear fit of the measured data points in the preceding table and record the linear fit values in the table.
12. Divide the measured linear fit slope by the slope of the DC source voltage points.
13. Record the Measured Gain value in the test record.

Example

Table 8: DC source voltage levels example

Index	DC source voltage	Vout (measured)	Vout (linear fit)
–2	–640 mV	–513 mV	–512 mV
–1	–320 mV	–256 mV	–256 mV
0	0 mV	0.0009 mV	0 mV
1	320 mV	258 mV	256 mV

Table continued…

Index	DC source voltage	Vout (measured)	Vout (linear fit)
2	640 mV	515 mV	512 mV

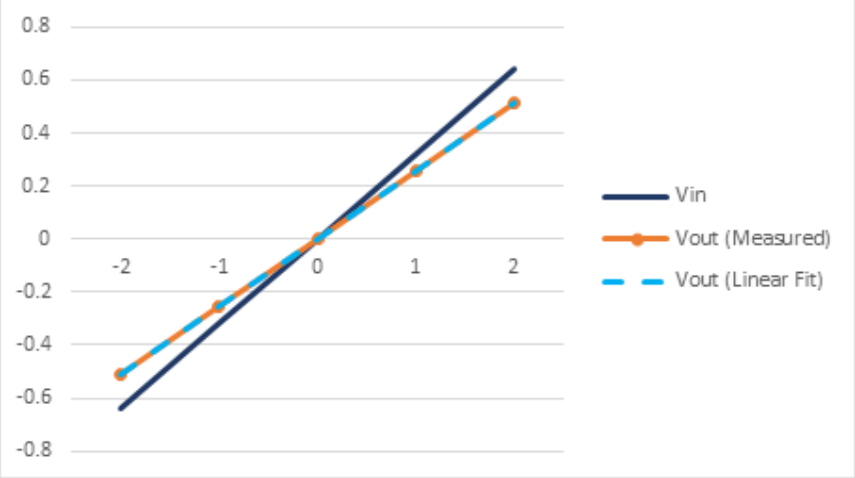


Figure 7: Example plot of measured values

The gain slope can either be obtained by using a spreadsheet to calculate the linear regression of the points, or graphically by hand. To obtain the gain slope graphically, carefully plot each measurement point on a rectangular coordinate system, the X axis is the DC source voltage and the Y axis is the measured DC output value. Using a straight edge, draw a line through the points, minimizing the error between the line and each point. The gain slope is taken by the slope of the drawn line (rise in Y divided by run in X), and the zero point error taken at the point at which the line crosses the Y axis. The DC output value can be predicted by the following equation:

$$Vout\,(n) = gainslope \times Vin\,(n) + zeropoint$$

Table 9: Example calculation of measured gain

Vout (linear fit) slope	Vin slope	Measured gain
0.257	0.320	0.803125

Check the DC input dynamic range

Use the following test to check the DC input dynamic range of the probe.

Before you begin

When using the DMM function in a Keithley SMU, turn on **FILTER** to reduce transient output values.

Procedure

1. Connect the test equipment as shown in the *DC setup diagram*.
2. Before attaching the probe to the TekVPI Calibration Verification adapter, measure the resistance of the feed-thru termination with the DMM.
3. Record its value.

   If it is out of specification, replace it before continuing the test.
4. Attach the probe to the TekVPI Calibration Verification adapter.
5. Ensure the probe offset is set to 0 V.

6. Set the DMM to DC Volts autoranging.
7. Set the DC source current limit to 3 mA.
8. Set the source measure unit (SMU) to +1 V and record the output voltage on the DMM.
9. Set the source measure unit (SMU) to –1 V and record the output voltage on the DMM.
10. Using the readings taken in steps 8 and 9, apply the following equation to calculate the gain of the probe: $Gain_{probe} = V_{source} \div V_{measured}$.
11. Verify that the gain is at least 90% of the nominal gain range for each input by dividing it by the nominal expected gain and multiplying by 100: $100 \times Gain_{measured} \div Gain_{nominal}$.
12. If the value is >90%, then that limit of the dynamic range is verified.
13. Record results in test record.
14. Switch the probe to DC Reject mode.
15. While measuring the output, apply +1 V and –1 V to the input of the probe.
16. Ensure that output does not shift by more than 0.01 V during the test.

    Result is reported as Pass or Fail.
17. Return the probe to **DC Coupling** mode.
18. Record the result in the test record.

Check the input offset range and scale accuracy

Use the following test to check the input offset range and scale accuracy of the probe.

Procedure

1. Connect the test equipment as shown in the *DC setup diagram*.
2. Before attaching the probe to the TekVPI Calibration Verification adapter, measure the resistance of the feed-thru termination with the DMM.
3. Record its value.

   If it is out of specification, replace it before continuing the test.
4. Attach the probe to the TekVPI Calibration Verification adapter.
5. Set the DMM to DC Volts autoranging.
6. Set the DC source current limit to 3 mA.
7. Sweep the DC source through the discrete points listed in the following table and set the probe offset range to the same set point using the Probe Setup window on the oscilloscope.

   Measure the probe response at each point with the DMM.

DC source voltage	Probe vertical offset setting
+12 V	+12 V
+1 V	+1 V
–1 V	–1 V
–12 V	–12 V

8. Record the result of each setting in the test record.

Check the analog bandwidth

Use the following test to check the analog bandwidth of the probe.

About this task

For more information on setting up a network analyzer, use the following links:

- *tek.com/how/making-basic-2-port-measurements-using-ttr500-vna*
- *tek.com/how/how-calibrate-ttr500-vector-network-analyzer*

Procedure

1. Connect the test equipment as shown in the *Analyzer setup diagram*.
2. Set the network analyzer to measure insertion loss (S21) in dB. Set the network analyzer to the following settings:
   a) Power Level: –10 dBm
   b) IF Bandwidth: 1 kHz
   c) Sweep Type: Linear
   d) Start Frequency: 300 kHz
   e) Stop Frequency: 6 GHz
   f) Number of points: 201
   g) Set scale factor: 1 dB
3. Set up the network analyzer with a fresh 2-port SOLT calibration to the reference planes of the SMA side of network analyzer cable (port 2) and the SMA side of the SMA-to-N adapter (port 1).
4. Place a marker on the S21 trace at the start frequency (300 kHz).
5. Place a marker on the S21 trace at the probe bandwidth (1 GHz for TPR1000 or 4 GHz for TPR4000).
6. Verify that the amplitude is greater than -3.97 dB (subtracting the 0.97 dB of probe attenuation range from the 3.97 dB target value yields the 3 dB limit).
7. Record the result in the test record.

Maintenance

This section contains maintenance information for your probe.

Note: There are no user replaceable parts within the probe. Refer to Accessories for a list of replaceable accessories for your probe.

Cleaning

Protect the probe from adverse weather conditions. The probe is not waterproof.

CAUTION: To prevent damage to the probe, do not expose it to sprays, liquids, or solvents. Avoid getting moisture inside the probe during exterior cleaning.

Do not use chemical cleaning agents; they may damage the probe. Avoid using chemicals that contain benzine, benzene, toluene, xylene, acetone, or similar solvents.

Clean the exterior surfaces of the probe with a dry, lint-free cloth or a soft-bristle brush. If dirt remains, use a soft cloth or swab dampened with a 75% isopropyl alcohol solution. A swab is useful for cleaning narrow spaces on the probe, use only enough solution to dampen the swab or cloth. Do not use abrasive compounds on any part of the probe.

Returning instrument for service

Use the following instructions for returning your instrument for service.

When repacking the instrument for shipment, use the original packaging. If the packaging is not available or unfit for use, contact your local Tektronix representative to obtain new packaging.

If you need to return your instrument for repair or calibration, call 1-800-438-8165 or complete the form at *tek.com/services/repair/rma-request*. When you request service, have the serial number, firmware, and software version of the instrument.

If you want to see the warranty or service agreements on your products, or if you want to create your own service price estimate, visit our quick service quote site at *tek.com/service-quote*.