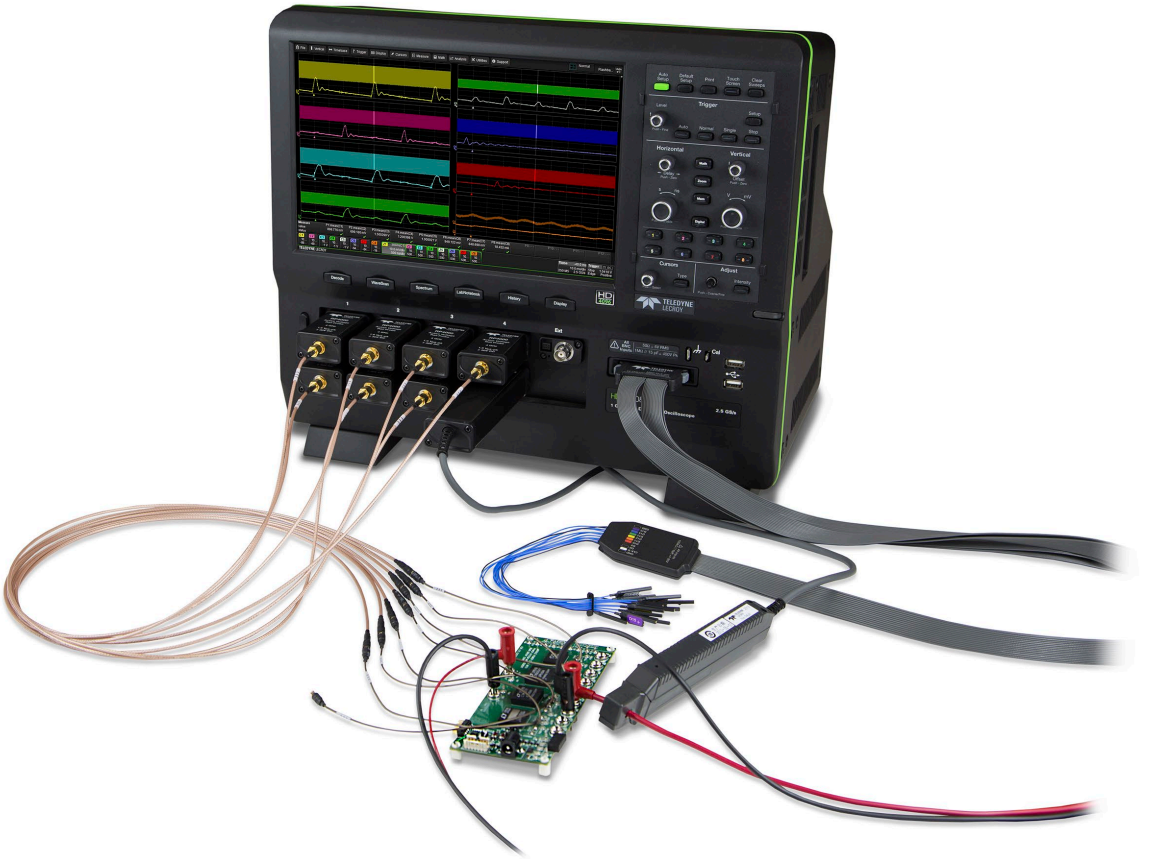
TELEDYNE LECROY
Everywhereyoulook™



User Manual

RP2060, RP4060
Power Rail Probes

RP2060/RP4060 Power Rail Probe User Manual

rpxx60-user-manual_15nov22.pdf
November, 2022

Contents

Safety Instructions

Follow these instructions to keep the probe operating in a correct and safe condition. Observe generally accepted safety procedures in addition to the precautions specified here.

The overall safety of any system incorporating this accessory is the responsibility of the assembler of the system.

Symbols

These symbols appear on the probe body or in documentation to alert you to important safety considerations.

	CAUTION of damage to probe or instrument, or WARNING of hazard to health. Refer to the manual to protect against personal injury or damage. Do not proceed until conditions are fully understood and met.
	ESD CAUTION. Risk of Electrostatic Discharge (ESD) that can damage the probe or instrument if anti-static measures are not taken.

Precautions

Comply with the following safety precautions to avoid personal injury or damage to your equipment:

Use only as specified. The probe is intended to be used only with compatible Teledyne LeCroy instruments. Using the probe and/or the equipment it is connected to in a manner other than specified may impair the probe's protection mechanisms.

Use only accessories compatible with the probe. Use only accessories that are rated for the application. Using accessories other than those shipped with the probe may create an electrical hazard.

Connect and disconnect properly. Connect the probe to the oscilloscope before connecting to the circuit being measured. De-energize the test circuit before connecting/disconnecting probe tips (excluding browsers). Disconnect probe from circuit before disconnecting probe from oscilloscope.

Do not use for measurements on Mains circuits.

Do not overload; observe all terminal ratings. Comply with the frequency derating when measuring signals with a high frequency component.

Do not excessively bend cables. Avoid tight radius bends, crushing, crimping, twisting or otherwise stressing cables.

Do not remove the probe's casing. Touching exposed connections may result in electric shock.

Do not disassemble the probe or remove inside parts. Refer all service to Teledyne LeCroy personnel.

Use only indoors within the operational environment listed. Do not use in wet or explosive atmospheres.

Keep product surfaces clean and dry.

Do not operate with suspected failures. Before each use, inspect the probe and accessories for damage. If any part is damaged, cease operation immediately and secure the probe from inadvertent use. Do not operate with suspected failures. Before each use, inspect the probe and accessories for damage such as tears or other defects in the probe body, cable jacket, accessories, etc. If any part is damaged, cease operation immediately and sequester the probe from inadvertent use.

Probe Handling

The rail probe is a precision test instrument. Exercise care when handling and storing the probe. Do not sharply bend leads or cables, or put excessive strain on them.

ESD Sensitive: Avoid damaging the probe by always following anti-static procedures (wear wrist strap, etc.) when using or handling the probe.

CAUTION: Maximum Safe Input Voltage for hand-held use is 60 Vdc (referenced to ground) per IEC/EN 61010-031:2015.

Introduction

The Teledyne LeCroy RP2060 and RP4060 Power Rail Probes meet the specific requirements of those who need to acquire a low-voltage DC signal in order to test:

- Digital power management components such as power management IC (PMIC); voltage regulator module (VMR); point-of-load (POL) switching regulator; or low-dropout regulator
- Complete embedded systems containing digital power management components

The rail probes will acquire a low-impedance, low-voltage DC power/voltage rail signal without loading the device under test (DUT). They provide high sensitivity (gain) with low noise and high offset—allowing DC power/voltage rail signals to be displayed in the vertical center of the oscilloscope.

Key Features

- High offset capability (±60 V) to permit the DC signal to be displayed in the vertical center of the oscilloscope grid, regardless of the gain/sensitivity setting
- Low attenuation (nominally 1.2:1) for very low probe only noise levels of:
    - RP2060, approximately 110 uVrms
    - RP4060, approximately 160 uVrms
- 50 Ω DC coupled to the oscilloscope with high DC input impedance (50 kΩ) to minimize loading on the DUT
- High dynamic range (±800 mV)
- 2 or 4 GHz of bandwidth
- ProBus interface with wide variety of leads for different probing needs

Low and High Frequency Measurements at High Bandwidths

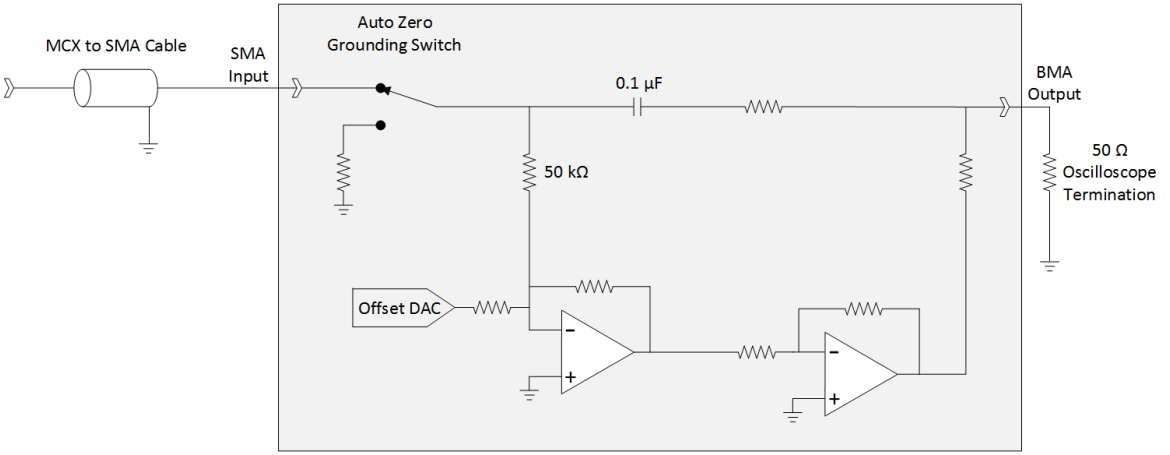
A rail probe is a superior solution to commonly used alternative methods.

One commonly used method is to terminate a 50 Ω transmission line into 1 MΩ coupling at the oscilloscope. While this will provide acceptable bandwidth performance for some, the loading impedance of a 50 Ω cable terminated to a 1 MΩ input will depend upon the length of the 50 Ω cable and will have null values when frequency is proportional to the length of the cable. A damping resistor could be used to mitigate this impact, but the 1 MΩ input to the oscilloscope is typically limited to 500 MHz, and the oscilloscope must inherently have high offset-adjust capability equivalent to the DC rail voltage at the most sensitive gain settings. This is rarely the case, although Teledyne LeCroy HDO oscilloscopes are a notable exception.

To avoid the need for high offset in the oscilloscope input channel, engineers may use a DC block between their cable connection and the oscilloscope input, or AC coupling of the oscilloscope input. A DC block has a non-ideal low-frequency response (typically blocking DC to 100 kHz or DC to 10 MHz), which eliminates low-frequency signal content that would normally be seen during typical oscilloscope acquisition times (100 ns to 10 ms). This approach might show the signal with a misunderstood non-zero DC offset, or might introduce a “droop” or “sag” in the waveform at a step voltage change due to the loss of low-frequency content. The frequency response of an oscilloscope when AC input coupled usually reaches closer to DC (~10 Hz low-pass cutoff), but is still not ideal.

The rail probe eliminates the above tradeoffs and permits more accurate and more convenient DC power/voltage rail probing at very high bandwidths.

In the simplified circuit diagram below, the rail probe portion is highlighted in gray. The input is through a high bandwidth SMA connector, terminated to ground with a 50 kΩ resistor in parallel with a 0.1 µF capacitor. This termination provides high input impedance near DC and low input impedance at high frequencies—highly desirable for low impedance DC power rail probing. A two-stage offset DAC provides ± 60 V range. This permits the offset value to be set with high accuracy (0.1% ± 3 mV). The output is through a BNC connection to the Teledyne LeCroy ProBus interface into a 50 Ω oscilloscope termination. An Auto Zero grounding switch permits Auto Zero of the DC value at any time without disconnecting the probe from the device under test (DUT).



Variety of Leads

An assortment of solder-in leads and MCX or U.FL (compatible with IPX or MMCX) PCB mount receptacles are supplied for connection to the power rails. Multiple solder-in leads or PCB mount receptacles can be left in place, while the probe MCX cable is moved from one lead/receptacle to another as test needs change. The compact (3mm x 3mm) U.FL PCB mount receptacles permit installation of many PCB mount receptacles on a compact, power dense mobile/handheld PCB. A separate browser tip accessory (the RP4000-BROWSER) is available at additional cost.

If desired, the cable and lead connection components may be used separately from the rail probe as a transmission line probe. This is useful for power sequencing tests where the dynamic range of the DC power/voltage rail exceeds the ±800 mV rating of the probe. See Connecting to the Circuit.

ProBus Interface

The rail probe uses the ProBus interface to connect to Teledyne LeCroy oscilloscopes. With the ProBus interface, the probe becomes an integral part of the measuring instrument. Power is provided to the probe through the interface, so there is no need for a separate power supply or batteries, and attenuation is automatically identified. All compatible Teledyne LeCroy oscilloscopes will support the connection of a rail probe on every input channel, if required.

Compatibility

Proper functioning of the rail probe requires the following MAUI (XStreamDSO) firmware versions:

- RP4060, 10.1.x.x or higher (32- or 64-bit MAUI oscilloscopes)
- RP2060, 10.2.x.x or higher (32- or 64-bit MAUI oscilloscopes)

Note: Rail probes are not compatible with any Teledyne LeCroy oscilloscope models that cannot be updated to the necessary firmware levels. Contact Service for available oscilloscope upgrades.

See our website for a list of compatible oscilloscope models.

For power integrity testing, digital power management, and system power management testing on one or more DC power/voltage rails, Teledyne LeCroy High Definition Oscilloscopes (HDO and HD models) are recommended due to their high resolution, high bandwidth, high inherent offset capability and the availability of eight or more channels.

An oscilloscope with ≥1 GHz bandwidth is recommended for power integrity testing.

Probe Kit

The following items are shipped with the RPxx60 probe.

Item	QTY
RP2060/RP4060 Active Voltage Rail Probe	1
SMA-to-MCX Adapter	1
SMA-to-MCX Extension Cable, 0.9 m	1
4 GHz MCX to Solder-in Lead, 18 cm	3
MCX 6 mm x 6 mm PCB Mounts	3
3 GHz MCX-to-U.FL Ultra-miniature Coaxial Cable, 8 cm	3
U.FL 3 mm x 3 mm PCB Mounts	5
Soft Storage Case with Foam Insert	1
Quick Start Guide	1

SMA-to-MCX Extension Cable

The cable adds a 0.9 m extension from the probe housing to the MCX connectors on leads and cables, or seats directly into MCX 6 mm x 6 mm PCB Mounts.

MCX Solder-in Leads

4 GHz rated, 18 cm long solder-in leads. Three leads are supplied with the rail probe, and more may be purchased as accessory or replacement items using part number RP4000-MCX-LEAD-SI.

MCX 6 mm x 6 mm PCB Mount (Receptacle)

The supplied SMA-to-MCX extension cable connects directly to these 6 mm^2 PCB mounts for optimum signal fidelity. Three mounts are supplied with the rail probe, and more may be purchased from TE Connectivity using part number 1061015-1.

Ultra-miniature U.FL Coaxial Cables

An ultra-miniature connector that is ideal for use in very dense or compact circuits, and is functionally equivalent to IPX and UMCC connectors. This 3 GHz rated coaxial cable assembly utilizes an IPX connector that was qualified with the U.FL PCB mount receptacles described below. Three cables are supplied with the rail probe.

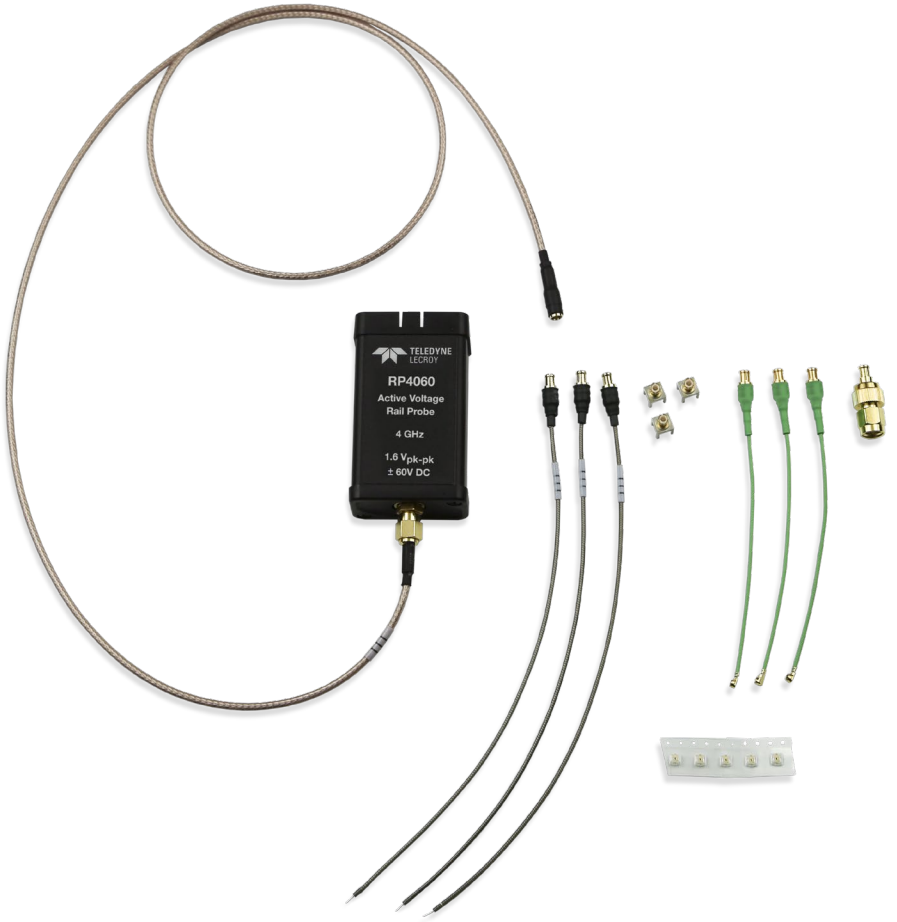
NOTE: While there are a variety of ultra-miniature PCB mounts and cables available from other manufacturers that are compatible with U.FL, Teledyne LeCroy has validated the frequency response of the supplied U.FL cables and mounts as a system, and we recommend that is how they be used.

U.FL 3 mm x 3 mm PCB Mount (Receptacle)

The 3 mm U.FL PCB mount is one fourth the size of the MCX and accepts the ultra-miniature U.FL cables. Five are supplied with the rail probe, and more may be purchased from Hirose using part number U.FL-R-SMT-1(10) T.

MCX-to-SMA Adapter

The adapter allows you to attach the extension cable to SMA connectors on DUTs.



RPxx60 Active Rail Probe Kit

RP4000-BROWSER Accessory

The RP4000-BROWSER accessory is a ÷1 high-frequency transmission line browser tip. The RP4000 browser tip and cable attaches to the SMA connector on the rail probe's housing, which is terminated with high input impedance near DC and with the oscilloscope's 50 Ω coupling at high frequency. The spring-loaded, hinged ground pin in the browser tip contributes to contact stability while making it easier to reach into dense circuitry.

Additional resistors are supplied so that the browser can be operated as a conventional ÷10 or ÷20 high-frequency transmission line probe connected directly to an oscilloscope SMA or BNC input. See the instructions in Using the RP4000-BROWSER as a Transmission Line Probe.

CAUTION: When using the rail probe and browser tip together, use only the pre-installed 0 Ω resistor. Only use the 450 Ω or 950 Ω resistors when operating the browser tip as a conventional transmission line probe separate from the rail probe.

Item	Part Number	QTY
Browser Accessory Kit, includes:	RP4000-BROWSER	
Browser Tip body		1
SMA-to-SMA cable		1
÷1 attenuating resistor (0 Ω, pre-installed)		1
÷10 attenuating resistor (450 Ω)		1
÷20 attenuating resistor (950 Ω)		1
Plastic nose housing, blue		1
SMA-to-BNC adapter		1

RP4000-BROWSER Kit

Specifications

For the most current specifications, see the product datasheet at teledynelecroy.com. Specifications are subject to change without notice.

NOTE: The components supplied with the rail probe are tested as a system, and the performance stated here represents the probe when used with these components. Replace lost or damaged components with factory-certified components to maintain the stated performance.

Warranted Characteristics

Warranted characteristics are parameters with guaranteed performance. Unless otherwise noted, tests are provided in the Performance Verification Procedure for all warranted specifications.

Bandwidth (MCX cable with PCB Mount)	RP2060: 2 GHz RP4060: 4 GHz
Attenuation Accuracy	1% into 50 Ω
Offset Accuracy	±0.1% ±3 mV

Nominal Characteristics

Nominal characteristics describe parameters and attributes that are guaranteed by design, but do not have associated tolerances.

Offset Range	±60 V
Attenuation	1.2x
DC Input Impedance	50 kΩ
Input Dynamic Range	±800 mV (single-ended)
Maximum Non-Destruct Input Voltage	100 V (DC + Peak AC)
Maximum Non-Destruct AC Voltage	50 Ω oscilloscope input limit
Maximum Safe Input Voltage	60 Vdc (referenced to ground) when hand-held per IEC/EN 61010-031:2015
Output Termination	50 Ω at oscilloscope input

Typical Characteristics

Typical characteristics are parameters with no guaranteed performance. Tests for typical characteristics are not provided in the Performance Verification Procedure.

Bandwidth*	4 GHz using MCX Solder-in Lead 3 GHz using U.FL Ultra-miniature Coax Cable with PCB Mount 500 MHz using Browser Tip
Rise Time (10-90%)	RP2060: 220 ps RP4060: 110 ps

*Bandwidth is lower of probe or tip rating.

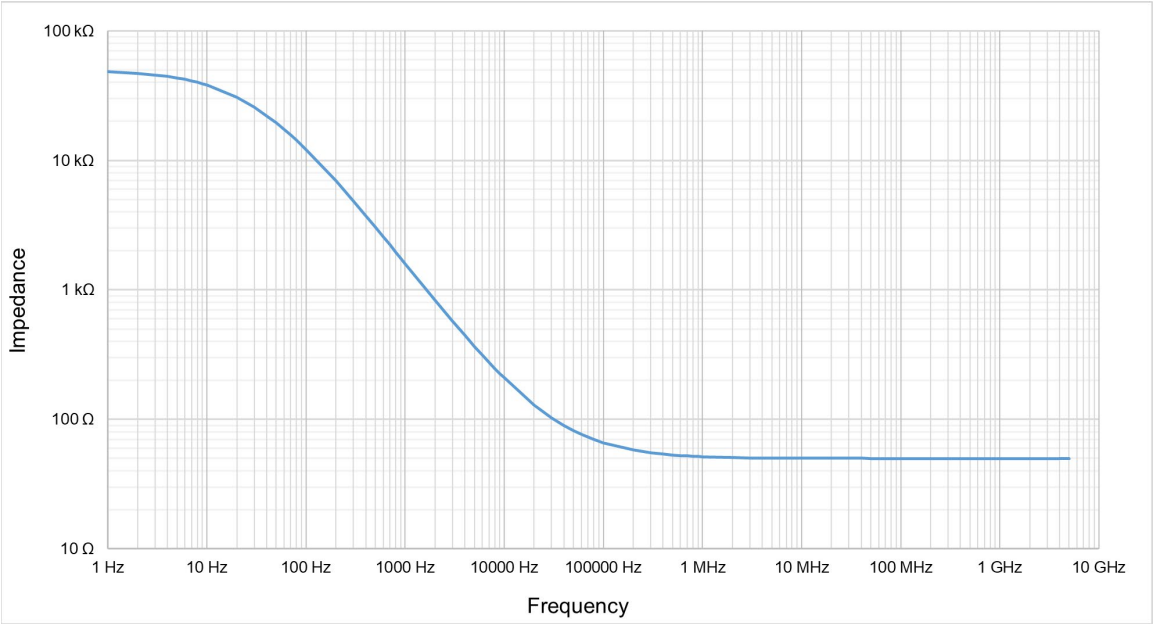
Physical Characteristics

Probe Weight (with all accessories and carrying case)	620 grams (1.37 lb.) net, including packaging material
Probe Dimensions	Probe: 38.1 mm W x 15.9 mm H x 73 mm L (1 1/2” x 5/8” x 2 7/8”) SMA-to-MCX Extension Cable: 914 mm (36”) length MCX Solder-in Lead: 191 mm (7 1/2”) usable length MCX-to-U.FL Coaxial Cable: 102 mm (4”) usable length
RP4000-BROWSER Dimensions	11.9 mm W x 9.5 mm H x 38 mm (15/32” x 3/8” x 1 1/2”) length SMA-to-SMA Cable: 1 m (39 3/8”) usable length

Environmental Characteristics

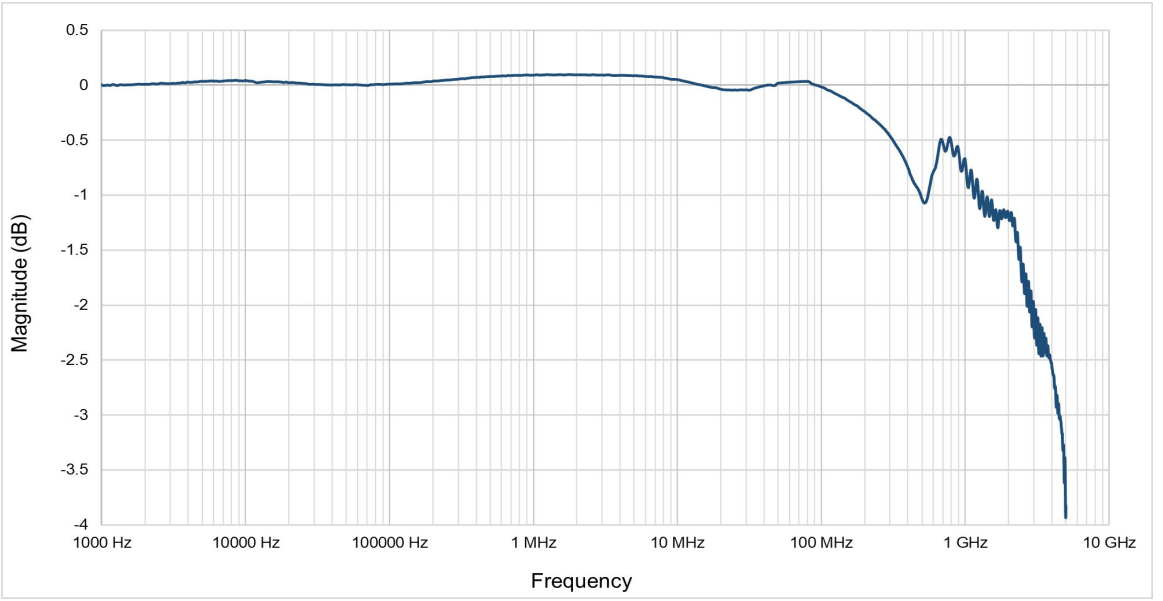
Temperature, Operating	0 °C to 50 °C
Temperature, Non-operating	-40 °C to 70 °C
Relative Humidity	5% to 80% RH (non-condensing) up to 30 °C, decreasing linearly to 45% RH at 50 °C
Altitude, Operating	3,000 m (9,842 ft.) maximum
Altitude, Non-operating	10,000 m
Pollution Degree	2, indoor use only. Per IEC/EN 61010-31:2015, this is an operating environment where normally only dry, non-conductive pollution occurs. Conductivity caused by temporary condensation should be expected.

Probe Impedance vs. Frequency (RP4060 and RP2060)

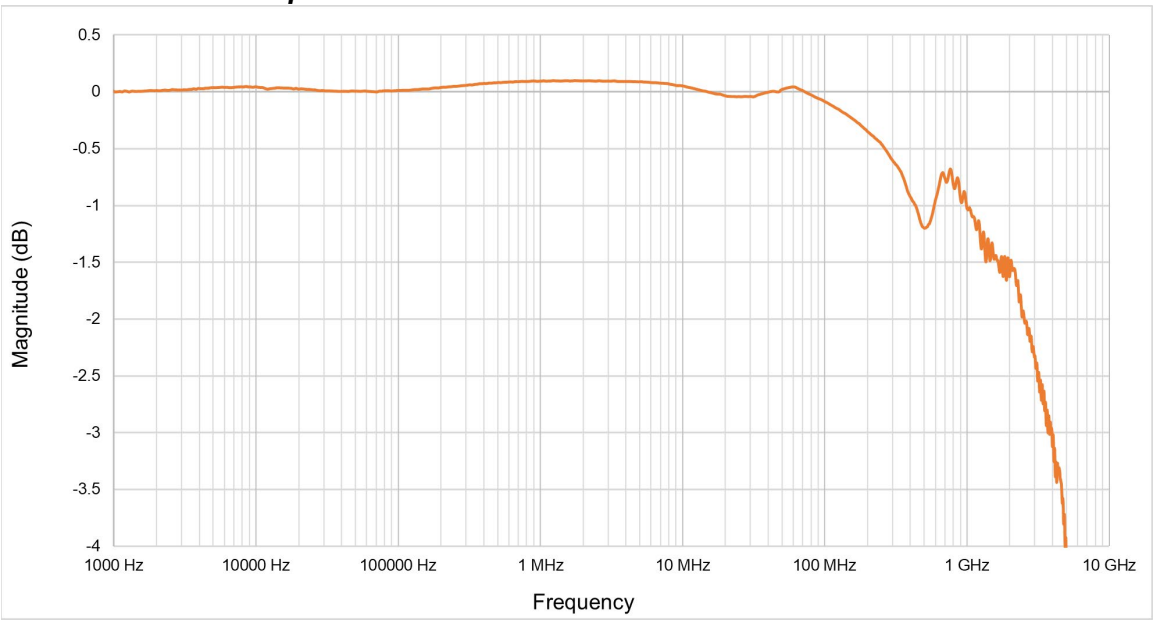


RP4060 Frequency Response

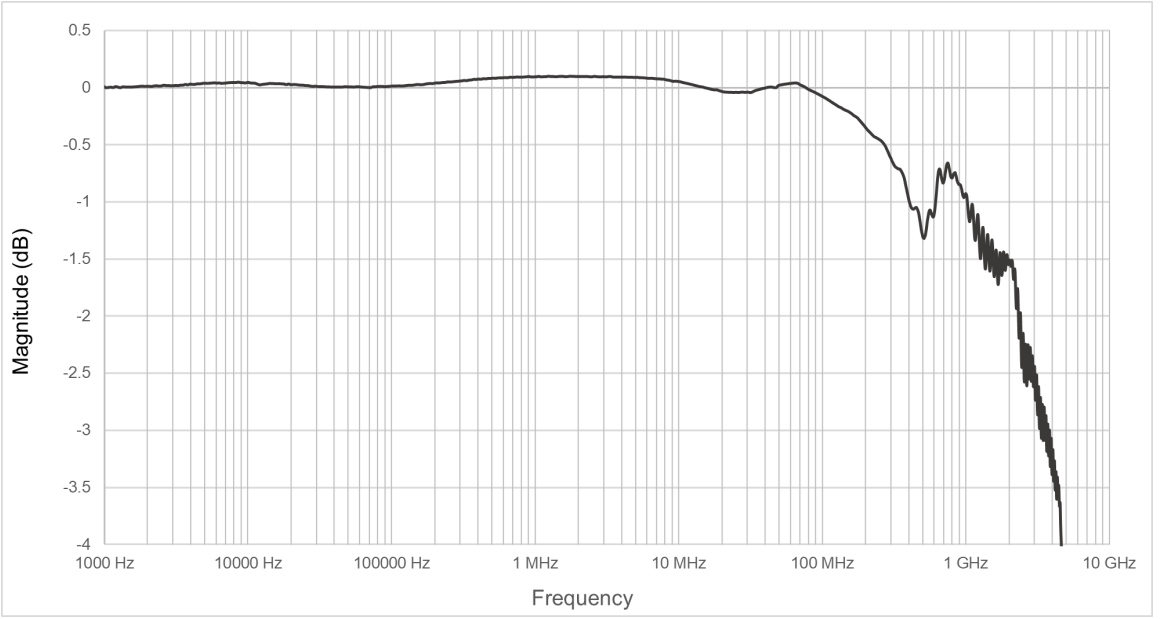
RP4060 MCX Cable into MCX PCB Mount



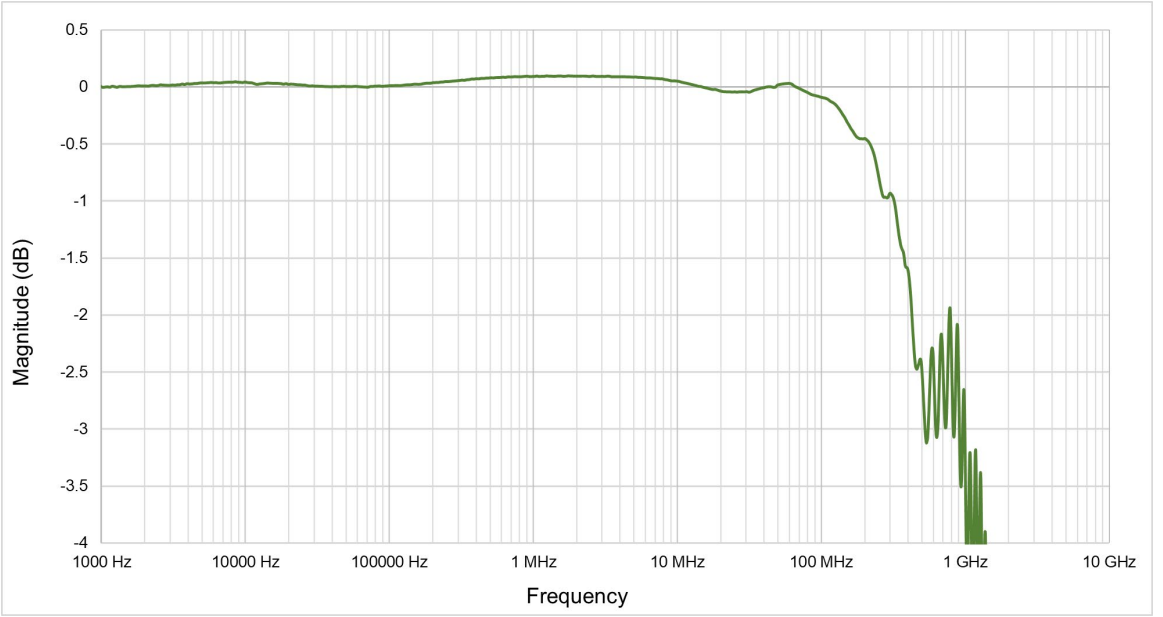
RP4060 with Solder-in Tip



RP4060 with U.FL Cable into U.FL PCB Mount

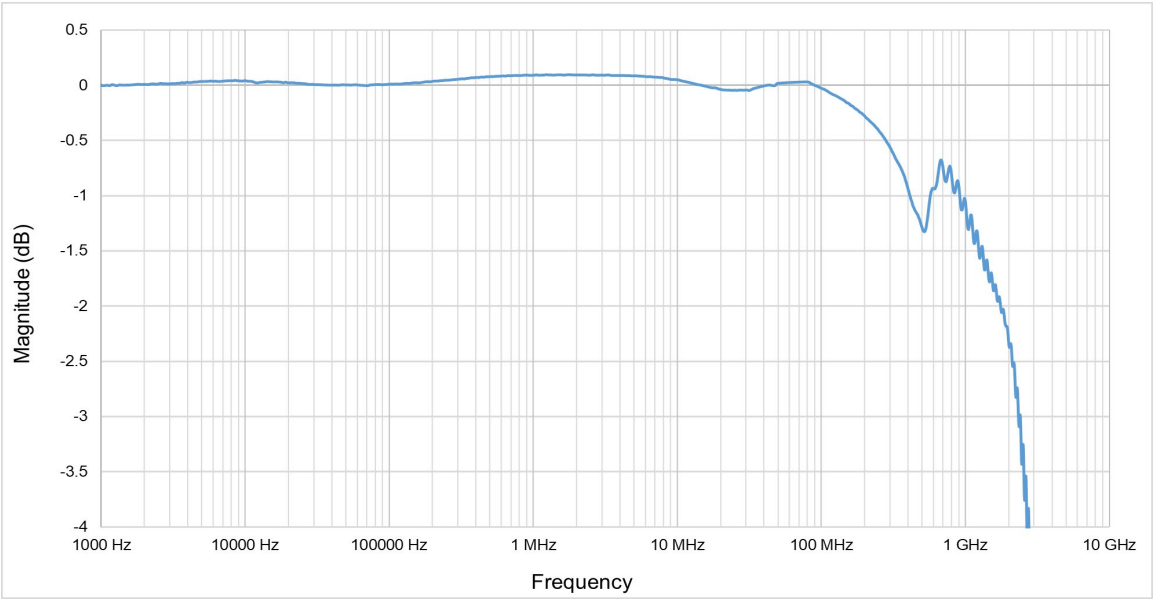


RP4060 with Browser Tip

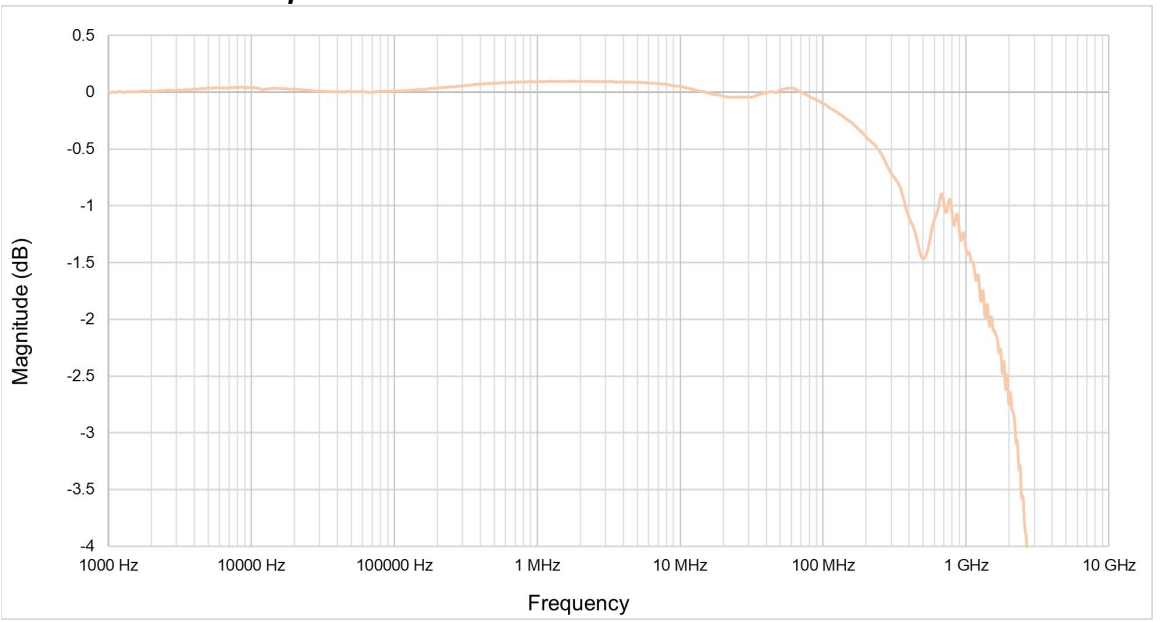


RP2060 Frequency Response

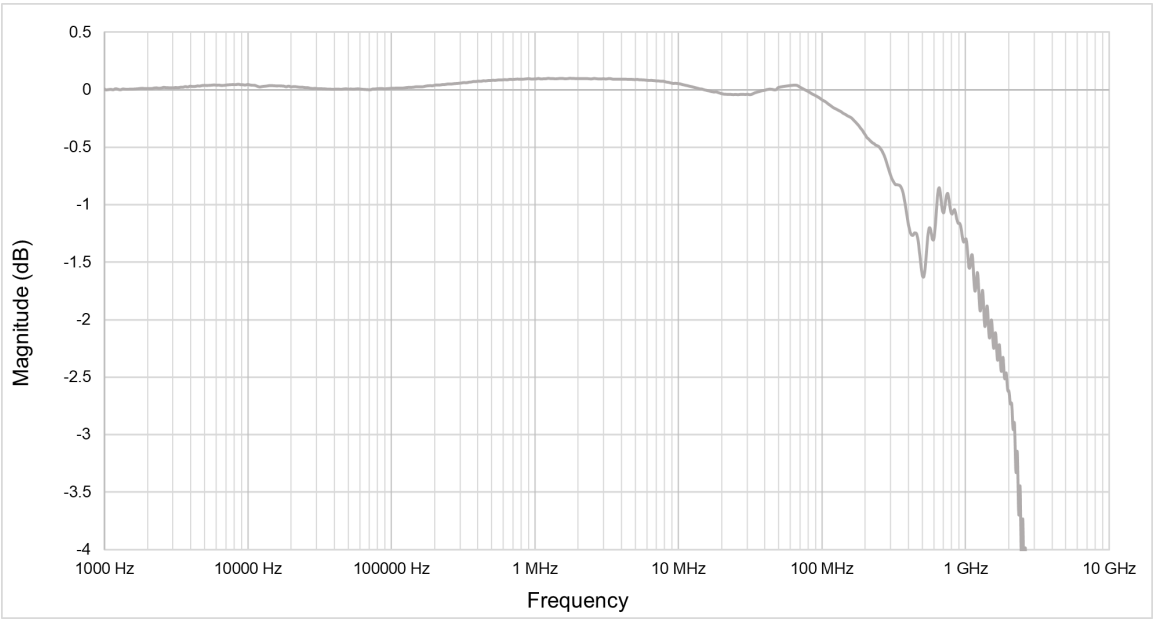
RP2060 MCX Cable into MCX PCB Mount



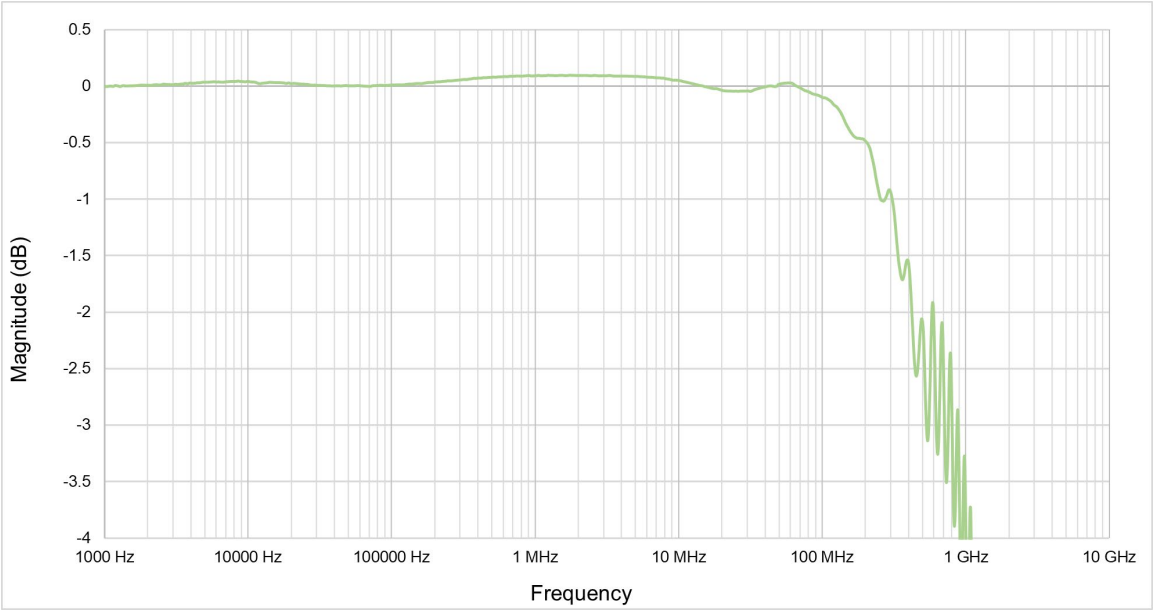
RP2060 with Solder-in Tip



RP2060 with U.FL Cable into U.FL PCB Mount



RP2060 with Browser Tip



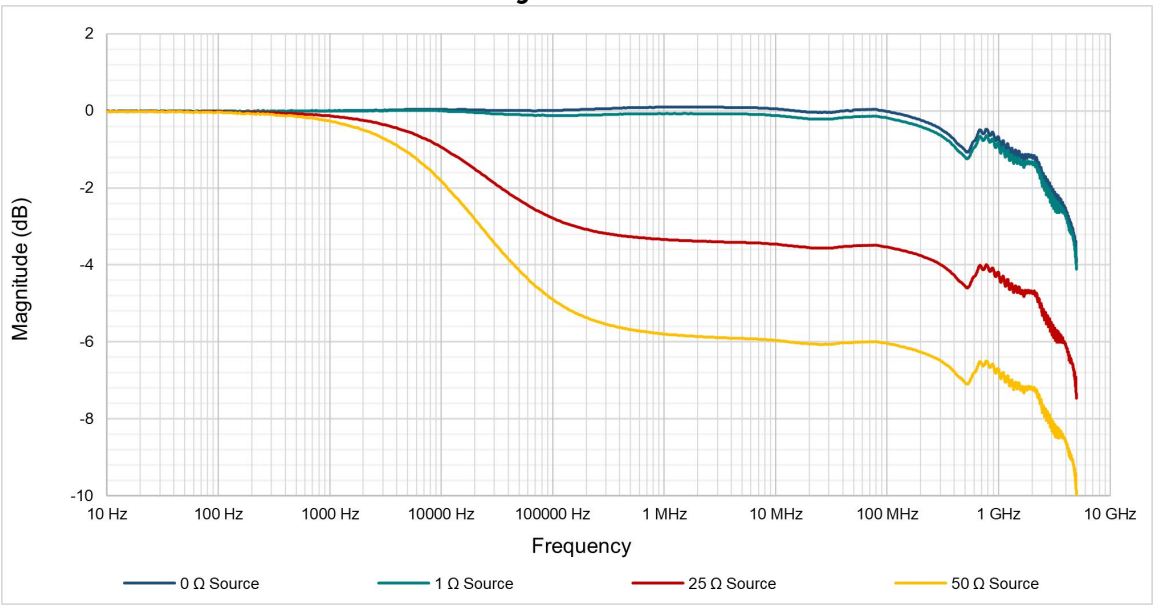
Frequency Response vs. Source Impedance

The rail probe is intended to probe low-impedance DC voltage and power rails. The probe's input impedance is optimized to provide a flat frequency response from DC to rated bandwidth when the source impedance is very low, but input impedance declines from 50 kΩ at DC to 50 Ω at ~1 MHz. If the source impedance is high, then the decline in probe input impedance at higher frequencies will reduce the bandwidth rating of the probe and may unacceptably load the source.

The frequency response and impedance vs. frequency plots above describe probe performance with a 0 Ω load. If the source impedance is non-zero, then the frequency response will degrade as shown in the plot below.

NOTE: Near-zero source impedance values (~1 Ω, blue) have little impact on probe performance, while source impedance values approaching 50 Ω have high impact on probe performance. This is to be expected based on the probe topology.

MCX Cable into MCX PCB Mount at Increasing Loads



NOTE: The plot above is an emulated representation of the frequency response shelf effect due to source impedance. Because the probe and oscilloscope are 50 Ω environments at high frequency, ripple in the bandwidth will increase as source impedance decreases from 50 to 0 Ω. This is not shown because a source impedance of 0 Ω out to 4 GHz can only be simulated and not measured. In addition, the ripple is a function of the variation in source impedance vs. frequency of a power plane, as well as the probing location and geometry of the power plane.

Operation

NOTE: Operation of the probe requires the correct version of MAUI firmware (see p.5). To confirm the version installed, choose Utilities > Utilities Setup from the oscilloscope menu bar, then open the Status dialog.

Probe Assembly

1. Attach the SMA-to-MCX extension cable to the SMA connector on the bottom of the probe housing.
2. Press the probe housing onto the oscilloscope ProBus channel connector. You will hear a click when it is seated properly.
3. Attach the desired tip (if any) to the MCX connector on the extension cable.
4. Allow the probe to warm up for at least 20 minutes after being connected to the oscilloscope before making measurements.

Connecting to the Circuit

Measuring AC Fluctuations on a DC Rail

For measuring AC fluctuation of a DC rail, you may make any of the following connections to the circuit. Refer to the sections below for instructions.

- Direct MCX connection using the extension cable into a user-installed MCX PCB mount (Up to 4 GHz bandwidth*, 36 mm2 PCB mount receptacle footprint)
- Direct U.FL connection using an U.FL ultra-miniature coaxial cable into a user-installed U.FL PCB mount (Up to 3 GHz of bandwidth, 7.7 mm2 PCB mount receptacle footprint)
- Solder-in connection using an MCX solder-in lead (Up to 4 GHz of bandwidth)
- Browser tip connection (500 MHz of bandwidth)

* Bandwidth is the lower of the probe or tip rating.

Measuring Full DC Rail Voltage

To measure the full DC rail voltage beyond the ±800 mV input dynamic range rating of the probe, use the rail probe accessories to connect as follows:

1. Set the oscilloscope channel Coupling to DC1MΩ.

   CAUTION: Do not change coupling to 50 Ω while the DUT is connected to the oscilloscope.

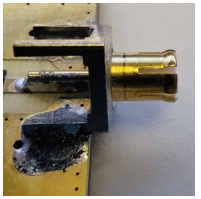
2. Connect the SMA-to-MCX extension cable to an MCX PCB mount, a solder-in lead, or U.FL ultra-miniature coaxial cable.
3. Connect an SMA-to-BNC converter to the SMA end of the cable, then connect it to the BNC input on the oscilloscope channel.

This is an easy way to utilize the same connections to a power rail for power integrity or transient rail voltage testing as for DC rail power startup/shutdown timing measurements.

Direct MCX Connection

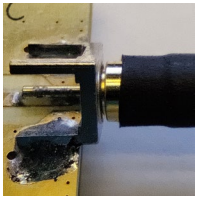
The MCX connection is exceptionally durable and provides the highest bandwidth connection, but it has a larger footprint than other solutions.

1. Solder the MCX PCB mounts to the board:
   - Solder the center pin to the signal
   - Solder one or more of the four posts to ground.

   CAUTION: Avoid excessive lateral or vertical force on the PCB mount once it has been installed.

2. Mate the extension cable to the mount by pressing the plug into the PCB receptacle.

For more information, refer to the manufacturer's instructions, TE Connectivity, PN 1061015-1.

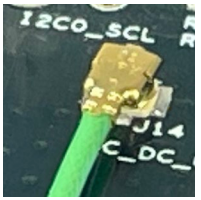
Direct U.FL Connection

The U.FL PCB mounts are used with the U.FL Ultra-miniature Coaxial Cables. This connection is only rated to 3 GHz, but the small footprint makes it useful for very dense or compact circuits.

1. Solder the U.FL PCB mounts to the board.

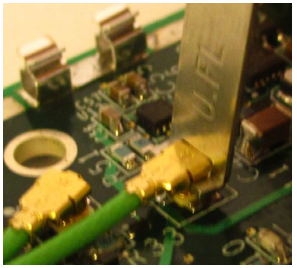
NOTE: For manual soldering, maximum temperature is 350 °C for five minutes. More specific instructions are provided by the manufacturer, Hirose, for reflow soldering.

2. Connect a U.FL coaxial cable to the SMA-to-MCX extension cable.
3. Mate the U.FL coaxial cable to the PCB receptacle:
   - Align the connectors, avoiding any type of extreme angle.
   - Press the cable plug into the receptacle. A “click” confirms proper mating.



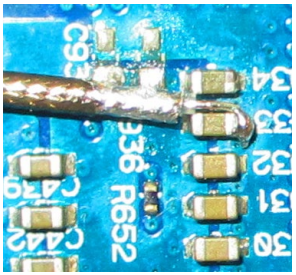
CAUTION: After the connectors are mated, do not apply a load to the cable in excess of 2 Newtons in a direction parallel to the mating axis, or in excess of 4 Newtons in a direction perpendicular to the mating axis. Do not forcefully twist or deform the wires.

The U.FL PCB mount receptacle is manufactured by Hirose (PN U.FL-R-SMT-1, with various suffixes to indicate the quantity). For more information, refer to the manufacturer’s instructions.



Hirose makes a Plug Extraction Tool (PN U.FL-LP-N-2) to assist in the unmating of the plug and the receptacle, shown at left. This tool is widely available from distributors around the world. It fits between the U.FL plug and receptacle to “pop” the plug out of the receptacle using lever action. Insert an edge under the cable plug connector flange, and lift it off vertically in the direction of the mating axis.

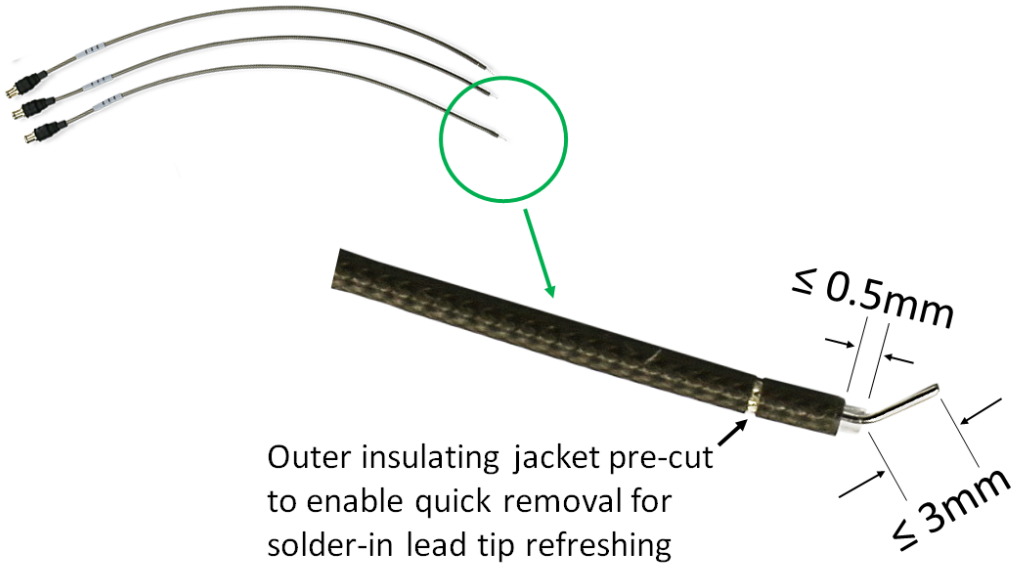
Solder-in Connection



The MCX to solder-in connection is a great solution for probing DC rails on a crowded board. The exposed ~3 mm inner conductor is connected to the DC rail, while the exposed ~0.5 mm outer conductor is connected to ground, ideally with as short a ground lead as possible.

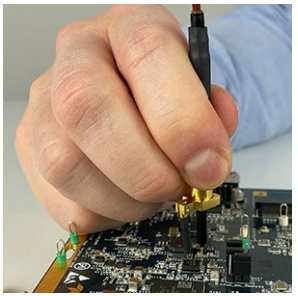
The image at left shows the solder-in lead center conductor soldered to the back side of a capacitor (where the DC power rail is applied) and the outer conductor (ground) soldered to the ground pad behind it. In this example, additional outer conductor was exposed so as to make connection to ground easier.

The solder-in lead may be re-used multiple times. If, after a few solder-in connections, it is difficult to solder down the cable, trim back the coaxial cable and expose the center conductor to as short a length as practical (<3 mm will provide the rated frequency response) and expose enough of the shield to solder to ground. These trimming operations may be performed multiple times; the shorter length of the cable does not negatively affect the frequency response.

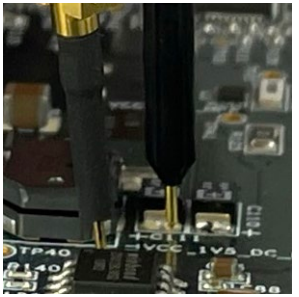


Browser Tip Connection

To use the browser tip with the rail probe, remove the MCX extension cable and attach the browser cable to the probe housing.



Place the browser tip on the test point, keeping the body as perpendicular to the circuit as posible to minimize parasitic capacitance. Insulate areas around the browser with tape to avoid inadvertent browser ground or contact with DC rail voltages to other components/areas.

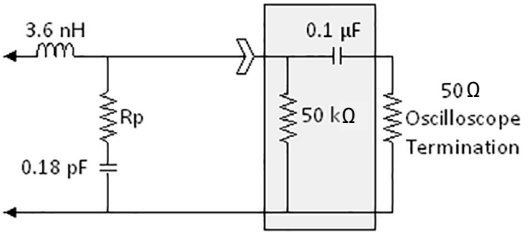


Place the adjacent ground tip on a nearby ground. The hinged ground can be gently pulled away from or toward the browser tip to fit it to the ground point.

The browser is shipped with a pass-through 0 Ω resistor installed for use with the rail probe. To maintain the high performance of the probe, exercise care when connecting the browser to the test circuit. Increasing the parasitic capacitance or inductance in the input paths may deteriorate the performance by introducing a “ring” or slowing the rise time of fast signals.

CAUTION: The only resistor that should be installed when the RP4000-BROWSER is used with the rail probe is the 0 Ω resistor. Do not use other resistors to change the rail probe attenuation. If the resistor is changed and is not reverted to 0 Ω prior to using the browser with the rail probe, the voltages displayed on the oscilloscope will be incorrect.

A simplified schematic for the RP4000-BROWSER when connected to the rail probe is shown below, with the simplified rail probe circuit highlighted in gray. The value of Rp is ~50 Ω.

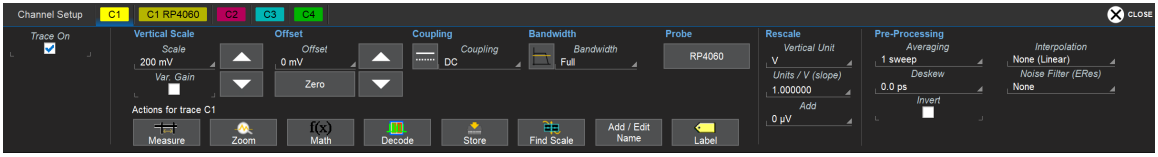


Operating from the Oscilloscope

For accurate measurements, allow the probe to warm up for at least 20 minutes after being connected to the oscilloscope.

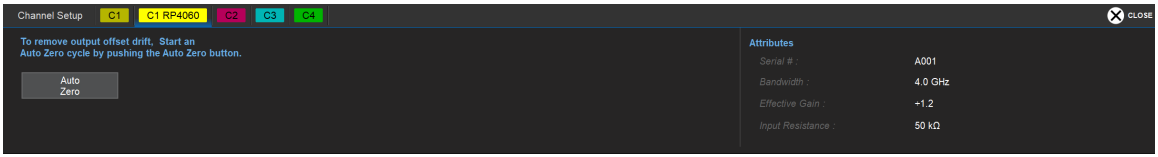
The rail probe has been designed for use with Teledyne LeCroy oscilloscopes equipped with the ProBus interface. When the probe is attached to the oscilloscope's input connector, the instrument will recognize the probe and:

- Set the oscilloscope input termination to DC50Ω
- Set the probe attenuation to 1.2x
- Activate the probe control functions on the oscilloscope user interface.



Channel setup dialog (C1) with Probe dialog (C1 RP4060) behind it.

The probe's attributes are shown on the Probe dialog, which appears behind the C*n* dialog when a probe is detected. The Probe dialog also contains an Auto Zero control.



RP4060 Probe dialog.

Vertical Scale (Volts/div)

The oscilloscope automatically factors in the nominal 1.2x attenuation and adjusts the Vertical Scale (gain) readout to reflect the attenuation value. No further scaling adjustment is needed.

NOTE: The maximum input dynamic range of the RPxx60 is ±800 mV. The maximum oscilloscope gain setting with the RPxx60 connected is ±200 mV/div. Most DC rail voltage exceeds 800 mV, so some applied offset is required to display the signal on the oscilloscope.

Offset

The rail probe has built-in offset capability of ±60 V using a 16-bit offset DAC for high offset accuracy and resolution. This allows you to remove a DC bias voltage from the input signal while maintaining DC coupling. By using probe offset, the full dynamic range of the probe can be centered around the vertical center of the oscilloscope grid so as to permit high sensitivity gain settings to be used on a DC-biased signal.

Probe offset is controlled using the front panel Vertical OFFSET knob. The amount of offset applied is displayed on the channel descriptor box.

NOTE: On Teledyne LeCroy oscilloscopes, the input offset displayed is the amount of offset required to zero the applied voltage (e.g., a -1 V offset is required to vertically center a 1 V DC rail on the grid).

Coupling

When the rail probe is connected to the oscilloscope, input coupling is automatically set to DC50Ω and cannot be changed.

Bandwidth Limit

The bandwidth of the rail probe ranges up to 4 GHz, depending on model and tip attachment. To limit bandwidth to less than the rating, make a selection from the C*n* dialog Bandwidth control.

Attenuation

When the rail probe is connected to the oscilloscope, attenuation is automatically set to 1.2x and cannot be changed.

NOTE: When using the browser tip as a transmission line probe directly connected to the oscilloscope, install the appropriate resistor and manually set Attenuation to ÷10 or ÷20 on the C*n* setup dialog. See Using the RP4000-BROWSER as a Transmission Line Probe.

Auto Zero

After 20 minutes of warm-up, or when the probe is exposed to a large shift in ambient temperature, some DC offset drift may occur. The Probe dialog incorporates an Auto Zero function to remove any DC offset drift.

To invoke Auto Zero, open the C*n* RPxx60 dialog and touch Auto Zero. The probe contains an internal relay to disconnect the input from the probe amplifier while Auto Zero is performed, so the probe does not need to be disconnected from the DUT prior to invoking Auto Zero.

NOTE: If the probe is open-circuited, a slight non-zero offset value may be observed on the probe following Auto Zero. This is normal and represents the small amount of input offset current from the probe amplifier into the 50 KΩ input impedance. When the probe is connected to a low-impedance DUT or is GND coupled, this offset is not observed because the current will flow through the low DUT impedance.

Best Practices

Avoiding Damage to DUT

CAUTION: Low voltage DC power rails carry large amounts of current, and if they are shorted to ground, large currents will flow, potentially damaging the DUT. To prevent this:

- Inspect solder-in and PCB mount connections carefully before powering up the DUT to ensure that there is no inadvertent connection between the power rail and ground.
- Use insulating tapes or other materials around the connection points (especially when using the solder-in lead, which has an exposed cable ground).
- Tape the solder-in lead and coaxial cables to the DUT to avoid stress on the connection point and/or accidental disconnection that could lead to short circuiting of the rail voltage or other damage to the circuit.
- Exercise extreme caution when using the browser accessory to avoid inadvertent contact between the ground pin and the conductive browser tip and tip assembly, or from the browser ground pin to the DC rail.

Avoiding Parasitic Inductance

All ground connections provided with the rail probe are very short (browser) or coaxial in nature. This is to ensure any parasitic inductance added to the circuit when the probe connection is made remains low.

If the browser ground lead is increased in length, or if long ground leads are attached to the coaxial solder-ins, then the parasitic loop inductance of the probe will greatly increase and the signal fidelity performance will deteriorate. This is seen on the signal as a “ringing” or a slowing rise time of fast signals. Additionally, large loop areas will pick up any radiated electromagnetic field which passes through the loop and may induce noise into the probe input.

To verify that no ground loop is present:

1. Connect the ground and tip to the DUT ground.
2. Validate that a low noise 0 Vdc signal is measured.

TIP: When using the browser tip, keep the browser body perpendicular to the circuit under test. This will minimize the parasitic capacitance and maintain high performance.

Choosing Probing Location

Power planes will typically exhibit 2-D standing waves. Place probe point land patterns as close to the area of interest as possible.

Using the RP4000-BROWSER as a Transmission Line Probe

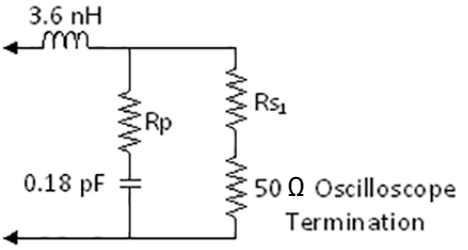
The RP4000-BROWSER accessory is the same as a PP066 Transmission Line Probe, except with a "pass-through" 0 Ω resistor pre-installed at shipment to provide 1x attenuation.

To use the RP4000-BROWSER tip as a transmission line probe, install the supplied 450 Ω (÷10) or 950 Ω (÷20) resistors in the browser body in place of the 0 Ω resistor:

1. Remove the nose housing by rotating it counter clockwise and pulling it away from the tip, taking care not to bend or twist the resistor inside the housing.
2. Pull the resistor straight out of the tip without twisting or bending the resistor.
3. Gently insert one end of the alternate resistor into the browser tip.

   NOTE: The 450 Ω (÷10) resistor is directional. Place the dotted end of the resistor towards the probe side. The 950 Ω (÷20) resistor is not directional.
4. Re-install the nose housing by carefully sliding it over the resistor and screwing it onto the tip. Additional nose housings have been supplied to indicate the probe's attenuation: a black one for the 450 Ω resistor and a blue one for the 950 Ω resistor.
5. On the input Channel (C*n*) setup dialog:
   - Select the proper **Attenuation**.
   - Set **Coupling** to DC50Ω.
6. Connect the browser cable to the oscilloscope's BNC input.
7. Position the browser tip over the circuit under test, with the ground connected…

Below is a simplified schematic for the RP4000 Browser when used as a conventional transmission line probe. Rs1 is the 450 Ω (10x operation) or 950 Ω (20x operation) accessory resistor, and Rp is ~60 Ω (10x) or 45 Ω (20x).



Performance Verification

This procedure can be used to verify the warranted characteristics of a rail probe. It tests LF Attenuation Accuracy and Offset Accuracy.

The recommended calibration interval for the rail probe is one year. Perform the complete performance verification procedure as the first step of annual calibration. The procedure can be done without removing the probe covers or exposing the user to hazardous voltages. Test results can be recorded on a photocopy of the RP4000 Test Record provided in this manual.

Required Test Equipment

The following table lists the test equipment and accessories (or their equivalents) required for performance verification of an RPxx60Power Rail probe. Because input and output connector types may vary on different equipment, additional adapters or cables may be required.

Description	Minimum Requirements	Example Equipment
Oscilloscope	ProBus interface equipped	Teledyne LeCroy HDO6000B, WaveRunner 9000
Digital Multimeter (2 required)	DC: 0.1% accuracy AC: 0.1% accuracy 5.5 digit resolution	Keysight Technologies 34401A Fluke 8842A-09
Function Generator	Sine Wave output amplitude adjustable to 14.14 Vp-p (5 Vrms) into 1 MΩ at 70 Hz	Teledyne LeCroy WaveStation 3082 Keysight Technologies 33120A Stanford Research Model DS340
BNC Coaxial Cable	Male to Male, 50 Ω, 36"	Pomona 2249-C-36 Pomona 5697-36
BNC Tee Connector	Male to Dual Female	Pomona 3285
Banana Plug Adapter	Female BNC to Dual Banana Plug	Pomona 1269
SMA(f) to BNC(m) adapter		Pomona 4289
Calibration Fixture	Probus Extender	LeCroy Probus-CF01
Precision BNC(f) to Dual Banana Plug 50 Ω Termination	50 Ω ±0.05%	LeCroy Term-CF01

NOTE: Some test equipment used may have environmental limitations required to meet the accuracy needed. Make sure that the ambient conditions meet the requirements of all the test instruments used in this procedure.

Functional Check

The functional check will verify the basic operation of the probe functions. It is recommended to perform the functional check prior to the performance verification procedure.

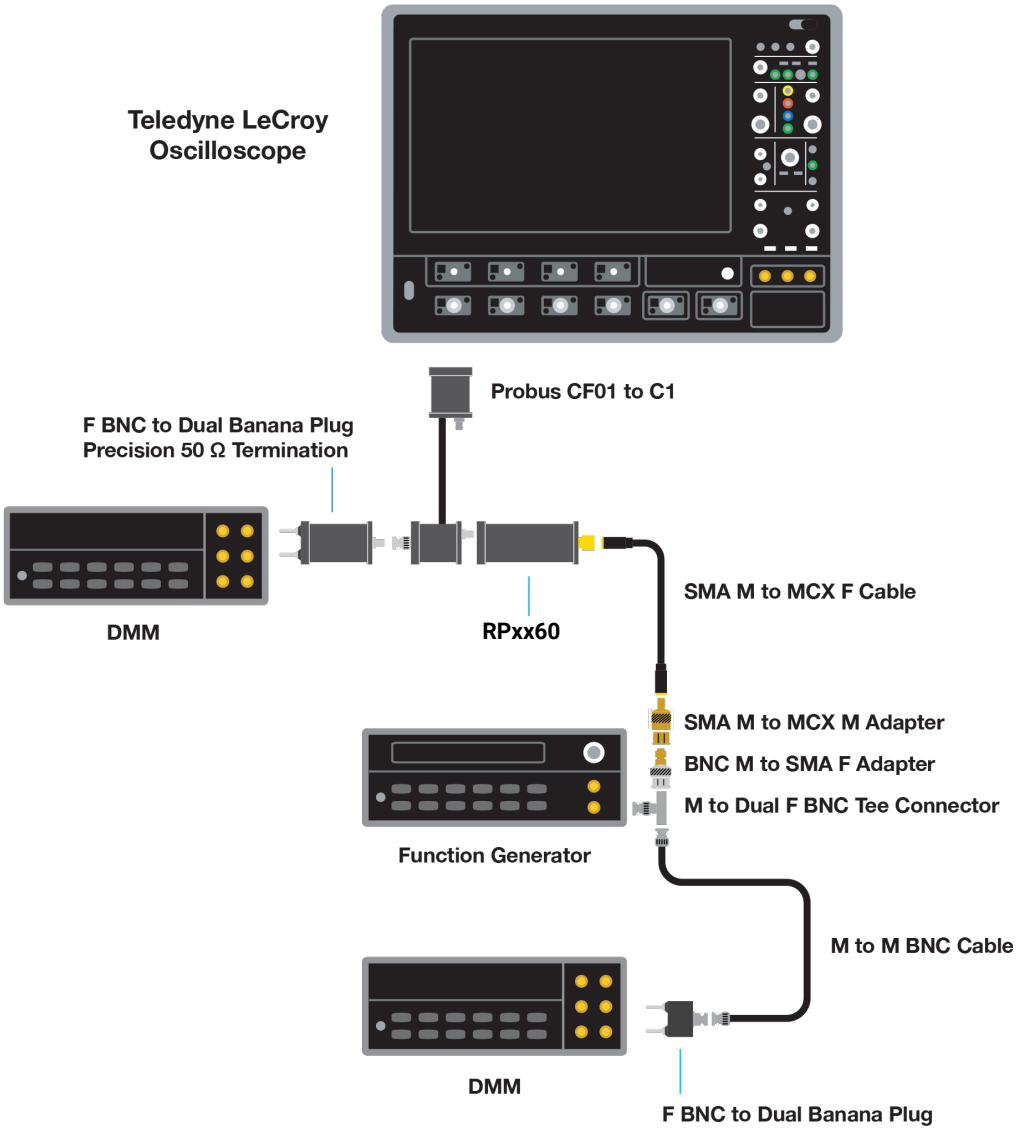
1. Connect the rail probe to the oscilloscope C1 input.
2. Verify that the C1 RPxx60 dialog tab appears behind the C1 setup dialog. This confirms the probe is sensed.
3. Open the C1 RPxx60 dialog and touch Auto Zero then OK to Auto Zero the probe.
4. Confirm that the message "Performing Auto Zero on RPxx60...." is displayed on the message bar and that no error messages appear.

Performance Verification Test

Before You Begin

1. Set up the rail probe and test equipment as shown in the diagram on page 28.
2. Connect the Probus-CF01 to the oscilloscope C1 input.

   NOTE: All instructions will refer to C1 as the assumed connection for the Probus-CF01.
3. Turn on the oscilloscope and allow at least 30 minutes warm-up time for the probe before performing the verification procedure.
4. Turn on the other test equipment and allow these to warm up for the time recommended by the manufacturer.
5. While the instruments are reaching operating temperature, make a photocopy of the Performance Verification Test Record, fill in the necessary data, and repeat step 2 of the “Functional Check” procedure to ensure the Probus-CF01 is working properly.



Performance Verification test setup.

Check LF Attenuation Accuracy

1. Connect the rail probe and test equipment as shown in the diagram on page 28.
2. Set both DMMs to measure Vac.
3. Set the function generator to output a sine wave of 50 Hz, amplitude 200 mVrms, at HiZ.
4. Record the voltage measured on the DMM in "Generator Output Voltage" on the Test Record (~200 mVAC).
5. Multiply the probe output voltage measured on the DMM by 1.2354 and record the result in "RPxx60 Measured Voltage" on the Test Record.

   NOTE: Probe output voltage is shown rounded to 1.2 in the Effective Gain attribute on the oscilloscope C1 RPxx60 dialog.

6. Calculate the attenuation accuracy (%) using the equation:

$$\frac{(Step\ 5\ value - Step\ 4\ value)}{Step\ 4\ value} . 100$$

7. Record the LF attenuation accuracy "Gain Error" on the test record.

Check Offset Accuracy

1. Connect the probe and test equipment as shown in the diagram on page 28.
2. Set both DMMs to measure DC Volts.
3. Set the function generator to output DC Volts.
4. Open the oscilloscope C1 setup dialog (not the C1 RPxx60 dialog) and set Coupling to ground (GND). Ensure that there is 0.00 mV Offset on C1.
5. Multiply the probe output voltage measured on the DMM by 1.2354 and record the result on the test record in "RPxx60 Offset Voltage".
6. On the C1 setup dialog, reset Coupling to DC.
7. Set the function generator to output +10 Vdc at HiZ.
8. Record the "Generator Output Voltage" measured on the DMM on the test record.
9. Set the C1 Offset to the negative of the generator output value measured on the DMM.
10. Multiply the probe output voltage measured on the DMM by 1.2354 and record the result on the test record in "RPxx60 Measured Voltage".

11. Calculate the offset accuracy (%) using the equation:

$$\frac{(Step\ 10\ value - Step\ 5\ value)}{Step\ 8\ value}.100$$

NOTE: Make sure all values are converted to Volts before calculating.

Record the result in Step 11 “Offset Error” on the test record.

12. Set the function generator to output -10 Vdc at HiZ.
13. Record the “Generator Output Voltage” measured on the DMM on the test record.
14. Set the C1 Offset to the negative of the generator output value measured on the DMM.
15. Multiply the probe output voltage measured on the DMM by 1.2354 and record the result on the test record in “RPxx60 Measured Voltage”.
16. Calculate the offset accuracy (%) using the equation:

$$\frac{(Step\ 15\ value - Step\ 5\ value)}{Step\ 13\ value}.100$$

NOTE: Make sure all values are converted to Volts before calculating.

Record the result in Step 16 “Offset Error” on the test record.

This completes the Performance Verification of the rail probe. Complete and file the Test Record as required to support your internal calibration procedure.

Permission is granted to photocopy the following page and record the results of the performance verification procedure on the copy. File the completed record as required by applicable internal quality procedures.

Results recorded under "Test Result" are the actual specification limit check. The test limits are included in all these steps. Record other measurements and intermediate calculations that support the limit check under "Intermediate Data".

RP___60 Test Record

Serial Number: _____

Asset/Tracking Number: _____

Date: _____

Technician: _____

Equipment	Model	Serial Number	Calibration Due Date
Digital Multimeter 1			
Digital Multimeter 2			
Oscilloscope			
Function Generator			N/A*

* The function generator is used for making relative measurements. The output of the generator is measured with a DMM or oscilloscope. Thus, it is not required to calibrate the generator.

LF Attenuation Accuracy

Step	Description	Intermediate Data	Test Result
4	Generator Output Voltage	mVrms	
5	RPxx60 Measured Voltage	mVrms	
6	Gain Error (< ±1.00%)		%

Offset Accuracy

Step	Description	Intermediate Data	Test Result
5	RPxx60 Offset Voltage	mVdc	
8	Generator Output Voltage	Vdc	
10	RPxx60 Measured Voltage	mVdc	
11	Offset Error (< ±0.10%)*		%
13	Generator Output Voltage	Vdc	
15	RPxx60 Measured Voltage	mVdc	
16	Offset Error (< ±0.10%)*		%

*The actual offset error specification is ±0.1% ±3 mV

Care and Maintenance

Cleaning

Clean the exterior of the probe and cable using only a soft cloth moistened with water or isopropyl alcohol. The use of abrasive agents, strong detergents or other solvents may damage the probe.

CAUTION: The probe case is not sealed and should never be immersed in any fluid.

Calibration Interval

The recommended calibration interval is one year. Adjustment should only be performed by qualified personnel. (A Performance Verification procedure is included in this manual.)

Service Strategy

The rail probe utilizes fine pitch surface mount devices, making it impractical to repair in the field. Defective probes must be returned to a Teledyne LeCroy service facility for diagnosis and exchange. A defective probe under warranty will be replaced with a factory refurbished probe. A probe that is not under warranty can be exchanged for a factory refurbished probe. A modest fee is charged for this service.

Troubleshooting

If the probe is not operating properly, before assuming the probe is defective, verify each of the following:

- The oscilloscope is running the required version of MAUI firmware (see p.5).
- The channel to which the rail probe is connected displays a probe dialog for the RPxx60, indicating the probe is sensed.
- The lead/tip connected to the MCX termination of the SMA-to-MCX extension cable is properly connected to the cable and the DUT.
- A suitable offset has been applied to the input so that the signal appears on the oscilloscope grid. On Teledyne LeCroy oscilloscopes, the input offset displayed on the oscilloscope is the amount of offset required to zero the applied voltage (e.g., a -1 V offset is required to vertically center a 1VDC rail on the oscilloscope grid).

Returning a Product for Service

Contact your local Teledyne LeCroy service center for calibration or other service. If the product cannot be serviced on location, the service center will give you a Return Material Authorization (RMA) code and instruct you where to ship the product. All products returned to the factory must have an RMA.

Return shipments must be prepaid. Teledyne LeCroy cannot accept COD or Collect shipments. We recommend air freighting. Insure the item you're returning for at least the replacement cost.

1. Remove all accessories from the probe.
2. Pack the probe in its case. If possible, include all tips. Do not include the manual.
3. Pack the case in its original shipping box, or an equivalent carton with adequate padding to avoid damage in transit.
4. Mark the outside of the box with the shipping address given to you by Teledyne LeCroy. Be sure to add the following:

   ATTN:<RMA code assigned by Teledyne LeCroy>

   FRAGILE
5. If returning a probe to a different country: contact Teledyne LeCroy Service for instructions on completing your import/export documents.

Extended warranty, calibration and upgrade plans are available for purchase. Contact your Teledyne LeCroy sales representative to purchase a service plan.

Technical Support

For a complete list of offices by country, including our sales & distribution partners, visit:
teledynelecroy.com/support/contact

Teledyne LeCroy
700 Chestnut Ridge Road
Chestnut Ridge, NY, 10977, USA

US Service and Support:
Ph: 800-553-2769 / 845-425-2000
FAX: 845-578-5985
customersupport@teledynelecroy.com

Warranty

THE WARRANTY BELOW REPLACES ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS, OR ADEQUACY FOR ANY PARTICULAR PURPOSE OR USE. TELEDYNE LECROY SHALL NOT BE LIABLE FOR ANY SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER IN CONTRACT OR OTHERWISE. THE CUSTOMER IS RESPONSIBLE FOR THE TRANSPORTATION AND INSURANCE CHARGES FOR THE RETURN OF PRODUCTS TO THE SERVICE FACILITY. TELEDYNE LECROY WILL RETURN ALL PRODUCTS UNDER WARRANTY WITH TRANSPORT PREPAID.

The product is warranted for normal use and operation, within specifications, for a period of one year from shipment. Teledyne LeCroy will either repair or, at our option, replace any product returned to one of our authorized service centers within this period. However, in order to do this we must first examine the product and find that it is defective due to workmanship or materials and not due to misuse, neglect, accident, or abnormal conditions or operation.

Teledyne LeCroy shall not be responsible for any defect, damage, or failure caused by any of the following: a) attempted repairs or installations by personnel other than Teledyne LeCroy representatives, or b) improper connection to incompatible equipment, or c) for any damage or malfunction caused by the use of non-Teledyne LeCroy supplies. Furthermore, Teledyne LeCroy shall not be obligated to service a product that has been modified or integrated where the modification or integration increases the task duration or difficulty of servicing the oscilloscope. Spare and replacement parts, and repairs, all have a 90-day warranty.

Products not made by Teledyne LeCroy are covered solely by the warranty of the original equipment manufacturer.

Certifications

For the full list of current certifications, see the EC Declaration of Conformity shipped with your product.

RPxx60 probes conform to the following standards:

IEC/EN 61010-031:2015+A1:2018 - Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 031: Safety requirements for hand-held probe assemblies for electrical measurement and test

IEC/EN 61326-1:2020 - EMC requirements for electrical equipment for measurement, control, and laboratory use

IEC/EN 61326-2-1:2021 - Particular requirements for sensitive test and measurement equipment for EMC unprotected applications

The probe is marked with this symbol to indicate that it complies with the applicable European Union requirements to Directives 2012/19/EU on Waste Electrical and Electronic Equipment (WEEE).

For more information about proper disposal and recycling of your Teledyne LeCroy product, visit teledynelecroy.com/recycle.

Unless otherwise specified, all materials and processes are compliant with RoHS Directive 2011/65/EU in its entirety, inclusive of any further amendments or modifications of said Directive.

rpxx60-user-manual_15nov22.pdf
November, 2022

700 Chestnut Ridge Road
Chestnut Ridge, NY 10977
USA
teledynelecroy.com