



**TIVH Series  
IsoVu™ Measurement System  
User Manual**



071-3556-02





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IsoVu™ Measurement System  
User Manual**

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For product information, sales, service, and technical support:

- In North America, call 1-800-833-9200.
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# 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.

To safely perform service on this product, additional information is provided at the end of this section. (See page vii, *Service safety summary*.)

## 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.

Comply with local and national safety 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

**Connect and disconnect properly.** Do not connect or disconnect sensor tip cables, test leads, or accessories while they are connected to a voltage source. Use only test leads and accessories supplied with the product, or indicated by Tektronix to be suitable for the product.

**Observe all terminal ratings.** To avoid fire or shock hazard, observe all ratings 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 or accessory.

Do not apply a potential that exceeds the maximum 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 it from the instrument. Clearly mark the product to prevent its further operation.

Before use, inspect accessories for mechanical damage and replace when damaged. Do not use them if they are damaged, or if there is exposed metal.

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

Use only specified replacement parts.

**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 a safe working environment.** Always place the product in a location convenient for viewing the display and indicators.

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

### Sensor tip cables

Maintain safe clearance from the sensor head and sensor tip cable while connected to the energized circuit as recommended in this manual.

Remove the sensor tip cable and adapters from the test circuit when not in use.

Leave the sensor tip cable connected to the sensor head when not in use.

Use only correct Measurement Category (CAT), voltage, temperature, altitude, and amperage rated sensor tip cables and accessories for any measurement.

**Beware of high voltages.** Understand the voltage ratings for the product you are using and do not exceed those ratings. It is important to know and understand the maximum measurement voltage rating of the product. The voltage rating depends on the measurement category, the instrument, 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 voltage category.*

---

**Connect and disconnect properly.**



---

**CAUTION.** *To avoid damage to the equipment, de-energize the test circuit before connecting or disconnecting the sensor tip cable.*

---

## Service safety summary

The *Service safety summary* section contains additional information required to safely perform service on the product. Only qualified personnel should perform service procedures. Read this *Service safety summary* and the *General safety summary* before performing any service procedures.

**To avoid electric shock.** Do not touch exposed connections.

**Do not service alone.** Do not perform internal service or adjustments of this product unless another person capable of rendering first aid and resuscitation is present.

**Disconnect power.** To avoid electric shock, switch off the product power and disconnect the power cord from the mains power before removing any covers or panels, or opening the case for servicing.

**Use care when servicing with power on.** Dangerous voltages or currents may exist in this product. Disconnect power, remove battery (if applicable), and disconnect test leads before removing protective panels, soldering, or replacing components.

**Verify safety after repair.** Always recheck ground continuity and mains dielectric strength after performing a repair.

## Terms in this manual

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.*

---

**Isolated, electrically floating.** The terms *isolated*, *electrically floating*, and *galvanically isolated* are used in this document to indicate a measurement where there is no direct conduction path to earth ground.

## Symbols and terms on the product

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.



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 symbol(s) may appear on the product:



CAUTION  
Refer to Manual



WARNING  
High Voltage

# Preface

This document provides information for installing and using the Tektronix TIVH Series IsoVu Measurement System. The measurement system offers a galvanically isolated measurement solution for accurately resolving high bandwidth, high voltage differential signals up to 2500 Vpk in the presence of large common mode voltages with the best in class common mode rejection performance across its bandwidth.

## Key features

- New IsoVu technology - galvanically isolated, floating, measurement system
  - Bandwidth from DC to 800 MHz (sensor tip cable dependent)
  - 160 dB (100 million to 1 common mode rejection ratio) from DC to 1 MHz, 120 dB (1 million to 1) at 100 MHz, 80 dB (10,000 to 1) at 800 MHz
- Differential voltages up to  $\pm 2500$  Vpk (sensor tip cable dependent)
- Large common mode voltage range up to 60 kV peak
- High impedance input up to 40 M $\Omega$  (sensor tip cable dependent)
- Large input offset range up to  $\pm 2500$  Vpk (sensor tip cable dependent)
- DC and AC input coupling

## Laser certification

CLASS 1 LASER PRODUCT

This product complies with 21 CFR 1040.10 and 1040.11 except for deviations pursuant to Laser Notice No. 50, dated June 24, 2007.



**CAUTION.** *Use of controls or adjustments for performance of procedures other than those specified herein may result in hazardous radiation exposure.*

# Product description

The Tektronix TIVH Series IsoVu Measurement System offers a completely galvanically isolated (optical isolation) system. The system consists of a sensor tip cable, a sensor head, a controller, and a TekVPI interface as shown in the following figure. Hazardous voltages in the sensor head are completely isolated from the controller and oscilloscope by optical fiber cables.

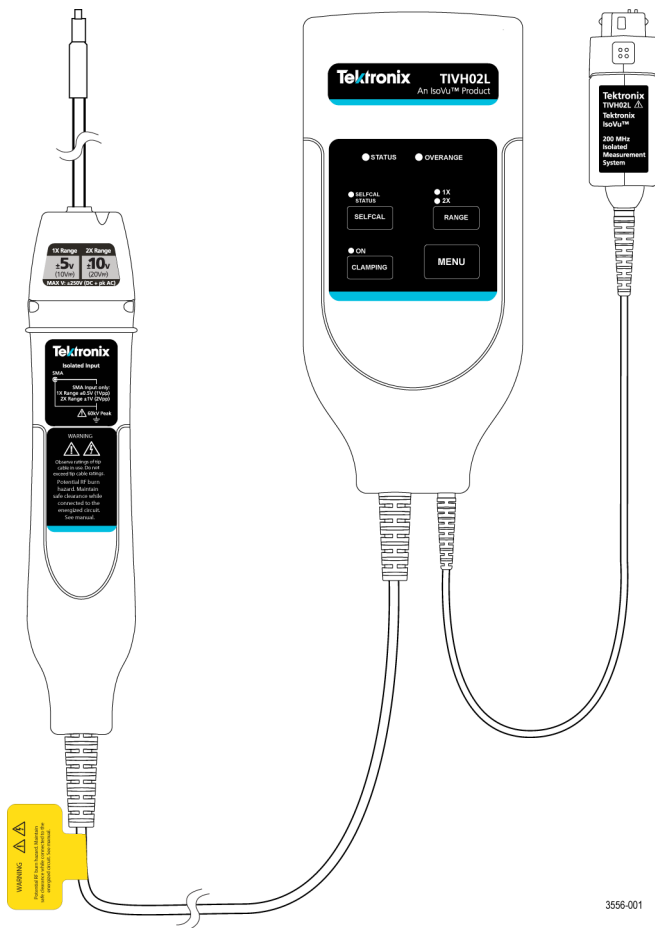


Figure i: TIVH Series IsoVu Measurement System

- Comp box** The TekVPI compensation box (Comp box) connects the measurement system to one of the input channels on the oscilloscope. Power is supplied to the measurement system through the TekVPI interface of the oscilloscope.
- Controller** The controller connects to the oscilloscope through a coaxial cable and the Comp box. Buttons and indicators on the controller provide a means for controlling the measurement system and indicating the overall status.



**Sensor head** The sensor head provides an interface between the device-under-test (DUT) and the controller. It contains an electro-optic converter that converts the electrical signal from the sensor tip cables to an optical signal sent to the controller.

**Sensor tip cables** Several sensor tip cables options are available to connect the sensor head to the DUT:

- MMCX10X, 10X tip cable connector
- MMCX50X, 50X tip cable connector
- MMCX250X, 250X tip cable connector
- SQPIN100X, 100X 0.1-inch (2.54 mm) square pin connector
- SQPIN500X, 500X 0.1-inch (2.54 mm) square pin connector
- WSQPIN1000X, 1000X 0.2-inch (5.08 mm) square pin connector
- WSQPIN2500X, 2500X 0.2-inch (5.08 mm) square pin connector

## Models

The TIVH Series IsoVu Measurement System includes the following models:

- TIVH08. Tektronix IsoVu 800 MHz High Voltage with 3 m cable
- TIVH08L. Tektronix IsoVu 800 MHz High Voltage with 10 m cable
- TIVH05. Tektronix IsoVu 500 MHz High Voltage with 3 m cable
- TIVH05L. Tektronix IsoVu 500 MHz High Voltage with 10 m cable
- TIVH02. Tektronix IsoVu 200 MHz High Voltage with 3 m cable
- TIVH02L. Tektronix IsoVu 200 MHz High Voltage with 10 m cable

## Supported oscilloscopes

The measurement system can be used with the following Tektronix oscilloscopes. For oscilloscopes not included in this list, contact your local Tektronix representative.

- 5 Series MSO



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**WARNING.** To prevent the 5 Series MSO oscilloscope from crashing, do not use the WSQPIN2500X tip without updating 5 Series MSO firmware to V1.6.X or later. If you use the WSQPIN2500X tip with earlier versions of 5 Series MSO firmware, the oscilloscope firmware will crash.

If you mistakenly connect the WSQPIN2500X tip to a 5 Series MSO with an early version of firmware and need help to recover your probe and/or oscilloscope, please do one of the following:

- View the FAQ at the Tektronix website.
- Contact your local Tektronix Service Center.

To view the FAQ:

1. Click the following link: [www.tek.com/isolated-measurement-systems](http://www.tek.com/isolated-measurement-systems).
  2. On the website, click Technical Docs & Downloads.
  3. Select FAQ in the Sort resources by: list.
  4. Click Apply.
- 

- MDO3000 Series (WSQPIN tip cables require V1.26 or later oscilloscope firmware)
- MDO4000C Series (WSQPIN tip cables require V1.06 or later oscilloscope firmware)
- MSO/DPO/MDO4000B Series (WSQPIN tip cables are not compatible)
- MSO/DPO5000B Series
- DPO7000C Series

In addition to the above oscilloscopes, the measurement system can also be used with the following oscilloscopes with a TCA-VPI50 adapter.

- MSO/DPO70000C series
- MSO/DPO70000DX series
- DPO70000SX series

# Operating information

## Accessories

This section lists the standard and optional accessories available for the measurement system.

### Standard accessories

Table 1: Standard accessories

Accessory	Tektronix part number
IsoVu product carrying case, soft case	016-2108-xx
IsoVu accessories carrying case, soft case	016-2110-xx
50X Sensor tip cable (MMCX-to-SMA)	MMCX50X
500X Sensor tip cable (Square pin-to-SMA)	SQPIN500X
5/16-inch SMA wrench/driver tool	003-1951-xx
Probe tip adapter (blue), MMCX to 0.1-inch (2.54 mm) square pin (0.025-inch (0.635 mm) square pins)	131-9717-xx
Flexible tripod with quick release	352-1171-xx
Flexible tripod feet, 3 each	344-0693-xx
Probe tip tripod support with living hinge, 2 each	352-1170-xx
User manual (this document)	071-3556-xx
Certificate of traceable calibration	—

**Optional accessories** Additional accessories, such as other sensor tip cables are available. The following table lists the optional accessories.

**Table 2: Optional accessories**

<b>Accessory</b>	<b>Tektronix part number</b>
1X Sensor tip cable (MMCX-to-SMA)	IVTIP1X <sup>1</sup>
10X Sensor tip cable (MMCX-to-SMA)	MMCX10X
250X Sensor tip cable (MMCX-to-SMA)	MMCX250X
100X Sensor tip cable (Square pin-to-SMA)	SQPIN100X
1000X Sensor tip cable (Square pin-to-SMA)	WSQPIN1000X
2500X Sensor tip cable (Square pin-to-SMA)	WSQPIN2500X
Solder aid for 0.062-inch (1.57 mm) pitch square pins (0.016 - 0.018-inch (0.4 - 0.46 mm) square pin installation tool)	003-1946-xx
DUT Interface pin kit with (qty 20) 0.018-inch (0.46 mm) round solder-in round pins	020-3169-xx
Probe tip adapter (white), MMCX to 0.062-inch (1.57 mm) square pin (0.016 - 0.018-inch (0.4 - 0.46 mm) square pins)	131-9677-xx
Lead, MMCX to IC grabber	196-3546-xx
Lead, 0.100-inch square pin header to IC grabber	196-3547-xx
Lead, 0.200-inch square pin header to banana jack <sup>2</sup>	020-3189-xx

<sup>1</sup> The electrical performance of this tip will vary widely based on the source impedance of the circuit being measured.

<sup>2</sup> Includes alligator clips AC285-FL. To prevent damage to the alligator clip insulation, do not use in high A/m magnetic fields at high frequencies, which can cause induction heating of the jaws.

## Operating considerations

Read this section before installing your measurement system to be aware of the operating requirements and clearance requirements including possible hazardous areas when the measurement system is connected to the DUT.

### Measurement system handling best practices

The measurement system consists of quality parts and should be treated with care to avoid damage or degrading the performance due to mishandling. Consider the following precautions when handling the fiber-optic cables and sensor tip cables:

- Do not crush, crimp, or sharply bend the fiber-optic cable. Avoid making loops in the fiber-optic cable smaller than 5 inches (12.7 cm).
- Do not twist the fiber-optic cable; twisting the cable will stress the optical fibers.
- Do not allow kinks or knots to develop in the fiber-optic cable.
- Avoid putting tension on the fiber-optic cable.
- Do not pull or jerk the fiber-optic cable, especially when kinks or knots are present.
- Do not drop the sensor head or controller assembly since damage and misalignment of the internal optical components can result.
- Avoid over-bending the sensor tip cables; do not exceed the minimum bend radius of 2.0 inches (5.1 cm).
- Avoid crushing the cables by accidentally running over the cable with a chair wheel or by dropping a heavy object onto the cable.
- Never support the weight of the sensor head or controller by the fiber-optic cable.
- Store the measurement system in the supplied carrying case when not in use.

## Environmental requirements

The following tables describe specifications and maximum operating environmental ratings for the measurement system when connected to a DUT and a Tektronix oscilloscope.

**Table 3: Input specifications**

Feature	Description
Common mode	60 kV peak <sup>1</sup>
Differential mode	Sensor tip cable dependent (See the Sensor tip cable voltage rating below.)

<sup>1</sup> This product is designed to be used in the circuit with expected transient overvoltage up to 5000 V peak.

**Table 4: Environmental considerations**

Feature	Description
Temperature	
Controller	
Operating	0 °C to 40 °C (32 °F to 104 °F)
Non-operating	-40 °C to 70 °C (-40 °F to 158 °F)
Sensor head	
Operating	0 °C to 70 °C (32 °F to 158 °F)
Non-operating	-40 °C to 70 °C (-40 °F to 158 °F)
Sensor tip cables/adapters	
Operating and non-operating	-40 °C to 85 °C (-40 °F to 185 °F)
Humidity	
Controller	
Operating	5% to 85% RH (Relative Humidity), at up to 40 °C (104 °F), non-condensing
Non operating	5% to 85% RH (Relative Humidity), at up to 40 °C (104 °F) 5% to 45 % RH above 40 °C (104 °F) up to 70 °C (158 °F), non-condensing

Table 4: Environmental considerations (cont.)

Feature	Description
Sensor head	
Operating	5% to 80% RH (Relative Humidity), at up to 40 °C (104 °F) 5% to 45 % RH above 40 °C (104 °F) up to 70 °C (158 °F), non-condensing
Non operating	5% to 85% RH (Relative Humidity), at up to 40 °C (104 °F) 5% to 45 % RH above 40 °C (104 °F) up to 70 °C (158 °F), non-condensing
Sensor tip cables/adapters	
Operating	5% to 80% RH (Relative Humidity), at up to 40 °C (104 °F) 5% to 45 % RH above 40 °C (104 °F) up to 85°C (185 °F), non-condensing
Non operating	5% to 85% RH (Relative Humidity), at up to 40 °C (104 °F) 5% to 45 % RH above 40 °C (104 °F) up to 70 °C (158 °F), non-condensing
Altitude	
Operating	3000 m (9843 ft.)
Non operating	12,000 m (39370 ft.)

## Clearance requirements

The unique common mode voltage range of the measurement system allows it to be used in the presence of high frequency/high voltage common mode signals. It is important to observe all precautions while using this product.



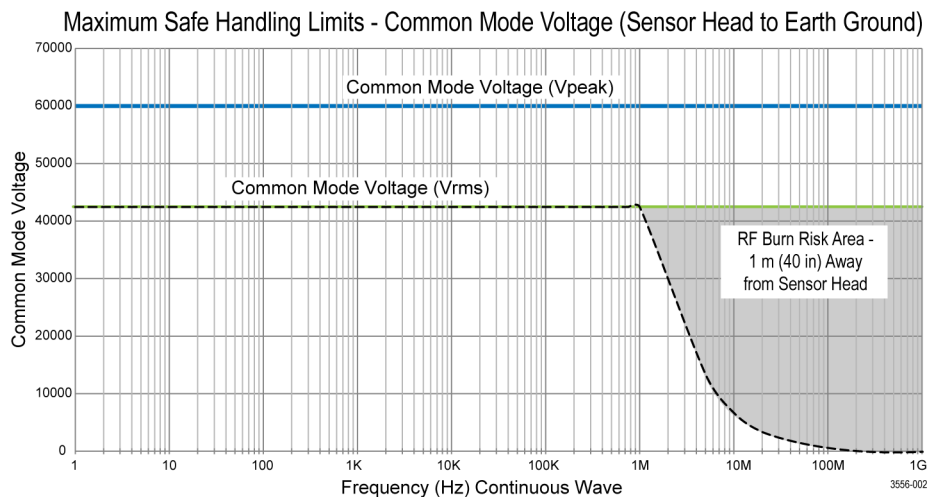
**WARNING.** RF burns can occur while using this measurement system. The system is intended to isolate the operator from hazardous input voltages (common voltages); the plastic case of the sensor head and the shield on the sensor tip cable do not supply safe isolation.

Maintain the safe clearance from the sensor head and sensor tip cable while the measurement system is connected to the energized circuit as recommended in this document. (See Figure 2 on page 7.) Do not access the RF Burn Hazard Zone while taking measurements on a live circuit.



**WARNING.** RF burns can occur while using this measurement system. Anyone making measurements that might come within the RF burn regions indicated in the following figure should be familiar with the hazards of working with signals in these regions and take appropriate action, such as RF shielding for the DUT.

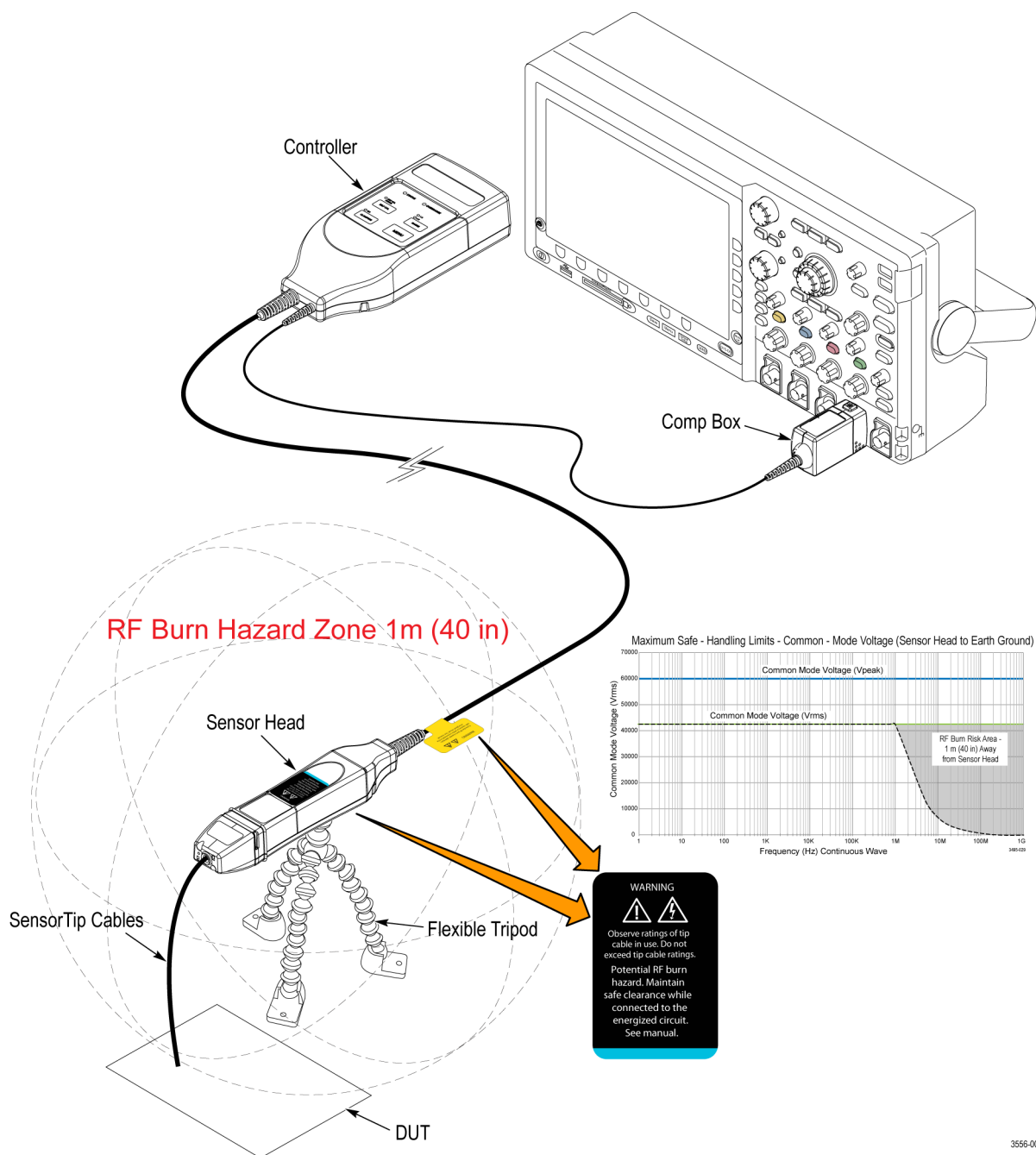
While measuring high frequency common mode signals, there is a risk of RF burns. Refer to the following derating curve to identify the danger areas. Measuring common mode signals within the gray shaded area can result in RF burns within 1 m (40 in.) of the sensor head and earth ground.



**Figure 1: Maximum safe handling limits for common mode voltages between the sensor head and earth ground.**



The following figure shows the components of the measurement system and the potential RF burn area when working with hazardous voltages.



3556-003

Figure 2: RF burn hazard zone around the sensor head

# Controls and indicators

**Controller**     The following figure shows the indicators and buttons on the controller; their functions are described in the following table.

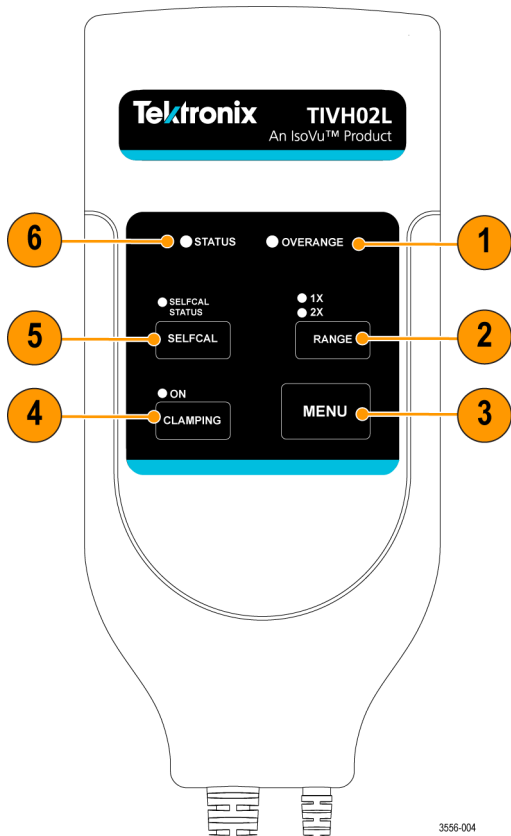


Figure 3: Controller indicators and buttons

Table 5: Controller indicators and buttons

Item	Description
1	OVERANGE Indicator. This red LED indicates if the DC/low frequency differential voltage applied to the sensor head or attached sensor tip cable has exceeded the maximum specified input voltage levels.
2	RANGE indicator. The two LEDs indicate the differential input range setting. RANGE button. Push this button to toggle between one of two differential input voltage ranges.
3	MENU button. Push this button to view the Probe Control menu on the oscilloscope display.

Table 5: Controller indicators and buttons (cont.)

Item	Description
4	CLAMPING indicator. This LED indicates whether the output clamping is enabled.
	CLAMPING button. Push this button to enable or disable the output clamping feature.
5	SELF CAL indicator. This LED indicates the self calibration status.
	■ Solid green. The self calibration has passed.
	■ Flashing orange. The self calibration is in progress.
	■ Solid red. The self calibration has failed.
	■ Solid Orange. The self calibration has not been run or is questionable.
	SELF CAL button. Push this button to start the self calibration routine.
6	STATUS indicator. This LED indicates the status of the measurement system:
	■ Solid green. The unit has powered on and passed the power-on self tests and is in normal operation.
	■ Flashing green. The unit has not completed the power-up sequence. This is typically due to a communication fault between the host oscilloscope and the IsoVu unit. Disconnect the TekVPI comp box and then reattach the comp box.
	■ Solid or flashing red. Error condition that requires the unit to be sent to Tektronix for service.
	■ Flashing red/yellow. The unit has failed the power on self tests. Cycle the power; if the problem persists, the unit needs to be sent to Tektronix for service.

**Sensor head** Labels on the sensor head provide high-level specifications for connecting to the DUT. They also provide reminders of the potential RF burn hazards while connected to the DUT.

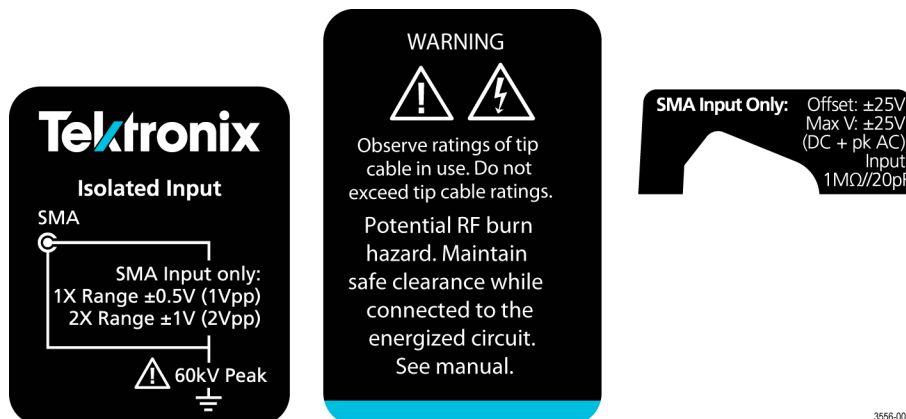


Figure 4: Labels on the sensor head

## Sensor tip cables

Each sensor tip cable has a set of labels on the top and bottom. The top labels provide reminders of the maximum differential input voltage range for each tip cable. The bottom labels include the name of the tip cable and the differential input resistance and capacitance for the tip cable (differential loading).

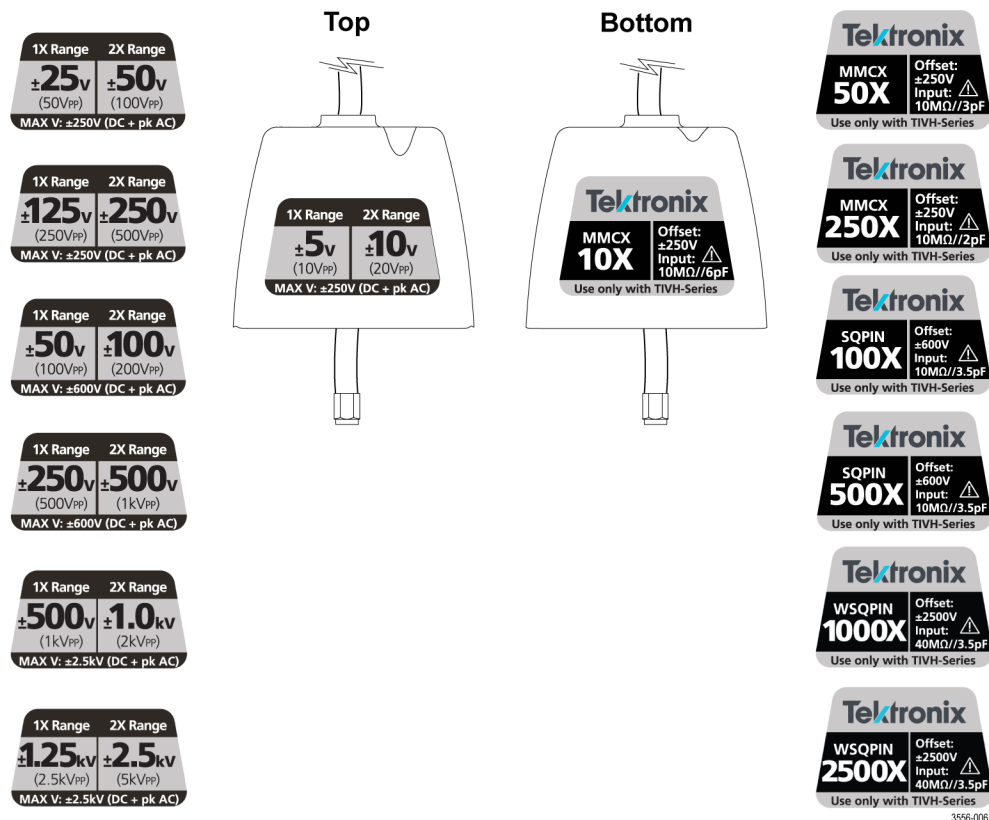


Figure 5: Sensor tip cable top and bottom labels

## Connecting to a circuit



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**WARNING.** This measurement system contains laser sources; exposing these laser sources may cause laser exposure. Except for the sensor tip cables on the sensor head, do not remove any plastic or metallic covers from the sensor head or controller or attempt to disassemble the product.

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**WARNING.** Do not connect the measurement system to an energized circuit to avoid the risk of shock. Always de-energize the circuit-under-test before installing or removing the tip cable from the circuit-under-test. The plastic case of the sensor head and the shield tip of the sensor cable do not supply the isolation.

---



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**WARNING.** To avoid the risk of electrical shock or RF burns while the DUT is energized, do not touch the sensor head or sensor tip cable while taking measurements. Always keep a 1 m (40 in.) clearance from the sensor head during the measurement. (See Figure 2 on page 7.)

Be sure to check the maximum ratings and derating curve for more information on the RF burn hazard zone. (See Figure 1 on page 6.)

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**CAUTION.** To avoid possible damage to the equipment, do not connect the coaxial (common) shield of the sensor tip cable or SMA input to the high impedance portion of a circuit. The additional capacitance can cause circuit damage. Connect the coaxial (common) shield to the low impedance section of the circuit.

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**NOTE.** Touching the sensor head or sensor tip cable when measuring a high frequency common mode signal increases the capacitive coupling and can degrade the common mode loading on the circuit-under-test.

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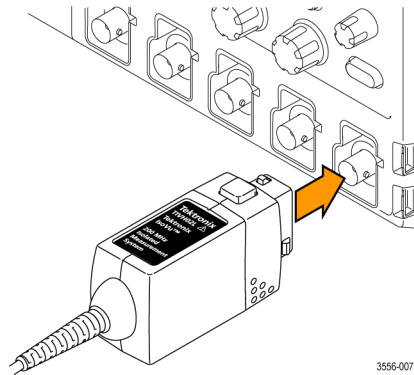
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**WARNING.** To prevent the arc flash caused by a different potential, do not place the sensor head or sensor tip cable on the circuit that has the different voltage.

---

The following steps describe the process for connecting the measurement system between a Tektronix oscilloscope and the DUT.

1. Verify the DUT is not connected to an energized circuit.
2. Connect the Comp box to one of the channels on the oscilloscope.



**Figure 6: Connect the Comp box to the oscilloscope**

3. Refer to the following figure and install the sensor tip cable to the sensor head.

- a. Line up the sensor tip cable with the sensor head.

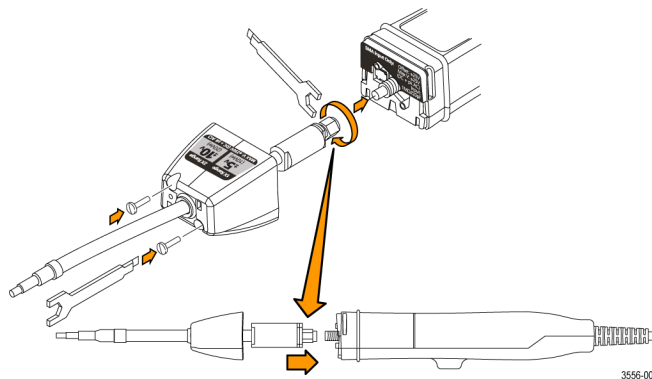
Take care to avoid bending or twisting the sensor tip cable assembly during this process.

- b. Connect the SMA connector of the sensor tip cable to the sensor head. Use the accessories wrench to tighten the SMA cable to 4 to 5-in lbs.

Use the adjustment tool that was shipped with your system.

- c. Press the sensor tip cable housing against the sensor head and then tighten the two screws to 3 to 5-in lbs.

Use the adjustment tool that was shipped with your system.



**Figure 7: Connecting the sensor tip cable to the sensor head**

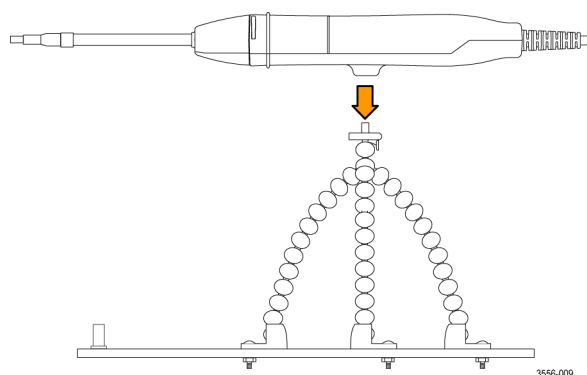
4. Connect the sensor head to the flexible tripod or a similar support.

This support keeps the sensor head steady reducing the potential mechanical stresses at the electrical connection point of the DUT. The support also keeps the sensor head away from surrounding circuits and conductive objects to minimize the parasitic capacitive coupling to these surroundings.

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**NOTE.** The mating thread in the sensor head is UNC $\frac{1}{4}$ -20. If you use a different support, make sure that mating thread is UNC $\frac{1}{4}$ -20.

---



**Figure 8: Connect the sensor head to the flexible tripod**

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**NOTE.** To obtain the most accurate measurement, allow the measurement system to warm up for 20 minutes. Then perform the self calibration before connecting the tip cable to the DUT and taking the measurement.

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5. Connect the sensor tip cable end to the DUT. If you are using MMCX sensor tip cable, connect it to an MMCX connector on the DUT or to a square pin adapter on the DUT. The adapters connect to square pins with either 0.100-inch (2.54 mm) spacing or 0.062-inch (1.57 mm) spacing. (See Figure 47 on page 57.) If you are using one of the square pin sensor tip cables, connect it directly to the square pins on the DUT. (See page 58, *Connecting the sensor tip cables*.)
6. Set up the controls on the oscilloscope.
7. Apply power to the DUT to take the measurement.

## Self calibration

Press the SELF CAL button on the controller to adjust the operating point of the measurement system for the current range and clamp setting. (This function is not available in the Probe Setup menu of the oscilloscope.)

---

**NOTE.** *Make sure there is no differential voltage present at the sensor tip cable when performing the self calibration.*

---

When you power on the measurement system, the SELF CAL status indicator on the controller is orange, indicating that the operating point of the measurement system has not been optimized. As a result, the accuracy of the measurement system might be degraded. The SELF CAL sequence should always be run on the system after it is first powered on and has warmed up for 20 minutes. After pushing the SELF CAL button, the indicator blinks orange during the self calibration process; it turns solid green when the operation completes or solid red when the operation fails.

There are situations when further self calibration is required. The SELF CAL status indicator turns orange to indicate when this is necessary:

- The measurement system is first attached to the oscilloscope.
- Changes are made to the range (1X|2X) or clamp (ON|OFF) setting.
- The temperature in the sensor head changes more than 10 °C.
- The internal compensation adjustments have shifted outside their normal operating ranges.
- The sensor tip cable is changed.

### Programming

Users wanting to initiate the self calibration through the programmatic interface must configure the measurement system to perform a self calibration every time it receives the AutoZero command. To link these functions, hold the MENU button down and momentarily press the SELF CAL button. The OVERRANGE indicator should blink red twice. This mode is non-volatile, and it also changes the operation of the AutoZero button in the Probe Setup menu of the oscilloscope. Restore the original operation by repeating the MENU-SELF CAL button pushes. In this case the OVERRANGE indicator will blink once.



## AutoZero

When the displayed waveform is not centered correctly (for example, due to a small DC offset error), you might need to press the AutoZero button in the Probe Setup menu of the oscilloscope. This might be necessary for the first time after the self calibration operation has completed. Make sure there is no differential signal present at the sensor tip cable.

## Menu button

Press the MENU button on the controller to view the Probe Setup menu on the oscilloscope, similar to the following figure.

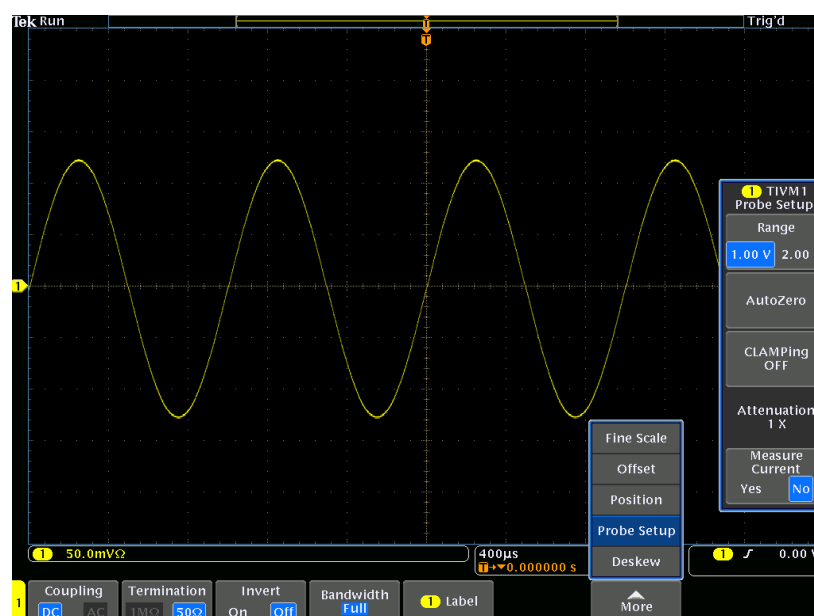


Figure 9: Probe Setup menu

Use the buttons on the oscilloscope to change the probe setups. Some of the functions are the same as pushing the buttons on the controller, such as turning clamping on or off, or setting the input ranges.

## Offset correction

The measurement system uses state-of-the-art technology that allows the DUT to be totally isolated from the oscilloscope. This results in a very large common mode rejection ratio (CMRR) and lets you see small signals that would otherwise be obscured by the high common mode interference.

The TIVH Series products implement an offset correction algorithm to minimize any drift in the system due to changes in temperature or fiber movement. The offset correction algorithm maintains a constant DC level for the displayed on-screen signal.

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**NOTE.** *In firmware version 2.02, an optional offset correction algorithm was added that improves DC performance over the original offset correction algorithm. In almost all cases, Tektronix recommends using the new, Enhanced Offset Correction mode.*

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To change Offset Correction mode, hold MENU and press CLAMPING. The Overrange LED will blink to indicate the current Offset Correction mode.

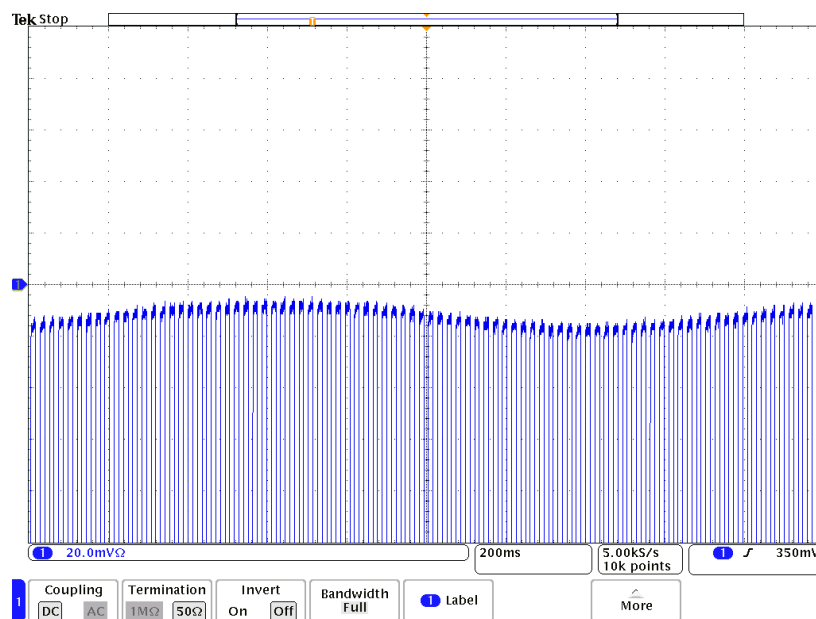
**Table 6: Offset Correction mode LED indicator**

Overrange LED blink count	Offset Correction mode
Once	Normal offset correction
Twice	Offset correction disabled
Three times <sup>1</sup>	Enhanced offset correction <sup>1</sup>

<sup>1</sup> Added in firmware version 2.02.

One of the components used for offset correction is a digital low-pass filter. Normally, the frequency of the signal is high enough that the operation of the filter is transparent. However, at low frequencies special care must be taken to prevent aberrations from being introduced.

When attempting to capture a signal that has a frequency near 43.5 Hz, 87.0 Hz, or 130.5 Hz, the display might show aliasing. If you cannot avoid these frequencies, the offset correction should be disabled. The sample rate of the digital filter was selected to not alias at 50 Hz or 60 Hz.



**Figure 10: Digital filter aliasing**

To disable the offset correction algorithm, hold down the MENU button on the controller and momentarily press the CLAMPING button. The OVERRANGE indicator on the controller should blink two times. To use Enhanced Offset Correction mode, repeat the MENU and CLAMPING procedure until the Overrange LED blinks three times.

Another source of aberrations is introduced when the signal is below the cutoff frequency of the digital filter (5.0 Hz). The following figure shows a close-up view of the front edge of a 0.1 Hz 800 mV<sub>p-p</sub> square wave. These aberrations are also created by the digital filter.

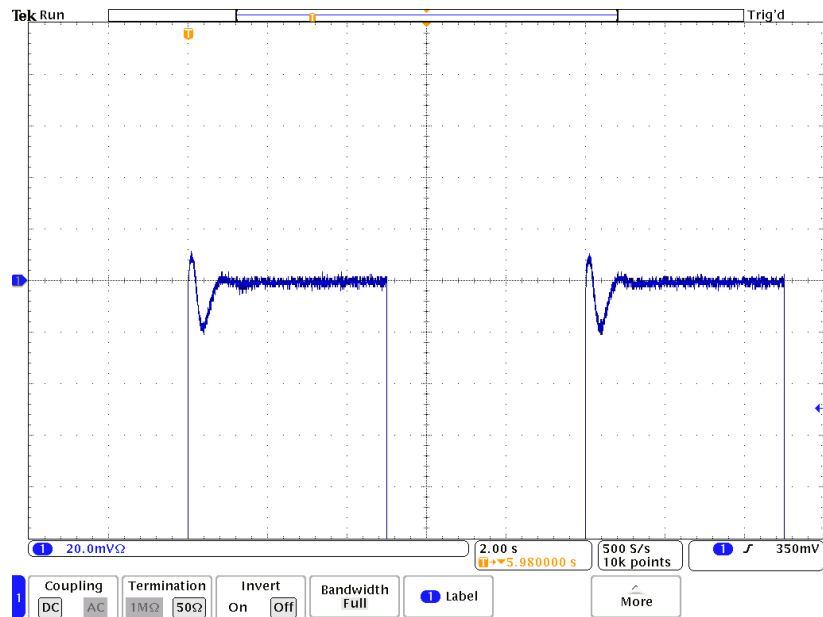


Figure 11: Digital filter aberrations (about 2.5% of  $V_{p-p}$ )

The following figure shows the aberrations after the offset correction has been disabled. When the offset correction is disabled, the system no longer corrects for long-term drift due to temperature change and fiber movement.

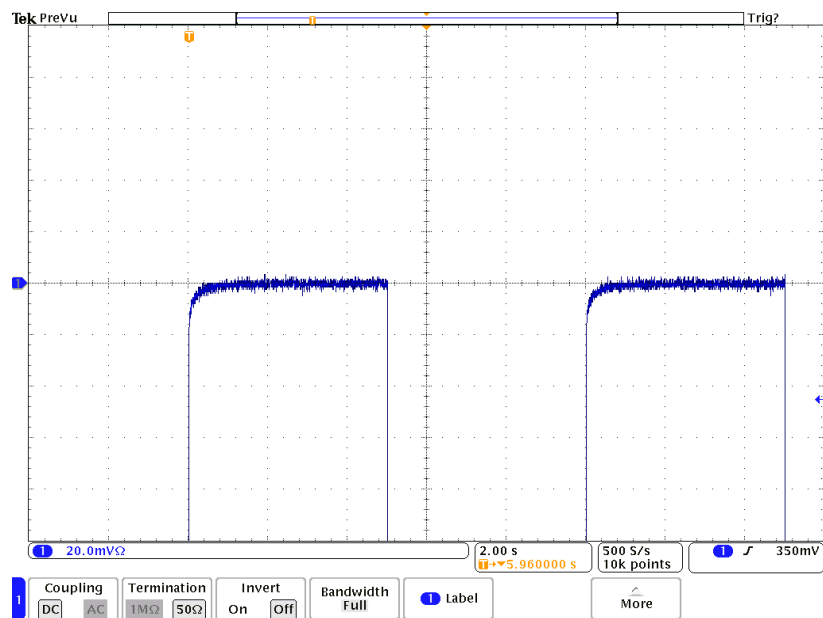


Figure 12: Digital filter aberrations after disabling offset correction

## 1X/2X Range

The top label of each sensor tip cable (MMCX10X, MMCX50X, MMCX250X, SQPIN100X, SQPIN500X, WSQPIN1000X, WSQPIN2500X) shows the dynamic range as a  $\pm$ peak-to-peak voltage (with the voltage shown in parenthesis).

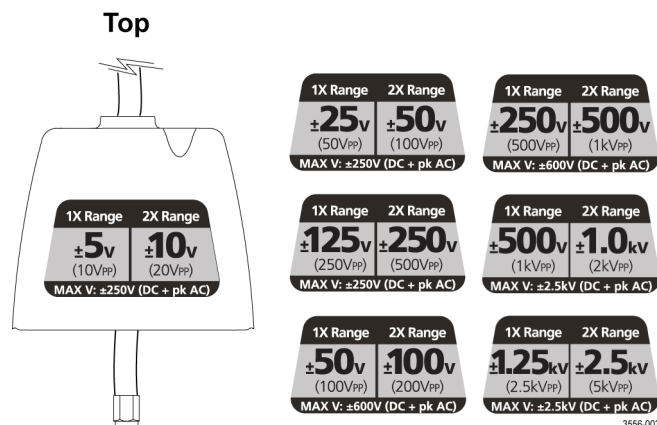


Figure 13: Top sensor tip labels

For example, the MMCX10X tip has a dynamic range of 10 V<sub>p-p</sub> when the 1X Range is selected. This means that you can display a signal with a  $\pm 5$  V differential voltage. When the 2X Range is selected, the dynamic range increases from 10 V<sub>p-p</sub> to 20 V<sub>p-p</sub> ( $\pm 10.0$  V). Refer to the *Linear differential input voltage range* in the specifications table for more information.



**CAUTION.** To avoid damaging the probe, do NOT exceed the Peak Voltage rating. The Maximum Non-Destruct Voltage limit (Peak Voltage) does not increase when the 2X Range is selected. For example, with the MMCX10X, the  $\pm 250$  V<sub>pk</sub> limit is the same for both the 1X or 2X Range.

## Auto Range

By default, the MSO/DPO5000, DPO7000, and MSO/DPO70000 Series Oscilloscopes select the 1X or 2X Range automatically when you change the V/div setting. This hides the complexity of selecting the range from casual users. However, there are combinations of Range and V/div settings that cannot be reached when Auto Range is selected. For these situations, select Manual Range when full flexibility is desired.

## Selecting a sensor tip cable



**CAUTION.** Avoid over-voltage conditions that can damage or degrade the sensor head input termination by selecting the correct sensor tip cable. Selecting the correct sensor tip cable attenuation factor is crucial to ensure that the sensor head input termination is not degraded or damaged by an over-voltage condition. Select the sensor tip cable that will provide the lowest attenuation possible for the signal being measured.

When selecting a sensor tip cable for a particular application, consider the following questions:

- What is the maximum RMS/Peak Voltage at the test point being measured (for example, under a fault condition)?
- What is the minimum differential loading (input resistance) that my circuit can tolerate?
- How large of a signal do I want to display at one time on the oscilloscope?
- What sensitivity do I need (for example, the minimum V/div setting)?

The following table will help you select the correct sensor tip. Start at the top of the table and work down. Choose the first tip that meets all of your criteria.

Table 7: Sensor tip selection table

Sensor tip	Most sensitive V/div setting <sup>1</sup>	Differential input specifications		
		Linear voltage range <sup>2</sup>	Maximum non-destruct voltage (DC + pk AC) <sup>3</sup>	Differential input resistance
WSQPIN2500X	2.5 V	±2500 V (5 kV <sub>P-P</sub> )	±2500 V	40 MΩ
WSQPIN1000X	1.0 V	±1000 V (2 kV <sub>P-P</sub> )	±2500 V	40 MΩ
SQPIN500X	500 mV	±500 V (1 kV <sub>P-P</sub> )	±600 V	10 MΩ
SQPIN100X	100 mV	±100 V (200 V <sub>P-P</sub> )	±600 V	10 MΩ
MMCX250X	250 mV	±250 V (500 V <sub>P-P</sub> )	±250 V	10 MΩ
MMCX50X	50 mV	±50 V (100 V <sub>P-P</sub> )	±250 V	10 MΩ
MMCX10X	10 mV	±10 V (20 V <sub>P-P</sub> )	±250 V	10 MΩ

<sup>1</sup> On 1X Range.

<sup>2</sup> On 2X Range.

<sup>3</sup> (See page 47, Maximum differential input voltage vs. frequency derating graphs.)

## Output clamping

The measurement system has a selectable output clamping feature. Push the button on the controller to enable or disable the output clamping feature. When enabled (indicator is on), the output clamping limits the output voltage swing of the measurement system into the oscilloscope input. It allows you to increase the vertical sensitivity without over-driving or saturating the oscilloscope input.

## Sensor tip loading

Each of the sensor tip cables (MMCX10X, MMCX50X, MMCX250X, SQPIN100X, SQPIN500X, WSQPIN1000X, WSQPIN2500X) has a differential input resistance listed on the bottom labels as shown in the following figure.

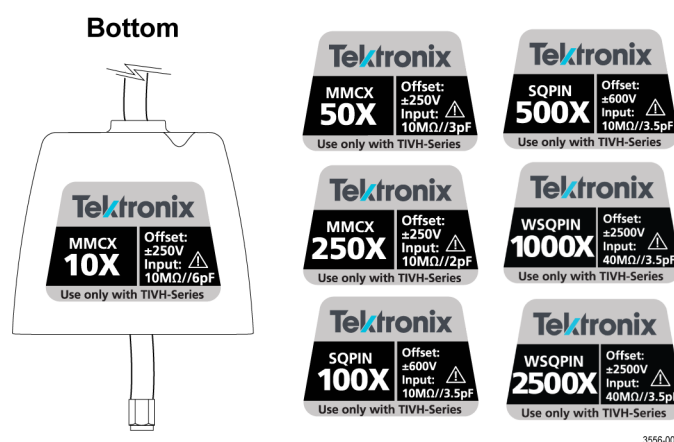


Figure 14: Bottom sensor tip labels

Refer to the *Input resistance/capacitance* section in the specifications table for more information. The sensor tip cables are specially designed to act as a common mode choke that helps reduce the common mode loading.

**NOTE.** The coaxial (common) shield of the sensor tip cable should always be connected to the lowest impedance point (usually a circuit common or power supply rail) in the circuit-under-test (relative to the sensor tip cable/center conductor) to obtain the most accurate waveform.

## Probe compensation

The DPO7000 and MSO/DPO70000 Series oscilloscopes have a Compensate Probe feature accessible from the Probe Setup window. Pressing this button always results in a failure when using these oscilloscopes because of an incompatibility between the oscilloscope and the TIVH system. The accuracy of the TIVH system is still guaranteed on these oscilloscopes even though the Compensate Probe feature fails.

## Deskew

Each oscilloscope family has a unique way of allowing you to adjust the timing relationship between signals acquired between different probes. Consult the user manual or online help of the oscilloscope for specific directions needed to deskew the probe. The 3 m and 10 m measurement systems have a propagation delay of approximately 35 ns and 68 ns respectively. The actual propagation delay is measured on each measurement system and is stored within each unit.

## Input offset

The measurement system provides a user-adjustable, input referred offset voltage. This allows you to view a portion of the signal that is off-screen. One of the controls on the oscilloscope can be assigned this function.

To achieve the best performance of the measurement system, ensure that you are properly using the input offset capability of the TIV Series of products. (See page 26, *Input offset voltage range*.)

## Input coupling (AC or DC)

The DC input coupling setting on the oscilloscope menu provides a direct, DC coupled, electrical path in the sensor head; it accepts all types of signals, including unchanging DC voltages, time-varying DC voltages, AC, and combinations of AC and DC.

When DC input coupling is enabled on the oscilloscope, the offset range is only dependent on the tip cable attenuation.

The DC Reject input coupling setting on the oscilloscope menu provides an AC-only path in the sensor head, removing DC offset from any mixed signal to view the AC component of the signal. DC reject is useful when you measure small amplitude signals superimposed on a large differential offset component. When DC Reject is enabled, the offset range is not only dependent on the tip cable attenuation, but also depends on the oscilloscope Volts/Div scale factor.



## TIV-Series voltage range

The TIV-Series is designed to enable characterization of high frequency circuits with a wide range of differential voltages in the presence of common mode voltages. Understanding the limits for the input operating voltages as discussed in this section is essential to optimize signal fidelity and measurement accuracy.

Although the common mode voltage range of the TIV-Series is very large ( $>60$  kV), the differential input range is limited and depends on the tip attenuation, the gain range selected, and the applied offset.

The input voltage conditions are divided into several different input ranges.

### Common mode voltage range

Since the TIV-Series sensor head is optically isolated from earth ground, the common mode input range is  $>60$  kV. The differential input range is more limited and refers to the signal that can be applied across the probe tip, regardless of the common mode voltage.

### Maximum non-destruct differential voltage range

The maximum non-destruct differential input range is the maximum differential voltage that can be applied to the input without damaging the probe. This is a DC +peak AC rating (i.e. no portion of the differential input signal should exceed this value). The maximum non-destruct differential voltage varies from  $\pm 25$  V to  $\pm 2500$  V depending of the tip cable being used. Exceeding this level can cause permanent damage to components of the sensor head.

Refer to the tip cable label for the maximum non-destruct input range when using each tip cable. For example, for direct input to the sensor head using the SMA connector this value is  $\pm 25$  V, but when using the SQPIN100X tip cable the value is  $\pm 600$  V.

### Linear differential voltage range

As with any analog measurement system, the sensor used in the TIV series has a limited differential input range. If the differential input signal exceeds this range, the gain accuracy is reduced.

In the TIV series there are two factors limiting the linear differential voltage range. The first is the output voltage range of the amplifier and the second is the linear range of the sensor. If the amplifier output voltage range is exceeded, the signal displayed on the oscilloscope will be clipped. The effects of exceeding the sensor linear range are less apparent and might lead to inaccurate measurements.

This limited linear range results in a reduction in gain that is gradual and might not always be apparent to the user. To obtain the most accurate measurements, the user must take care to maintain the differential input signals within both the amplifier range and the sensor linear range.

To ensure that the signal to be measured is within the linear range, the tip attenuation value should be selected to keep the peak-to-peak signal within the most accurate range. Check the label on the tip cable to verify that the appropriate tip cable and range have been selected for the signal being applied.

In addition, the TIV series of products all provide input offset capability to assist in maintaining differential input signals in the most accurate range. (See page 26, *Input offset voltage range*.) The TIV series also includes a self-calibration function that optimizes and centers this range. The self-calibration procedure should always be executed prior to making any critical measurements.

**System Transfer Function – 1X Range.** For the System transfer function in the 1X Range, accuracy is best when the peak-to-peak signal is within the  $\pm 60\%$  window.

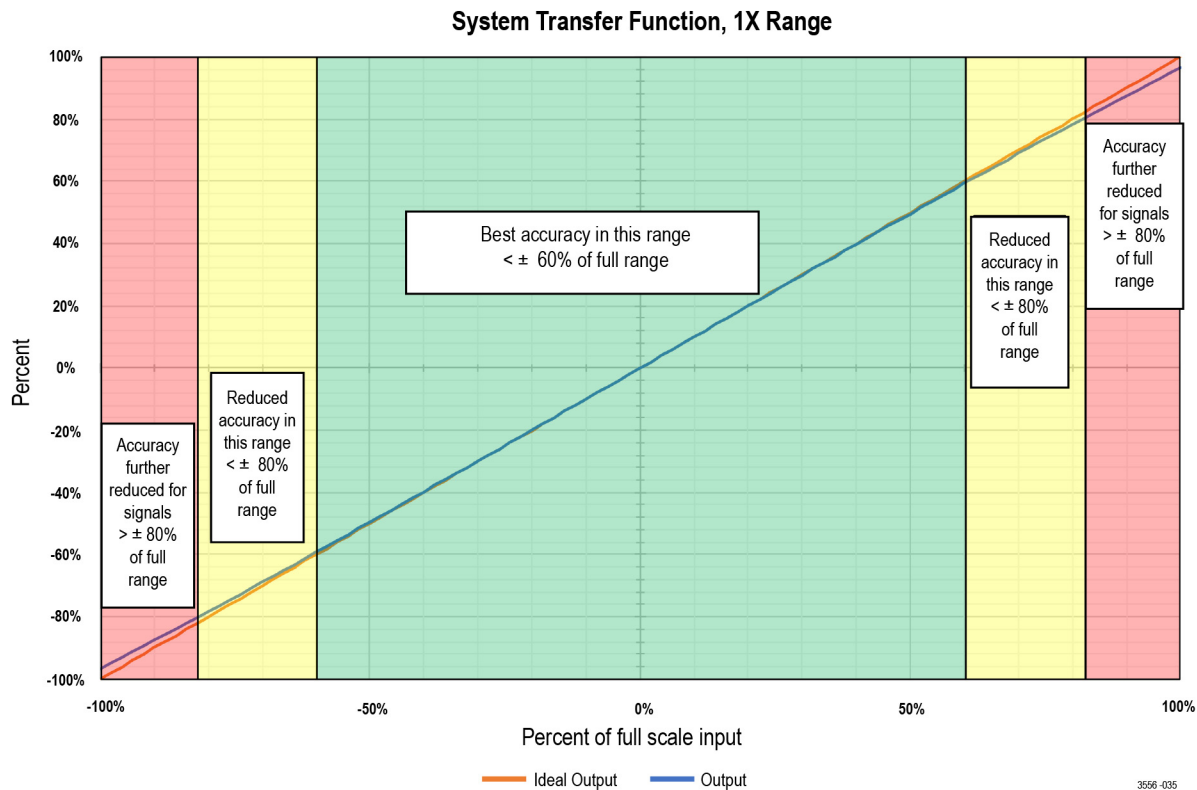


Figure 15: System Transfer Function – 1X Range

**System Transfer Function – 2X Range.** For the System transfer function in the 2X Range, accuracy is best when the peak-to-peak signal is within the  $\pm 60\%$  window.

Note that the error is higher in the 2X Range than it is in the 1X Range.

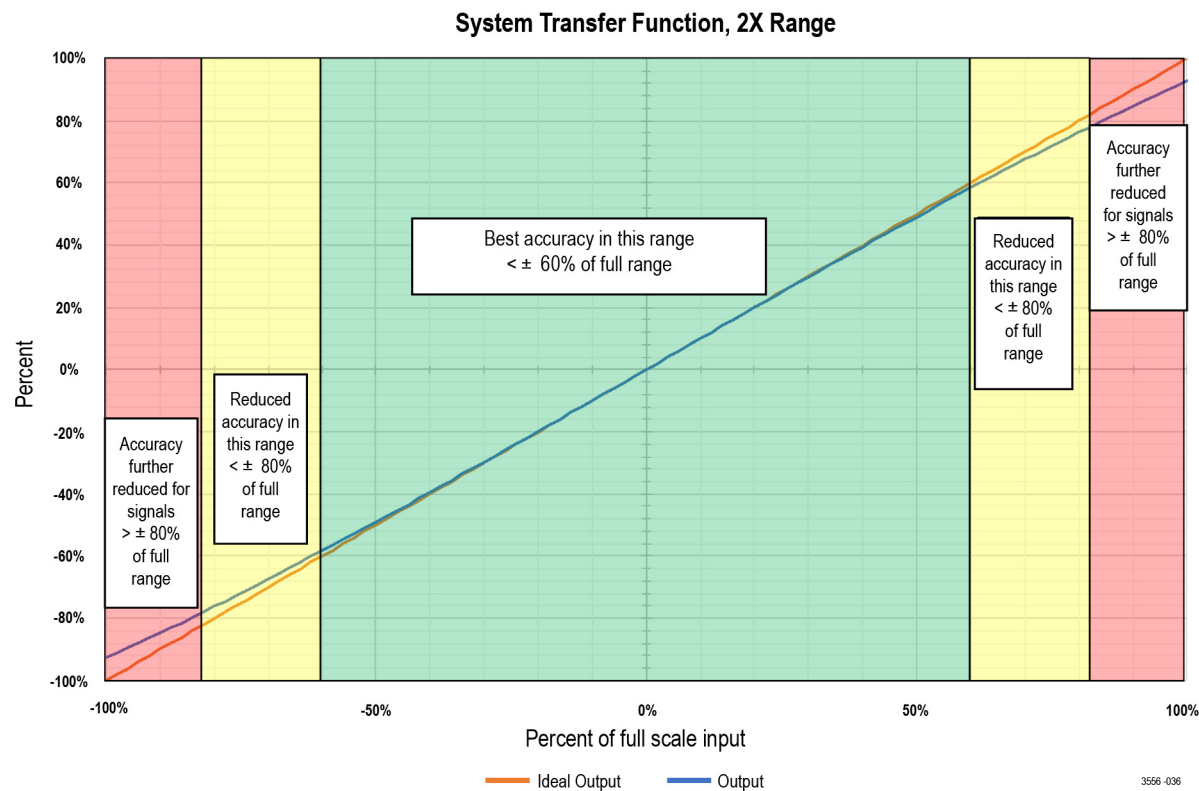


Figure 16: System Transfer Function – 2X Range

**Linear differential input range.** The linear differential input range is divided into several regions. This range depends on the tip cable attenuation, the gain range (1X / 2X) of the system, the state of the clamping circuit, and the input offset.

**Table 8: Differential input voltages – 2X Range**

Sensor tip	Differential input voltage in 2X range (100% of Full Range)	Input offset adjustment range	Range for optimum signal fidelity <sup>1</sup>
Sensor Head Input SMA	$\pm 1 \text{ V}$ ( $2 \text{ V}_{\text{P-P}}$ )	$\pm 25 \text{ V}$	$\pm 600 \text{ mV}$ ( $1.2 \text{ V}_{\text{P-P}}$ )
MMCX10X	$\pm 10 \text{ V}$ ( $20 \text{ V}_{\text{P-P}}$ )	$\pm 250 \text{ V}$	$\pm 6 \text{ V}$ ( $12 \text{ V}_{\text{P-P}}$ )
MMCX50X	$\pm 50 \text{ V}$ ( $100 \text{ V}_{\text{P-P}}$ )	$\pm 250 \text{ V}$	$\pm 30 \text{ V}$ ( $60 \text{ V}_{\text{P-P}}$ )
MMCX250X	$\pm 250 \text{ V}$ ( $500 \text{ V}_{\text{P-P}}$ )	$\pm 250 \text{ V}$	$\pm 150 \text{ V}$ ( $300 \text{ V}_{\text{P-P}}$ )
SQPIN100X	$\pm 100 \text{ V}$ ( $200 \text{ V}_{\text{P-P}}$ )	$\pm 600 \text{ V}$	$\pm 60 \text{ V}$ ( $120 \text{ V}_{\text{P-P}}$ )
SQPIN500X	$\pm 500 \text{ V}$ ( $1 \text{ kV}_{\text{P-P}}$ )	$\pm 600 \text{ V}$	$\pm 300 \text{ V}$ ( $600 \text{ V}_{\text{P-P}}$ )
WSQPIN1000X	$\pm 1000 \text{ V}_{\text{P-P}}$ <sup>(1)</sup>	$\pm 2500 \text{ V}$	$\pm 600 \text{ V}$ ( $1000 \text{ V}_{\text{P-P}}$ )
WSQPIN2500X	$\pm 2500 \text{ V}_{\text{P-P}}$ <sup>(1)</sup>	$\pm 2500 \text{ V}$	$\pm 1500 \text{ V}$ ( $2500 \text{ V}_{\text{P-P}}$ )

<sup>1</sup> Peak-to-peak signal should be maintained in this range for best accuracy.

### Input offset voltage range

To achieve the best performance of the measurement system, it is critical that the user understands the proper use of the input offset capability of the TIV Series of products. Referring to the table above, the input offset capability of the TIV Series extends from  $\pm 25 \text{ V}$  to  $\pm 2500 \text{ V}$  depending on the tip used. This offset capability can be used to bring signals that are outside the linear range of the sensor into the region with the most accurate response.

The minimum/maximum offset is different for each sensor tip cable. It is the same when the 1X or 2X Range is selected; it is also the same for all V/div settings. (See Table 8.)

**Input offset example 1: 2X Range, clamping off, no tip cable.** In this state, the linear differential input range is specified to be  $\pm 1\text{ V}$  ( $2\text{ V}_{\text{P-P}}$ ). This means that the voltage level at the input connector should be within the range  $\pm 1\text{ V}$  with no offset. Without input offset applied, any input voltage outside this  $\pm 1\text{ V}$  range will not be displayed with the best accuracy.

However, the input offset control can be used to adjust the signal level so that the signal of interest is within this  $\pm 1\text{ V}$  window. One way to maintain the signal in the optimum range is to use the scope position control to set the trace (with no input signal applied) to the middle of the screen. Then with the input signal applied, use the offset control to adjust the trace location to display symmetrically around the center of the screen.

For example, if the input signal is a 0 to +1 V triangle wave as shown below, using the 2X Range with no input offset applied will result in a distorted/compressed signal. To make this measurement in this example, the signal should be offset by +500 mV to center it in the most accurate range of the TIV system. In the following figure, the signal compression is exaggerated for illustrative purposes.

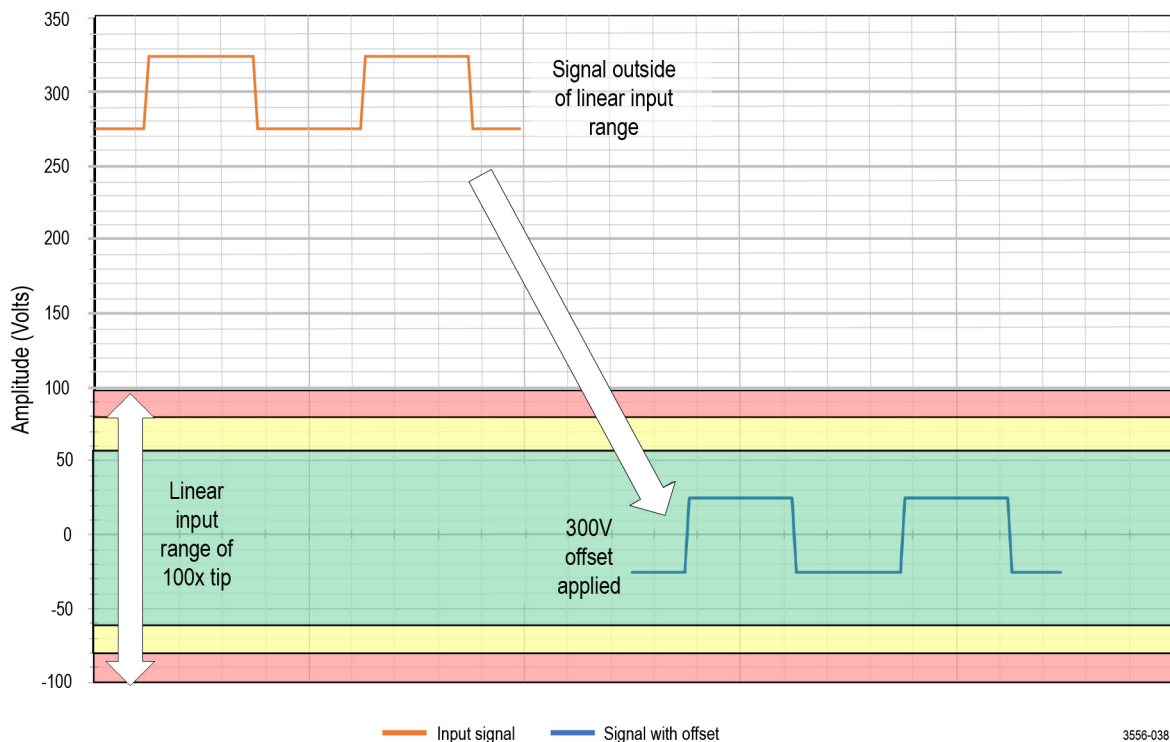


**Figure 17: Use of input offset to improve signal fidelity**

**Input offset example 2: 50 V square wave from +275 V to +325 V.** The peak-to-peak signal of 50 V is within the linear differential input range of several of the tips. However, the peak signal of +325 V exceeds the absolute maximum rating of the MMCX tips.

The SQPIN100X tip can be used to measure this signal since this tip has a  $\pm 600$  V maximum input voltage rating and a linear differential input range of  $\pm 50$  V (100 V<sub>p-p</sub>) in the 1X Range. To make this measurement in this example, an offset of +300 V should be applied to center the signal in the TIV linear range.

### Use of offset to bring signal into linear range



**Figure 18: Use of input offset to bring a signal into the measurement system input range**

**Input offset example 3: Output voltage clipping.** The TIV Series supports two different gain ranges (1X and 2X) that are selectable from the controller panel or from the oscilloscope. The 1X Range has better sensitivity while the 2X Range has a larger input voltage range. In the 1X Range, the peak input voltage is limited by the amplifier output voltage range as illustrated in the following figures.

In each of the following figures, the input signal is the same amplitude ( $1 V_{P-P}$ ). The difference is the amount of offset in the input signal and the amount of amplifier input offset applied by the measurement system.

**Output voltage clipping examples (1X Range).** In the following figure, the signal is within the input and output range of the measurement system. The system is in the 1X Range with direct input to the input SMA connector.

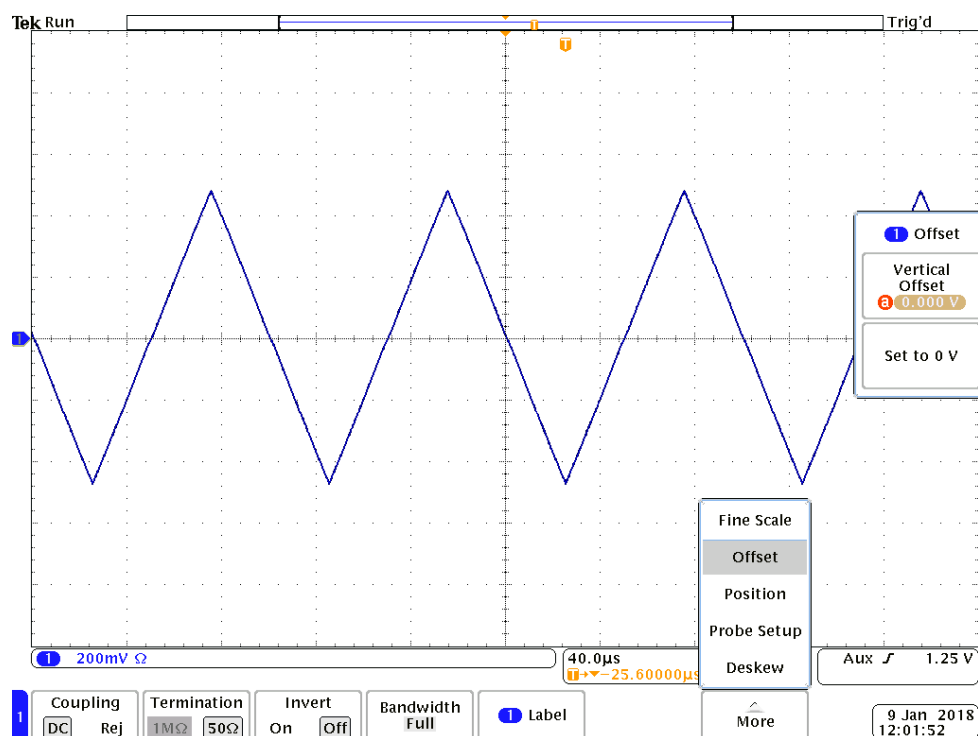


Figure 19:  $1 V_{P-P}$  signal ( $\pm 500$  mV) centered at 0 V with no input offset applied

In the following figure, the signal is outside the output range of the measurement system and is causing the amplifier output to be clipped. The system is in the 1X Range with direct input to the input SMA connector.

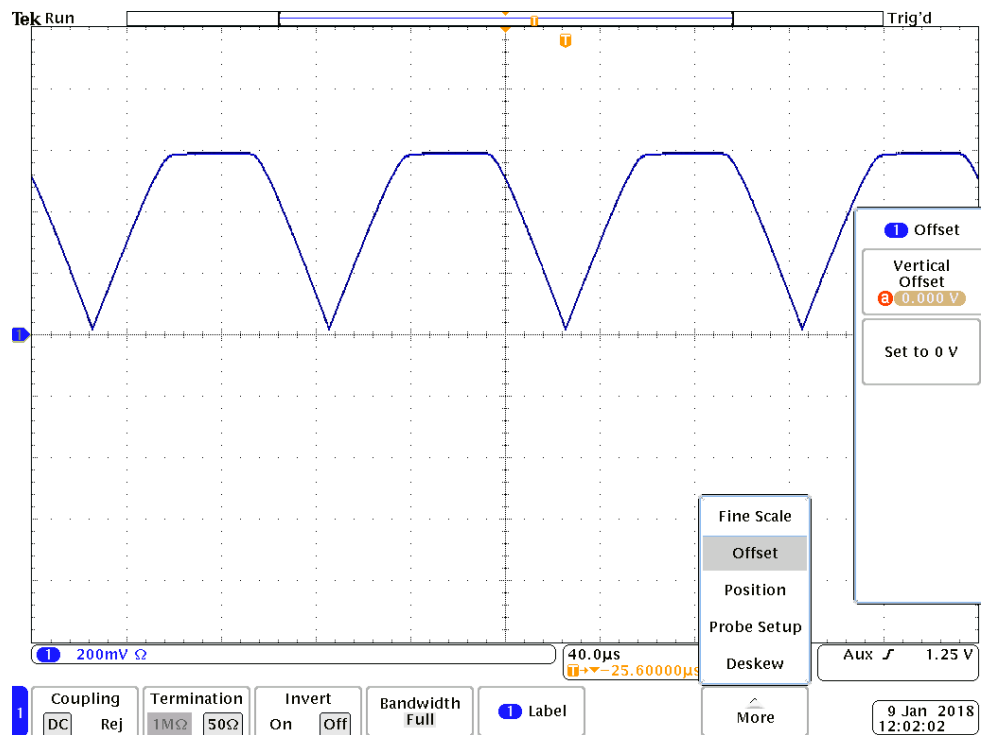


Figure 20: 1 V<sub>p,p</sub> signal (0 to +1 V) with no input offset applied



In the following figure, this is the same signal as in the previous figure. With offset applied, this signal is within the input and output range of the measurement system. The system is in the 1X Range with direct input to the input SMA connector.

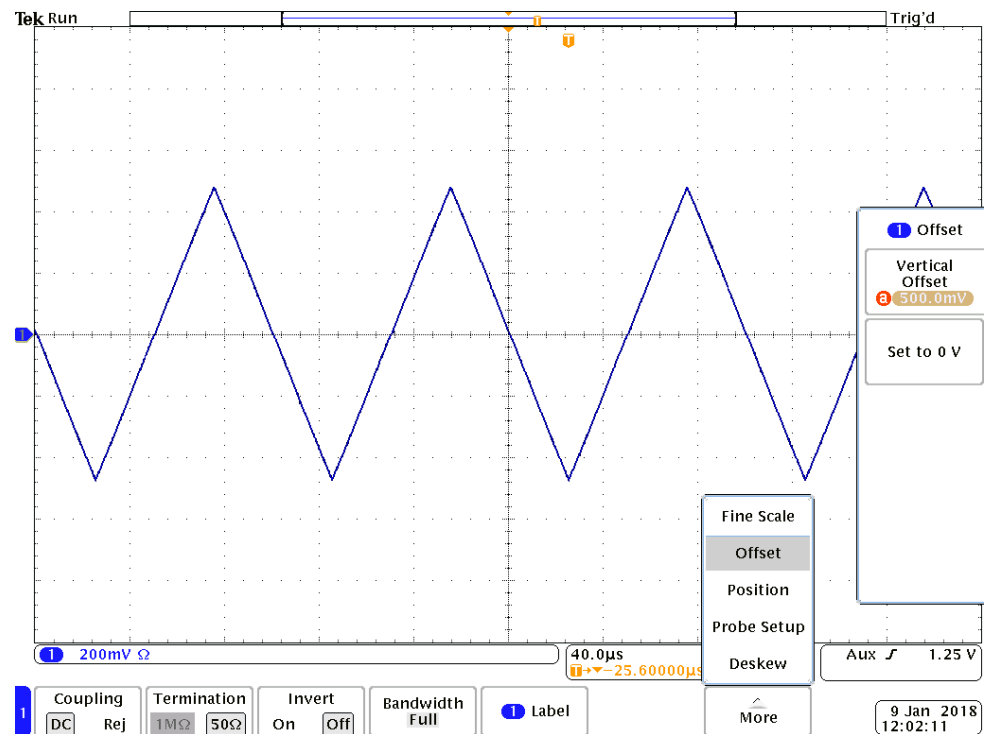


Figure 21: 1 V<sub>P-P</sub> signal (0 to +1 V) with 500 mV input offset applied

**Output voltage clipping examples (2X Range).** This is the same signal as in the 1X example. (See Figure 19 on page 29.) This signal is within the input and output range of the measurement system. The system is in the 2X Range with direct input to the input SMA connector.

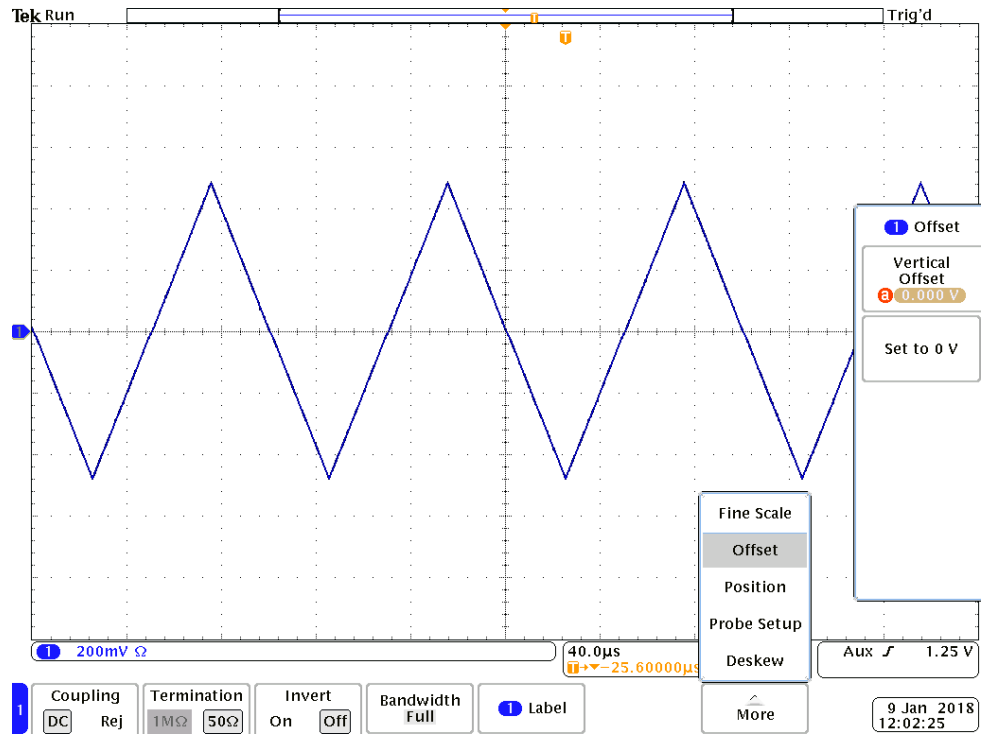


Figure 22: 1 V<sub>p-p</sub> signal (±500 mV) centered at 0 V with no input offset applied

In the following figure, the signal is within the output range of the measurement system, but the peak level is at the upper limit of the input range and is slightly compressed. The system is in the 2X Range with direct input to the input SMA connector.

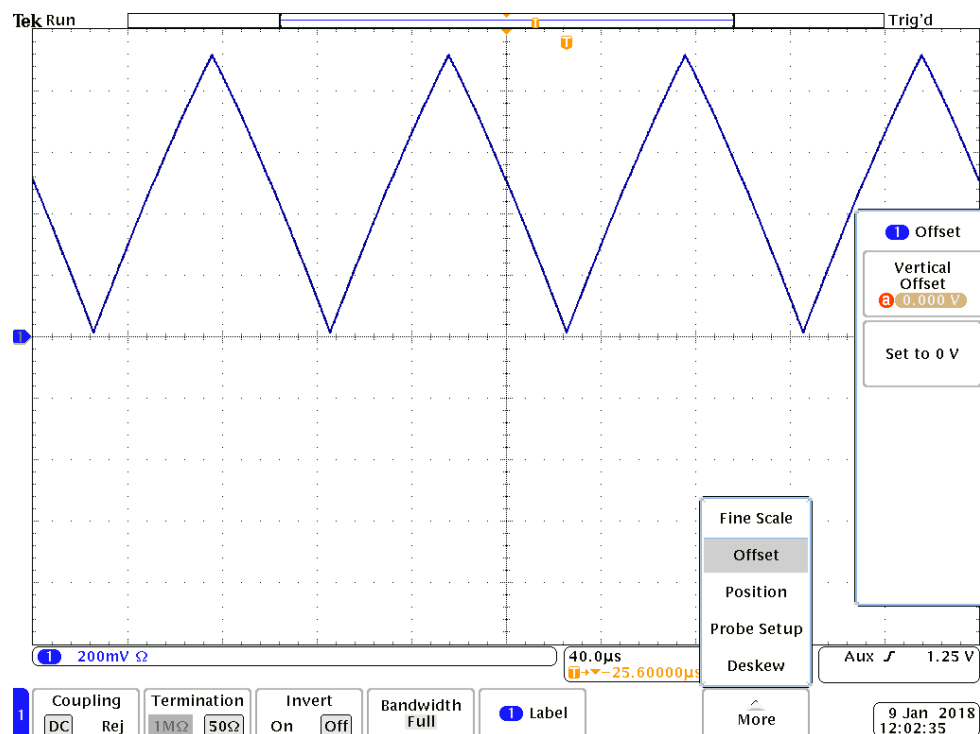


Figure 23: 1 V<sub>p-p</sub> signal (0 to +1 V) with no input offset applied

In the following figure, with offset applied, the signal is centered within the input and output range of the measurement system, optimizing the measurement accuracy. The system is in the 2X Range with direct input to the input SMA connector.

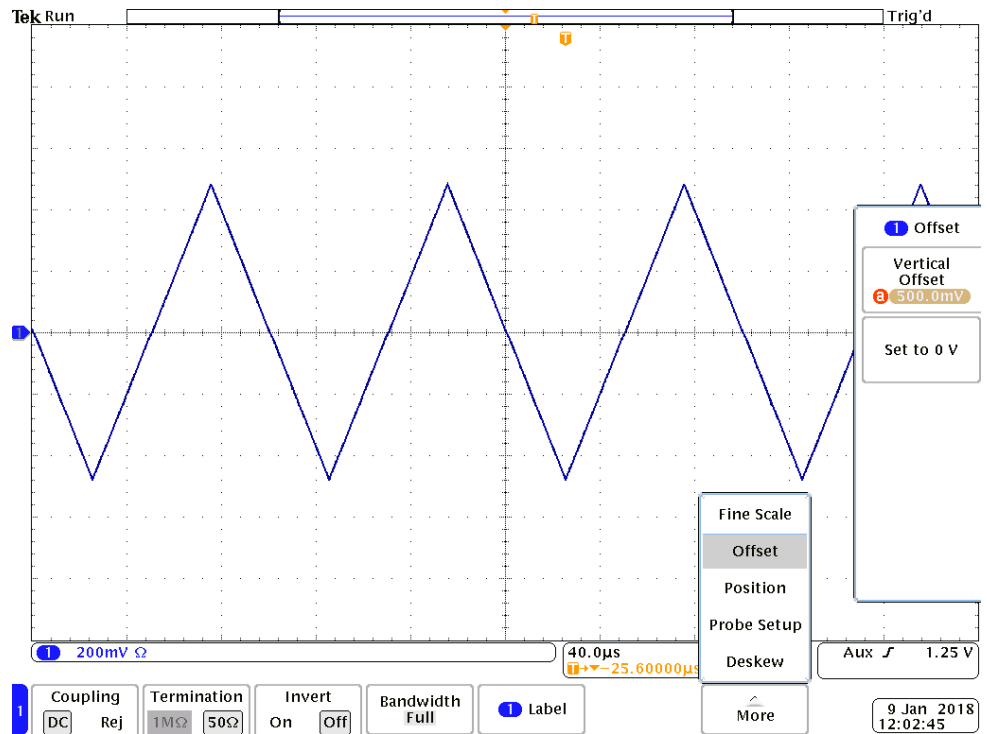


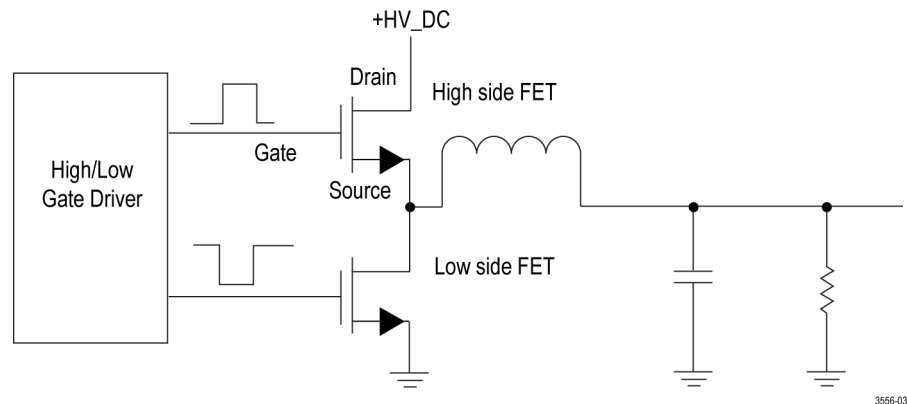
Figure 24: 1 V<sub>p-p</sub> signal (0 to +1 V) with 500 mV input offset applied

# Application examples

The following examples are provided to help you become familiar with the TIVH Series IsoVu measurement system and to achieve the best performance for your application.

## Example 1: High-side $V_{GS}$ and $V_{DS}$ measurement

Advancements in the components used in switching power supplies have made characterizing the performance of these power supplies increasingly difficult and challenging. A particularly challenging measurement is measuring the high-side  $V_{GS}$  and  $V_{DS}$  in a half bridge. To accurately make this measurement, an exceptionally good CMRR is required from the test system, especially for measuring the high-side  $V_{GS}$ . The following figure shows an example of this circuit.



**Figure 25: Half-bridge circuit showing the gate, source, and drain of the high-side FET**

In this type of circuit, the gate-source voltage is of interest because the rate at which the device switches is determined by the gate drive characteristics. The reference node for this measurement is the high-side source node, which switches between the input supply voltage and the local PCB ground during operation. In a measurement system without sufficient CMRR, this rapidly changing common mode voltage results in interference which obscures the measurement. It is important to note that the CMRR for all measurement systems is frequency dependent; however, the frequency that is critical for this measurement is not the switching frequency, but the frequency corresponding to the edge rate. For example, to accurately characterize a power supply with a switching frequency of 100 kHz and an edge rate of 1 ns, a system with good CMRR at 350 Mhz is necessary because of the edge speed.

In this example, the gate drive voltage could be about 5 V but usually has some ringing and overshoot which are important to characterize. For this measurement, it is appropriate to use a 10X tip with a 10 V<sub>p-p</sub> input (on the 1X Range) so that the signal is fully resolved and is within the dynamic range of the measurement system.

To get the best CMRR from your TIVH Series IsoVu measurement system, pay careful attention when connecting the measurement system to the DUT. This connection should preserve the signal fidelity and shield the signal from unwanted interference. To achieve the best performance from the measurement system, use an MMCX connector as close to the test point as possible. The MMCX connectors are available from a number of vendors and are relatively inexpensive. The key attributes of these connectors, which make them excel for this application, are their compact footprint and solid metal body. The solid metal body and gold contacts provide a well-shielded signal path.

The TIVH series IsoVu input provides a floating differential measurement with *differential input resistance* from 10 M $\Omega$  to 40 M $\Omega$ , depending on the tip attenuation. In the VGS measurement example the 10X tip with a 10 M $\Omega$  input impedance is used. The *common mode resistance* is extremely high, greater than G  $\Omega$ , in parallel with a small capacitance from the tip cable shield to ground, typically 2 pF or less. Keep these impedances in mind when determining how to connect the measurement system to the DUT. The source node in the half bridge circuit is a very low impedance point, and is the point that should be used to drive the tip cable shield capacitance. The gate driver output, which is also a low impedance node (but not as low impedance as the source), should be used to drive the center contact of the sensor tip cable. The input impedance of the sensor tip cable for the 10X tip is 10 M $\Omega$  || 6 pF relative to the shield – not to ground.

An example of a measurement that is possible with IsoVu is measuring the high-side turn-on characteristics shown in the following figure.

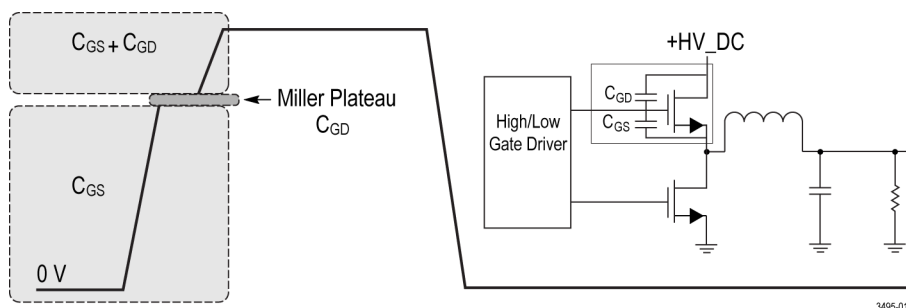


Figure 26: High-side turn-on characteristics

In general there are three characteristic regions of interest of the turn-on waveform (See Figure 26 on page 36.):

- The first region is the  $C_{GS}$  charge time.
- The second region is the Miller Plateau (the time required to charge the gate-drain Miller capacitance ( $C_{GD}$ ), and is  $V_{DS}$  dependent. The charge time increases as  $V_{DS}$  increases.
- The third region occurs when the channel is in conduction and the gate charges up to its final value.

Due to the rapid rise of the voltage on the switch node during the high side turn-on, there can be very high frequency and high amplitude common mode voltage changes during the transition. If this common mode voltage transient is not rejected, then the measurement of the high-side  $V_{GS}$  during the transition is not possible.

## Example 2: High-side $V_{DS}$ measurement

Another challenging measurement is the high-side  $V_{DS}$  measurement in a half bridge. Again, like the  $V_{GS}$  measurement in Example 1, the reference node for this measurement is the high-side source node, which switches between the input supply voltage and the local PCB ground during operation. In a measurement system without sufficient CMRR, this rapidly changing common mode voltage results in interference which obscures or distorts the measurement.

To get the best CMRR from your TIVH Series IsoVu measurement system, pay careful attention when connecting the measurement system to the DUT. This connection should preserve the signal fidelity and shield the signal from unwanted interference. To achieve the best performance from the measurement system, keep the input leads from the  $V_{DS}$  test points to the IsoVu tip cable as short as possible.

The combination of the high CMRR, high input voltage capabilities, and high bandwidth of the TIVH, enables the ability to measure the actual  $V_{DS}$  turn-on risetime ( $t_r$ ), and  $V_{DS}$  turn-off falltime ( $t_f$ ), and capture the simultaneous time correlated  $V_{GS}$  (input) and  $V_{DS}$  (output) switching characteristics and interactions. (See Figure 27 on page 38.)

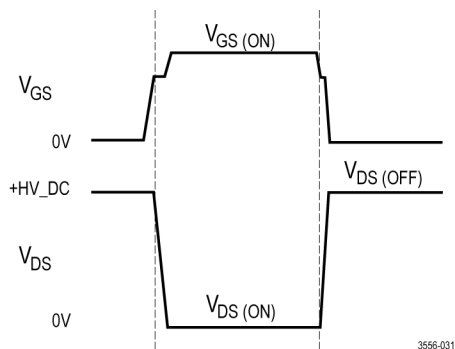


Figure 27:  $V_{GS}$  and  $V_{DS}$  switching characteristics

### Example 3: High-side drain current measurement

Current sensing is a critical measurement in many applications. Using the half bridge circuit again as an example, measuring the high-side drain current,  $I_D$ , can be very challenging particularly during startup. At startup, there can be common mode voltage transients due to parasitic inductance in the supply leads in addition to large current swings. Inserting a conventional current probe into the circuit at this point would require adding excessive inductance, which might limit circuit performance. Using a small value resistor as a current shunt makes it possible to take very high frequency current measurements with minimal additional impedance in the drain connection. (See Figure 28.)

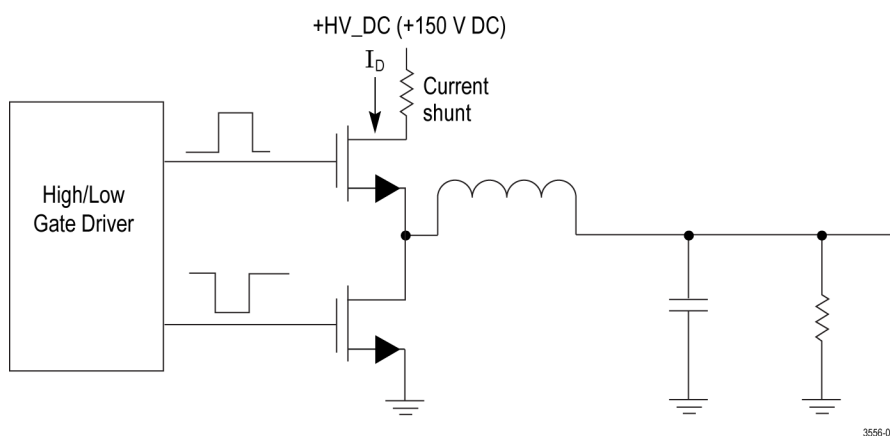
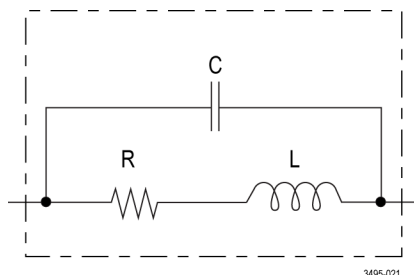


Figure 28: High side current shunt

In a typical application, a  $0.25\ \Omega$  resistor might be used to measure a transient current of 1 A, resulting in a voltage swing of 0.25 V, which can be measured with the measurement system using a 10X tip. A typical surface mount resistor can have a series inductance of less than 0.2 nH and series capacitance of less than 0.04 pF, resulting in much lower impedance at high frequency than could be obtained with a conventional current probe.





**Figure 29: SMT resistor model**

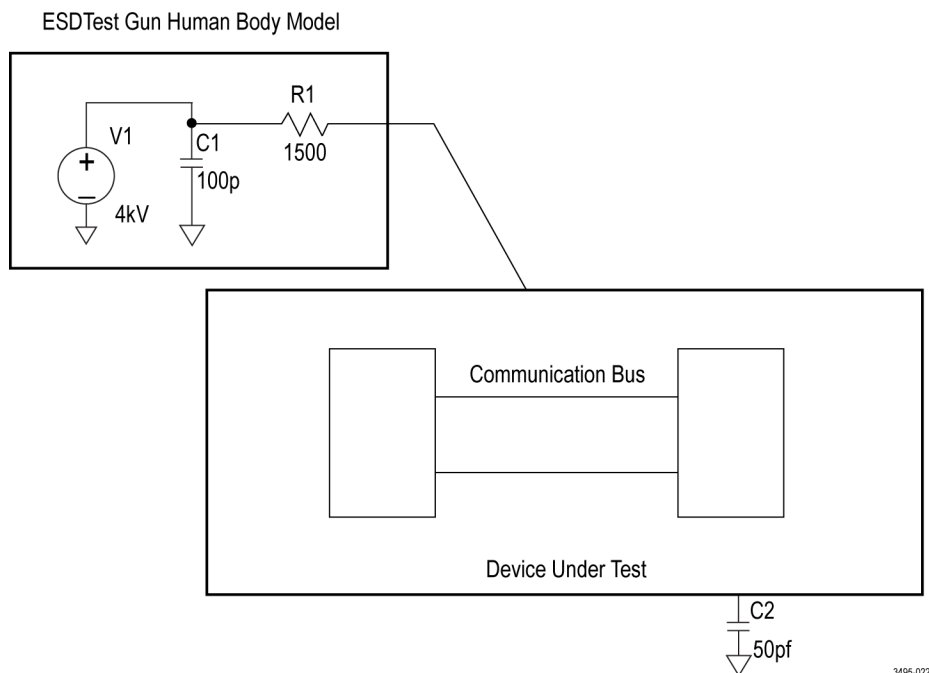
Go to <http://www.vishay.com/docs/60107/freqresp.pdf> for models of different types of surface mount resistors.

In general, surface mount resistors have fairly low power ratings; care must be taken not to exceed these ratings when using them as current shunts. Several vendors make very high power parts that can be used when high power dissipation is required. For example, the RP0402CB-R500FN-2Q from Barry Industries (<http://www.barryind.com/>) is a 1.0 W, 0.5  $\Omega$  0402 resistor on an AlN substrate, or the RP0402CB-R500FN-2Q from US Microwaves (<http://www.usmicrowaves.com/>) is a 1.5 W, 1  $\Omega$  resistor on a BeO substrate.

## Example 4: ESD troubleshooting

Many devices and systems can be negatively affected by ESD discharges. Troubleshooting problems that occur during an ESD discharge can be very difficult. A piece of test equipment connected to a device undergoing ESD testing has to not only withstand the ESD discharge, but it also has to reject interference caused by the rapid changes in potential on the DUT during an ESD discharge test.

For example, consider using the standard human body model of 100 pF and 1500  $\Omega$ . If the DUT is being tested to 4 kV and has a capacitance of 50 pF, the test equipment will be exposed to a voltage change of more than 1 kV in tens of nanoseconds.



3495-022

**Figure 30: ESD discharge test example**

In this example, if it is suspected that there is a glitch on the communication bus between two devices during the ESD discharge, then it is helpful to connect to the signals on the bus and to inspect them during the discharge. Because the measurement system uses Galvanic isolation, it rejects any interference from the ESD transient and tolerates the high common mode voltage during the discharge; the communication bus can be monitored throughout the ESD discharge and any irregularities can be investigated without interference from the ESD discharge.

# Reference information

## Specifications

The following tables list the specifications for the measurement system. The specifications are guaranteed unless otherwise indicated.

The performance limits in this specification are valid with these conditions:

- The instrument must be in an environment with temperature, altitude, and humidity within the operating limits described in these specifications.
- The instrument must have had a warm-up period of at least 20 minutes.
- The measurement system is powered from a TekVPI compatible oscilloscope.

Warranted specifications describe guaranteed performance with tolerance limits or certain type-tested requirements.

The performance verification procedures for the Propagation delay are listed later in this document. (See page 66, *Propagation delay*.)

**Table 9: Warranted specifications**

Characteristic	Description
Propagation delay (Warranted)	3 m fiber length: 35 ns $\pm$ 5 ns (actual propagation delay is measured and stored within each unit) 10 m fiber length: 68 ns $\pm$ 7 ns (actual propagation delay is measured and stored within each unit)

**Table 10: Electrical specifications**

Characteristic	Description		
Controller output termination	Terminate the controller output into 50 $\Omega$		
Controller output coupling	DC coupled		
Range attenuation	<i>Sensor tip cable/adapter</i>	<i>1X Range</i>	<i>2X Range</i>
	Sensor head input SMA	1X ( $\div$ 1)	2X ( $\div$ 2)
	MMCX10X, 10X tip cable	10X ( $\div$ 10)	20X ( $\div$ 20)
	MMCX50X, 50X tip cable	50X ( $\div$ 50)	100X ( $\div$ 100)
	MMCX250X, 250X tip cable	250X ( $\div$ 250)	500X ( $\div$ 500)
	SQPIN100X, 100X tip cable	100X ( $\div$ 100)	200X ( $\div$ 200)
	SQPIN500X, 500X tip cable	500X ( $\div$ 500)	1000X ( $\div$ 1000)
	WSQPIN1000X, 1000X tip cable	1000X ( $\div$ 1000)	2000X ( $\div$ 2000)
	WSQPIN2500X, 2500X tip cable	2500X ( $\div$ 2500)	5000X ( $\div$ 5000)

Table 10: Electrical specifications (cont.)

Characteristic	Description		
Input resistance/capacitance (attached to sensor head, 1 M $\Omega$ termination), (Typical) (See page 48, <i>Differential input impedance graphs</i> .)	Sensor tip cable/adaptor	Resistance	Capacitance
	Sensor head input SMA	1 M $\Omega$ $\pm$ 2%	20 pF
	MMCX10X, 10X tip cable	10 M $\Omega$	6 pF
	MMCX50X, 50X tip cable	10 M $\Omega$	3 pF
	MMCX250X, 250X tip cable	10 M $\Omega$	2 pF
	SQPIN100X, 100X tip cable	10 M $\Omega$	3.5 pF
	SQPIN500X, 500X tip cable	10 M $\Omega$	3.5 pF
	WSQPIN1000X, 1000X tip cable	40 M $\Omega$	3.5 pF
	WSQPIN2500X, 2500X tip cable	40 M $\Omega$	3.5 pF
Maximum non-destructive differential input voltage range, (Typical)	Sensor tip cable/adaptor	V (DC + pk AC)	
	Sensor head input SMA	$\pm$ 25 V	
	MMCX10X, 10X tip cable	$\pm$ 250 V	
	MMCX50X, 50X tip cable	$\pm$ 250 V	
	MMCX250X, 250X tip cable	$\pm$ 250 V	
	SQPIN100X, 100X tip cable	$\pm$ 600 V	
	SQPIN500X, 500X tip cable	$\pm$ 600 V	
	WSQPIN1000X, 1000X tip cable	$\pm$ 2500 V	
	WSQPIN2500X, 2500X tip cable	$\pm$ 2500 V	
Linear differential input voltage range, (Typical)		Clamping Off, 1X Range	Clamping Off, 2X Range
	Sensor tip cable/adaptor	$\pm$ V peak (DC + peak AC)	$\pm$ V peak (DC + peak AC)
	Sensor head input SMA	$\pm$ 0.5 V	$\pm$ 1 V
	MMCX10X, 10X tip cable	$\pm$ 5 V	$\pm$ 10 V
	MMCX50X, 50X tip cable	$\pm$ 25 V	$\pm$ 50 V
	MMCX250X, 250X tip cable	$\pm$ 125 V	$\pm$ 250 V
	SQPIN100X, 100X tip cable	$\pm$ 50 V	$\pm$ 100 V
	SQPIN500X, 500X tip cable	$\pm$ 250 V	$\pm$ 500 V
	WSQPIN1000X, 1000X tip cable	$\pm$ 500 V	$\pm$ 1000 V
	WSQPIN2500X, 2500X tip cable	$\pm$ 1250 V	$\pm$ 2500 V



**CAUTION.** To avoid damaging the measurement system, be aware of the input voltage limits; this specification applies to both the 1X Range and 2X Range.

(See page 47, *Maximum differential input voltage vs. frequency derating graphs*.)

Table 10: Electrical specifications (cont.)

Characteristic	Description		
Output clamping range (Input referred) (Typical)			
	Sensor tip cable/adapter	Clamping on, 1X Range	Clamping on, 2X Range
	Sensor head input SMA	±100 mV	±200 mV
	MMCX10X, 10X tip cable	±1 V	±2 V
	MMCX50X, 50X tip cable	±5 V	± 10 V
	MMCX250X, 250X tip cable	±25 V	±50 V
	SQPIN100X, 100X tip cable	±10 V	±20 V
	SQPIN500X, 500X tip cable	±50V	±100 V
	WSQPIN1000X, 1000X tip cable	±100 V	±200 V
	WSQPIN2500X, 2500X tip cable	±250 V	±500 V
Output clamping overdrive recovery (Typical)	< 20 ns		
System noise (input referred) (Typical)			
	Sensor tip cable/adapter	1X Range	2X Range
	TIVH08/TIVH08L Sensor head input SMA	< 1.2 mV <sub>rms</sub>	< 1.4 mV <sub>rms</sub>
	TIVH05/TIVH05L Sensor head input SMA	< 0.72 mV <sub>rms</sub>	< 0.85 mV <sub>rms</sub>
	TIVH02/TIVH02L Sensor head input SMA	< 0.61 mV <sub>rms</sub>	< 0.75 mV <sub>rms</sub>
	Input referred noise with tip cable	(Sensor head input SMA noise) * (Tip cable attenuation)	(Sensor head input SMA noise) * (Tip cable attenuation)
	Examples:	TIVH08 1X Range with MMCX10X tip cable: Noise = (1.2 mV <sub>rms</sub> ) * (10) = 12 mV <sub>rms</sub>	TIVH08 2X Range with MMCX10X tip cable: Noise = (1.4 mV <sub>rms</sub> ) * (10) = 14 mV <sub>rms</sub>
DC gain accuracy <sup>1</sup> , (Input referred) (Typical)			
Differential DC gain accuracy in 1X Range	±3% ±DC offset error voltage ± input offset accuracy error		
Differential DC gain accuracy in 2X Range			
60% of ±Full Scale	±3% ±DC offset error voltage ± input offset accuracy error		
>60% to 80% of ±Full Scale	0% to −4% ±DC offset error voltage ± input offset accuracy error		
>80% to 100% of ±Full Scale	0% to −7% ±DC offset error voltage ± input offset accuracy error		

Table 10: Electrical specifications (cont.)

Characteristic	Description		
DC offset error voltage <sup>2</sup> (Input referred) (Typical)	Sensor tip cable/adapter	1X Range	2X Range
	Sensor head input SMA	±2 mV	±4 mV
	MMCX10X, 10X tip cable	±20 mV	±40 mV
	MMCX50X, 50X tip cable	±100 mV	±200 mV
	MMCX250X, 250X tip cable	±500 mV	±1 V
	SQPIN100X, 100X tip cable	±200 mV	±400 mV
	SQPIN500X, 500X tip cable	±1 V	±2 V
	WSQPIN1000X, 1000X tip cable	±2 V	±4 V
	WSQPIN2500X, 2500X tip cable	±5 V	±10 V
Input offset voltage range <sup>3</sup> (Typical)	Sensor tip cable/adapter	Input offset voltage range	
	Sensor head input SMA	±25 V	
	MMCX10X, 10X tip cable	±250 V	
	MMCX50X, 50X tip cable	±250 V	
	MMCX250X, 250X tip cable	±250 V	
	SQPIN100X, 100X tip cable	±600 V	
	SQPIN500X, 500X tip cable	±600 V	
	WSQPIN1000X, 1000X tip cable	±2500 V	
	WSQPIN2500X, 2500X tip cable	±2500 V	
Input offset voltage accuracy (Typical)			
SMA input	±1%		
With probe tip	±2%		
DC Reject (AC coupling) (Typical)	< 7 Hz (-3 dB) – low frequency cutoff		
Small signal rise time (10% to 90%) (Typical) (SMA input and with sensor tip cables)			Rise time
	TIVH08/TIVH08L	435 ps to 700 ps (depending on the tip) <sup>4</sup>	
	TIVH05/TIVH05L	≤ 700 ps	
	TIVH02/TIVH02L	≤ 1.8 ns	
Small signal frequency response (Typical) (SMA input and with sensor tip cables)			-3 dB bandwidth
	TIVH08/TIVH08L	DC to 500 MHz or 800 MHz (depending on the tip) <sup>4</sup>	
	TIVH05/TIVH05L	DC to ≥ 500 MHz	
	TIVH02/TIVH02L	DC to ≥ 200 MHz	
Common mode voltage range	60 kV peak <sup>5</sup>		
Common mode resistance (Typical)	N.A. due to Galvanically isolation (fiber optic connection)		
Common mode capacitance (Typical)	~2 pF		

Table 10: Electrical specifications (cont.)

Characteristic	Description	
Overload indicator range <sup>6</sup> (Typical)	Sensor tip cable/adaptor	Overload indicator On
	Sensor head input SMA	$V_{in} < -25\text{ V}$ or $V_{in} > +25\text{ V}$
	tip cables	$V_{in} \leq (\text{Maximum tip voltage})$ or $V_{in} \geq (\text{Maximum tip voltage})$ Example: for MMCX10X: $V_{in} \leq 250\text{ V}$ or $V_{in} \geq 250\text{ V}$

<sup>1</sup> The difference between the measured DC gain and the nominal DC gain, divided by the nominal DC gain and expressed as a percent.

<sup>2</sup> The input referred offset error voltage when the input is shorted and the probe input offset is set to 0 volts

<sup>3</sup> User adjustable input referenced referred DC Offset Voltage Range. It is independent of range and clamp settings.

<sup>4</sup> The 800 MHz bandwidth is achieved with the 50X and greater attenuation tips (MMCX50X, MMCX250X, SQPIN100X, SQPIN500X, WSQPIN1000X, or WSQPIN2500X).

<sup>5</sup> This product is designed to be used in the circuit with expected transient overvoltage up to 5000 V peak.

<sup>6</sup> The Overload indicator is active when the sensor head input DC/LF voltage exceeds the limits in this table. This overload detection will not detect mid and high frequency voltage transients that can damage the sensor head. This overload detection will not detect an overvoltage condition when the sensor head's DC Reject (AC coupling) is enabled. The limits are independent of range and clamp settings.

### Common mode rejection ratio graphs

The ability to measure common mode rejection ratios (CMRR) of the IsoVu system below 100 kHz is limited by the dynamic range of test systems. Due to the optical isolation of the IsoVu sensor head, the DC CMRR performance of all tip cables is expected to be greater than 160 dB.

The following figure shows the typical CMRR values for the SMA cable and the MMCX10x, MMCX50X, and MMCX250X probe tip cables.

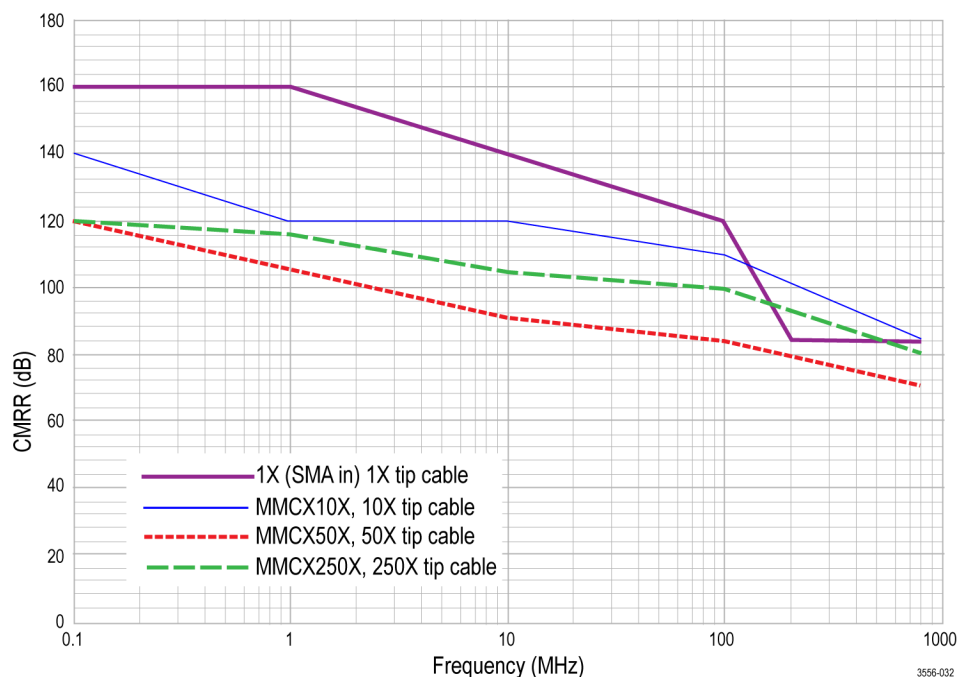


Figure 31: Typical CMRR values for 1X SMA cable and MMCX series probe tip cables

The following figure shows the typical CMRR values for the SQPIN100X, SQPIN500X, WSQPIN1000X, and WSQPIN2500X square pin tips.

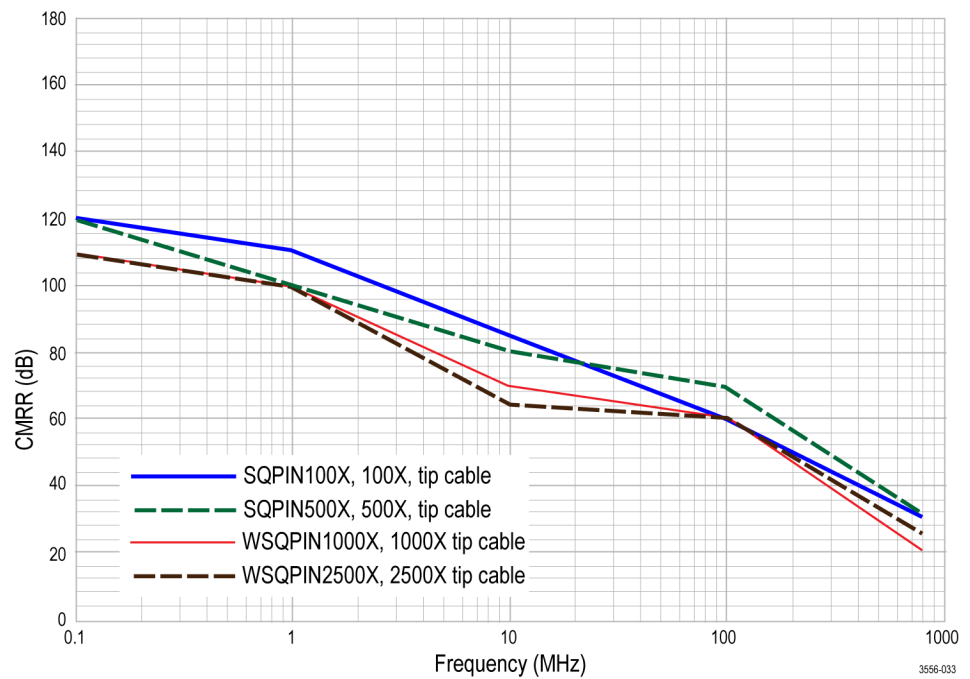
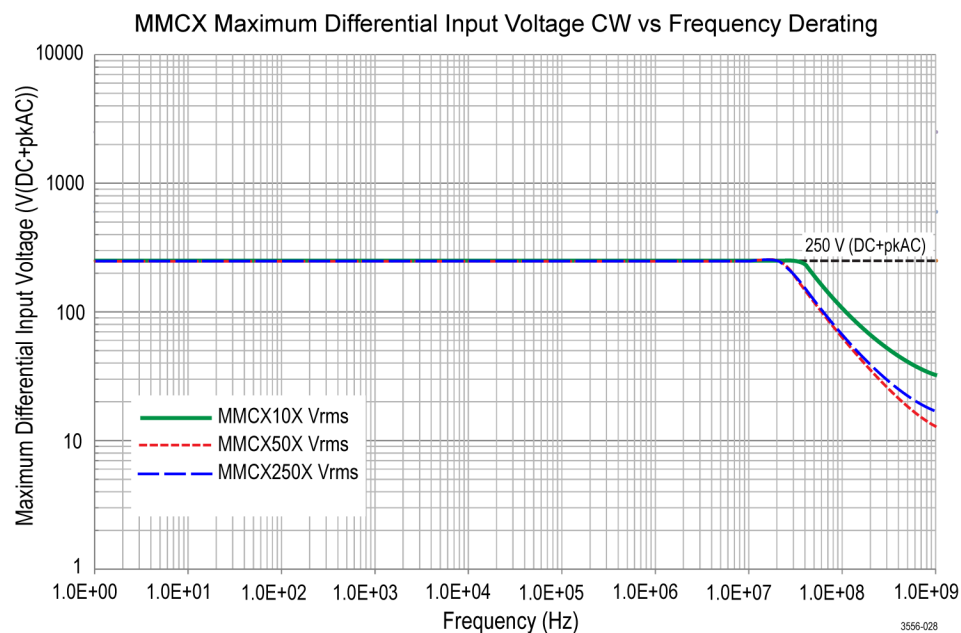


Figure 32: Typical CMRR values for square pin probe tips



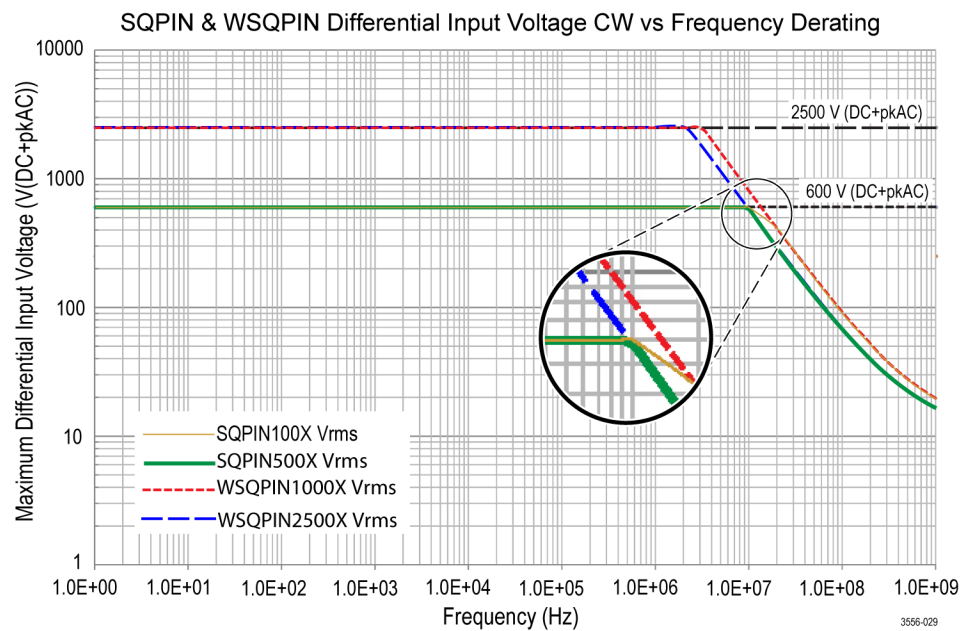
### Maximum differential input voltage vs. frequency derating graphs

The following figure shows the derating values for MMCX10X, MMCX50X, and MMC250X probe tips.



**Figure 33: Maximum differential input voltage vs. frequency for MMCX series probe tips**

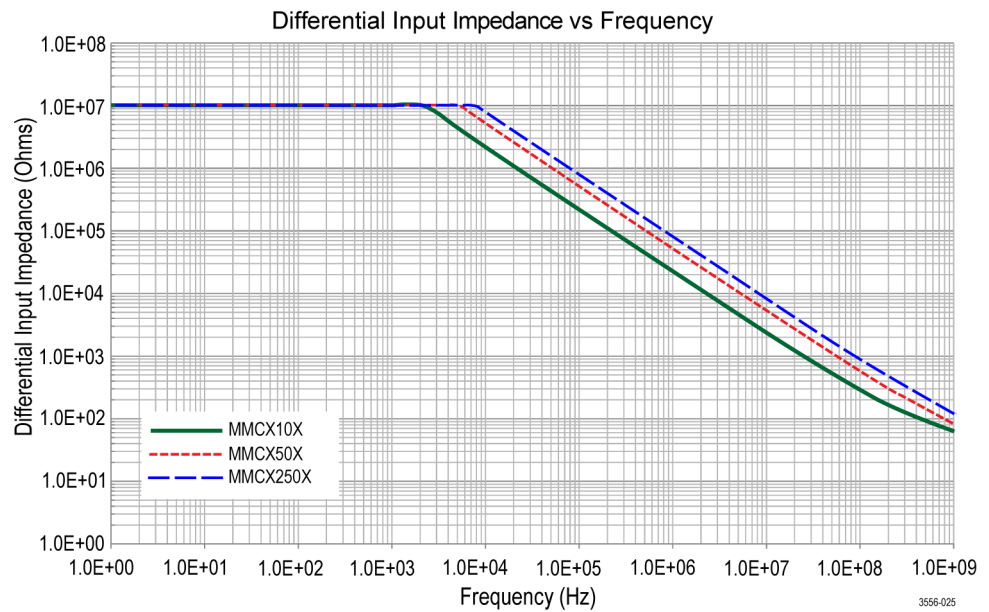
The following figure shows the derating values for SQPIN100X, SQPIN500X, WSQPIN1000X, and WSQPIN2500X square pin probe tips.



**Figure 34: Maximum differential input voltage vs. frequency for square pin probe tips**

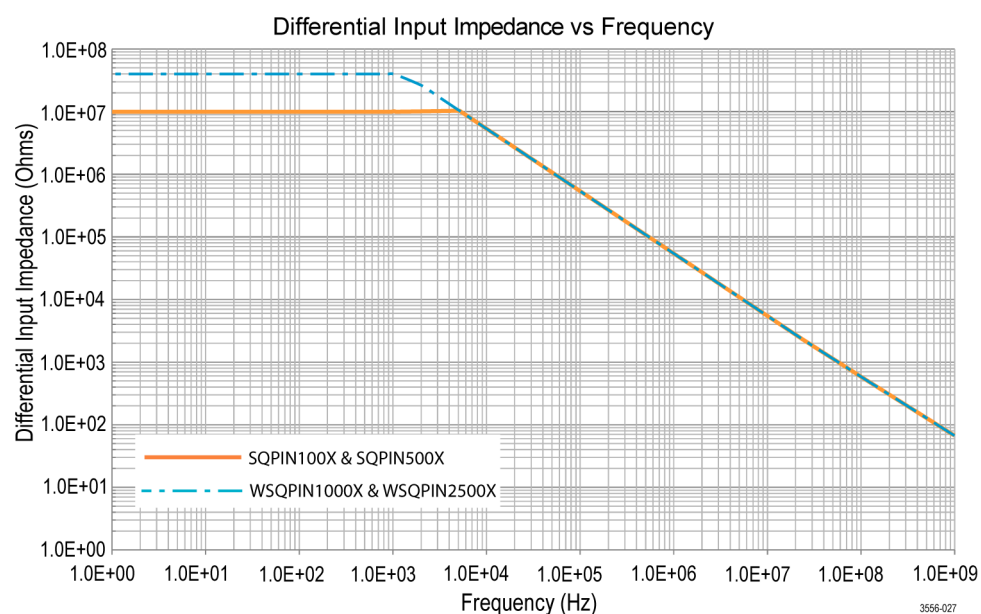
**Differential input impedance graphs**

The following figure shows the differential input impedance vs. frequency values for the MMCX10X, MMCX50X, and MMC250X probe tips.



**Figure 35: Differential input impedance vs. frequency chart for the MMCX series probe tips**

The following figure shows the differential input impedance vs. frequency values for the SQPIN100X, SQPIN500X, WSQPIN1000X, and WSQPIN2500X probe tips.



**Figure 36: Differential input impedance vs. frequency chart for the square pin probe tips**

**Table 11: Physical specifications**

Characteristic	Description
Net weight	(Weight does not include accessories and packaging.)
Sensor tip cables	0.025 kg (0.055 lb)
Sensor head	0.363 kg (0.8 lb)
Controller box	0.816 kg (1.8 lb)
TekVPI Comp box	0.57 kg (0.125 lb)
Sensor tip cable length	15.24 cm (6.0 in)
Fiber cable length	
TIVH08, TIVH02, TIVH05	3 m (9.84 ft)
TIVH08L, TIVH02L, TIVH05L	10 m (32.81 ft)
TekVPI cable length	55.88 cm (22 in)
Overall length and tolerances	
Comp box to controller	0.5588 m $\pm$ 3.81 cm (22 in $\pm$ 1.5 in) shoulder-to-shoulder, Boot area included in the overall length.

Table 11: Physical specifications (cont.)

Characteristic	Description
Controller to sensor head (TIVH08, TIVH02, TIVH05)	2.9718 m $\pm$ 10.2 cm (117 in $\pm$ 4 in)
Controller to sensor head (TIVH08L, TIVH02L, TIVH05L)	9.982 m $\pm$ 10.2 cm (393 in $\pm$ 4 in)

Dimensional drawings

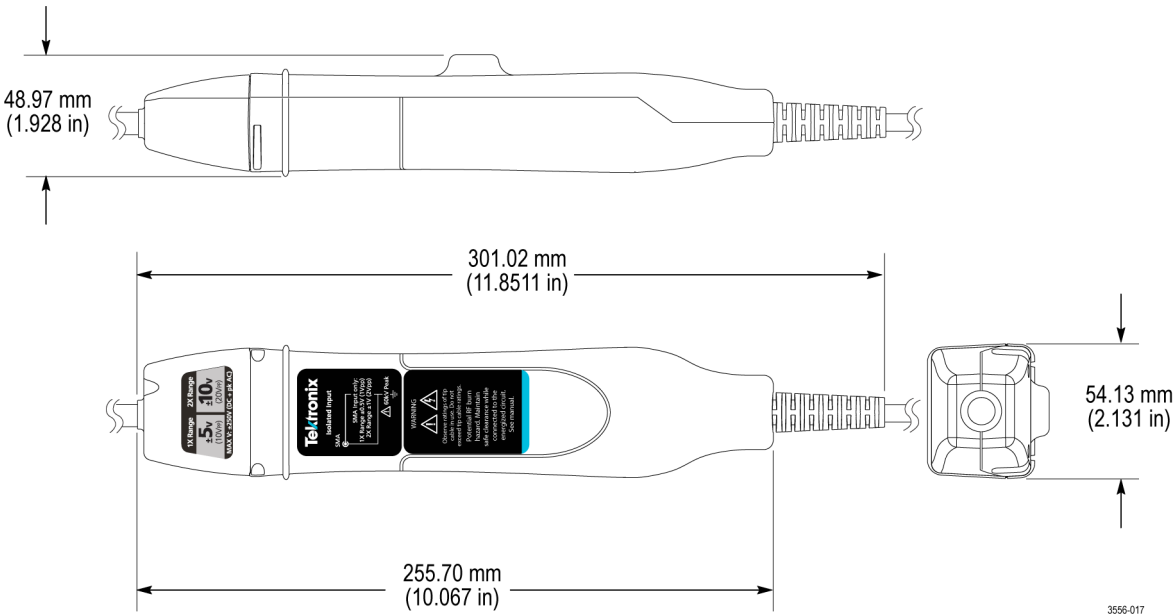
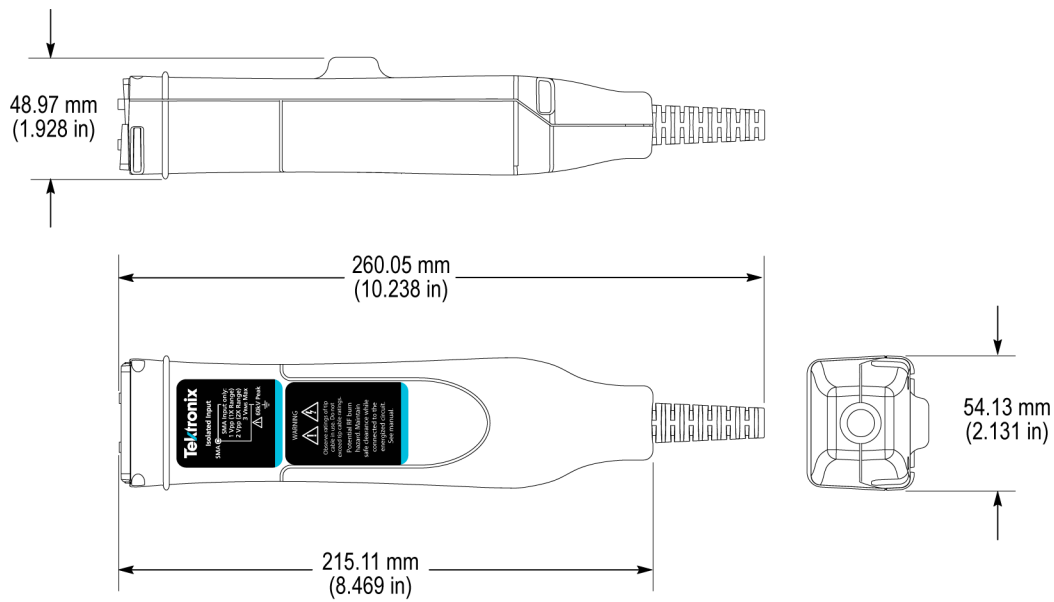
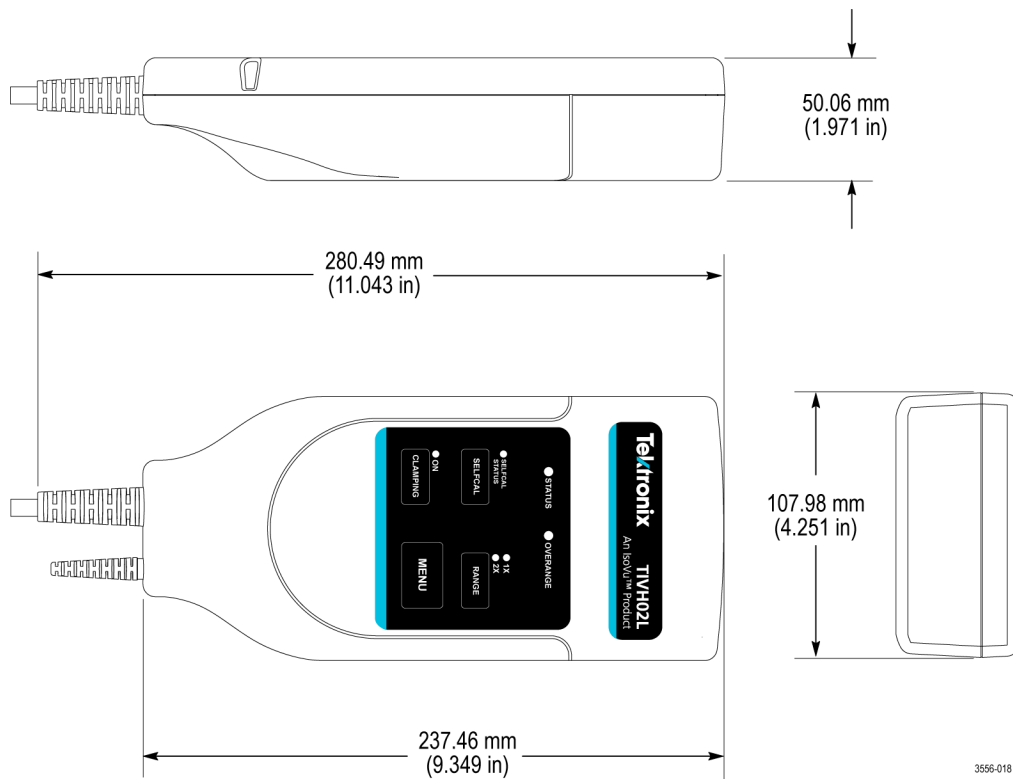


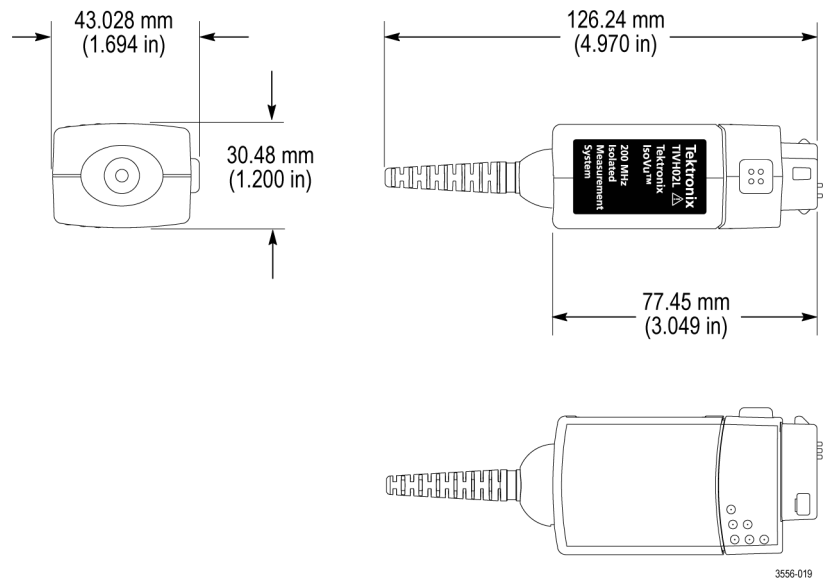
Figure 37: Sensor head dimensions with probe tip cover



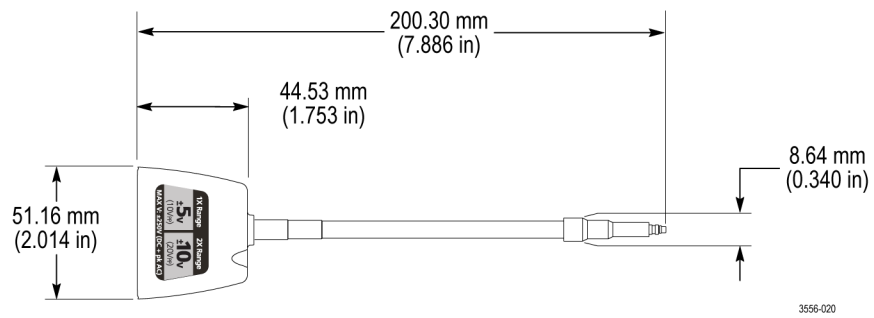
**Figure 38: Sensor head dimensions without probe tip cover**



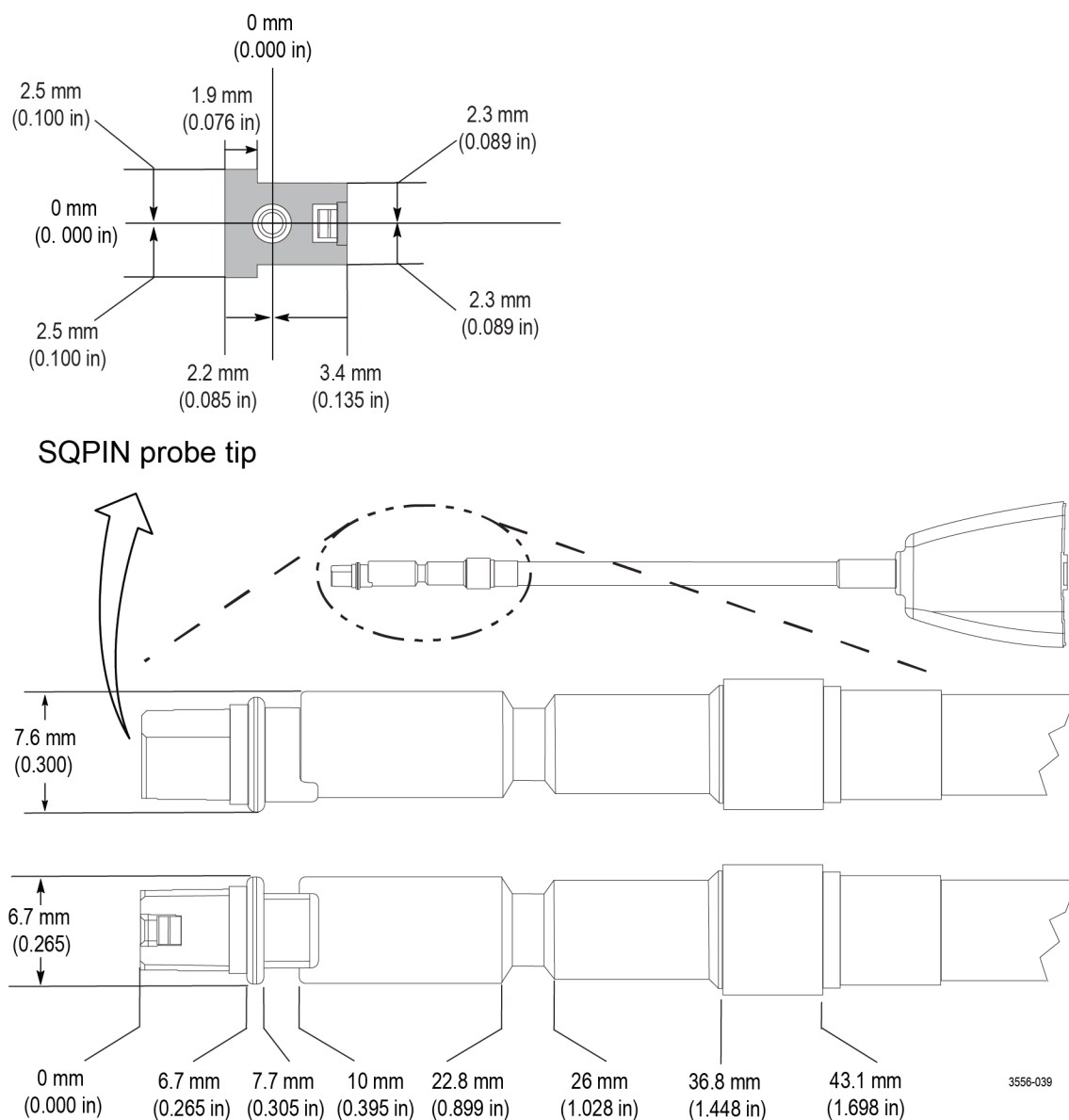
**Figure 39: Controller dimensions**



**Figure 40: Comp box dimensions**



**Figure 41: Probe tip adapter dimensions**



**Figure 42: SQPIN probe tip dimensions**

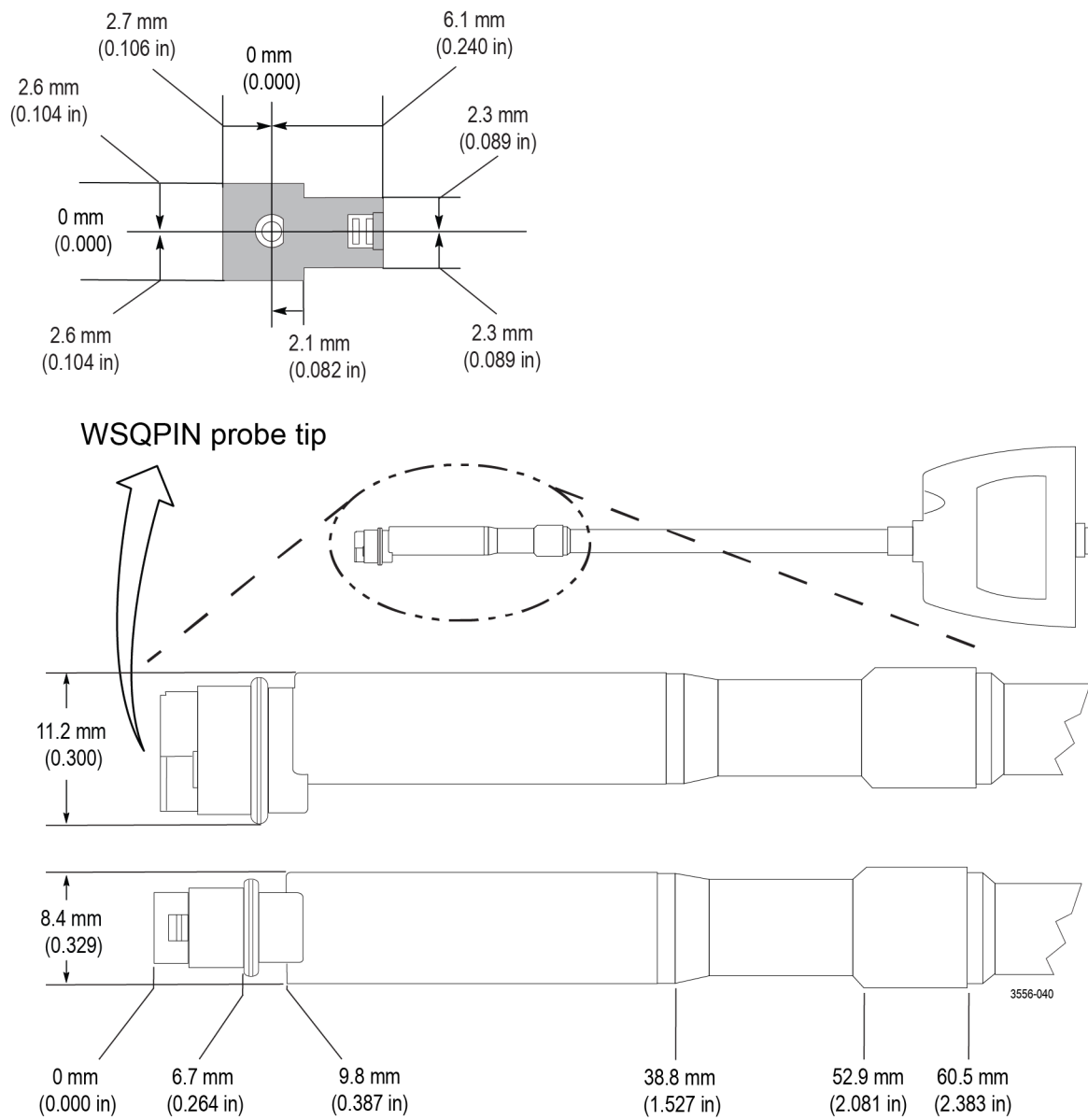
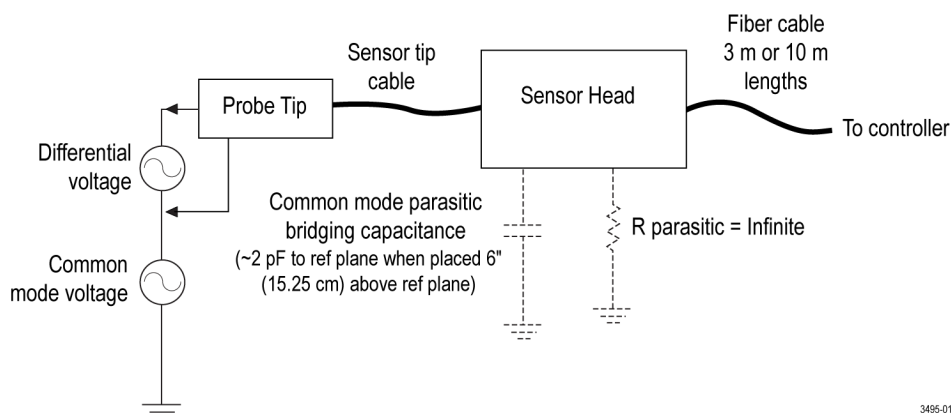


Figure 43: WSQPIN probe tip dimensions



## IsoVu measurement system block diagram

The following figure shows a block diagram of the IsoVu measurement system.



**Figure 44: Block diagram**

The common mode resistance and capacitance to earth ground is shown in the figure. (See Figure 44.) The common mode resistance is shown as  $R_{parasitic}$  and is essentially infinite with the IsoVu measurement system since it is galvanically isolated and can be ignored. The common mode coupling capacitance to earth ground and the surrounding circuit is shown as the Parasitic Bridging Capacitance ( $C_{parasitic}$ ). This parasitic capacitance will be approximately 2 pF when the sensor head is placed six (6) inches (15.25 cm) above a ground plane.

To minimize the effects of common mode capacitive loading consider the following items:

- Whenever possible, choose a reference point in the circuit-under-test that is static potential with respect to earth ground.
- Connect the coaxial (common) shield of the sensor tip cable to the lowest impedance point of the circuit.
- Increasing the physical distance between the sensor head and any conductive surface will reduce the parasitic capacitance.
- When using multiple IsoVu systems to measure different points in the circuit that do not have the same common mode voltages, keep the sensor heads separated to minimize the capacitive coupling.

## Tripods

Tektronix provides two tripods as accessories with the measurement system. The Flexible tripod holds the sensor head while connected to the DUT. The Probe tip tripod supports the sensor tip cables while they are connected to adapters on the circuit board.

### Flexible tripod

The tripod can be connected to the DUT in different ways. You can secure the tripod to the DUT using optional feet. The feet can be clamped or attached to the DUT using common screws. This allows you to install the tripod upside down or right side up as shown in the following figures.

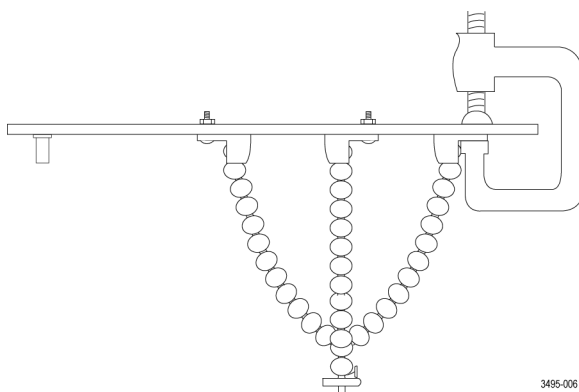


Figure 45: Installing the flexible tripod under the DUT.

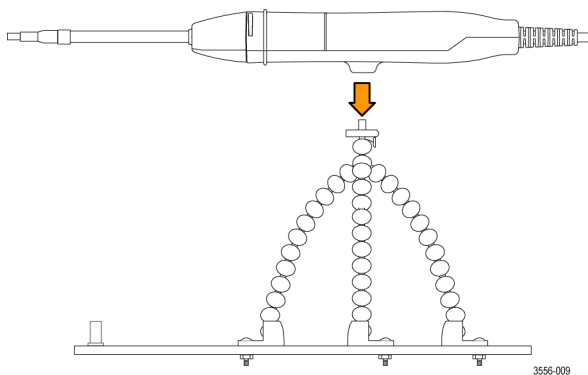


Figure 46: Connecting the sensor head to the top of the DUT with the flexible tripod.

### Probe tip tripod

Use the probe tip tripod to connect the sensor tip cables to adapters on the circuit board. This tripod has flexible hinges to easily position the probe tip cable above the adapter on the circuit board. Tektronix recommends gluing the tripod in place on the circuit board to provide additional support for the sensor tip cables. The following figure shows an example of connecting to an adapter on the circuit board with the tripod; it reduces stresses on the test point.

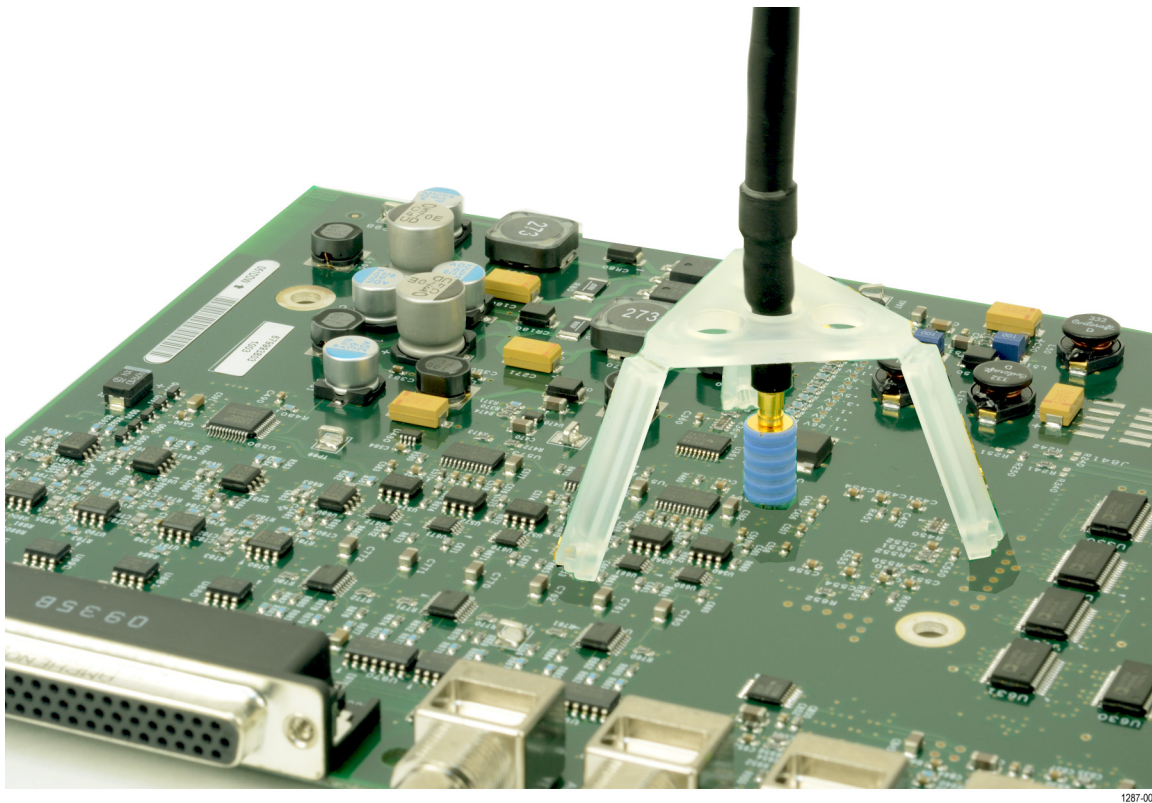


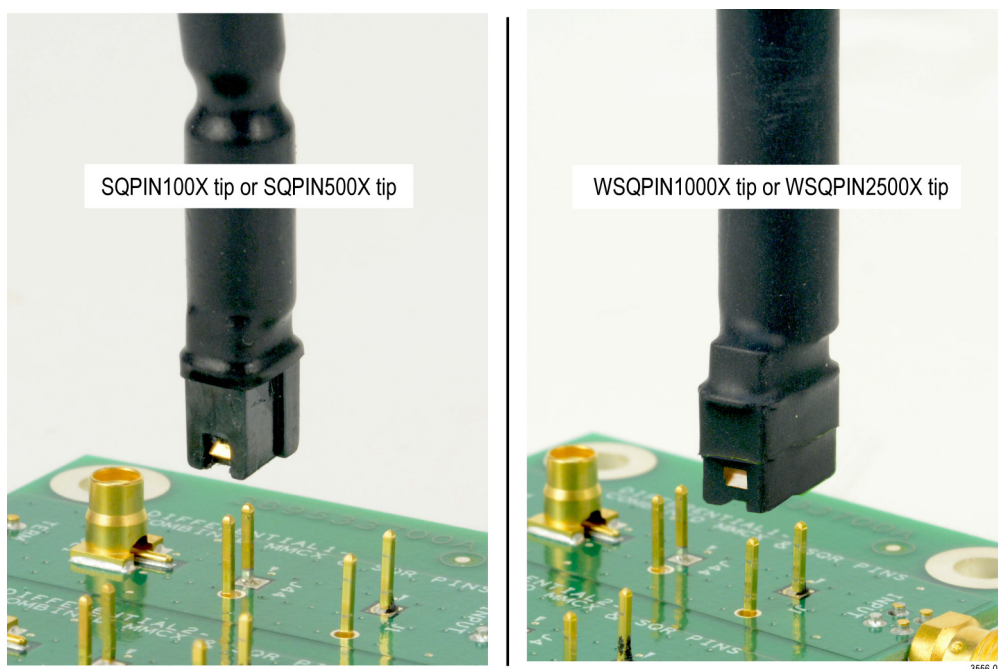
Figure 47: Connecting to an adapter on the circuit board with the probe tip tripod

## Connecting the sensor tip cables

Tektronix provides different types of sensor tip cables to connect to the circuit board.

The MMCX sensor tip series connect directly to MMCX connectors on the circuit board or to probe tip adapters installed on the circuit board. (See page 59, *Installing the probe tip adapters*.)

The square pin series sensor tip cables connect directly to the circuit board as shown in the following figure.



**Figure 48: Square pin series sensor tip cables**

The SQPIN series sensor tip cables connect to 0.1-inch (2.54 mm) square pins on the circuit board. The WSQPIN series sensor tip cables connect to 0.2-inch (5.08 mm) square pins on the circuit board.

## Installing the probe tip adapters

Tektronix provides two probe tip adapters to connect the MMCX sensor tip cables to pins on the circuit board. The MMCX-to-0.1-inch (2.54 mm) pitch adapter and the MMCX-to-0.062-inch (1.57 mm) pitch adapter.

One end of each adapter has an MMCX socket for connection to an IsoVu MMCX tip cable. The other end of the adapter has a center pin socket and four common (shield) sockets around the outside of the adapter. Notches on the adapters can be used to locate the shield sockets. The procedure for installing these adapters are the same, the main difference is the spacing of the pins on the circuit board.

To install the adapters onto the square pins, line up the center of the adapter with the signal source pin on the circuit board. Use the notch on the adapter to align one of the shield sockets to the common pin on the circuit board. The following figures show examples of lining up the adapters on the circuit board.

To achieve the best electrical performance, especially the CMRR performance and EMI susceptibility, place the probe tip adapter as close as possible to the circuit board.

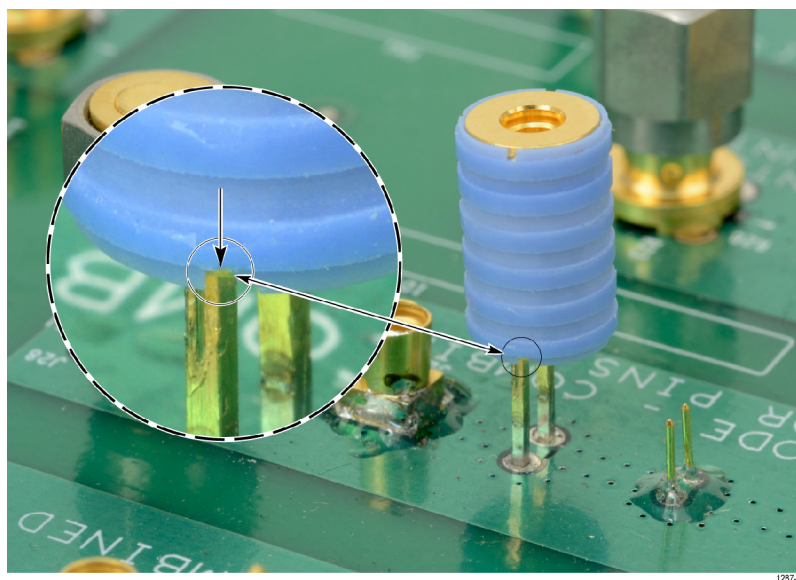
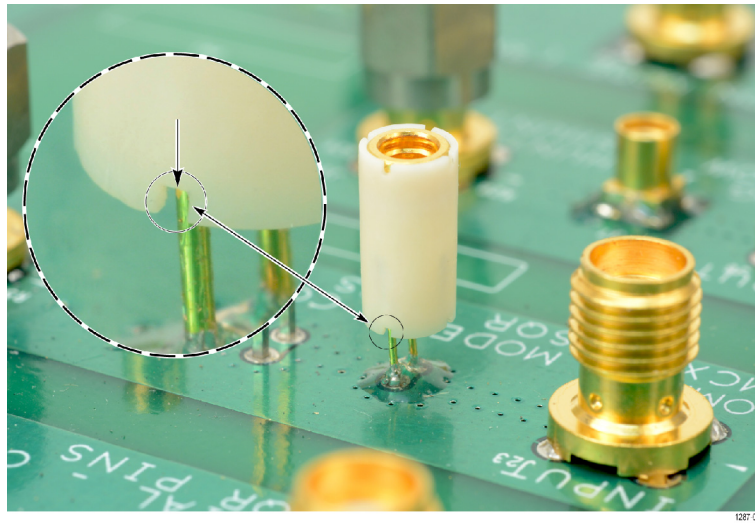


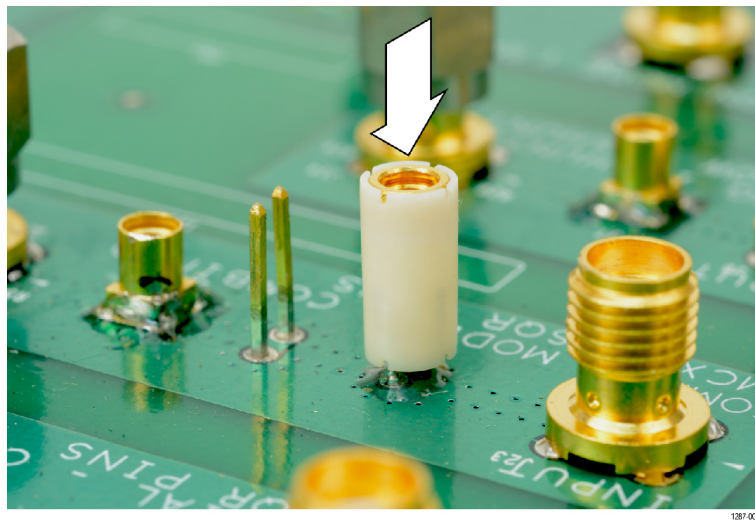
Figure 49: Lining up the MMCX-to-0.1-inch (2.54 mm) adapter on the circuit board



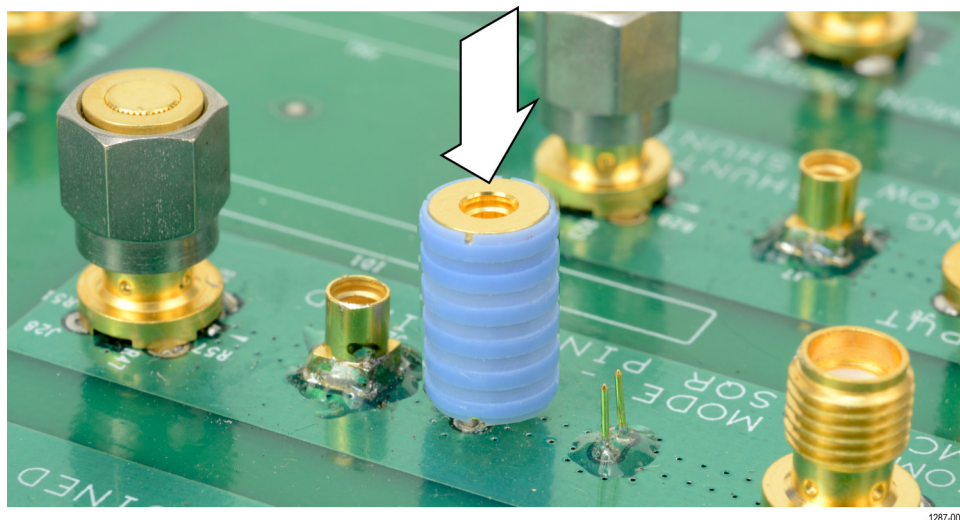


**Figure 50: Lining up the MMCX-to-0.062-inch (1.57 mm) adapter on the circuit board**

After lining up the adapters gently push down on the adapter to seat it in place on the circuit board.



**Figure 51: Pushing the MMCX-to-0.062-inch (1.57 mm) adapter in place**



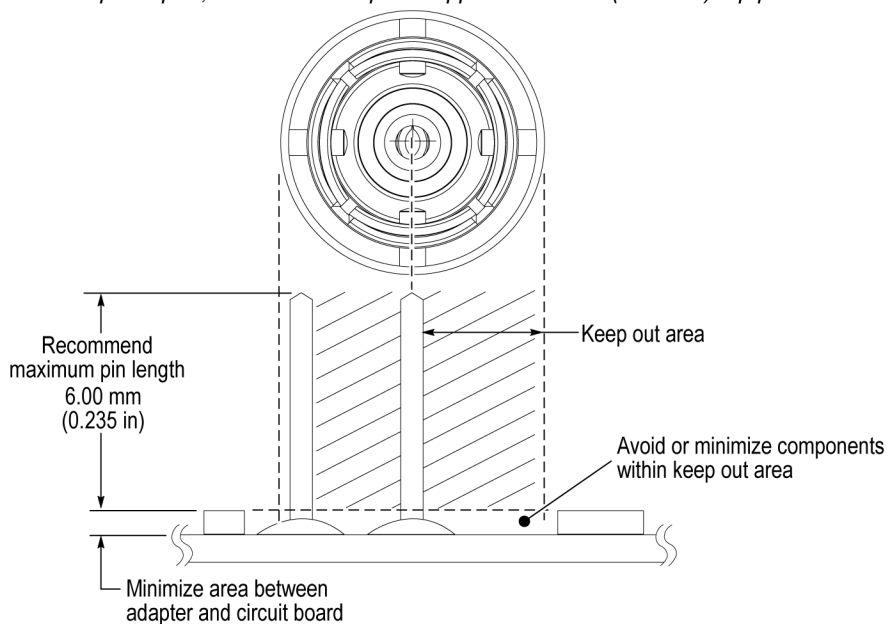
**Figure 52: Pushing the MMCX-to-0.1-inch (2.54 mm) adapter in place**

When the adapters are firmly in place on the circuit board connect the sensor tip cable to the top of the adapter while using the probe tip tripod to ease the tension off the probe tip cable and adapter. (See Figure 47 on page 57.)

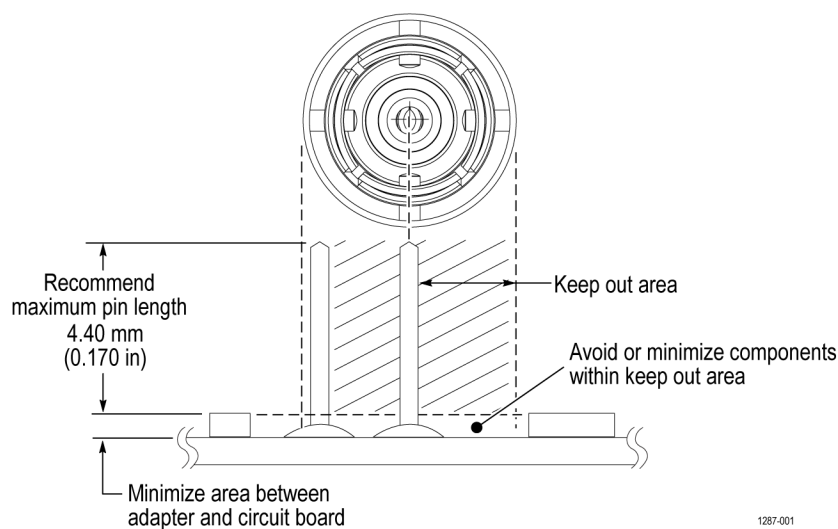
## Installing the square pins on the circuit board

The following figure shows the recommended clearance requirements for connecting the adapters to the square pins on the circuit board. The bottoms of the adapters are shown at the top.

*Probe Tip Adapter, MMCX to 0.1" pitch sq pin 0.635 mm (0.025 in) sq. pins*



*Probe Tip Adapter, MMCX to 0.062 in pitch sq pin 0.406 mm (0.016 in) sq. pins*

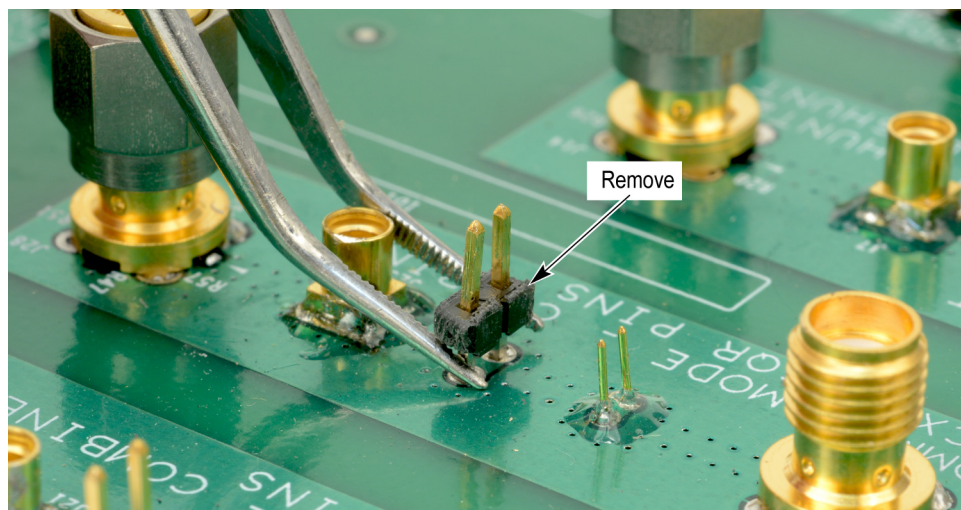


1287-001

**Figure 53: Adapter clearance requirements**



The 0.025-inch (0.635 mm) square pins should already be located on the circuit board. Some square pins might have headers installed on the circuit board. Tektronix recommends removing the plastic spacer from the square pins to gain closer access to the circuit board as shown in the following figure to achieve the best electrical performance, especially CMRR. You might need to use a pair of tweezers to remove the spacer as shown in the figure.



1287-002

**Figure 54: Removing the header from square pins on the circuit board**

Tektronix provides a set of solder pins (0.018-inch (0.46 mm) diameter) to install on the circuit board for use with the MMCX to 0.062-inch (1.57 mm) adapter. Use the soldering aide tool accessory (Tektronix part number, 003-1946-xx) to install these pins on the circuit board.

---

**NOTE.** The solder pins are extremely small and can be challenging to handle. Tektronix recommends using tweezers and a magnifying tool when installing the pins on the circuit board.

The solder pins can be installed around a surface mounted component on the circuit board, but adequate clearance should be maintained for a good electrical connection for the adapter. (See Figure 53 on page 62.)

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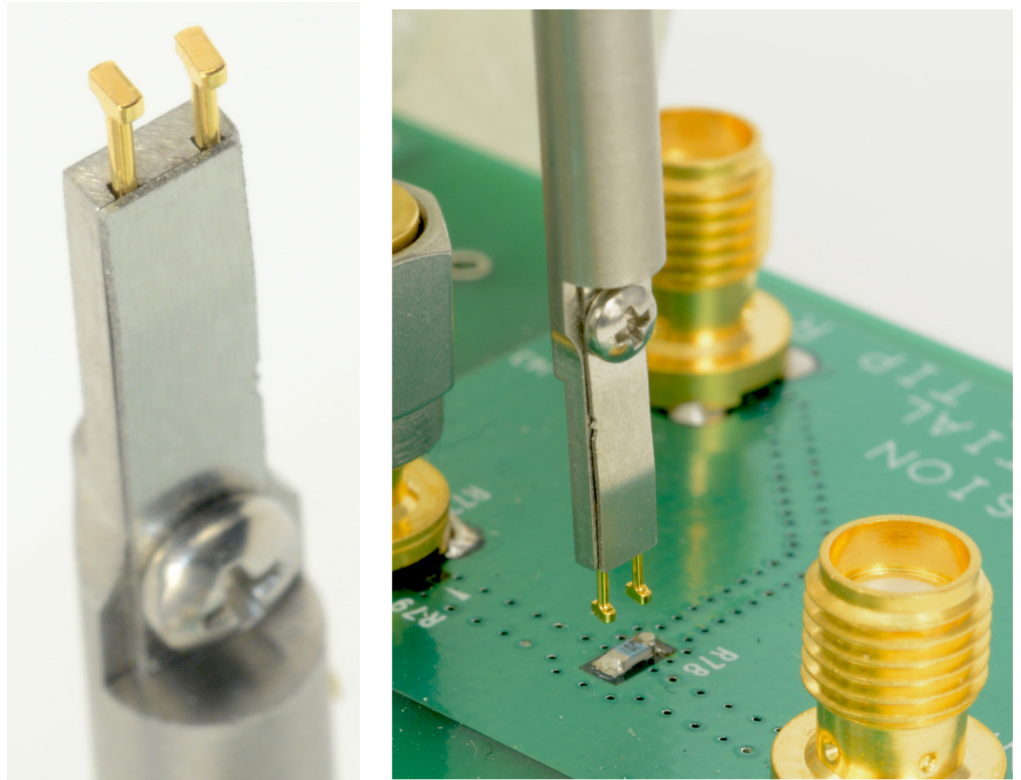
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**NOTE.** The coaxial (common) shield of the sensor tip cable and tip adapters should always be connected to the lowest impedance point (usually a circuit common or power supply rail) in the circuit-under-test (relative to the sensor tip cable/center conductor) to obtain the most accurate waveform.

---

Use the following steps to install the solder pins using the soldering aid on the circuit board:

1. Carefully insert the solder pins into the soldering aid as shown in the following illustration.



**Figure 55: Using the soldering aid to install the square pins on the circuit board**

2. Use the soldering aid to hold the square pins in place while soldering the square pins to the circuit board.
3. If necessary apply a small amount of adhesive to further strengthen the connection to the circuit board. However, keep the height of the adhesive to a minimum to provide good electrical contact for the adapter. (See Figure 53.)

---

# User service

## Service offerings

Tektronix provides service to cover repair under warranty and other services that are designed to meet your specific service needs.

Whether providing warranty repair service or any of the other services listed below, Tektronix service technicians are well equipped to service the IsoVu measurement system. Services are provided at Tektronix Service Centers and on-site at your facility, depending on your location.

### Warranty repair service

Tektronix warrants this product as described in the warranty statements at the front of this manual. Tektronix technicians provide warranty service at most Tektronix service locations worldwide. The Tektronix Web site provides information on all service locations worldwide.

### Calibration and repair service

In addition to warranty repair, Tektronix Service offers calibration and other services that provide cost-effective solutions to your service needs and quality standards compliance requirements. Tektronix instruments are supported worldwide by the leading-edge design, manufacturing, and service resources of Tektronix to provide the best possible service.

## Preventive maintenance



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**CAUTION.** *To prevent damage to the measurement system, do not expose it to sprays, liquids, or solvents. Avoid getting moisture inside the controller or sensor head when cleaning the exterior.*

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Clean the exterior surfaces 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. Use only enough solution to dampen the cloth or swab. Do not use abrasive compounds on any part of the instrument.

## Performance verification procedures

Use the following procedures to verify the performance of the IsoVu measurement system. Before beginning the procedures, photocopy the test record and use it to record the performance results. (See page 73, *Test record*.)

**Required equipment** The equipment required to perform the performance verification procedures are shown in the following table.

**Table 12: Required equipment for performance verification**

Description	Minimum requirements	Example product
Oscilloscope with TekVPI interface	$\geq 1$ GHz, 50 $\Omega$ input support, fully compatible with TekVPI interface	Tektronix MDO4104C
Pulse generator	1 V <sub>p-p</sub> , <1ns risetime	Tektronix Tek-DPG
TIVH series 10X sensor tip cable	As per description	Tektronix MMCX10X
MMCX Jack (female) to BNC female adapter	As per description	Fairview Microwave Product SKU: SM3610
Termination	As per description	Tektronix 011-0049-xx

**Preparation** Prepare the equipment as follows:

1. Turn on the TekVPI oscilloscope.
2. Connect the Tek-DPG Deskew pulse generator into Channel 2 of the TekVPI oscilloscope.
3. Allow the test equipment to warm up for 20 minutes at an ambient temperature of 20 °C to 30 °C.

## Propagation delay

This procedure verifies that the TIVH Series IsoVu measurement system is functioning and meets the warranted propagation delay specification. The propagation delay will be measured by first applying the output of the pulse generator to the input of the oscilloscope and storing the captured waveform as a reference waveform. Next, the measurement system is connected to the oscilloscope and the output of the pulse generator is connected to the input of the measurement system. The delay is then measured between the saved reference waveform and the acquired waveform of the measurement system.

---

**NOTE.** *This procedure is valid for all versions of the TIVH Series IsoVu measurement systems.*

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**Create the reference waveform**

Complete the following steps to create the reference waveform:

1. Connect the Tek-DPG Deskew Pulse Generator output BNC cable directly to Channel 1 input of the TekVPI oscilloscope.
2. Enable Channel 2 and use the following setups:
  - Vertical Scale: **500 mV/div**.
  - Vertical Position: -3 divisions
  - Set Termination: **1 M $\Omega$** ,
  - Coupling: **DC**
  - Bandwidth: **FULL**
  - Deskew: **0** seconds
3. Set the Trigger menu using the following setups:
  - Type: **Edge**
  - Source: **CH2**
  - Slope: **Negative**
  - Level: **+1.50 V**
  - Coupling: **DC**
4. Use the following setups for Channel 1.
  - Vertical Scale: **200 mV/div**
  - Coupling: **DC**
  - Termination: **50  $\Omega$**
  - Bandwidth: **FULL**
  - Position: **0** (centered)
  - Offset: **-500 mV**
  - Deskew: **0** seconds
5. Set the Horizontal menu to the following setups:
  - Horizontal Scale to **10 ns/div**.
  - Horizontal Position: **40 ns**
  - Acquire: **Average 128**
6. Set the Tek-DPG to the following setups:
  - **0 to -1 kHz mode** (Mode 1)
  - Output Enable: **ON**

7. The Channel 1 waveform should appear approximately on the center of the oscilloscope display. If the waveform is not vertically centered in the display, adjust the display as necessary to vertically center the waveform.
8. Use the following steps to save the Channel 1 waveform as the reference waveform (R1).
  - Press **MENU** on the oscilloscope.
  - Select **Save Waveform**.
  - Source: **CH1**.
  - Destination: **R1**.
  - Select **OK Save** to save the Channel 1 waveform as reference waveform R1. The new reference waveform should now be displayed on the oscilloscope.
9. Disable the output of the Tek-DPG.
10. Disconnect the Tek-DPG Deskew Pulse Generator output BNC cable from the Channel 1 input of the TekVPI oscilloscope.

#### Create the TIVH series waveform

Complete the following steps to set up the TIVH series waveform:

1. Connect the Comp box of the TIVH series measurement system to Channel 1 of the TekVPI oscilloscope.
2. Connect an MMCX10X sensor tip cable to the TIVH series input (tighten the SMA connector from the cable to the sensor head and attach the nose cone.)
3. Allow the measurement system to warm up for 20 minutes at an ambient temperature of 20 ° to 30 °C.
4. Connect an MMCX Jack (female) to BNC female adapter to the 50  $\Omega$  termination and to the output BNC cable of the Tek-DPG.
5. Set the TIVH series to the following:
  - Range: **1X**
  - CLAMPING: **Off**
  - Push the SELF CAL button to perform the self calibration (wait for the SELF CAL Status indicator to turn solid green).
6. On Channel 1 of the oscilloscope set the Vertical Scale to 200 mv/div.
7. Connect the MMCX10X sensor tip cable to the MMCX Jack (female) to BNC female adapter.

8. Enable the output of the Tek-DPG.
9. The Channel 1 waveform should appear on the oscilloscope display and be approximately vertically centered on the display. If not, **ONLY** adjust the vertical settings as necessary to center the waveform on the display.

### Measure the propagation delay

Complete the following steps to measure and record the propagation delay.

1. Set up the delay measurement on the oscilloscope as follows:
  - a. Select **Measure**.
  - b. Select **Add Measurement**.
  - c. Select Measurement Type: **Delay**.
  - d. Select Configure: **Delay**.
  - e. Set the Source to **R1**.
  - f. Set the Delay to **CH1**.
  - g. Select **OK Add Measurement**.
2. The oscilloscope display should be similar to the following figure.

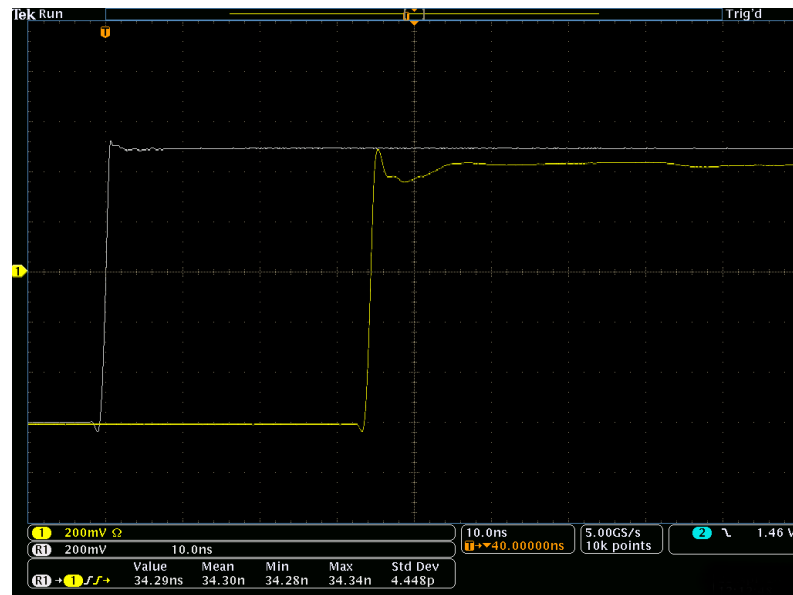


Figure 56: Propagation delay measurement

Record the resulting delay measurement on the test record.

3. Disable the output of the Tek-DPG.



## Troubleshooting and error conditions

The following table lists possible problems that you might encounter when taking measurements with TIVH Series IsoVu measurement system. Use the table as a quick troubleshooting reference before contacting Tektronix for service.

**Table 13: Problems and possible solutions**

Problem	Remedy
The measurement system will not power on; no indicators are on.	Verify the TekVPI comp box is securely attached to the oscilloscope. Detach and then reattach the comp box (using a different oscilloscope channel if necessary). If the condition persists, return the system to Tektronix for service.
Controller STATUS indicator is flashing green.	Detach and then reattach the comp box (using a different oscilloscope channel if necessary). Do not force the comp box into the oscilloscope connector at an angle; connect it to the oscilloscope with a firm, horizontal force. If the condition persists, return the system to Tektronix for service.
Controller STATUS indicator is flashing red and yellow	This condition indicates a failure in the measurement system. Most often, a failure is detected when the measurement system is first connected to the oscilloscope (while executing power-on self tests). Detach and then reattach the comp box to the scope. If the condition persists, return the system to Tektronix for service.
Controller SELF CAL STATUS indicator turns solid red after pressing SELF CAL button (or never completes).	<ul style="list-style-type: none"> <li>■ Remove input signal (differential must be 0.0V).</li> <li>■ Allow system to warm up 20 minutes.</li> <li>■ Make sure the fiber cable is not subjected to dynamic mechanical or thermal stresses.</li> <li>■ If the self calibration does not complete in a minute, detach and reattach the comp box to the oscilloscope – then try again.</li> </ul>
Waveform distortion when the signal from the DUT is less than 5 Hz or a multiple of 43.5 Hz	Disable the Offset Correction. Refer to the <i>Offset correction</i> section earlier in this document. (See page 16.)
Output waveform is clipped or distorted	<ul style="list-style-type: none"> <li>■ Verify that the Output Clamp is disabled.</li> <li>■ Check that the proper sensor tip cable is being used for the measurement. Refer to <i>Selecting a sensor tip cable</i> section earlier in this document. (See page 20.)</li> <li>■ Change the Input Offset to center the signal on-screen.</li> <li>■ Make sure the correct Range is selected (1X or 2X).</li> </ul>
Frequency response is rolled off	<ul style="list-style-type: none"> <li>■ Check the bandwidth limit on the oscilloscope.</li> <li>■ Check the sensor tip cable continuity and sensor head input resistance (see below).</li> </ul>
Output waveform is unstable (low frequency noise and/or DC offset keep changing)	<ul style="list-style-type: none"> <li>■ Make sure the fiber cable is not subjected to dynamic mechanical and thermal stresses.</li> <li>■ Verify that Offset Correction is enabled (detach and then reattach the comp box to make sure it has been re-enabled).</li> </ul>



Table 13: Problems and possible solutions (cont.)

Problem	Remedy																
Measurements are inaccurate	<ul style="list-style-type: none"> <li>■ Run SELF CAL.</li> <li>■ Check that the proper sensor tip cable is being used for the measurement. Refer to <i>Selecting a sensor tip cable</i> section earlier in this document. (See page 20.)</li> <li>■ Make sure the correct Range is selected (1X or 2X).</li> <li>■ Make sure the signal is on-screen.</li> </ul>																
Cannot achieve high CMRR	Try a different sensor tip cable.																
Too much noise and cannot accurately resolve signal	<ul style="list-style-type: none"> <li>■ Switch to the 1X Range.</li> <li>■ Choose a sensor tip cable with less attenuation.</li> </ul>																
No signal detected; waveform is a flat line	<ul style="list-style-type: none"> <li>■ Check the sensor tip cable continuity: <table> <tr> <th><i>Sensor tip cable</i></th><th><i>Resistance</i></th></tr> <tr> <td>MMCX10X - 10X sensor tip cable</td><td>9 M<math>\Omega</math></td></tr> <tr> <td>MMCX50X - 50X sensor tip cable</td><td>10 M<math>\Omega</math></td></tr> <tr> <td>MMCX250X - 250X sensor tip cable</td><td>10 M<math>\Omega</math></td></tr> <tr> <td>SQPIN100X - 100X sensor tip cable</td><td>10 M<math>\Omega</math></td></tr> <tr> <td>SQPIN250X - 100X sensor tip cable</td><td>10 M<math>\Omega</math></td></tr> <tr> <td>WSQPIN1000X - 1000X sensor tip cable</td><td>40 M<math>\Omega</math></td></tr> <tr> <td>WSQPIN2500X - 2500X sensor tip cable</td><td>40 M<math>\Omega</math></td></tr> </table> </li> <li>■ Measure the SMA input resistance of the Sensor Head; it should be between 950 k<math>\Omega</math> and 1.05 M<math>\Omega</math>. If not, then the Sensor Head has been damaged and needs to be returned to Tektronix for service.</li> <li>■ Check the controller STATUS indicator for possible error conditions.</li> <li>■ Apply a test signal directly to the SMA input of sensor head to determine if the problem is the sensor tip cable or the sensor head.</li> </ul>	<i>Sensor tip cable</i>	<i>Resistance</i>	MMCX10X - 10X sensor tip cable	9 M $\Omega$	MMCX50X - 50X sensor tip cable	10 M $\Omega$	MMCX250X - 250X sensor tip cable	10 M $\Omega$	SQPIN100X - 100X sensor tip cable	10 M $\Omega$	SQPIN250X - 100X sensor tip cable	10 M $\Omega$	WSQPIN1000X - 1000X sensor tip cable	40 M $\Omega$	WSQPIN2500X - 2500X sensor tip cable	40 M $\Omega$
<i>Sensor tip cable</i>	<i>Resistance</i>																
MMCX10X - 10X sensor tip cable	9 M $\Omega$																
MMCX50X - 50X sensor tip cable	10 M $\Omega$																
MMCX250X - 250X sensor tip cable	10 M $\Omega$																
SQPIN100X - 100X sensor tip cable	10 M $\Omega$																
SQPIN250X - 100X sensor tip cable	10 M $\Omega$																
WSQPIN1000X - 1000X sensor tip cable	40 M $\Omega$																
WSQPIN2500X - 2500X sensor tip cable	40 M $\Omega$																
Large DC offset in waveform	<ul style="list-style-type: none"> <li>■ Run SELF CAL.</li> <li>■ Run AutoZero.</li> <li>■ Set Input Offset to 0.0 V.</li> </ul>																
Cannot select between 1X and 2X Range (5000/7000/70000 Series oscilloscopes)	When Auto Range is turned ON, the Range is selected automatically when the V/div setting is changed. You cannot change the Range directly (the button will appear to not function).																
Probe compensation fails (7000/70000 Series oscilloscopes)	This is a normal condition. You can ignore the failure.																

## Repack the measurement system for shipment

If you need to return the measurement system to Tektronix for repair, use the original packaging. If this is unavailable or not fit for use, contact your Tektronix representative to obtain new packaging.

When you return the measurement system to Tektronix, attach a tag showing the following information:

- Name of the product owner
- Address of the owner
- Instrument serial number
- A description of problems encountered and/or service required

## Test record

Photocopy this test record for recording the results of the performance verification procedures.

**Table 14: Test record**

Model number:

Certificate number:

Serial number:

RH %:

Temperature:

Technician:

Date of calibration:

<b>Propagation delay</b>	<b>Minimum</b>	<b>Incoming</b>	<b>Outgoing</b>	<b>Maximum</b>
TIVH08 (3 m fiber length)	30 ns			40 ns
TIVH08L (10 m fiber length)	61 ns			75 ns
TIVH02 (3 m fiber length)	30 ns			40 ns
TIVH02L (10 m fiber length)	61 ns			75 ns
TIVH05 (3 m fiber length)	30 ns			40 ns
TIVH05L (10 m fiber length)	61 ns			75 ns



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## Appendix A: Remote programming

This appendix describes commands and queries that can be sent to the sensor head when attached to a Tektronix oscilloscope. Long-form and short-form keywords are indicated with upper/lower case letters. The commands and queries are supported by most oscilloscopes; differences in supporting oscilloscopes, if any, are described with the commands.

For details on the command syntax, refer to the programmer documentation for your oscilloscope.

### CH<n>:PRObe?

Returns probe information for channel <n>. Query only.

### CH<n>:PRObe:AUTOZero EXECute

This command executes the AutoZero function. The operation is first performed by the measurement system and then by the oscilloscope. Command only.

The system can be configured (with special keystrokes) to perform a full self calibration before the oscilloscope does its AutoZero.

Refer to the self calibration procedure for information on performing the self calibration. (See page 14, *Self calibration*.)

### CH<n>:PRObe:COMMAND “CLAMP”, {“ON” | “OFF”}

Only supported by 3000/4000 Series oscilloscopes.

The command enables or disables the clamp circuitry. The parameters enclosed in quotes are case sensitive and must be sent as capital letters.

CH<n>:PRObe:COMMAND? “CLAMP”. The query returns either “ON” or “OFF” enclosed in quotes.

### CH<n>:PRObe:SET {“CLAMP ON” | “CLAMP OFF”}

Only supported by 5000/7000/70000 Series oscilloscopes.

The command enables or disables the clamp circuitry. The parameters enclosed in quotes are case insensitive.

CH<n>:PRObe:SET?. The query returns either “CLAMP ON” or “CLAMP OFF” enclosed in quotes.

## CH<n>:PRObe:SET {"CLAMPING ON" | "CLAMPING OFF"}

Only supported by MSO 5 Series oscilloscopes.

The command enables or disables the clamp circuitry. The parameters enclosed in quotes are case insensitive.

CH<n>:PRObe:SET?. The query returns either "CLAMPING ON" or "CLAMPING OFF" enclosed in quotes.

## CH<n>:PRObe:FORCEDRange <NR3>

The command selects the dynamic range of the sensor tip in  $V_{p-p}$  and is dependent the attached sensor tip cable.

The following table lists the sensor tip cables and the dynamic range.

**Table 15: Sensor tip cables and dynamic ranges**

Sensor tip cable	Dynamic Range $V_{p-p}$
No tip	1.0 or 2.0
10X	10.0 or 20.0
50X	50.0 or 100.0
100X	100.0 or 200.0
250X	250.0 or 500.0
500X	500.0 or 1000.0
1000X	1000.0 or 2000.0
2500X	2500.0 or 5000.0

CH<n>:PRObe:FORCEDRange? The query returns the dynamic range of the sensor tip in  $V_{p-p}$ .

## CH<n>:PRObe:GAIN?

Returns the gain factor of the sensor tip (inverse of attenuation). Dependent on the attached sensor tip cable. Query only.

## CH<n>:PRObe:ID {:SERnumber | :TYPe}?

Query only. When sending only PRObe:ID?, the query returns the sensor tip type string followed by the serial number string.

When sending PRObe:SERnumber?, the query returns the serial number string.

When sending PRObe:TYPe?, the query returns one of the following sensor tip type strings (note the trailing spaces within the return strings):

- "TIVH08 " (800 MHz, 3m)
- "TIVH08L" (800 MHz, 10m)
- "TIVH05 " (500MHz, 3m)
- "TIVH05L" (500MHz, 10m)
- "TIVH02 " (200MHz, 3m)
- "TIVH02L" (200MHz, 10m)

## CH<n>:PRObe:PROPDElay?

Only supported by 3000/4000 Series oscilloscopes.

Returns the propagation delay value (in seconds). Query only.

## CH<n>:PRObe:RECDESkew?

Only supported by 3000/4000 Series oscilloscopes.

Returns the recommended deskew value (in seconds). Query only.

## CH<n>:PRObe:RESistance?

Returns the input resistance (in ohms). It depends on the attached sensor tip cable. Query only.

## CH<n>:PRObe:UNIts?

Returns the units of the sensor tip (always "V"). Query only.

## **CH<n>:PROBECOntrol {AUTO | MAN}**

Only supported by 5000/7000/70000/MSO 5 Series oscilloscopes.

The command sets the Auto or Manual sensor tip range control.

CH<n>:PROBE:PROBECOntrol?. The query returns the keyword AUTO or MANUAL.

## **CH<n>:PROBEFunc:EXTAtten <NR3>**

Only supported by 5000/7000/70000/MSO 5 Series oscilloscopes.

The command sets user-defined external attenuation factor.

CH<n>:PROBEFunc:EXTAtten?. The query returns the external attenuation factor.

## **CH<n>:PROBEFunc:EXTDBatten?**

Only supported by 5000/7000/70000/MSO 5 Series oscilloscopes.

Returns the external attenuation factor expressed in dB. Query only.



## Appendix B: 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.

Questions about the following compliance information may be directed to the following address:

Tektronix, Inc.  
PO Box 500, MS 19-045  
Beaverton, OR 97077, USA  
[www.tek.com](http://www.tek.com)

### Safety compliance

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

#### EU low voltage directive

Compliance was demonstrated to the following specification as listed in the Official Journal of the European Union:

Low Voltage Directive 2014/35/EU.

- EN 61010-1. Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 1: General Requirements.
- EN 61010-031. Particular requirements for handheld probe assemblies for electrical measurement and test equipment (partially applicable).

#### U.S. nationally recognized testing laboratory listing

- UL 61010-1. Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 1: General Requirements.
- UL 61010-031. Particular requirements for handheld probe assemblies for electrical measurement and test equipment (partially applicable).

#### Canadian certification

- CAN/CSA-C22.2 No. 61010-1. Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 1: General Requirements.
- CAN/CSA-C22.2 No. 61010-031. Particular requirements for handheld probe assemblies for electrical measurement and test equipment (partially applicable).

<b>Additional compliances</b>	<ul style="list-style-type: none"> <li>■ IEC 61010-1. Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 1: General Requirements.</li> <li>■ UL 61010-031. Particular requirements for handheld probe assemblies for electrical measurement and test equipment (partially applicable).</li> <li>■ EN 60825-1. Safety of Laser Products-Part 1: Equipment Classification and Requirements - Edition 3 (2014)</li> <li>■ IEC 60825-1. Safety of Laser Products-Part 1: Equipment Classification and Requirements - Edition 3 (2014)</li> <li>■ US 21CFR PT1010 Performance Standard for Electronic Parts 2015.</li> <li>■ US 21CFR PT1040 Performance Standards for Light Emitting Products 2015.</li> </ul>
<b>Equipment type</b>	Test and measuring equipment.
<b>Pollution degree descriptions</b>	<p>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.</p> <ul style="list-style-type: none"> <li>■ 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.</li> <li>■ 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.</li> <li>■ 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.</li> <li>■ Pollution degree 4. Pollution that generates persistent conductivity through conductive dust, rain, or snow. Typical outdoor locations.</li> </ul>
<b>Pollution degree rating</b>	Pollution degree 2 (as defined in IEC 61010-1). Rated for indoor, dry location use only.
<b>IP rating</b>	IP20 (as defined in IEC 60529).

### Measurement and overvoltage category descriptions

Measurement terminals on this product may be rated for measuring mains voltages from one or more of the following categories (see specific ratings marked on the product and in the manual).

- Category I. Circuits not directly connected to a mains supply.
- Category II. Circuits directly connected to the building wiring at utilization points (socket outlets and similar points).
- Category III. In the building wiring and distribution system.
- Category IV. At the source of the electrical supply to the building.

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**NOTE.** Only measurement circuits have a measurement category rating. Other circuits within the product do not have either rating.

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## Environmental considerations

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](http://www.tek.com/productrecycling)).



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