



**TDP1500**  
**1.5 GHz Differential Probe**  
**Technical Reference**

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# General safety summary

Review the following safety precautions to avoid injury and prevent damage to this product or any products connected to it.

To avoid potential hazards, use this product only as specified.

*Only qualified personnel should perform service procedures.*

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.

## To avoid fire or personal injury

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

**Ground the product.** This product is indirectly grounded through the grounding conductor of the mainframe power cord. To avoid electric shock, the grounding conductor must be connected to earth ground. Before making connections to the input or output terminals of the product, ensure that the product is properly grounded.

**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.

Connect the probe reference lead to earth ground only.

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

**Do not operate without covers.** Do not operate this product with covers or panels removed.

**Do not operate with suspected failures.** If you suspect that there is damage to this product, have it inspected by qualified service personnel.

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

**Do not operate in wet/damp conditions.**

**Do not operate in an explosive atmosphere.**

**Keep product surfaces clean and dry.**

## Terms in this manual

These terms may appear in this manual:



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

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

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## 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.

The following symbol(s) may appear on the product:



CAUTION  
Refer to Manual



# Preface

This is the Technical Reference Manual for the TDP1500 differential probe. This manual provides specifications and performance verification procedures for the probe.

# Specifications

The specifications in Tables 1 through 4 apply to a TDP1500 differential probe installed on a Tektronix DPO7000 oscilloscope. When the probe is used with another oscilloscope, the oscilloscope must have an input impedance of 50  $\Omega$  and a bandwidth of 1 GHz. The probe must have a warm-up period of at least 20 minutes and be in an environment that does not exceed the limits described. (See Table 1 on page 1.) The probe calibration routines should be run on the host instrument before verifying the warranted probe specifications. Specifications for the TDP1500 and differential probe fall into three categories: warranted, typical, and nominal characteristics.

## Warranted Characteristics

Warranted characteristics describe guaranteed performance within tolerance limits or certain type-tested requirements. (See Table 1.) Warranted characteristics that have checks in the *Performance Verification* section are marked with the ✓ symbol.

Warranted characteristics describe guaranteed performance within tolerance limits or certain type-tested requirements. (See Table 1.) Warranted characteristics that have *Performance Verification* checks are marked with the ✓ symbol. Performance verification procedures are contained in the *TDP1500 Technical Reference*, which is Tektronix part number 071-2296-XX.

**Table 1: Warranted electrical characteristics**

Specification	850 mV range	8.5 V range
✓ Differential signal range (DC coupled)	$\pm 0.85 \text{ V}_{(\text{DC} + \text{peak AC})}$ ; $0.6 \text{ V}_{\text{RMS}}$	$\pm 8.5 \text{ V}_{(\text{DC} + \text{peak AC})}$ ; $6 \text{ V}_{\text{RMS}}$
Common-mode signal range (DC coupled)	$\pm 7 \text{ V}_{(\text{DC} + \text{peak AC})}$ ; $25 \text{ V}_{\text{RMS}}$	
Maximum nondestructive input voltage between signal and common of the same channel	$\pm 25 \text{ V}_{(\text{DC} + \text{peak AC})}$	
✓ DC attenuation accuracy	$\leq \pm 0.75 \text{ V}$ input: $\pm 2\%$ of input $\leq \pm 0.85 \text{ V}$ input: $\pm 5\%$ of input	$\leq \pm 7.5 \text{ V}$ input: $\pm 2\%$ of input $\leq \pm 8.5 \text{ V}$ input: $\pm 5\%$ of input
✓ Bandwidth (both ranges, probe only, 0 °C to + 40 °C)	DC to $\geq 1.5 \text{ GHz}$	
✓ Rise time	<265 ps	
✓ Common-mode rejection ratio	>60 dB at 1 MHz >38 dB at 100 MHz >35 dB at 500 MHz >30 dB at 1 GHz	>45 dB at 1 MHz >25 dB at 100 MHz >20 dB at 500 MHz >18 dB at 1 GHz
Temperature	Operating: 0 to +40 °C (32 °F to +104 °F) Nonoperating: -40 to +71 °C (-40 °F to +160 °F) <sup>1</sup>	
Humidity	Operating: 5-90% RH, tested at up to +40 °C (+104 °F) Nonoperating: 5-90% RH, tested at up to +60 °C (+140 °F)	

<sup>1</sup> See warning that follows.



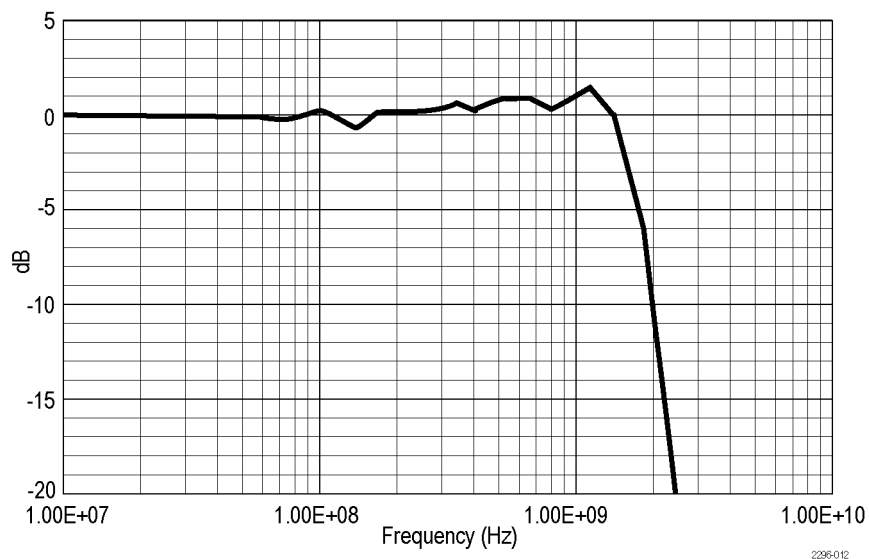
**WARNING.** To avoid a burn hazard at high ambient temperatures, do not touch the probe with bare hands at nonoperating temperatures above +50 °C.

## Typical Characteristics

Typical characteristics describe typical but not guaranteed performance.

**Table 2: Typical electrical characteristics**

Differential input resistance, DC coupled	200 k $\Omega$
Common mode input resistance	100 k $\Omega$ $\pm$ 2%
Differential input capacitance	<1.0 pF at 10 MHz
Common-mode input capacitance	<2.0 pF per side at 10 MHz
Harmonic distortion	$\leq$ 1.5% measured using 495 mV <sub>RMS</sub> (or 1.4 V <sub>P-P</sub> ) output at 100 MHz
Offset accuracy	$\pm$ 10 mV
Differential offset range	$\pm$ 7 V (both ranges)
Common mode rejection ratio	(See Figure 3 on page 3.)
System noise	< 2 mV RMS
Referred to probe output	<50 nV/ $\sqrt$ Hz at 100 MHz
Input impedance	(See Figure 4 on page 4.)
Delay time	5.4 ns $\pm$ 2 ns



**Figure 1: Typical bandwidth**

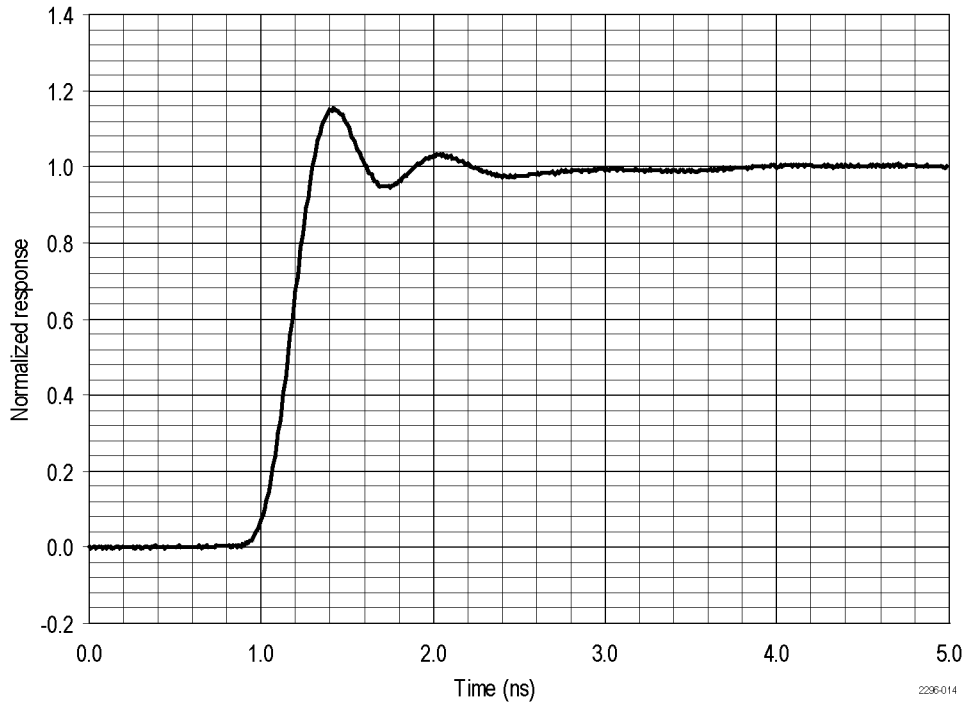


Figure 2: Typical rise time

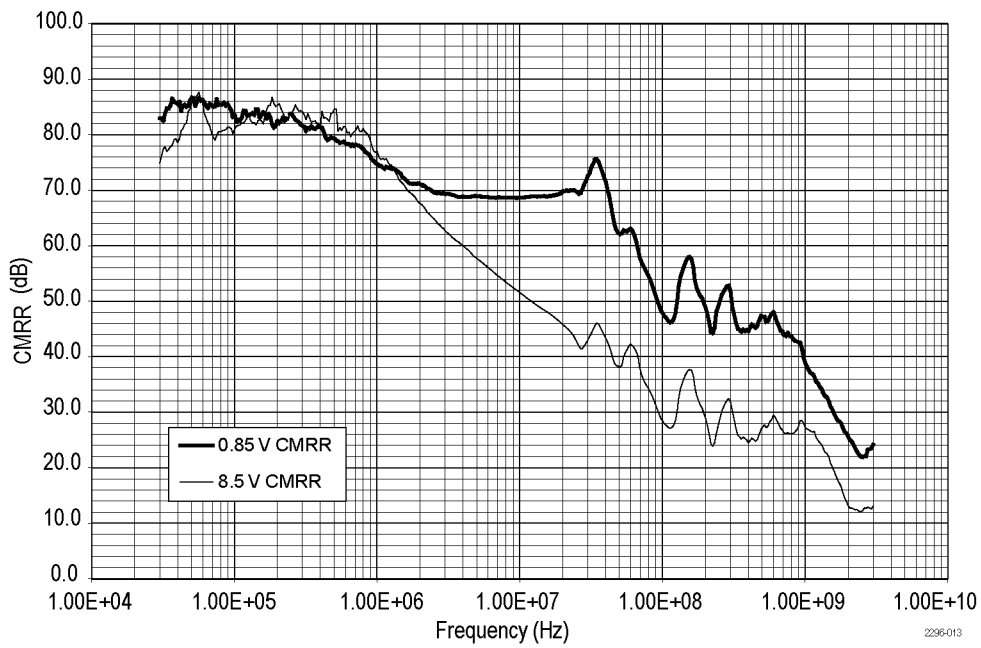


Figure 3: Typical Common-Mode Rejection Ratio

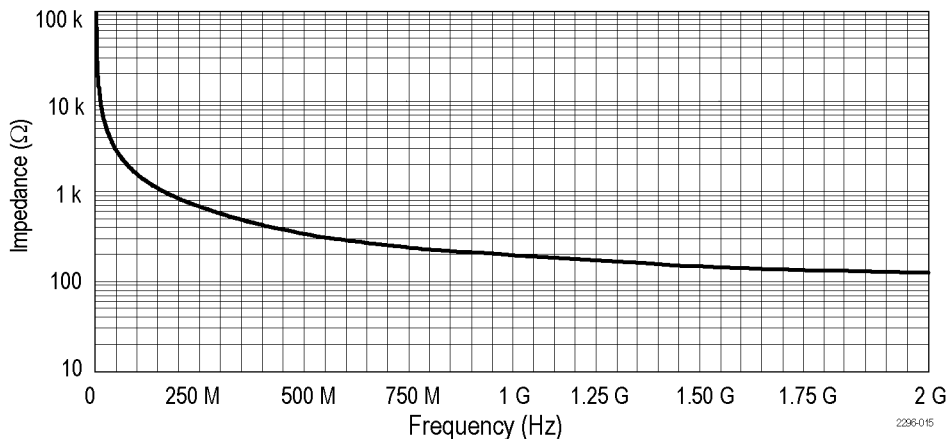


Figure 4: Typical input impedance versus frequency

Table 3: Typical mechanical characteristics

Dimensions, input connection	0.63 mm (0.025 in) square pin on 2.54 mm (0.100 in) centers
Dimensions, control box	117 mm × 41 mm × 29 mm (4.6 in × 1.6 in × 1.15 in)
Dimensions, probe head	86 mm × 11 mm × 8.9 mm (3.4 in × 0.45 in × 0.35 in)
Dimensions, output cable	1.22 m (48 in)
Unit weight (probe only)	144.5 g (5.1 oz)

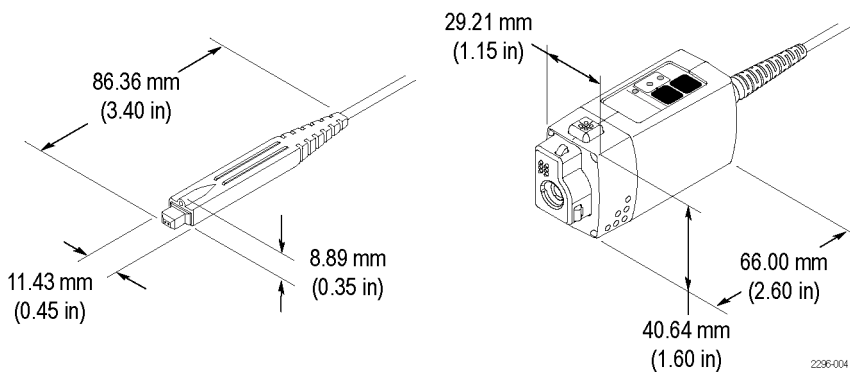


Figure 5: Probe dimensions

## Nominal Characteristics

Nominal characteristics (Table 4) describe guaranteed traits, but the traits do not have tolerance limits.

**Table 4: Nominal electrical characteristics**

Input configuration	Differential (two inputs, + and - ), with case ground
Output coupling	DC coupling
Voltage ranges	850 mV (1X) and 8.5 V (10X)
Termination	Terminate output into 50 $\Omega$

## Probe Tip Adapter Specifications

This section describes the characteristics of the adapters that are included in your accessory kit. The adapters are listed in order of performance, beginning with the fastest. You will get the best probe performance by connecting the probe directly to square pins on your circuit. However, as test points are not always as convenient, these adapters make taking measurements easier while maintaining the best signal fidelity.

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**NOTE.** All adapter specifications are typical unless otherwise indicated.

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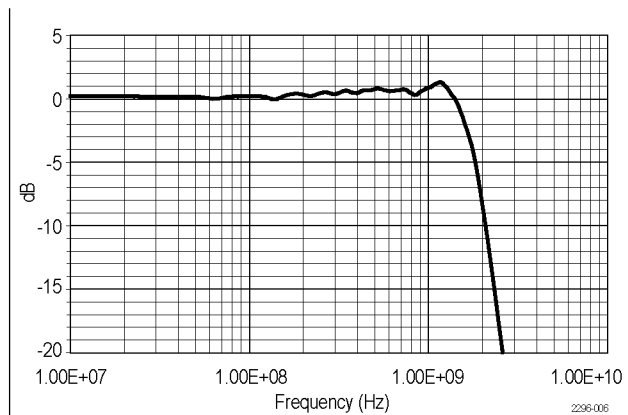
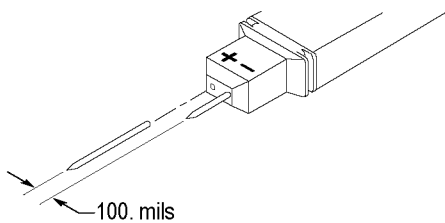
### Straight Pins

Tektronix part number: 016-1891-xx

Bandwidth: >1.5 GHz

10/90 Rise time: <233 ps

Best overall signal fidelity of the available adapters.



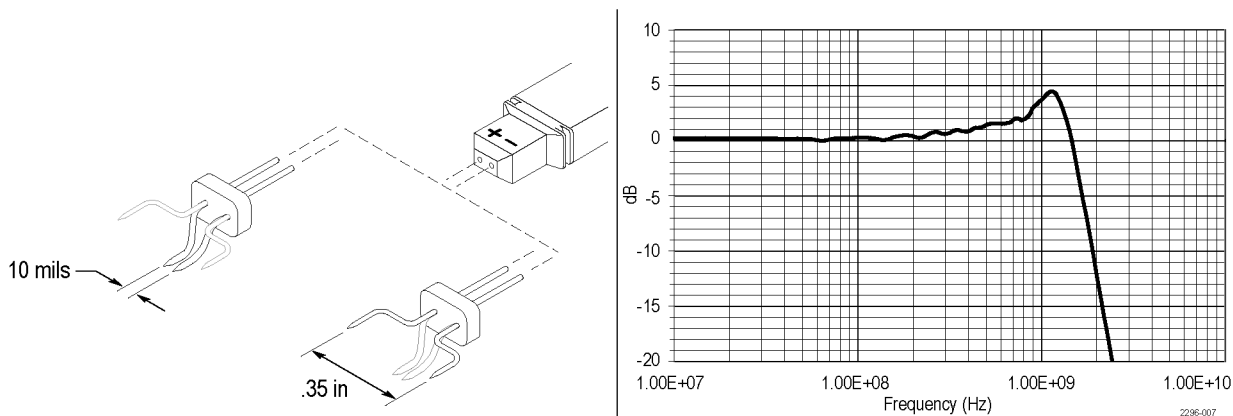
## Longhorn Adapter

Tektronix part number: 016-1780-xx

Bandwidth: >1.5 GHz

10/90 Rise time: <233 ps

This adapter has sharp, adjustable pins that can span up to 0.35 inch apart. They are useful for probing small circuit board features such as vias and narrow traces.



## 1" Solder Down Adapter

Tektronix part number: 196-3504-xx

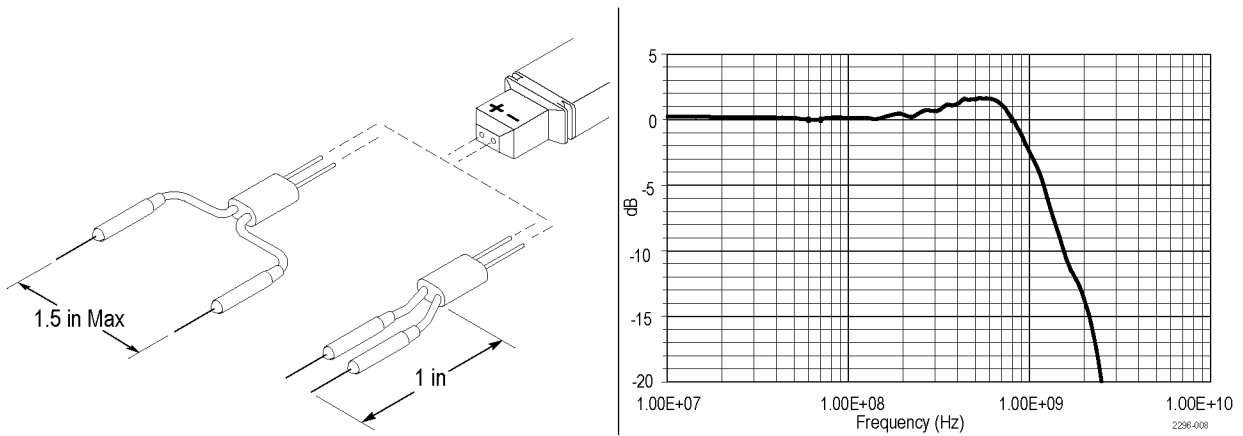
Bandwidth: >1 GHz

10/90 Rise time: <233 ps

Use this adapter on test points that you frequently check that do not have square pins or other convenient connections. Solder the leads to your test points, spaced up to 1.5 inches apart.



**CAUTION.** To prevent short circuits, solder and dress the adapter leads carefully, and make sure that the adapter pins do not touch other conductors when the adapter is not connected to the probe.





### 3" Solder Down Adapter

Tektronix part number: 196-3505-xx

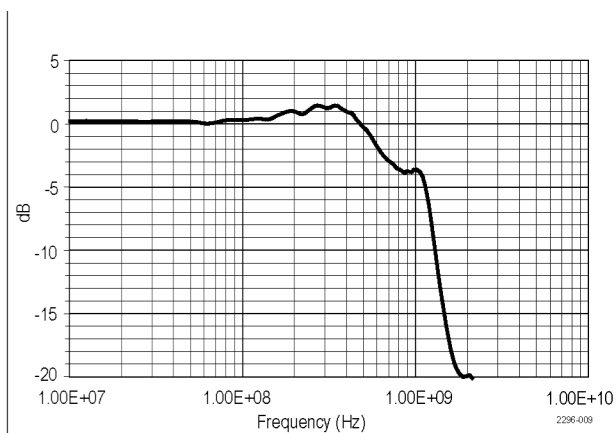
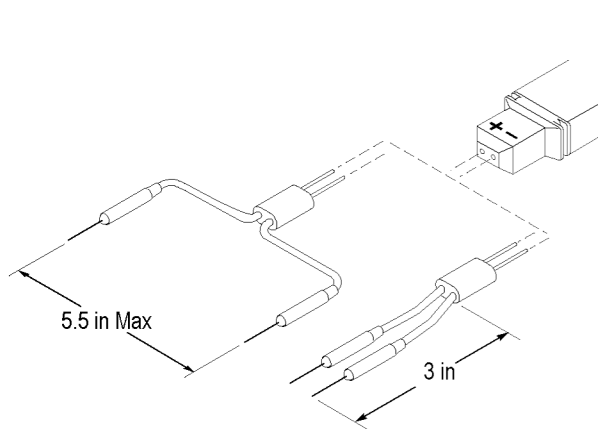
Bandwidth: >600 MHz

10/90 Rise time: <265 ps

Use this adapter on test points that you frequently check that do not have square pins or other convenient connections. Solder the leads to your test points, spaced up to 5.5 inches apart.



**CAUTION.** To prevent short circuits, solder and dress the adapter leads carefully, and make sure that the adapter pins do not touch other conductors when the adapter is not connected to the probe.



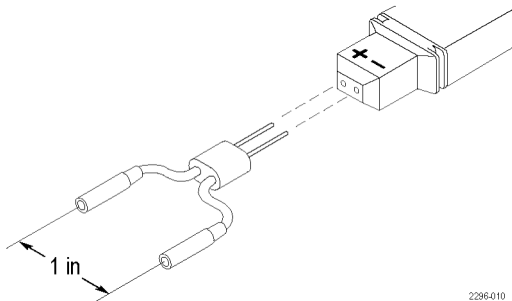
### Y-Lead Adapter

Tektronix part number: 196-3434-xx

Usable Bandwidth: <100 MHz

Calculated rise time: 3.5 ns

Use this adapter for DC and low-frequency measurements. The socket ends plug onto square pins, component leads, and the MicroCKT test tips that are included with the probe.



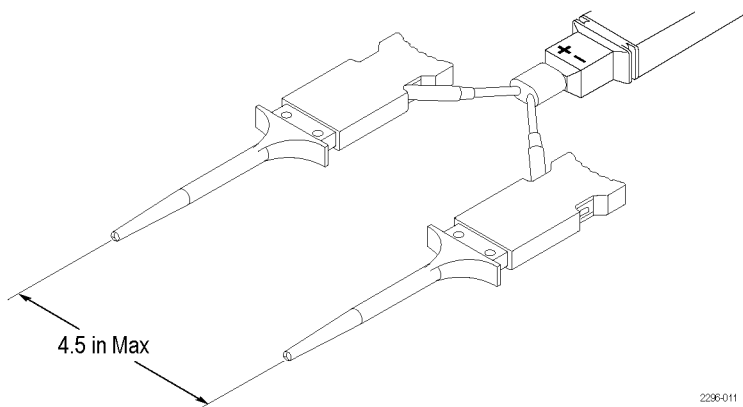
### MicroCKT Test Tip

Tektronix part number: 206-0569-xx

Usable Bandwidth: <100 MHz

Calculated rise time: 3.5 ns

Use the MicroCKT Test Tips with the Y-lead adapters. Due to the length of these adapters, they are only recommended for DC and low-frequency measurements.



## Performance Verification

Use the following procedures to verify the warranted specifications of the TDP1500 Differential Probe. Before beginning these procedures, photocopy the test record and use it to record the performance test results. (See Table 7 on page 27.) The recommended calibration interval is one year.

These procedures test the following specifications:

- DC attenuation accuracy
- Differential signal range
- Analog bandwidth\*
- Common mode rejection ratio\*
- Rise time

\* These tests require a network analyzer. Alternate test procedures that use a synthesizer and spectrum analyzer are provided in the Appendix.

## Required Equipment

Table 5 lists the equipment required to perform the performance verification procedure. The types and quantities of connectors may vary depending on the specific equipment you use.

**NOTE.** The procedures in this section require a network analyzer to perform the analog bandwidth and CMRR tests. Alternative procedures that do not require a network analyzer are included in this manual. (See page 28, Appendix A: Alternate Verification Procedures.)

**Table 5: Test equipment**

Description	Minimum requirements	Example product
Network analyzer	100 kHz to $\geq 2$ GHz, with cables and adapters to BNC male and SMA male	Agilent E5071C
Digitizing oscilloscope with TekVPI interface	Fully compatible with TekVPI interface	Tektronix DPO7000 series oscilloscope (w/V3.02 or higher firmware)
Sampling oscilloscope		Tektronix TDS8000 series oscilloscope
Sampling Module		Tektronix 80E0x
Sampling Module	TDR output; 250 mV step, <100 ps rise time	Tektronix 80E04
TekVPI Calibration Fixture	Optional probe accessory	Tektronix part number 067-1701-xx
BNC-to-probe tip adapter	Optional probe accessory	Tektronix part number 067-1734-xx
BNC Male-to-SMA Female adapter	As per description	Tektronix part number 015-0572-xx
Calibrated DC voltage source	Adjustable from 0 V to $\geq 20$ V. Outputs must be isolated from earth ground.	Keithley 2400
DMM (2 required)	DC Accuracy $\geq 0.5\%$ on range to measure 20 V, averaging mode.	Fluke 187
BNC cables (2)	50 $\Omega$ , 42 inch	Tektronix part number 012-0057-xx
SMA cables (2)	50 $\Omega$ , 28 inch	Tektronix part number 012-0649-xx
Banana-to-banana patch cords (2)	1 red 1 black	Tektronix part number 012-0031-xx Tektronix part number 012-0039-xx
Dual-male-banana-to-female BNC adapter	As per description	Tektronix part number 103-0090-xx
Precision inline BNC terminator	50 $\Omega \pm 0.1\%$	Tektronix part number 011-0129-xx
Y-lead adapter	Standard accessory included w/probe	Tektronix part number 196-3434-xx
MicroCKT Test Tips (2)	Standard accessory included w/probe	Tektronix part number 206-0569-xx

## Special Adapters

Some of the adapters used in these procedures are available only from Tektronix. These adapters are described on the following pages.

### TekVPI Calibration Fixture

The TekVPI Calibration Fixture, Tektronix part number 067-1701-xx, connects between the host instrument and the probe under test. (See Figure 6.) An SMA connector on the rear of the fixture provides access to the probe output signal for performance verification measurements.

1. SMA connector for probe output measurements
2. TekVPI socket for probe under test
3. BNC connection used for some tests

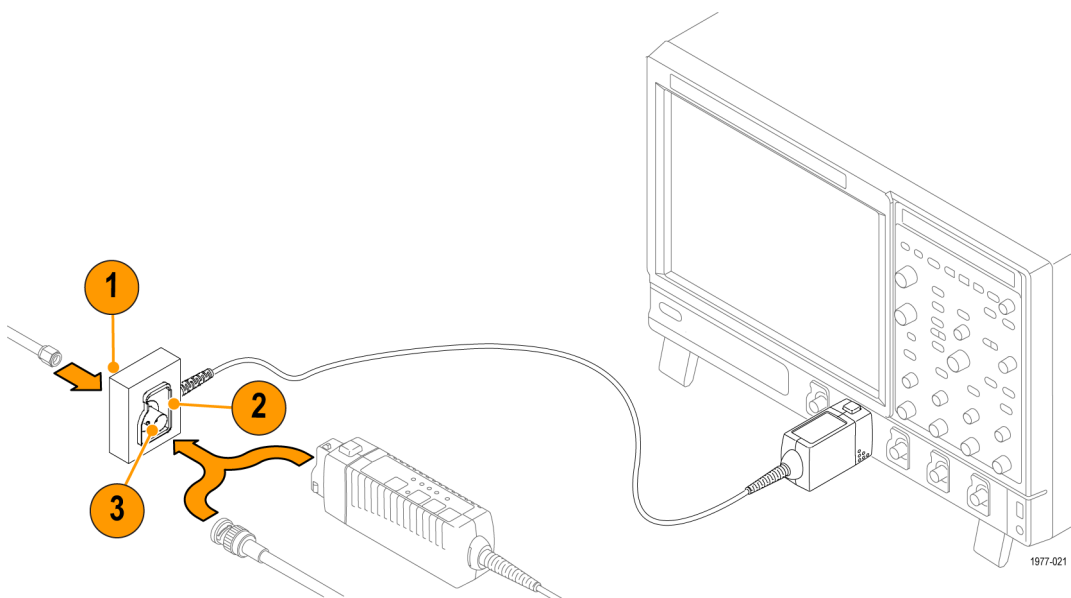


Figure 6: TekVPI Calibration Fixture

### BNC-to-Probe Tip Adapter

The BNC-to-Probe Tip Adapter, Tektronix part number 067-1734-xx, provides connections for signal sources and probe test points. (See Figure 7.) The adapter breaks out the signal input on the BNC connector to pairs of square pins, one each for common-mode and differential-mode connections.

1. BNC connector for input signals
2. Differential Mode (DM) square-pin pair
3. Common Mode (CM) square-pin pair (with ground pin)

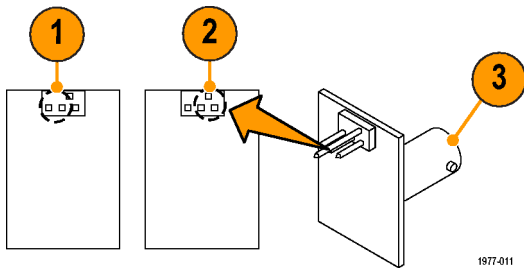


Figure 7: BNC-to-Probe Tip Adapter

## Preparation

Prepare the equipment as follows:

1. Turn on the TekVPI oscilloscope.
2. Connect the TekVPI Calibration Fixture to the oscilloscope.
3. Connect the SMA M-to-BNC F adapter to the SMA output of the TekVPI Calibration Fixture.
4. Connect the precision termination to the BNC end of the SMA M-to-BNC F adapter.
5. Connect one end of the BNC cable to the precision termination.
6. Connect the other end of the BNC cable to the BNC-to-dual banana adapter.
7. Connect the BNC-to-dual banana adapter to the DMM input. Note: This DMM is used to measure the probe output voltage.
8. Connect the probe to the TekVPI Calibration Fixture and verify that one of the Range LEDs on the probe illuminates.
9. Connect the Y-lead adapter to the probe head. Observe proper polarity: red to (+), black to (-).
10. Connect the MicroCKT test tips to the Y-lead adapter.
11. Set the vertical offset to 0 V. (Check that the offset is set to zero before performing each test unless instructed otherwise.)

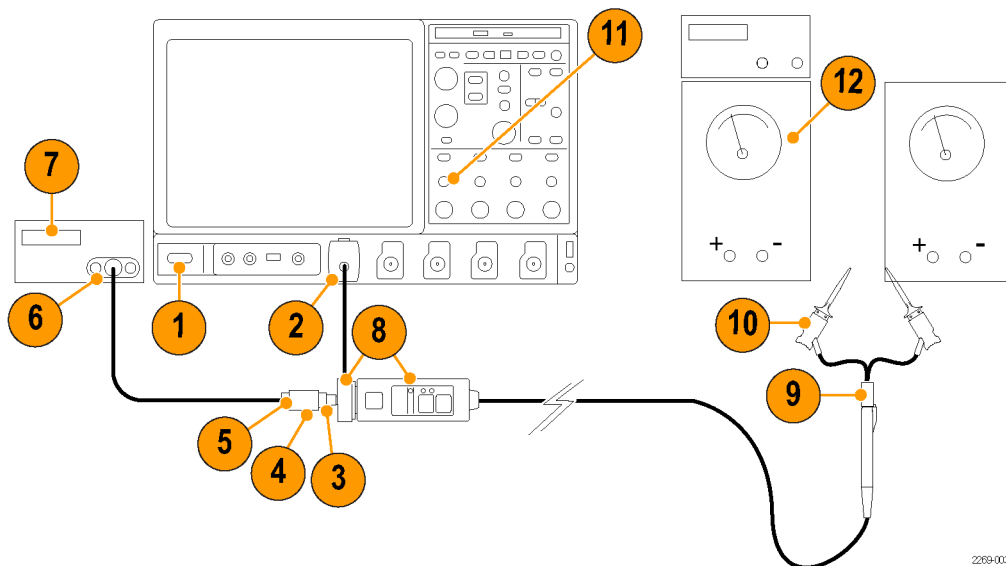


Figure 8: Preliminary test setup

12. Turn on the remaining test equipment listed in the table.
13. Allow the probe and test equipment to warm up for 20 minutes at an ambient temperature of 20 °C to 30 °C.
14. Photocopy the test record and use it to record the test results. (See Table 7 on page 27.)

Perform the verification procedures in order.

## DC Attenuation Accuracy and Differential Signal Range

This test checks the attenuation accuracy of the probe by first measuring known voltages with a multimeter. The probe is then used to measure the same voltages, and then a comparison calculation is made. These tests are done over the full differential range of the probe.

### Preparation

1. Check that the vertical offset is set to 0 V.
2. Set the probe to the 8.5 V range.
3. Connect the probe to the DC sources as shown. (See Figure 9.) Observe proper polarity: red to (+), black to (-).

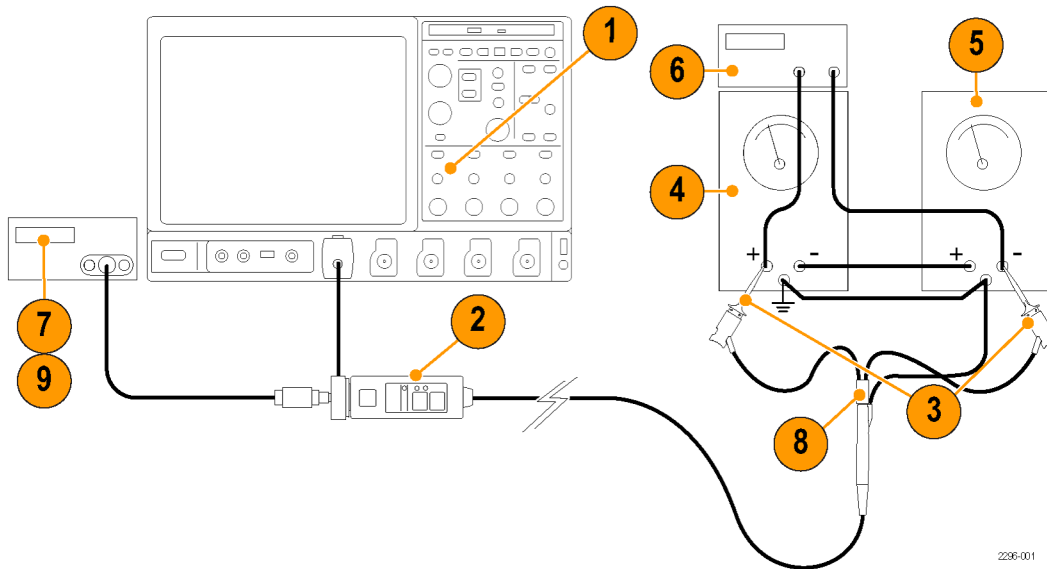


Figure 9: Setup for differential-mode tests



## Verification

### 8.5 V Range.

4. Set the input voltage on the DC source that is connected to the (+) input of the probe to +3.75 V  $\pm$ 50 mV.
5. Set the input voltage on the DC source that is connected to the (–) input of the probe to –3.75 V  $\pm$ 50 mV.
6. Verify with the multimeter that the total output across the two sources is +7.50 V  $\pm$ 100 mV. Record the actual voltage as  $V_{in1}$ .
7. Record the output voltage (on the first DMM) as  $V_{out1}$ .
8. Reverse the polarity of the input voltage. (You can do this by reversing the Y-lead connection at the probe). Record the actual voltage as  $V_{in2}$ .
9. Record the output voltage (on the first DMM) as  $V_{out2}$ .
10. Calculate the attenuation using the values from the measurements as follows:

$$\text{Attenuation} = (V_{in1} - V_{in2}) \div (V_{out1} - V_{out2})$$

Example:

$$= [7.50 \text{ V} - (-7.50 \text{ V})] \div [0.75 \text{ V} - (-0.75 \text{ V})]$$

$$= 15 \text{ V} \div 1.5 \text{ V}$$

$$= 10.0$$

11. Verify that the attenuation is in the range of 9.8 to 10.2. Record the results in the test record.
12. Reverse the polarity of the input back to positive. For example, if you reversed the Y-leads, connect them: red to (+), black to (–).
13. Set the input voltage on the DC source that is connected to the (+) input of the probe to +4.25 V  $\pm$ 50 mV.
14. Set the input voltage on the DC source that is connected to the (–) input of the probe to –4.25 V  $\pm$ 50 mV.
15. Verify with the multimeter that the total output across the two sources is +8.50 V  $\pm$ 100 mV. Record the actual voltage as  $V_{in1}$ .
16. Repeat steps 7 through 10 to check the attenuation at  $\pm$ 8.50 V. This also checks the full differential signal range of the probe on the 8.5 V range. Note that the specification is wider at these input levels ( $\pm$ 5%).
17. Verify that the attenuation is in the range of 9.5 to 10.5. Record the results in the test record.

**850 mV Range.**

18. Set the input voltage on the DC source that is connected to the (+) input of the probe to +0.375 V  $\pm$ 10 mV.
19. Set the input voltage on the DC source that is connected to the (-) input of the probe to -0.375 V  $\pm$ 10 mV.
20. Verify with the multimeter that the total output across the two sources is +0.750 V  $\pm$ 20 mV. Record the actual voltage as  $V_{in1}$ .
21. Set the probe to the 850 mV range.
22. Record the output voltage as  $V_{out1}$ .
23. Reverse the polarity of the input voltage. Record the actual voltage as  $V_{in2}$ .
24. Record the output voltage as  $V_{out2}$ .

25. Calculate the attenuation using the values from the measurements as follows:

$$\text{Attenuation} = (V_{in1} - V_{in2}) \div (V_{out1} - V_{out2})$$

Example:

$$\begin{aligned} &= [0.750 \text{ V} - (-0.750 \text{ V})] \div [0.75 \text{ V} - (-0.75 \text{ V})] \\ &= 1.5 \text{ V} \div 1.5 \text{ V} \\ &= 1.0 \end{aligned}$$

26. Verify that the attenuation is in the range of 0.98 to 1.02. Record the results in the test record.
27. Reverse the polarity of the input back to positive: red to (+), black to (-).
28. Set the input voltage on the DC source that is connected to the (+) input of the probe to +0.425 V  $\pm$ 10 mV.
29. Set the input voltage on the DC source that is connected to the (-) input of the probe to -0.425 V  $\pm$ 10 mV.
30. Verify with the multimeter that the total output across the two sources is +0.850 V  $\pm$ 20 mV. Record the actual voltage as  $V_{in1}$ .
31. Repeat steps 22 through 25 to check the attenuation at  $\pm$ 0.850 V. This also checks the full differential signal range of the probe on the 850 mV range. Note that the specification is wider at these input levels ( $\pm$ 5%).
32. Verify that the attenuation is in the range of 9.5 to 10.5. Record the results in the test record.

## Analog Bandwidth

The following steps prepare the network analyzer for measuring bandwidth and CMRR. The actual settings may vary with different models of network analyzer. Refer to the user documentation supplied with the network analyzer for details on performing these steps.

### Preparation

1. Set the network analyzer to measure transmission loss,  $S_{21}$ . Attach cables to both ports.
2. Set the display format to log magnitude, 1 dB/div, reference value 0 dBm, and linear frequency.
3. Set the start frequency to  $\approx 1$  MHz and the stop frequency to  $\approx 2$  GHz.
4. Set the test port power to 0 dBm.
5. Connect the TekVPI Calibration Fixture to any channel on the oscilloscope.
6. Attach the cable from port 1 of the network analyzer to the BNC connector in the probe socket on the TekVPI Calibration Fixture. Use a male BNC adapter if necessary.
7. Attach the cable from port 2 of the network analyzer to the SMA connector on the TekVPI Calibration Fixture. Use a male BNC adapter if necessary. The setup should now appear as shown. (See Figure 10.)
8. Normalize the network analyzer to remove the loss through the TekVPI Calibration Fixture.

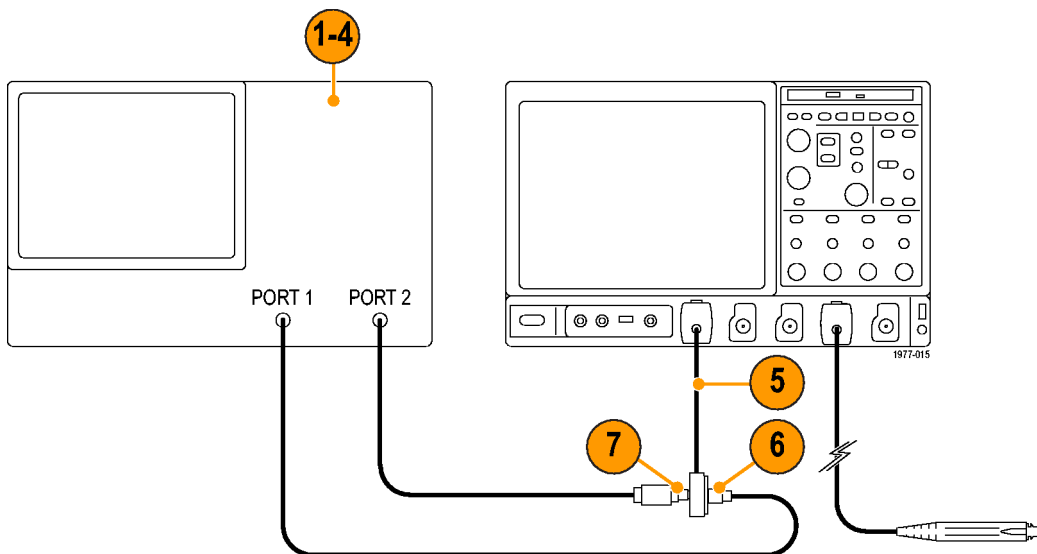


Figure 10: Normalize the signal path for the following tests

## Verification

### 850 mV Range.

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**NOTE.** Do not remove the cable end that is connected to the network analyzer. Connect the cable to the Probe Tip-to-BNC adapter.

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1. Disconnect the port 1 cable from the BNC connector in the probe socket on the TekVPI Calibration Fixture.
2. Connect the port 1 cable to the BNC connector on the Probe Tip to BNC adapter.
3. Connect the probe to the TekVPI Calibration Fixture.
4. Connect the probe head to the DM pins on the Probe Tip to BNC adapter. Polarity is unimportant, but do not connect the ground pin. (See Figure 11.)
5. Set the probe to the 850 mV range.

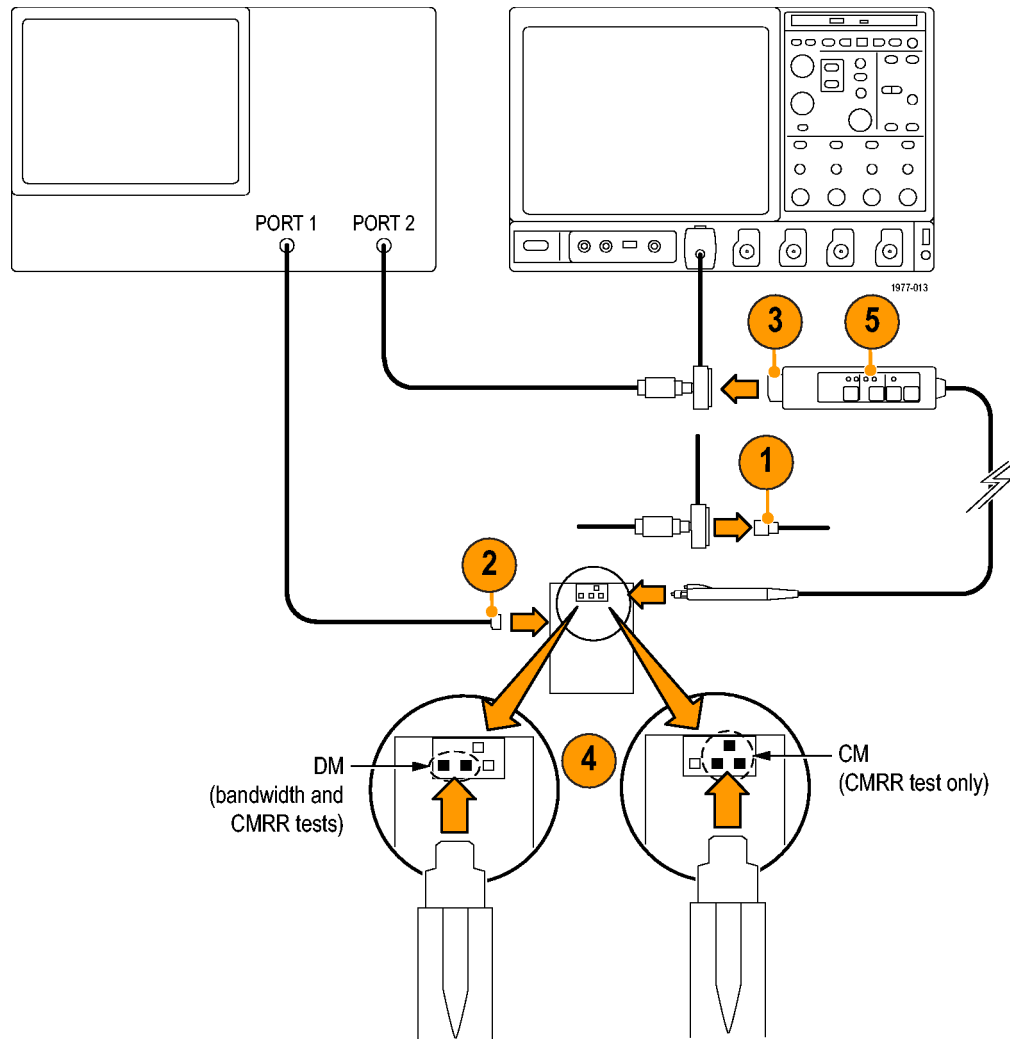


Figure 11: Setup for the analog bandwidth and CMRR tests

6. Read the amplitude at 1.5 GHz. The use of the marker function, (if equipped), will simplify resolving the bandwidth.
7. Verify that the amplitude is greater than  $-3$  dB. Record the results in the test record.

#### 8.5 V Range.

8. Set the probe to the 8.5 V range.
9. Change the reference value on the network analyzer to keep the plot on screen ( $-20$  dBm).
10. Using the marker (if equipped), measure the output amplitude at 1.5 GHz.
11. Verify that the amplitude is greater than  $-20$  dB. Record the results in the test record.
12. Retain the setup for the next test.

## Common Mode Rejection Ratio

If verification of analog bandwidth was not performed, or the calibration of the network analyzer has been altered, perform the calibration and normalization steps in the *Preparation* section of the Analog Bandwidth verification.

In this test, you first plot the differential mode gain, and then the common mode gain. Next, using the math function on the network analyzer, you create a plot that represents the reciprocal of the CMRR.

### Verification

#### 850 mV Range.

1. Set the reference value of the network analyzer to 0 dB and position the reference near the top of the screen.
2. Verify that the test port power is set to 0 dBm.
3. Connect the probe input to the DM pins on the Probe Tip-to-BNC adapter. Polarity is unimportant, but do not connect the ground pin.
4. Set the probe to the 850 mV range.
5. The plot that is displayed represents the differential mode gain of the probe. Save this plot to the instrument memory.
6. Disconnect the probe input from the DM pins and connect it to the CM pins on the Probe Tip-to-BNC adapter. Do not connect the probe to the ground pin on the fixture. (See Figure 11 on page 20.)
7. The plot that is displayed represents the common mode gain of the probe. You may need to adjust the reference level and scale to view the plot.
8. Use the math function of the network analyzer to divide this plot by the differential plot that you saved in step 5. The resulting plot is the reciprocal of the common mode rejection ratio. The CMRR can be read by inverting the sign of the magnitude.
9. Measure the CMRR at 1 MHz, 100 MHz, 500 MHz, and 1 GHz. Analyzers with marker capability can do this directly by setting the marker intercepts at 1 MHz, 100 MHz, 500 MHz, and 1 GHz. If necessary, turn on the network analyzer Average mode with 16 averages to stabilize the reading.
10. Verify that the CMRR is less than the values listed in Table 6, and record the results in the test record.

**Table 6: CMRR limits**

Frequency	850 mV Range CMRR	8.5 V Range CMRR
1 MHz	≥60 dB	≥45 dB
100 MHz	≥38 dB	≥25 dB
500 MHz	≥35 dB	≥20 dB
1 GHz	≥30 dB	≥18 dB

#### 8.5 V Range.

11. Change the range on the probe to 8.5 V.
12. Measure the CMRR at 1 MHz, 100 MHz, 500 MHz, and 1 GHz.
13. Calculate the actual CMRR by subtracting 20 dB from the absolute magnitudes to compensate for the attenuation (for example,  $|-68 \text{ dB}| - 20 \text{ dB} = 48 \text{ dB}$ ).

14. Verify that the CMRR is less than the values in the 8.5 V column of Table 6, and record the results in the test record.
15. Disconnect the probe from the TekVPI Calibration Fixture and connect it to any channel on the oscilloscope to keep the probe at operating temperature.

## Rise Time

This procedure verifies that the probe meets the warranted rise time specification. Two rise times are measured; the test system alone, and then the test system with the probe included. The probe rise time is calculated using the two measurements.

This test uses the TDR function of the 80E04 sampling head as a fast rise time signal source. A second 80E0X sampling head is used to take the measurements. Although the following procedure assigns the TDR and measurement functions to specific oscilloscope channels, any channels can be used. However, the TDR function is only available on 80E04 sampling heads.



**CAUTION.** To prevent damage, use care when working with SMA connectors: support equipment to avoid mechanical strain on the connectors, and when tightening connections, use a torque wrench to 7.5 in-lbs.

### Test System Rise Time

1. Connect the 80E04 sampling head to Channel 1 of the sampling oscilloscope. (See Figure 12.)
2. Connect the 80E0X sampling head to Channel 8 of the sampling oscilloscope.
3. Connect SMA cables to Channels 1 and 8 on the sampling heads.
4. Connect the SMA cable from Channel 1 to an SMA-to-BNC Adapter, and then to the BNC connector on the TekVPI Adapter.
5. Connect the SMA cable from Channel 8 to the SMA connector on the TekVPI Adapter.
6. Turn on Channel 8 and set the vertical scale to 50 mV/div.

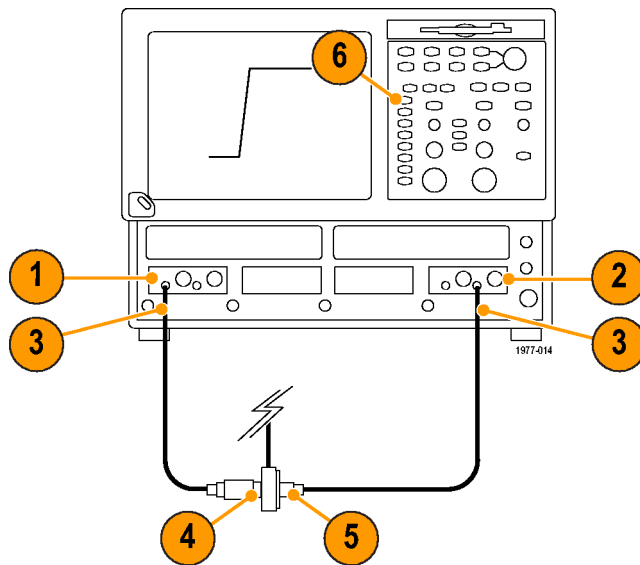


Figure 12: Test system rise time setup



7. Set the Channel 1 sampling head to TDR mode: press the **SETUP DIALOGS** button and select the TDR tab. (See Figure 13.)
8. Set the Channel 1 (**C1**) **Polarity** to positive (rising).
9. Set the **Preset** of Channel 1 on. TDR Preset sets Internal Clock in the Trigger menu, turns on the TDR Step in the TDR Setups menu, turns on the channel and selects the acquisition Units in the TDR Setups menu, and sets the horizontal scale, position, and reference. The sampling module will turn on a red light next to the SELECT channel button, indicating that TDR is activated for that channel.

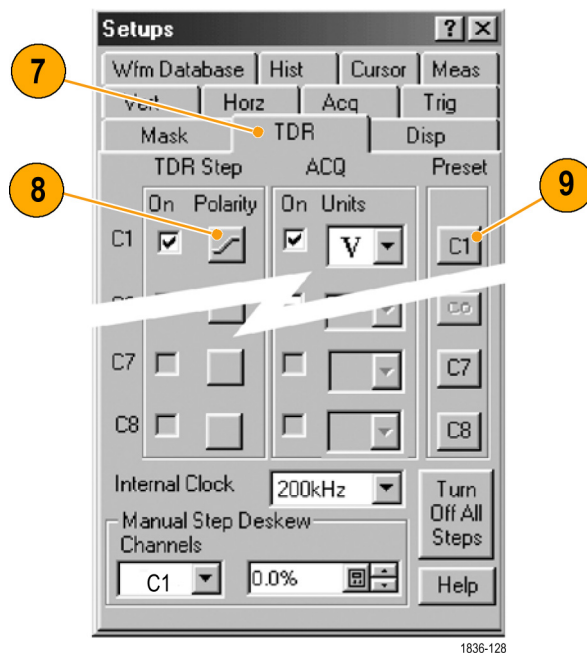


Figure 13: TDR parameter setup

10. Turn off the display for Channel 1 so that only Channel 8 is shown on screen.
11. Use the oscilloscope measurement capability to display rise time. Adjust the oscilloscope horizontal and vertical position controls to display a signal similar to that shown. (See Figure 12 on page 23.)
12. Set the oscilloscope horizontal scale to 200 ps/div and center the waveform.
13. Increase the stability of the pulse edge measurement by using averaging, if available. Rise time is determined from the 10% and 90% amplitude points on the waveform. Record the rise time as  $t_s$ .

## Test System and Probe Rise Time

14. Disconnect the SMA cable and BNC adapter from the Channel-1 side of the TekVPI Calibration fixture. (See Figure 14.)
15. Connect the SMA cable and BNC adapter from Channel 1 of the sampling oscilloscope to the BNC connector on the BNC-to-Probe Tip Adapter.
16. Connect the probe to the TekVPI Calibration fixture, and set the probe to the 850 mV range.
17. Connect the probe head to the DM pins on the BNC-to-Probe Tip Adapter.
18. Set the TekVPI oscilloscope offset to 0.0 V.

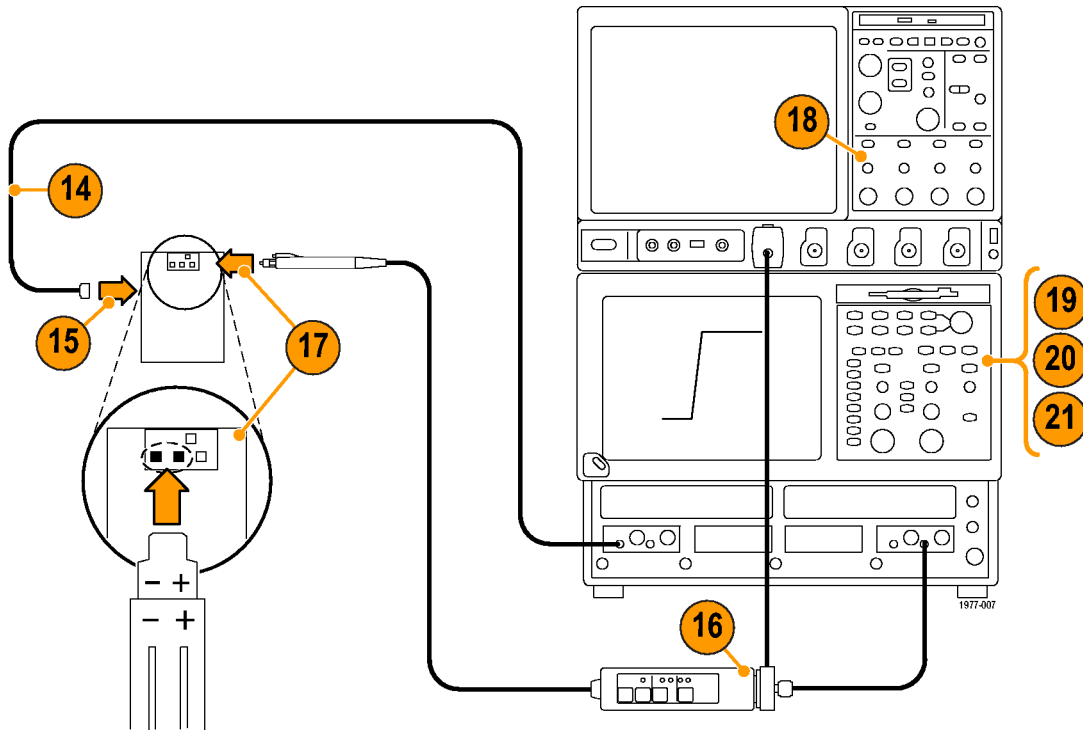


Figure 14: Probe rise time setup

**NOTE.** The following measurements are taken with the sampling oscilloscope. The TekVPI oscilloscope only provides power and offset to the probe.

19. On the sampling oscilloscope, expand the horizontal scale to locate the step edge: set the vertical scale to 50 mV/div, and adjust horizontal range to 200 ps/div while maintaining the edge view. For a more stable measurement display, turn on averaging.
20. Adjust the position controls on the sampling oscilloscope to display the entire leading edge waveform.
21. Use the measurement capability of the sampling oscilloscope to display rise time. Increase the stability of the pulse edge measurement by using averaging, if available. Rise time is determined from the 10% and 90% amplitude points on the waveform. Record the rise time as  $t_{s+p}$ .
22. Using the test system rise time ( $t_s$ ) that you measured in step 13, and the test system and probe rise time ( $t_{s+p}$ ) that you measured in step 21, calculate the probe-only rise time using the formula shown.

$$t_p = \sqrt{t_{(s+p)}^2 - t_s^2}$$

Example:

$$t_p = \sqrt{(450^2 - 50^2)}$$

$$t_p = \sqrt{202500 - 2500}$$

$$t_p = \sqrt{200000}$$

$$t_p = 447.2 \text{ ps}$$

23. Record the calculated rise time in the test record.
24. Set the probe to the 8.5 V range.
25. Repeat steps through for the 8.5 V range.

This completes the procedure.

**Table 7: Test Record**

Probe Model/Serial Number: \_\_\_\_\_ Certificate Number: \_\_\_\_\_

Temperature: \_\_\_\_\_ RH % : \_\_\_\_\_

Date of Calibration: \_\_\_\_\_ Technician: \_\_\_\_\_

Performance test	Minimum	Measured/calculated	Maximum
<b>DC attenuation accuracy</b>			
8.5 V range			
@ ±7.50 V	9.8	_____	10.2
@ ±8.50 V	9.5	_____	10.5
850 mV range			
@ ±0.750 V	0.98	_____	1.02
@ ±0.850 V	0.95	_____	1.05
<b>Rise time</b>			
850 mV range	≤265 ps	_____	N/A
8.5 V range	≤265 ps	_____	N/A
<b>Analog bandwidth</b>			
850 mV range	- 3 dB	_____	N/A
8.5 V range	- 3 dB	_____	N/A
<b>CMRR</b>			
850 mV range			
1 MHz	60 dB	_____	N/A
100 MHz	38 dB	_____	N/A
500 MHz	35 dB	_____	N/A
1 GHz	30 dB	_____	N/A
8.5 V range			
1 MHz	45 dB	_____	N/A
100 MHz	25 dB	_____	N/A
500 MHz	20 dB	_____	N/A
1 GHz	18 dB	_____	N/A

## Appendix A: Alternate Verification Procedures

This appendix contains alternate procedures for verifying the following specifications:

- Analog bandwidth
- Common mode rejection ratio

Use these alternate procedures only if you cannot obtain a network analyzer.

### Equipment Required

**Table 8: Test equipment**

Description	Minimum requirements	Example product
Sine wave generator (preferably a synthesizer)	0 dBm to 20 dBm from 1 MHz to 1.5 GHz.	Fluke 6061A
Spectrum analyzer	DC to 3 GHz (dynamic range $\geq 100$ dBm at 1 MHz)	Advantest RSA 3303A
TekVPI Calibration Fixture	Optional probe accessory	Tektronix part number 067-1701-xx
BNC-to-Type N coaxial adapters (2)	Type N male-to-BNC female	Tektronix part number 103-0045-xx
BNC cables (2)	50 $\Omega$ , 18 inch	Tektronix part number 012-0076-xx
Probe tip adapter BNC-to-probe tip	Optional probe accessory	Tektronix part number 067-1734-xx

### Preparation

Prepare the equipment as follows:

1. Connect the equipment as shown. (See Figure 15 on page 29.) This setup is identical to the network analyzer setup in the main procedure, except that the synthesizer and spectrum analyzer replace the network analyzer. (See Figure 10 on page 18.)
2. Allow all test equipment to warm up for 20 minutes in an environment that is within the environmental conditions listed in the specifications section.

Perform the verification procedures in order.

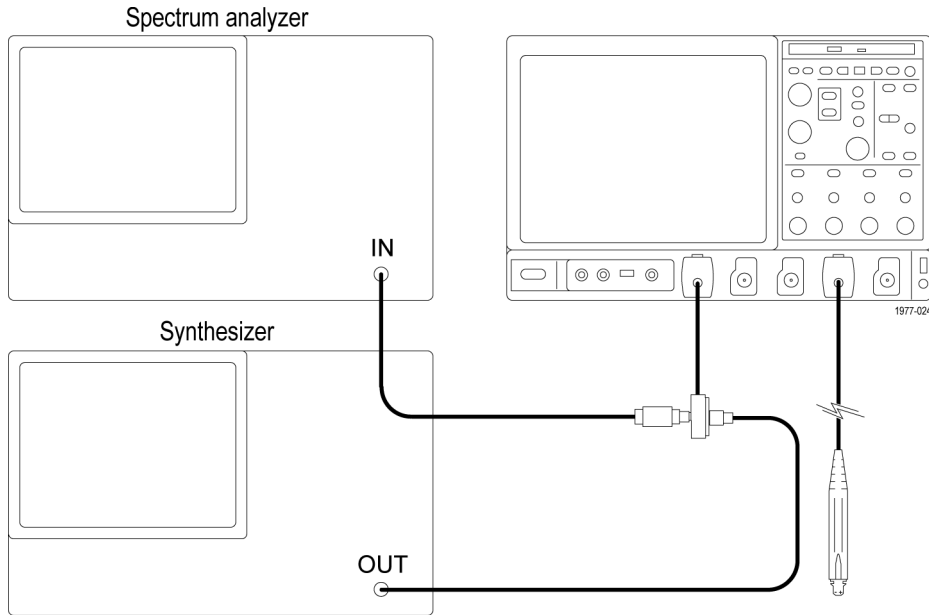


Figure 15: Alternate Bandwidth and CMRR test setup

## Analog Bandwidth

### Normalize the Setup

1. Set the synthesizer for 1.5 GHz/0 dBm.
2. Set the spectrum analyzer:
  - Center frequency at 1.5 GHz.
  - Span to 10 MHz.
  - Resolution bandwidth to auto.
  - Reference level to 0 dBm.
  - Vertical sensitivity to 2 dB/div.
3. Record the level displayed on the spectrum analyzer. (This level represents the synthesizer output minus the signal path loss.)

## Verification

4. Disconnect the BNC cable from the BNC connector in the probe socket on the TekVPI Calibration Fixture.
5. Connect the BNC cable to the BNC-to-probe tip adapter.
6. Connect the probe into the probe socket on the TekVPI Calibration Fixture, and set the probe offset to 0 V.
7. Connect the probe tip to the DM pins of the BNC-to-probe tip adapter. (See Figure 16.)

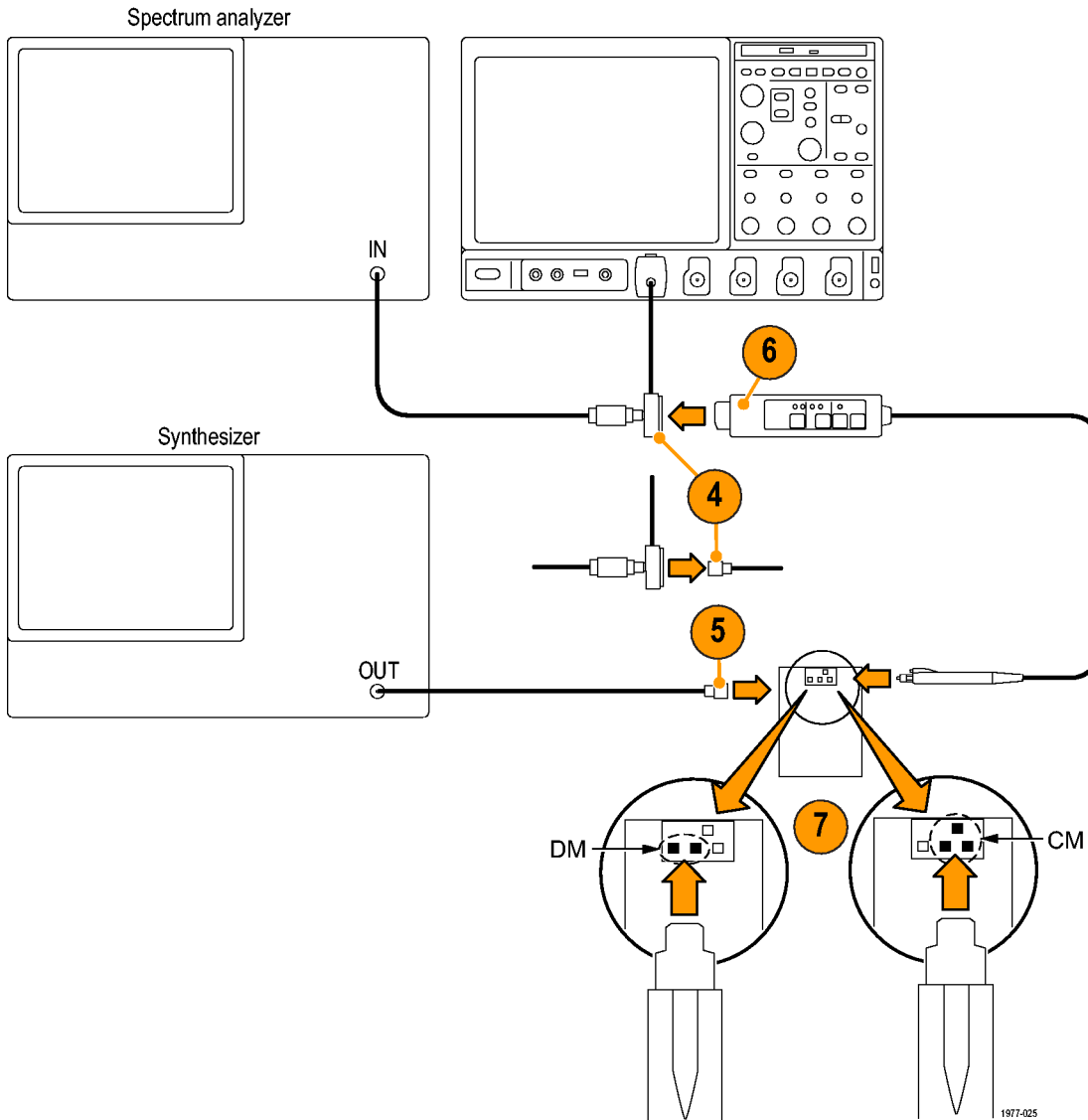


Figure 16: Probe tip test connections

8. Set the probe to the 850 mV range.
9. Adjust the reference level of the spectrum analyzer to display a signal on screen.

10. Record the level displayed on the spectrum analyzer. This level must be within 3 dB of the level that you recorded in step 3.
11. Set the probe to the 8.5 V range.
12. Change the reference level of the spectrum analyzer to -10 dBm. If the signal is not on screen, adjust the reference level to bring the signal on screen.
13. Record the level displayed on the spectrum analyzer. This level must be within 23 dB of the level that you recorded in step 3. For example, if the reference level from step 3 is -1 dBm, and the level that you measured in this step is -22 dBm, then the difference between the two measurements is 21 dBm, which is within the probe specification.
14. Keep the setup for the next procedure (CMRR).



## CMRR (Common Mode Rejection Ratio)

### Verification

Use the setup from the previous test, and enter your measurements in the table below to calculate the CMRR. Record the calculated CMRR in the test record.

1. Set the probe to the 850 mV range.
2. Connect the probe to the DM pins of the BNC-to-probe tip adapter.
3. Set the synthesizer for 1 MHz and 0 dBm.
4. Set the reference level to 5 dBm, the center frequency to 1 MHz, and the vertical scale to 1 dB/div.
5. Adjust the span to 10 kHz and the resolution bandwidth to auto.
6. Record the level displayed on the spectrum analyzer. This represents the differential mode measurement at the 850 mV range.
7. Set the probe to the 8.5 V range.
8. Set the reference level of the spectrum analyzer to -15 dBm.
9. Record the level displayed on the spectrum analyzer. This represents the differential mode measurement at the 8.5 V range.
10. Connect the probe to the CM pins on the BNC-to-probe tip adapter.
11. Adjust the reference level of the spectrum analyzer to display the waveform. Use the noise filter for easier measuring.
12. Record the level displayed on the spectrum analyzer. This represents the common mode measurement at the 8.5 V range.
13. Set the probe to the 850 mV range.
14. Record the level displayed on the spectrum analyzer. This represents the common mode measurement at the 850 mV range.
15. Calculate the CMRR for each voltage range by subtracting the common mode measurement from the differential mode measurement.
16. Repeat the procedure for the remaining frequencies listed in the table.
17. Transfer the calculated values from the table to the test record.

Test frequency	Differential mode measurements		Common mode measurements		CMRR @ 850 mV (calculated)	CMRR @ 8.5 V (calculated)
	850 mV	8.5 V	8.5 V	850 mV		
1 MHz						
100 MHz						
500 MHz						
1 GHz						

## Maintenance

This section contains maintenance information for the TDP1500 differential probe.

### Inspection and Cleaning

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



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**CAUTION.** To prevent damage to the probe, do not expose it to sprays, liquids, or solvents. Do not use chemical cleaning agents; they may damage the probe. Avoid using chemicals that contain benzene, toluene, xylene, acetone, or similar solvents.

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



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**CAUTION.** To prevent damage to the probe, avoid getting moisture inside the probe during exterior cleaning, and use only enough solution to dampen the swab or cloth. Use a 75% isopropyl alcohol solution as a cleanser, and rinse with deionized water.

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### Replacement Parts

Due to the sophisticated design of these differential probes, there are no user replaceable parts within the probes. Refer to the *Quick Start User Manual* for a list of replaceable accessories for your probe.

If your probe does not meet the specifications tested in the Performance Verification, you can send the probe to Tektronix for repair. Follow the procedure below to prevent damage to the probe during shipping.

### Preparation for Shipment

If the original packaging is unfit for use or not available, use the following packaging guidelines:

1. Use a corrugated cardboard shipping carton having inside dimensions at least one inch greater than the probe dimensions. The box should have a carton test strength of at least 200 pounds.
2. Put the probe into an antistatic bag or wrap to protect it from dampness.
3. Place the probe into the box and stabilize it with light packing material.
4. Seal the carton with shipping tape.
5. Refer to *Contacting Tektronix* on the copyright page for the shipping address.