P6250 & P6251
500 MHz and 1 GHz High Voltage Differential Probes

Technical Reference

www.tektronix.com

071-2432-00

Tektronix

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- In North America, call 1-800-833-9200.
- Worldwide, visit www.tektronix.com to find contacts in your area.

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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:

***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.*

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

Service Safety Summary

Only qualified personnel should perform service procedures. Read this *Service Safety Summary* and the *General Safety Summary* before performing any service procedures.

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 instrument power, then disconnect the power cord from the mains power.

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.

To avoid electric shock, do not touch exposed connections.

Preface

This is the Technical Reference for the P6250 & P6251 differential probes. This manual provides specifications and performance verification procedures for the probes.

Specifications

The specifications in the following Tables apply to a P6250 or P6251 differential probe installed on a Tektronix TDS5000B oscilloscope. When the probe is used with another oscilloscope, the oscilloscope must have an input impedance of 50 Ω 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.) The probe calibration should be run on the host instrument before verifying the warranted probe specifications. Specifications for the P6250 and P6251 differential probes 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.

Table 1: Warranted electrical characteristics

Specification	P6250	P6251
✓ Differential signal range (DC coupled)	±4.25 V$_{(DC + peak AC)}$; 3 V $_{RMS}$ ±42 V $_{(DC + peak AC)}$; 30 V $_{RMS}$	±4.25 V$_{(DC + peak AC)}$; 3 V $_{RMS}$ ±42 V $_{(DC + peak AC)}$; 30 V $_{RMS}$
Common-mode signal range (DC coupled)	± 35 V $_{(DC + peak AC)}$; 25 V $_{RMS}$	± 35 V $_{(DC + peak AC)}$; 25 V $_{RMS}$
Maximum nondestructive input voltage between signal and common of the same channel	±100 V$_{(DC + peak AC)}$	±100 V$_{(DC + peak AC)}$
✓ DC attenuation accuracy	±5% of input (both ranges)	±5% of input (both ranges)
✓ Bandwidth (4.25 V range (÷ 5), probe only)	DC to ≥500 MHz	DC to ≥1 GHz
✓ Rise time, 4.25 V range (÷ 5), probe only (10–90%, + 20 °C to + 30 °C)	≤700 ps	≤350 ps
✓ Common-mode rejection ratio	42 V range (÷ 50): >55 dB at 30 kHz >50 dB at 1 MHz >18 dB at 250 MHz	42 V range (÷ 50): >55 dB at 30 kHz >50 dB at 1 MHz >18 dB at 250 MHz
Temperature	Operating: 0 to +40 °C (32 °F to +104 °F) Nonoperating: –55 to +75 °C (–67 °F to –167 °F) [1]	
Humidity	Operating: 0-90% RH, tested at + 30 to +40 °C Nonoperating: 0-90% RH, tested at +30 to +60 °C	

1 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 (Tables 2 and 3) describe typical but not guaranteed performance for both probes.

Table 2: Typical electrical characteristics

Differential input resistance, DC coupled	1 MΩ
Common mode input resistance	500 kΩ
Differential input capacitance	<1.0 pF at 1 MHz
Common-mode input capacitance	<2.0 pF per side at 1 MHz
Harmonic distortion	≤1.5% measured using 495 mV_{RMS} (or 1.4 V_{P-P}) output at 100 MHz
Offset accuracy	±10 mV ±2% of offset setting at 20 to +30 °C (68 °F to +86 °F)
Differential offset range	±4.25 V (÷ 5), ±42 V (÷ 50)
Common mode rejection ratio	(See Figure 5 on page 5.) (See Figure 6 on page 6.)
System noise	
Referred to probe output	<2.0 mV_{RMS} (4.25 V range (÷ 5)), <1.0 mV_{RMS} (42 V range (÷ 50))
Input impedance	(See Figure 7 on page 6.)
Bandwidth limit	≥ –3 dB at 5 MHz
Propagation delay	6.5 ns from probe tip to output

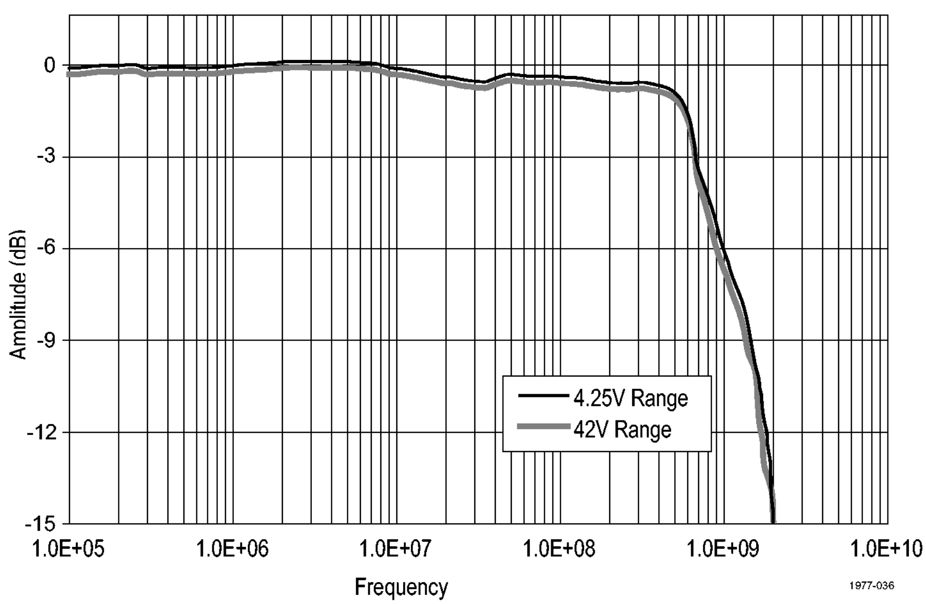


Figure 1: Typical bandwidth (P6250)

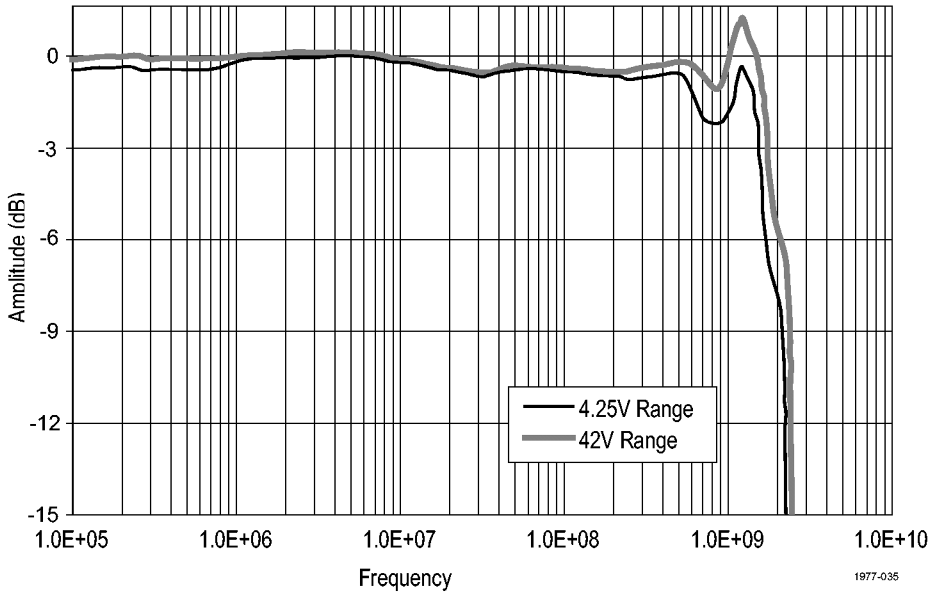


Figure 2: Typical bandwidth (P6251)

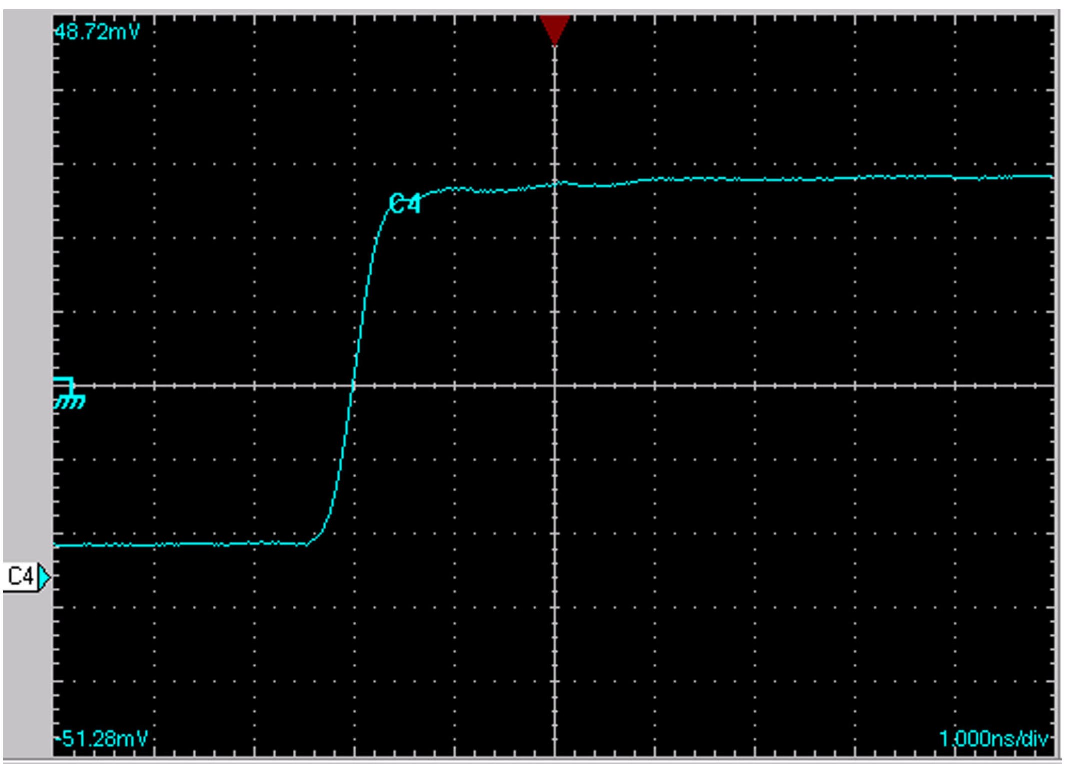


Figure 3: Typical rise time (P6250)

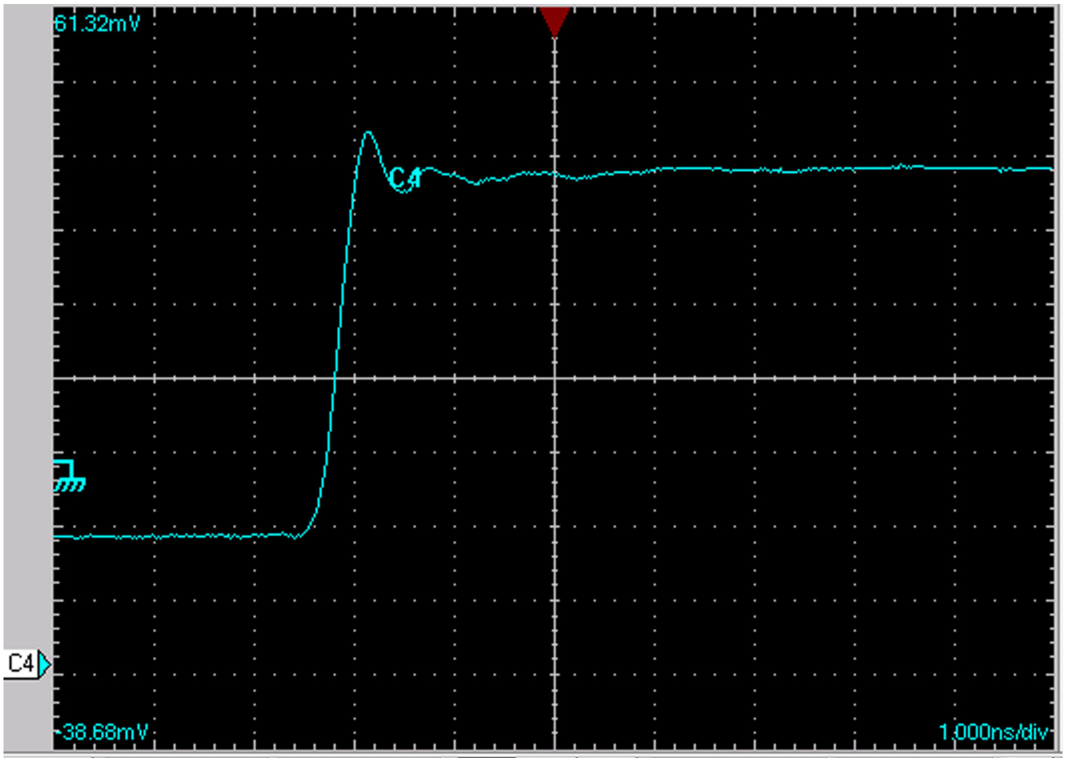


Figure 4: Typical rise time (P6251)

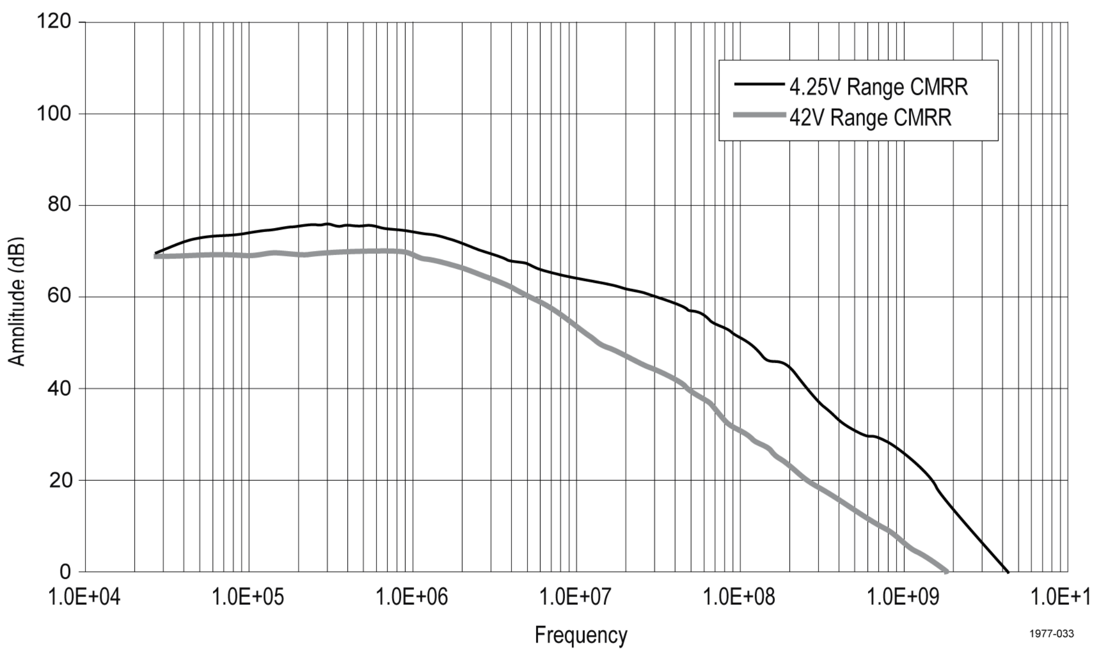


Figure 5: Typical Common-Mode Rejection Ratio (P6250)

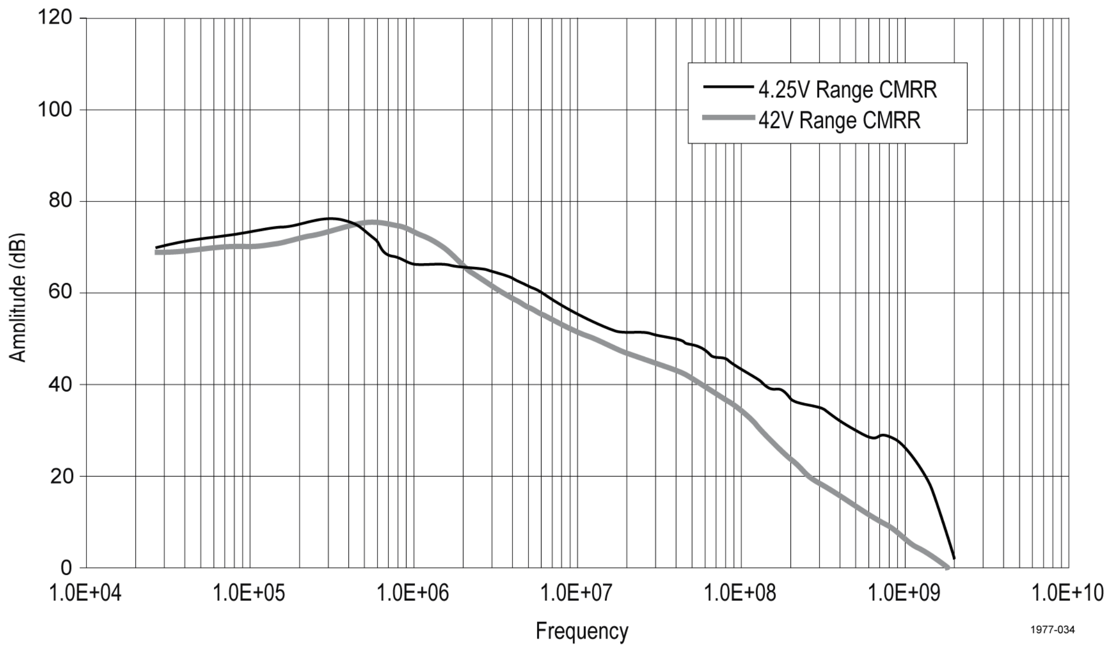


Figure 6: Typical Common-Mode Rejection Ratio (P6251)

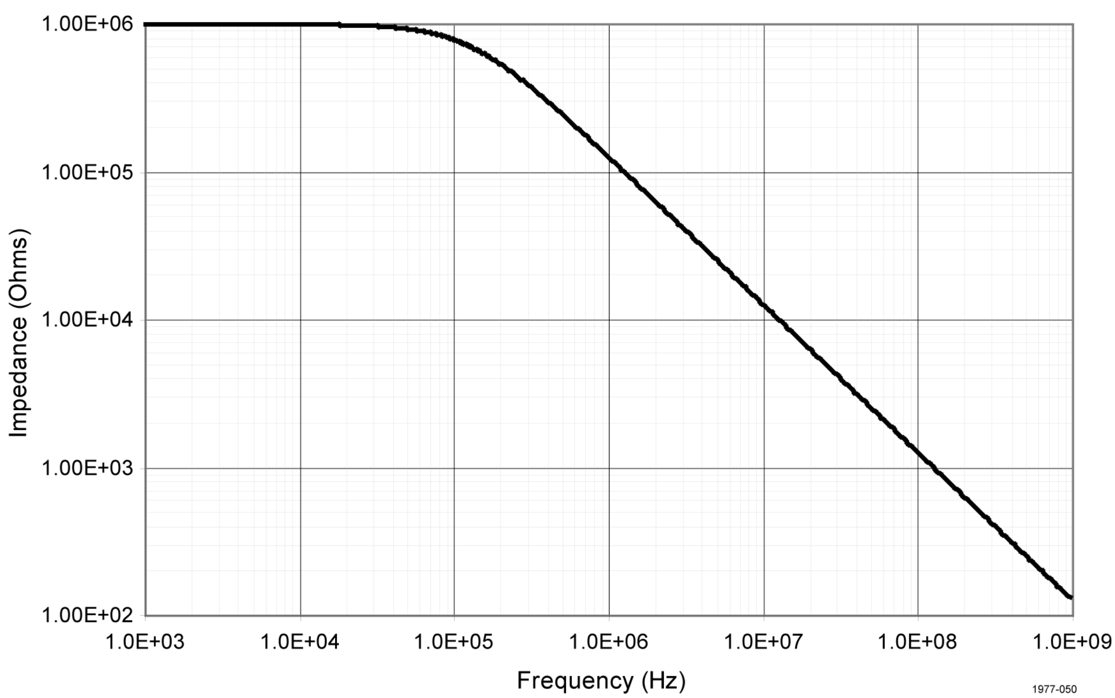
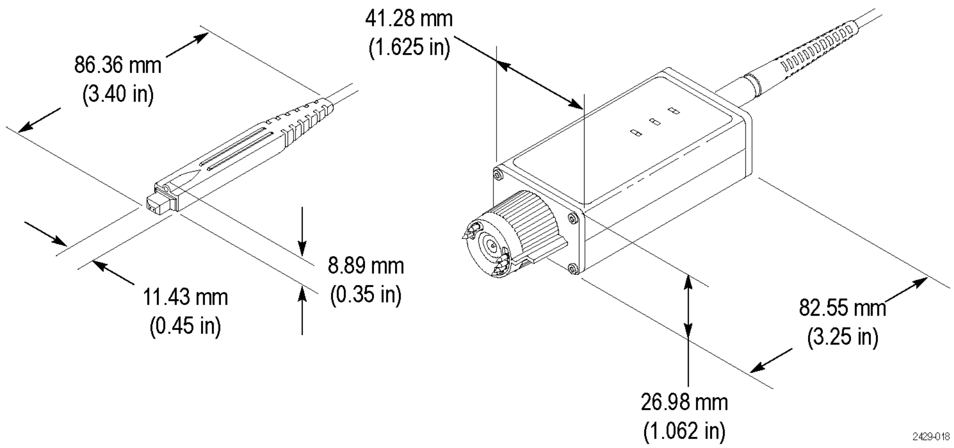


Figure 7: Typical input impedance versus frequency

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	82 mm × 41 mm × 26 mm (3.2 in × 1.6 in × 1.0 in)
Dimensions, probe head	86 mm × 11 mm × 6.3 mm (3.4 in × 0.45 in × 0.25 in)
Dimensions, output cable	1.22 m (48 in)
Unit weight (probe only)	163 g (5.24 oz)



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	4.25 V and 42 V
Termination	Terminate output into 50 Ω

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 obtain 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.

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

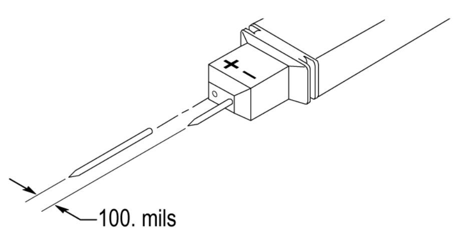
Straight Pins

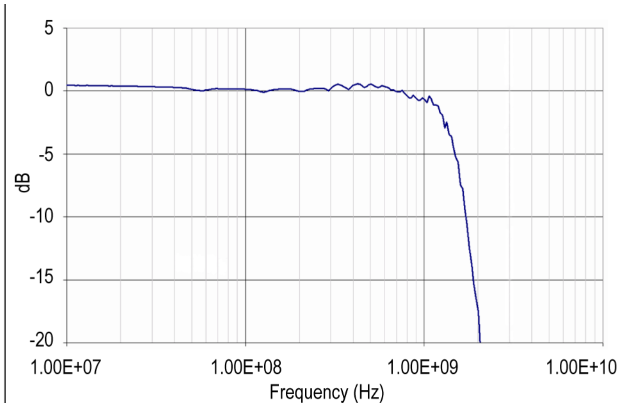
Tektronix part number: 016-1891-xx

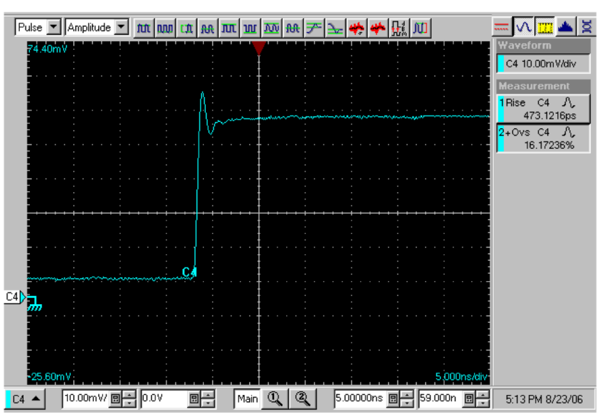
Bandwidth: >1.0 GHz

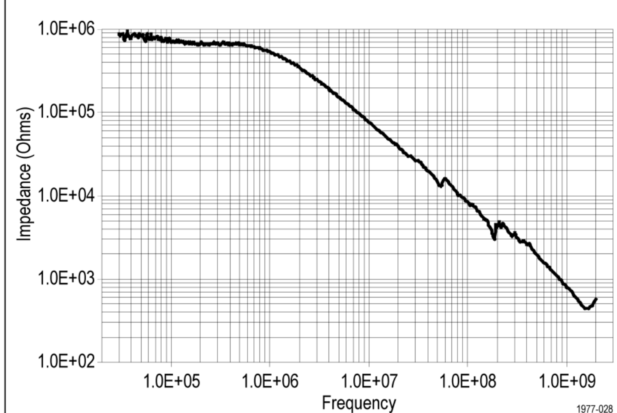
10/90 Rise time: <350 ps

Best overall signal fidelity of the available adapters.









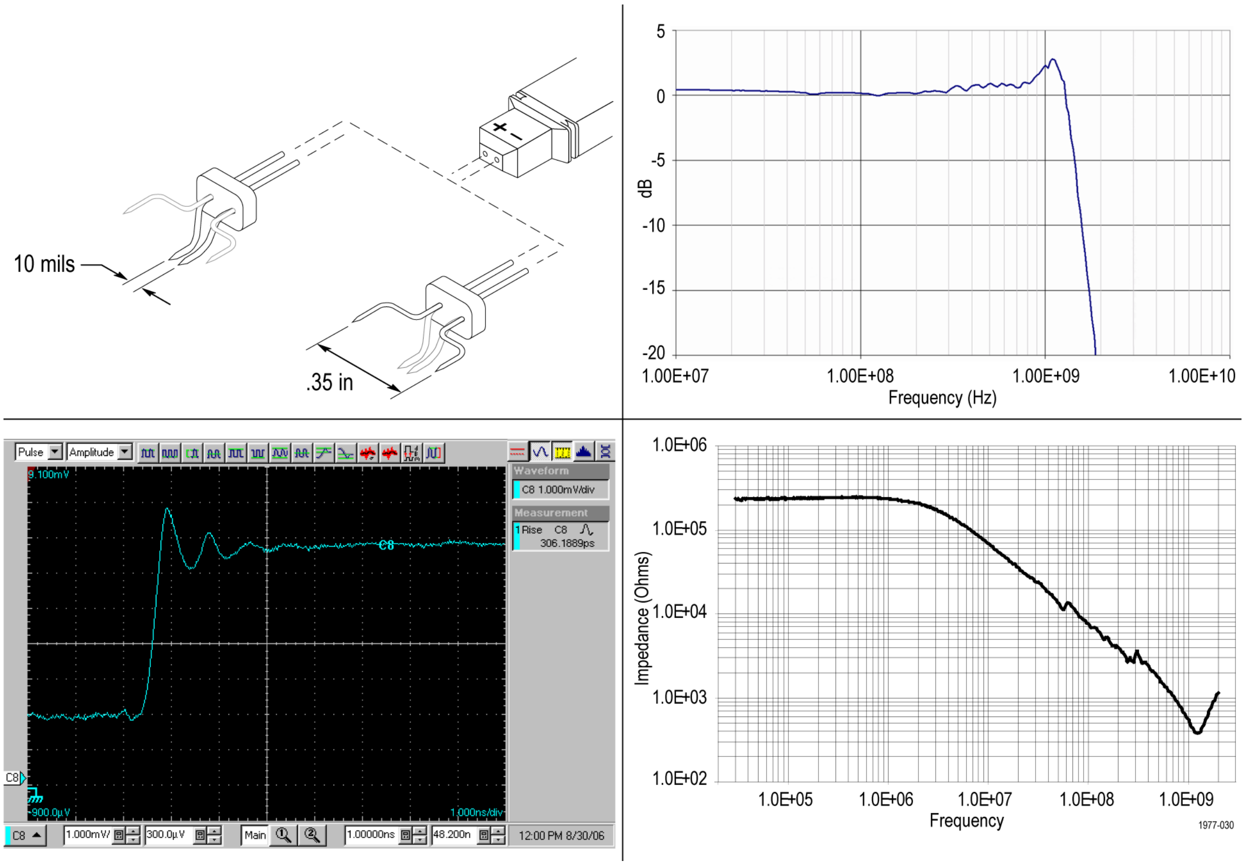
Longhorn Adapter

Tektronix part number: 016-1780-xx

Bandwidth: >1.0 GHz

10/90 Rise time: <350 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.



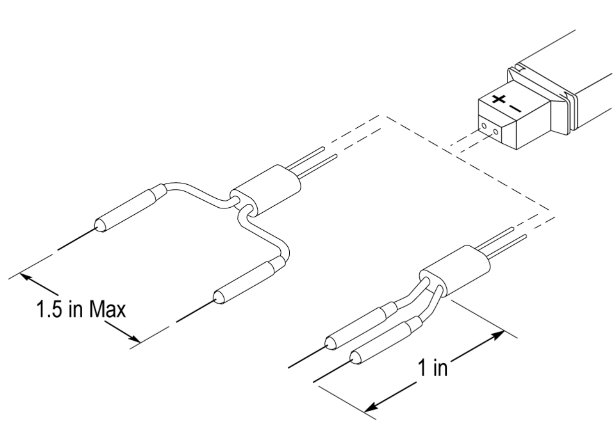
1” Solder Down Adapter

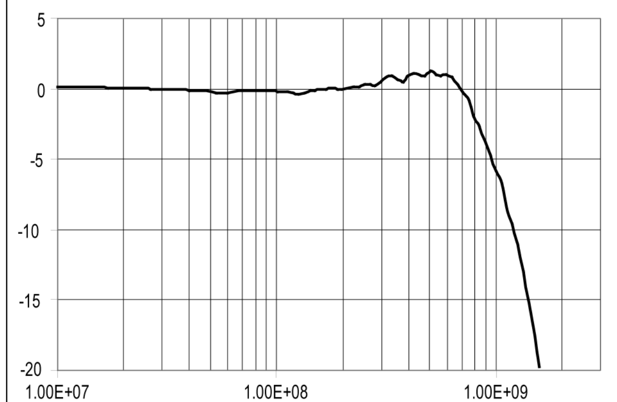
Tektronix part number: 196-3504-xx

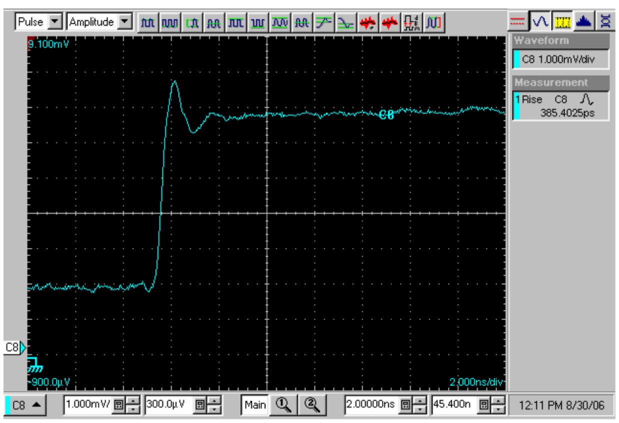
Bandwidth: >820 MHz

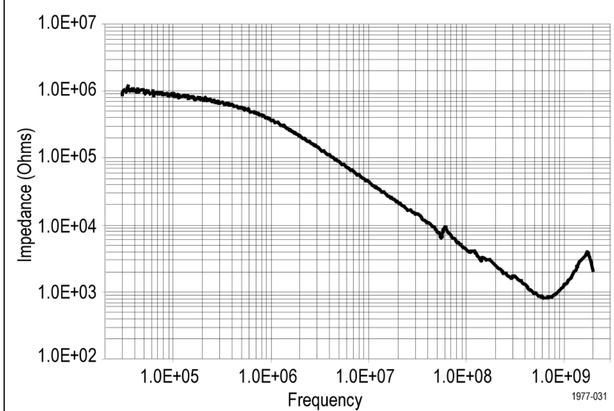
10/90 Rise time: <430 ps

Use this adapter to provide easy access to test points that you frequently check, or that may be difficult to probe with other methods.









3” Solder Down Adapter

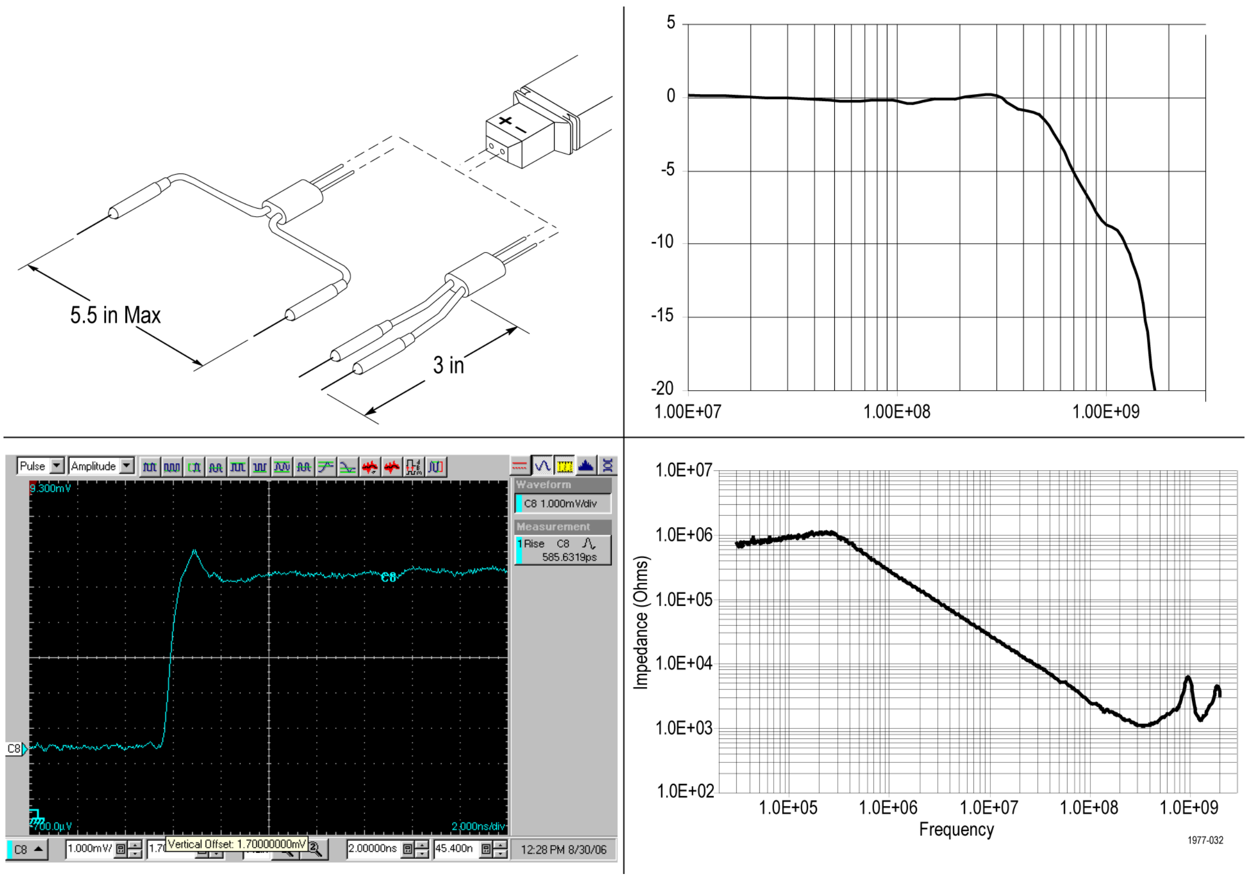
Tektronix part number: 196-3505-xx

Bandwidth: >550 MHz

10/90 Rise time: <635 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.*



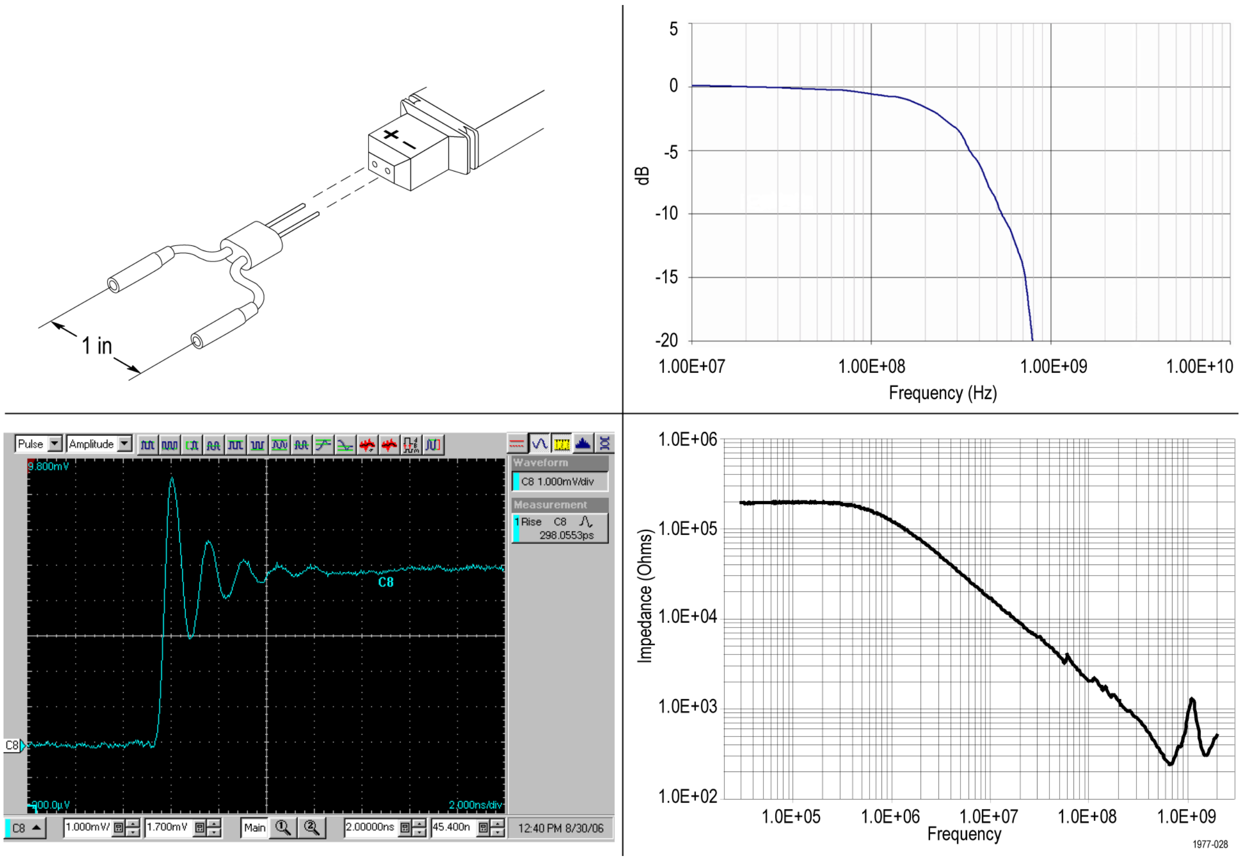
Y-Lead Adapter

Tektronix part number: 196-3434-xx

Usable Bandwidth: <250 MHz

Calculated rise time: 1.4 ns

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



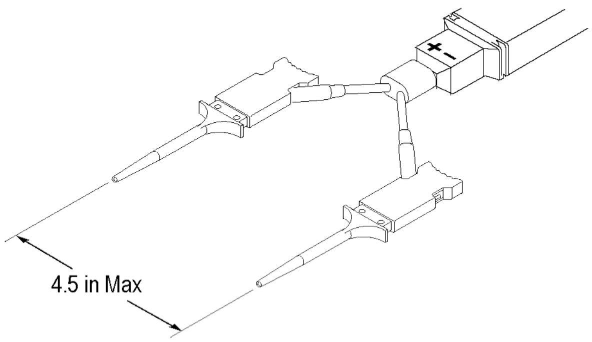
MicroCKT Test Tip Adapter

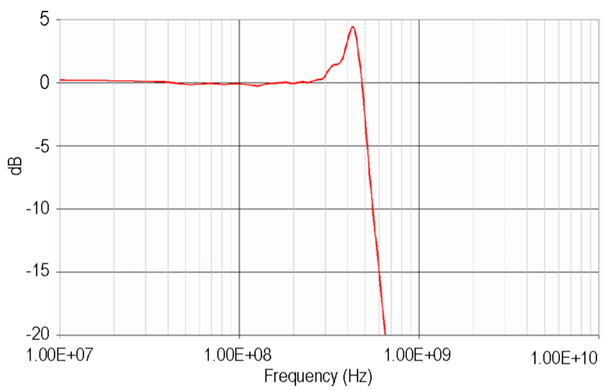
Tektronix part number: 206-0569-xx

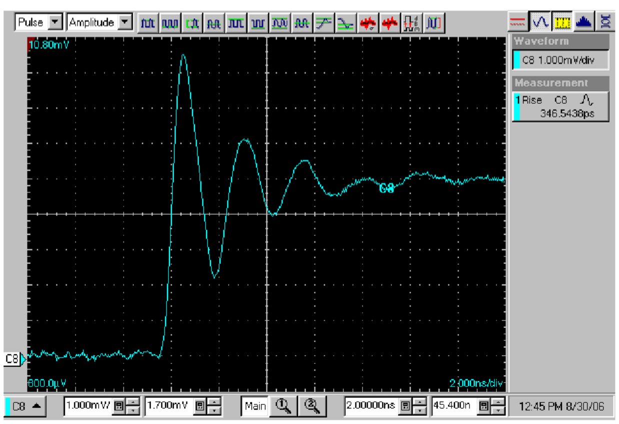
Usable Bandwidth: <100 MHz

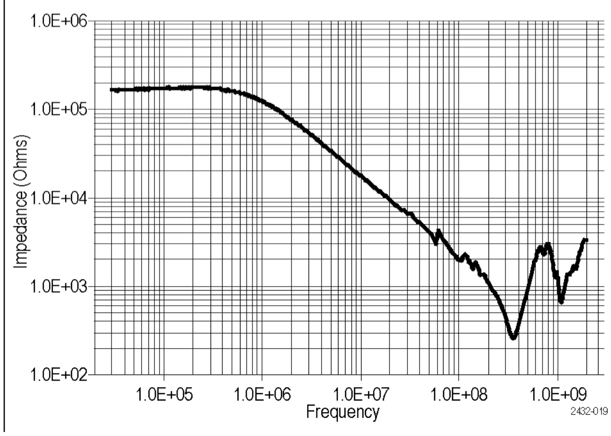
Calculated rise time: 3.5 ns

Use the microCKT test tip adapters 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 P6250 and P6251 Differential Probes. Before beginning these procedures, photocopy the test record and use it to record the performance test results. (See Table 7 on page 35.) 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.

Optional procedures are provided to test the following typical specifications:

- High voltage rise time

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.*

Table 5: Test equipment

Description	Minimum requirements	Example product
Network analyzer	100 kHz to ≥2 GHz, with cables and adapters to BNC male and SMA male	Hewlett Packard 8753D
Sampling oscilloscope		Tektronix TDS8000 series oscilloscope
Sampling Module	TDR output; 250 mV step, <100 ps rise time	Tektronix 80E04
Power Supply		Tektronix 1103 power supply
BNC-to-probe tip adapter	Optional probe accessory	Tektronix 067-1734-xx
BNC-to-SMA Female adapter (2)	As per description	Tektronix 015-0572-xx
Calibrated DC voltage source (2)	Adjustable from 0 V to ≥42 V. Outputs must be isolated from earth ground.	Keithley 2400
DMM (2 required)	DC Accuracy ≥ 0.5% on range to measure 42 V, averaging mode.	Fluke 187
BNC cables (2)	50 Ω, 42 inch	Tektronix 012-0057-xx
SMA cable (2)	50 Ω, 28 inch	Tektronix 012-0649-xx
Banana-to-banana patch cords (3)	2 red 1 black	Tektronix 012-0031-xx Tektronix 012-0039-xx
Dual-male-banana-to-female BNC adapter (3)	As per description	Tektronix 103-0090-xx
BNC male to dual binding post adapter (2)	As per description	Tektronix 103-0035-xx
Precision inline BNC terminator	50 Ω ±0.1%	Tektronix 011-0129-xx
Y-lead	Standard accessory included w/probe	Tektronix 196-3434-xx
MicroCKT test tip (2)	Standard accessory included w/probe	Tektronix 206-0569-xx
0.025” square pins (3)	Approximately 3/4 inch long, smooth, gold plated.	
Note: The equipment listed below is for the optional 42 V rise time test.		
High Voltage Pulse Generator	42 V, 300 ps rise time	Picosecond Labs 2600C
Probe calibration fixture	Optional probe accessory	Tektronix 067-0419-xx
Termination	50 W, 50 Ω, SMA connector	JFW 50T 334–1.0

Attenuator	100 X, 50 W, BNC connector	Aeroflex 60B50W-40dB
Spring-loaded probe tip pins	P7260 probe accessory	Tektronix 016-1917-xx

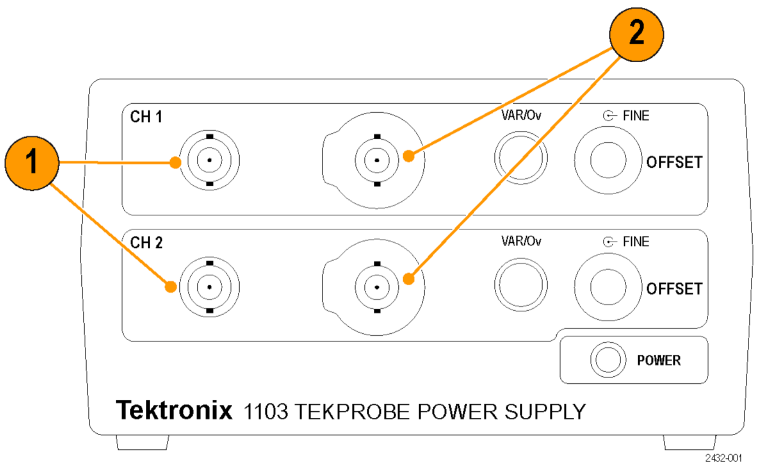
Special Adapters

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

1103 Power Supply

The 1103 power supply is used to power the probe under test. BNC connectors on the front of the power supply provides access to the probe output signal for performance verification measurements.

1. BNC connector for probe output measurements
2. BNC input connections



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 8.) 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)

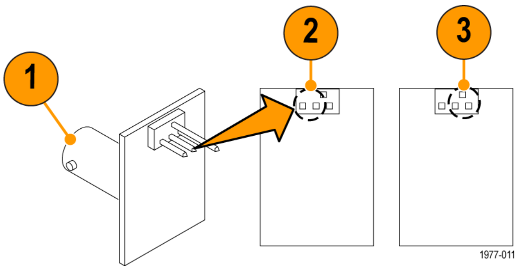


Figure 8: BNC-to-probe tip adapter

Probe Calibration Fixture (Optional)

The Probe Calibration Fixture, Tektronix part number 067-0419-xx, provides a means to check the rise time specification of the probe at the 42 V range (÷ 50) (See Figure 9.) This check is not required to complete the performance verification of the probe, but is provided for users who want to check the probe rise time at the higher voltage range.

1. SMA connectors for input/output signals and terminations
2. Common Mode (CM) test points
3. Differential Mode (DM) test points

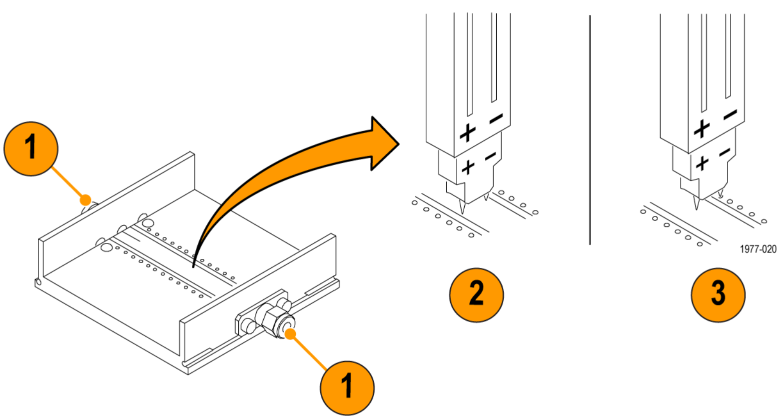


Figure 9: Probe calibration fixture connections

Preparation

***CAUTION.** To prevent damage to the 80E04 sampling head, plug in the sampling head and then power on the TDS8000 oscilloscope.*

Prepare the equipment as follows:

1. Connect the 80E04 sampling head to channel 1 of the sampling oscilloscope and then power on the TDS8000 oscilloscope.
2. Plug in and power on all test equipment. (See Table 5 on page 16.)
3. Connect the probe to channel 1 of the 1103 power supply.
4. Allow the probe and test equipment to warm up for 20 minutes at an ambient temperature of 20 °C to 30 °C.
5. Photocopy the test record and use it to record the test results. (See Table 7 on page 35.)

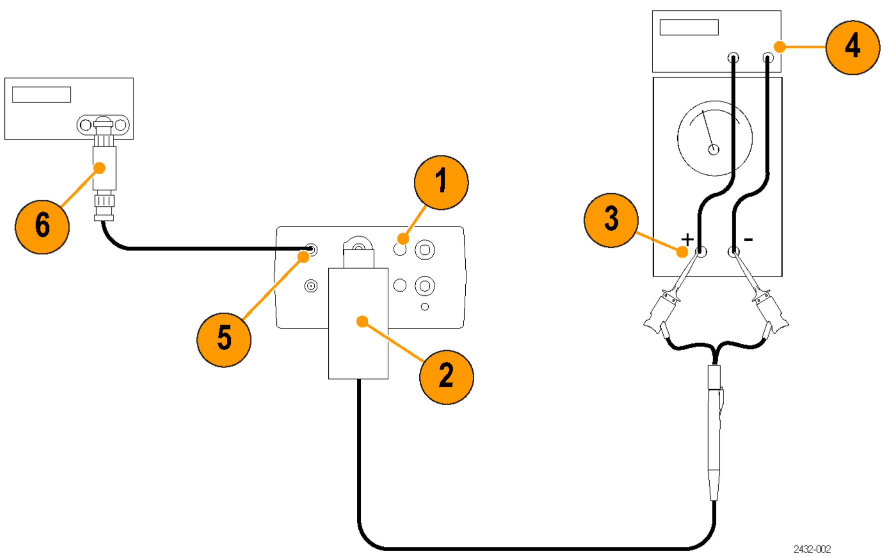
Perform the verification procedures in order.

DC Attenuation Accuracy

This test checks the probe gain by measuring known voltages with a multimeter. The probe is then used to measure the same voltages, and then a comparison calculation is made.

Preparation

1. Press the VAR/0v button to the off position on the 1103 power supply (the button is not lighted).
2. Set the probe to the 42 V range (÷ 50), DC reject off, and full bandwidth.
3. Connect the MicroCKT test tips to the DC source. Observe proper polarity: red to (+), black to (–).
4. Connect a DMM to the DC source and set the DMM to DC volts.
5. Connect the BNC cable to the output connector of channel 1 on the 1103 power supply.
6. Connect the Precision BNC terminator (011-0129-XX) to the second DMM using a BNC-to-dual banana adapter .
7. Connect the other end of the BNC cable to the Precision BNC terminator.



Verification

42 V Range (÷ 50).

8. Set the input voltage on the DC source to approximately 40 V. Record the actual voltage as $V_{in}1$.
9. Record the output voltage as $V_{out}1$.
10. Set the input voltage on the DC source to approximately 20 V. Record the actual voltage as $V_{in}2$.
11. Record the output voltage as $V_{out}2$.
12. Set the input voltage on the DC source to approximately 5 V. Record the actual voltage as $V_{in}3$.
13. Record the output voltage as $V_{out}3$.

14. Calculate the attenuation twice, using the values from the measurements as follows: $(V_{in}1 - V_{in}2) \div (V_{out}1 - V_{out}2)$ and $(V_{in}2 - V_{in}3) \div (V_{out}2 - V_{out}3)$.

15. Verify that the attenuation is in the range of 49 to 51. Record the results in the test record.

4.25 V Range (÷ 5).

16. Set the input voltage on the DC source to approximately 4.2 V ±50 mV. Record the actual voltage as $V_{in}1$.

17. Change the probe voltage range to 4.25 V (÷ 5).

18. Record the output voltage as $V_{out}1$.

19. Set the input voltage on the DC source to 2 V, and record the actual voltage as $V_{in}2$.

20. Record the output voltage as $V_{out}2$.

21. Set the input voltage on the DC source to approximately 0.5 V. Record the actual voltage as $V_{in}3$.

22. Record the output voltage as $V_{out}3$.

23. Calculate the attenuation twice, using the formulas from the previous test. Refer to step 14.

24. Verify that the attenuation is in the range of 4.9 to 5.1. Record the results in the test record.

25. Slide the DC Reject switch on the probe to turn DC reject on.

26. Verify that the output returns to approximately 0 volts. (This is a functional check; there is no specified performance limit.)

27. Slide the DC Reject switch on the probe to turn DC reject off.

28. Keep the output connections for the next procedure.

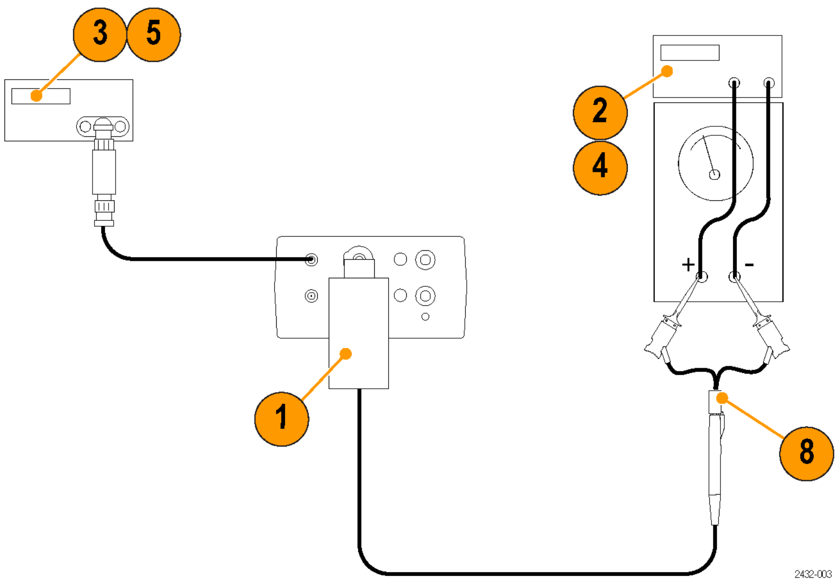
Differential Signal Range

This procedure *directly* verifies the differential signal range and *indirectly* verifies the common-mode signal range. This procedure uses the setup from the previous test.

Verification

42 V Range (÷ 50).

1. Set the probe to the 42 V range (÷ 50), DC reject off, and full bandwidth.
2. Set the input voltage on the DC source to 0 V, and verify that it is 0 V with the multimeter.
3. Measure the probe output voltage as V_{offset}. You will use this offset voltage to acquire accurate results in the calculations below.



4. Set the input voltage on the DC source to 42 V ±100 mV, and record the actual voltage as V_{in}.
5. Measure and record the output voltage as V_{out}.
6. Calculate attenuation as $|V_{in} \div (V_{out} - V_{offset})|$.
7. Verify that the attenuation is in the range of 47.5 to 52.5. Record the results in the test record.
8. Reverse the Y-lead connection on the probe to reverse the polarity of your following measurements.
9. Measure and record the output voltage as V_{out}.
10. Calculate attenuation using the formula in step 6.
11. Verify that the attenuation is in the range of 47.5 to 52.5. Record the results in the test record.

4.25 V Range (÷ 5).

12. Reverse the Y-lead connection on the probe (back to: red to +, black to –).
13. Set the DC source to 4.25 V ±10 mV, and record the actual voltage as V_{in}.

14. Set the probe to the 4.25 V range (÷ 5).

15. Measure and record the output voltage as V_{out}.

16. Calculate attenuation using the formula in step 6.

17. Verify that the attenuation is in the range of 4.75 to 5.25. Record the results in the test record.

18. Reverse the Y-lead connection on the probe to reverse the polarity of your following measurements.

19. Measure and record the output voltage as V_{out}.

20. Calculate attenuation using the formula in step 6.

21. Verify that the attenuation is in the range of 4.75 to 5.25. Record the results in the test record.

22. Disconnect the probe from the test setup and connect it to any oscilloscope channel to keep the probe at operating temperature.

Analog Bandwidth

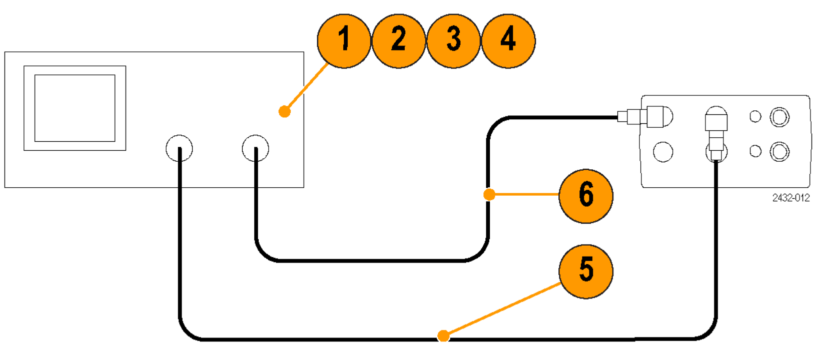
The following steps prepare the network analyzer for measuring bandwidth and CMRR. The actual settings may vary with different models of network analyzer. Refer to the user documentation supplied with the network analyzer for details on performing these steps.

***NOTE.** An alternative procedure for testing the analog bandwidth and CMRR without a network analyzer is available.*

Preparation

The 1103 power supply can operate two probes. To keep the probe warmed up, move it to channel 2 of the 1103 while normalizing channel 1.

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 –14 dB, and linear frequency.
3. Set the start frequency to ≈ 30 kHz (or the lowest frequency on the network analyzer) and the stop frequency to ≈ 2 GHz.
4. Set the test port power to +10 dBm .
5. Set the IF bandwidth to 10 kHz.
6. Attach the cable from port 1 to the 1103 channel 1 input connector (TekProbe connector). Use a male BNC adapter if necessary.
7. Attach the cable from port 2 to the 1103 channel 1 output connector (conventional BNC). Use a male BNC adapter if necessary.
8. Normalize the network analyzer to remove the loss through channel 1 of the 1103 power supply.

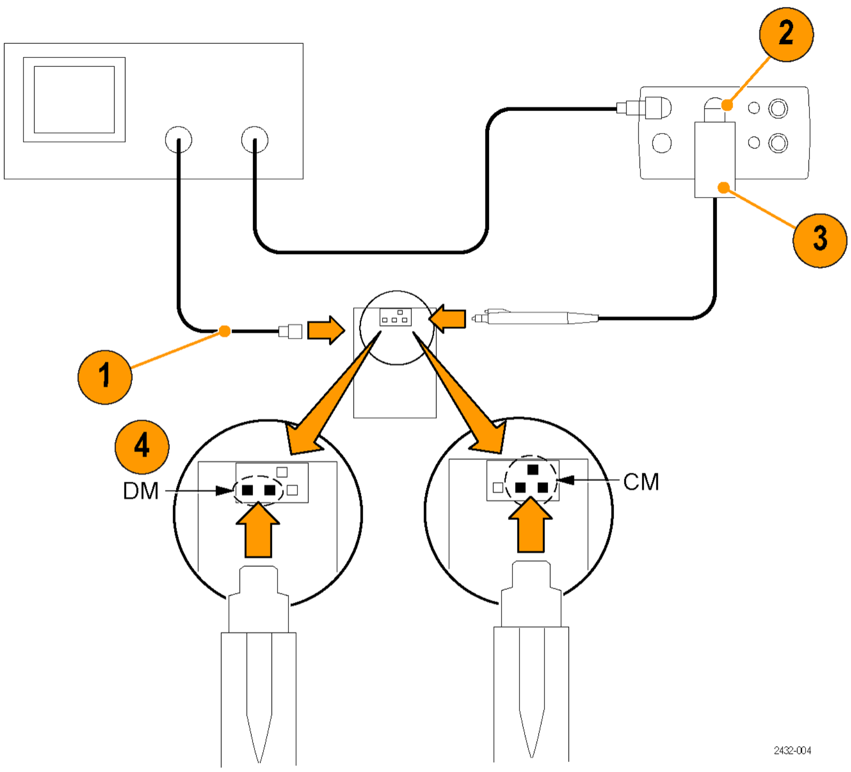


Verification

4.25 V Range (÷ 5).

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

1. Disconnect the port 1 cable from the 1103 channel 1 input connector and connect to the BNC-to-probe tip adapter.
2. Move the probe from the 1103 channel 2 to channel 1 input connector.
3. Set the probe for ÷ 5 attenuation, full bandwidth, DC reject off.
4. Connect the probe input to the DM pins on the BNC-to-probe-tip adapter. Polarity is unimportant.
5. The setup should now appear as shown below.



6. Read the amplitude at 500 MHz for the P6250 or 1 GHz for the P6251. The use of the marker function, (if equipped), will simplify resolving the bandwidth.
7. Verify that the amplitude is greater than –17 dB. (Subtracting the –14 dB of probe attenuation in the 4.25 V range (÷ 5) from the –17 dB target value yields the 3 dB limit.) Record the results in the test record.

42 V Range (÷ 50).

8. Set the probe to the 42 V range (÷ 50).

9. Change the reference value on the network analyzer to keep the plot on screen (–34 dB).

10. Using the marker (if equipped), measure the output amplitude at 500 MHz for the P6250 or 1 GHz for the P6251.

11. Verify that the amplitude is greater than –37 dB. (Subtracting the –34 dB of probe attenuation in the 42 V range from the –37 dB target value yields the –3 dB limit.) 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

42 V Range (÷ 50).

1. Set the reference value of the network analyzer to –34 dB and position the reference near the top of the screen.
2. Verify that the test port power is set to +10 dBm.
3. Connect the probe input to the DM pins on the BNC-to-probe tip adapter. Polarity is unimportant.
4. Set the probe to the 42 V range (÷ 50), full bandwidth, and DC reject off.
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 BNC-to-probe tip adapter. Make sure to connect the probe ground socket to the long ground pin on the fixture.
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 30 kHz, 1 MHz, and 250 MHz. Analyzers with marker capability can do this directly by setting the marker intercepts at 30 kHz, 1 MHz, and 250 MHz. If necessary, turn on the network analyzer Average mode with 16 averages to stabilize the reading.
10. Verify that the CMRR is greater than the values listed in the following, and record the results in the test record.

Table 6: CMRR limits

Frequency	42 V Range (÷ 50) CMRR
30 kHz	≥55 dB
1 MHz	≥50 dB
250 MHz	≥18 dB

11. Disconnect the equipment.

Rise Time

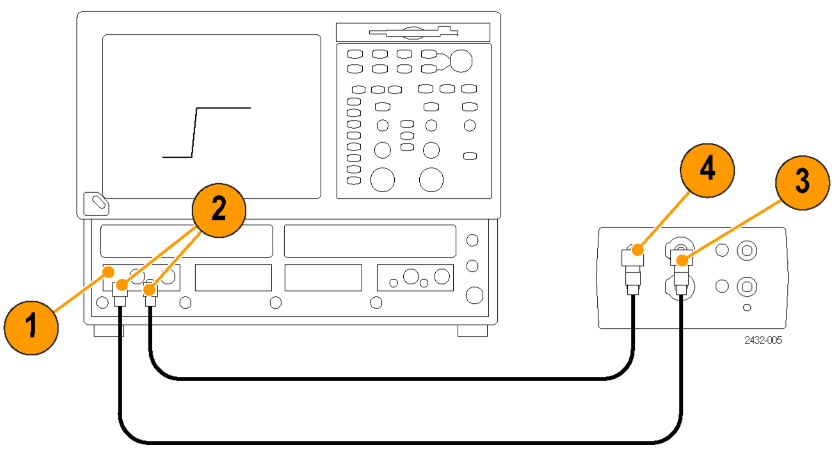
This procedure verifies that the probe meets the warranted rise time specification of the 4.25 V range (÷ 5). Two rise times are measured; the test system alone, and then the test system with the probe included. The probe rise time is calculated using the two measurements.

This test uses the 80E04 as a fast rise time signal source. The second channel of the 80E04 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 to the SMA connectors, 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.*

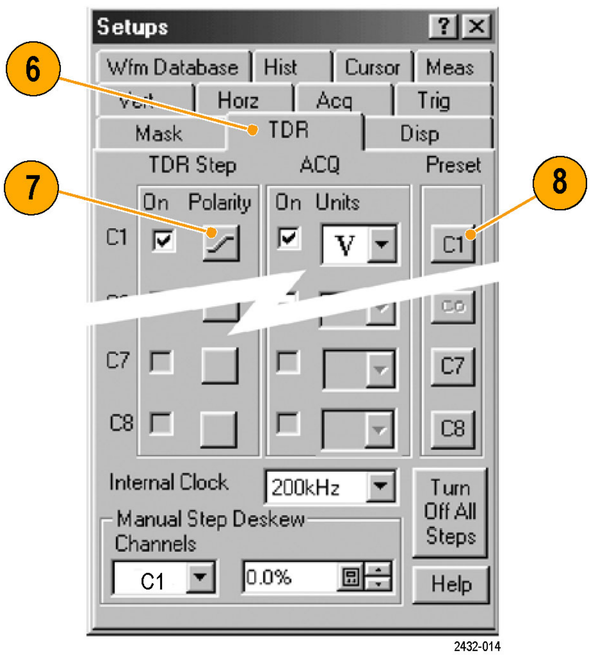
Test System Rise Time

1. Connect the 80E04 sampling head to Channel 1 of the sampling oscilloscope.
2. Connect SMA cables to Channels 1 and 2 on the sampling head.
3. Connect the SMA cable from Channel 1 to the probe input BNC connector on the 1103 power supply using an SMA-BNC adapter.
4. Connect the SMA cable from Channel 2 to an SMA-to-BNC Adapter, and then to the output BNC connector on the 1103 power supply.
5. Turn on Channel 2 and set the vertical scale to 50 mV/div.



6. Set the Channel 1 sampling head to TDR mode: press the **SETUP DIALOGS** button and select the TDR tab. Refer to the following illustration.
7. Set the Channel 1 (**C1**) **Polarity** to positive (rising).
8. 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.



9. Turn off the display for Channel 1 so that only Channel 2 is shown on screen.
10. Adjust the oscilloscope vertical positioning to center the signal on screen.
11. Set the oscilloscope horizontal scale to 200 ps/div and center the waveform.
12. Use the oscilloscope measurement capability 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.
13. Record the rise time as t_s. This measurement represents the rise time of the test system without the probe.

    The following steps instruct you to assemble the test setup that includes the probe. The system and probe rise time (ts+p) that you measured in step 12 is used to calculate the probe rise time (tp) in step 14.

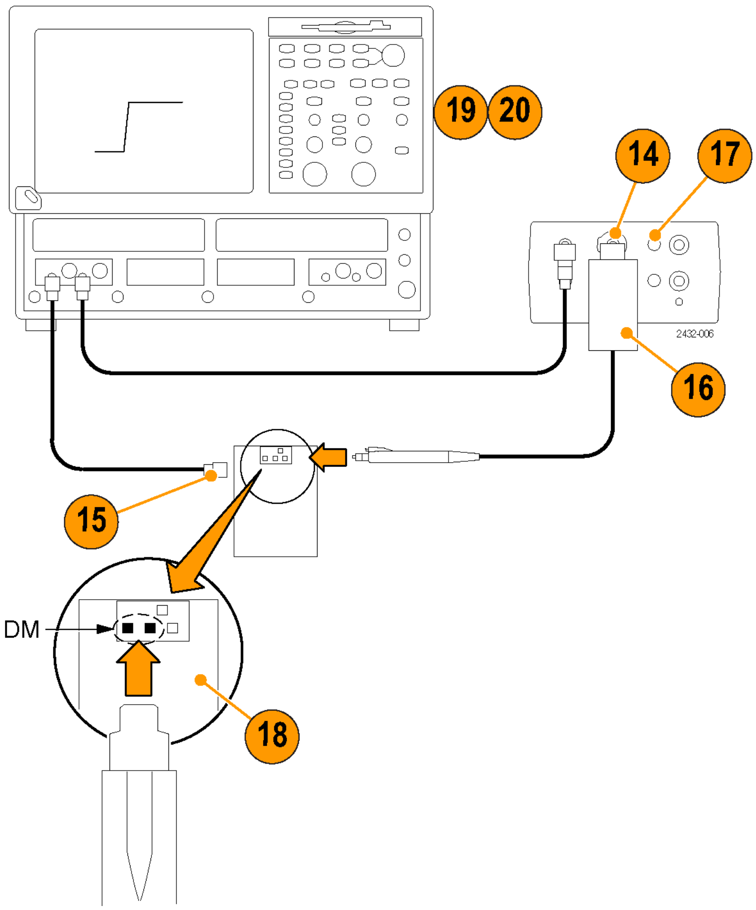
Test System and Probe Rise Time

14. Disconnect the SMA cable and BNC adapter from the Channel 1 input of the 1103 power supply.

15. Connect the SMA cable to the BNC-to-probe tip adapter.

16. Connect the probe to the 1103 power supply channel 1 input and set the attenuation to ÷ 5.

17. Turn off the offset control on channel 1 of the 1103 power supply.



18. Connect the probe to the DM test points on the BNC-to-probe tip adapter.

19. Adjust the oscilloscope vertical scale to 20 mV/div, averaging on.

20. Adjust the oscilloscope horizontal positioning to place the rising edge of the signal so that it crosses the second vertical and center horizontal graticule lines.

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.

22. Record the rise time as t_{s+p}.

23. Using the test system rise time (t_s) that you measured in step 12, 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:

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

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

$$t_p = \sqrt{200000}$$

$$t_p = 447.2\,ps$$

24. Record the calculated probe rise time on the test record.

This completes the performance verification. An optional rise time check for the 42 V range (÷ 50) follows.

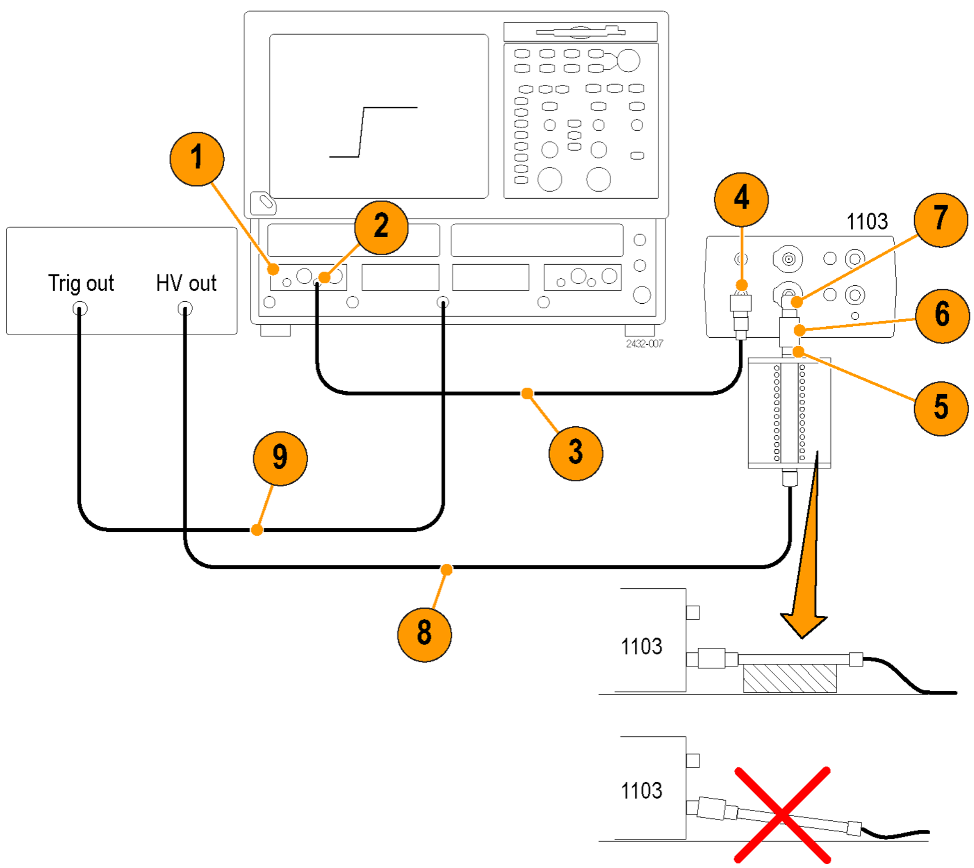
High Voltage Rise Time Check (Optional)

Use the following optional test to check the probe rise time on the 42 V range (÷ 50) setting.

***WARNING.** Burn hazard exists. The 50 W termination used in this test becomes hot if the duty cycle of the pulse generator is higher than 10%. Use caution when locating the termination in your test setup.*

Test System Rise Time

1. Connect the 80E04 sampling head to the sampling oscilloscope.
2. Connect an SMA cable to Channel 2 on the sampling head.
3. Connect an SMA to BNC adapter to the other end of the SMA cable.
4. Connect the SMA cable from Channel 2 to the output of the 1103 power supply.
5. Connect an SMA-to-BNC adapter to one of the SMA connectors on the probe calibration fixture.
6. Connect one end of the high power attenuator to the BNC adapter on the probe calibration fixture.
7. Connect the other end of the high power attenuator to the BNC connector on the 1103 power supply (Channel 2). It is recommended that you support the probe calibration fixture as shown below, when it is attached to the 1103 power supply.



8. Connect a short SMA cable from the other SMA connector on the probe calibration fixture to the high voltage output connector on the pulse generator.

9. Connect the trigger out from the pulse generator to the trigger in on the sampling oscilloscope.

WARNING. *To reduce the risk of electric shock, do not exceed 42 Vpk on the pulse generator. Use caution when making measurements.*

10. Turn on Channel 2 and set the vertical scale to 100 mV/div.

11. Turn on the pulse generator and set the output to approximately 40 V.

12. Adjust the oscilloscope horizontal and vertical position controls to display a rise time signal similar to that shown in the setup figure.

13. Set the oscilloscope horizontal scale to 500 ps/div and center the waveform.

14. Use the oscilloscope measurement capability 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.

15. Record the rise time as t_s.

Test System and Rise Time

16. Disconnect the SMA-to-BNC adapter from the BNC connector on the 1103 power supply.

17. Connect the BNC end of the adapter to the 50 W termination.

18. Connect the probe to the 1103 power supply.

19. Connect two spring-loaded probe tips to the probe head sockets.

20. Slide the switch on the probe to the 42 V range (÷ 50).

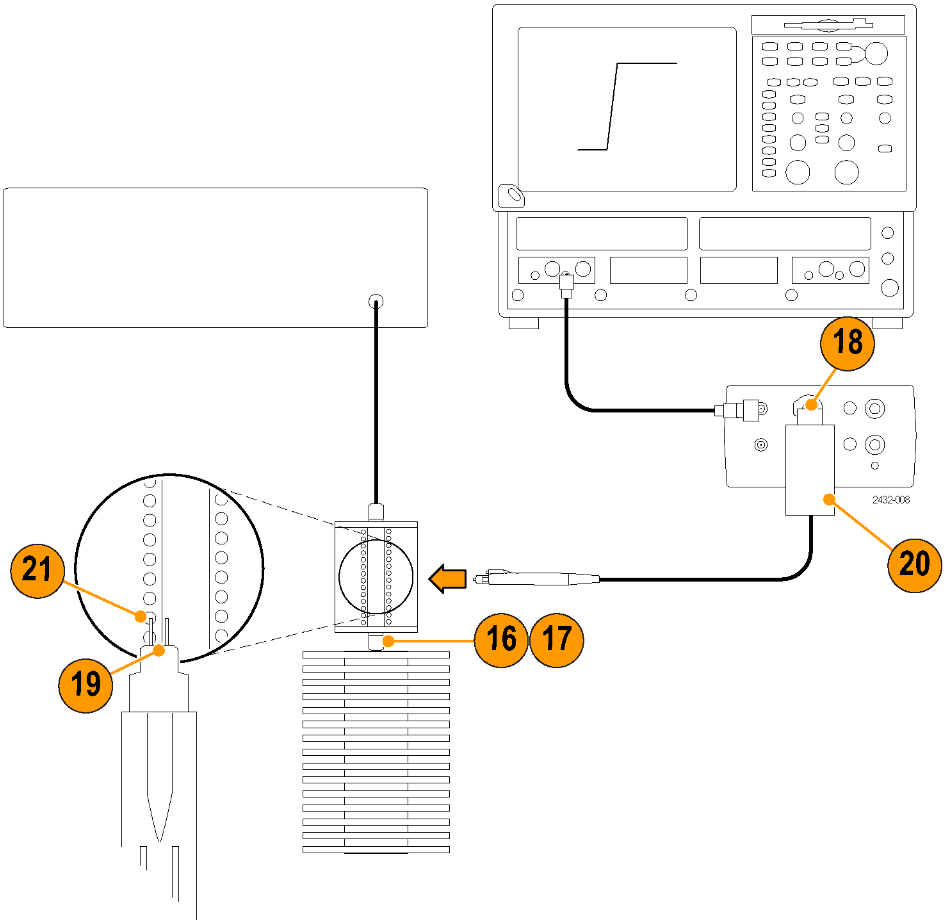
21. Touch the probe tips to the DM pads on the probe calibration adapter and measure the rise time.

22. Perform the calculation with the two measured rise times and the formula below. A typical result is about 330 ps.

23. Record the measured rise time of the system and probe as t_{s+p}. This measurement at the 42 V range (÷ 50) is typically about 400 ps.

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

This completes the performance verification procedures.


18
20
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2432-008

Table 7: Test Record

Probe Model/Serial Number: _____________ Certificate Number: _____________

Temperature: _____________ RH % : _____________

Date of Calibration: _____________Technician: _____________

Performance test	Minimum	Measured/Calculated	Maximum
DC attenuation accuracy			
42 V range (÷ 50)	49	_____________	51
4.25 V range (÷ 5)	4.9	_____________	5.1
Differential signal range			
42 V range (÷ 50)	47.5	_____________	52.5
with connections reversed	47.5	_____________	52.5
4.25 V range (÷ 5)	4.75	_____________	5.25
with connections reversed	4.75	_____________	5.25
Rise Time			
4.25 V range (÷ 5)			
P6250 at 500 MHz	≤700 ps	_____________	N/A
P6251 at 1 GHz	≤350 ps	_____________	N/A
Analog bandwidth			
P6250 at 500 MHz			
P6251 at 1 GHz			
4.25 V range (÷ 5)	- 3 dB	_____________	N/A
42 V range (÷ 50)	- 3 dB	_____________	N/A
CMRR			
42 V range (÷ 50)			
30 kHz	55 dB	_____________	N/A
1 MHz	50 dB	_____________	N/A
250 MHz	18 dB	_____________	N/A

Alternate Verification Procedures

This section 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 for Performance Verification

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 GHz.	Fluke 6061A
Spectrum analyzer	DC to 3 GHz (dynamic range ≥100 dBm at 1 MHz)	Advantest RSA 3303A
Power supply		Tektronix 1103 power supply
BNC-to-Type N coaxial adapters (2)	Type N male-to-BNC female	Tektronix 103-0045-xx
BNC cables (2)	50 Ω, 18 inch	Tektronix 012-0076-xx
Probe tip adapter BNC-to-probe tip	Optional probe accessory	Tektronix 067-1734-xx

Preparation

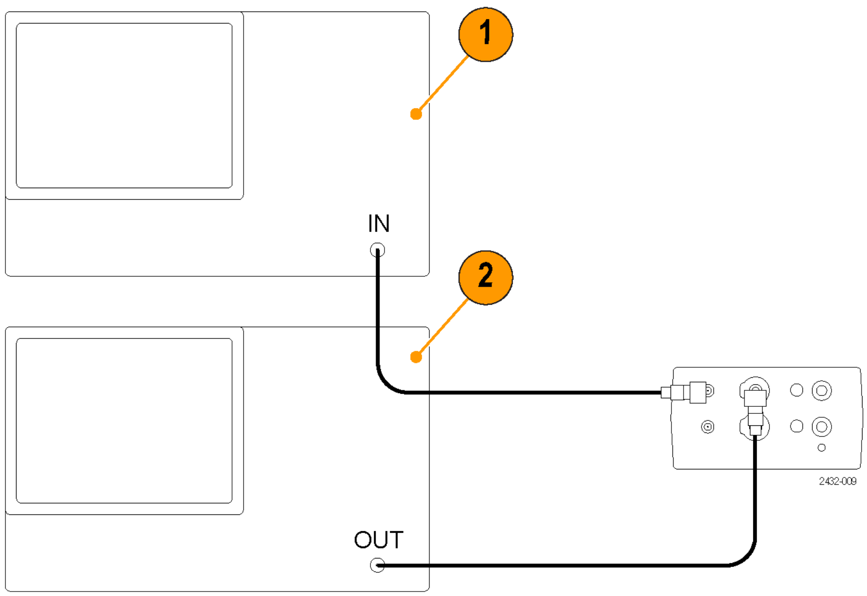
This setup is identical to the network analyzer setup in the main procedure, except that the synthesizer and spectrum analyzer replace the network analyzer.

Allow all test equipment to warm up for 20 minutes in an environment that is within the environmental conditions listed in the specifications section.

Prepare the equipment as follows:

1. Connect a BNC cable to the input of the spectrum analyzer and the other end of the cable with a BNC-to-Type N coaxial adapter to the output of the 1103 power supply.
2. Connect a BNC cable from the output of the synthesizer and the other end of the cable with a BNC-to-Type N coaxial adapter to the input of the 1103 power supply.

Perform the verification procedures in order.



Analog Bandwidth

Normalize the Setup

1. Set the synthesizer for 500 MHz/10 dBm for P6250 probe and 1 GHz/10 dBm for the P6251 probe.
2. Set the spectrum analyzer:

   Center frequency at 500 MHz for the P6250 probe, and 1 GHz for the P6251 probe.

   Span to 10 MHz.

   Resolution bandwidth to auto.

   Reference level to 10 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 1103 power supply.

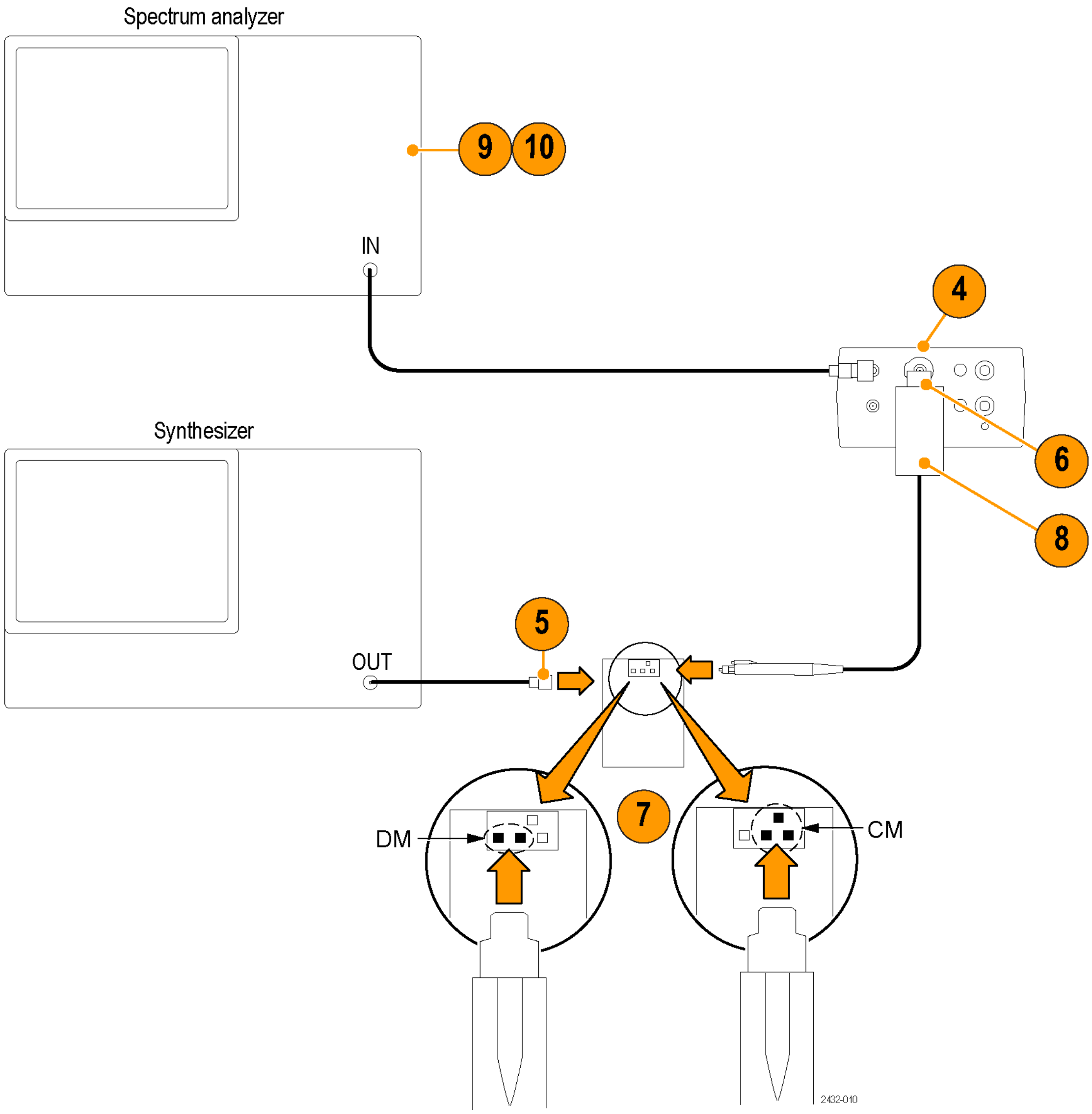
5. Connect the BNC cable to the BNC-to-probe tip adapter.

6. Connect the probe into the probe socket on the 1103 power supply.

7. Connect the probe tip to the DM pins of the BNC-to-probe tip adapter.

8. Set the probe to 4.25 V range (÷ 5), DC reject off, full bandwidth.

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 17 dB of the level that you recorded in step 3. For example, if the reference level from step 3 is 9 dBm, and the level that you measured in this step is -7 dBm, then the difference between the two measurements is 16 dBm, which is within the probe specification.

11. Set the probe to the 42 V range (÷ 50).
12. Change the reference level of the spectrum analyzer to -24 dBm.
13. Record the level displayed on the spectrum analyzer. This level must be within 37 dB of the level that you recorded in step 3. For example, if the reference level from step 3 is 9 dBm, and the level that you measured in this step is -26 dBm, then the difference between the two measurements is 35 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 42 V range (÷ 50).
2. Connect the probe to the DM pins of the BNC-to-probe tip adapter.
3. Set the synthesizer for 1 MHz and 10 dBm.
4. Adjust the spectrum analyzer input attenuator to accept the high level of 10 dBm.
5. Set the reference level to 0 dBm, the center frequency to 1 MHz, and the vertical scale to 10 dB/div.
6. Adjust the span to 10 kHz and the resolution bandwidth to auto.
7. Record the level displayed on the spectrum analyzer. This represents the differential mode measurement at the 42 V range (÷50).
8. Record the level displayed on the spectrum analyzer. This represents the differential mode measurement at the 42 V range (÷ 50).
9. Connect the probe to the CM and ground pins on the BNC-to-probe tip adapter.
10. Adjust the reference level of the spectrum analyzer to display the waveform. Use the noise filter for easier measuring.
11. Record the level displayed on the spectrum analyzer. This represents the common mode measurement at the 42 V range (÷ 50).
12. Calculate the CMRR for each voltage range by subtracting the common mode measurement from the differential mode measurement.
13. Repeat the procedure for the remaining frequencies listed in the table below.

Test frequency	Differential mode measurements	Common mode measurements	CMRR @42 V (Calculated)
	42 V	42 V	
30 kHz			
1 MHz			
250 MHz			

Adjustment Procedures

These procedures are for use by qualified service personnel only. Refer to the service safety summary at the beginning of this manual before servicing this product.

WARNING. *To avoid injury from electric shock, do not touch exposed connections. Use care when servicing equipment that is powered on. Dangerous voltages or currents may exist in this product. Disconnect power and test leads before removing protective panels.*

Prepare the probe for adjustment as follows:

1. Remove the four screws attaching the top cover from the control box.
2. Remove the top cover.
3. Attach the probe to the 1103 Power Supply.
4. If necessary, set the line selector to the correct voltage.
5. Turn on the 1103 power supply.
6. Set the 1103 power supply offset to off (button not illuminated).
7. Allow at least 20 minutes for the equipment to warm up.

NOTE. *Ambient temperature must be within 20 C to 30 C when you adjust the probe.*

Tools

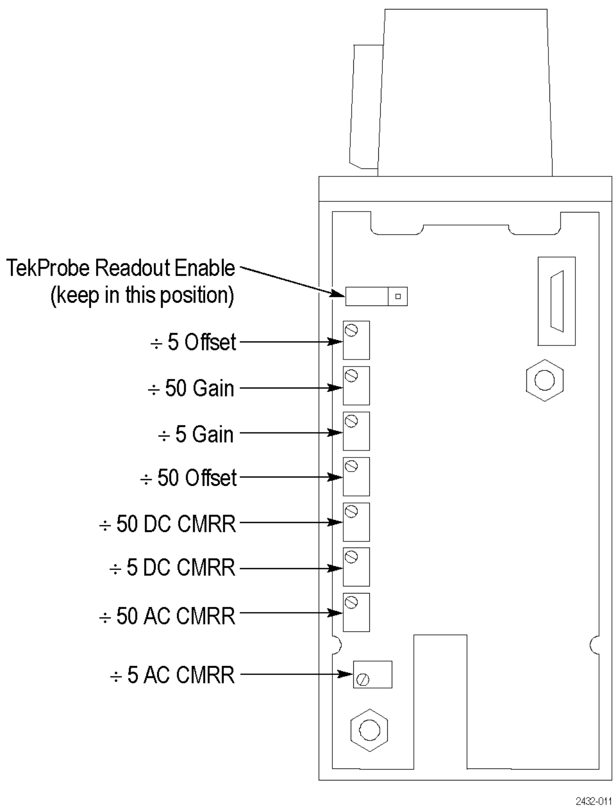
- Flat-bladed screw drive
- Potentiometer, trimmer adjustment tool

Equipment Required for Adjustment Procedure

In addition to the equipment required to perform the performance verification, the adjustment procedures require the equipment listed in Table 7.

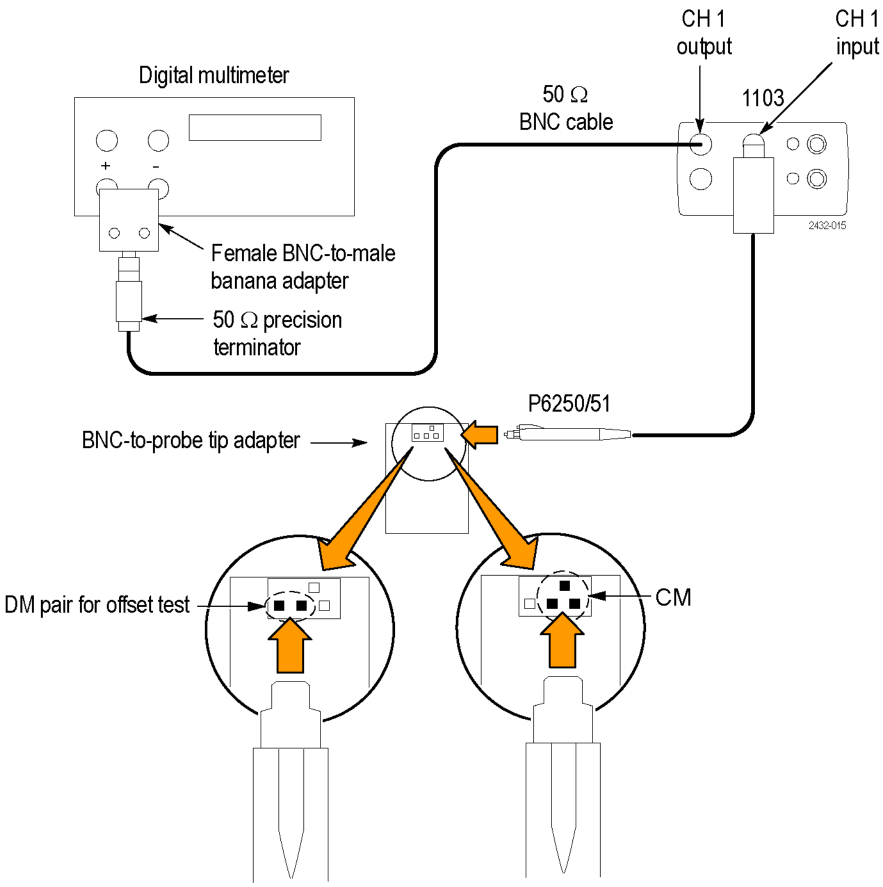
Table 9: Test equipment

Description	Minimum requirements	Example product
Digitizing oscilloscope (Required for adjustment procedure only)	Bandwidth ≥100 MHz, average acquisition mode, vertical sensitivity 2 mV/div	Tektronix TDS3000 series
Function generator (Square and sine wave output)	Output level adjustable to 10 Vpk-pk, Separate Trigger or Sync output	Tektronix AGF300 series
50 Ω termination (needed only if oscilloscope does not support 50 Ω termination)	50 Ω ±1 Ω	011-0045-xx



Offset (Preliminary)

NOTE. *Do not attempt to adjust offset directly on an oscilloscope equipped with a TekProbe Interface. These oscilloscopes utilize a closed loop compensation system for gain and offset which will interfere with the manual adjustment of the probe.*



1. Connect the probe as shown above, with the probe tip connected to the DM pin of the BNC-to-probe tip adapter.
2. Set the DMM to DC volts, 200 mV or 300 mV range.
3. Set the probe to ÷ 5 attenuation, 5 MHz bandwidth, DC reject off.
4. Adjust the ÷ 5 Offset adjustment for 0 mV ± 1 mV.
5. Change the probe attenuation to ÷ 50.
6. Adjust the ÷ 50 Offset adjustment for 0 mV ± 1 mV.
7. Keep the output cable set up for the next step.

Gain

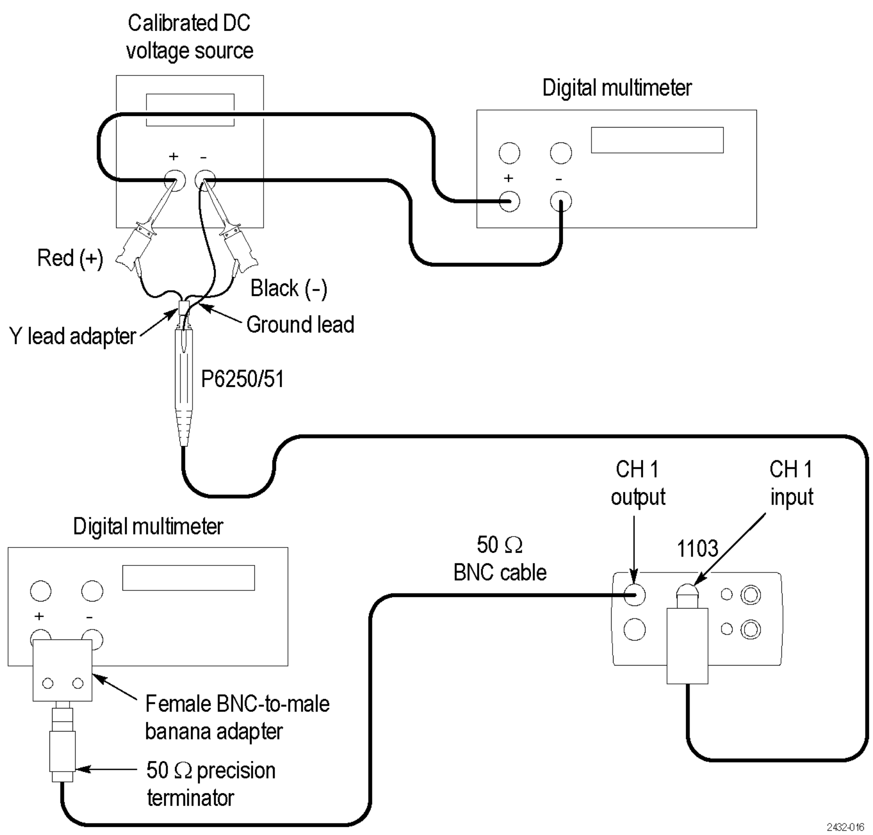
1. Setup the equipment as shown in following illustration:

   a. Remove the BNC to probe tip adaptor from the probe input. Insert the Y-lead adaptor into the probe tip.

   b. With MicroCKT test tip, connect the red lead to the power supply positive terminal, and the black lead to the power supply negative terminal.

   c. With MicroCKT test tip, connect a ground lead from the probe case ground to the negative terminal of the power supply.

   d. Connect a second DMM to a pair of banana leads from the power supply outputs.



2. Set the DMM monitoring the output to DC volts, up to the 2 volt range.

3. Set the DMM monitoring the input to the 2 or 3 volt range. Keep averaging turned on, if necessary.

4. Set the probe to ÷ 5 attenuation, 5 MHz bandwidth, DC reject off.

5. Adjust the power supply to output about 700 mV.

6. Adjust the ÷ 5 Gain adjustment until the DMM output reads 1/5 of the same voltage (≈140 mV) as the DM monitoring the input within ± 5 mV.

7. Change the probe attenuation to ÷ 50.

8. Change the DMM monitoring the input up to the 20 volt range.

9. Adjust the power supply to output approximately 7 V.
10. Adjust the ÷ 50 gain adjustment until the DMM measuring the output reads 1/50 of the same voltage (≈140 mV) as the DMM monitoring the input within ± 5 mV.
11. Keep the probe output connections for the next step.
12. Disconnect the probe head from the power supply.

Offset (Final)

NOTE. *The offset and gain adjustments interact.*

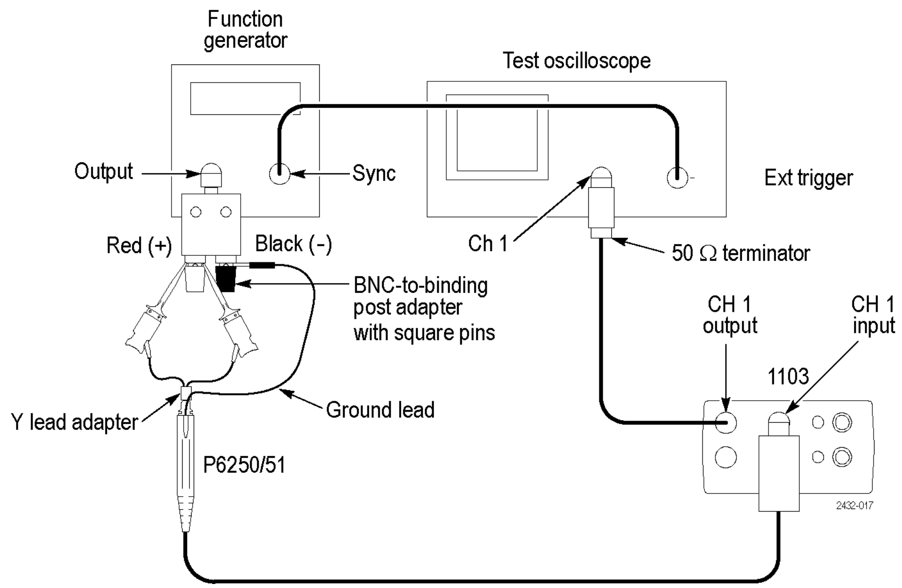
1. Repeat steps 1 through 6 of the Offset (preliminary) procedure.
2. Remove the output cable termination from the BNC-to-male banana adapter and the probe Y lead input from the DC voltage source for the next procedure.

DC CMRR

1. Setup the equipment as shown below:
   a. Connect a BNC cable from the output of the 1103 power supply to the Channel 1 input of the oscilloscope. If the scope does not have 50 Ω input setting, add a 50 Ω inline BNC terminator at the scope input.
   b. Connect the Y-lead adaptor to the probe input. Using square pins, connect both leads to the red binding post of a binding-post-to-BNC adaptor that is connected to the function generator.
   c. If the function generator reference (shield of the BNC connector) is isolated from ground, connect the ground lead from the probe case to the black binding post.

   NOTE. *Do not use the BNC-to-probe tip adaptor for this connection. The power level of the generator will exceed the terminator rating.*

   d. Connect a second BNC cable from the function generator Trigger or Sync Output to the External Trigger or Channel 2 Input of the oscilloscope.



2. Set the probe to ÷ 5 attenuation, 5 MHz bandwidth, DC reject off.
3. Set the function generator to square wave, 1 ms period (1 kHz frequency), approximately 4 V pk-pk, (2 Vpk).
4. Set the oscilloscope to display channel 1. Set channel 1 to DC and 50 Ω input impedance (or use external terminator), 2 mV/div. Set the time/division to 10 s/div. Set the trigger source to external (or Channel 2) Set the acquisition mode to average 8 to 10 acquisitions. Apply vertical bandwidth limiting if available to reduce noise.
5. Adjust the trigger level for a stable trigger. (If the trigger is obtained through channel 2, it may be necessary to change the volts/div setting.)
6. The displayed square wave is the common mode feedthrough. If the probe is severely misadjusted the waveform may be off screen. If necessary, increase the channel 1 volts/div to keep the waveform on screen.
7. Adjust the ÷ 5 DC CMRR adjustment for minimum amplitude in the flat portions of the displayed waveform. This adjustment does not effect the leading edge transitions. Increase the vertical sensitivity as the amplitude decreases.
8. Change the probe to ÷ 50 attenuation.
9. Set the function generator to square wave, 1 ms period (1 kHz frequency, approximately 10 Vpk-pk, (5 V peak).
10. Adjust the ÷ 50 DC CMRR adjustment for minimum amplitude in the flat portions of the displayed waveform. This adjustment does not effect the leading edge transitions.
11. Keep the connections for the next procedure.

AC CMRR

1. Change the function generator to sine wave.
2. Set the frequency of the function generator to 1 MHz and the output amplitude to approximately 4 V pk-pk, (2 V peak).
3. Set the probe to ÷ 5 attenuation, 5 MHz bandwidth, DC reject off.
4. Change the scope horizontal setting to 100 ns/div. If necessary, adjust the channel 2 volts/div and trigger level for a stable trigger.
5. The displayed sine wave is the common mode feedthrough. If the probe is severely misadjusted, the waveform may be off screen.
6. Adjust the ÷ 5 AC CMRR adjustment for minimum amplitude. Usually it is not possible to completely eliminate the high frequency feedthrough.
7. Change the probe to ÷ 50 attenuation.
8. Set the output amplitude of the function generator to approximately 10 V pk-pk (5 V pk).
9. Adjust the ÷ 50 AC CMRR adjustment for minimum amplitude.
10. There is some interaction between the DC and AC CMRR adjustments. Repeat the DC CMRR adjustment steps 3 to 10.
11. Remove all connections from the probe. Carefully replace the top cover of the control box and the four retaining screws.

This completes the adjustment procedures.

Maintenance

This section contains maintenance information for the P6250 and P6251 differential probes.

Inspection and Cleaning

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

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

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

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.*

Replacement Parts

Due to the sophisticated design of these differential probes, there are no 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

Contact Tektronix Service Center to request an RMA (Return Material Authorization) number. For contact information, refer to the back of the title page of this manual.

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.