

TCP0150
20 MHz, 150 A AC/DC Current Probe
Instruction Manual

www.tektronix.com
071-2251-00

Tektronix

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

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

Warranty 2

Tektronix warrants that this product will be free from defects in materials and workmanship for a period of one (1) year from the date of shipment. If any such product proves defective during this warranty period, Tektronix, at its option, either will repair the defective product without charge for parts and labor, or will provide a replacement in exchange for the defective product. Parts, modules and replacement products used by Tektronix for warranty work may be new or reconditioned to like new performance. All replaced parts, modules and products become the property of Tektronix.

In order to obtain service under this warranty, Customer must notify Tektronix of the defect before the expiration of the warranty period and make suitable arrangements for the performance of service. Customer shall be responsible for packaging and shipping the defective product to the service center designated by Tektronix, with shipping charges prepaid. Tektronix shall pay for the return of the product to Customer if the shipment is to a location within the country in which the Tektronix service center is located. Customer shall be responsible for paying all shipping charges, duties, taxes, and any other charges for products returned to any other locations.

This warranty shall not apply to any defect, failure or damage caused by improper use or improper or inadequate maintenance and care. Tektronix shall not be obligated to furnish service under this warranty a) to repair damage resulting from attempts by personnel other than Tektronix representatives to install, repair or service the product; b) to repair damage resulting from improper use or connection to incompatible equipment; c) to repair any damage or malfunction caused by the use of non-Tektronix supplies; or d) to service a product that has been modified or integrated with other products when the effect of such modification or integration increases the time or difficulty of servicing the product.

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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.

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.

Connect and Disconnect Properly. De-energize the circuit under test before connecting or disconnecting the current probe.

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

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.

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

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

Do Not Operate Without Covers. Do not operate this product with covers or panels removed.

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.

Provide Proper Ventilation. Refer to the manual's installation instructions for details on installing the product so it has proper ventilation.

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:



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.

Environmental Considerations

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

Product End-of-Life Handling

Observe the following guidelines when recycling an instrument or component:

Equipment Recycling. Production of this equipment required the extraction and use of natural resources. The equipment may contain substances that could be harmful to the environment or human health if improperly handled at the product's end of life. In order to avoid release of such substances into the environment and to reduce the use of natural resources, we encourage you to recycle this product in an appropriate system that will ensure that most of the materials are reused or recycled appropriately.

The symbol shown below indicates that this product complies with the European Union's requirements according to Directive 2002/96/EC on waste electrical and electronic equipment (WEEE). For information about recycling options, check the Support/Service section of the Tektronix Web site (www.tektronix.com).



Restriction of Hazardous Substances

This product has been classified as Monitoring and Control equipment, and is outside the scope of the 2002/95/EC RoHS Directive. This product complies with the RoHS Directive requirements except for the presence of hexavalent chromium in the surface coating of the aluminum chassis parts, assembly hardware, and 63/37 tin/lead solder used in the fabrication of the circuit boards.

Preface

This manual describes the installation and operation of the TCP0150 current probe. Basic probe operations and concepts are presented in this manual. You can also access the Tektronix Web site for this document and other related information.

Documentation

To read about

TCP0150 Probe: First Time Operation, Functional Check, Operating Basics, Specifications, Performance Verification

In-depth oscilloscope operation, user interface help, GPIB commands

Use these documents *

Read this Instruction Manual.

Access the online help from the Help menu on the host instrument.

* To access the documentation that is installed on your instrument, click **Start** in the taskbar and select **Programs > TekApplications**.

Conventions Used in this Manual

The following icon is used throughout this manual to indicate a step sequence.

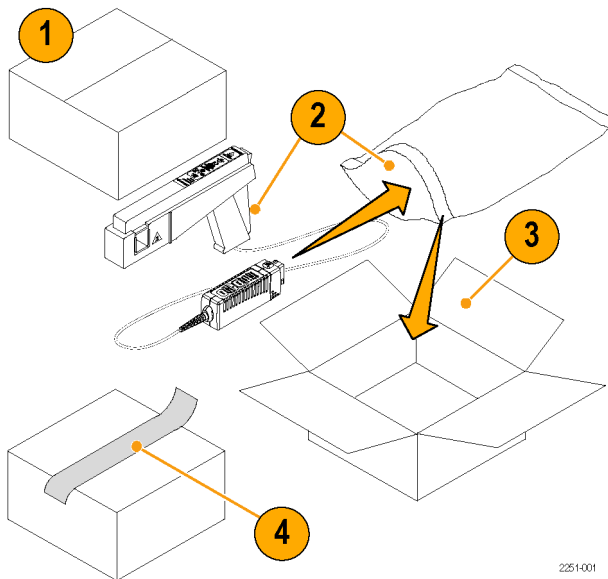


Returning the Probe for Servicing

If your probe requires servicing, you must return the probe to Tektronix. If the original packaging is unfit for use or not available, use the following packaging guidelines:

Preparation for Shipment

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 it 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* at the beginning of this manual for the shipping address.

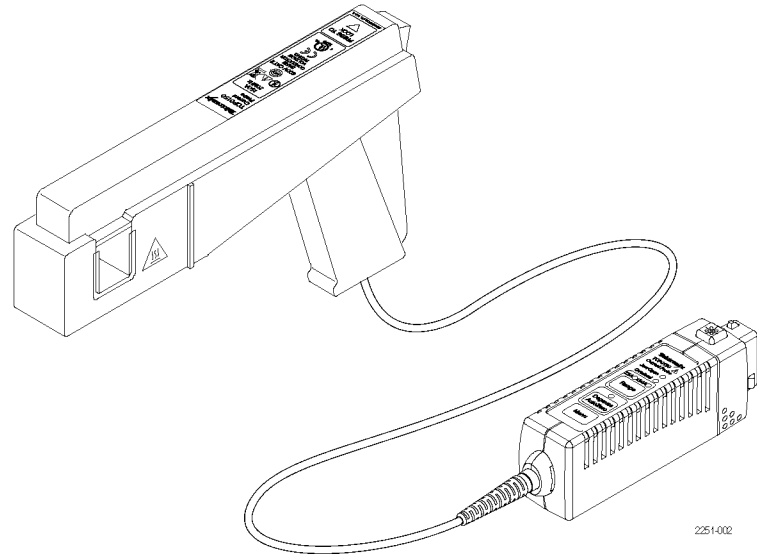


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Key Features

You can use the TCP0150 current probe to make accurate measurements from DC to 20 MHz. The probe combines proven Hall-effect technology with the Tektronix TekVPI oscilloscope interface. Key features include:

- >20 MHz bandwidth, <17.5 ns rise time
- AC/DC Measurement capability
- 500 A peak pulse current (PW <30 μ s)
- 25 A and 150 A range settings
- 5 mA sensitivity (on TekVPI oscilloscopes that support the 1 mV/div setting)
- 1% DC Accuracy (typical)
- One-button degauss/autozeroing
- Probe control through the oscilloscope menus or remotely through the oscilloscope
- Direct scaling and unit readout on host instruments
- AC coupling (oscilloscope dependent)



Installation

1. Slide the probe into the TekVPI receptacle. The probe snaps in when fully engaged.

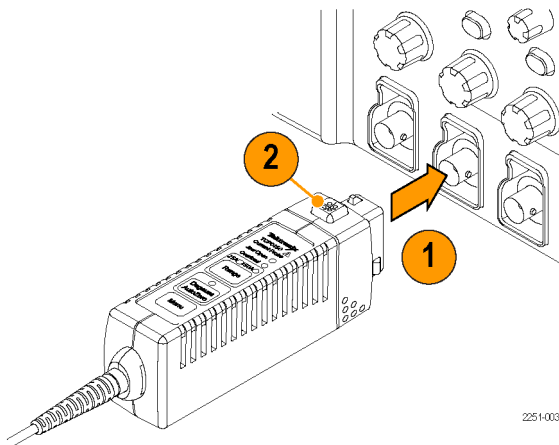
When the probe is connected, the host instrument reads information from the probe and identifies the device. All of the probe LEDs light briefly for a quick visual check.

2. To disconnect, press the latch button and pull the probe away from the instrument.

NOTE. Your TekVPI instrument may require a firmware upgrade to support full functionality of the probe. (See page 55, Oscilloscope Firmware.)



CAUTION. To prevent the compensation box from overheating, ensure that all ventilation openings are unobstructed when connected to the oscilloscope.



2251-003

Using the Probe Head

1. The U-shaped current-sensing core (the jaw) is located at the front of the probe.



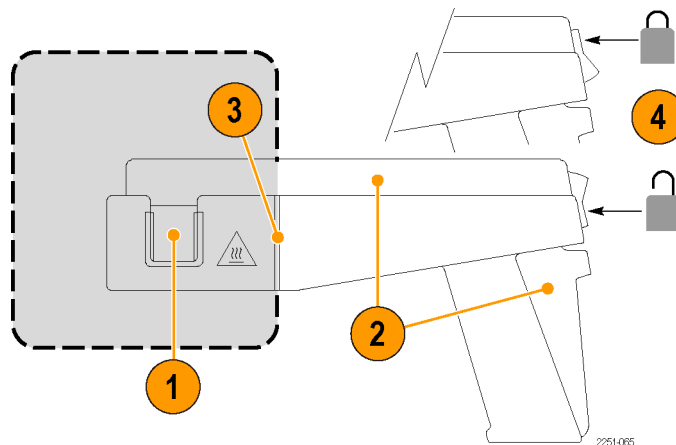
CAUTION. To prevent risk of fire, do not connect or disconnect the current probe to or from a live, uninsulated conductor. The core is not insulated. When you test uninsulated circuits, remove power before you connect or disconnect the probe.

2. The trigger at the rear of the probe opens and closes the sliding bar over the jaw and the conductor under test.
3. Keep your hands behind the tactile barrier (away from the shaded area) when connected to live circuitry.



WARNING. To prevent risk of electric shock, keep your hands behind the tactile barrier which indicates the limit of safe access.

4. Press the lock switch up to lock the slide and down to unlock it.



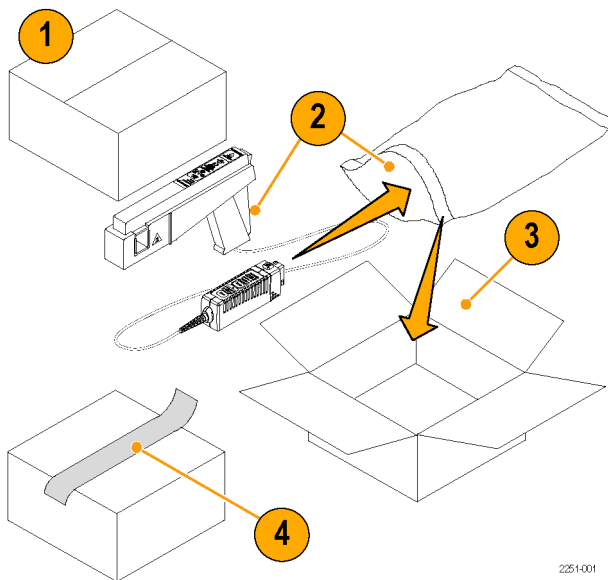
Degaussing the Probe

1. After the probe is identified by the host instrument:

- The screen display prompts you to degauss the probe
- The multicolor Degauss/AutoZero status LED on the probe flashes red

NOTE. The DC gain and offset are not guaranteed when this LED flashes red.

2. With no conductor in the jaw, lock the probe slide.
3. Press the **Degauss/AutoZero** button on the probe or in the Degauss window on the host instrument.
4. The multicolor Degauss/AutoZero status LED glows green to indicate a successful degauss routine was run, and that the probe is in normal operating mode.

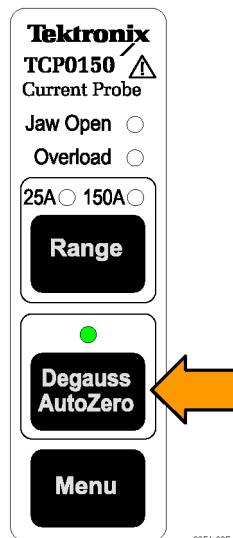


2251-001

Quick Tip

To maintain measurement accuracy, degauss your probe in each of these cases:

- After you turn on the measurement system and allow a 20-minute warm-up period
- Before you connect the probe to a conductor
- Whenever a current or thermal overload condition occurs
- Whenever you subject the probe to a strong external magnetic field



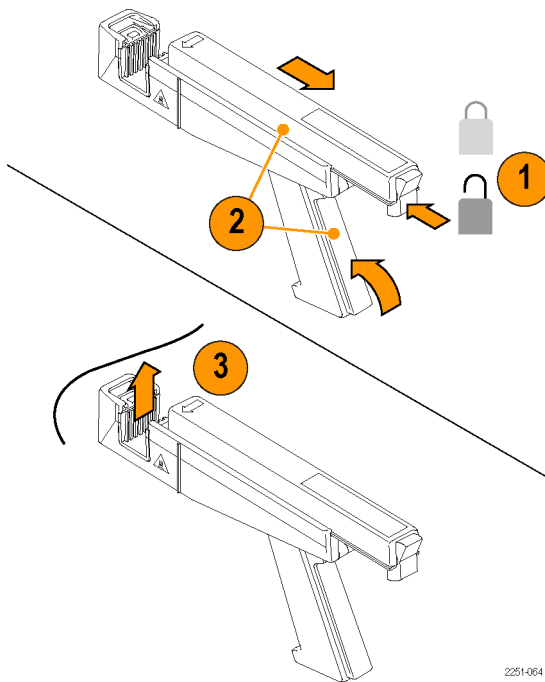
2251-005

Connecting to the Circuit



CAUTION. To avoid damage to the probe core, do not drop the probe or subject it to physical shock, strain, or sudden changes in ambient conditions.

1. Press the lock switch down to unlock the slide.
2. Squeeze the trigger handle to open the jaw.
3. Place the jaw around the conductor in the circuit.



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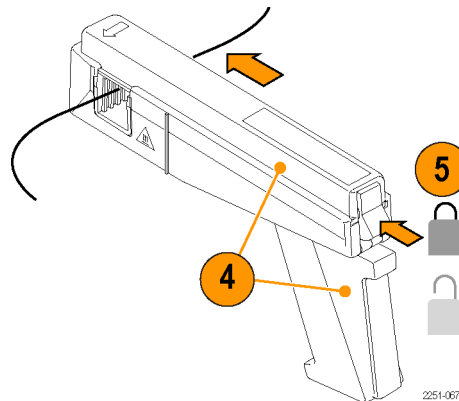
4. Release the trigger to close the slide over the jaw.
5. Press the lock switch up to lock the slide.



WARNING. To prevent risk of electric shock, use protective equipment (gloves, for example), if you use the probe on accessible uninsulated wires or bus bar.



WARNING. Do not exceed the bare wire voltage rating of the probe. Refer to the specification section for details.

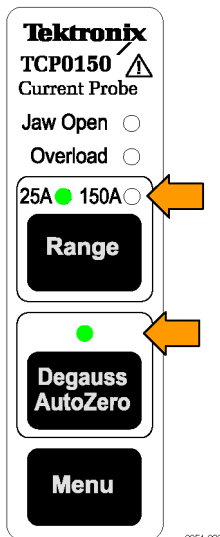


Probe Controls and Indicators

When you connect the probe to the oscilloscope, all of the indicator LEDs light briefly, and then at least two LEDs remain lighted to indicate:

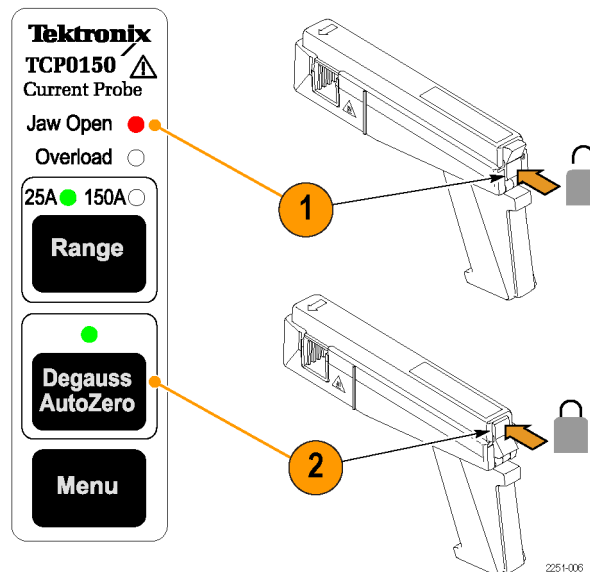
- The current range selected
- The Degauss/AutoZero status

NOTE. On some host instruments, the probe retains the range state and restores it when it is power cycled.



Jaw Open LED

1. If the Jaw Open LED glows, the probe slide is unlocked.
2. Lock the probe slide to accurately measure current or to degauss the probe.



Overload LED

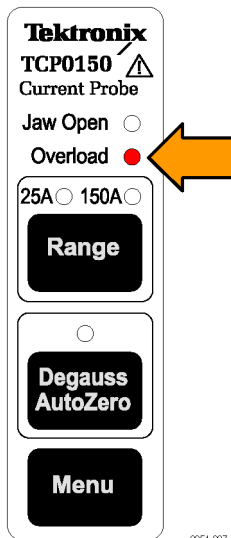
The multicolor Overload LED alerts you that the probe specifications are being exceeded. The Overload LED alert conditions are:

- Glowing red. The maximum continuous input current limit has been exceeded
- Glowing orange. The safe operating temperature of the probe has been exceeded
- Flashing red and orange. Both the maximum continuous input current limit and the safe operating temperature of the probe have been exceeded

NOTE. The probe will shut down if you exceed the safe operating temperature. To reset the probe, disconnect the probe from the oscilloscope, let it cool, and then reconnect it.

Quick Tip

An input current overload can magnetize the probe. Always degauss the probe after an overload.

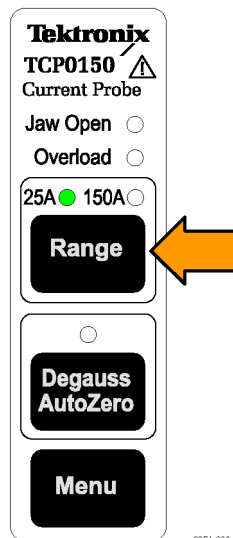


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Range Button and LEDs

Press the **Range** button to select between the 25 A and 150 A current range settings.

The green LEDs indicate the selected range. The range and units are also displayed on the oscilloscope screen.



2251-008

Degauss/AutoZero Button and LED

When the multicolor Degauss/AutoZero status LED flashes red, you must degauss the probe.

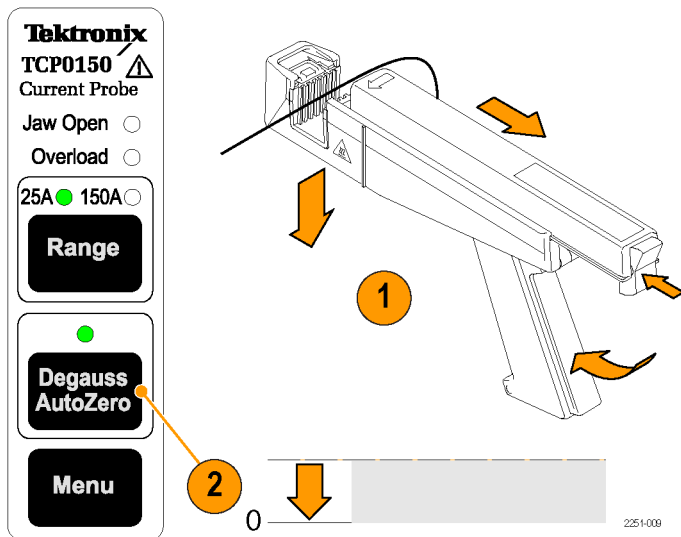
If the LED flashes orange, you should degauss the probe. The DC gain and offset accuracy are not guaranteed when this LED flashes orange.

The Degauss/AutoZero function also clears (AutoZeroes) any DC offset in the probe.

To degauss the probe, do the following:

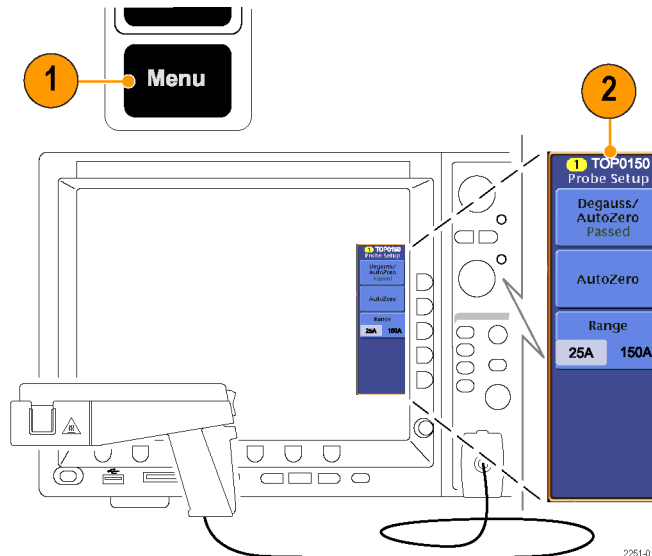
1. Disconnect the probe from the current source and lock the slide.
2. Press the Degauss/AutoZero button to initiate the degauss routine.

The LED glows green after successfully completing the Degauss/AutoZero routine.



Menu Button

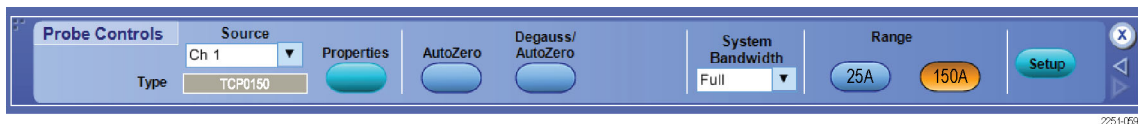
1. Press the **Menu** button on the probe.
2. The Probe Setup or Probe Controls screen displays and shows your probe settings; the screen differs by oscilloscope model. (See page 14, *Optional Probe Screens*.)
Use the screen buttons to change the settings or to access other probe information.
3. Press the **Menu** button again to close the screen.



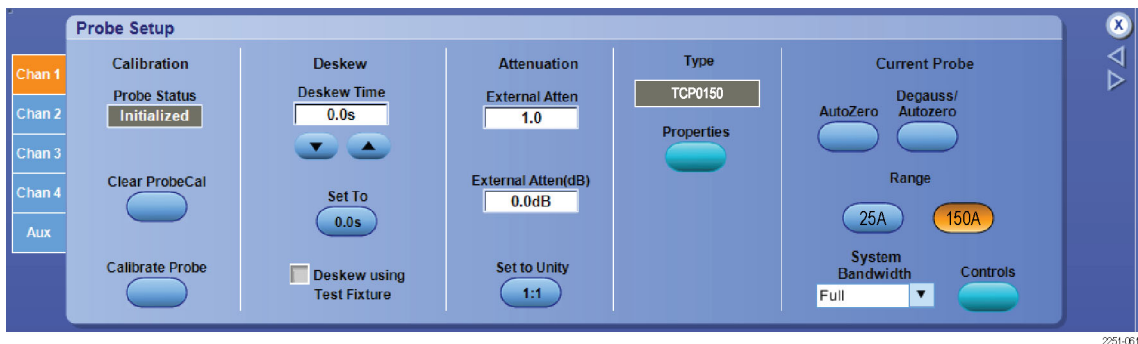
Optional Probe Screens

The following screens may be available for the probe, depending on the host oscilloscope model.

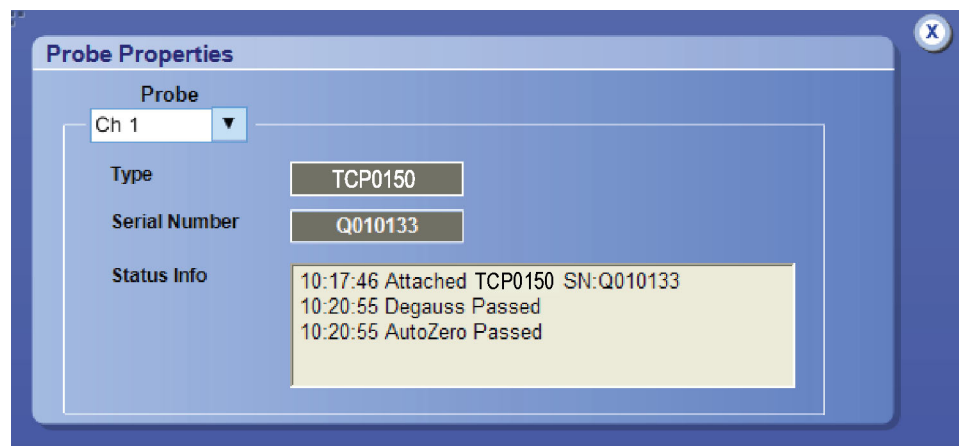
The Probe Controls screen may be accessed from the probe **Menu** button or other probe screens. It contains buttons for common probe functions and for access to other probe screens, such as Probe Setup and Probe Properties.



Click the **Setup** button to display the Probe Setup screen.



Click the **Properties** button to display the Probe Properties screen.



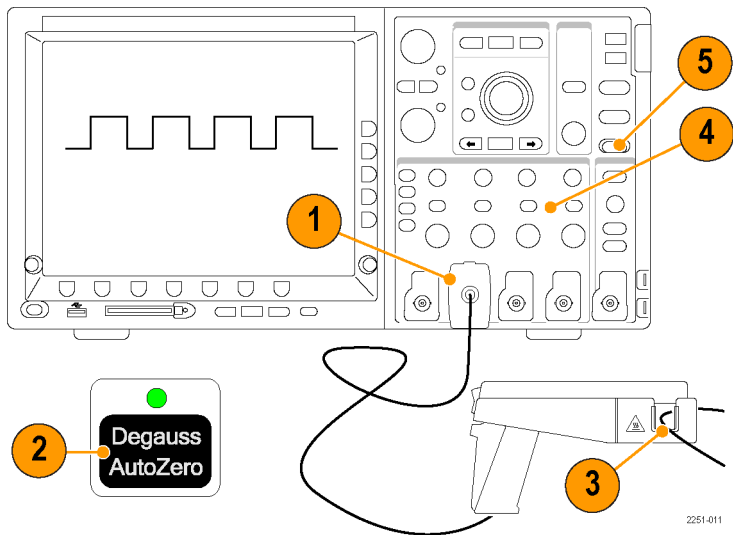
2251-000

Functional Check and Basic Operation

The following procedure checks that your probe is functioning properly. To verify that your probe meets the warranted specifications, refer to the *Performance Verification* procedures. (See page 57.)

1. Connect the probe to any channel (1–4) of the oscilloscope.
2. Press the Degauss/AutoZero button.
3. When the Degauss/AutoZero LED glows green, connect the probe to your circuit.
4. Set the oscilloscope to display the probe channel.
5. Adjust the oscilloscope or press **Autoset** to display a stable waveform.

A stable waveform indicates that your probe is functioning correctly.

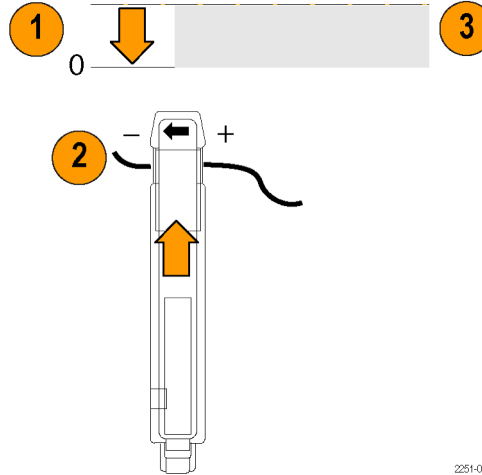


Basic Operation

1. Check the oscilloscope display before connecting the probe to a conductor.
If there is a DC offset, degauss the probe.
(See page 4, *Degaussing the Probe*.)
2. For correct polarity reading, connect the probe so that the positive-to-negative current flow is aligned with the arrow on the probe jaw.
Close and lock the probe jaw over the conductor.
3. Read the measurement on the oscilloscope display.



CAUTION. To prevent risk of electric shock or fire, do not exceed the bare wire voltage rating of the probe. (See page 43, *Specifications*.)



2251-012

Application Examples

This section explains ways to use your probe in common troubleshooting tasks and how to extend the use of your measurement system.

Inductance Measurements

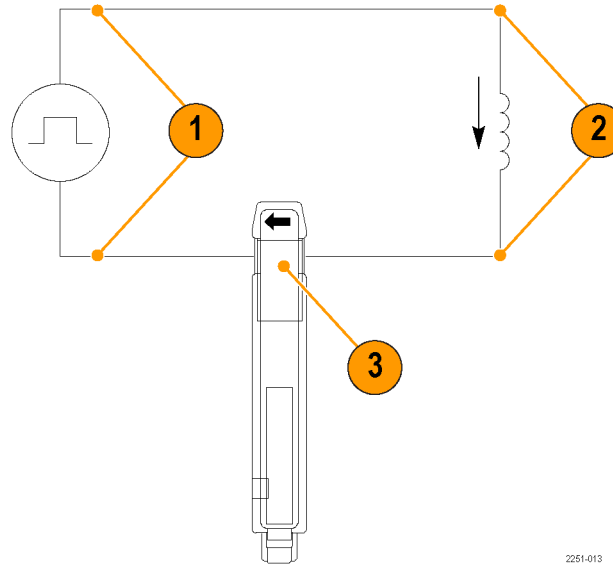
You can use the current probe to measure the inductance of coils that have either a low-impedance or high-impedance pulse source of a known value.

Low-Impedance Pulse Sources

This figure shows a constant-voltage pulse generator of extremely low output impedance connected to an inductor that has low resistance.

1. Connect the inductor across the output terminals of the pulse generator.
2. Maintain a constant voltage across the inductor.
3. Clamp the current probe over one of the source leads.

NOTE. If the probe impedance is a significant part of the total circuit inductance, measurement accuracy will be affected. Refer to the probe specifications for probe insertion impedance.



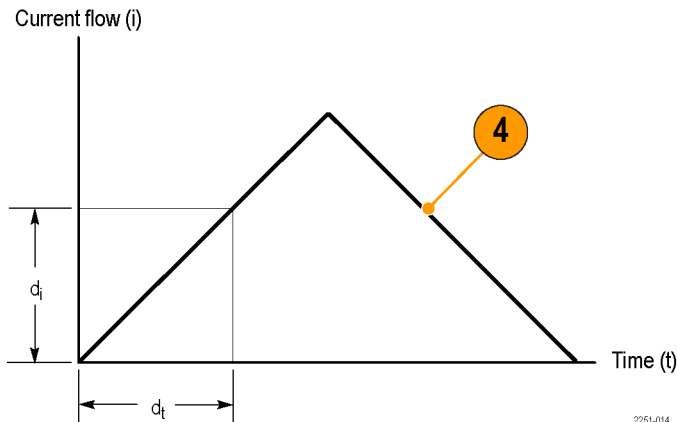
2251-013

4. Measure the current ramp. The inductance is effectively defined by the slope of the current ramp shown here.
5. Calculate the inductance using the following formula:

$$L = \frac{-E}{\frac{di}{dt}}$$

where:

L is the inductance in henries,
 E is the voltage of the pulse generator,
 dt is the change in time, and
 di is the change in current.



2251-014

High-Impedance Pulse Sources

If the pulse source has a higher impedance of known resistance, such that the output voltage drops as the current increases, the inductance of a coil can be calculated by the time constant of the charge curve.

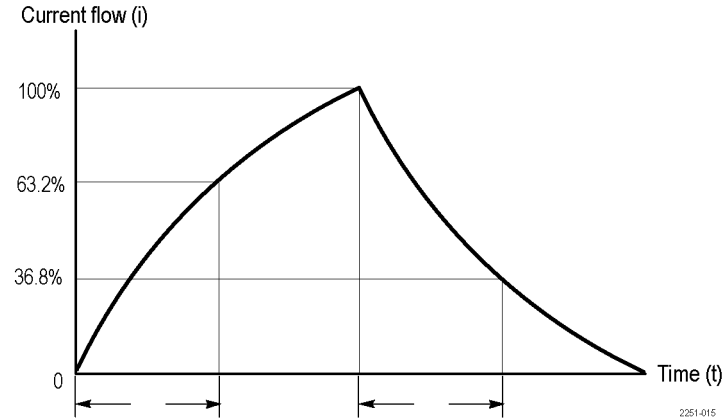
The current ramp shows how the values for the inductance formula are obtained.

Use this formula to calculate the inductance based on the current measurement:

$$L = \tau R$$

where:

L is the inductance in henries,
 τ is the time required for the current to rise or fall 63.2% of the total current value, and
 R is the source resistance of the pulse generator.



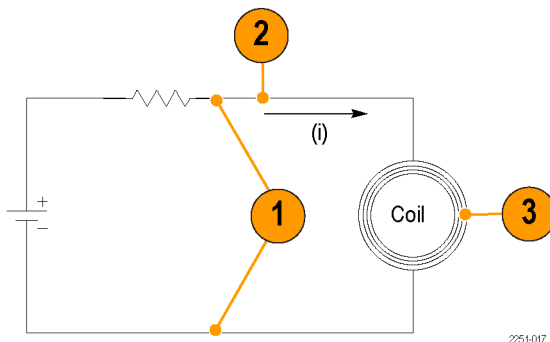
Measuring Inductor Turns Count

To obtain an approximate turns count of an inductor, do the following:

1. Connect the inductor to a current limited source, as shown.
2. Measure the input current on one of the inductor leads.
3. Clamp the current probe around the inductor and note the current value.

The number of turns is equal to the ratio of coil current to input current.

NOTE. The accuracy of this method is limited by the current measurement accuracy. See the next page for a more accurate procedure.



2251-017

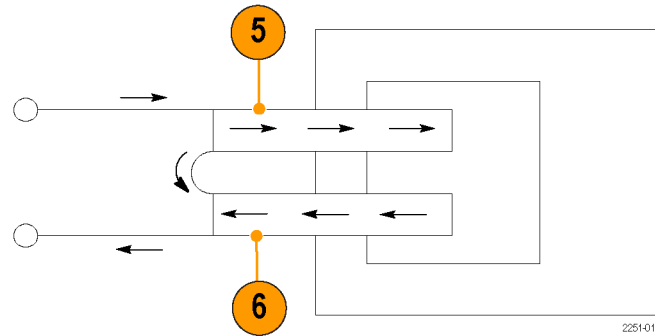
For a more precise turns count, you need a coil with a known number of turns to use as a reference. Do the following:

4. Repeat steps 1 and 2 and then make the following changes:
5. Insert the reference coil into the current probe.
6. Insert the test coil into the current probe so that the currents oppose each other as shown. You must observe the polarity of coil current to determine whether the test coil has fewer or more turns than the reference coil. The turns are calculated by using the formula:

$$N_2 = N_1 \times (I_m \div I_1)$$

where:

N_2 is the number of turns in the test coil,
 N_1 is the number of turns in the reference coil,
 I_m is the measured coil current, and
 I_1 is the input current.



Accessories and Options

This section lists the standard accessories and provides information on how to use the accessories. Specifications are provided where appropriate so that you can choose the accessory that best fits your needs.

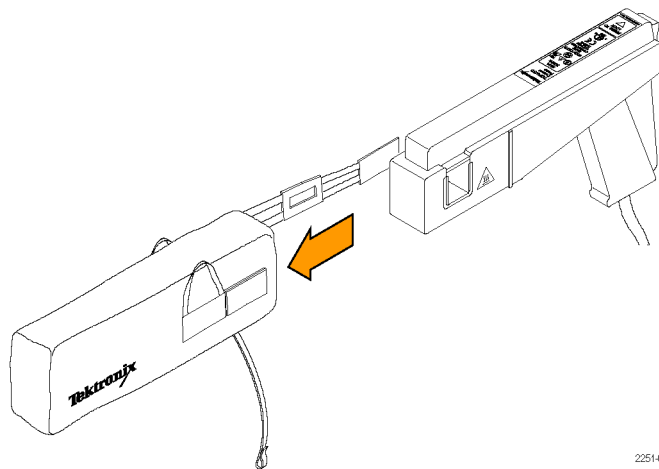
Standard Accessories

Protective Cover

At your workbench, put the probe in the padded protective cover to prevent accidental damage to the probe.

1. Insert the probe into the protective cover.
2. Close the protective cover with the strap to secure the cover to the probe.
3. To keep the cover with the probe, attach the cover leash to the probe cable.

Reorder Tektronix part number: 016-1924-XX



2251-019

Instruction Manual

The instruction manual provides operating and maintenance instructions.

Reorder Tektronix part number:

- 071-2251-XX (English)
- 071-2252-XX (Japanese)
- 071-2253-XX (Simplified Chinese)



Optional Accessories

This section lists the optional accessories that you can purchase to help you with your probing tasks.

Current Loop

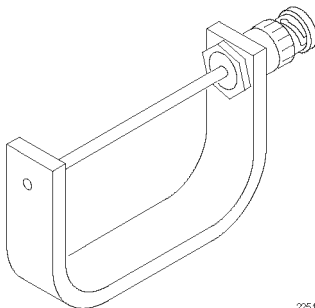
Use the 1-turn, 50 Ω current loop for the performance verification procedures. The BNC connector allows for easy connections to current sources.



WARNING. To reduce the risk of shock, do not use this accessory on voltages above 30 Vrms, 42 Vpk, or 60 VDC.

This accessory is limited to 0.5 Wrms and is not intended to be used with hazardous voltages.

Reorder Tektronix part number: 015-0601-50



2251-020

Deskew/Calibration Fixture

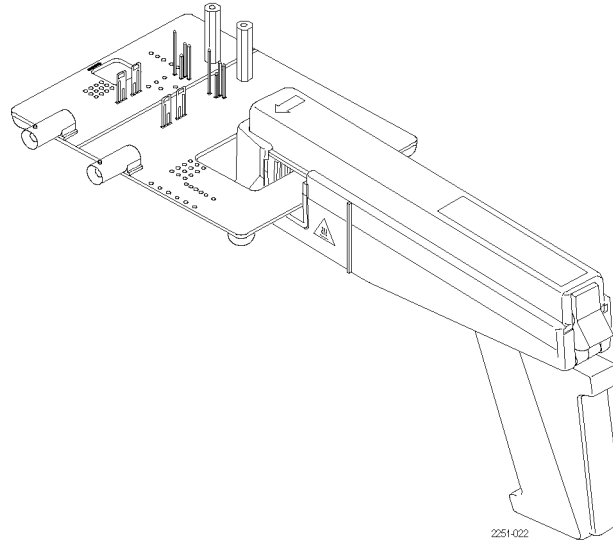
Connect this fixture to host instruments that support the probe calibration or deskew procedures. The deskew procedures compensate for gain errors and timing differences between current and voltage probes. Refer to your oscilloscope manual or fixture documentation for instructions.



WARNING. To reduce the risk of shock, do not use this accessory on voltages above 30 Vrms, 42 Vpk, or 60 VDC.

This accessory is limited to 2 Wrms and is not intended to be used with hazardous voltages.

Reorder Tektronix part number: 067-1686-00

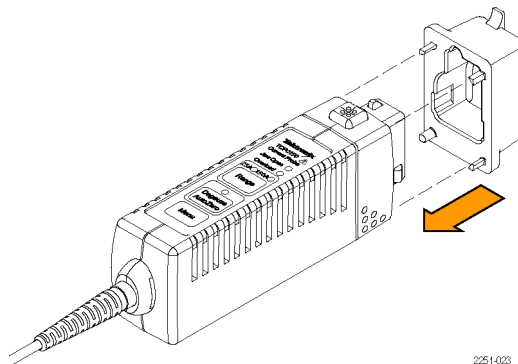


2251-022

Compensation Box Tool

Use this tool to open the compensation box when servicing the probe (replacing the switch panel, cable, or compensation box). Refer to the compensation box replacement procedures for instructions for using the tool.

Reorder Tektronix part number: 003-1892-00

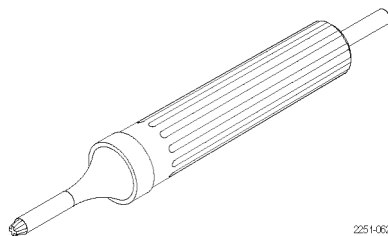


2251-023

Adjustment Tool

Use this tool to access the adjustment controls in the compensation box. Refer to the adjustment procedures for instructions.

Reorder Tektronix part number: 003-1433-02



2251-062

Options

Service Options

- **Option CA1.** Provides coverage for a single calibration event
- **Option C3.** Calibration Service 3 years
- **Option C5.** Calibration Service 5 years
- **Option D1.** Calibration Data Report
- **Option D3.** Calibration Data Report, 3 years (with Option C3)
- **Option D5.** Calibration Data Report, 5 years (with Option C5)
- **Option R3.** Repair Service 3 years
- **Option R5.** Repair Service 5 years

Manual Options

- **Option L0.** English language instruction manual
- **Option L5.** Japanese language instruction manual
- **Option L7.** Simplified Chinese language instruction manual

Probing Principles

The following information is provided to help you use the full potential of your current probe.

Degaussing a Probe with an Unpowered Conductor in the Jaws

You can degauss your current probe while a conductor of an unpowered circuit is clamped in the jaws. The advantage of degaussing with an unpowered circuit is that any offset from stray DC magnetic fields is compensated. Degaussing with the conductor in the probe jaws eliminates the need to manually remove the probe.

NOTE. *Be certain that the conductor in the probe jaws is completely unpowered. Any current flowing through the conductor will cause a residual offset in the current probe and may cause an inaccurate measurement or an error condition.*

The impedance of your circuit must be higher than 10 m Ω for the degauss procedure to work. (The probe core will not saturate with a circuit impedance of less than 10 m Ω). While degauss occurs, the probe will induce a 60 mV, 200 Hz signal in the unpowered circuit. Your circuit must be able to absorb this induced voltage. With low impedance circuits, several amperes may be induced in the circuit being measured. This may be of concern when you are using very small conductors.

Measuring Differential Current

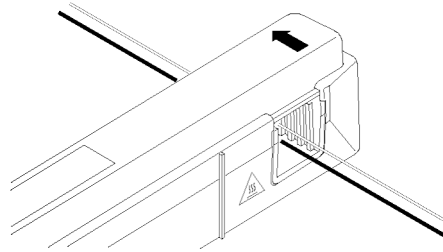
To simplify your differential or null current measurements, you can place two conductors in one current probe.



CAUTION. To prevent damage to the probe head, do not force the slide closed. Damage to the probe may result. If you cannot close the slide around the conductor(s), either reduce the number of conductors you are measuring, or, if possible, take your measurement on a smaller conductor.



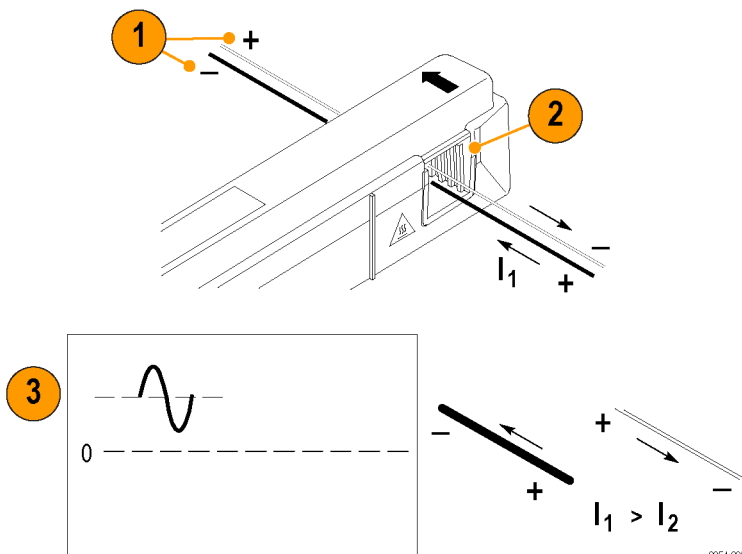
CAUTION. To prevent the risk of fire, ensure that when you are using multiple conductors from different sources, that all conductors are adequately insulated from each other.



2251-024

1. Orient the two conductors under test so that the polarities (+ and -) oppose each other.
2. Clamp the current probe around the two conductors. Be careful not to pinch a conductor in the probe jaws.
3. Measure the current.

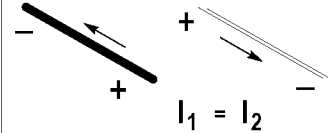
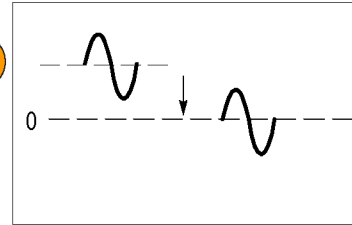
Conventional current flows from positive to negative. A waveform above the baseline indicates that the conductor with the conventional current flow in the direction of the probe arrow is carrying the greater current.



2251-025

4. To adjust for a current null, adjust the current in one of the conductors until the displayed measurement is zero.

4



2251-006

Extending Current Range

If your measurement exceeds the maximum current rating of the connected probe, you can extend the AC and DC current ranges without exceeding specified limits by using the following methods.



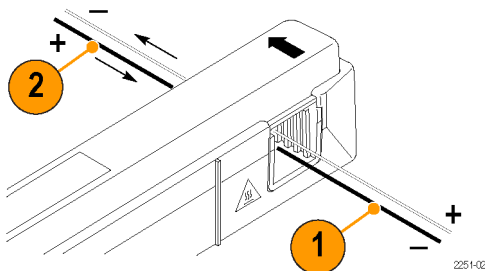
WARNING. To avoid personal injury or equipment damage, do not exceed the specified electrical limits of the probe or any applicable accessories. When using multiple conductors, do not exceed current limits on either conductor.

Extending DC Range

If you want to measure a low-amplitude AC component that is superimposed on an extremely large steady-state DC component (such as in a power supply), or if you want to extend the DC current range of your probe, you can add offset (bucking) current with a second conductor.

To supply additional bucking current:

1. Place a second conductor that has a pure DC component of known value in the probe jaw with the conductor under test.
2. Orient the second conductor so that the bucking current flows in the opposite direction of the DC flow in the conductor under test.
3. To determine measurement values, add the value of the bucking current to the displayed measurement.

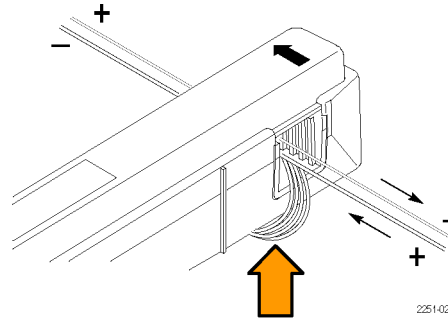


NOTE. Adding a second conductor to the probe increases the insertion impedance and reduces the upper bandwidth limit of the probe. Winding multiple turns further increases the insertion impedance, further reducing the upper bandwidth limit.

To increase the value of the bucking current, wind multiple turns of the second conductor around the probe.

The bucking current is equal to the current flowing in the conductor, multiplied by the number of turns wound around the probe.

For example, if the second conductor has a current of 100 mA DC and is wrapped around the probe five times, the DC bucking current is 100 mA multiplied by 5, or 500 mA DC.

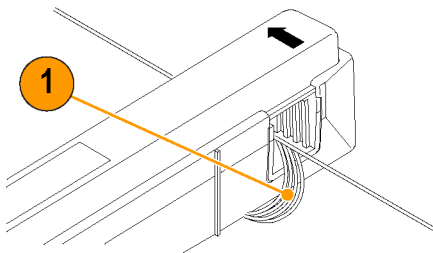


Increasing Sensitivity

If you are measuring DC or low-frequency AC signals of very small amplitudes, you can increase measurement sensitivity of your current probe by doing the following:

1. Wind several turns of the conductor under test around the probe as shown. The signal is multiplied by the number of turns around the probe.
2. To obtain the actual current value, divide the displayed amplitude by the number of turns.

For example, if a conductor is wrapped around the probe five times and the oscilloscope shows a reading of 5 mA DC, the actual current flow is 5 mA divided by 5, or 1 mA DC.



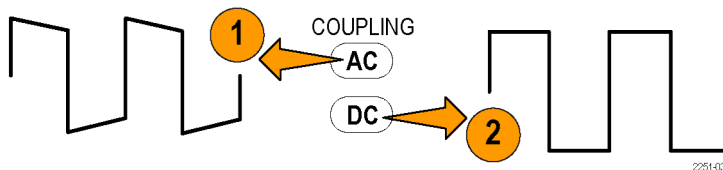
2251-029

NOTE. Winding more turns around the probe increases the insertion impedance and reduces the upper bandwidth limit of the probe.

AC and DC Coupling

You can couple the signal input to the oscilloscope with either DC or AC coupling. DC coupling shows both the DC and AC measurement components. AC coupling removes the DC component from the displayed signal.

1. This low-frequency square wave is displayed using AC coupling. The signal exhibits low-frequency rolloff.
2. Press the DC Coupling button to display the waveform as truly square.



2251-031

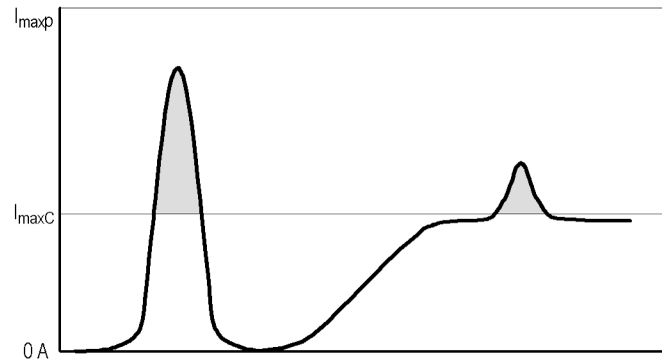


WARNING. To prevent personal injury or probe damage, make sure that the input DC current does not exceed the probe specification when you use AC coupling.

Maximum Current Limits

Current probes have three maximum current ratings: pulsed, continuous, and Ampere-second product. Exceeding any of these ratings can saturate the probe core, which magnetizes the core and causes measurement errors. Refer to the specifications for the maximum current ratings of the probe. (See Table 2 on page 45.)

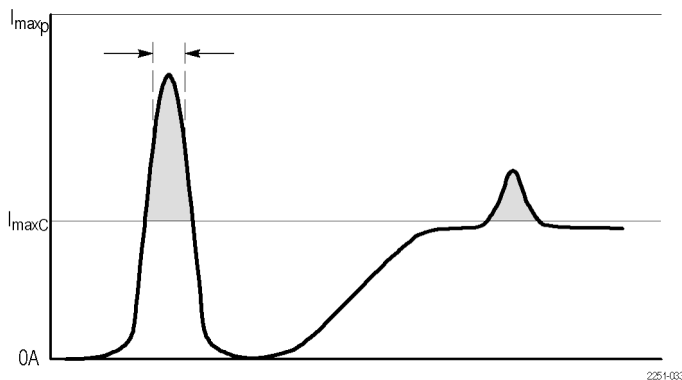
- Maximum Pulsed Current ($I_{\max P}$) is the maximum peak value of pulsed current the probe can accurately measure, regardless of how short (within bandwidth limitations) the pulse duration is.
- Maximum Continuous Current ($I_{\max C}$) is the maximum current that can be continuously measured at DC or at a specified AC frequency. The maximum continuous current value is derated with frequency; as the frequency increases, the maximum continuous current rating decreases.



2251-032

- Ampere-Second Product is the maximum width of pulsed current that you can measure when the pulse amplitude is between the maximum continuous and maximum pulsed current specifications. The maximum continuous specification varies by frequency.

To determine if your measurement exceeds the Ampere-second product, you must first determine the maximum allowable pulse width or maximum allowable pulse amplitude, as described in the following section.



NOTE. Always degauss the probe after measuring a current that exceeds the maximum continuous current, maximum pulsed current, or Ampere-second product rating of the probe. Exceeding these ratings can magnetize the probe and cause measurement errors.

Maximum Allowable Pulse Width

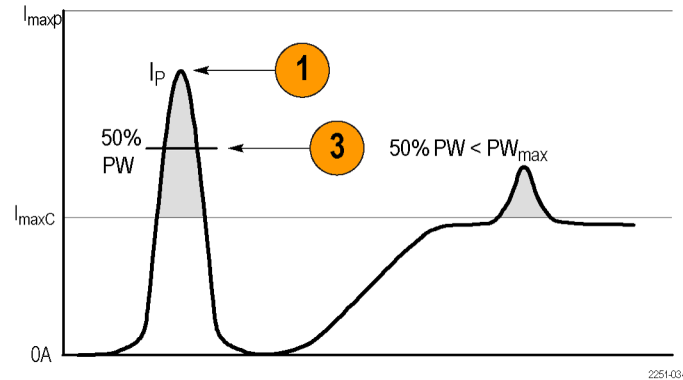
To determine the maximum allowable pulse width do the following:

1. Measure the peak current of the pulse.
2. Divide the Ampere-second (or Ampere-microsecond) specification for the range setting of the TCP0150 probe by the measured peak current of the pulse:

$$\frac{A \cdot \mu s}{I_P} = PW_{max}$$

The quotient is the maximum allowable pulse width (PW_{max}).

3. Check that the pulse width at the 50% point of the measured signal is less than the calculated maximum allowable pulse width (PW_{max}).



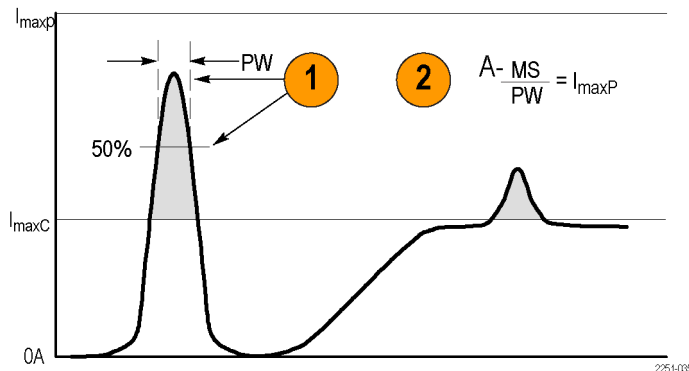
Maximum Allowable Pulse Amplitude

To determine the maximum allowable pulse amplitude, do the following:

1. Measure the pulse width at the 50% points.
2. Divide the Ampere-second (or Ampere-microsecond) specification for the range setting of the TCP0150 probe by the pulse width.

The quotient is the maximum allowable pulse amplitude; the peak amplitude of the measured pulse must be less than this value.

For example, the TCP0150 probe has a maximum Ampere-second product of 15000 A- μ s in the 150 A range setting. If a pulse measured with the probe has a width of 40 μ s, the maximum allowable peak current would be 15000 A- μ s divided by 40 μ s, or 375 A.



Specifications

The specifications in Tables 1 through 5 are valid under the following conditions:

- The probe has been calibrated at an ambient temperature of $23\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$.
- The probe is connected to a host instrument with an input impedance of $1\text{ M } \Omega$.
- 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 3.)

Specifications for the TCP0150 current 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. Warranted characteristics that have checks in the *Performance Verification* section are marked with the ✓ symbol.

Table 1: Warranted electrical characteristics

Characteristic	Description
✓ DC gain accuracy	<3% (typical <1% at +23 °C, ± 5 °C)
✓ Rise time (10% to 90%)	≤ 17.5 ns
✓ Bandwidth (calculated)	DC to 20 MHz

Typical Characteristics

Typical characteristics describe typical but not guaranteed performance.

Table 2: Typical electrical characteristics

Characteristic	Description
Maximum continuous current — DC and Low frequency (See Figure 3.)	25 A Range: 25 A RMS 150 A Range: 150 A RMS Control box derated to 100 A RMS above 40 °C
Maximum peak current (See Figure 3.)	500 A maximum peak pulse
Displayed RMS Noise	≤500 μ A RMS. (Limit measurement bandwidth to 20 MHz)
Insertion impedance	(See Figure 2.)
Signal delay	~21 ns
Maximum voltage on bare wire	600 V RMS CAT II, 300 V RMS CAT III
Maximum Amp·Second product (See graph on page 49.)	25 A Range: 3000 A μ s 150 A Range: 15000 A μ s

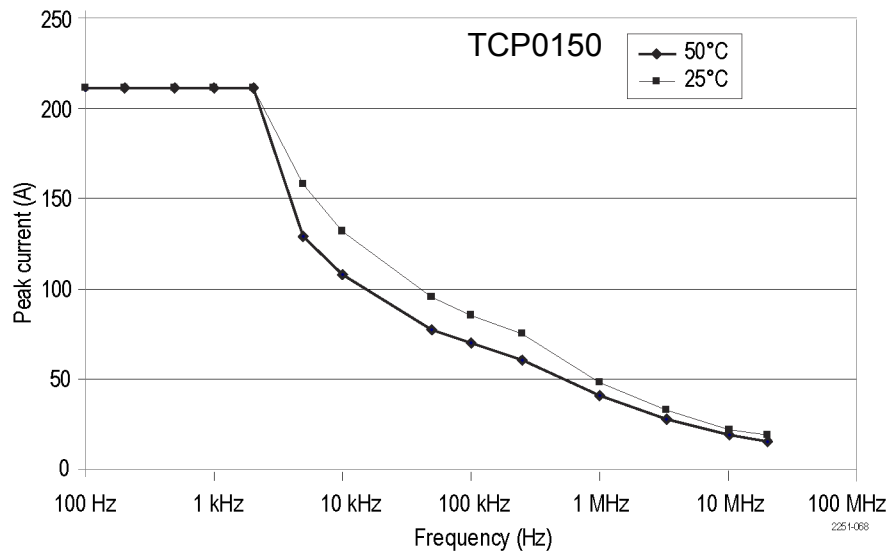


Figure 1: Frequency derating (peak current versus frequency)

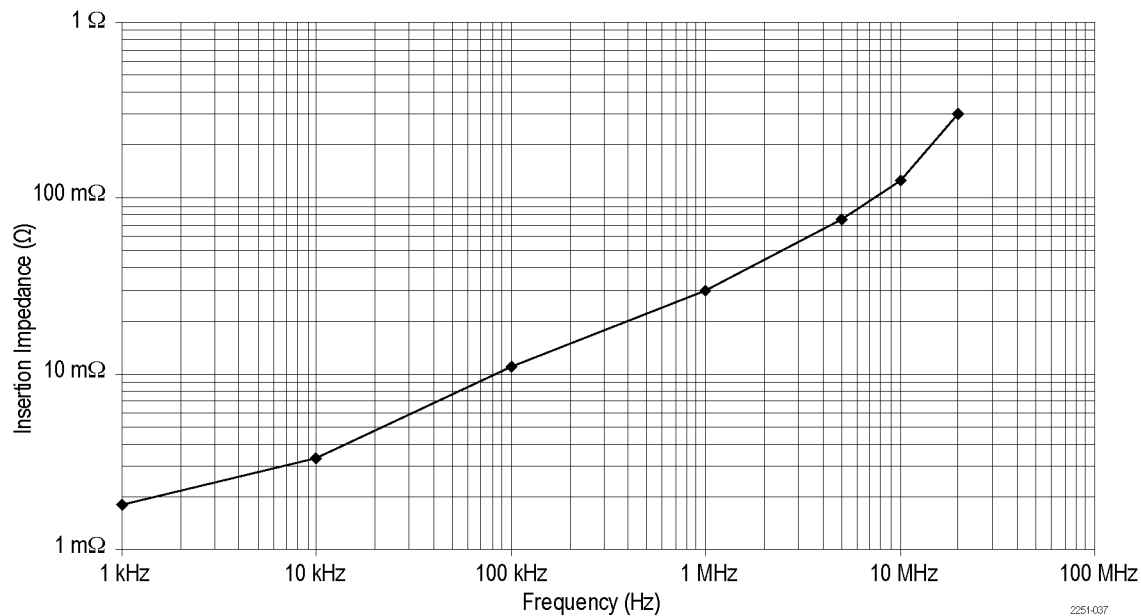


Figure 2: Typical differential input impedance versus frequency

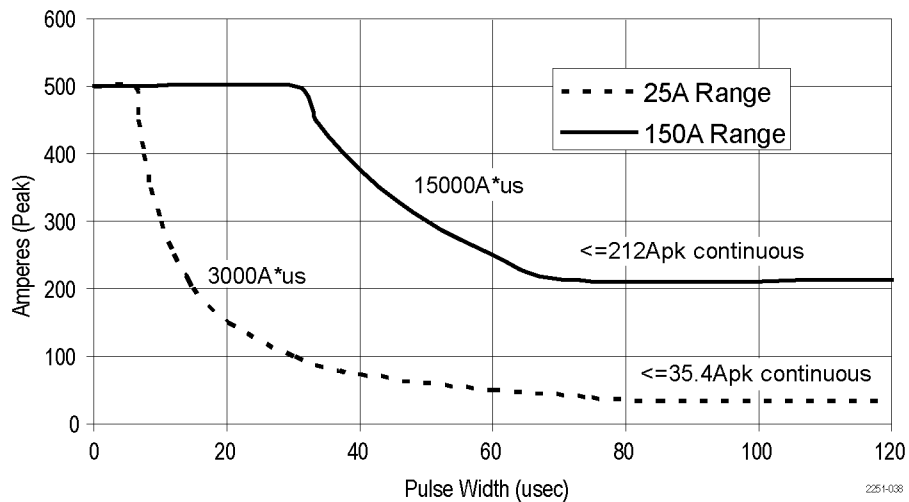


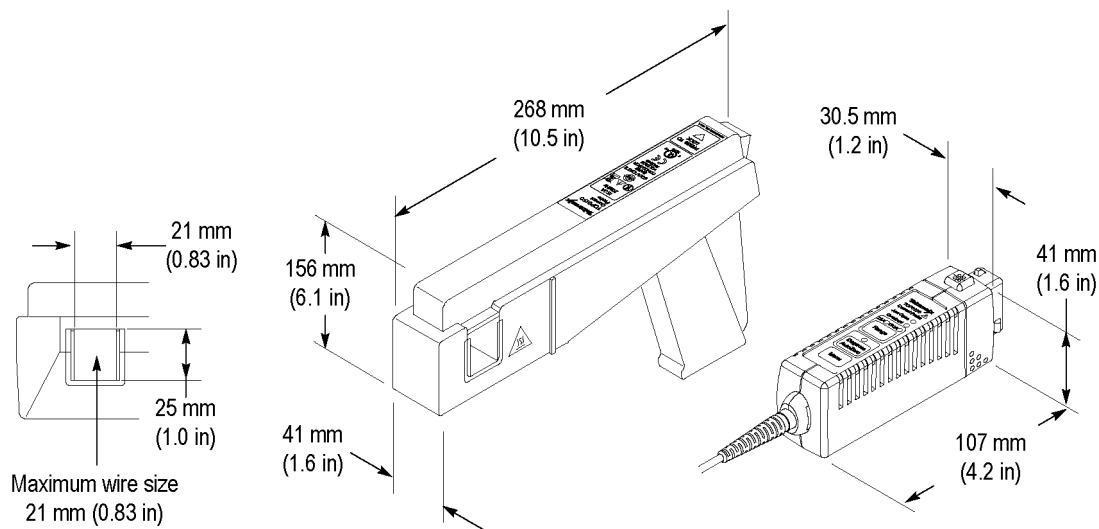
Figure 3: Maximum peak pulse versus pulse width

Table 3: Environmental characteristics

Characteristic	Description
Temperature	Operating: 0 to +50 °C (+32 to +122 °F) Nonoperating: -40 to +75 °C (-40 to +167 °F)
Humidity	Operating: 5-95% RH, tested up to +30 °C (+86 °F) 5-85% RH, tested at +30 °C to +50 °C (+86 °F to +122 °F) Nonoperating: 5-95% RH, tested up to +30 °C (+86 °F) 5-85% RH, tested at +30 °C to +75 °C (+86 °F to +167 °F)
Altitude	Operating: Up to 2000 meters (6,560 feet), Nonoperating: Up to 12,192 meters (40,000 feet)

Table 4: Typical mechanical characteristics

Characteristic	Description
Dimensions, compensation box	107 mm × 41 mm × 30.5 mm (4.2 in × 1.6 in × 1.2 in)
Dimensions, probe head	268 mm × 40.5 mm × 156 mm (10.5 in × 1.6 in × 6.13 in)
Dimensions, cable length	2 m (79 in) (from the probe head to the compensation box)
Unit weight	1.45 kg (3.2 lbs) (probe, accessories, and packaging)



2251-016

Figure 4: Probe dimensions

Nominal Characteristics

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

Table 5: Nominal electrical characteristics

Characteristic	Description
Input coupling	DC
Current ranges	25 A and 150 A
Termination	Terminate output into 1 M Ω
Compatibility	Oscilloscopes equipped with the TekVPI interface

Certifications and Compliances

EC Declaration of Conformity - Low Voltage

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

Low Voltage Directive 2006/95/EC.

- EN 61010-1:2001. Safety requirements for electrical equipment for measurement control and laboratory use.
- EN 61010-2-032:2002. Particular requirements for handheld current clamps for electrical measurement and test equipment.

U.S. Nationally Recognized Testing Laboratory Listing

- UL 61010B-1:2003. Standard for electrical measuring and test equipment.
- UL 6010B-2-032:2003. Particular requirements for handheld current clamps for electrical measurement and test equipment.

Canadian Certification

- CAN/CSA C22.2 No. 1010.1:1997. Particular requirements for electrical equipment for measurement, control, and laboratory use. Part 1.
- CAN/CSA C22.2 No. 1010.2.032-96. Particular Requirements for Hand Held Current Clamps for Electrical Measurement and Test.

Additional Compliance

- IEC 61010-1:2001. Safety requirements for electrical equipment for measurement, control, and laboratory use.
- IEC 61010-2-032:2002. Particular requirements for handheld current clamps for electrical measurement and test equipment.

Equipment Type

Test and measuring equipment.

Safety Class

Class 1 – grounded product.

Pollution Degree Descriptions

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

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

Pollution Degree

Pollution Degree 2 (as defined in IEC 61010-1). Note: Rated for indoor use only.

Measurement (Overvoltage) Category Descriptions

This product may have different measurement (overvoltage) category designations. The measurement categories are:

- Measurement Category IV. For measurements performed at the source of low-voltage installation.
- Measurement Category III. For measurements performed in the building installation.
- Measurement Category II. For measurements performed on circuits directly connected to the low-voltage installation.
- Measurement Category I. For measurements performed on circuits not directly connected to MAINS.

Measurement Category

Measurement Category II (as defined in IEC 61010-1).

User Maintenance

This section contains information on how to resolve use-related problems and how to care for your probe.

Oscilloscope Firmware

If some of the LEDs or features do not appear to function correctly, first go to www.tektronix.com/software to check for probe/oscilloscope compatibility and to download the latest oscilloscope firmware. Read the release notes and other information associated with the firmware upgrades to learn about any anomalies that may exist with your probe/oscilloscope combination when using that version of firmware. It is good practice to periodically check the Web site for new firmware versions that enhance the performance and capabilities of your Tektronix instruments.

Troubleshooting

The LEDs on the probe alert you to error or status conditions affecting the probe. If you have the latest firmware installed on the host oscilloscope and the probe LEDs do not light as expected, or if some of the probe features do not work properly, an error condition may exist. See the following table:

Symptom	Possible cause
LEDs on the probe do not light.	The oscilloscope channel may be bad: Try another channel or another oscilloscope. If the probe still does not work, the probe is defective, and must be returned to Tektronix for repair.
An error message displays on the oscilloscope.	The message will describe the cause and solution. For example, if the Degauss Needed message appears, perform the degauss procedure.

Cleaning



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

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

Do not use chemical cleaning agents; they may damage the probe. Do not use 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 and rinse with deionized water. A swab is useful for cleaning narrow spaces on the probe; use only enough solution to dampen the swab or cloth. Do not use abrasive compounds on any part of the probe.

Performance Verification



WARNING. *The following servicing instructions are for use only by qualified personnel. To avoid injury, do not perform any servicing other than that stated in the operating instructions unless you are qualified to do so. Refer to all safety summaries before performing any service.*

The procedures that follow verify the warranted specifications of the probe, listed below. The recommended calibration interval is one year.

- DC gain accuracy
- Rise time
- Bandwidth

Perform the following verification procedures in the order listed.

Equipment Required

Table 6 lists the equipment required for the performance verification procedure.

Table 6: Test equipment

Description and quantity	Performance requirement	Recommended example ¹
Oscilloscope	TekVPI interface, 500 MHz or greater bandwidth	Tektronix DPO4000
High Amplitude Pulse Generator	Risetime <1 ns, pulse width >100 ns, amplitude >10 V _{pp} into 50 Ω	Picosecond Labs 2600C
Calibrator	DCA: 0.25% accuracy, 0 to ± 10 A ACA: 0.25% accuracy, 0 to ± 7.5 A, square wave output	Fluke/Wavetek 9100 w/Options 100 and 250 or 600
Digital Multimeter (DMM)	DCV: 0.2% accuracy	Keithley 2700
TekVPI Calibration/Verification adapter	TekVPI interface	067-1701-XX
DC Current loop	5 turns 18 AWG coated wire on 3 inch form	See instructions that follow
HF Current loop	50 Ω $\pm 0.5\%$, BNC male	015-0601-50
BNC-to-Dual banana adapter		103-0090-00
SMA M-to-BNC F adapter		015-0554-00
BNC Cable	50 Ω , 0.76 m (30 in) length	012-0117-00

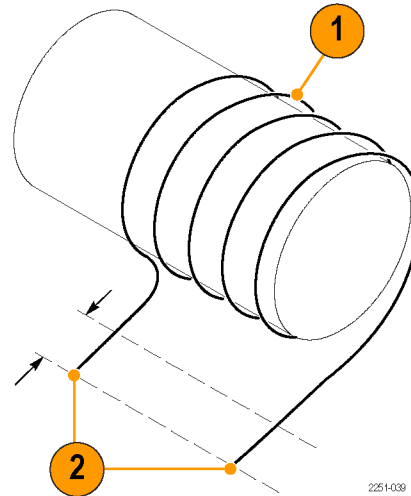
¹ Nine-digit part numbers (xxx-xxxx-xx) are Tektronix part numbers.

Making the DC Current Loop

Construct the loop using #18 coated wire and a cylindrical form approximately 3 inches in diameter:

1. Wind *exactly* 5 turns of #18 coated wire around the form.
2. Scrape about a half-inch of coating off of the ends of the wire.

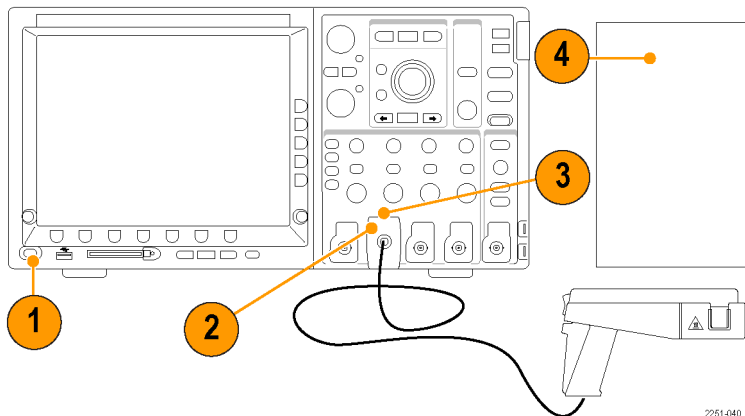
NOTE. Ensure that the current loop has exactly 5 turns. A significant error will result for each turn variance from 5 turns.



Equipment Setup

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

1. Turn on the oscilloscope.
2. Connect the probe to any channel (1–4) of the oscilloscope.
3. Press the Degauss/AutoZero button.
4. Power on the DMM, current source, and the pulse generator.
5. Allow 20 minutes for the equipment to warm up.
6. Photocopy the test record and use it to record the test results. (See page 66.)

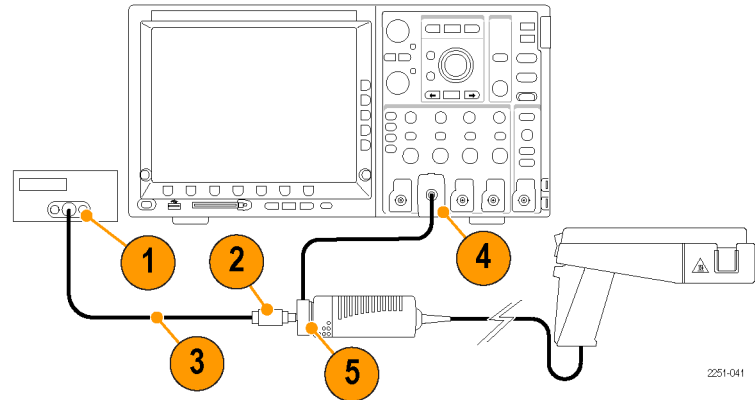


2251-040

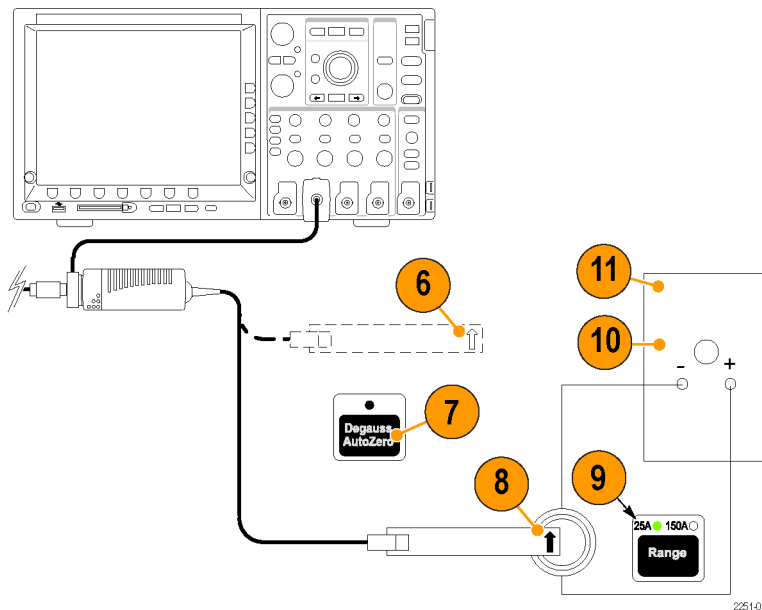
DC Gain Accuracy

This test checks the DC gain accuracy of the probe. If the measurements are out of the specified limits in the test record, refer to the *Adjustments* section. (See page 67.)

1. Connect a BNC-to-Dual Banana adapter to the DMM input.
2. Connect the SMA M-to-BNC F adapter to the SMA output of the TekVPI Calibration/Verification adapter.
3. Connect the BNC cable between the BNC adapter on the TekVPI Calibration/Verification adapter and the BNC adapter attached to the DMM.
4. Connect the TekVPI Calibration/Verification adapter to any channel (1–4) of the oscilloscope.
5. Connect the probe to the TekVPI Calibration/Verification adapter.



6. Do not clamp the current probe around any conductor, but make sure the jaws are locked shut.
7. Press the probe Degauss/AutoZero button. Wait for the Degauss/AutoZero routine to complete before proceeding. The routine is complete when the indicator light turns green.
8. Clamp the current probe around the 5 turn current loop as shown. Maintain proper polarity; the arrow-shaped indicator on the probe points away from the (+) terminal of the current source.
9. Set the probe range to 25 A.
10. Set the current source output to +2.50 A.
11. Enable the output of the current source.



12. Record the exact measurement of the digital multimeter as M1.
13. Set the current source output to -2.50 A.
14. Record the exact measurement of the digital multimeter as M2.
15. Compute the %Error using the measured amplitude values and the formula shown.
For example, you might measure values of 2.475 V for M1 and -2.495 V for M2. With an expected output voltage (Ve) of 2.5 V, compute the % Error as follows:
16. Set the probe range to 150 A.
17. Repeat steps 9 through 15 for the 150 A range, using +/-10.0 A as the test current.
18. Disable the calibrator output.

25 A Range

Test current = +/-2.50 A Expected output voltage (Ve) = 2.5 V

150 A Range

Test current = +/-10.0 A Expected output voltage (Ve) = 1.0 V

$$\%Error = \frac{[(M1 - M2) - 2 V_e]}{2 V_e} \times 100$$

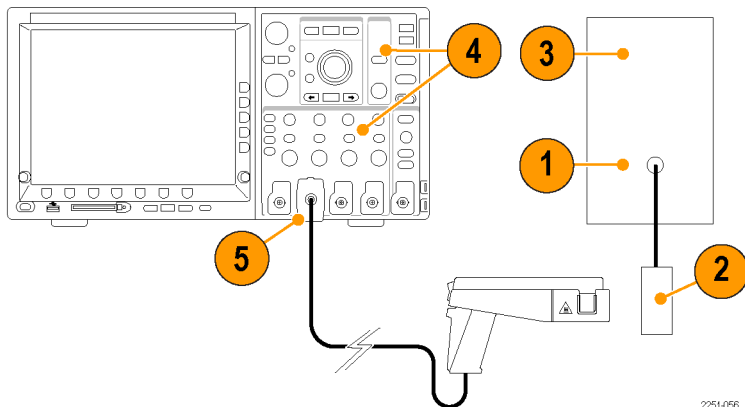
Example:

$$\frac{[(2.475 V - (-2.495 V) - 2 (2.5 V))]}{5.0 V} \times 100 = -0.6\%$$

Rise Time and Bandwidth

This procedure verifies that the probe meets the rise time specification. The bandwidth of the probe is then calculated using the measured probe rise time.

1. Connect the BNC cable to the output of the pulse generator.
2. Connect the other end of the BNC cable to the HF current loop.
3. Set the pulse generator output and pulse width to maximum.
4. Set the oscilloscope as follows:
 - Vert: 250 mA/div, Horiz: 10 ns/div
 - Trigger at 50%, Averaging on (32)
 - Coupling to DC
 - Automeasurement to Rise Time
5. Connect the probe directly to one of the oscilloscope channels (1–4).

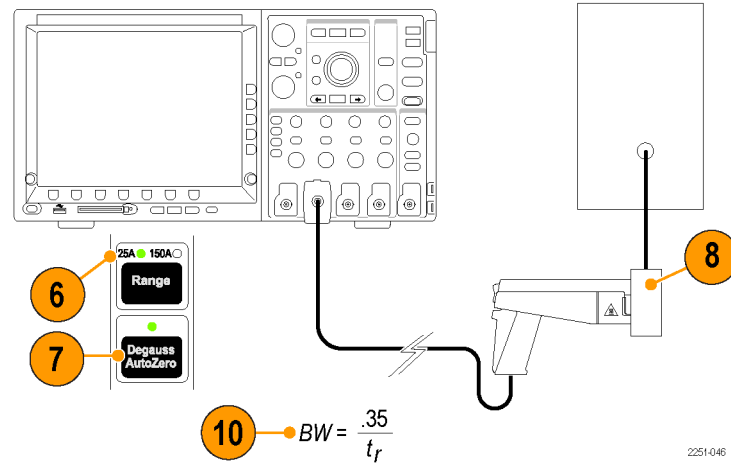


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6. Set the probe range to 25 A.
7. Degauss the probe.
8. Clamp the current probe around the HF current loop. Verify that the arrow-shaped indicator on the probe points away from the pulse generator.
9. Record the rise time measurement in the Test Record.

NOTE. If you measure higher rise times than expected, check your oscilloscope firmware version. (See page 55, Oscilloscope Firmware.) Early versions of oscilloscope firmware may engage the bandwidth limit filter, which will yield inaccurate rise time measurements.

10. Calculate the probe bandwidth using the measured rise time in the formula shown.
11. Record the calculated bandwidth value in the test record.



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Test Record

Probe Model/Serial Number:

Certificate Number:

Temperature:

RH %:

Date of Calibration:

Technician:

Performance test	Range	Test Current	Calibrator output	Expected output	Minimum	Incoming	Outgoing	Maximum
DC Gain	25 A	± 12.5 A	2.50 A	2.5 V	-3%			+3%
Accuracy	150 A	± 50.0 A	10.0 A	1.0 V	-3%			+3%
Rise time	25 A	~ 1 A	< 500 ps	<17.5 ns	NA			17.5 ns
Bandwidth	25 A	NA	NA	>20 MHz	20 MHz			NA

Adjustments

The procedures that follow describe the DC gain accuracy adjustments to the probe to bring the performance within the warranted specifications.

Equipment Required

Refer to the *Performance Verification* procedure for the equipment required. You also need an insulated adjustment tool. (See page 28, *Adjustment Tool*.)

Equipment Setup

Refer to the *Performance Verification* procedure for the equipment setup.



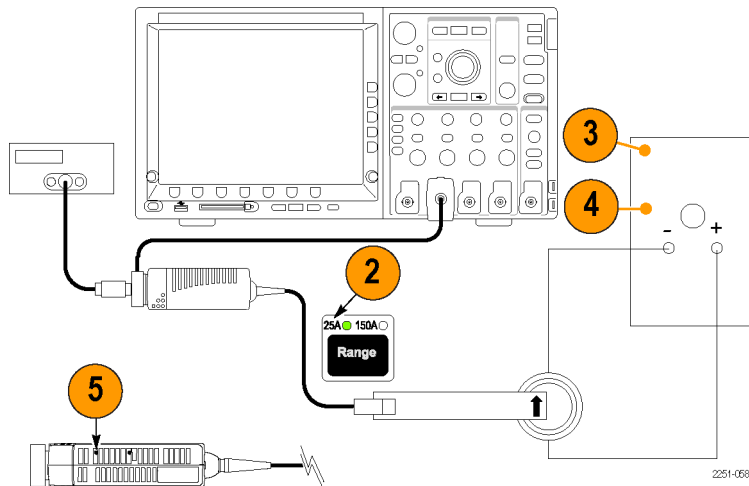
CAUTION. To avoid ESD damage to the probe, use an antistatic wrist strap and work at a static-approved workstation when handling the probe.

DC Gain Accuracy

This procedure describes the DC gain accuracy adjustments for the probe at the 25 A and 150 A range settings.

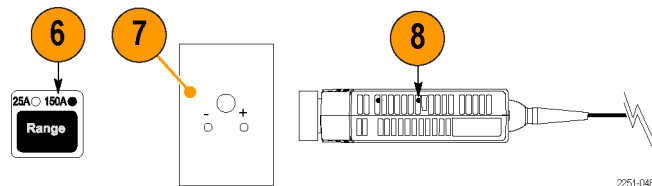
Adjust the 25 A Range

1. Complete steps 1–8 of the *DC Gain Accuracy Test* in the *Performance Verification* procedure. (See page 61, *DC Gain Accuracy*.)
2. Set the probe range to 25 A.
3. Set the current source to:
 - 40 Hz square wave
 - 1.0 Amp AC output
4. Enable the output of the current source.
5. Adjust the 25 A gain on the probe to display 1.000 V, +/- .005 V on the DMM.



Adjust the 150 A Range

6. Set the probe range to 150 A.
7. Set the calibrator output to 7.5 A.
8. Adjust the 150 A gain on the probe to display 750 mV, ± 3 mV on the DMM.
9. Disconnect the probe from the current source.



Repair



WARNING. To reduce the risk of shock or probe damage, all service procedures, including disassembly/reassembly and repair/replacement of parts, must be performed by qualified service personnel.

Repairing the Probe

The subassemblies listed below can be replaced on the probe. The replacement procedures are on the following pages.

Replaceable component	Procedures to use
Transformer	Probe Head Disassembly, Transformer Replacement
Circuit Board Assembly	Probe Head Disassembly, Cable/Circuit Board Assembly Replacement, Compensation Box Replacement
Cable	Probe Head Disassembly, Cable/Circuit Board Assembly Replacement, Compensation Box Replacement
Compensation Box	Compensation Box Replacement
Switch Panel	Compensation Box Replacement

Required Equipment

The following equipment is necessary to perform the repair procedures.

Tool	Description
Screwdriver	3/32 Allen bit
Soldering iron	25 W
Cleaner	Isopropyl alcohol
Lubricant	Silicone-based grease
Compensation box separator ¹	Order Tektronix part number 003-1892-00 (See page 28, <i>Compensation Box Tool</i> .)

¹ Required for cable, switch panel, and compensation box replacement procedures

Probe Disassembly

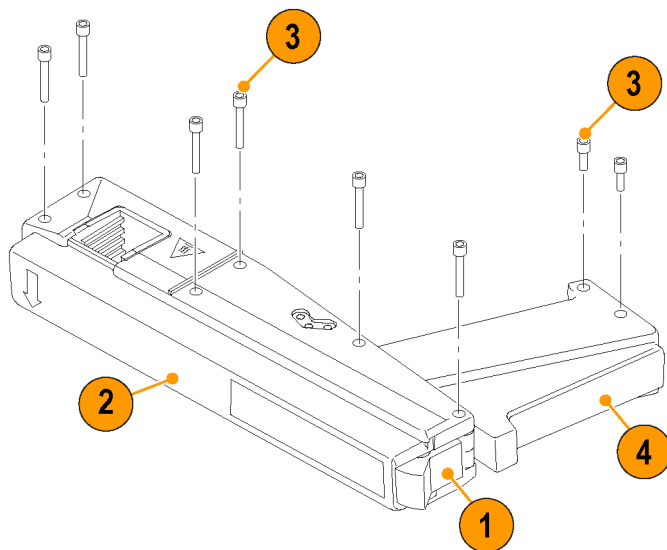
The following procedures explain how to disassemble the probe and replace the components.



WARNING. To reduce the risk of shock or probe damage, all service procedures, including disassembly/reassembly and repair/replacement of parts, must be performed by qualified service personnel.

Probe Head

1. Unlock the probe slide.
2. Place the probe on a flat surface with the screw heads facing up.
3. Using a 3/32 inch Allen wrench, remove the eight retaining screws from the case.
4. Separate the case halves and remove the slide.

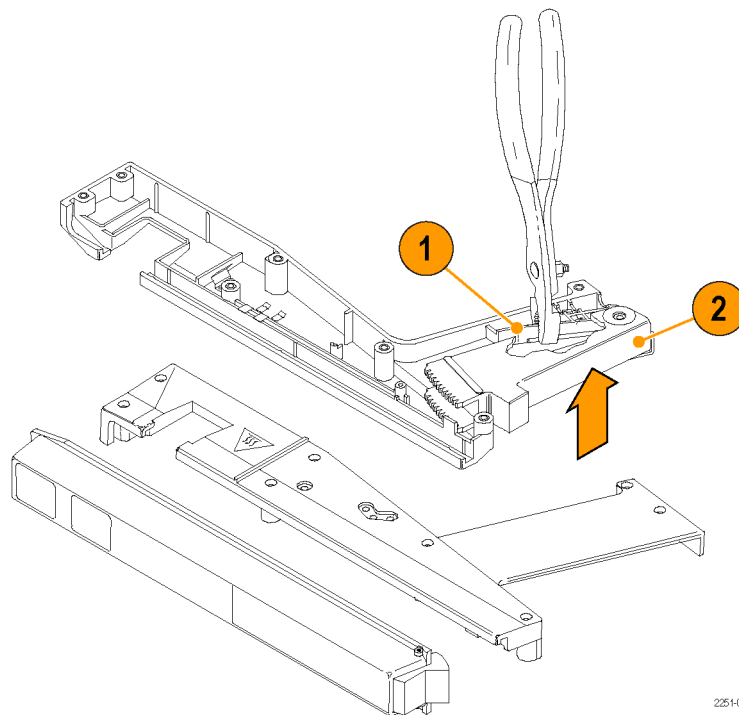


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WARNING. To reduce the risk of injury, use care when disassembling the probe. The spring in the squeeze handle is under tension and can pop out.

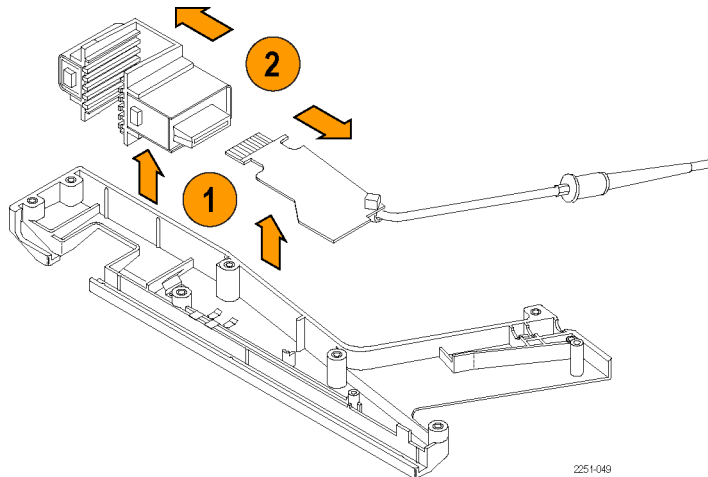
1. Lift the cable out of the probe handle and insert a pair of pliers in the handle as shown.
2. While maintaining a firm grip on the pliers, carefully lift the squeeze handle and gear out of the probe.



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Transformer

1. To remove the current transformer, lift the assembly out of the probe as shown.
2. Disconnect the transformer from the circuit board.

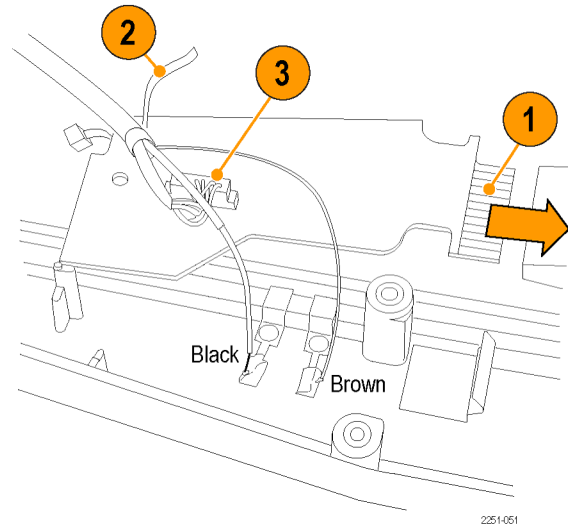


Circuit Board

The circuit board and cable are replaceable separately.

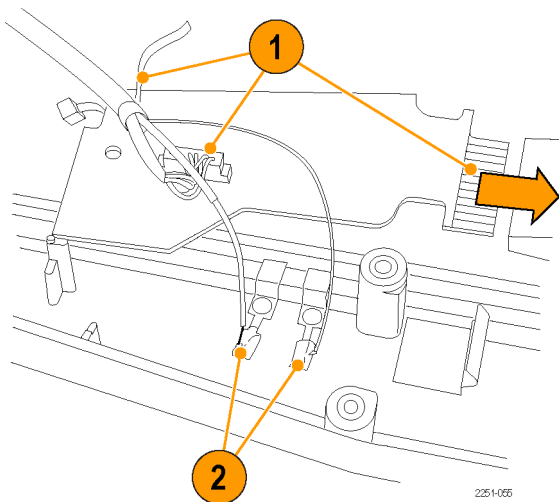
1. Remove the transformer as described in the previous procedure.
2. To remove the circuit board, cut the cable tie that secures the cable to the board.
3. Disconnect the cable from the board.

When reassembling the probe, do not tighten the new cable tie until you seat the board and cable in the probe case, to allow enough cable length for a proper fit.



Cable

1. Remove the transformer and circuit board as described in the previous procedures.
2. Unsolder the two switch wires.
3. Proceed to the *Compensation Box* procedure to detach the cable from the compensation box. (See page 77.)
4. To reassemble the probe after replacing the cable, perform steps 1 through 3 of this procedure in reverse. (See the following Caution statement.)

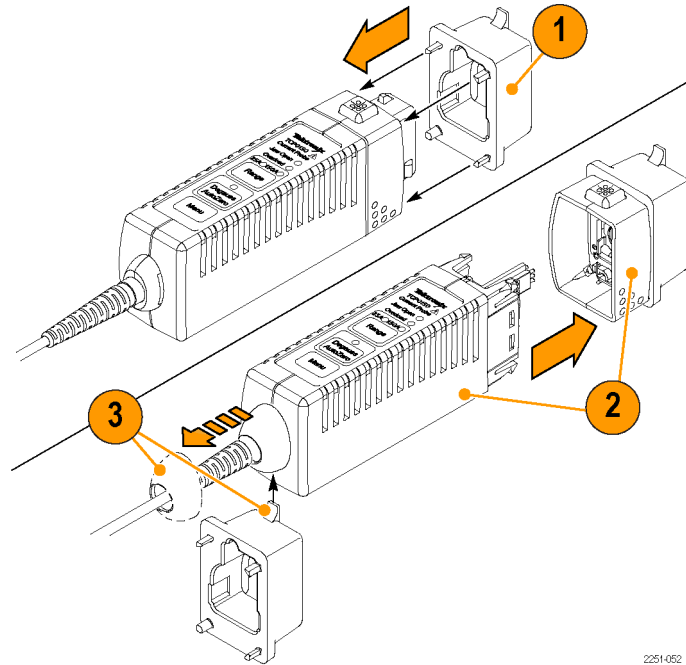


CAUTION. To avoid damaging the wires inside the probe, carefully dress the wires in the lower body half to avoid contact with the slide assembly.

To avoid damaging the switch contacts, exercise care when fitting the slide back into the probe body. Aligning the switch contacts requires precision.

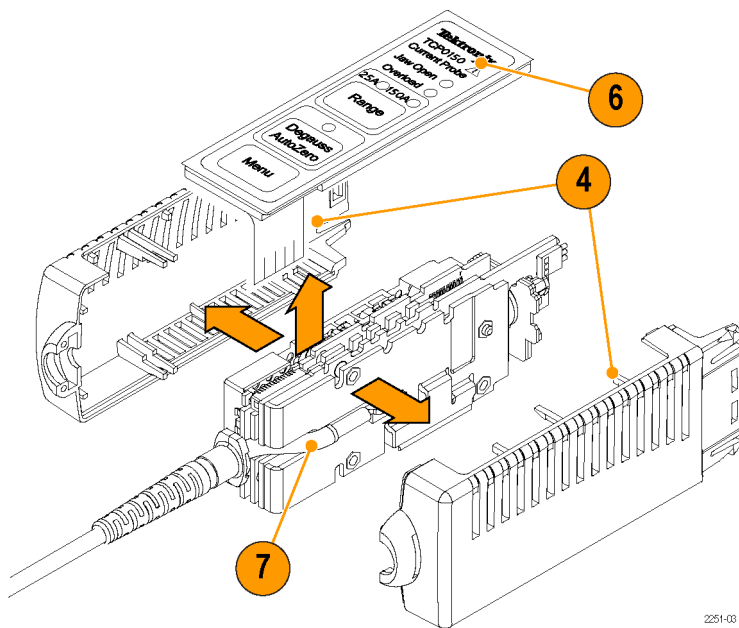
Compensation Box

1. Insert the separator tool into the four holes to disengage the front section of the compensation box from the main section.
2. Grasp the tool and front section together with one hand. Hold the main section with the other hand and gently pull the two sections apart.
3. Use the separator tool tab to pop the cable cover off of the back section of the compensation box.



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4. Separate the two halves of the compensation box enclosure.
5. If you are only replacing the switch panel, remove the metal shield from the main assembly.
6. Release the connector to disconnect the panel cable, replace it, and then reassemble the compensation box.
7. If you are replacing the cable or compensation box, disconnect the cable connector.
8. Install the new cable or compensation box by performing this procedure in reverse. If you are replacing the cable, refer also to the *Cable/Circuit Board Assembly* procedure to complete the cable replacement.



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Reassembly

1. Before reassembling the probe body, be sure to verify the following:
 - a. The gap between the stationary and moveable core pieces is clean. If necessary, use isopropyl alcohol or a similar cleaning agent to clean the pieces.
 - b. The contacts of the slide switch are clean. (Clean them if necessary.)
 - c. The plastic slide assembly is lubricated. If necessary, apply silicone-based grease sparingly to the parts.
2. Reassemble the probe body by following steps 1 and 2 of the probe head disassembly procedure in reverse. (See page 71, *Probe Disassembly*.)



CAUTION. *To avoid damaging the wires inside the probe, carefully dress the wires in the lower body half to avoid contact with the slide assembly.*

To avoid damaging the switch contacts, exercise care when fitting the slide back into the probe body. Aligning the switch contacts requires precision.

If the slider does not work smoothly after tightening the two screws, loosen the screws slightly.

Replaceable Parts

This section contains a list of the replaceable parts for the probe. Use this list to identify and order replacement parts.

Parts Ordering Information

Replacement parts are available through your local Tektronix field office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available and to give you the benefit of the latest circuit improvements. Therefore, when ordering parts, it is important to include the following information in your order:

- Part number
- Instrument type or model number
- Instrument serial number
- Instrument modification number, if applicable

Using the Replaceable Parts List

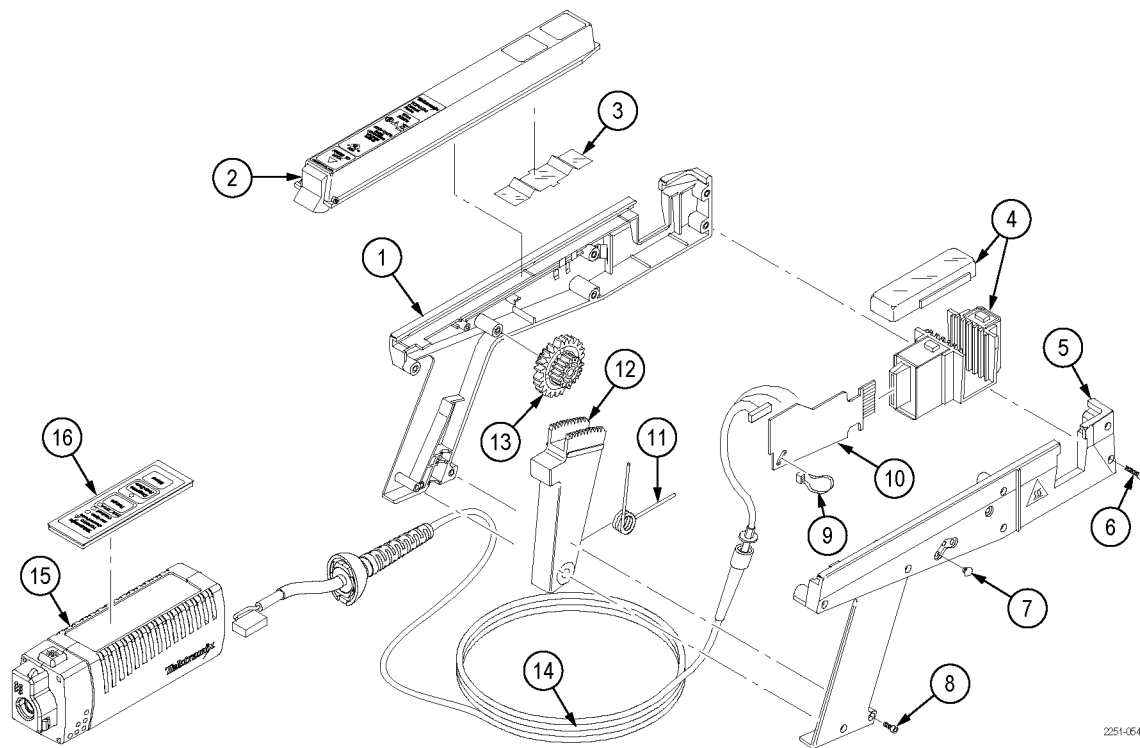
This section contains a list of the mechanical and/or electrical components that are replaceable for the probe. Use this list to identify and order replacement parts. Table 8 describes each column in the parts list.

Table 7: Parts List Column Descriptions

Column	Column name	Description
1	Figure & Index Number	Items in this section are referenced by figure and index numbers to the exploded view illustrations that follow.
2	Tektronix Part Number	Use this part number when ordering replacement parts from Tektronix.
3 and 4	Serial Number	Column three indicates the serial number at which the part was first effective. Column four indicates the serial number at which the part was discontinued. No entries indicates the part is good for all serial numbers.
5	Qty	This indicates the quantity of parts used.
6	Name & Description	An item name is separated from the description by a colon (:). Because of space limitations, an item name may sometimes appear as incomplete. Use the U.S. Federal Catalog handbook H6-1 for further item name identification.

Abbreviations

Abbreviations conform to American National Standard ANSI Y1.1-1972.



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Figure 5: Replaceable Parts

Table 8: Replaceable Parts

Fig. & Index Number	Tektronix Part Number	Qty	Name & Description
5-1	204-0713-02	1	BODY HALF,PROBE:LEFT W/CONTACTS
-2	—	1	SLIDE ASSEMBLY:CONTACT TEKTRONIX SERVICE
-3	214-2422-00	1	SPRING,FLAT:UPPER CAN
-4	120-2099-00	1	TRANSFORMER:SUBASSEMBLY, TOP AND BOTTOM
-5	204-0712-02	1	BODY HALF,PROBE:RIGHT W/CONTACTS
-6	211-0093-00	6	SCREW,CAP:4-40 X 0.75,SCH,STL,CD PL,HEX REC
-7	348-0023-00	4	PLUG,HOLE:U/W0.14 DIA HOLE,WHT PLSTC
-8	211-0183-00	2	SCREW,CAP:4-40 X 0.5,SCH,STL,CD PL,HEX REC
-9	343-0149-00	1	STRAP, TIEDOWN,E,6.75L,PLASTIC
-10	878-0119-00	1	CIRCUIT BOARD ASSEMBLY
-11	214-2446-00	1	SPR,HLCL,TRSN:0.1 OD X 0.5 L,MUSIC WIRE
-12	367-0218-00	1	HANDLE,SQUEEZE:PROBE
-13	401-0352-00	1	GR CLUSTER,SPUR:(2)18 AND (1) 24 T,PLASTIC
-14	174-5450-00	1	CABLE ASSEMBLY, RF, COAX, 12 COND
-15	206-0583-00	1	CONTROL BOX
-16	260-2873-00	1	MEMBRANE SWITCH

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