Instruction Manual

Tektronix

P6021
60 MHz Current Probe

070-0947-07

Warning
The servicing instructions are for use by qualified personnel only. To avoid personal injury, do not perform any servicing unless you are qualified to do so. Refer to all safety summaries prior to performing service.

www.tektronix.com

Contacting 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.

THIS WARRANTY IS GIVEN BY TEKTRONIX WITH RESPECT TO THE PRODUCT IN LIEU OF ANY OTHER WARRANTIES, EXPRESS OR IMPLIED. TEKTRONIX AND ITS VENDORS DISCLAIM ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. TEKTRONIX' RESPONSIBILITY TO REPAIR OR REPLACE DEFECTIVE PRODUCTS IS THE SOLE AND EXCLUSIVE REMEDY PROVIDED TO THE CUSTOMER FOR BREACH OF THIS WARRANTY. TEKTRONIX AND ITS VENDORS WILL NOT BE LIABLE FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES IRRESPECTIVE OF WHETHER TEKTRONIX OR THE VENDOR HAS ADVANCE NOTICE OF THE POSSIBILITY OF SUCH DAMAGES.

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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. 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 grounded through the grounding conductor of the 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 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 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:

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.

To avoid electric shock, do not touch exposed connections.

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.

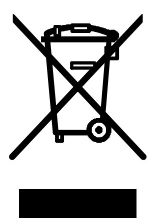
Environmental Considerations

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 to the left 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.

Operator Information

Thank you for choosing a Tektronix current probe. This manual describes the P6021 current probe with passive termination and provides information about making measurements with the probe.

Description

The P6021 current probe converts an alternating current waveform to a voltage that can be displayed and measured on an oscilloscope display. The probe provides accurate current measurements over a wide range of frequencies and allows you to measure current without breaking the circuit.

The P6021 probe is compatible with general purpose oscilloscopes having a 1 MΩ input impedance. The P6021 probe comes with a passive termination that matches oscilloscope and probe impedance, optimizes the probe performance, and provides two sensitivity settings.

The P6021 probe comes with a 5-foot cable and termination.

Installation

This section describes both attaching the probe to an oscilloscope and using the standard accessories with the probe.

To ensure the best performance from your probe and oscilloscope measurement system, check that the probe and oscilloscope are appropriately matched. The oscilloscope inputs should use BNC connectors and have an impedance of 1 MΩ.

Figure 1 shows the probe and various parts referred to in this manual.

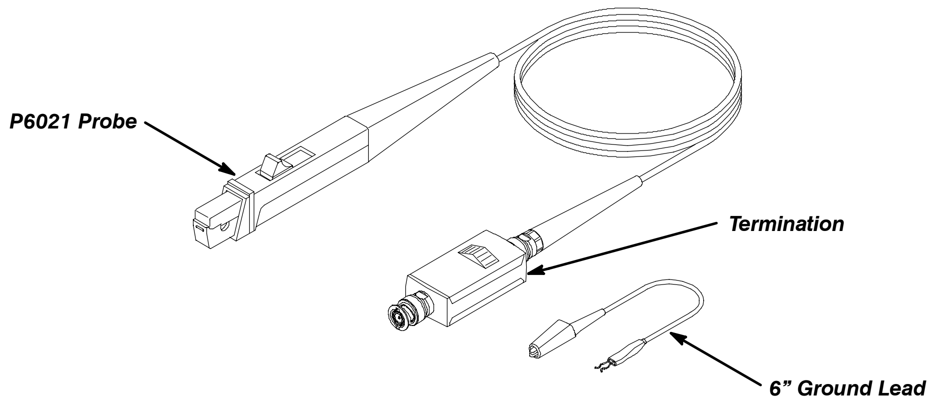


Figure 1: The P6021 Probe and termination

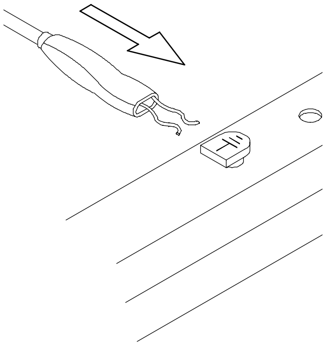
Attaching the Probe and Termination to an Oscilloscope

Attach the probe to the termination as shown in Figure 1.

An alligator-style ground clip is supplied to improve EMI rejection at high frequencies (2 MHz and above). Snap the ground lead to the probe transformer post and attach the alligator clip directly to RF ground. This will reduce ringing and help bypass capacitively-coupled RF currents that can flow into the probe cable.

WARNING. *To avoid injury or damage to the equipment, do not disconnect the probe termination and leave the P6021 clamped around the conductor when you measure high currents. If you leave the probe cable unterminated, you can cause a high voltage to develop in the secondary winding, which may damage the current probe transformer.*

Using the Standard Accessories



Your P6021 is shipped with the following accessories:

- **This instruction manual —** Read these instructions to familiarize yourself with the features, specifications, and operation of the P6021 current probe.
- **6-inch ground lead —** Use the 6-inch ground lead to ground the shield around the probe transformer at the probe end of the cable. This allows you to move the ground connection closer to the circuit that you are measuring, thereby improving high frequency response. The ground lead clips onto the ground connector on the bottom of the probe as shown.

Please refer to the parts list in the section entitled *Replaceable Mechanical Parts* for part numbers.

Optional Accessories

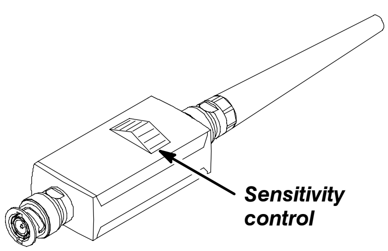
Your P6021 may be used with the following optional accessory:

- **CT-4 Current Probe —** The CT-4 is a robust clip-on transformer that extends the current range of the P6021 up to 1000 amps (provided the amp-second rating is not exceeded). The CT-4 has receptacles for current probes in either 20:1 or 1000:1 step-down ratios.

Operating Considerations

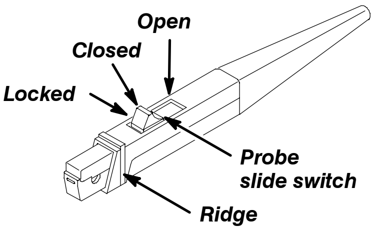
The information in this section will help you make effective use of your P6021 probe.

Features and Controls



- **Sensitivity Control —** The P6021 termination has a control that allows you to select probe sensitivity. The switch has two positions: 2 mA/mV and 10 mA/mV. When the control is in the 2 mA/mV position, the oscilloscope displays 1 mV for every 2 mA of current in the circuit under test. When the control is in the 10 mA/mV position, the oscilloscope displays 1 mV for every 10 mA of current in the circuit under test.

  You can set vertical scale on the oscilloscope to any scale factor, as determined by the signal amplitude. To calculate the overall vertical scale factor for the oscilloscope, probe, and termination, multiply the termination sensitivity control setting by the vertical scale factor of the oscilloscope. For example, if the termination control is set to the 10 mA/mV position and the oscilloscope to a vertical scale of 20 mV/division, the overall scale factor is 10 X 20, or 200 mA/division.



- **Probe Slide Switch —** The slide switch on the probe has three positions: open, closed, and locked. Use your thumb to move the probe slide switch. The switch is spring loaded so that it automatically moves from the open to closed positions.

To Use the Probe:

WARNING. *To avoid injury or equipment damage, only take measurements on insulated conductors with the probe. The probe is not rated for bare wire voltages above 30 Vrms, 42 Vpk, 60 VDC.*

NOTE*. An insulated conductor is any conductor that is surrounded by an insulating material that is capable of isolating the voltage present on the conductor. Lacquer coatings like those typically found on transformer windings do not provide sufficient, reliable insulation for use with current probes. The lacquer coating can be easily nicked or damaged, which compromises the insulating capabilities of the lacquer coating.*

CAUTION. *To prevent damage to the probes, do not force the slide closed. 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.*

a. Pull the slide switch toward you, and hold the switch in position.

b. Place the conductor-under-test inside the exposed transformer core. The arrow on the transformer end of the probe indicates conventional current flow. If you place the probe on the conductor so that the arrow on the probe matches conventional current flow through the conductor, orientation of the displayed waveform will be correct.

c. Release the switch, allowing the probe to close.

d. Lock the slide switch. To lock the switch, push it firmly toward the transformer (the switch will move only about 1/8th inch). Locking the switch assures maximum contact between the two halves of the transformer secondary. The conductor now becomes the primary of the transformer. (When measuring current, always check that the probe slide switch is moved completely forward into the locked position.)

Insertion Impedance

When you insert a conductor into the probe, you add impedance to the circuit you are measuring. This additional impedance affects signals; this is particularly important if you are measuring fast rise times. Figure 2 illustrates the equivalent circuit with the additional impedance introduced by the P6021.

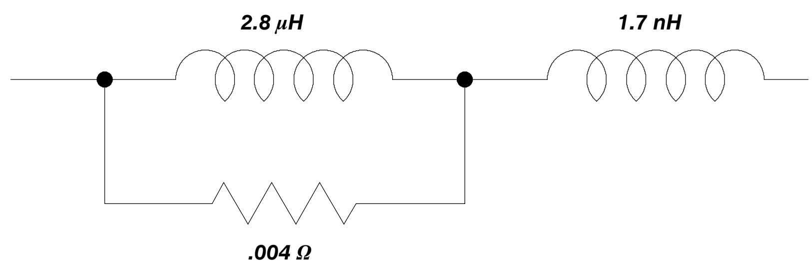


Figure 2: Insertion Impedance of the P6021

Minimizing Loading Effect

To minimize the loading effect of the probe, clamp it at the low or ground end of a component lead when possible. This method also minimizes noise or stray signal interference.

Increasing Probe Sensitivity

You can increase the current sensitivity of the probe by increasing the number of times a conductor passes through it. For example, if the conductor loops through the probe twice (a two-turn primary winding), the secondary current is doubled.

For example, suppose you set the termination sensitivity to 2 mA/mV and the oscilloscope vertical scale to 10 mV/division. Ordinarily, this would result in the equivalent of 2 X 10, or 20 mA/division. However, if the conductor is looped through the probe twice, the vertical scale is divided by two, resulting in the equivalent of 10 mA/division.

Looping the conductor twice effectively doubles vertical sensitivity; however, impedance from the probe winding is also reflected into the circuit being measured. This impedance is proportional to the square of the number of loops. This additional impedance affects signals; this impedance is particularly important when you are measuring high-frequency current waveforms or waveforms with fast rise times.

Probe Shielding

The P6021 is shielded to minimize the effect of external magnetic fields. However, strong fields can interfere with the current signal being measured. If you suspect that an external field is interfering with your measurement, remove the probe from the conductor, but keep it in the same location as when you made the suspect measurement. If a signal still appears on the oscilloscope, try to measure the conductor current at a point farther from the location of the magnetic field.

If you must measure current in the presence of a strong magnetic field, you can minimize its interference by using two current probes and a differential-input oscilloscope. To do so, follow these steps.

1. Connect the probes (with termination) to the positive and negative inputs of the oscilloscope.
2. Clamp one probe around the conductor whose current you want to measure.
3. Place the other probe as close as possible to the first. Ensure that its slide switch is completely closed, without a conductor inside it.
4. Set the oscilloscope to subtract the component of the signal that is common to both probes.
5. Adjust the positions of the probes for best results. It may be difficult to eliminate the undesirable signal completely, due to differences between the probes or their terminations.

Droop

The flat-top response of any AC current probe displays a certain amount of droop. This is caused by probe inductance loading the source impedance, causing an L/R exponential decay. For short pulse widths, the response looks nearly flat. The amount of droop can be calculated from the following relationship:

$\%\ \text{Droop} = 200\ (\pi)\ T\ f$

where:
T=pulse duration in microseconds
f=lower 3 dB frequency of probe in Hertz

For example, to calculate the percent droop of a 100 μs pulse measured with a P6021 probe:

In the 10 mA/mV position, f=120 Hz

$$\begin{aligned}\%\ \text{Droop} &= 200\ (\pi)\ T\ f\\ &= 200\ (\pi)\ (100*10^{-6})\ (120)\\ &= 0.075\%\end{aligned}$$

Service Information

Warranted Characteristics

This section lists the various warranted characteristics that describe the P6021 Current Probe. Included are warranted electrical and environmental characteristics.

Warranted characteristics are described in terms of quantifiable performance limits which are warranted.

The electrical characteristics listed in Table 1 apply under the following conditions:

NOTE. *The probe and instrument must be in an environment whose limits are described in Table 2.*

Table 1: Warranted electrical characteristics

Characteristic	Information
Sensitivity setting	2 mA or 10 mA for each mV at oscilloscope input, selected by termination sensitivity control
Midband accuracy	±3%
System bandwidth (-3 db) (with BW>200 MHz oscilloscope)	
2 mA/mV	450 Hz to 60 MHz
10 mA/mV	120 Hz to 60 MHz

Table 2: Warranted environmental characteristics

Characteristic	Information
Temperature range	
Operating	-0 °C to +50 °C (+32 °F to +122 °F)
Nonoperating	-40 °C to +65 °C (-40 °F to +149 °F)
Altitude	
Operating	Up to 4,572 m (15,000 ft)
Nonoperating	To 15,240 m (50,000 ft)

Table 3: Maximum ratings

Characteristic	Information
Maximum continuous (CW) current	Refer to Figure 3 for frequency derating curves
2 mA/mV	5 A_{p-p} sine wave between 1.2 kHz and 5 MHz
10 mA/mV	15 A_{p-p} sine wave between 300 Hz and 5 MHz
Maximum Pulse Current	250 A peak, not to exceed 500 (A · μs) or 5 A_{RMS}. An (A · s) product greater than 500 (A · μs) reduces probe output to zero due to core saturation
Maximum voltage on bare wire*	30 Vrms, 42 Vpk, 60 VDC, for voltages above these limits, use insulated conductors only.

* **An insulated conductor is any conductor that is surrounded by an insulating material that is capable of isolating the voltage present on the conductor. Lacquer coatings like those typically found on transformer windings do not provide sufficient, reliable insulation for use with current probes. The lacquer coating can be easily nicked or damaged, which compromises the insulating capabilities of the lacquer coating.**

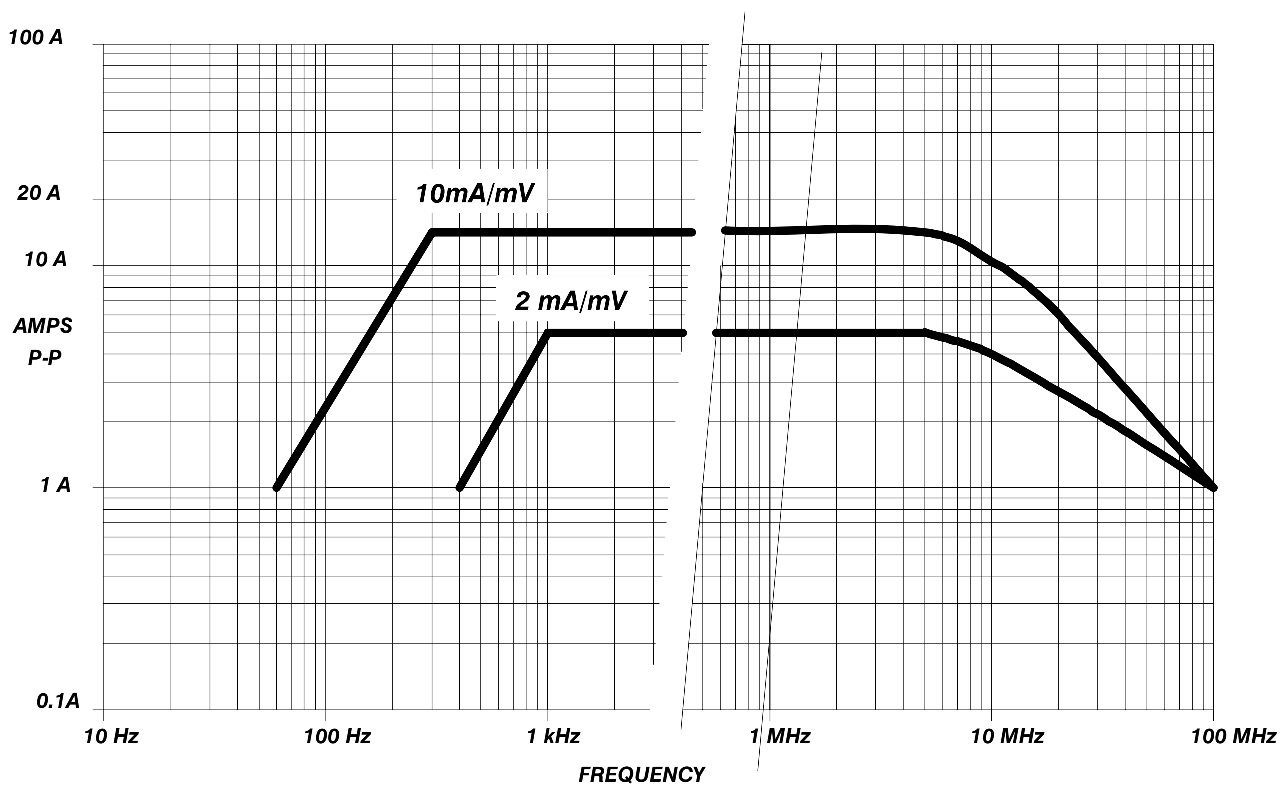


Figure 3: Probe and termination input current vs. frequency derating

Typical Characteristics

This section lists the various typical characteristics that describe the P6021 Current Probe. Included are typical electrical and mechanical characteristics.

Typical characteristics are described in terms of typical or average performance. Typical characteristics are not warranted.

Table 4: Electrical characteristics

Characteristic	Information
Tilt	
2 mA/mV	2.8% or less within 10 µs of step
10 mA/mV	7.5% or less within 100 µs of step
Maximum DC saturation	0.5 A
Signal Delay	
5-foot probe with termination	Approximately 9 ns
Insertion Impedance	0.03 Ω or less at 1 MHz, increasing to 1.0 Ω or less at 60 MHz
Probe Rise Time	≤5.8 ns
Step Response	*Because the oscilloscope input capacitance becomes a part of the termination network, the step response will vary with different oscilloscopes*
Aberrations (probe and termination at either sensitivity setting.)	≤10% peak-to-peak within 50 ns of step; ≤2% peak-to-peak thereafter

Table 5: Mechanical characteristics

Characteristic	Information	
Probe cable length	5 ft	1.5 m
Net weight:		
Probe and 5-foot cable	3.60 oz	≈103 gm
Termination	1.7 oz	≈48 gm
Termination	L 3.47 in W 1.10 in H 0.86 in	88 mm 28 mm 22 mm
Probe body	L 7.9 in W 0.63 in H 1.25 in	200 mm 16 mm 32 mm
Maximum conductor diameter	0.141 in	3.58 mm

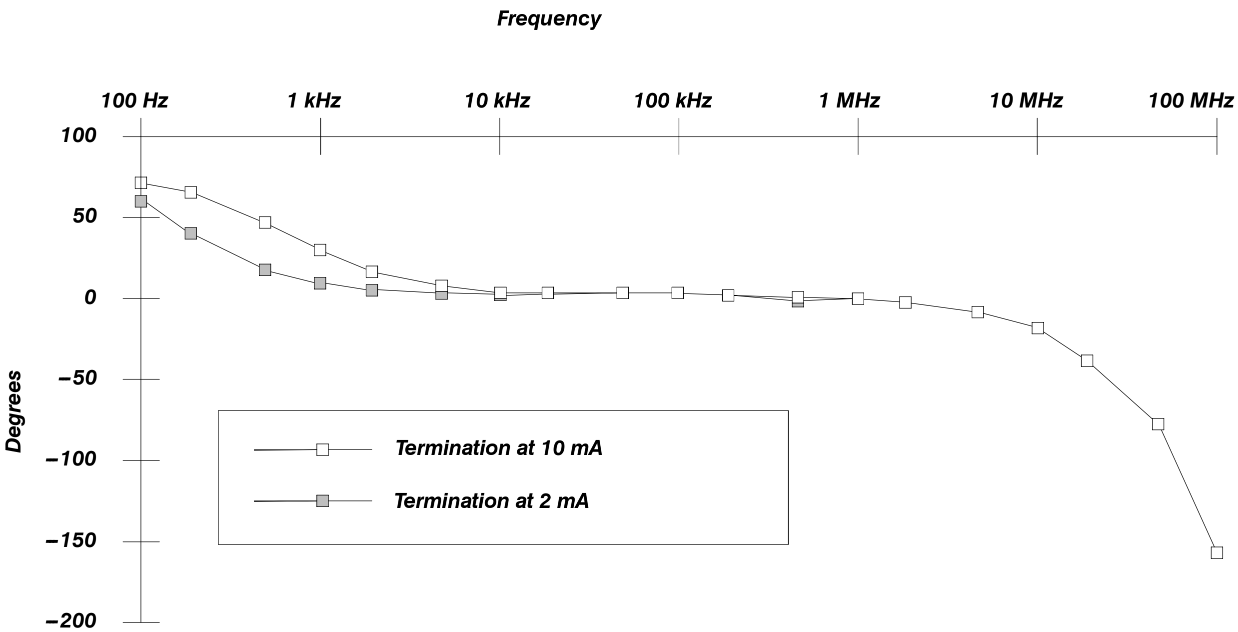


Figure 4: Typical P6021 phase response

Circuit Description

This section describes the circuits in the P6021 current probe and termination.

Current Probe

The P6021 current probe consists of a current transformer mounted in the nose of the probe head case, an impedance-matching network, and an internal switch to disconnect the transformer shield from ground.

The transformer contains a two-section U-shaped ferrite core. One section is stationary; the other is mechanically movable to permit closing the core around the conductor being measured. The conductor under test forms a one-turn primary winding for the transformer; the windings around the stationary portion of the core are the secondary windings. The circuitry between the transformer and the coaxial cable corrects any differences in level between the signal induced in the parallel windings of the secondary and matches the balanced probe winding to the cable.

As indicated on the probe body, the turns ratio of the P6021 is 125:1. This refers to the number of windings in the secondary of the probe transformer.

The probe transformer is shielded to eliminate interference from outside signals. To eliminate the possibility of creating a short circuit from this shield to the conductor being measured, the slide switch disconnects the ground from the shield when you open the sliding portion of the probe to connect or remove it from a conductor.

Termination

The P6021 termination consists of an impedance-matching network to terminate the coaxial cable and a voltage divider that is switched in by a sensitivity control to change the sensitivity by a factor of five. When the control is in the 2 mA/mV position, a 10 mA current signal in the conductor under test induces a 5 mV signal at the output of the termination. (This assumes that the termination is connected to a 1 MΩ input oscilloscope.)

When the sensitivity control is in the 10 mA/mV position, a 10 mA current signal is attenuated to induce a 1 mV signal at the output of the termination.

Probe Performance

WARNING. *To avoid personal injury and damage to the probe, remove the probe from any signal source before attempting to adjust or service the probe.*

This probe should be serviced only by qualified service personnel.

Do not service electrical equipment alone. If you must service or adjust equipment that is attached to a signal or power source, do so only when another person capable of rendering first aid and resuscitation is present.

This section provides procedures to check the performance of the P6021 or to calibrate it. These procedures require the equipment listed in Table 6 on page 13. Specifications given are the minimum necessary for accuracy. If equipment is substituted, it must meet or exceed the specifications of the recommended equipment. Test equipment is assumed to be correctly calibrated and operating within the given specifications.

Also, if equipment is substituted, control settings or equipment setup may need to be altered. For detailed operating instructions for the test equipment, refer to the instruction manual for each unit.

To ensure measurement accuracy, check the performance of the probe and termination whenever you begin using them with a different oscilloscope input, especially when you have changed input capacitance. Recalibrate the probe if necessary.

The recommended calibration interval of the probe and termination is every twelve months.

Before calibrating the probe, thoroughly inspect and clean it as described in the section entitled *Maintenance* on page 23. Dirty or worn mating surfaces between the transformer and the lid can degrade low-frequency response. Clean these surfaces if necessary.

Calibration procedures can also be used as performance checks by completing all steps except those that adjust the probe. This checks the probe and termination to the original performance standards without requiring you to remove the termination cover or make internal adjustments.

Table 6: Equipment list

Item	Description	Recommended equipment[1]
Oscilloscope		TDS420A, TDS303X, or TDS305X
Bandwidth	DC to ≥200 MHz	
Vertical sensitivity	1 mV/div	
Measurement functions	Amplitude averaging	
Calibration generator		
Fast Rise Step	≤1 ns, 1 V_{P-P} into 50 Ω	Wavetek 9100 with option 100:250 or Tektronix PG506A
Sinewave Voltage	5 V_{P-P} into 50 Ω (100 mA), 120 Hz to >60 MHz, 1.5% flatness	Wavetek 9100 with option 100:250, Tektronix SG5030, or SG503
Digital Multimeter (DMM)	5 1/2 digits or better	Keithley 2000, or HP 3458A
RMS ACV	50 kHz, ≤ ±0.5%	
Adapter	BNC "T"	Tektronix part number 103-0030-XX
Coaxial cables (2)	36-inch, 50 Ω precision	Tektronix part number 012-0482-XX
Adapter	BNC-to-dual banana	Tektronix part number 103-0090-XX
Calibration fixture	Current probe, calibration	Tektronix part number 067-0559-XX

1 **Or equivalent**

Performance Verification

Check Midband Accuracy. Refer to Figure 5 when making equipment connections.

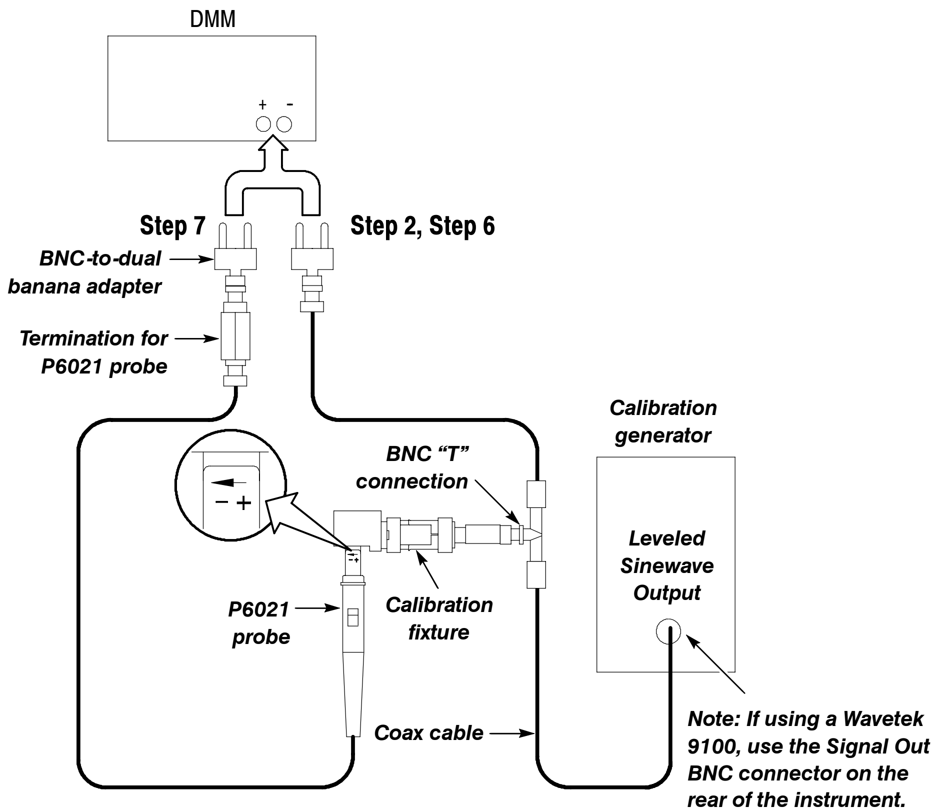


Figure 5: Midband accuracy test setup

1. Set the P6021 termination sensitivity to 2 mA/mV.
2. Connect the Leveled Sinewave Output of the calibration generator to a BNC “T” connector. Connect one branch of the BNC “T” connector to the calibration fixture. Connect the other branch of the BNC “T” to the DMM input using a BNC-to-dual banana adapter.
3. Set the DMM to ACV (autorange).
4. Set the Leveled Sinewave Output of the calibration generator to 50 kHz and an amplitude of 5 V_{pp}.
5. Measure and record the DMM output as M1.
6. Disconnect the coax cable from the BNC-to-dual banana adapter.

7. Connect the P6021 termination and probe to the BNC-to-dual banana adapter.

8. Connect the probe to the calibration fixture.

9. Record the DMM output as M2.

10. Calculate the % of error:

$$Itest = \frac{M1}{50\,\Omega}$$

$$\%Error = \frac{2 \times M2 \quad - \quad Itest}{Itest} \times 100$$

11. Record the results in the test record and compare the results on page 19 against the midband specification on page 7.

12. Set the P6021 termination sensitivity to 10 mA/mV.

13. Record the DMM output as M3.

14. Calculate the % of error:

$$\%Error = \frac{10 \times M3 \quad - \quad Itest}{Itest} \times 100$$

15. Record the results in the test record and compare the results on page 19 against the midband specification on page 7.

Check Low Frequency Response. Refer to Figure 5 when making equipment connections.

1. Connect the calibration fixture to the Leveled Sinewave Output of the calibration generator.

2. Connect the BNC-to-dual banana adapter to the input of the DMM.

3. Connect the P6021 termination and probe to the BNC-to-dual banana adapter connected to the DMM.

4. Set the DMM to ACV (autorange).

5. Set the P6021 termination sensitivity to 2 mA/mV.

6. Set the Leveled Sinewave Output of the calibration generator to 50 kHz and an amplitude of 5 V_{pp}.

7. Connect the probe to the calibration fixture.

8. Enable the Leveled Sinewave Output of the calibration generator.

9. Measure and record the DMM output as M1 in Table 7.
10. Set the Leveled Sinewave Output of the calibration generator to 450 Hz.
11. Measure and record the DMM output as M2 in Table 7.
12. Calculate the low frequency bandwidth ratio:

$$\textit{low frequency bandwidth ratio} = \frac{M2}{M1}$$

13. Record the results in the test record on page 19 and compare the results against the low frequency specification on page 19.
14. Set the P6021 termination sensitivity to 10 mA/mV.
15. Set the Leveled Sinewave Output of the calibration generator to 50 kHz and an amplitude of 5 V_{pp}.
16. Measure and record the DMM output as M3 in Table 7.
17. Set the Leveled Sinewave Output of the calibration generator to 120 Hz.
18. Measure and record the DMM output as M4 in Table 7.
19. Calculate the low frequency bandwidth ratio:

$$\textit{low frequency bandwidth ratio} = \frac{M4}{M3}$$

20. Record the results in the test record on page 19 and compare the results against the low frequency specification on page 19.

NOTE. *Dirty or worn mating surfaces between the transformer and the lid degrade the low-frequency response. Clean them if necessary. See page 23 for cleaning instructions.*

Table 7: Low frequency bandwidth measurements

Probe Sensitivity	Leveled Sinewave Output frequency (Calibration generator)	M1	M2	$\frac{M2}{M1}$	M3	M4	$\frac{M4}{M3}$
2 mA/mV	50 kHz						
	450 Hz						
10 mA/mV	50 kHz						
	120 Hz						

Check High Frequency Bandwidth. Refer to Figure 6 when making equipment connections.

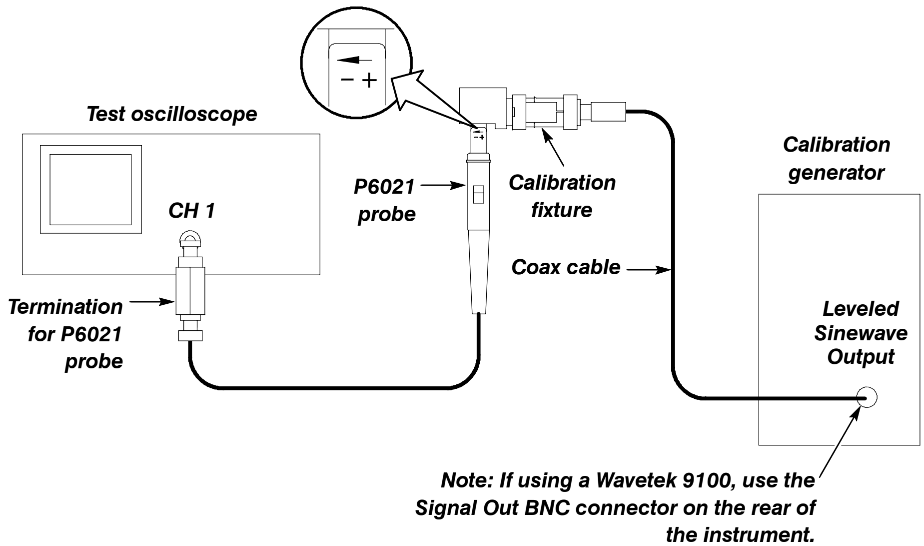


Figure 6: High frequency bandwidth test setup

1. Set the P6021 termination sensitivity to 2 mA/mV.
2. Connect the calibration fixture to the Leveled Sinewave Output of the calibration generator.
3. Connect the P6021 termination and probe to CH1 of the oscilloscope.
4. Set the oscilloscope Vertical Deflection to 10 mV/div.
5. Set the oscilloscope Horizontal Scale to 10 µs/div.
6. Set the oscilloscope Auto Measurement to display “Amplitude”.
7. Set the Leveled Sinewave Output of the calibration generator to 50 kHz and an amplitude of 5 V_{pp}.
8. Connect the P6021 probe to the calibration fixture.
9. Enable the Leveled Sinewave Output of the calibration generator.
10. Measure and record the oscilloscope “amplitude” Auto Measurement as M1 in Table 8.
11. Set the oscilloscope Horizontal Scale to 10 ns/div.
12. Set the Leveled Sinewave Output of the calibration generator to 60 MHz.

13. Measure and record the oscilloscope amplitude Auto Measurement as M2 in Table 8.

14. Calculate the high frequency bandwidth ratio:

$$\textit{high frequency bandwidth ratio} = \frac{M2}{M1}$$

15. Record the results in the test record on page 19 and compare the results against the high frequency specification page 19.

16. Set the P6021 termination sensitivity to 10 mA/mV.

17. Set the oscilloscope Vertical Deflection to 2 mV/div.

18. Set the oscilloscope Horizontal Scale to 10 µs/div.

19. Set the Leveled Sinewave Output of the calibration generator to 50 kHz and an amplitude of 5 V_{pp}.

20. Measure and record the oscilloscope amplitude Auto Measurement as M3 in Table 8.

21. Set the oscilloscope Horizontal Scale to 10 ns/div.

22. Set the Leveled Sinewave Output of the calibration generator to 60 MHz.

23. Measure and record the oscilloscope amplitude Auto Measurement as M4 in Table 8.

24. Calculate the high frequency bandwidth ratio:

$$\textit{high frequency bandwidth ratio} = \frac{M4}{M3}$$

25. Record the results in the test record on page 19 and compare the results against the high frequency specification page 19.

When you are done, disconnect all test equipment and replace the termination cover.

Table 8: High frequency bandwidth measurements

Probe sensitivity	Vertical deflection	Horizontal scale	Leveled Sinewave Output frequency (calibration generator)	M1	M2	$\frac{M2}{M1}$	M3	M4	$\frac{M4}{M3}$
2 mA/mV	10 mV/div	10 µs/div	50 kHz						
		10 ns/div	60 MHz						
10 mA/mV	2 mV/div	10 µs/div	50 kHz						
		10 ns/div	60 MHz						

P6021 Test Record

Photocopy this form and use it to record the performance test results.

P6021 test record

Instrument Serial Number:		Certificate Number:	
Temperature:		Relative Humidity %:	
Date of Calibration:		Technician:	

Performance test	Range, mA/mV	Minimum	Measured/calculated	Maximum
Midband Accuracy (% Error)	2	-3%		+3%
	10	-3%		+3%
Low Frequency Response (ratio)	2	0.707		—
	10	0.707		—
High Frequency Response (ratio)	2	0.707		—
	10	0.707		—

Adjustment Procedure

If the probe does not pass the performance verification procedure or you want to optimize the performance of the probe, perform the following adjustment procedure:

Preparation

1. Insert a small screwdriver between the cover and the termination near the part number, and gently pry up the top cover of the P6021 termination by twisting the screwdriver. Leave the bottom cover on, since it must be in place when the termination is in use.

2. Set up the oscilloscope as described below:

Vertical mode	CH 1
Horizontal mode	Main
Trigger source	CH 1
Trigger coupling	AC
Trigger mode	Peak-to-peak, auto
Trigger slope	Positive
Trigger level	As required
Ch 1 coupling	DC
Ch 1 resistance	1 MΩ
Volts/division	2 mV
Time/division	10 ns
Averages	5 to 10

***NOTE**. When using a Wavetek 9100 calibrator with the scopecal option, no other calibrators are required. The following setups are generic with nominal settings indicated for the major adjustment steps.*

Adjust Aberrations

***CAUTION.** To avoid damaging the probe, do not disconnect the probe termination when measuring high currents. Leaving the probe unterminated can cause a high voltage to develop in the secondary winding that may damage the current probe transformer.*

1. Connect the current probe calibration fixture to the fast rise output of the calibration generator.

2. Set the fast rise output to maximum (1 Vpp).

3. Connect the P6021 probe BNC connector to the termination.

4. Connect the P6021 termination to the oscilloscope Ch 1 input.

5. Set the P6021 termination sensitivity to 2 mA/mV.

6. Connect the probe to the current probe calibration fixture. Figure 7 shows the proper probe orientation to the current probe calibration fixture.

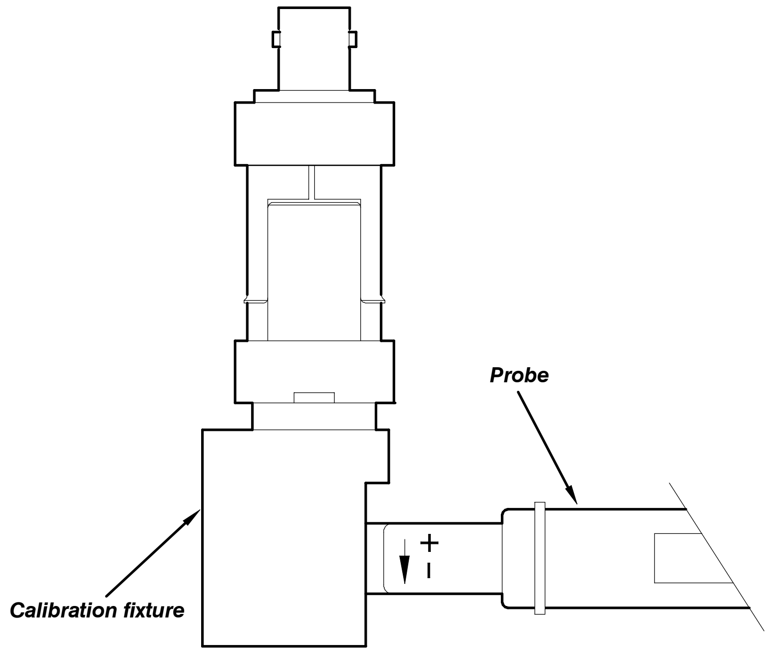


Figure 7: Connecting the probe to the calibration fixture

7. The following adjustments affect aberrations and flat-top response: C13, R10, and R12 of the probe (see Figure 8) and C22, C25, and R36 of the termination (see Figure 9). To minimize aberrations and achieve the best flat-top response, the following procedure is recommended. However, these adjustments interact; you may have to readjust several of them to ensure minimum aberrations..

a. Adjust R10 and R12 for flat response (see Figure 8). (Controls overshoot in the first 10 ns time domain.)

b. Adjust C13 for flat response. (Controls slope in first 20 ns.)

c. Adjust R36 for flat response (see Figure 9). (Controls front corner, first 5 ns.)

d. Adjust C25 to minimize aberrations in the 10 to 20 ns domain.

e. Adjust C22 to minimize aberrations in the 15 to 25 ns domain.

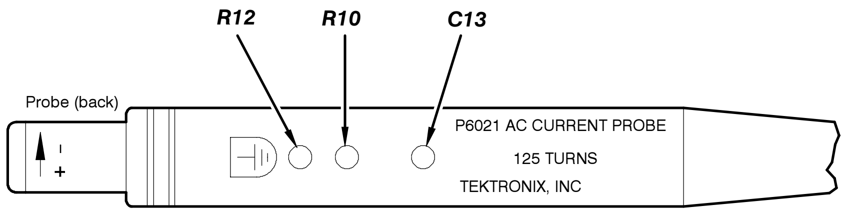


Figure 8: Location of probe adjustments

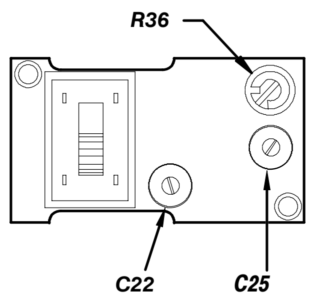


Figure 9: Location of termination adjustments

8. Set the termination sensitivity control to the 10 mA/mV position.
9. Set the oscilloscope Vertical Deflection to 1 mV/division.
10. Readjust adjustments as needed to ensure the optimum pulse response on both sensitivity settings.

Maintenance

The information in this section will help you maintain your probe for a long service life.

CAUTION. *To prevent damage to probe materials, avoid using chemicals that contain benzene, benzine, toluene, xylene, acetone, or similar solvents.*

To avoid degrading the performance of the probe, do not lubricate the polished mating surfaces of the transformer.

Cleaning

To clean the probe body, use a soft cloth dampened in a solution of mild detergent and water. To clean the core, open the jaw and clean the exposed core surfaces with a cotton swab dampened with isopropyl alcohol (isopropanol) or ethyl alcohol (fotocol or ethanol).

Do not lubricate the mating surfaces of the jaws. Any lubricant between the core pieces should be removed with a recommended solvent.

Do not use chemicals containing benzine, benzene, toluene, xylene, acetone, or similar solvents.

Do not use a petroleum based lubricant on the plastic. If the plastic slide assembly requires lubrication, use a silicone-based grease sparingly.

Do not immerse the probe in liquids or use abrasive cleaners.

When cleaning the probe, look for any excessive wear of the slide parts that might cause the probe to operate improperly. Dirty or worn mating surfaces between the transformer and the lid can degrade low-frequency response. Clean these surfaces if necessary.

Disassembling the Probe

Use the following procedure to disassemble the probe for cleaning or repair. You will need a #1 PoziDriv screwdriver. Work over a smooth, clean surface so that you can easily find any small pieces that may drop. Refer to Figure 10.

CAUTION. *To avoid degrading the performance of the probe, do not touch the polished mating surfaces of the transformer after cleaning.*

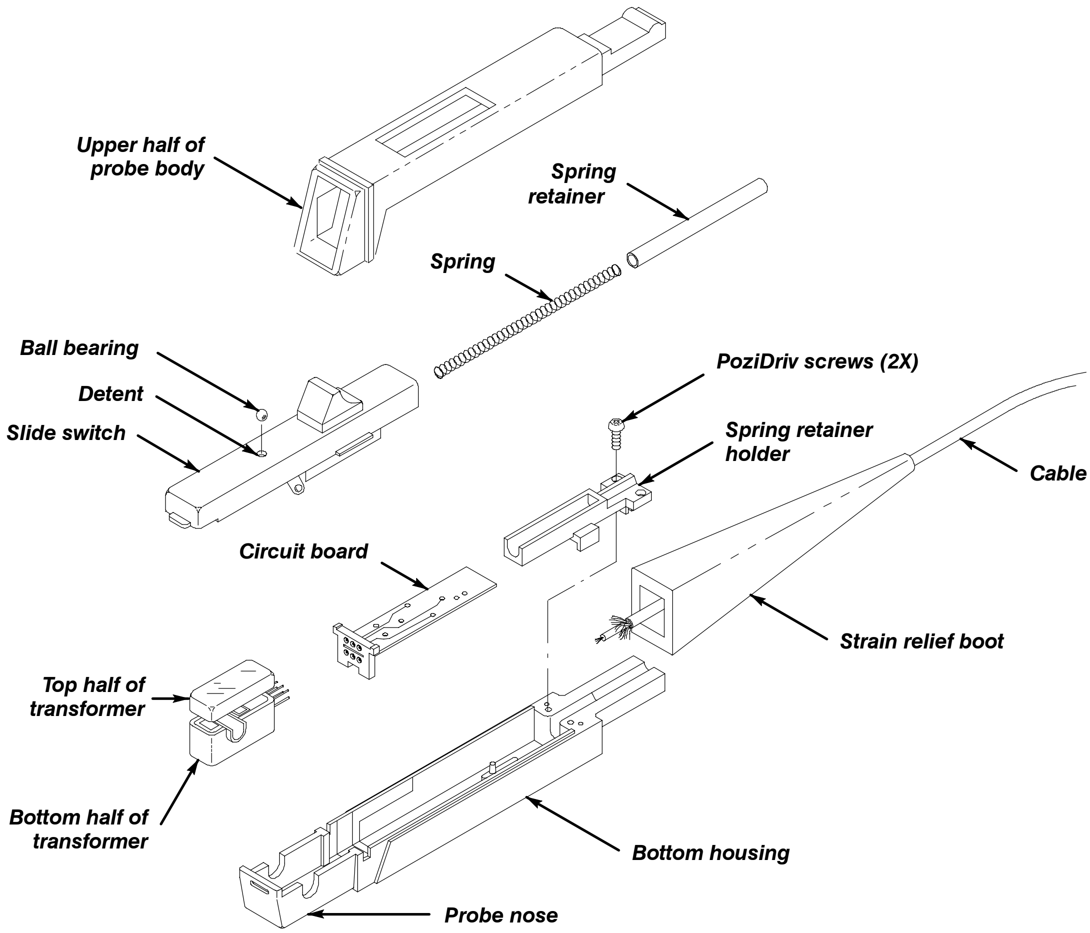


Figure 10: Disassembling the probe

1. Hold the probe horizontally with the slide switch up.
2. Move the strain relief boot back over the cable.
3. Be careful not to lose the small ball bearing you are about to expose.
4. Slowly lift the upper half of the probe body slightly at the cable end, and push the assembly forward over the nose and off.
5. Remove the small ball bearing from the detent in the slide switch.
6. Lift the back of the return spring retainer out of the holder.
7. Remove the slide switch, spring retainer, and the top of the transformer as a unit. Note the orientation of the movable portion of the transformer in the slide.

8. Remove the two PoziDriv screws that secure the spring retainer holder to the probe body; then remove the small black plastic holder.

9. Lift the circuit board, transformer, and cable out of the probe body as a unit. If you need to, you can unplug the transformer from the circuit board.

10. To reassemble the probe, reverse the procedure above.

    When replacing the slide switch, spring retainer, and transformer top as a unit, push the slide switch contacts gently inside the sides of the bottom housing.

Repairing the Probe

To make repairs inside the probe body, disassemble the probe as described in the previous section. If you need to solder on the circuit board, use a minimum of heat, and observe normal circuit board procedures.

If you need to replace the current transformer, replace the entire assembly including the other half of the transformer core mounted in the slide switch. The transformer halves are matched at the factory before shipment.

Repairing the Termination

Repairing the termination can consist of replacing either the connectors or the circuit board. These tasks are described below.

Replacing the Connectors. To replace the connectors, follow these steps.

1. Insert a small screwdriver between the cover and the termination near the part number, and gently pry up the plastic snap-on cover from the termination.

2. Using a heat sink, unsolder the leads from the defective connector.

3. Unscrew and remove the defective connector.

4. Replace the defective connector with the new one.

5. Screw and solder the new connector back in place.

6. Align the switch with the slider in the front cover, and replace the front cover.

Replacing the Circuit Board. To replace the circuit board, follow these steps.

1. Remove the plastic snap-on covers from the front and back of the termination.

2. Using a heat sink, unsolder the leads from the connectors.

3. Unscrew the two screws from the back of the circuit board.

4. Remove the circuit board from the termination and repair it as you require, being careful to use a minimum of heat and observe normal circuit board procedures.

5. Replace the circuit board by reversing the above procedure.

6. Align the switch with the slider in the front cover, and replace the front cover.

Replaceable Electrical Parts

This section contains a list of the electrical components for the P6021. 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 products are sometimes made to accommodate improved components as they become available and to give you the benefit of the latest 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

If you order a part that has been replaced with a different or improved part, your local Tektronix field office or representative will contact you concerning any change in part number.

Using the Replaceable Electrical Parts List

The tabular information in the Replaceable Electrical Parts List is arranged for quick retrieval. Understanding the structure and features of the list will help you find all of the information you need for ordering replacement parts. The following table describes each column of the electrical parts list.

Parts list column descriptions

Column	Column name	Description
1	Component number	The component number appears on diagrams and circuit board illustrations, located in the diagrams section. Assembly numbers are clearly marked on each diagram and circuit board illustration in the *Diagrams* section, and on the mechanical exploded views in the *Replaceable Mechanical Parts* list section. The component number is obtained by adding the assembly number prefix to the circuit number (see Component Number illustration following this table). The electrical parts list is arranged by assemblies in numerical sequence (A1, with its subassemblies and parts, precedes A2, with its subassemblies and parts). Chassis-mounted parts have no assembly number prefix, and they are located at the end of the electrical parts list.
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 entry indicates the part is good for all serial numbers.
5	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.

Component Number

Component Number

A23A2R1234 **A23** **A2** **R1234**

Assembly number Subassembly Number (optional) Circuit Number

Read: Resistor 1234 (of Subassembly 2) of Assembly 23

List of Assemblies

A list of assemblies is located at the beginning of the electrical parts list. The assemblies are listed in numerical order. When a part's complete component number is known, this list will identify the assembly in which the part is located.

Chassis Parts

Chassis-mounted parts and cable assemblies are located at the end of the Replaceable Electrical Parts List.

Replaceable electrical parts list

Component number	Tektronix part number	Serial no. effective	Serial no. discont'd	Name & description
				Figure 11
A1	670-1117-XX			CIRCUIT BD ASSY:PROBE
A1C13	281-0122-XX			CAP,VAR,CER DI:2.5-9PF,100V
A1C14	283-0182-XX			CAP,FXD,CER DI:51PF,5%,400V
A1L10	108-0526-XX			COIL,RF:FIXED,50UH
A1L12	108-0526-XX			COIL,RF:FIXED,50UH
A1L14	108-0529-XX			COIL,RF:FIXED,1.6UH
A1R10	311-0635-XX			RES,VAR,NONWW:TRMR,1K OHM,0.5W
A1R12	311-0635-XX			RES,VAR,NONWW:TRMR,1K OHM,0.5W
A1R13	317-0821-XX			RES,FXD,CMPSN:820 OHM,5%,0.125W
A1R14	317-0121-XX			RES,FXD,CMPSN:120 OHM,5%,0.125W
A1T1	120-0614-XX			TRANSFORMER,CUR:UPPER AND LOWER HALF
A1T14	120-0468-XX			XFMR,TOROID:6 TURNS,BIFILAR,454
A2	670-1052-XX			CIRCUIT BD ASSY:TERMINATION
A2C22	281-0123-XX			CAP,VAR,CER DI:5-25PF,100V
A2C25	281-0123-XX			CAP,VAR,CER DI:5-25PF,100V
A2C30	283-0140-XX			CAP,FXD,CER DI:4.7PF,+/-0.25PF,50V
A2J20	131-0602-XX			CONN,RF PLUG:BNC;50 OHM,MALE, STR,FEEDTHRU/FRONT PNL, 1.555L,0.285 L 0.375-32 THD,0.5
				Figure 12
A2L22	108-0525-XX			COIL,RF:FIXED,123NH
A2L31	108-0395-XX			COIL,RF:FIXED,64UH
A2P39	131-0106-XX			CONN,RCPT,ELEC:BNC,FEMALE
A2R22	317-0101-XX			RES,FXD,CMPSN:100 OHM,5%,0.125W
A2R24	321-0077-XX			RES,FXD,FILM:61.9 OHM,1%,0.125W,TC=T0
A2R31	321-0069-XX			RES,FXD,FILM:51.1 OHM,1%,0.125W,TC=T0
A2R33	321-0039-XX			RES,FXD,FILM:24.9 OHM,1%,0.125W,TC=T0
A2R34	321-0038-XX			RES,FXD,FILM:24.3 OHM,1%,0.125W,TC=T0
A2R35	317-0036-XX		8843	RES,FXD,CMPSN:3.6 OHM,5%,0.125W
A2R35	317-0240-XX	8844		RES,FXD,CMPSN:24 OHM,5%,0.125W
A2R36	311-0605-XX			RES,VAR,NONWW:TRMR,200 OHM,0.5W
A2SW30	260-0723-XX			SWITCH,SLIDE:DPDT,0.5A,125VAC

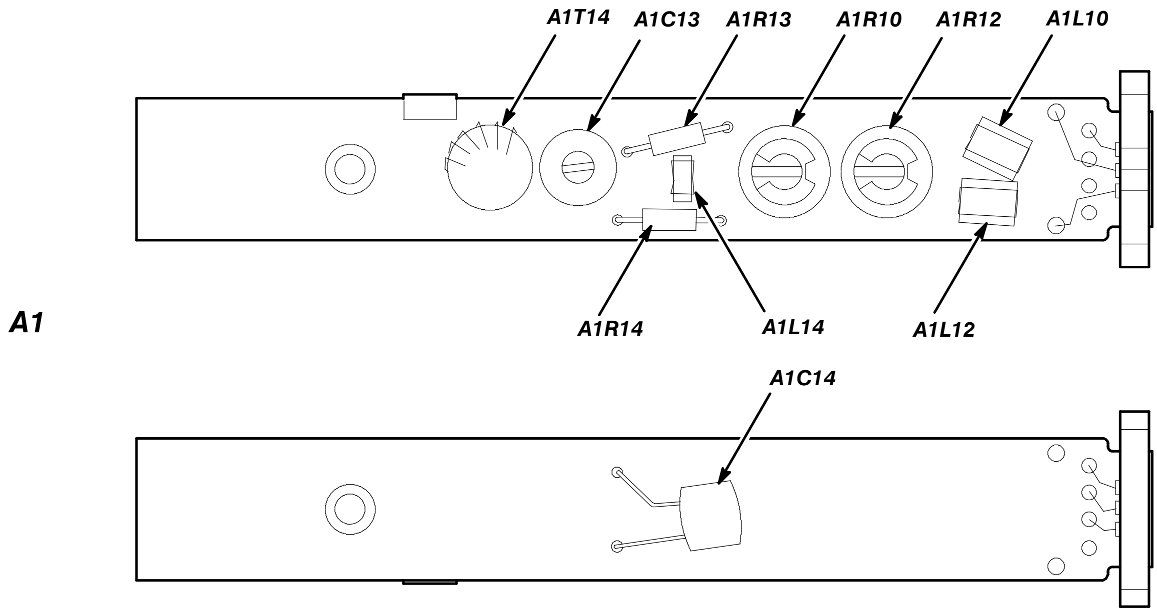


Figure 11: P6021 probe component location

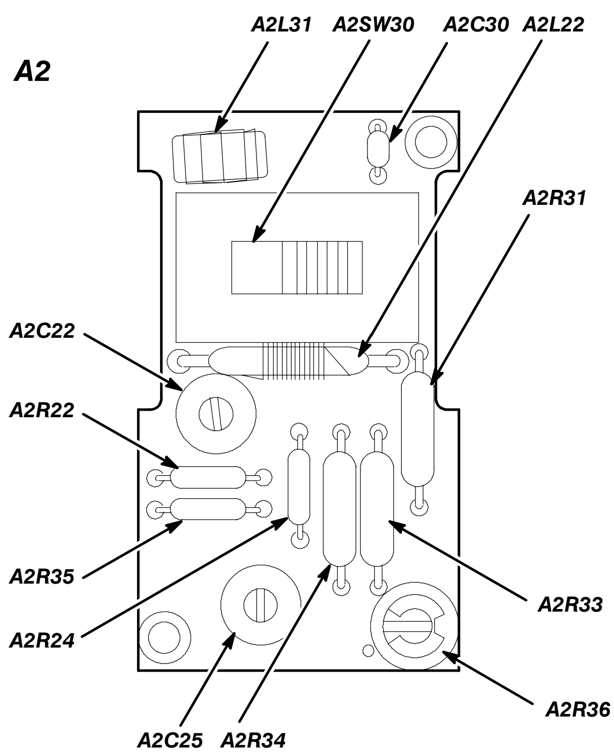


Figure 12: P6021 termination component location

Replaceable Mechanical Parts

This section contains a list of the replaceable mechanical components for the P6021. 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 products are sometimes made to accommodate improved components as they become available and to give you the benefit of the latest 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

If you order a part that has been replaced with a different or improved part, your local Tektronix field office or representative will contact you concerning any change in part number.

Using the Replaceable Mechanical Parts List

The tabular information in the Replaceable Mechanical Parts List is arranged for quick retrieval. Understanding the structure and features of the list will help you find all of the information you need for ordering replacement parts. The following table describes the content of each column in the parts list.

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 entry 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.

Chassis Parts

Chassis-mounted parts and cable assemblies are located at the end of the Replaceable Electrical Parts List.

Replaceable mechanical parts list

Fig. & index number	Tektronix part number	Serial no. effective	Serial no. discont'd	Qty	Name & description
13-	--------			1	P6021,PROBE,CURRENT:60 MHZ,250A,5FT W/TERM
-1	204-0367-XX			1	.BODY HALF,PROBE:UPPER
-2	214-0997-XX			1	.BALL,BEARING:0.094,SST
-3	351-0191-XX			1	.SLIDE,TEST PROD:
-4	214-0835-XX			1	.SPRING,HLCPS:0.127 OD X 2.65 L,SST
-5	214-0849-XX			1	.RTNR RETURN SPR:BRS CD PL
-6	131-0715-XX			1	.CONTACT,ELEC:SPR,UPR SHL,CU BE NI PL
-7	--------			1	.TRANSFORMER:(SEE T1 REPL)
-8	136-0252-XX			6	.SOCKET,PIN TERM:PCB,;FEMALE,STR,ACCOM .0.013.-0.020 DIA PIN,TIN/TIN SLEEVE,CLOSED .BOTTOM.,0.142 L,0.038 DIA
-9	352-0158-XX			1	.HOLDER,CKT BD:DELRIN
-10	--------			1	.CIRCUIT BD ASSY:PROBE(SEE A1 REPL)
-11	352-0159-XX			1	.HOLDER,SPR RTNR:BLACK DELRIN ATTACHING PARTS
-12	211-0001-XX			2	.SCREW,MACHINE:2-56 X 0.25,PNH,STL END ATTACHING PARTS
-13	204-0368-XX			1	.BODY HALF,PROBE:LOWER
-14	175-1041-XX			1	.CABLE ASSY,RF:62.5 OHM COAX,63.0 L.(STANDARD ONLY)
-15	200-0852-XX			1	.COVER,COAX TERM:W/SHLD & KNOB
-16	131-0602-XX			1	.CONN,RF PLUG::BNC,;50 OHM,MALE,STR, .FEEDTHRU./FRONT PNL, .1.555L,0.285 L .0.375-32 THD,0.5. L 22 AWG .TAB,0.384 DIA MTG
-17	426-0423-XX			1	.FRAME,COAX TERM:
-18	131-0106-XX			1	.CONN,RCPT,ELEC:BNC,FEMALE
-19	361-0219-XX			2	.SPACER,SLEEVE:0.06 L X 0.093 ID,BRS
-20	--------			1	.CIRCUIT BD ASSY:TERMINATION(SEE A2 REPL) ATTACHING PARTS
-21	211-0180-XX			2	.SCR,ASSEM WSHR:2-56 X .0.25,PNH,BRS, .NP,POZ END ATTACHING PARTS
-22	200-0851-XX			1	.COV,COAX TERMN:
					STANDARD ACCESSORIES
-23	196-3120-XX			1	LEAD,ELEC,PROBE GROUND;SDI,23 AWG,6.0 L
	070-0947-XX			1	MANUAL,TECH:INSTRUCTION,P6021
					OPTIONAL ACCESSORIES
	--------			1	CT-4,CURRENT XFMR:20MHZ,1KA

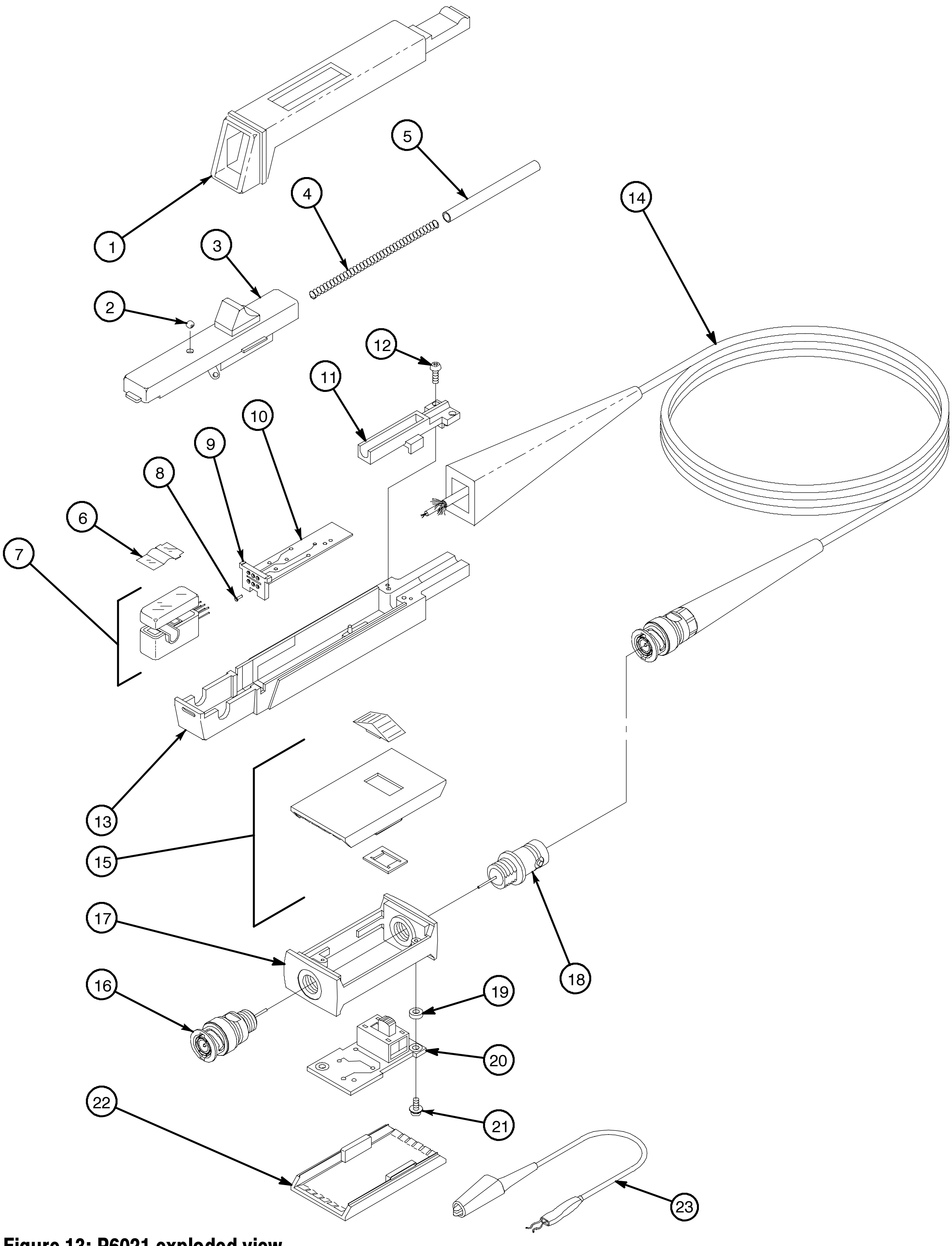


Figure 13: P6021 exploded view

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