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CT-1 and CT-2
Current Transformer

Instructions



070-7957-02

Tektronix

CT-1 and CT-2 Current Transformer

Instructions

www.tektronix.com
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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

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.

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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.

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 that there is damage to this product, have it inspected by qualified service personnel.

Avoid Exposed Circuitry. Do not touch exposed connections and components when power is present.

Do Not Operate in Wet/Damp Conditions.

Do Not Operate in an Explosive Atmosphere.

Keep Product Surfaces Clean and Dry.

Terms in this Manual

These terms may appear in this manual:

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

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

Symbols and Terms on the Product

These terms may appear on the product:

- DANGER indicates an injury hazard immediately accessible as you read the marking.
- WARNING indicates an injury hazard not immediately accessible as you read the marking.
- CAUTION indicates a hazard to property including the product.

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



CAUTION
Refer to Manual



Chassis Ground

Compliance Information

This section lists the safety and environmental standards with which the instrument complies.

Safety Compliance

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.

Additional Compliances

- IEC 61010-1: 2001. Safety requirements for electrical equipment for measurement, control, and laboratory use.

Equipment Type

Test and measuring equipment.

Pollution Degree Description

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.

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.



This symbol indicates that this product complies with the applicable European Union requirements according to Directives 2002/96/EC and 2006/66/EC on waste electrical and electronic equipment (WEEE) and batteries. 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.

Introduction

The CT-1 and CT-2 are high-frequency, bidirectional current probes. The CT-1 is a 1 GHz current probe and the CT-2 is a 200 MHz current probe. Each current probe comes with a P6041 probe cable to allow you to connect directly to an oscilloscope to take measurements.

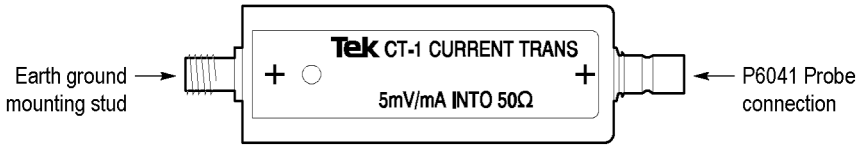


Figure 1: CT-1 current probe

WARNING. *To avoid electric shock, do not exceed the bare wire voltage ratings (30 VAC or 42 Vpk). Depending on which instrument the CT-1 or CT-2 is connected to, the exposed current transformer case metal may be floating (elevated above earth potential). Whenever possible, connect the mounting stud to earth ground.*

The chassis ground symbol (⏚) as shown on the product indicates that the exposed current transformer case metal may not be connected to earth ground. Use caution when the probe is not grounded.

The CT-1 and CT-2 are available as separately purchased units (Option 09). The *Replaceable Parts List* contains ordering information. (See page 11.)

This manual provides information on four subjects:

- *Description*
- *Operation*
- *Specifications*
- *Replaceable Parts List*

Description

The CT-1 (1 GHz) and CT-2 (200 MHz) are current probes designed for either permanent or temporary installation in the device-under-test (DUT). These probes are particularly useful for measuring high-frequency currents in solid state circuitry with minimum circuit loading. Due to bidirectional compatibility, the CT-1 and CT-2 can be used to inject a signal or as an interstage transformer.

The probes inductively measure current through a conductor and develop a voltage proportional to the current. For each mA of input current the signal terminal develops 5 mV (CT-1) or 1 mV (CT-2) when properly terminated into 50 Ω. The sensitivity of the CT-1 is 5 mV/mA (200 µA/mV) and the CT-2 is 1 mV/mA (1 mA/mV) when properly terminated into 50 Ω.

Since the CT-1 and the CT-2 are dynamic current probes (non-DC), the presence of DC current affects their performance. The following figures show the influence of DC current on frequency response.

This response was obtained with the + side of the CT-1 facing the signal source (preferred connection above 800 MHz).

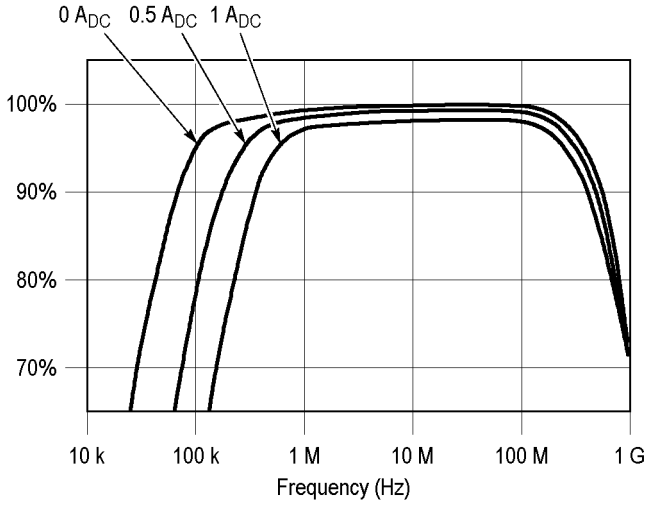


Figure 2: CT-1 frequency response vs. DC current

This response was obtained with the + side of the CT-2 facing the signal source (preferred connection).

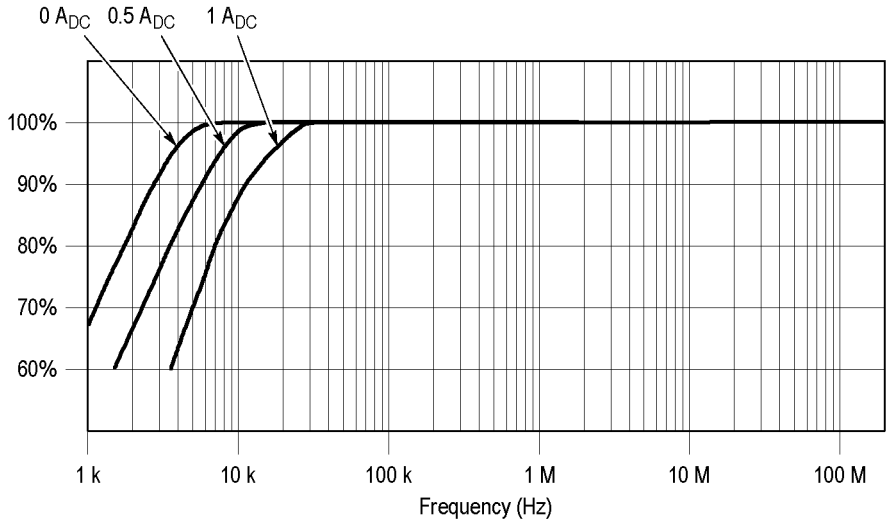


Figure 3: CT-2 frequency response vs. DC current

The CT-1 and CT-2 consist of a current transformer and a flexible probe cable that attaches between the transformer and the oscilloscope. In addition, the CT-1 and CT-2 have an internal termination resistor that reduces reflections that allows the transformer to be disconnected from the probe cable and left in the circuit. The following figure shows a simplified circuit of the CT-1 and CT-2.

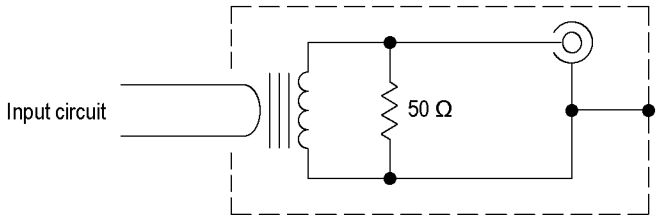


Figure 4: CT-1 and CT-2 simplified circuit

Operation

This section describes how to install the CT-1 or CT-2, discusses low-frequency probing, and provides information on safety and product care.

WARNING. *To avoid electric shock, do not exceed the bare wire voltage ratings (30 VAC, 42 Vpk). Depending on which instrument the CT-1 or CT-2 is connected to, the exposed current transformer case metal may be floating (elevated above earth potential). Whenever possible, connect the mounting stud to earth ground.*

The chassis ground symbol (⏚) as shown on the product indicates that the exposed current transformer case metal may not be connected to earth ground. Use caution when the probe is not grounded.

Installing the CT-1 or CT-2

The CT-1 or CT-2 transformers can be attached to the chassis or circuit board to measure current in transistors, diodes, or other components. Any number of transformers can be used.

When observing the output of a CT-1 or CT-2 transformer, ensure it is terminated into 50 Ω. If the oscilloscope input is not 50 Ω, use a suitable matching terminator (see recommended accessories in the *Replaceable Parts List*). The following figure shows the output of the CT-1 compared with the input pulse from a 250 ps fast-rise pulse generator and the output of the CT-2 as seen by a 100 MHz oscilloscope system.

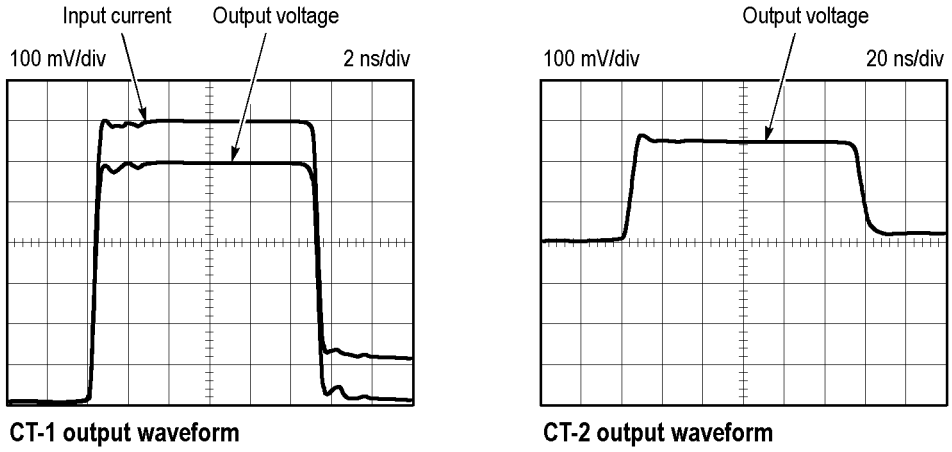


Figure 5: CT-1 and CT-2 output waveforms

If the CT-1 or CT-2 is connected so that the positive (+) label side faces the signal source, the input current and output voltage are in phase. This is the preferred connection. For pulses with a risetime slower than 1 ns, the CT-1 or CT-2 may be connected in either polarity.

The voltage on the signal wire must be limited to 30 VAC or 42 Vpk. Voltage ratings apply to insulated and non-insulated conductors.

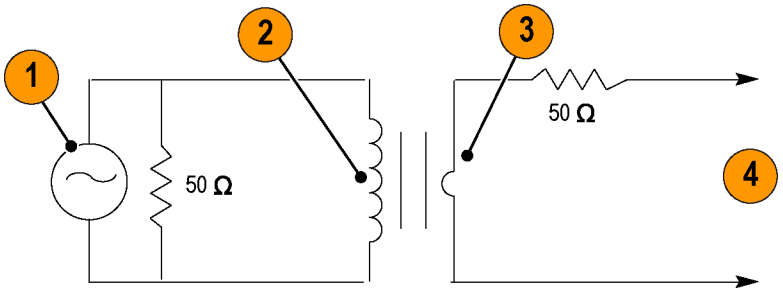
WARNING. *To reduce risk of electric shock, use only insulated conductors with these probes on circuits with voltages above 30 VAC or 42 Vpk. These probes are not rated for bare wire voltages above 30 VAC or 42 Vpk.*

WARNING. *To reduce risk of electric shock and fire, do not connect or disconnect the current probe to the DUT with the circuit energized. The metal stud and output terminal are not insulated. Always remove power before you connect or disconnect the CT-1 or CT-2 to or from the DUT.*

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.*

Injecting Current Signals

When injecting AC current into a single conductor, the current probe acts as the primary winding and the conductor acts as the secondary winding of a transformer.



1. Signal generator
2. Current probe primary
3. Circuit under test (secondary)
4. To circuit under test

Passing a wire one time through the transformer core results in a single turn secondary. To generate larger secondary signals, pass the wire through the transformer core multiple times.

To calculate how much voltage to apply to the CT-1 probe to inject a desired amount of current, multiply the desired current to be injected by 5. For the CT-2 the voltage to apply is equivalent to the desired current. For example, if you want to inject a 50 MHz signal that is 30 mA_{P-P} using the CT-1, the amount of voltage to apply is 30 × 5 = 150 mV_{P-P}. If you want to inject this same 30 mA_{P-P} signal with a CT-2, the amount of voltage to apply is 30 mV_{P-P}.

WARNING. *To reduce risk of shock, ground the metal mounting stud.*

WARNING. *To reduce risk of RF burns, connect the probe to the circuit and signal source before you apply the stimulus signal.*

CAUTION. *To reduce risk of fire and prevent damage to the probe, do not exceed the maximum injection voltage of 7 V_{p-p}.*

Low Frequency Response

The low-frequency response of the current transformer is proportional to the inductance of the transformer windings. A DC component in the current being measured tends to reduce this inductance. (See Figure 2.) (See Figure 3.)

You can also see this effect in the time domain. The pulse tilt is increased in the presence of significant DC current. (See Figure 6.) The DC current required to increase the tilt by a factor of two is about 0.3 A. Pulse currents that start at zero and remain unidirectional have a DC component that the user should consider.

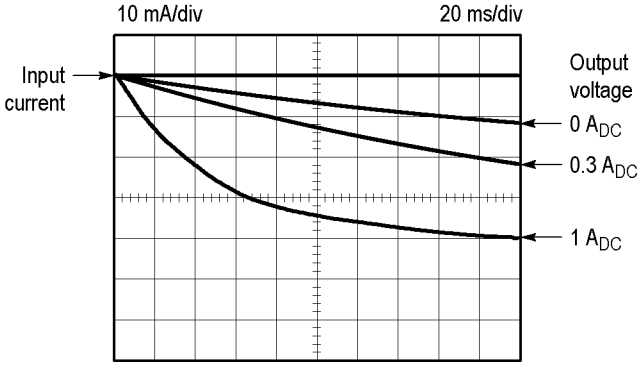


Figure 6: CT-1 decay characteristics referenced to front corner

When droop is present at low frequencies, the apparent overall peak-to-peak height from top to bottom is not the true current. The height of a flat-top pulse still can be measured accurately by observing the transition edge of the pulse. The 50 mA pulse is faithfully reproduced at the high-to-low transition at the center of the screen. (See Figure 7.)

Pulse width, tilt, and the lower 3 dB frequency are related by the formula:

$$\text{Percent tilt} = 200\pi \, Tp \, f_l$$

Where:

Tp = pulse width

f_l = lower 3 dB frequency

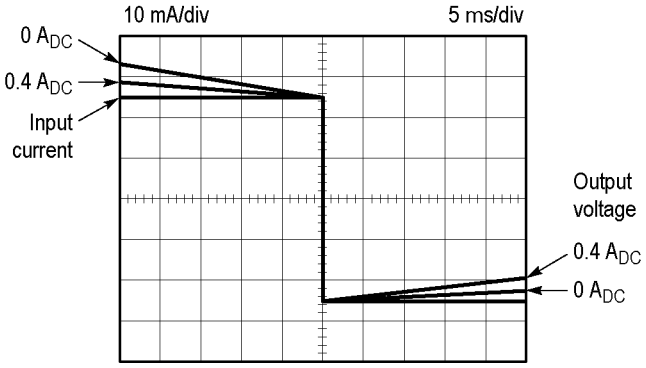


Figure 7: CT-2 decay characteristics referenced to transition

Additional consideration needs to be given to the amp-second rating of the transformer. The product of the pulse current and the pulse duration should be less than the amp-second rating to keep the transformer core from saturating. When saturation occurs, the output voltage falls to zero.

Probe Handling

Only normal handling considerations are necessary with the CT-1 and CT-2 transformers. They are sealed units and are not designed to be disassembled. If the transformer or cable is damaged, return it to Tektronix for replacement.

CAUTION. *Dropping the CT-1 or CT-2 transformer may break the probe. Do not pull or stretch the P6041 cable or place objects on the cable. This may damage the probe cable.*

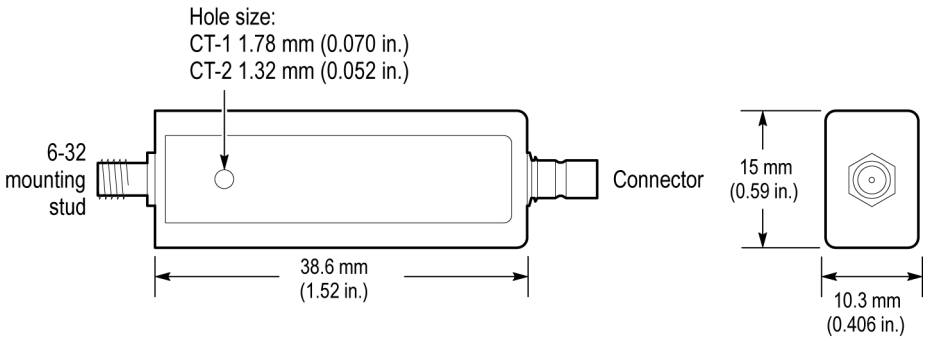
Specifications

The following table lists the electrical characteristics of the CT-1 and CT-2 Transformers when they are connected to the P6041 Probe cable.

Table 1: Electrical characteristics

Specification	CT-1 with P6041 Probe	CT-2 with P6041 Probe
Sensitivity	5 mV/mA, ±3% into a 50 Ω load	1 mV/mA, ±3% into a 50 Ω load
Pulse Response	Rise time: < 0.35 ns, 10% to 90% Aberrations: < 5% as seen by a 1 GHz system	Rise time: < 0.5 ns, 10% to 90% Aberrations: + 4%, -8% as seen by a 200 MHz system
L/R time constant	Approximately 5 µs	Approximately 125 µs
Insertion Impedance	50 Ω termination: 1 Ω shunted by approximately 5 mH Unterminated: 2 Ω shunted by approximately 5 mH	50 Ω termination: 0.04 Ω shunted by approximately 5 mH Unterminated: 0.08 Ω shunted by approximately 5 mH
Frequency Response, affected by DC component of current (See Figure 2.) (See Figure 3.)	25 kHz to 1 GHz	1.2 kHz to 200 MHz
Turns Ratio	1:5	1:25
Capacitive Loading	#14 bare wire: typically 1.5 pF #20 bare wire: typically 0.6 pF	#16 bare wire: typically 1.8 pF #22 bare wire: typically 0.7 pF
Maximum Bare Wire Voltage (uninsulated)	30 VAC 42 Vpk	30 VAC 42 Vpk
Signal Delay (with P6041 Probe Cable)	Approximately 2.8 ns measured from 50% points on leading edge of the current step and output voltage CT-1 Transformer only: 0.4 ns	Approximately 5.8 ns measured from 50% points on leading edge of the current step and output voltage CT-2 Transformer only: 0.3 ns
Effect of Direct Current (See Figure 5.) (See Figure 6.)	Approximately 0.3 A_{DC} increases decay by a factor of 2	Approximately 0.3 A_{DC} increases decay by a factor of 2
Amp × Second Rating	1 A·µs When this product is exceeded, the core saturates and the CT-1 output drops to zero	50 A·µs When this product is exceeded, the core saturates and the CT-2 output drops to zero
Pulse Current Rating	12 A	36 A
RMS Current Rating	0.5 A maximum	2.5 A maximum
Maximum Injection Voltage	7 V_{p-p}	7 V_{p-p}
Signal Connector	Amphenol Sub-Minax #27-3	Amphenol Sub-Minax #27-3

Table 2: General specifications (CT-1 and CT-2)

Environmental	
Temperature	Operating: –10 °C to +55 °C (+14 °F to +131 °F) Nonoperating: -51 °C to +71 °C (-60 °F to +160 °F)
Humidity	Operating: 5% to 95% RH (relative humidity) at up to +30 °C (+86 °F), 5% to 60% RH above +30 °C (+86 °F) up to +55 °C (+131 °F), non-condensing Nonoperating: 5% to 95% RH (relative humidity) at up to +30 °C (+86 °F), 5% to 60% RH above +30 °C (+86 °F) up to +71 °C (+160 °F), non-condensing
Altitude	Operating: 4,572 m (15,000 feet) Nonoperating: 15,240 m (50,000 feet)
Mechanical	
Dimensions	
P6041 Probe cable length	106.68 mm (42 in.)
Weight	15 gm (0.525 oz.) without P6041 47 gm (1.655 oz.) with P6041

Replaceable Parts List

This section contains a list of the replaceable parts for the CT-1 and CT-2. 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.

Change information, if any, is located at the rear of this manual.

Using the Replaceable Parts List

The tabular information in the Replaceable 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.

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.

Column	Column name	Description
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.
7	Mfr. code	This indicates the code of the actual manufacturer of the part.
8	Mfr. part number	This indicates the actual manufacturer's or vendor's part number.

Abbreviations

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

Mfr. Code to Manufacturer Cross Index

The table titled Manufacturers Cross Index shows codes, names, and addresses of manufacturers or vendors of components listed in the parts list.

Replaceable Parts List

Table 3: Manufacturers cross index

Mfr. code	Manufacturer	Address	City, state, zip code
24931	BERG ELECTRONICS INC	BERG ELECTRONICS RF/COAXIAL DIV 2100 EARLYWOOD DR PO BOX 547	FRANKLIN, IN 46131
80009	TEKTRONIX INC	14150 SW KARL BRAUN DR PO BOX 500	BEAVERTON, OR 97077-0001
29585	XEROX CORPORATION	14181 SW MILLIKAN WAY	BEAVERTON, OR 97005

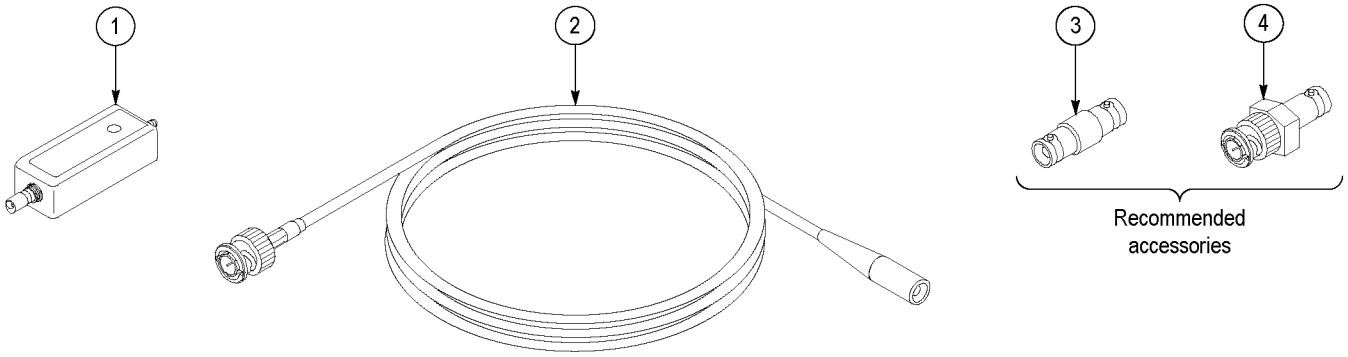


Figure 8: CT-1 and CT-2 accessories

Table 4: Replaceable parts list

Fig. & index number	Tektronix part number	Serial no. effective	Serial no. discont'd	Qty	Name & description	Mfr. code	Mfr. part number
8-1					CURRENT TRANSFORMER:CT-1 OR CT-2 WITH P6041 (OPTION 09 W/O P6041)		CT-1 OR CT-2
-2				1	P6041	80009	P6041
-3	103-0028-00			1	ADAPTER,CONN:BNC,FEMALE TO FEMALE,1.3 L,GOLD/NICKEL	24931	28A100-2
-4	011-0049-01			1	TERMN,COAXIAL:50 OHM,2W,BNC	80009	011-0049-01
	070-7957-XX			1	MANUAL,TECH:CT1/CT2 PROBE,DP	TK2548	PER TEK DOCUMENTATION

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